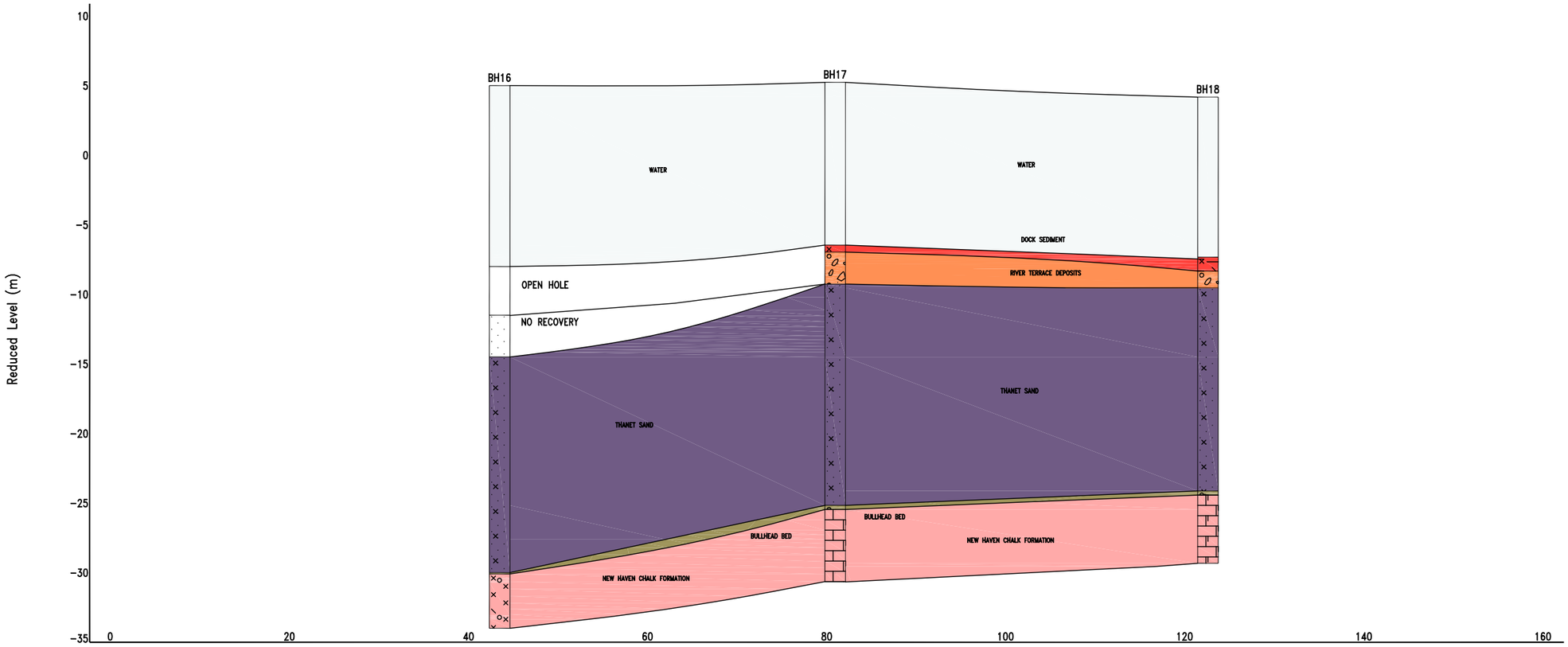
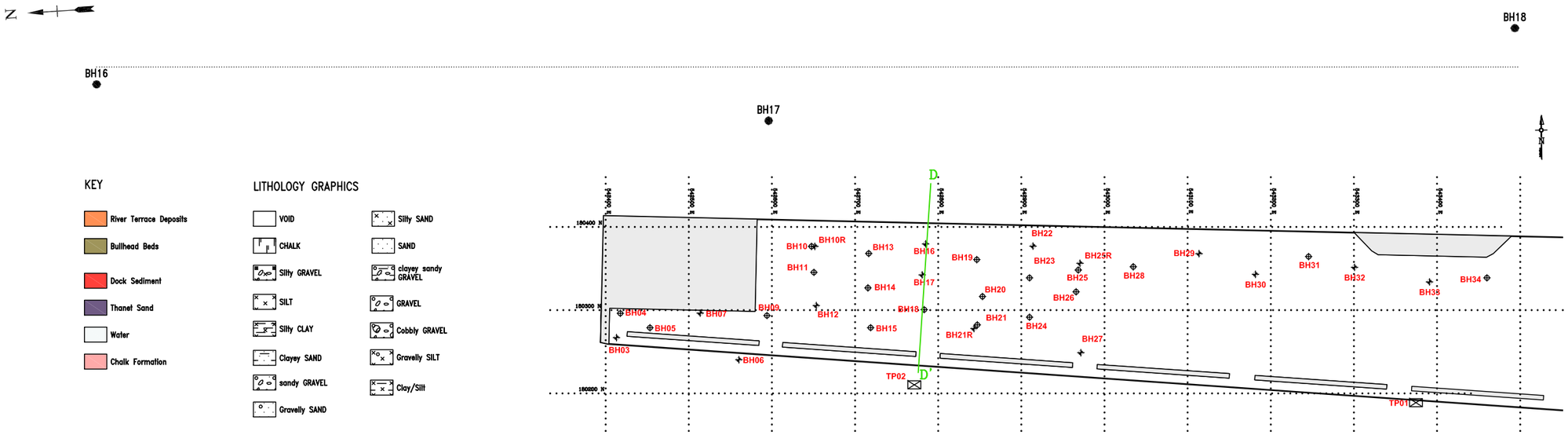
NOTES

1. This drawing should not be scaled.



Geological Section D-D'



No	Revision	Drawn	Checked	Passed	Date

CONCEPT SITE INVESTIGATIONS

Unit 8, Warple Mews
Warple Way
London W3 0RF

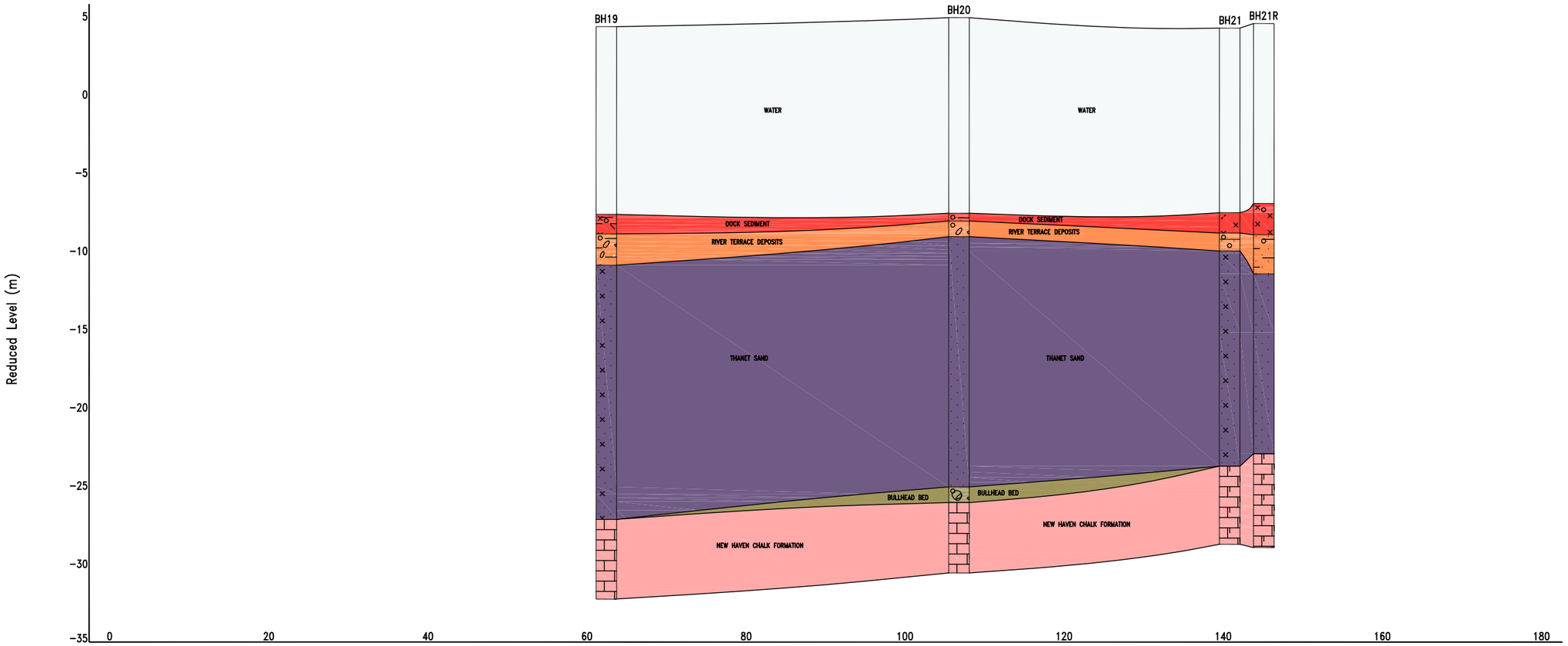
Tel: 020 8811 2880
Fax: 020 8811 2881

e-mail: concept@conceptconsultants.co.uk

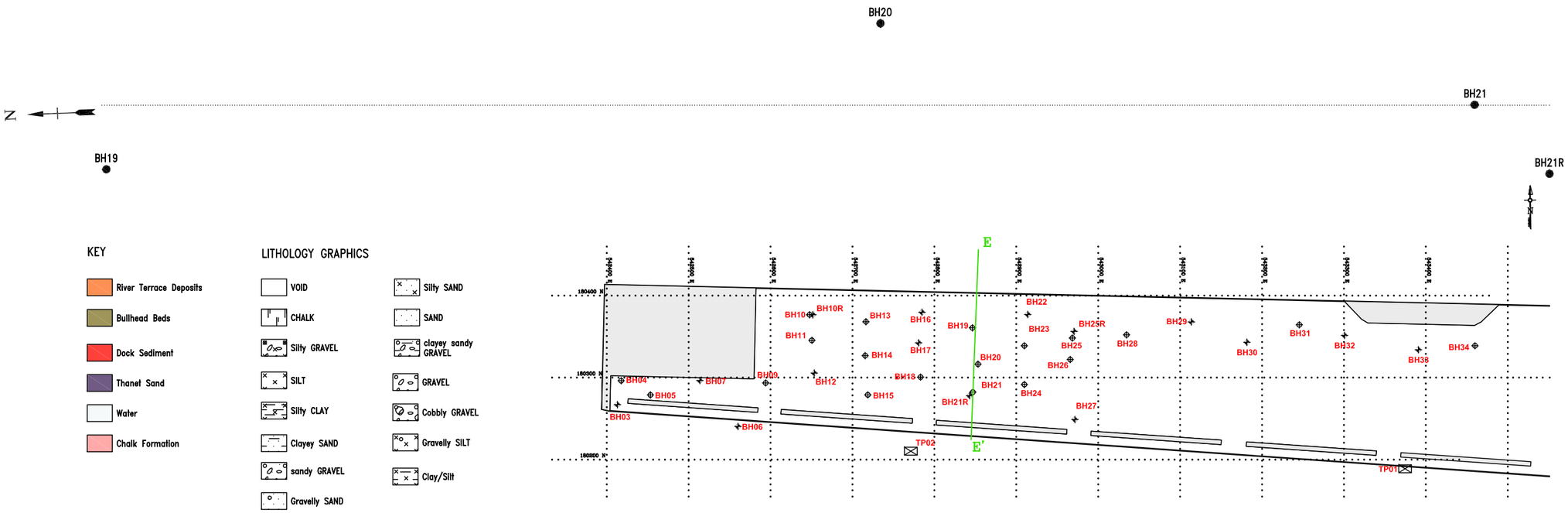
www.conceptconsultants.co.uk

Client:	London City Airport
Project:	CADP Surveys - Ground Investigation (Dock) - Phase 2
Title:	Figure 4 d - Geological Section D-D'
Dwg. No:	16200/04
Status:	Issue
Scale:	NTS

Drawn	Checked	Passed	Date
EV	OS	MD	February 17



Geological Section E-E'



KEY

- River Terrace Deposits
- Bullhead Beds
- Dock Sediment
- Thanet Sand
- Water
- Chalk Formation

LITHOLOGY GRAPHICS

- VOID
- CHALK
- Silty GRAVEL
- SILT
- Silty CLAY
- Clayey SAND
- sandy GRAVEL
- Gravelly SAND
- Silty SAND
- SAND
- clayey sandy GRAVEL
- GRAVEL
- Cobbly GRAVEL
- Gravelly SILT
- Clay/Silt

NOTES

1. This drawing should not be scaled.

No	Revision	Drawn	Checked	Passed	Date

CONCEPT SITE INVESTIGATIONS

Unit 8, Warple Mews
Warple Way
London W3 0RF

Tel: 020 8811 2880
Fax: 020 8811 2881

e-mail: concept@conceptconsultants.co.uk

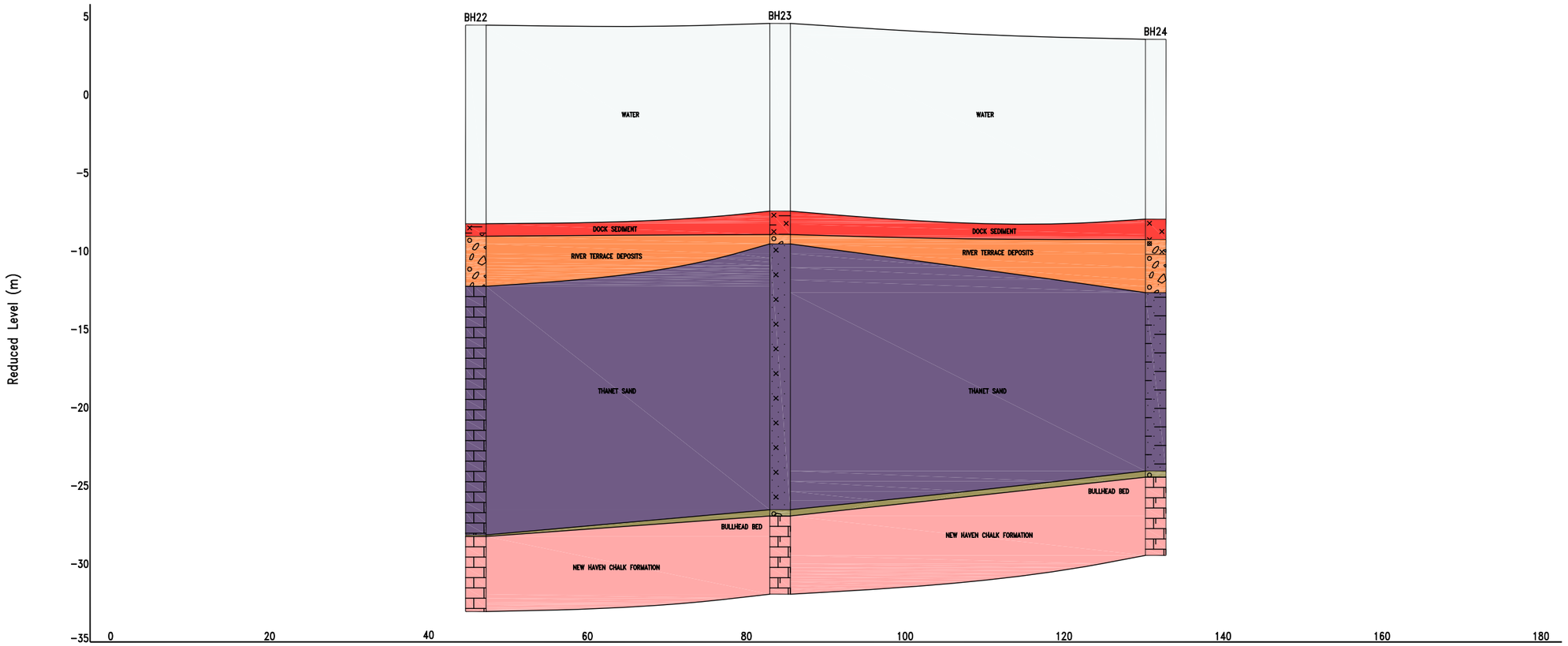
www.conceptconsultants.co.uk

Client:	London City Airport
Project:	CADP Surveys - Ground Investigation (Dock) - Phase 2
Title:	Figure 4e - Geological Section E-E'
Dwg. No:	16200/05
Status:	Issue
Scale:	NTS

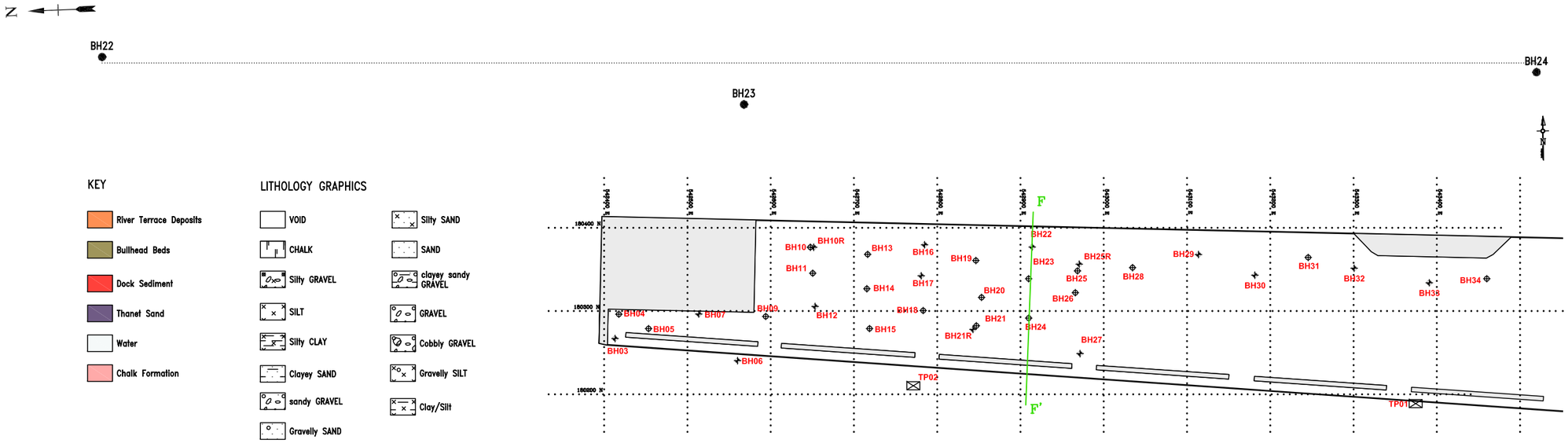
Drawn	Checked	Passed	Date
EV	OS	MD	February 17

NOTES

1. This drawing should not be scaled.



Geological Section F-F'



No	Revision	Drawn	Checked	Passed	Date

CONCEPT SITE INVESTIGATIONS

Unit 8, Warple Mews
Warple Way
London W3 0RF

Tel: 020 8811 2880
Fax: 020 8811 2881

e-mail: concept@conceptconsultants.co.uk

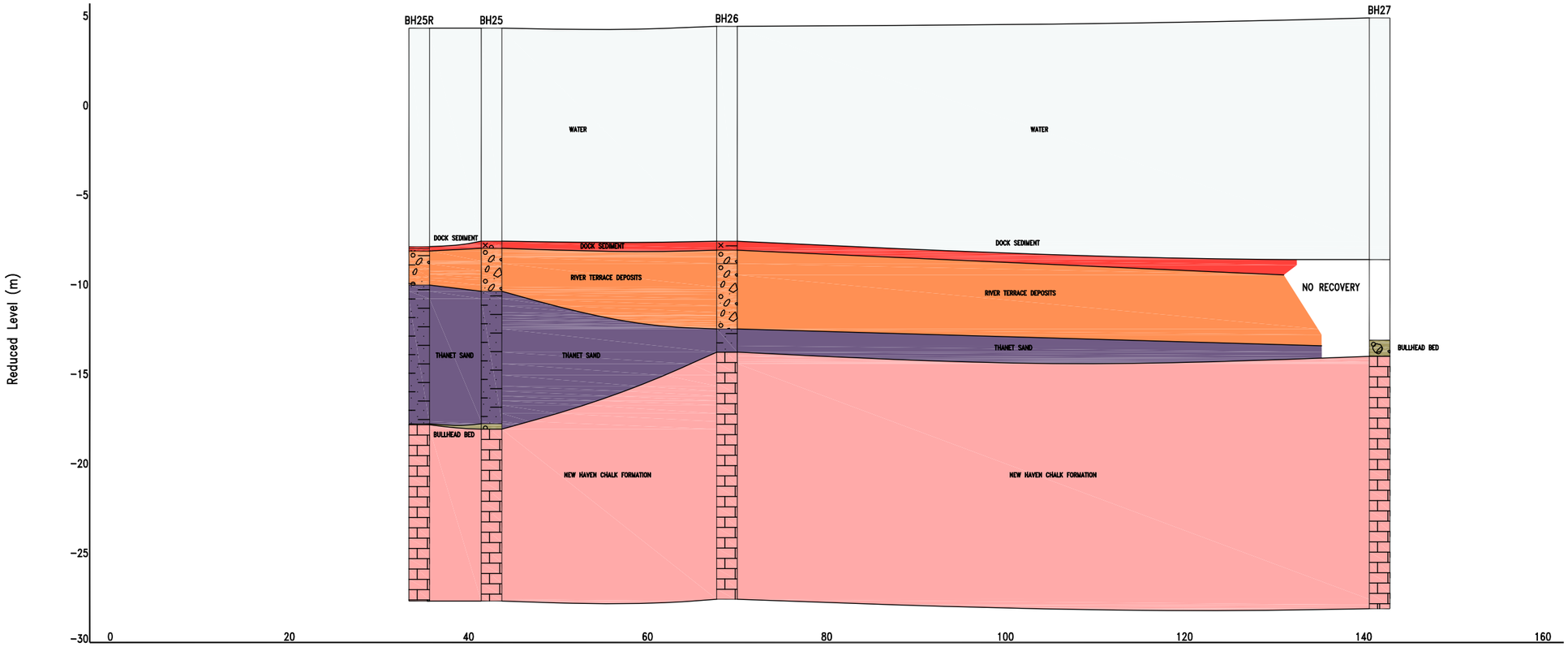
www.conceptconsultants.co.uk

Client:	London City Airport
Project:	CADP Surveys - Ground Investigation (Dock) - Phase 2
Title:	Figure 4f - Geological Section F-F'
Dwg. No:	16200/06
Status:	Issue
Scale:	NTS

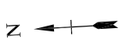
Drawn	Checked	Passed	Date
EV	OS	MD	February 17

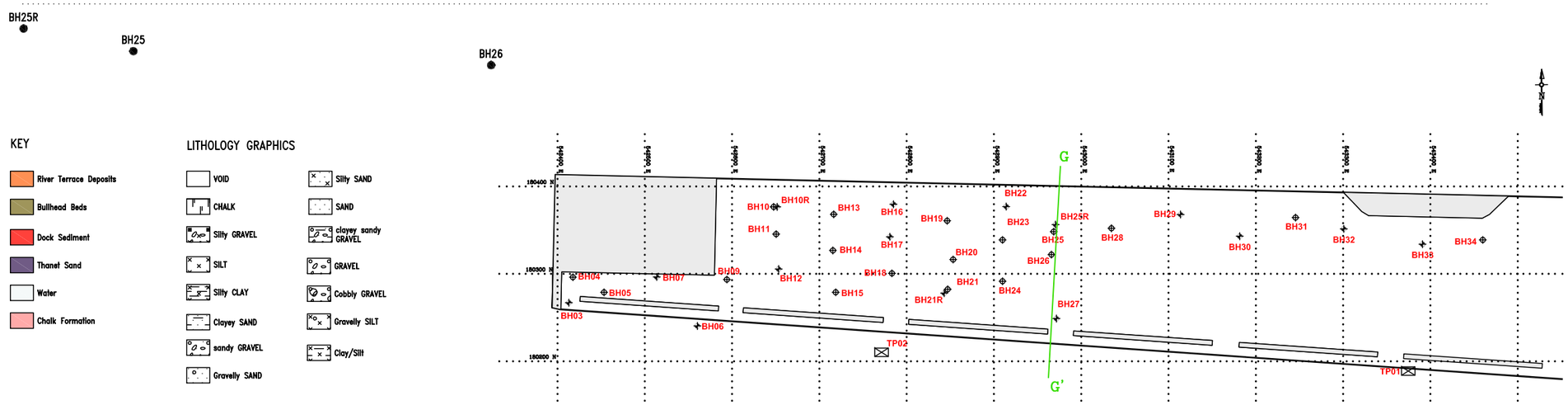
NOTES

1. This drawing should not be scaled.



Geological Section G-G'





KEY

- River Terrace Deposits
- Bullhead Beds
- Dock Sediment
- Thanet Sand
- Water
- Chalk Formation

LITHOLOGY GRAPHICS

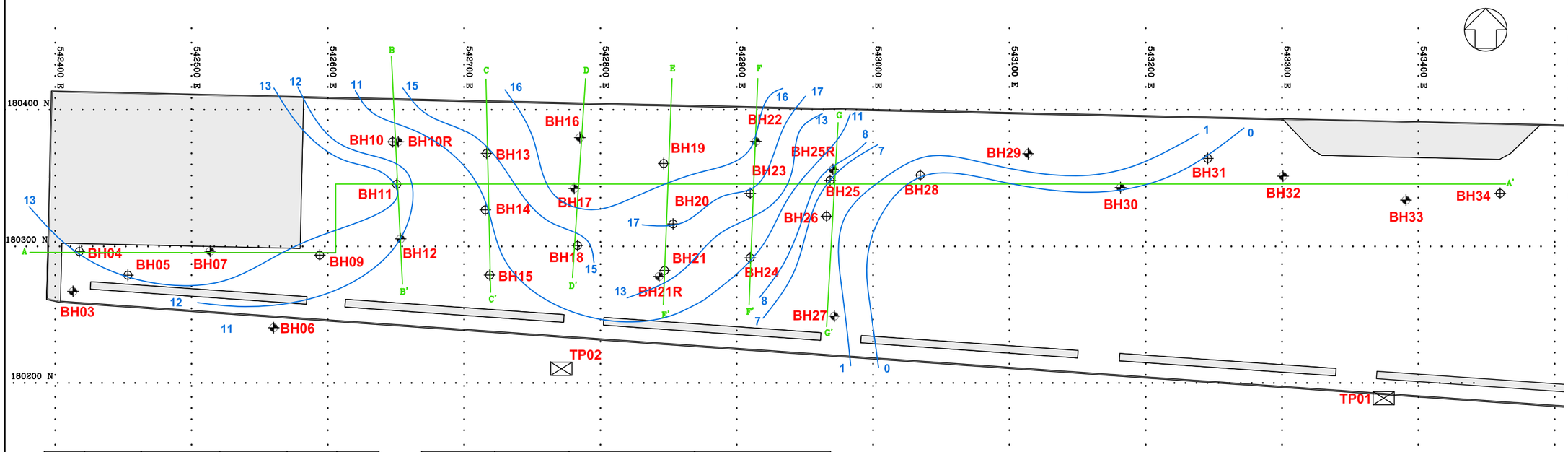
- VOID
- CHALK
- Silty GRAVEL
- SILT
- Silty CLAY
- Clayey SAND
- sandy GRAVEL
- Gravelly SAND
- Silty SAND
- SAND
- clayey sandy GRAVEL
- GRAVEL
- Cobbly GRAVEL
- Gravelly SILT
- Clay/Silt

No	Revision	Drawn	Checked	Passed	Date

CONCEPT SITE INVESTIGATIONS
Unit 8, Warple Mews
Warple Way
London W3 0RF
Tel: 020 8811 2880
Fax: 020 8811 2881
e-mail: concept@conceptconsultants.co.uk
www.conceptconsultants.co.uk

Client:	London City Airport
Project:	CADP Surveys - Ground Investigation (Dock) - Phase 2
Title:	Figure 4g - Geological Section G-G'
Dwg. No:	16200/07
Status:	Issue
Scale:	NTS

Drawn	Checked	Passed	Date
EV	OS	MD	February 17



NOTES

1. This drawing should not be scaled, only use annotated dimensions.
2. * The Bullhead Bed formation is included in the extrapolated contours of the thickness of the Thanet Sand. Its thickness is given in the table.

DISCLAIMER

1. The contours of the top of the chalk were extrapolated from the available investigation data. Conditions may vary at locations not investigated.

2. The accuracy of the extrapolation is subject to the limitations of the methods of measurements during drilling. Fluctuations in dock water level during drilling may further impact the accuracy of the data.

PointID	HoleDepth	East	North	Elevation	TYPE
BH03	34.60	542413.37	180267.86	4.77	DS/RC
BH04	37.50	542417.70	180296.25	4.89	CP
BH05	33.95	542452.30	180279.08	4.68	CP
BH06	30.80	542560.27	180240.47	5.69	DS/RC
BH07	33.50	542513.76	180296.37	4.95	DS/RC
BH09	32.00	542594.06	180293.69	5.02	CP
BH10	32.50	542647.53	180376.79	4.34	CP
BH10R	32.80	542651.71	180376.70	4.46	DS/RC
BH11	31.50	542650.53	180345.58	4.92	CP
BH12	32.00	542653.37	180305.55	5.29	RC
BH13	34.50	542716.47	180368.24	4.88	CP
BH14	31.50	542716.89	180326.61	4.67	CP
BH15	30.45	542718.78	180279.03	4.10	CP
BH16	39.00	542785.28	180379.68	5.01	RC
BH17	35.90	542780.80	180342.43	5.24	DS/RC
BH18	33.50	542783.21	180300.56	4.18	CP
BH19	36.60	542846.43	180360.76	4.34	CP
BH20	35.50	542853.06	180316.15	4.92	CP
BH21	33.00	542847.09	180282.34	4.25	CP
BH21R	33.50	542842.98	180278.21	4.54	DS/RC
BH22	37.50	542914.01	180377.07	4.44	DS/RC
BH23	36.50	542909.73	180338.93	4.55	CP
BH24	33.00	542909.85	180291.63	3.54	CP
BH25	32.00	542968.45	180348.39	4.31	CP
BH25R	32.00	542970.56	180356.36	4.31	DS/RC
BH26	32.00	542965.95	180322.20	4.41	CP
BH27	33.00	542971.44	180248.90	4.88	RC
BH28	32.00	543034.61	180352.20	4.79	CP
BH29	45.50	543114.06	180367.98	4.93	RC
BH30	33.00	543181.64	180343.20	4.23	DS/RC
BH31	32.00	543245.51	180364.44	6.49	CP
BH32	31.40	543300.74	180351.60	4.61	DS/RC
BH33	32.00	543390.97	180334.13	4.19	DS/RC
BH34	31.50	543459.99	180338.91	4.96	CP
TP01	2.00	543374.64	180188.76	5.44	TP
TP02	3.50	524771.33	180210.40	5.55	TP

PointID	Top of Chalk (mOD)	Thicknes of Thanet Sand (m)	Thickness of Bullhead Bed (m)
BH03	-25.03	>8.80	0.30
BH04	-25.21	13.60	0.10
BH05	-24.32	13.00	0.20
BH06	-20.62	11.80	0.10
BH07	-24.26	13.85	0.90
BH09	-21.98	13.00	0.30
BH10	-22.66	11.20	0.00
BH10R	-23.04	11.80	0.20
BH11	-22.08	13.00	0.50
BH12	-21.01	12.10	0.60
BH13	-25.12	15.00	0.50
BH14	-21.83	11.00	0.00
BH15	-21.40	11.50	1.00
BH16	-30.09	>15.6	0.10
BH17	-25.46	16.20	0.30
BH18	-24.42	14.90	0.30
BH19	-27.16	16.25	0.00
BH20	-26.08	17.00	1.00
BH21	-23.75	13.75	0.00
BH21R	-22.96	11.50	0.00
BH22	-28.26	16.00	0.10
BH23	-26.95	17.40	0.40
BH24	-24.46	11.80	0.40
BH25	-18.09	7.70	0.30
BH25R	-17.84	7.80	0.05
BH26	-13.79	1.30	0.00
BH27	-14.02	>0.90	0.90
BH28	-12.71	0.00	0.00
BH29	-13.57	>1.5	0.00
BH30	-12.87	0.10	0.10
BH31	-8.51	0.00	0.00
BH32	-9.09	0.00	0.00
BH33	-9.81	0.00	0.00
BH34	-9.95	0.00	0.00

KEY

- DS/R - Dynamic Sampling / Rotary
- CP - Cable Percussion
- TP - Trial Pit

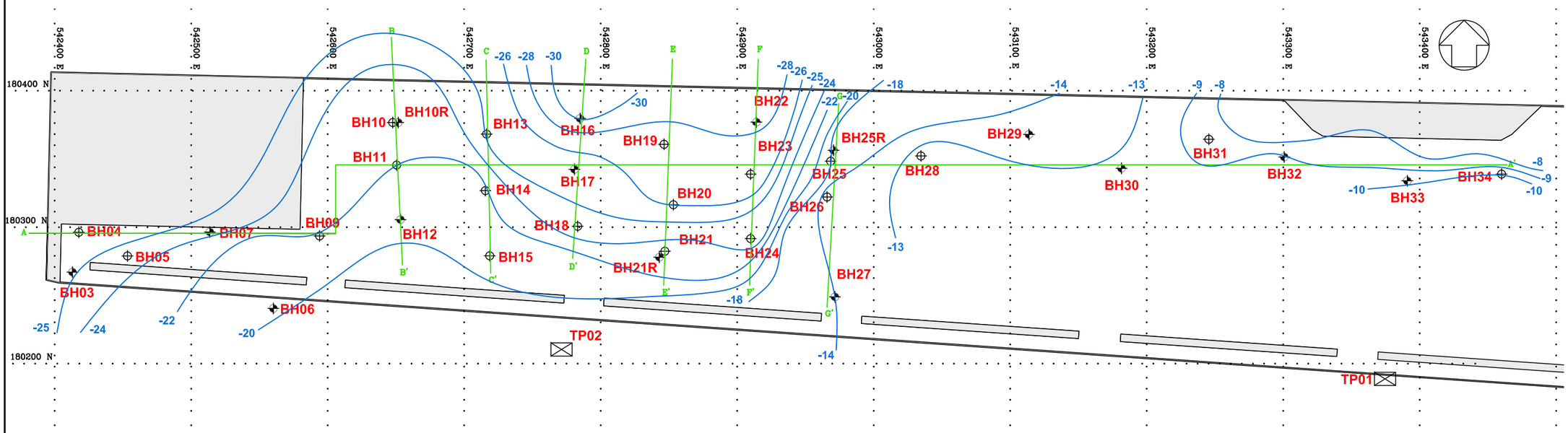
No	Revision	Drawn	Checked	Passed	Date

CONCEPT SITE INVESTIGATIONS

Unit 8, Warple Mews
Warple Way
London W3 0RF
Tel: 020 8811 2880
Fax: 020 8811 2881
e-mail: concept@conceptconsultants.co.uk
www.conceptconsultants.co.uk

Client:	London City Airport
Project:	CADP Surveys - Ground Investigation (Dock) - Phase 2
Title:	Figure 5 - Extrapolated Contours of the Thickness of the Thanet Sand
Dwg. No:	162900/01
Status:	Issue
Scale:	NTS

Drawn	Checked	Passed	Date
RD/EV	OS	MD	March 17



NOTES

1. This drawing should not be scaled, only use annotated dimensions.
2. * The Bullhead Bed formation is included in the extrapolated contours of the thickness of the Thanet Sand. Its thickness is given in the table.

DISCLAIMER

1. The contours of the top of the chalk were extrapolated from the available investigation data. Conditions may vary at locations not investigated.

2. The accuracy of the extrapolation is subject to the limitations of the methods of measurements during drilling. Fluctuations in dock water level during drilling may further impact the accuracy of the data.

PointID	HoleDepth	East	North	Elevation	TYPE
BH03	34.60	542413.37	180267.86	4.77	DS/RC
BH04	37.50	542417.70	180296.25	4.89	CP
BH05	33.95	542452.30	180279.08	4.68	CP
BH06	30.80	542560.27	180240.47	5.69	DS/RC
BH07	33.50	542513.76	180296.37	4.95	DS/RC
BH09	32.00	542594.06	180293.69	5.02	CP
BH10	32.50	542647.53	180376.79	4.34	CP
BH10R	32.80	542651.71	180376.70	4.46	DS/RC
BH11	31.50	542650.53	180345.58	4.92	CP
BH12	32.00	542653.37	180305.55	5.29	RC
BH13	34.50	542716.47	180368.24	4.88	CP
BH14	31.50	542716.89	180326.61	4.67	CP
BH15	30.45	542718.78	180279.03	4.10	CP
BH16	39.00	542785.28	180379.68	5.01	RC
BH17	35.90	542780.80	180342.43	5.24	DS/RC
BH18	33.50	542783.21	180300.56	4.18	CP
BH19	36.60	542846.43	180360.76	4.34	CP
BH20	35.50	542853.06	180316.15	4.92	CP
BH21	33.00	542847.09	180282.34	4.25	CP
BH21R	33.50	542842.98	180278.21	4.54	DS/RC
BH22	37.50	542914.01	180377.07	4.44	DS/RC
BH23	36.50	542909.73	180338.93	4.55	CP
BH24	33.00	542909.85	180291.63	3.54	CP
BH25	32.00	542968.45	180348.39	4.31	CP
BH25R	32.00	542970.56	180356.36	4.31	DS/RC
BH26	32.00	542965.95	180322.20	4.41	CP
BH27	33.00	542971.44	180248.90	4.88	RC
BH28	32.00	543034.61	180352.20	4.79	CP
BH29	45.50	543114.06	180367.98	4.93	RC
BH30	33.00	543181.64	180343.20	4.23	DS/RC
BH31	32.00	543245.51	180364.44	6.49	CP
BH32	31.40	543300.74	180351.60	4.61	DS/RC
BH33	32.00	543390.97	180334.13	4.19	DS/RC
BH34	31.50	543459.99	180338.91	4.96	CP
TP01	2.00	543374.64	180188.76	5.44	TP
TP02	3.50	524771.33	180210.40	5.55	TP

PointID	Top of Chalk (mOD)	Thicknes of Thanet Sand (m)	Thickness of Bullhead Bed (m)
BH03	-25.03	>8.80	0.30
BH04	-25.21	13.60	0.10
BH05	-24.32	13.00	0.20
BH06	-20.62	11.80	0.10
BH07	-24.26	13.85	0.90
BH09	-21.98	13.00	0.30
BH10	-22.66	11.20	0.00
BH10R	-23.04	11.80	0.20
BH11	-22.08	13.00	0.50
BH12	-21.01	12.10	0.60
BH13	-25.12	15.00	0.50
BH14	-21.83	11.00	0.00
BH15	-21.40	11.50	1.00
BH16	-30.09	>15.6	0.10
BH17	-25.46	16.20	0.30
BH18	-24.42	14.90	0.30
BH19	-27.16	16.25	0.00
BH20	-26.08	17.00	1.00
BH21	-23.75	13.75	0.00
BH21R	-22.96	11.50	0.00
BH22	-28.26	16.00	0.10
BH23	-26.95	17.40	0.40
BH24	-24.46	11.80	0.40
BH25	-18.09	7.70	0.30
BH25R	-17.84	7.80	0.05
BH26	-13.79	1.30	0.00
BH27	-14.02	>0.90	0.90
BH28	-12.71	0.00	0.00
BH29	-13.57	>1.5	0.00
BH30	-12.87	0.10	0.10
BH31	-8.51	0.00	0.00
BH32	-9.09	0.00	0.00
BH33	-9.81	0.00	0.00
BH34	-9.95	0.00	0.00

KEY

- DS/R - Dynamic Sampling / Rotary
- CP - Cable Percussion
- TP - Trial Pit

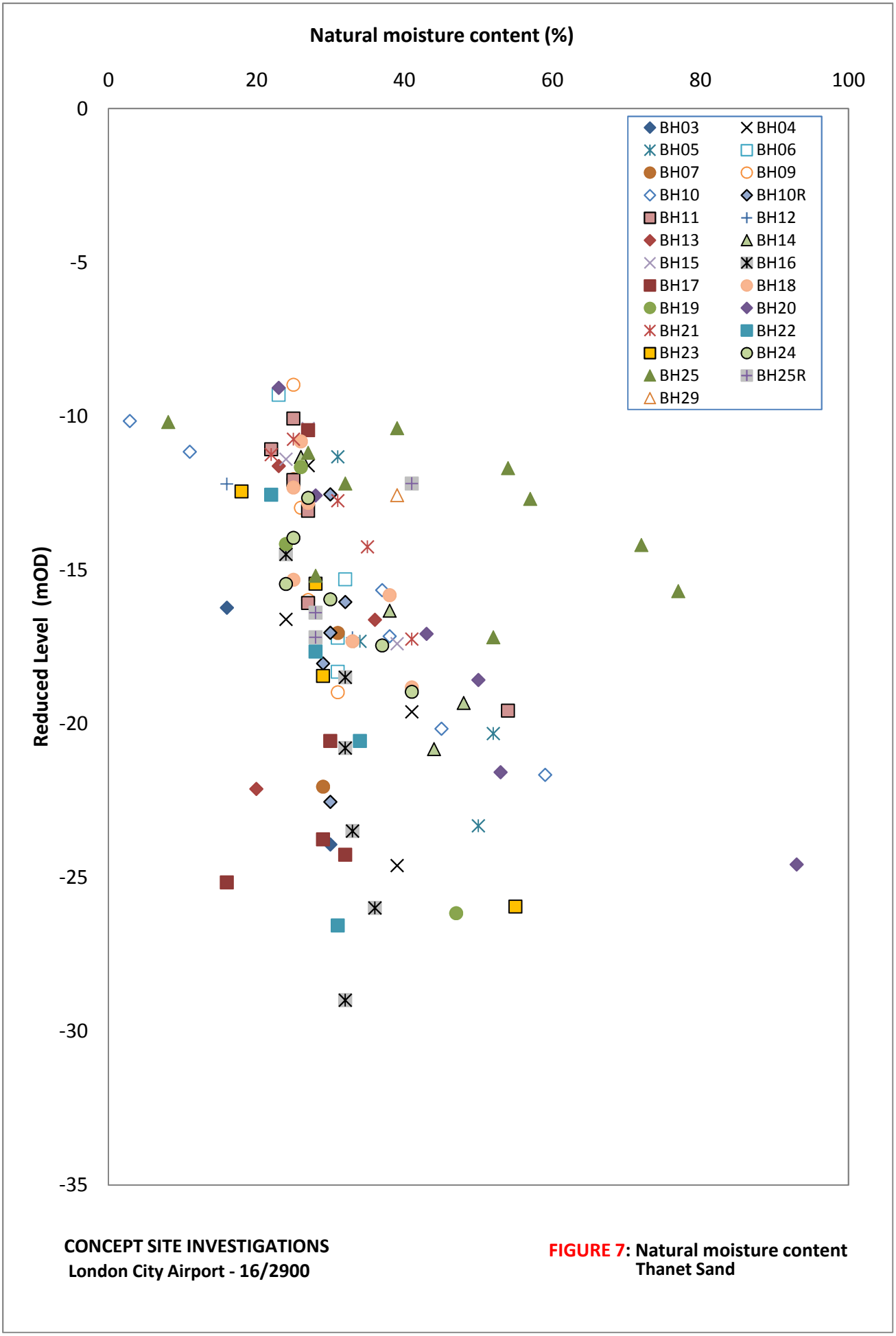
No	Revision	Drawn	Checked	Passed	Date

CONCEPT SITE INVESTIGATIONS

Unit 8, Warple Mews
Warple Way
London W3 0RF
Tel: 020 8811 2880
Fax: 020 8811 2881
e-mail: concept@conceptconsultants.co.uk
www.conceptconsultants.co.uk

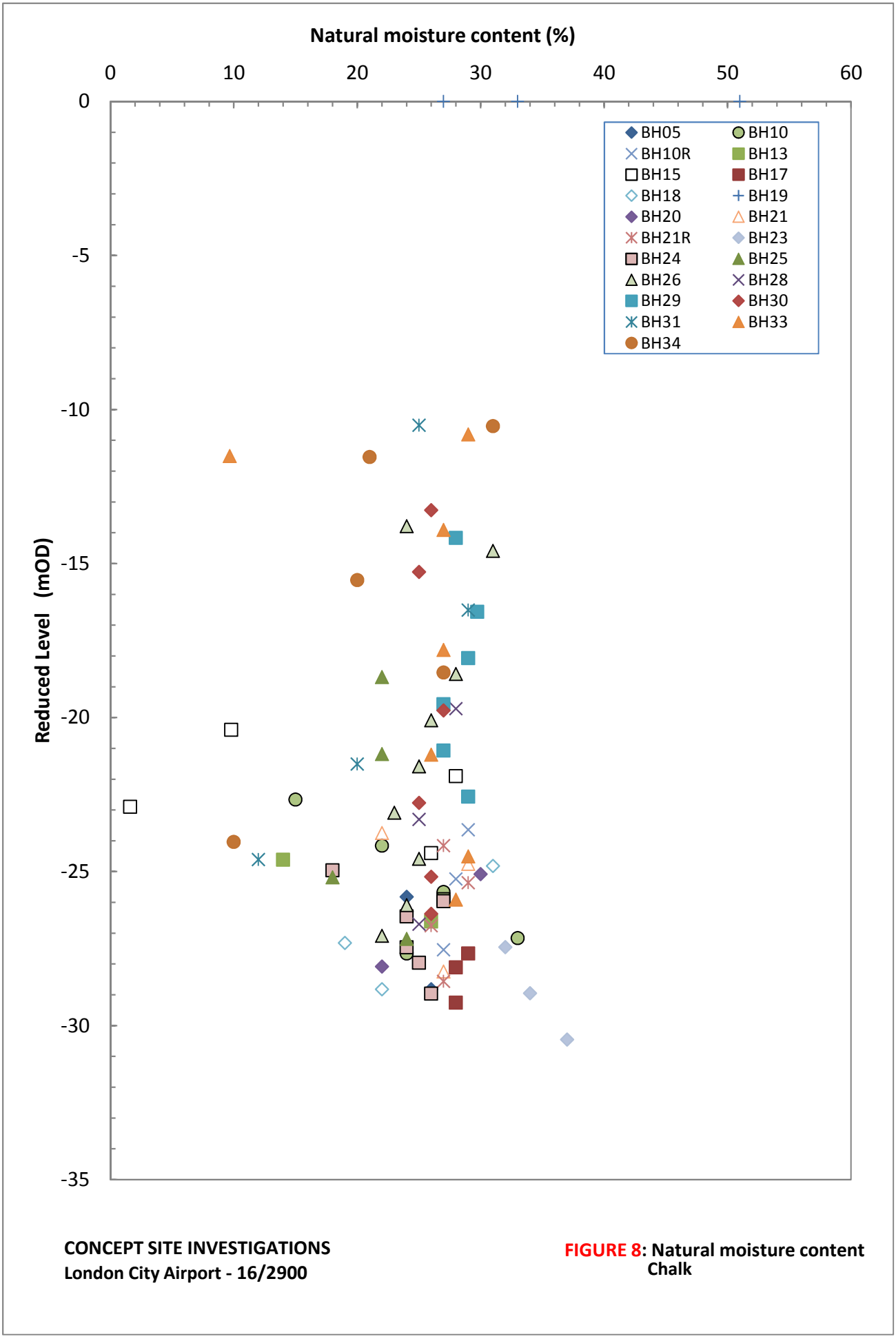
Client:	London City Airport
Project:	CADP Surveys - Ground Investigation (Dock) - Phase 2
Title:	Figure 6 - Extrapolated Contours of the Top of the Chalk
Dwg. No:	162900/02
Status:	Issue
Scale:	NTS

Drawn	Checked	Passed	Date
RD/EV	OS	MD	March 17



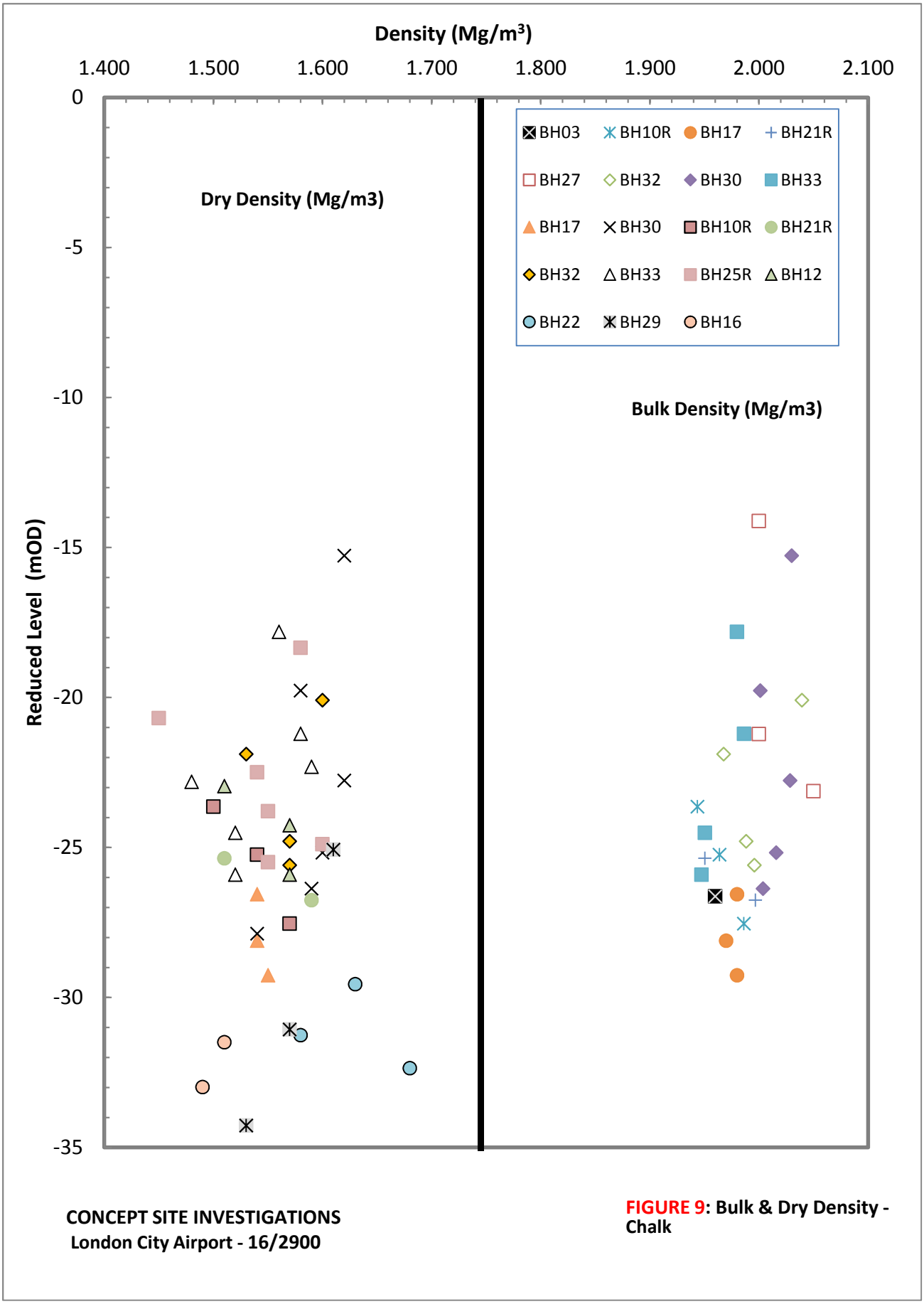
CONCEPT SITE INVESTIGATIONS
London City Airport - 16/2900

FIGURE 7: Natural moisture content
Thanet Sand



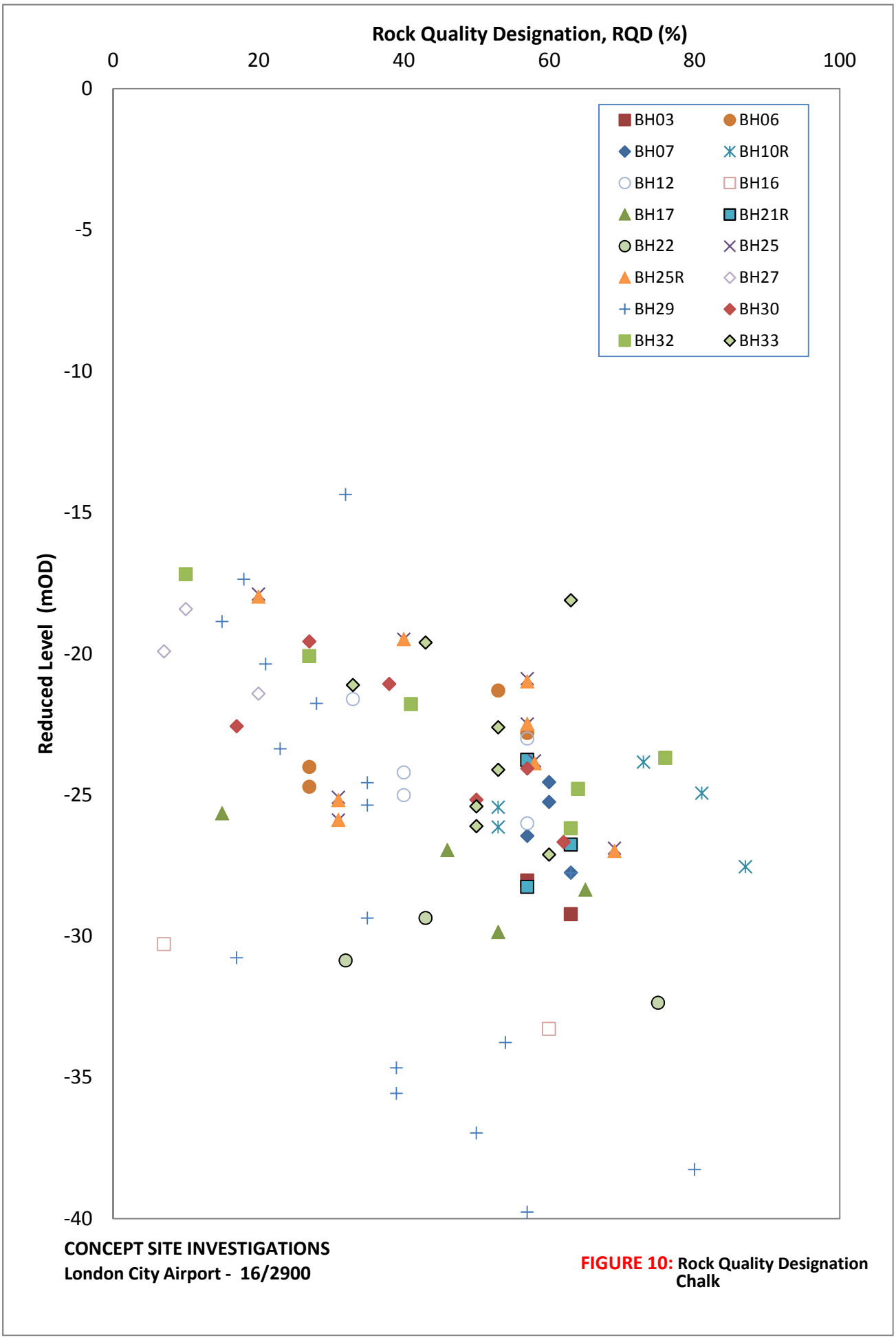
CONCEPT SITE INVESTIGATIONS
London City Airport - 16/2900

FIGURE 8: Natural moisture content
Chalk



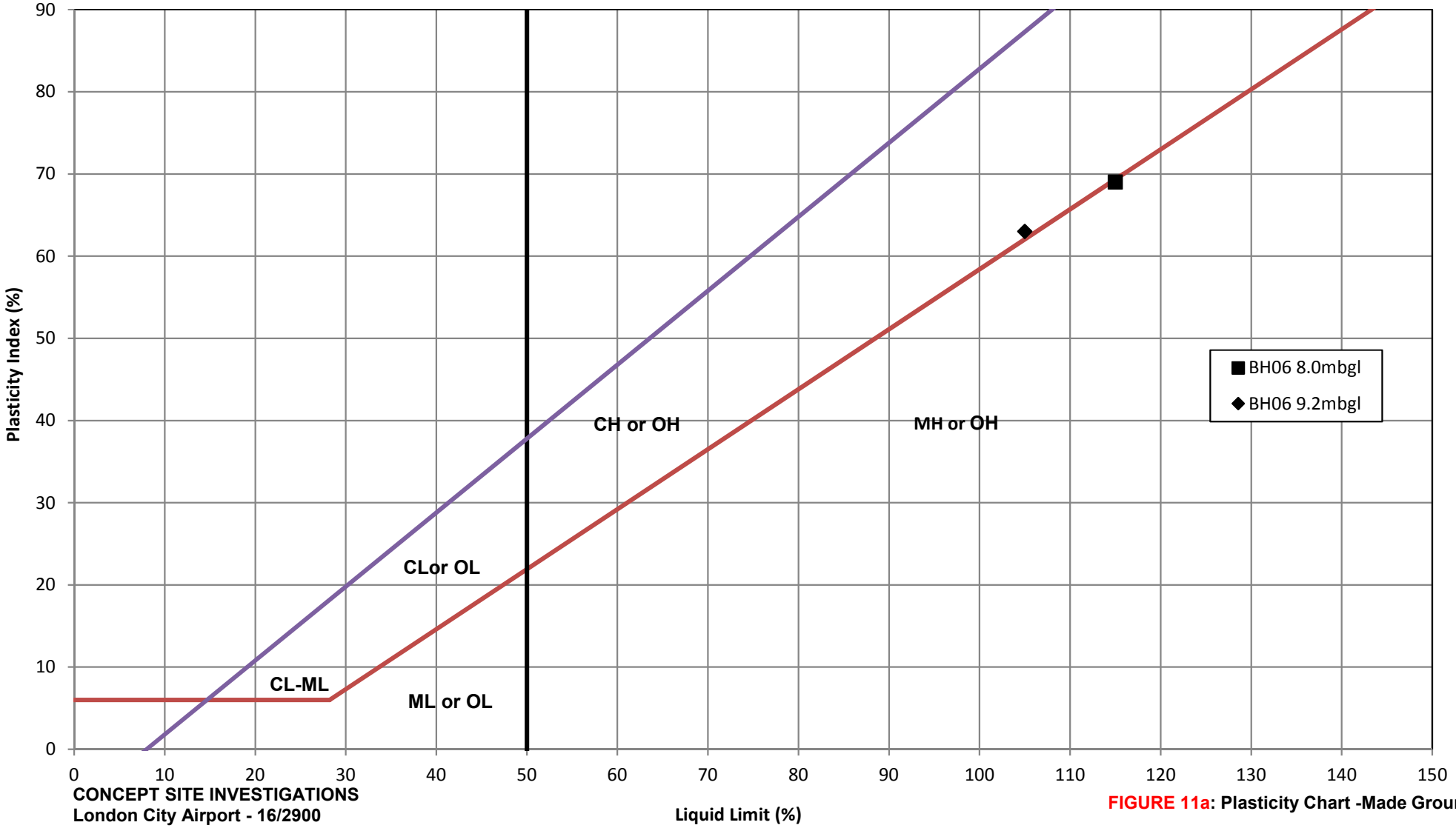
CONCEPT SITE INVESTIGATIONS
London City Airport - 16/2900

FIGURE 9: Bulk & Dry Density - Chalk



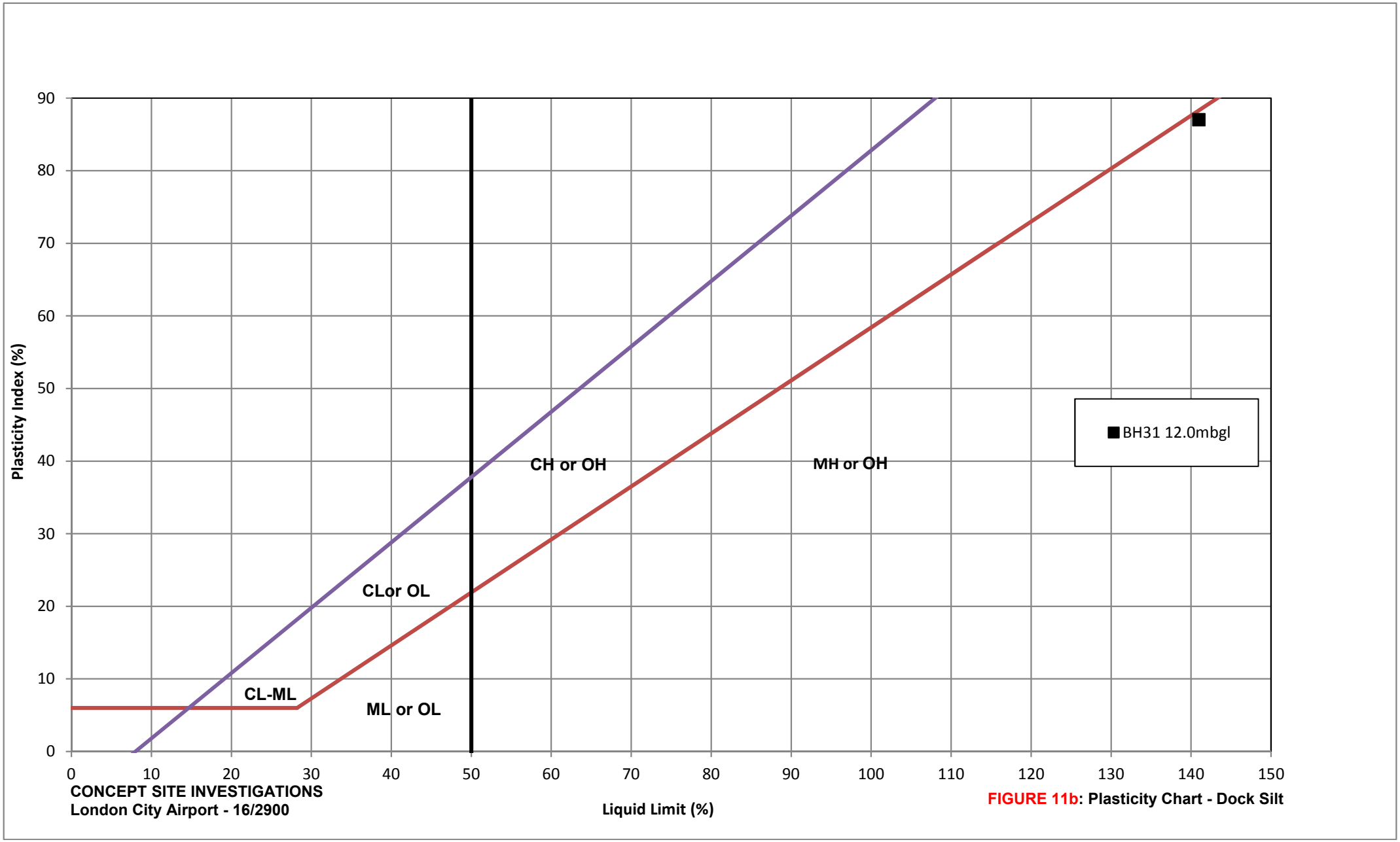
CONCEPT SITE INVESTIGATIONS
London City Airport - 16/2900

FIGURE 10: Rock Quality Designation
Chalk



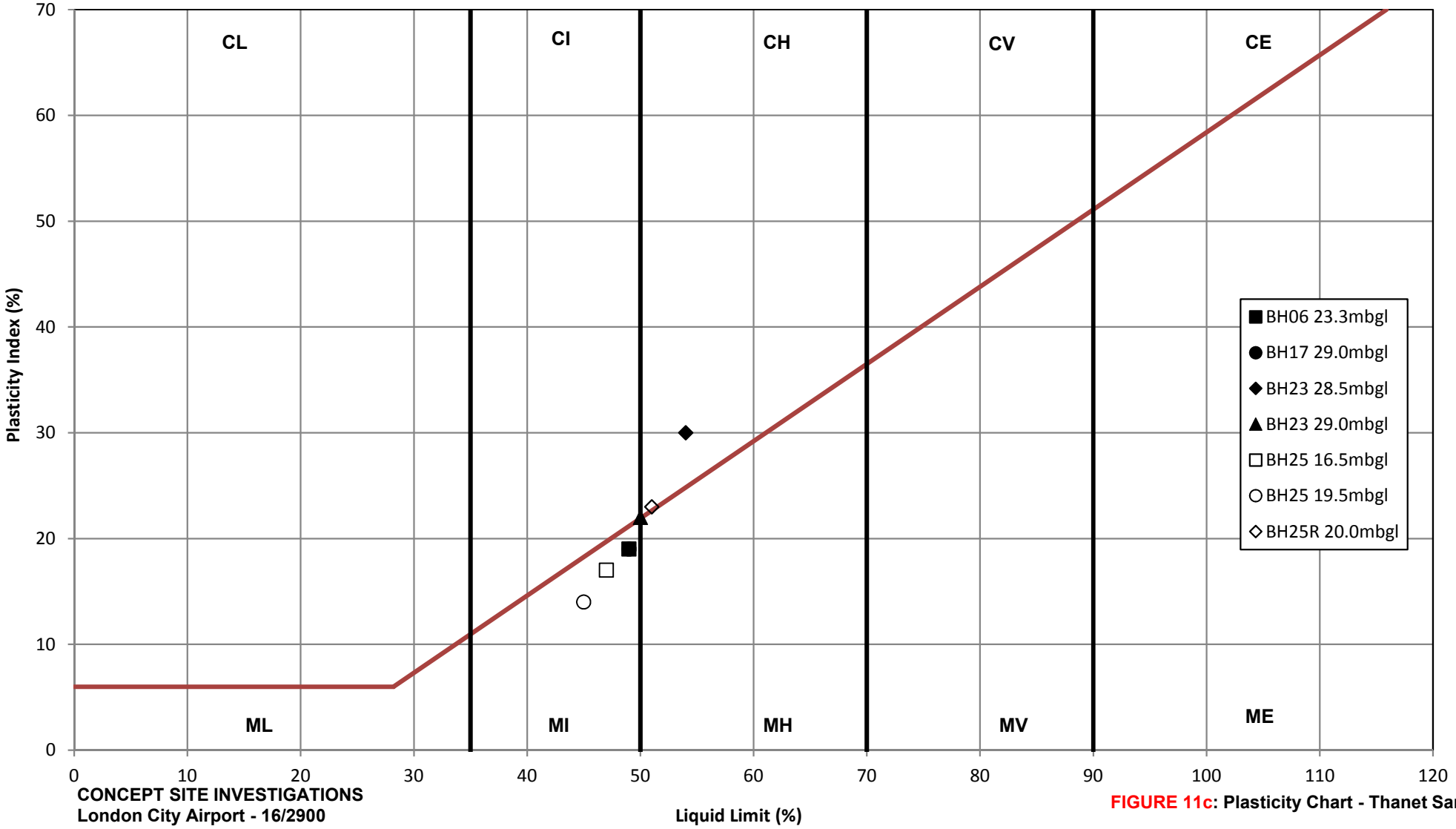
CONCEPT SITE INVESTIGATIONS
London City Airport - 16/2900

FIGURE 11a: Plasticity Chart -Made Ground



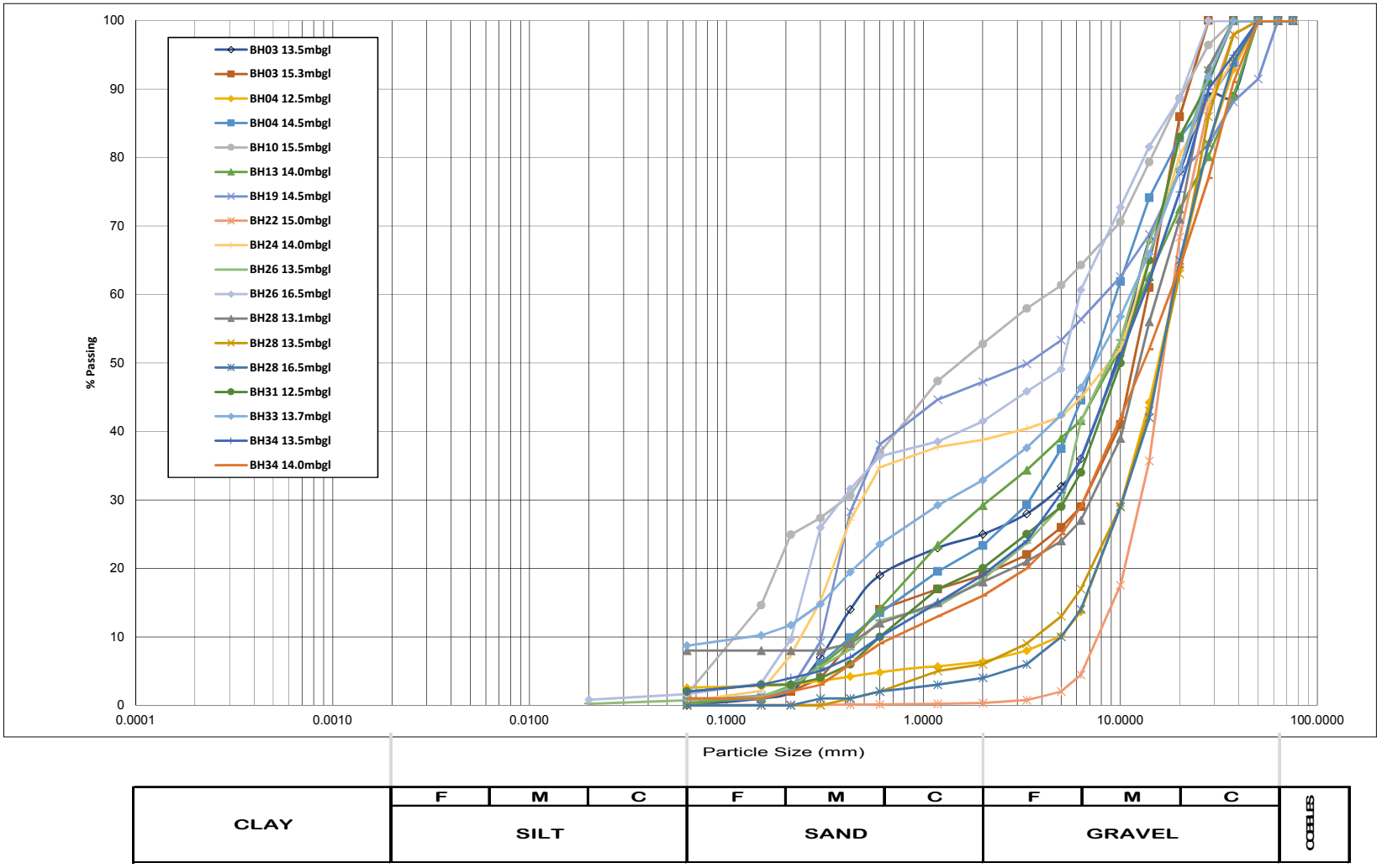
CONCEPT SITE INVESTIGATIONS
London City Airport - 16/2900

FIGURE 11b: Plasticity Chart - Dock Silt



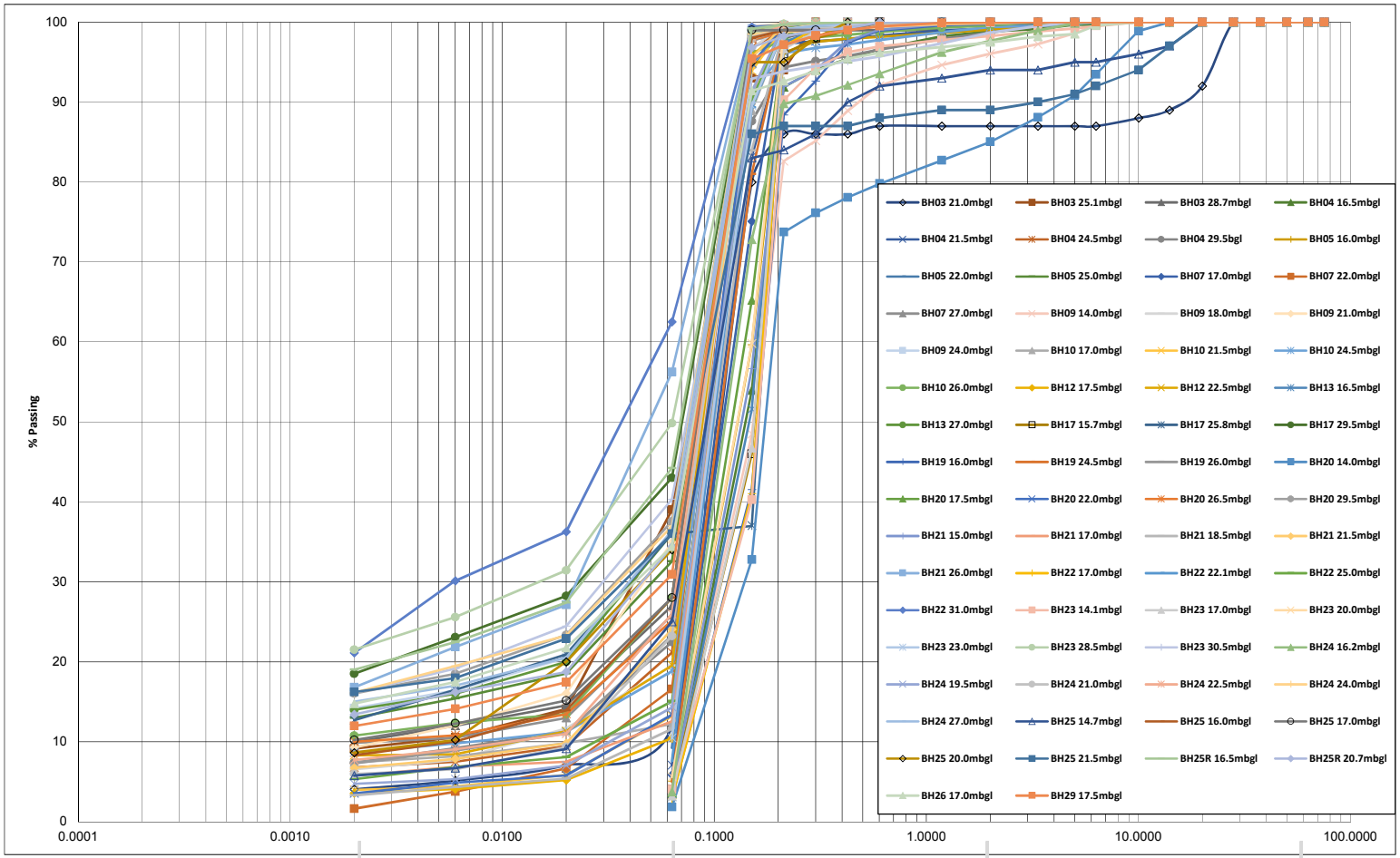
CONCEPT SITE INVESTIGATIONS
London City Airport - 16/2900

FIGURE 11c: Plasticity Chart - Thanet Sand



CONCEPT SITE INVESTIGATIONS
London City Airport - 16/2900

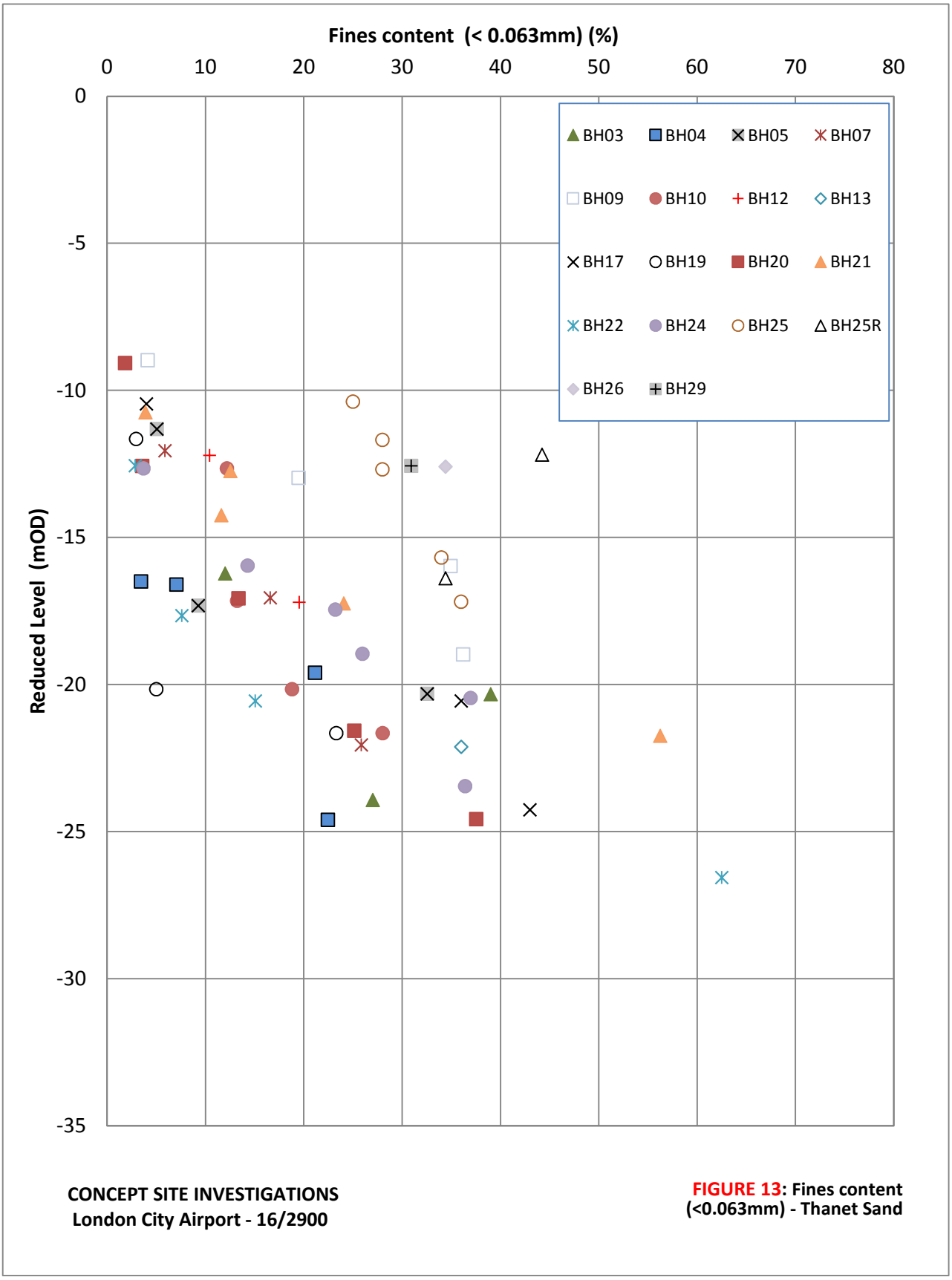
FIGURE 12a: PSD Results -River Terrace Deposits



CLAY	F	M	C	F	M	C	F	M	C	COBBLES
	SILT			SAND			GRAVEL			

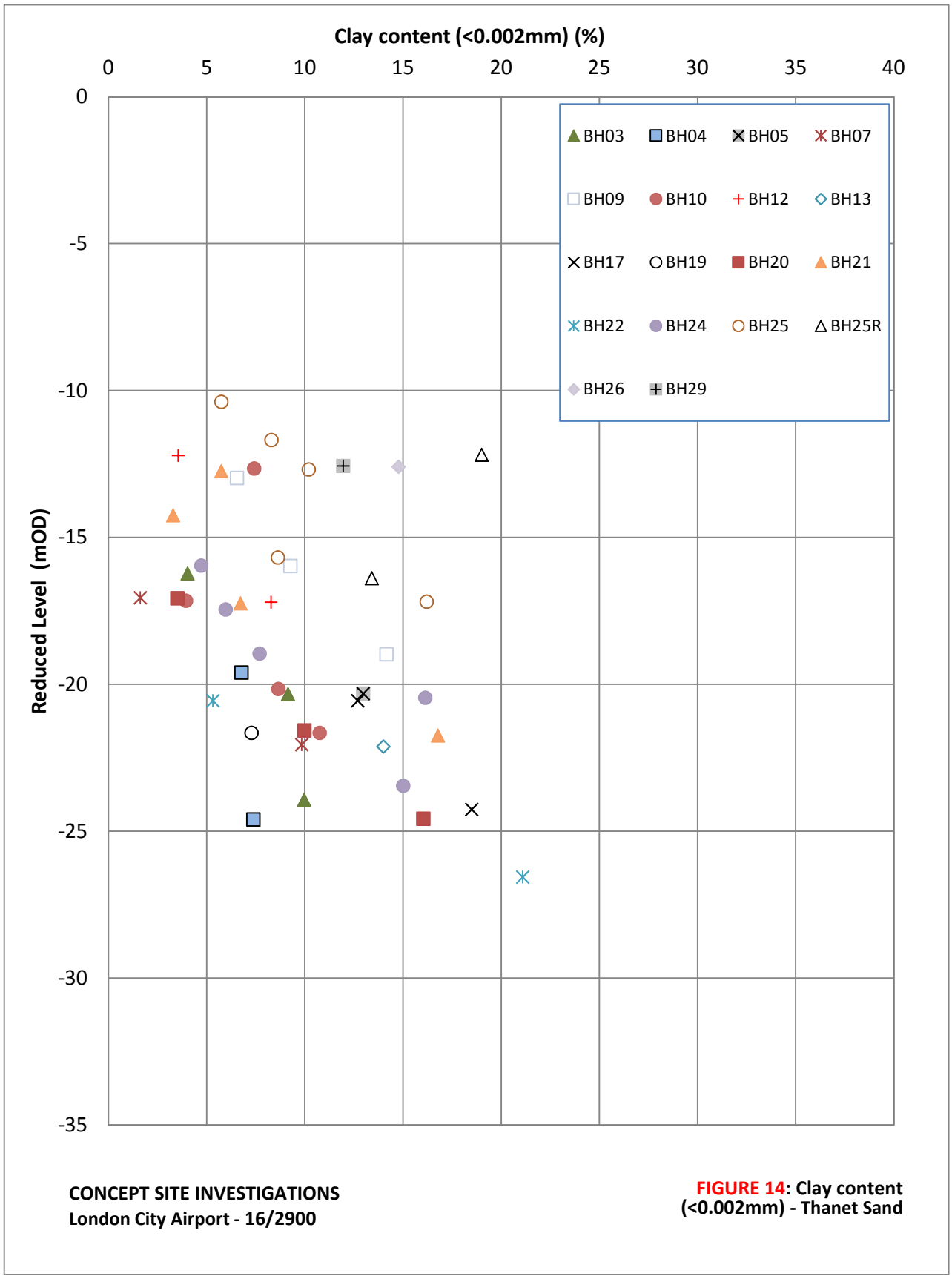
CONCEPT SITE INVESTIGATIONS
London City Airport - 16/2900

FIGURE 12b: PSD Results-Thanet Sand



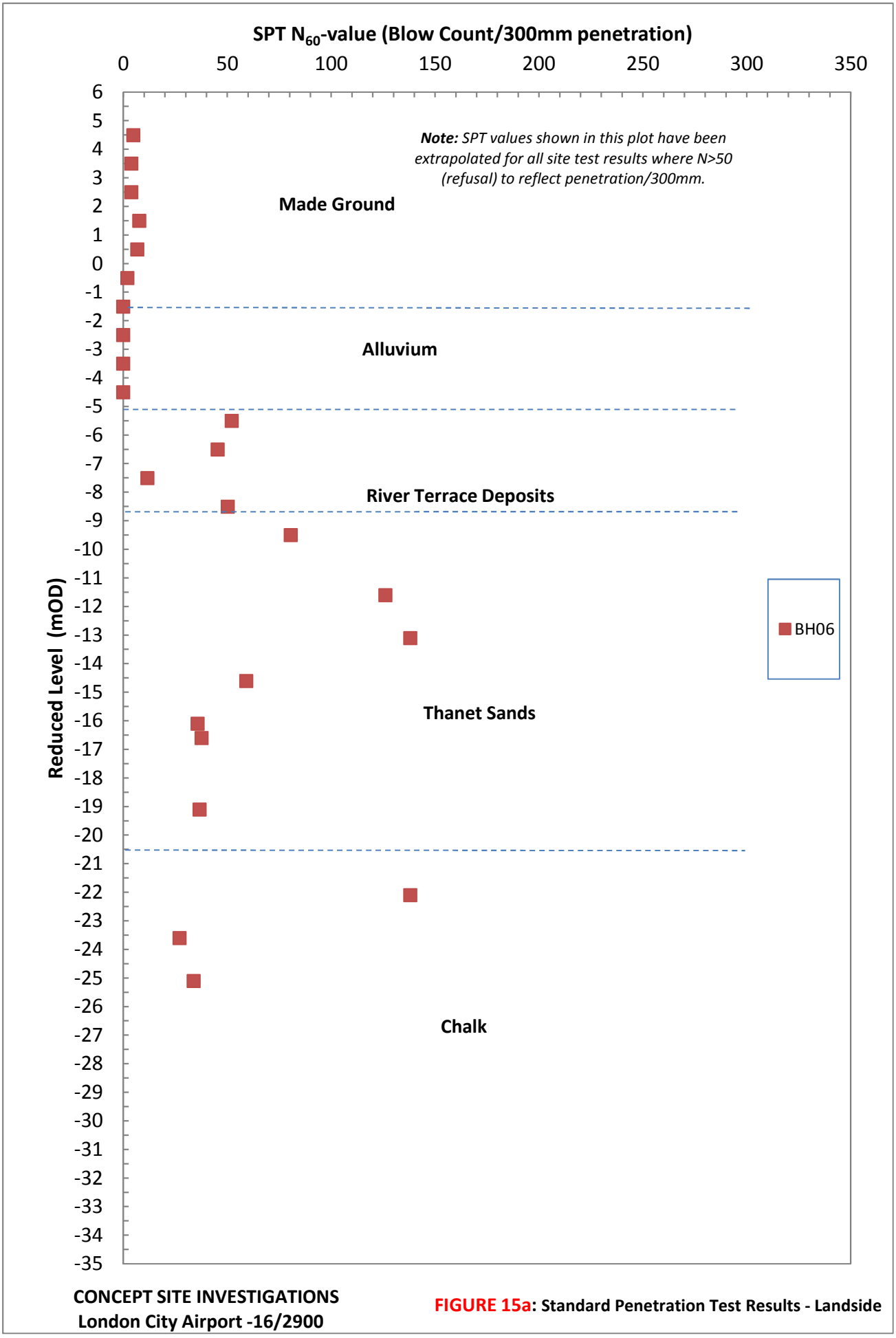
CONCEPT SITE INVESTIGATIONS
London City Airport - 16/2900

FIGURE 13: Fines content (<0.063mm) - Thanet Sand



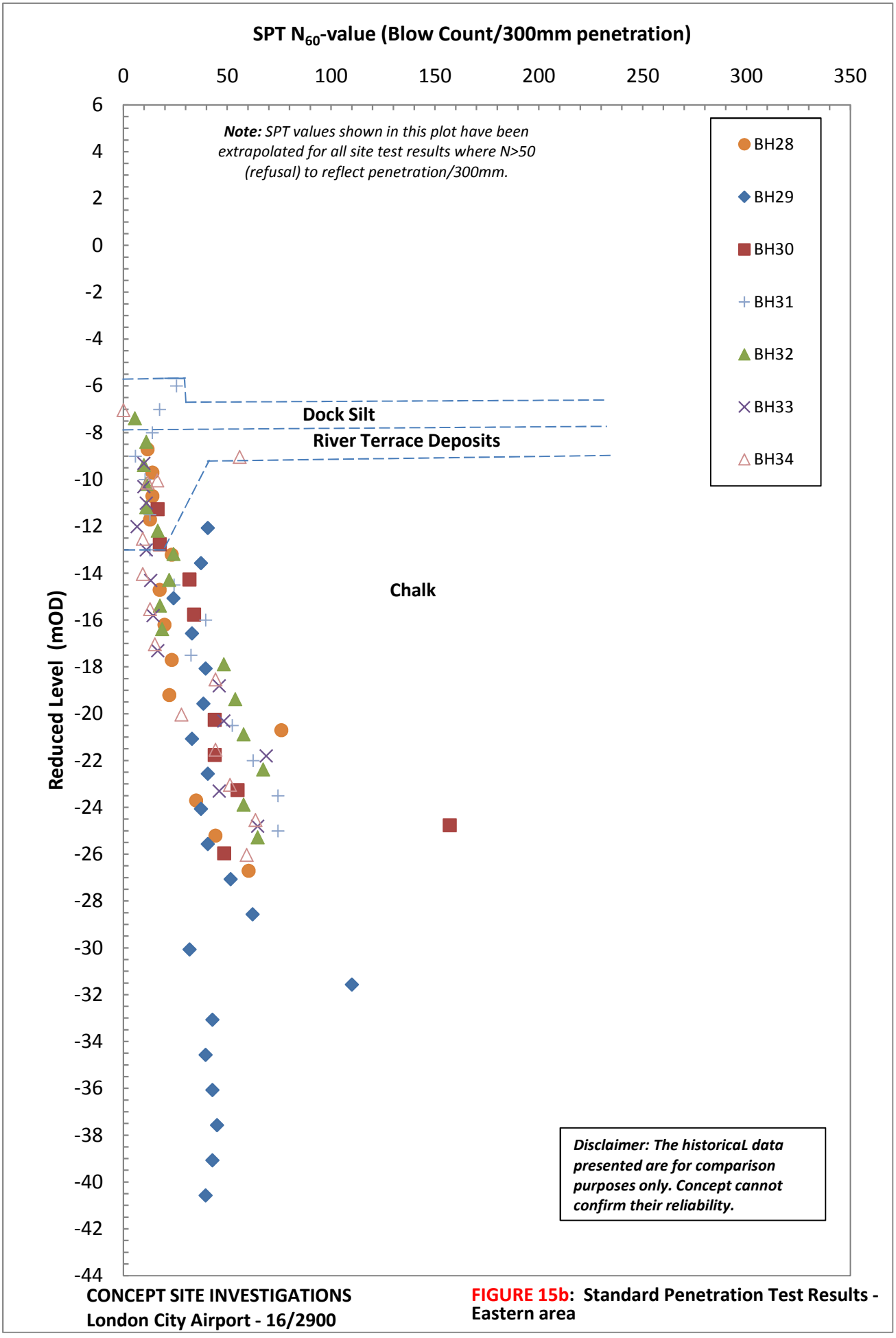
CONCEPT SITE INVESTIGATIONS
London City Airport - 16/2900

FIGURE 14: Clay content (<0.002mm) - Thanet Sand



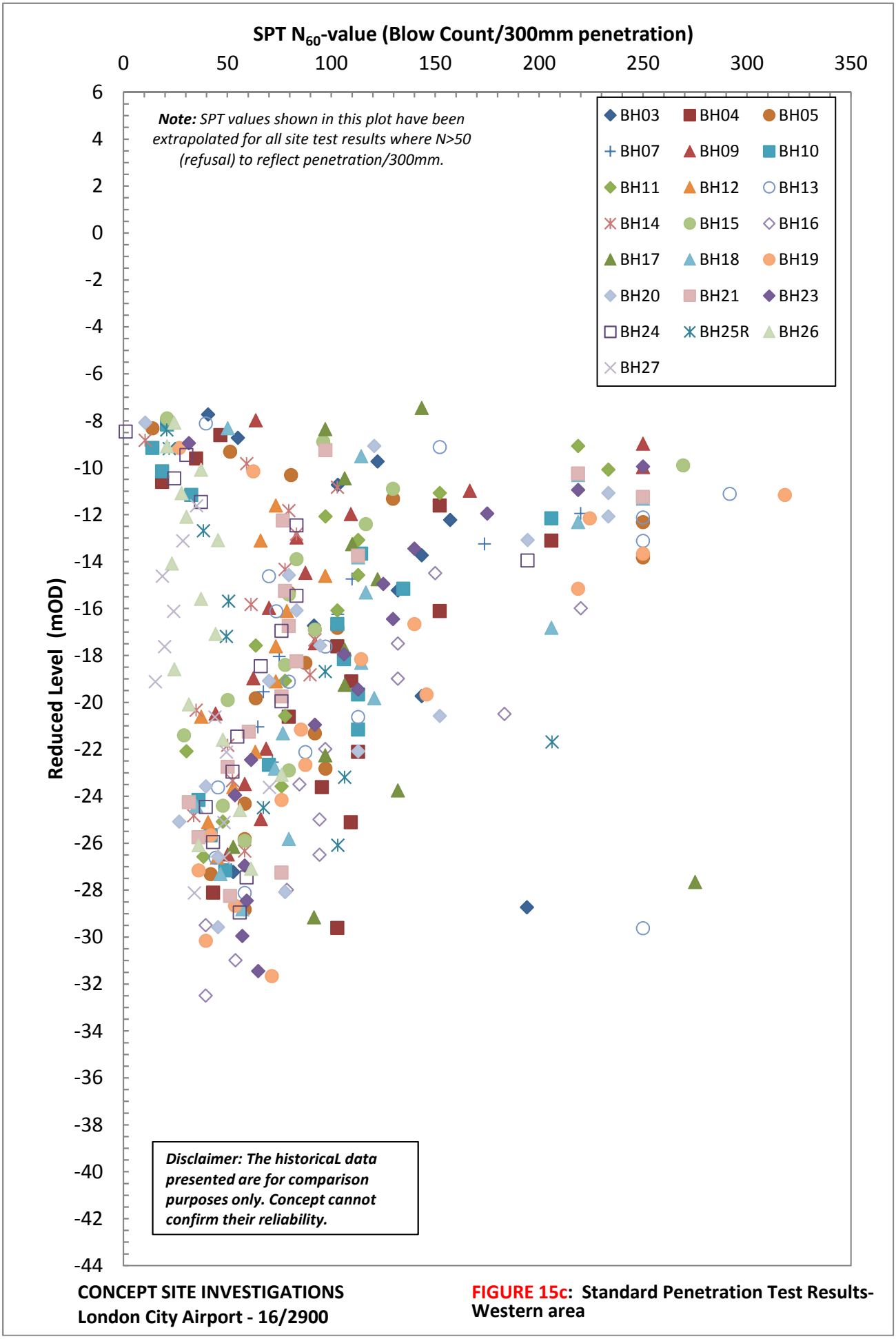
CONCEPT SITE INVESTIGATIONS
London City Airport -16/2900

FIGURE 15a: Standard Penetration Test Results - Landside



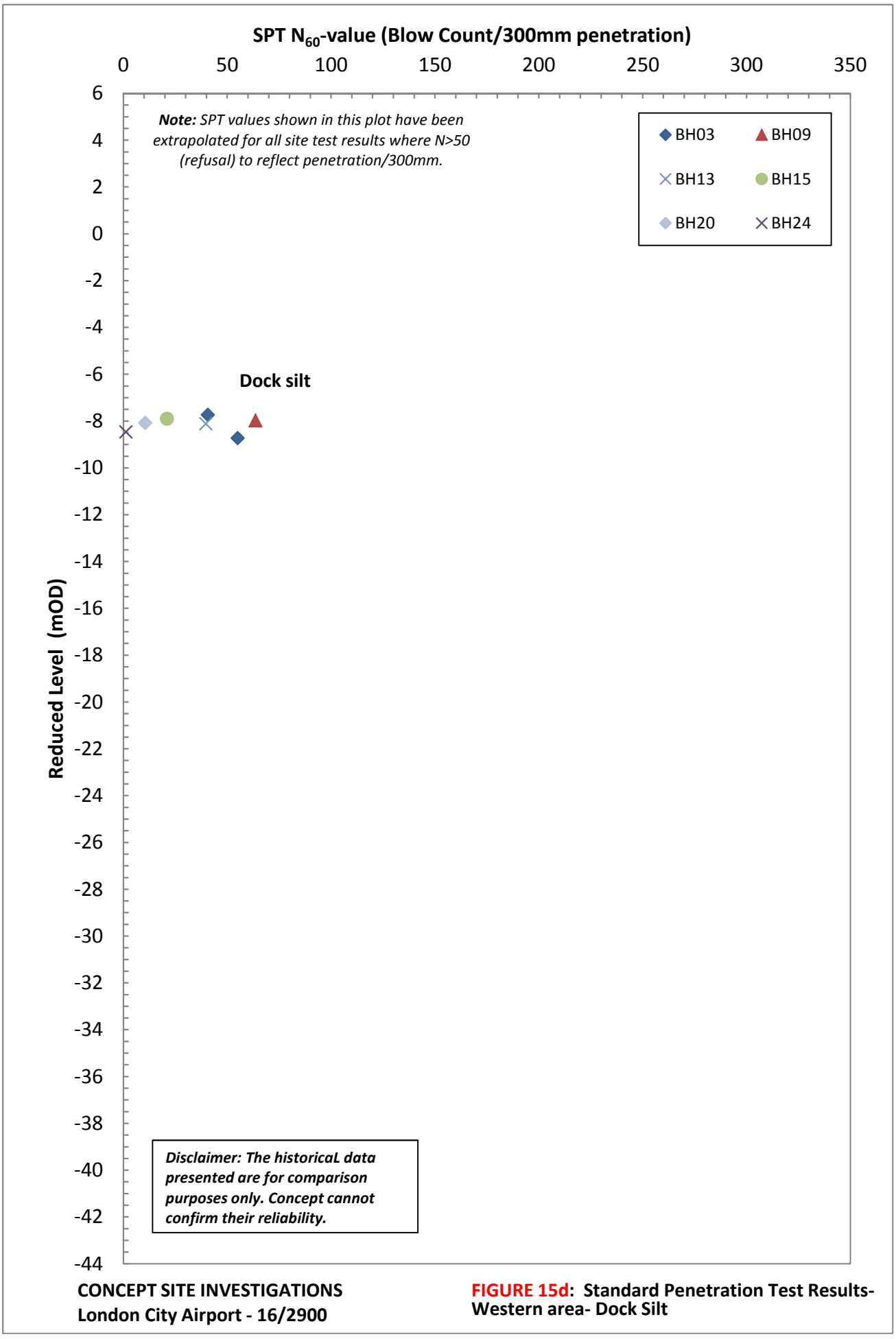
CONCEPT SITE INVESTIGATIONS
London City Airport - 16/2900

FIGURE 15b: Standard Penetration Test Results - Eastern area



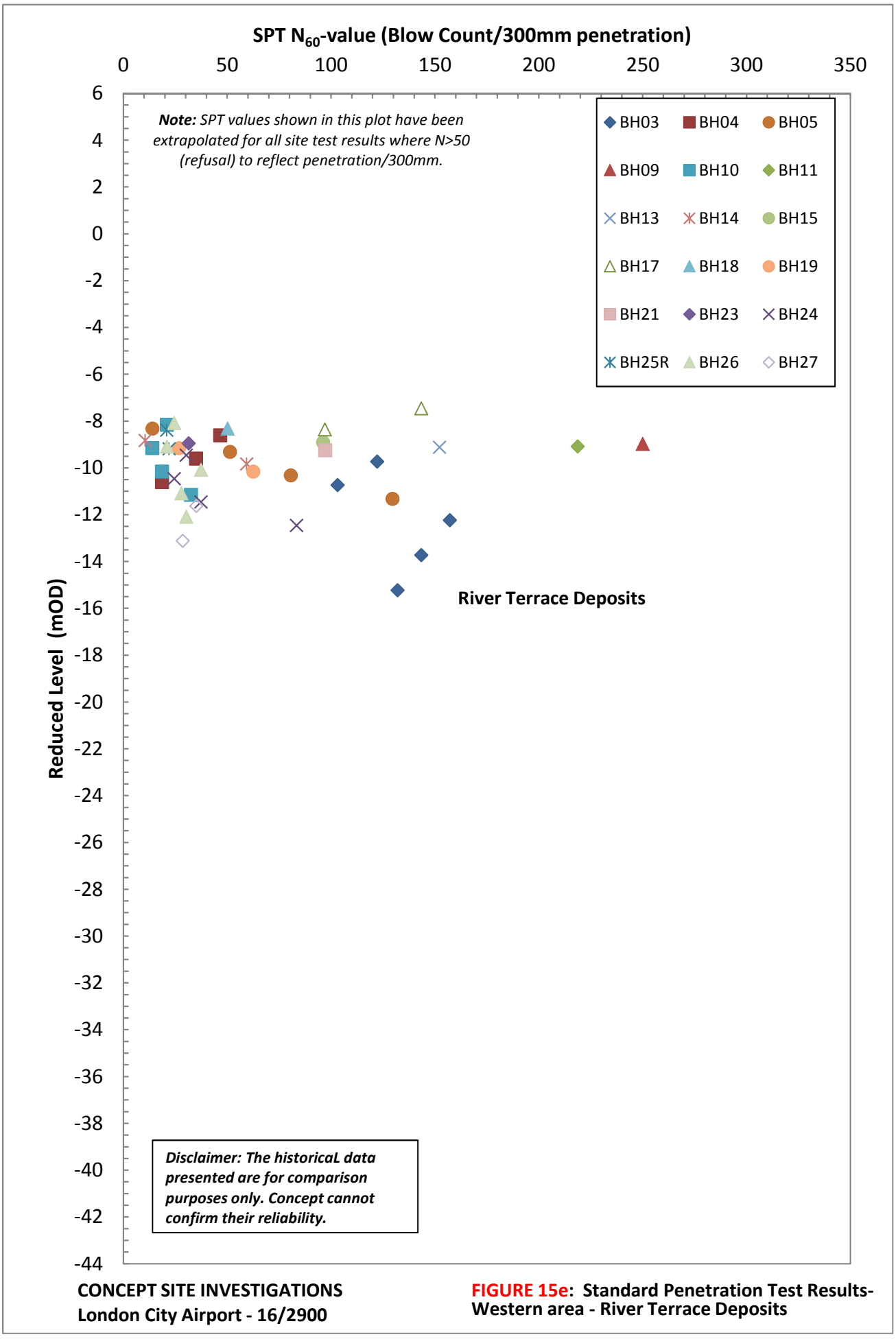
CONCEPT SITE INVESTIGATIONS
London City Airport - 16/2900

FIGURE 15c: Standard Penetration Test Results-Western area



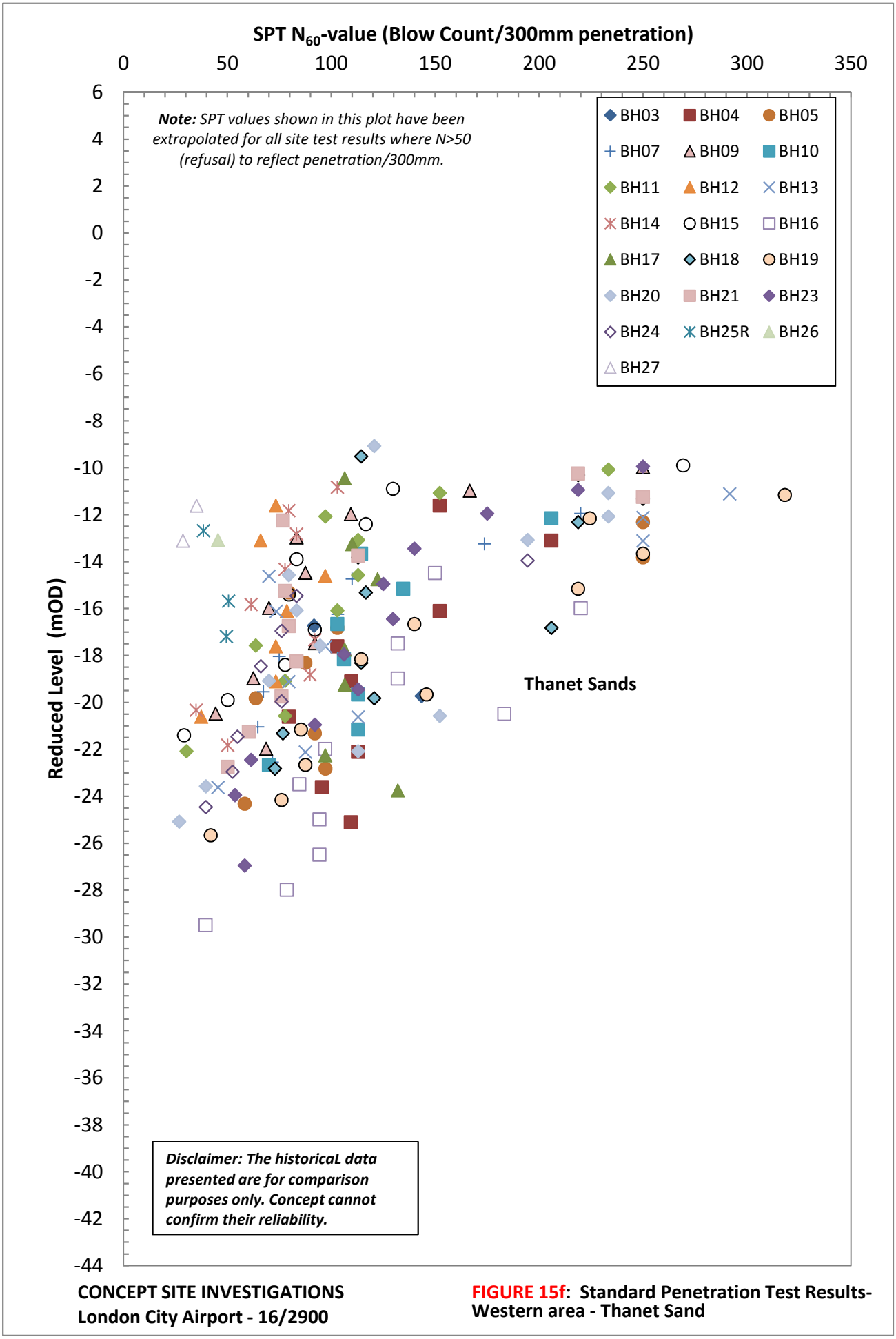
CONCEPT SITE INVESTIGATIONS
London City Airport - 16/2900

FIGURE 15d: Standard Penetration Test Results- Western area- Dock Silt



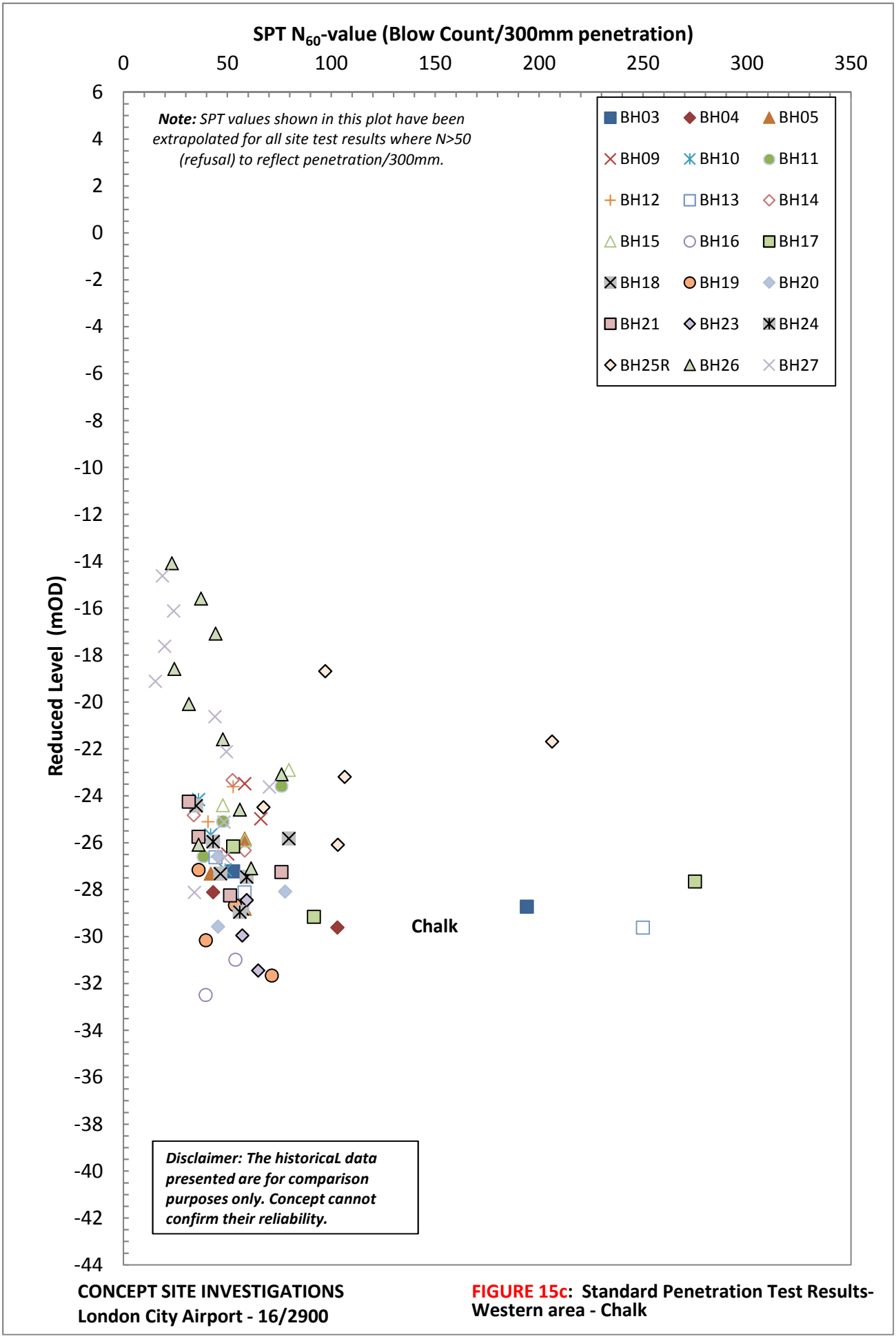
CONCEPT SITE INVESTIGATIONS
London City Airport - 16/2900

FIGURE 15e: Standard Penetration Test Results- Western area - River Terrace Deposits



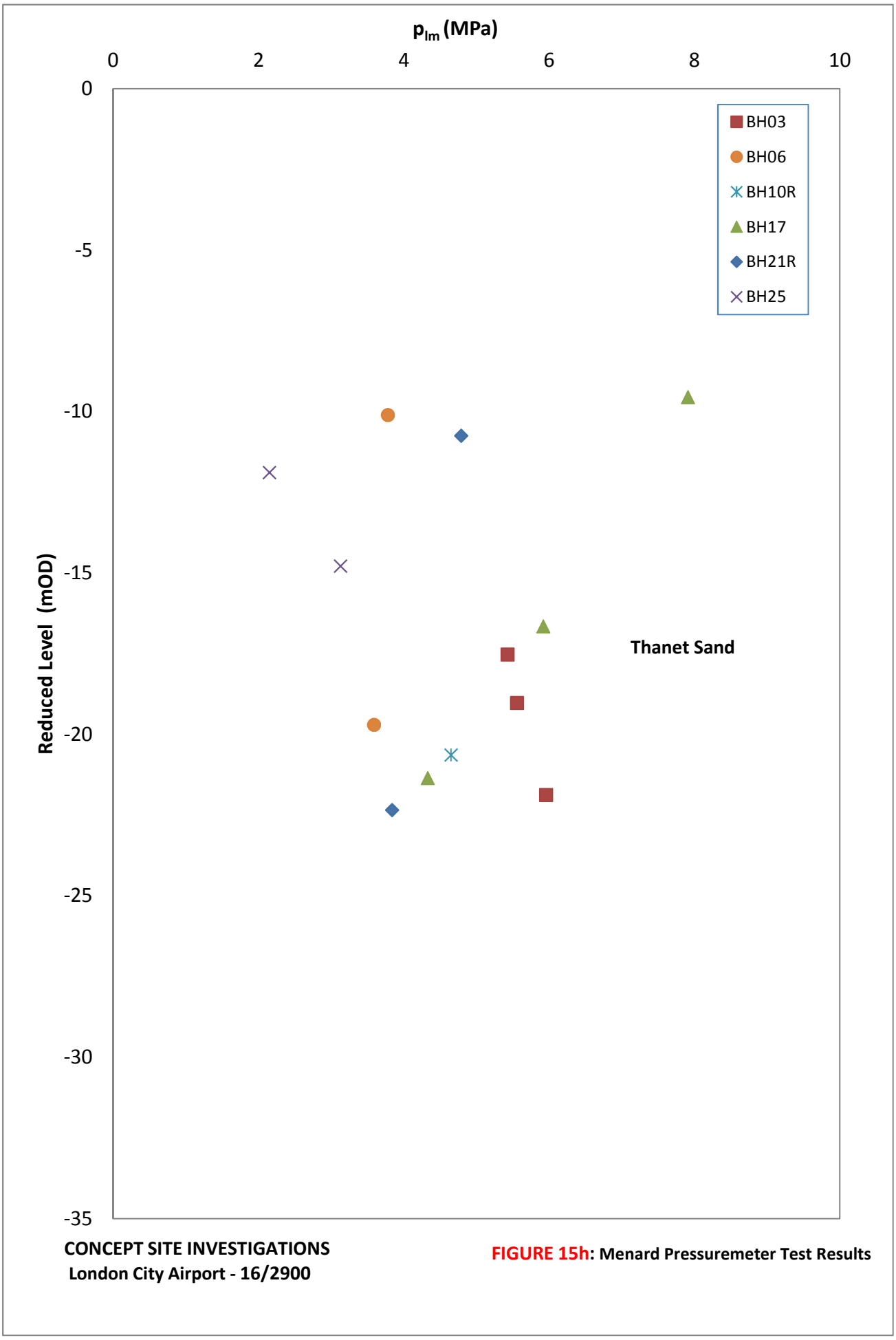
CONCEPT SITE INVESTIGATIONS
London City Airport - 16/2900

FIGURE 15f: Standard Penetration Test Results- Western area - Thanet Sand



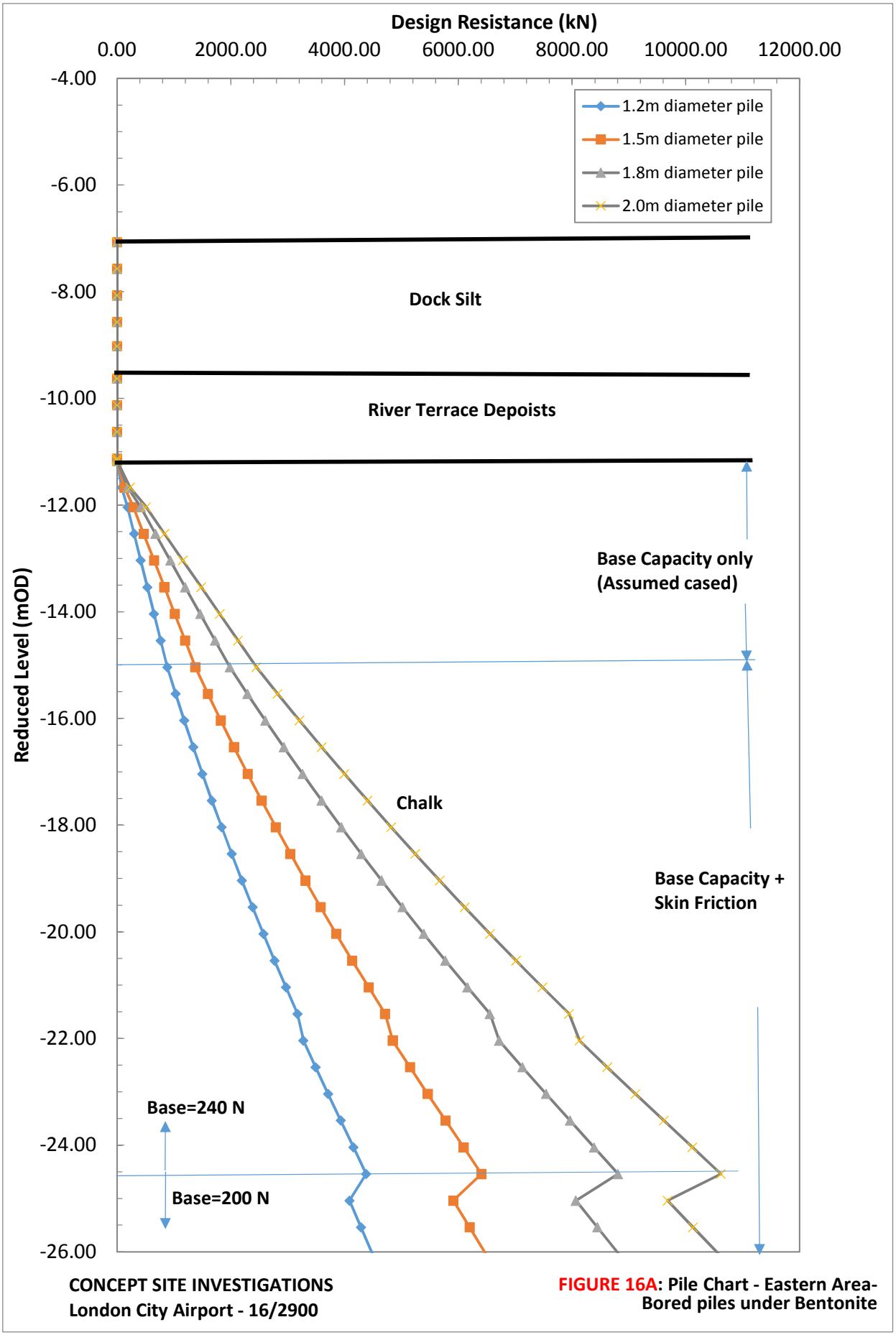
CONCEPT SITE INVESTIGATIONS
London City Airport - 16/2900

FIGURE 15c: Standard Penetration Test Results- Western area - Chalk



CONCEPT SITE INVESTIGATIONS
London City Airport - 16/2900

FIGURE 15h: Menard Pressuremeter Test Results



CONCEPT SITE INVESTIGATIONS
London City Airport - 16/2900

FIGURE 16A: Pile Chart - Eastern Area- Bored piles under Bentonite

Pile Diameter (m)	Min Toe Depth (2.0x diam. below top of Thanet Sands) (mOD)	Design Resistance (kN)
1.2	-14.4	4,524
1.5	-15	7,069
1.8	-15.6	10,180
2.0	-16	12,568

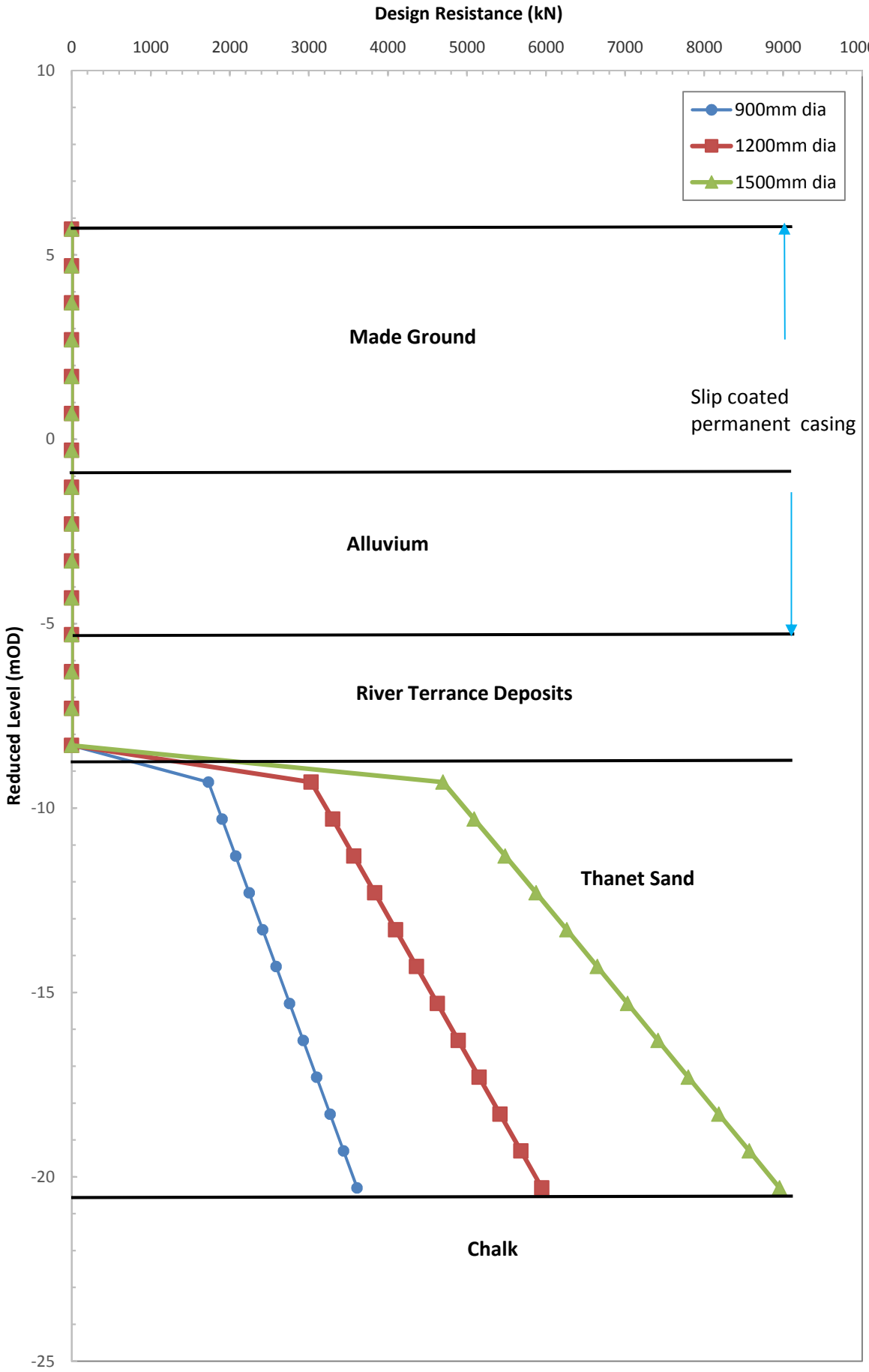
Note 1): Skin Friction ignored due to permanent casing. Type and installation details to be decided by piling contractor.

Note 2): A minimum thickness of at least 3.0m should be present below the toe of the piles.

Note 3) For piles founded close to the boundary with the Chalk, consideration should be given to avoid exceedance of the bearing capacity of this layer.

Note 4) In the areas where there is insufficient thickness of the Thanet Sand to achieve the above conditions the piles should be designed for bearing in the Chalk

FIGURE 16b: Pile Chart - Western Area - Bored piles under Bentonite



CONCEPT SITE INVESTIGATIONS
London City Airport - 16/2900

FIGURE 16c: Pile Chart - Landside area

TPS Consult Ltd
Interchange,
81-85 Station Road,
Croydon,
CR0 2RD

+44 (0) 1902 422431

info@tpsconsult.co.uk
www.tpsconsult.co.uk

Offices also at
Birmingham, Edinburgh,
Manchester, Sheffield and
Wolverhampton

linkedin/company/tps-consult/

@TPSConsult

APPENDIX G

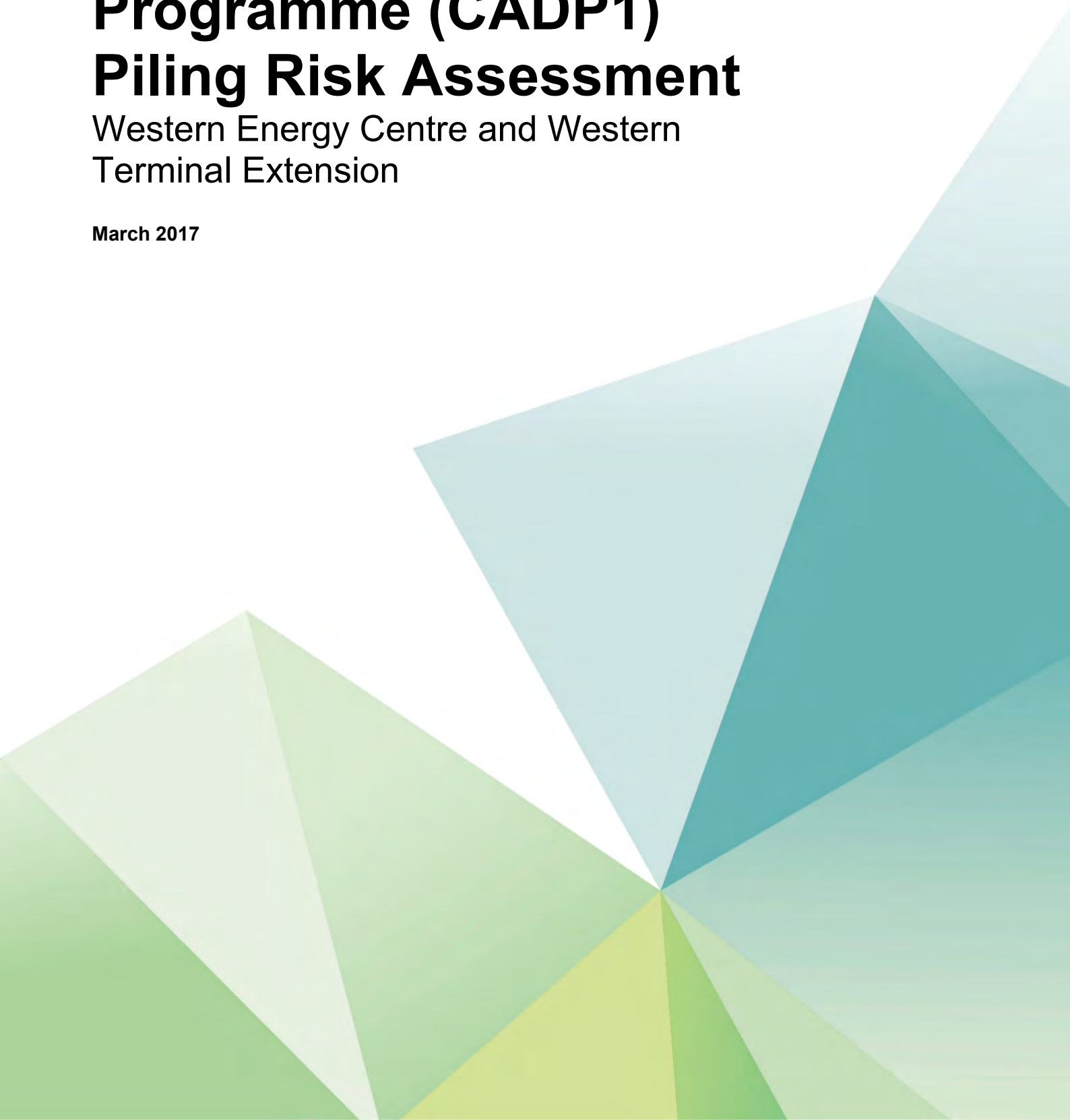
Atkins Piling Risk Assessment Reports 2017

ATKINS

City Airport Development Programme (CADP1) Piling Risk Assessment

Western Energy Centre and Western Terminal Extension

March 2017



Notice

This document and its contents have been prepared and are intended solely for London City Airport's information and use in relation to the proposed piling works for the Western Terminal Extension and Western Energy Centre.

Atkins Limited assumes no responsibility to any other party in respect of or arising out of or in connection with this document and/or its contents.

This document has 29 pages including the cover.

Document history

Job number: 5151383			**Document ref: A400-ATK-C-00-XXX-DC-RP-915-001**			
Revision	Purpose description	Originated	Checked	Reviewed	Authorised	Date
Rev 1.0	Draft Piling Risk Assessment	Conor McCabe	Bala Palananthakumar	Elizabeth Waterfall	Jonathan Steeds	March 2017
Rev 2.0	Addressed RPS comments	Conor McCabe	Bala Palananthakumar	Elizabeth Waterfall	Jonathan Steeds	March 2017

Client signoff

Client	London City Airport
Project	City Airport Development Programme (CADP1)
Document title	Piling Risk Assessment
Job no.	5151383
Copy no.	
Document reference	

Table of contents

Tables

1. Introduction

1.1. General

The City Airport Development Programme (CADP) 1 planning application (13/01228/FUL) was granted planning permission by the Secretaries of State for Communities and Local Government and Transport in July 2016 following an appeal and public inquiry which was held in March/April 2016.

The Environment Agency has raised a specific query to the London Borough of Newham (LBN) it an email of 27th February 2017, regarding the need for a Piling Risk Assessment (PRA) to be prepared for the proposed 'landside' piling works associated with the CADP Interim Works. This is because such piles could be advanced through contaminated made ground soils which could in turn potentially result in the transfer of contaminated material into the underlying aquifer units.

Atkins Limited (Atkins) has been commissioned by London City Airport to produce this PRA and to propose appropriate mitigation measures in accordance with the Environment Agency guidance document 'Piling into Contaminated Sites'. This PRA is provided as an appendix to the overarching report prepared by RPS (on behalf of London City Airport) in order to discharge Planning Condition 39: Contamination and to obtain the approval of the Environment Agency.

This PRA is based on current Environment Agency guidance for piling within brownfield land (Ref. (1) and (2)) and focuses on the following two elements of the CADP1 Interim Works:

- Western Energy Centre (WEC); and
- Western Terminal Extension (WTE).

The foundations of the WEC and the WTE will require piles as shown in Drawings A400- ATK-S-00-L00_DR-GA-940-001-01-S0 and ATK-S-00-L00_DR-GA-940-002-01-S0 in Appendix A. This assessment is based on current pile designs, which are provisional and may be subject to change upon appointment of the Piling Contractor, although the principle of preventing pollution of the underlying aquifers shall be retained. Accordingly, this assessment may need to be revised following any changes to design and resubmitted to the Environment Agency and LBN.

The WEC includes a basement, which will be constructed using a secant pile wall which is proposed to consist of 150 no. piles, the secant piles will be 600 mm diameter and will extend 13 – 20 m below ground level (bgl). The basement slab is proposed to be supported by 30 No. piles 600 mm in diameter extending to 13 -20 m bgl, as the basement slab will support a water tank (15m x 5m x 3m deep). The western portion of the WEC is proposed to have 15 no. piles, 600mm in diameter extending 13 - 20 m bgl for foundation support.

It is proposed that the foundations of the WTE will have 110 No. piles, 600 mm in diameter and extending to a depth of 13 – 30 m bgl. The locations and layout of the piles are shown on Drawing A400-ATK-S-00-L00_DR-GA-940-001-01-S0 and A400-ATK-S-00-L00_DR-GA-940-002-01-S0 in Appendix A.

The piles are expected to be installed by Continuous Flight Auger (CFA). However, Rotatory Bored (RB) piles with temporary casing (extending into the Alluvium) may be considered if necessary (particularly if obstructions are encountered). As such, the suitability of both piling methods are evaluated in this assessment.

This PRA addresses the potential risks to controlled waters only from the proposed piling activities associated with the foundations of the WTE and WEC. The PRA assesses potential risk posed by the proposed piling methods by reviewing various Source-Pathway-Receptors (SPR) linkages associated with controlled waters and whether or not mitigation / control measures are required to manage these risks. The PRA does not seek to replace any method statements, or health and safety plans for the test piling or piling, but should be used as an informative document to such plans.

The following relevant information was made available to Atkins for the purposes of this report:

- RPS (2013) London City Airport Western Terminal Extension, Phase 1 Preliminary Risk Assessment Report, HLEI32363/001R. (Ref. (3));
- RPS (2013) London City Airport Environmental Site Investigation Report, HLEI24974/001R (Ref. (4));
- RPS (December 2014). London City Airport Western Terminal Extension, Phase 2: Environmental and Geotechnical Site Investigation, HLEI32363/001R. (Ref. (5));
- RPS (2017) City Airport Development Programme, Submission under condition 39 of planning Permission 13/01228/FUL – Contaminated Land assessment and Outline Remediation Strategy. HLEI45199/001R (Ref. (6));
- Atkins (2017) City Airport Development Programme (CADP1), Pre-commencement Condition 87: Construction, Design and Method Strategy (Ref. (7)); and
- Ground Investigation Report, New Immigration Facility, London City Airport, by Soils Ltd, dated March 2014, reference 14113/GIR (Ref. (8)).

1.2. Scope of Document

This PRA has been prepared in accordance with the Environment Agency's guidance (Refs. (1) and (2)) in order to assess the potential risks to controlled waters associated with the proposed piling techniques, and to recommend mitigation measures as appropriate. The scope of the assessment includes:

- review of available background information on the environmental setting including the hydrogeological / hydrological regime;
- identification and assessment of the Source Pathway Receptor (SPR) linkages associated with the proposed piling works;
- qualitative assessment of risks from SPR linkages based on CIRA Report 552, Ref. (9);
- review and discussion of the various potential pollution scenarios, in line with Environment Agency guidance, Refs. (1) and (2); and
- identification of mitigation measures, if required, in order to minimise impacts associated with piling and ground improvement methods.

This PRA focuses on the risks to controlled waters receptors (i.e. surface water and groundwater) as it is understood that the Contractor will adopt safe methods of working to mitigate human health risks from potentially contaminated soils and water arisings during construction, as required by Condition 39 and associated legislation. Potential risks to human health including from ground gases are addressed separately by RPS in the main volume of the Condition 39 report.

1.3. Assumptions and Limitations

This report is based on the following assumptions and limitations:

- the document has been prepared based on available ground investigation data, for soil and groundwater, provided by third parties;
- the pile specifications have been based upon the current known piling designs and could be subject to change;
- this document covers matters in connection with risks to controlled waters associated with ground contamination only and does not seek to replace the Method Statement or Health and Safety Plan for the piling as a whole. Separate detailed method statements covering wider issues will be produced by the Contractor prior to the commencement of piling works;
- human health, built structures and ecological receptors have not been considered within this piling risk assessment as the focus is the assessment of controlled waters risks; and
- the information presented is in part a summary of works undertaken by others and provided by the Client, and the sources of such data and the accuracy of the data provided are assumed to be correct and have not been verified by Atkins.

2. Site Location, History and Environmental Setting

2.1. Site Location and Description

The site is located within the curtilage of London City Airport, adjacent to the western side of the existing terminal building and currently comprises a service area. The site occupies an area of approximately 760 square metres and is predominately covered by hardstanding. There are a number of contractor cabins on site. The site is currently used for deliveries to the terminal building and the fire escapes from the terminal building and the Docklands Light Railway (DLR) station (to the south of the site) exit into this area.

The site is situated within the London Borough of Newham and centred on National Grid Reference (NGR) 542302, 180298. Site location and site boundary plans are presented as Figures 1 and Figure 2 respectively.

The surrounding land uses are:

- North: London City Airport – Runway;
- West: DRL station and track, which runs from the north-west to the south-east;
- South: beyond the train line is a Travel Lodge, school and residential housing; and
- East: London City Airport Terminal.

2.2. Site History

The following site history has been taken directly from RPS 2017 (Ref. (6)). From available historic maps the site is undeveloped from 1869 to 1938, in 1938 on the northern boundary there is dry dock and on the eastern boundary is King George the V dock. The dry dock is present until 1991.

2.2.1. Western Energy Centre

The area of the WEC comprised marshland from at least 1869 until c.1938 when a road was indicated to run through the centre of this area. By c.1962, a railway line was indicated to be present to the north of the road. By c.1984, the railway line was no longer indicated to be present and by c.2006, the road was no longer indicated to be present. By c.2006, the area resembled a similar form/layout to the present day.

2.2.2. Western Terminal Extension

The area of the WTE comprised marshland from at least 1869 until c 1916, when a school encroached into the south of this area. The remainder of this area appeared to comprise undeveloped land, likely associated with the adjacent docks (to the north and east). By c.1938, a road was indicated to be present across the north of this area, running north-west/south-east (this is a continuation of the road which was present across the area of the WEC). By c.1962, a railway line was indicated to be present to the north of the road. By c.1984, the railway line was no longer indicated to be present. By c.2006, the road and school were no longer indicated to be present, with the area resembling a similar form/layout to the present day.

2.3. Previous Ground Investigations at the Site.

2.3.1. RPS 2013

The site investigation was carried out by RPS between 11th and 19th February 2013: The investigation consisted of the following:

- 21 No. window sampler boreholes (WS1 - WS23) advanced to depths between 0.5m and 5.0m below ground level (bgl) with the installation of groundwater and gas monitoring wells. Soil and groundwater samples were taken for laboratory analysis; and
- Seven No. hand dug pits (HP1 – HP7) with depths between 0 to 0.5 m bgl, in which falling head permeability tests were carried out.

Only four locations (WS03, WS04, HP1 and HP2) of the RPS 2013 ground investigation were located within the site boundary. The borehole locations are included on Figure 3.

2.3.2. RPS 2014

The site investigation was carried out by RPS between 22nd October and the 6th November 2014. The investigation comprised the drilling of five cable percussion boreholes (BH1 to BH5) to depths ranging from 20 m bgl to 25 m bgl. In situ geotechnical testing, the installation of groundwater and ground gas monitoring wells and California Bearing Ratio (CBR) testing was undertaken in four locations. BH1, BH2, BH3 and BH4 are dual installations, with shallow (Made Ground and Alluvium) and deep response zones (River Terrace Deposits and Thanet Sands). Soil samples and groundwater samples were taken for laboratory testing. There were also three gas monitoring rounds. The borehole locations are included on Figure 3.

2.3.3. Soils 2014

The aim of the investigation was to ascertain the geotechnical information on soils beneath the site so that foundations could be designed to support a relocated column within the existing terminal building. The ground investigation consisted of drilling one borehole to a depth of 10 m bgl using cable percussion methods in a location within the existing terminal, a short distance to the north-east of the proposed WTE. A groundwater monitoring well was installed to a depth of 9.00 m bgl, screened within the Made Ground and Alluvium. No environmental analysis for potential contaminants of concern was carried out as part of this investigation

2.4. Geology

The published geology for the site (Ref. (10)), indicates the presence of superficial deposits of Alluvium and Shepperton Gravel Member / River Terrace Deposits (RTD) and deeper strata comprising the Thanet Sand Formation which overlies the Chalk Group.

A summary of the geology encountered during the intrusive works completed by RPS 2013 (Ref. 3), RPS 2014 (Ref. (5)) and Soils 2014 (Ref. 8) is presented in Table 2-1 below, also included are data from BGS borehole scan of TQ48SW466, which is located approximately 300 m north-west of the site, the borehole log included in Appendix A.

Table 2-1 Summary of Geology.

Strata	Description	Base of Strata (m bgl)	Thickness of Strata (m)
Made Ground (MG)	Grey-brown clayey sandy gravel and gravelly SAND. Gravel comprised predominantly fine to coarse brick, concrete and flint with occasional glass, ash, tarmac, plastic, wood, ceramic and metal.	3.4 – 5.2	3.4 – 5.14
Alluvium (ALV)	Grey, brown and red, sandy, occasionally peaty CLAY. This was underlain by a layer of clayey peat at depths ranging from 6.3 m to 7.3 m bgl.	8.6 – 9.6	4.1 – 6.0
River Terrace Deposits (RTD)	Grey-brown sandy GRAVEL of fine to coarse angular to rounded flint	18.1 to 22.3	8.7 – 12.7
Thanet Sand (TS)	Dark grey, silty, fine. SAND	~32.2*	19.3 – 23.3*
Chalk	Cream to white rubbly CHALK with visible*	Not proven	-

*Based on data from TQ48SW466

2.5. Hydrogeology

The Environment Agency website (Ref. (11)) indicates that the Alluvium (superficial deposits) is a Secondary Undifferentiated Aquifer and that the RTD (superficial deposits) and Thanet Sand Formation (bedrock) are Secondary A Aquifers. The Chalk is a Principal Aquifer.

According to information provided on the Environment Agency website, the site does not lie within a Source Protection Zone. There is only one licensed groundwater abstraction (for use as industrial, commercial or public service), located approximately 1km north-west of the site.

RPS 2014 (Ref. (5)) found that there was perched water present within the Made Ground with levels varying from approximately 3.5 to 4.0 m above Ordnance Datum (aOD) (3.05 m to 3.52 m bgl). The perched water did not display any tidal influence as the water levels measured during three monitoring rounds were reasonably constant. It was considered that the Alluvium was acting as confining layer with groundwater levels rising to 5 – 6 m bgl from 8.6 – 9.6 m bgl in 20 minutes after entry into the RTD during drilling.

The results of the groundwater monitoring suggest that the RTD and the Thanet Sands are a continuous water body with the water levels rages from -1.85 to 1.6m aOD (4.1m to 2.7m bgl). No evidence of hydrocarbon free product was encountered during the monitoring.

Groundwater level loggers were not used in this investigation to assess tidal influence on groundwater levels.

2.6. Hydrology

King George V Dock is situated to the east of the terminal and the Royal Albert Dock is situated adjacent to the northern boundary of the airport. It is understood that the docks are lined to maintain the impounded water level of 4.5 m aOD. The River Thames is located approximately 460m to the south. It is tidally influenced and generally flows in an easterly direction.

There are records of two licensed surface water abstractions within 1km of the site. These both relate to abstractions from the River Thames by Tate and Lyle Sugars Ltd and the abstractions are recorded as being located approximately 375m and 480m south of the site (11).

2.7. Potential Contaminants

RPS Phase 1 Preliminary Risk Assessment (Ref. (3)) identified a number of on-site and off-site potential sources of contamination associated with current and past land use.

2.7.1. On Site

Current and historical on site potential sources of contamination are limited to the presence of Made Ground beneath the site, associated with the development of the nearby docks and airport. Potential contaminants of concern associated with Made Ground include metals, hydrocarbons, asbestos and ground gas.

2.7.2. Off-Site

Potentially contaminative historical land uses in the immediate surrounding area have included a white lead works, distilleries, foundries, breweries, a drugs mill and an engineering works. Current potentially contaminative land uses in the immediate surrounding area include two disused underground diesel tanks beneath the courtyard to the east of the site. Potential contaminants of concern associated with these land uses include metals, hydrocarbons and solvents.

2.8. Summary of Previous Contamination Assessments

2.8.1. RPS 2013

None of the soil samples analysed were found to contain concentrations of contaminants of concern above the RPS derived Assessment Criteria (AC) for human health (commercial site user). Elevated concentrations of TPH contamination in the C10 – C35 (diesel) range were identified in borehole WS4 with a total 6500 mg/kg aliphatic and 2900 mg/kg aromatic compounds were below AC for human health. TPH concentrations were below the limit of detection in a deeper sample taken at 2.0 m bgl from the same borehole suggesting that this is an area of localised contamination in shallow Made Ground.

No leachate samples were taken. Some soil samples were Waste Acceptance Criteria (WAC) tested, of which one soil sample is from WS3 and likely to be suitable for disposal as inert waste. Groundwater samples were taken from each location the results of which have been reassessed below in section 2.8.3.

2.8.2. RPS 2014

RPS 2014 (Ref. (5)) noted the following visual evidence of soil contamination at the site as summarised below in Table 2.2..

Table 2-2 Visual evidence of contamination.

Borehole	Depth (m bgl)	Stratum	Evidence of Contamination	Location	Notes
BH2	0.50 to 1.80	Made Ground	Ash	West of site	1
BH2	2.40 to 3.40	Made Ground	Tarmac	West of site	2
BH4	3.50 to 3.70	Made Ground	Ash	East of site	1
BH5	4.00 to 4.80	Made Ground	Ash	East of site	1

There was one PID reading of 237 ppm in borehole BH3 0.5 (m bgl), which was from Made Ground. Soil samples underwent contamination testing but none of the samples were subjected to leachate testing. Five samples were WAC tested.

Soil samples were screened against human health screening criteria (commercial) which identified only exceedance of lead in BH05 (4.1 m bgl) with a concentration of 25,000 mg/kg (GAC applied was 6,215 mg/kg). Asbestos was also detected in three samples from the Made Ground, BH3 at 0.80m bgl and within borehole BH5 at depths of 0.60m and 4.10m bgl.

Sulphate, selenium, cyanide, TPH CWG and PAH were recorded at concentrations in excess of their relevant drinking water standard (DWS), within groundwater samples collected from beneath the site.. The groundwater data have been reassessed in the following section (Section 2.8.3).

2.8.3. Groundwater Quality Assessment

Perched water and groundwater quality data from the RPS 2013 (Ref. (4) and RPS 2014 (Ref. (5)) site investigations were screened against current Drinking Water Standards (DWS) and Environmental Water Quality Standards (EQS) based on:

- The Water Framework Directive (Standards and Classification) Directions 2015; and
- Water Supply (Water Quality) Regulations 2016.

A conservative approach was taken for selecting the Water Quality Standard (WQS), which was to screen the data against the lowest value of either the DWS or EQS for that determinand. Perched water and groundwater screening sheets are presented in Appendix B and results are summarised in Table 2-3.

Table 2-3 Summary of screening of groundwater and perched water against WQS

Determinand	Units	LOD	WQS	Maximum	No. of Samples	No of Exceedances	Locations
Perched water							
Zinc	µg/l	1.25	7.9	490.0	5	4	BH2, BH3, BH4, WS03 and WS04
Chromium	µg/l	0.25	0.6	23.0	5	3	BH2, BH4, WS03 and WS04
Aliphatic C5-C35	µg/l	10	10	55.0	5	2	BH2, WS03 and WS04
Arsenic	µg/l	0.16	10	40.0	5	2	BH2 and BH3
Fluoranthene	µg/l	0.01	0.0063	0.1	5	2	BH2 and WS04
Lead	µg/l	0.09	1.3	32.0	5	2	BH2 and BH4
Sulphate	mg/l	0.1	250	977.0	5	2	WS03 and WS04
Aliphatic C16-C21	µg/l	1	10	12.0	5	1	BH3 and WS04
Aliphatic C21-C35	µg/l	1	10	54.0	5	1	BH2
Benzo(a)pyrene	µg/l	0.01	0.00017	0.0	5	1	BH3
Benzo(b)fluoranthene	µg/l	0.01	0.017	0.0	5	1	BH2
Nickel	µg/l	0.5	8.6	20.0	5	1	BH2
Cadmium	µg/l	0.03	0.2	0.8	5	1	WS03
Copper	µg/l	0.4	21	35.0	5	1	WS03
Selenium	µg/l	0.25	10	21.0	5	1	WS04
Zinc	µg/l	1.25	7.9	490.0	5	4	BH4
Groundwater – RTD							
Zinc	µg/l	1.25	7.9	26.50	5	3	BH2, BH3 and BH4
Sulphate	mg/l	0.1	250	260.00	5	3	BH2, BH3 and BH4
Aliphatic C16-C21	µg/l	1	10	16.00	5	2	BH2 and BH3
Aliphatic C21-C35	µg/l	1	10	110.00	5	2	BH2 and BH3
Aliphatic C5-C35	µg/l	10	10	130.00	5	2	BH2 and BH3
Chromium	µg/l	0.25	0.6	0.31	5	1	BH2
Nickel	µg/l	0.5	8.6	6.20	5	1	BH4
Aromatic C16-C21	µg/l	1	10	18.00	5	1	BH3
Aromatic C21-C35	µg/l	1	10	560.00	5	1	BH3
Aromatic C5-C35	µg/l	10	10	580.00	5	1	BH3
Groundwater – Thanet Sands							
Zinc	µg/l	1.25	7.9	413.0	5	2	BH1 and BH5
Arsenic	µg/l	0.16	10	19.0	5	2	BH1 and BH5
Sulphate as SO4	mg/l	0.1	250	390.0	5	1	BH1
Aliphatic C16-C21	µg/l	1	10	49.0	5	1	BH1
Aliphatic C21-C35	µg/l	1	10	450.0	5	1	BH1

Determinand	Units	LOD	WQS	Maximum	No. of Samples	No of Exceedances	Locations
Aliphatic C5-C35	µg/l	10	10	510.0	5	1	BH1
Cyanide	µg/l	40	1	89.0	5	1	BH1
Fluoranthene	µg/l	0.01	0.0063	0.1	5	1	BH1
Benzo(b)fluoranthene	µg/l	0.01	0.017	0.1	5	1	BH1
Benzo(k)fluoranthene	µg/l	0.01	0.017	0.04	5	1	BH1
Benzo(a)pyrene	µg/l	0.01	0.0001 7	0.1	5	1	BH1

3. Pile Design

The piling design is in accordance with the Environment Agency guidance (Reference (1) & (2)) and takes into consideration potentially contaminated soils and groundwater.

All concrete and steel used for the piles will be specified and designed based upon site specific ground investigation results so as to resist chemical attack associated with aggressive ground conditions, where relevant.

The locations and layout of the piles are shown on Drawings A400-ATK-S-00-L00_DR-GA-940-001-01-S0 and A400-ATK-S-00-L00_DR-GA-940-002-01-S0. The design of the piles is at a provisional stage but the current specification is summarized in Table 3-1, below.

Table 3-1 Provisional piling design and construction details

Location/ description	Proposed construction method	Type	Number of Piles (See note 2)	Design depth (m bgl) (See note 2)	Diameter (mm) (See note 2)
WEC – secant pile wall	CFA (See note 1)	Secant pile	150	13 - 20	600
WEC – foundation piles	CFA (See note 1)	Contiguous	15	13 - 20 m bgl	600
WEC – basement slab support	CFA (See note 1)	Contiguous	30	13 - 20 m bgl	600
WTE	CFA (See note 1)	Contiguous	110	13 - 30 m bgl	600

Notes

1: Pile type is expected to be continuous flight auger (CFA). Final pile design is by contractor so may vary. Other bored pile techniques may be used, particularly if obstructions are encountered. A temporary pile casing or support fluid may be used depending on piling method and the ground encountered, particularly if a bored cast in situ technique is required.

2: Detailed pile design will be performed by a specialist pile contractor after contract award.

The proposed construction method for the piles is Continuous Flight Auger (CFA), which is discussed in more detail below along with the alternative method, rotary bored piles with temporary casing.

The rotary bored pile technique may be used in the event that CFA cannot penetrate the ground due to unforeseen obstructions.

3.1. Continuous Flight Auger Bored Piles

CFA is the chosen method for installing the piles. This technique relies on the retention of soil on the auger flights to provide support to the surrounding soil until the auger is withdrawn and the concrete or grout intruded. CFA piles are considered to present a low risk piling solution where contamination is present as material is brought to the surface and not driven down into lower units / groundwater as with driven techniques.

It is vital to the CFA technique that the intruded material (concrete) is placed under pressure at a rate consistent with that of the withdrawal of the auger to ensure that the hole is supported. This can be difficult to achieve near to the surface. Care has to be taken to ensure that water and concrete pressures are balanced in order to minimise concrete losses in permeable horizons.

3.2. Rotary Bored Piles

Rotary boring will be used in the event that an obstruction is encountered. The rotary bored piles are installed by drilling a borehole, which is stabilised using temporary casing. The temporary casing inhibits the creation of a groundwater pathway by preventing inflow into the borehole and maintains the stability of the soils around the borehole.

The hole is bored to the desired depth, concrete mixture, which will form the pile, is then pumped into the annulus within minutes of the pile being drilled, as the temporary casing is (generally) removed.

The option of temporary casing will assist in preventing migration of contamination from the perched water in the Made Ground into the borehole (clean drilling technique used on contaminated site) and entering the RTD Formation (Secondary A aquifer) and potentially subsequently to the River Thames.

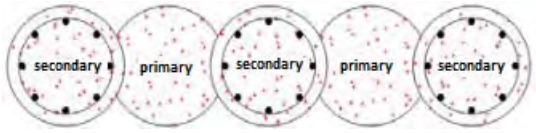
3.3. Secant Pile Wall

Secant pile walls are used as retaining walls, for groundwater control, and to support basements and/or foundations. Secant pile walls have been proposed for the construction of the basement of the WEC.

Secant piles will be installed by CFA and can consist of a contiguous pile wall or interlocking piles.

The secant pile wall is constructed by drilling primary piles first and leaving a space between the piles. The distance between the primary piles is less than the diameter of the secondary pile which is drilled into the space between the primary piles and in doing so cuts into the primary piles as shown in Figure 4 below.

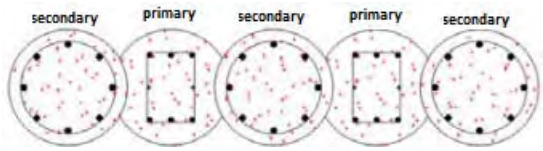
Figure 4 Secant piles (Hard/Soft)



Source Retaining-Walls.pdf

The strength of secant pile walls can be varied depending on the construction requirements by varying the strength of the concrete mixture used to construct the piles and with the addition of steel reinforcement. Based on the strength of the concrete used, secant walls can be classed as Hard/Soft or Hard/Firm or Hard/Hard. Steel reinforcement may also be added to the primary pile as shown in Figure 5

Figure 5 Secant piles (Hard/Hard)



Source Retaining-Walls.pdf

4. Conceptual Site Model

A preliminary conceptual site model (CSM) has been developed to enable an assessment of the potential risks posed to controlled waters, and constraints which may be imposed on the proposed piling works.

The CSM describes the relationship between contamination which may be present from past and current activities on a site (and any off-site activities which may affect the site), and receptors of that contamination. As part of the CSM development, three elements are considered:

- a source of contamination (potentially contaminative activity) and associated contaminants;
- a receptor, or receptors, of that contamination; and
- a pathway to connect the two.

This assessment considers only controlled waters receptors (surface water and groundwater) as described in Section 1.2.

A risk to controlled waters can only be present if all three aforementioned elements are present, which is described as a potential pollutant linkage (PPL).

4.1. Sources

Based on historical investigations completed at the site, the lead concentration in the Made Ground was in excess of human health criteria at one location. No leachate samples are available for the Made Ground.

There is perched water present in the Made Ground with the following contaminants above WQS:

- general inorganics – sulphate;
- metals,/metalloids – arsenic, cadmium, copper chromium, lead, selenium and zinc;
- PAH - benzo(b)fluoranthene, benzo(a)pyrene, and fluoranthene;
- TPH - Aliphatic C16-C21 and C21-C35.

The following contaminants are above WQS in the groundwater within the RTD and Thanet Sands:

- general Inorganics – sulphate and cyanide;
- metals,/metalloids – arsenic, chromium, nickel and zinc;
- PAH - benzo(b)fluoranthene, benzo(a)pyrene, benzo(k)fluoranthene and fluoranthene; and
- TPH - Aliphatic C16-C21 and C21-C35; and Aromatic C16-C21, C21-C35 and C5-C35.

4.2. Receptors

The identified sources and contaminants may affect the following receptors:

- groundwater in the Secondary A (RTD and Thanet Sands) and Principal aquifers (Chalk); and
- surface water bodies (mainly King George V Dock and the River Thames).

The aquifers within the RTD, Thanet Sand and Chalk are considered to be in hydraulic continuity as there is no confining layer separating the three aforementioned units.

4.3. Pathways

The potential pathways associated with the installation of piled foundations, to controlled waters receptors, are considered in terms of construction and post-construction (long term impact) phases, as follows:

- pathway created by the action of the piling driving material downwards from the Made Ground into the RTD (Secondary A Aquifer), Thanet Sands (Secondary A Aquifer) and Chalk (Principal Aquifer);
- perched water from Made Ground/Alluvium migrating downwards via a preferential pathway created by the piling operations into the underlying aquifers; and
- subsequent migration of impacted groundwater to surface water features (i.e. King George V Dock and River Thames).

4.4. Risk to Controlled Waters

Table 4-1 summarises the CSM for the concrete piles and assigns a risk rating to the identified controlled waters receptors. The risk rating definitions are in general accordance with those provided in CIRIA Report C552 (Ref. (9))following consideration of the potential consequence and likelihood of exposure occurring at each piling location, as summarised below:

Very High Risk: There is a high probability that severe harm could arise to a designated receptor or there is evidence that severe harm to a designated receptor is currently happening. This risk, if realised, is likely to result in a substantial liability.

High Risk: Harm is likely to arise to a designated receptor. Realisation of the risk is likely to present a substantial liability.

Medium Risk: It is possible that harm could arise to a designated receptor. However, it is either relatively unlikely that any such harm would be severe, or if any harm were to occur it is more likely that the harm would be relatively mild.

Low Risk: It is possible that harm could arise to a designated receptor, but it is likely that this harm, if realised, would be mild.

Very Low Risk: The possibility of harm to the designated receptor is either not plausible or, if the possibility of harm is plausible, risk is considered to be very unlikely with attenuation along the exposure pathway.

Table 4-1 Pile Specification, Conceptual Site Model and Controlled Waters Risk Rating

Pile Reference	Specifications					Conceptual Site Model					
	Type	No. of Piles	Pile Depth (m bgl)	Pile diameter/ width, mm)	Temporary casing (toe) Depth	Contamination Present?	Underlying Geology	Controlled Waters Receptors	Pile Toe Corresponding Geology	SPZ	CWR
WEC – secant pile wall	Continuous flight auger / rotary bored with temporary casing –	150	10 - 20	600	top of Alluvium	Yes in MG, RTD and TS	MG, ALV, RTD, TS, CH	Superficial Deposits (Secondary A Aquifer), Bedrock Deposits (Secondary A Aquifer and Principal Aquifer).	RTD or top of TS	No	Low
WEC – foundation piles	Continuous flight auger / rotary bored with temporary casing –	15	13 - 20	600	top of Alluvium	Yes in MG, RTD and TS	MG, ALV, RTD, TS, CH	Superficial Deposits (Secondary A Aquifer), Bedrock Deposits (Secondary A Aquifer and Principal Aquifer).	RTD or top of TS	No	Low
WEC – basement slab support	Continuous flight auger / rotary bored with temporary casing –	30	13 - 20	600	top of Alluvium	Yes in MG, RTD and TS	MG, ALV, RTD, TS, CH	Superficial Deposits (Secondary A Aquifer), Bedrock Deposits (Secondary A Aquifer and Principal Aquifer).	RTD or top of TS	No	Low
WTE	Continuous flight auger / rotary bored with temporary casing –	110	13 - 30	600	top of Alluvium	Yes in MG, RTD and TS	MG, ALV, RTD, TS, CH	Superficial Deposits (Secondary A Aquifer), Bedrock Deposits (Secondary A Aquifer and Principal Aquifer).	RTD or TS	No	Low

Note: Geological definitions: MG = Made Ground, ALV = Alluvium, RTD = River Terrace Deposits, TS = Thanet Sand, CH = Chalk, LC = London Clay, CWR = Controlled Waters Risk.

5. Pollution Scenarios and Mitigation Measures

5.1. Introduction

The Environment Agency guidance document *Piling and Penetrative Ground Improvement Methods on Land Affected by Contamination: Guidance on Pollution Prevention*, (Reference (1)), presents initial technical guidance on the potential impact that intrusive ground improvement and piling techniques can have on the environment, focusing on the potential for pollution of groundwater and risks to human health.

In accordance with the Environment Agency guidance document, (Ref. (2)), potential Pollution Scenarios have been considered below, based on the CSM presented in Section 4. Mitigation measures have been outlined, where relevant, for any of the Pollution Scenarios.

5.2. Pollution Scenario 1

Creation of preferential pathways through an aquitard to allow potential contamination of an aquifer

The geology at the locations of the piles comprises (generally) Made Ground directly overlying superficial deposits comprising Alluvium (aquiclude/ aquitard) and RTD (Secondary A Aquifer) which directly overlies the Thanet Sands (Secondary A Aquifer) and Chalk (Principal Aquifer). It is likely the RTD, Thanet Sands and the Chalk are hydraulically connected and this hypothesis is supported with by the similar concentrations of determinants present within the RTD and Thanet Sands.

The proposed drilling methods, CFA or rotary bored with temporary casing, will prevent the movement of perched water down into the RTD or deeper groundwater from the Made Ground.

During CFA drilling the downward migration of material is prevented. Material is carried out on the flights of the auger, which also supports the borehole walls. As the auger is withdrawn, concrete is injected into the borehole .As concrete is more dense than water it prevents the ingress of water into the borehole, which also stops the downward migration of water.

Considering the use of non-displacement techniques such as CFA or rotary bored with temporary casing, the piling is unlikely to result in any additional impact on the groundwater in either the RTD or Thanet Sands.

5.3. Pollution Scenario 2

Creation of preferential pathways through a low permeability surface layer, allowing migration of soil gas or contaminant vapours to the surface

This pollution scenario is outside the scope of this document. It should be noted that RPS 2016 (Ref. (5) have undertaken a ground gas assessment for the site that indicates CIRIA Characteristic Situation 2 is applicable, whereby ground gas protection measures are required. This issue is described more fully by RPS in the main volume of the Condition 39 report.

5.4. Pollution Scenario 3

Direct contact of site workers and others with contaminated soil arising that have been brought to the surface

This pollution scenario is outside the scope of this document. According to the available investigation data, contamination is present in the Made Ground, perched water and RTD groundwater within the vicinity of the piling locations. Specific construction related risks will be considered by the Contractor as part of the health and safety risk assessment process. The Contractor shall ensure that suitable working practices and the use of appropriate personal protective equipment (PPE) are maintained so as to minimise exposure to potentially harmful pile arisings. This issue is described more fully by RPS in the main volume of the Condition 39 report.

5.5. Pollution Scenario 4

Direct contact of the piles with contaminated soil or leachate, contaminated perched water/shallow groundwater and NAPL (if present) causing degradation of materials

All concrete and steel will be specified, using site specific ground investigation data, to be resistant to contamination and naturally occurring aggressive ground conditions e.g. high sulphate concentrations.

5.6. Pollution Scenario 5

Forced movement of solid contaminants down into an underlying aquifer during pile driving

The proposed method of piling for CFA or rotary bored with temporary casing, which are non-displacement piling where the soil is extracted and replaced with a pile. Displacement of the surrounding soil is, therefore, minimised and removing potentially contaminated soil reduces the risk to groundwater resources.

5.7. Pollution Scenario 6

Contamination of groundwater and subsequently surface waters by concrete, cement paste or grout

It is understood that the concrete mixture with a high slump value (> 150 mm, S4 class) will be used for the pour. However, considering the pH of the groundwater which varies from 7.2 to 8.0 and indicating RTD groundwater to be slightly alkaline, potentially soluble constituents of the concrete (alkaline) should not readily dissolve into the groundwater. It is therefore considered that risk to this scenario is low.

5.8. Other Scenarios

Impact on ground- and surface water flow direction

The secant pile walls have the potential to impede groundwater flow in the RTD. The two main potential impacts from impeded groundwater flow are groundwater mounding and reduced base flow to the River Thames.

Groundwater mounding will not be an issue as the Alluvium confines the RTD, the RTD is sufficiently permeable to allow the groundwater to flow around the structure as such there will be limited impact from mounding and flow will not be significantly reduced to the River Thames.

Unexploded ordnance

Although outside the scope of this report it is considered that risks may be present from unexploded ordnance (UXO). As the docklands was a target for bombing raids an appropriate UXO risk assessment must be done before intrusive works and mitigation measures adopted if necessary.

6. Conclusions and Recommendations

Based on the available ground investigation data and the proposed piling methodology (CFA or rotary bored with temporary casing), the assessment has shown that there is a **low risk** to controlled waters receptors.

Based on the findings of this piling risk assessment, no additional environmental monitoring is considered necessary for the proposed piling operations.

Perched water from the Made Ground should not be allowed to pass through the Alluvium into the RTD groundwater during the piling activities and so the use of CFA or rotary bored with temporary casing is recommended. Should another technique be employed it should also satisfy this requirement.

All Made Ground pile arisings should be assessed during the works to ensure that waste classification and subsequent disposal is appropriate. All pile arisings going off-site will need to be classified / assessed in accordance with appropriate Waste Management Legislation and guidance and materials managed under Duty of Care. A safe method of work should be adopted for workers exposed to potentially contaminated pile arisings, specifically to limit dermal contact and ingestion pathways.

7. References

1. **Environment Agency.** *Piling and Penetrative Ground Improvement Methods on Land Affected by Contamination: Guidance on Pollution Prevention. National Groundwater & Contaminated Land Centre report NC/99/73.* May 2001.

2. **Environment Agency** . *Piling into contaminated sites. ISBN 1 85705 803 8.* February 2002.

3. **RPS.** *London City Airport Western Terminal Expansion, Phase 1 Preliminary Risk Assessment Report.* 2013. 19695-001R.

4. RPS. *London City Airport Environmental Site Investigation Report.* 2013. HLEI 24974/001R.

5. **RPS .** *London City Airport Western Terminal Extension, Phase 2: Environmental and Geotechnical Site Investigation.* December 2014. HLEI32363/001R.

6. RPS. *City Airport Development Programme, Submission under condition 39 of planning Permission 13/01228/FUL – Contaminated Land assessment and Outline Remeditaion Stategy. .* 2017. HLEI45199/001R.

7. **Atkins.** *City Airport Development Programme (CADP1), Pre-commencement Condition 87: Construction, Design and Method Strategy.* ().

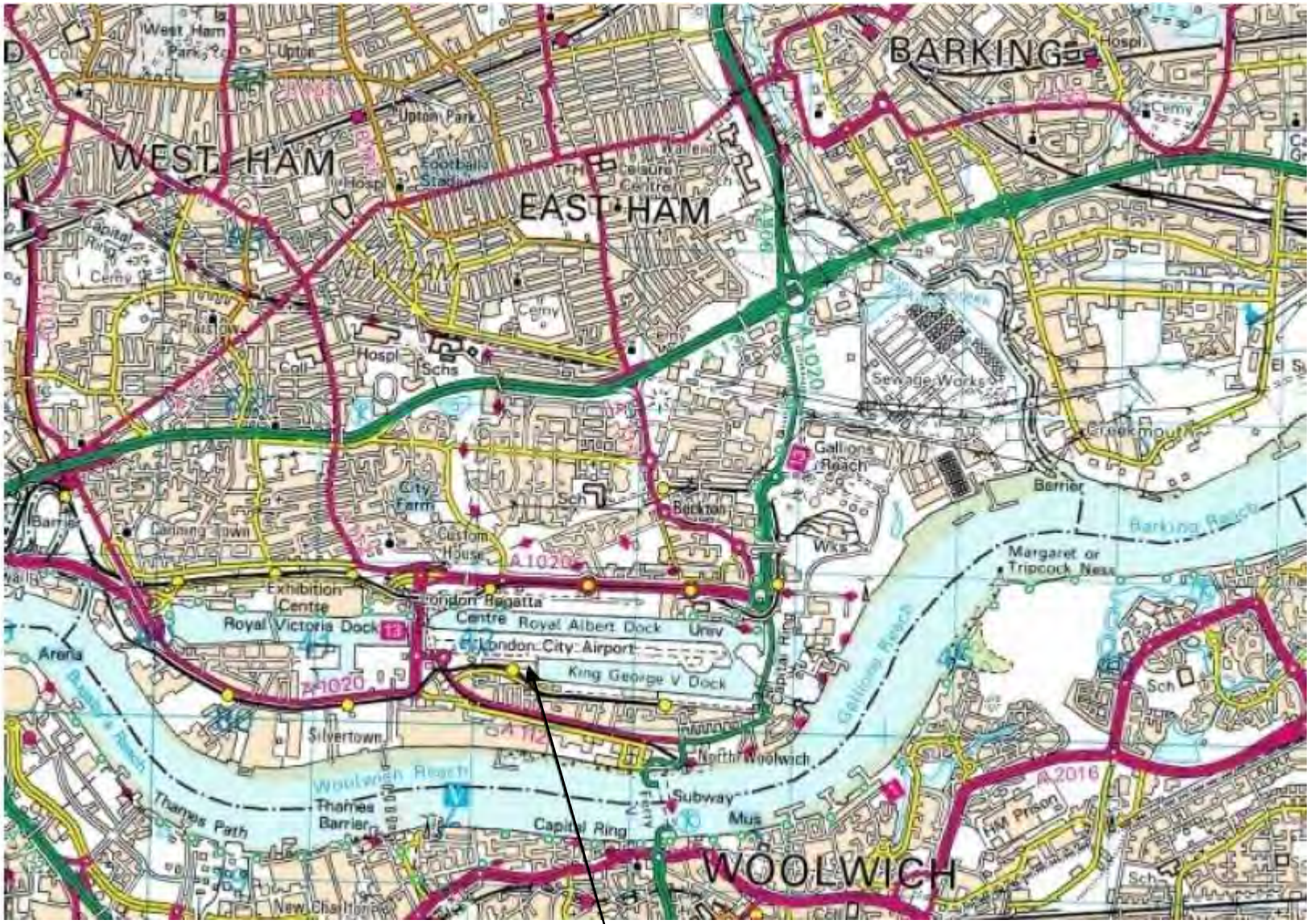
8. **Soil Ltd.** *Ground Investigation Report, New Immigration Facility, London City Airport.* 2014. 14113/GIR .

9. **CIRIA.** *C552 Contaminated Land Risk Assessment – A Guide to Good Practice. IBN 0 86017 552 9.* 2001.

10. **British Geological Survey.** Geology of Britain Viewer. [Online] [Cited: 03 March 2017.] http://mapapps.bgs.ac.uk/geologyofbritain/home.html.

11. **Environemnta Agency.** Whats in Your Back yard. [Online] [Cited: 03 03 2017.] http://maps.environment-agency.gov.uk/wiyby/wiybyController?x=531500.0&y=181500.0&topic=groundwater&ep=map&scale=5&location=London,%20City%20of%20London&lang=_e&layerGroups=default&distance=&textonly=off.

Figures



Site Location Plan

ATKINS

Drawing Number
Figure 1
Rev.
A

Rev.	Description	By	Date	Chk'd	Auth
	FOR INFORMATION / COMMENT	A			
	Purpose of Issue	Rev	Date		Authorised

ATKINS
Consulting Engineers
Woodcote Grove,
Ashley Road,
Epsom, Surrey, England,
KT18 5BW
Fax (01372) 740055
Tel. (01372) 726140

Client
London City Airport

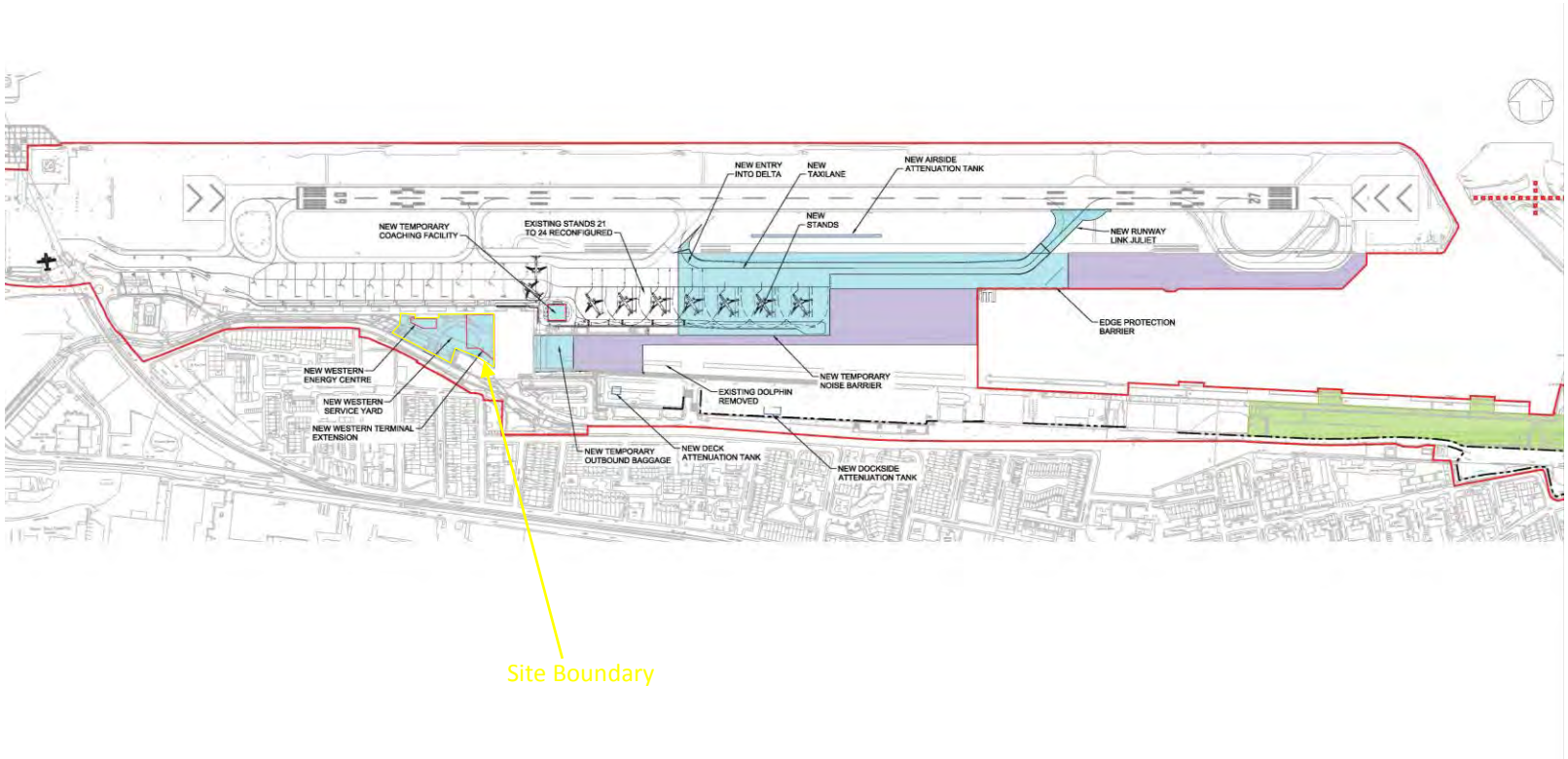
Project
London City Airport, Western Terminal Expansion

Title
Site Location Plan

Original Scale	Drawn	Checked	Authorised	
NTS	CMC Date 03/03/17	CMC Date 03/03/17	EX Date 03/03/17	A4

Drawing Number
Figure 1

Rev
A



Rev.	Description	By	Date	Chk'd	Auth
	FOR INFORMATION / COMMENT	A			

Purpose of Issue	Rev	Date	Authorised

ATKINS
Consulting Engineers
Woodcote Grove,
Ashley Road,
Epsom, Surrey, England,
KT18 5BW
Fax (01372) 740055
Tel. (01372) 726140

Client
London City Airport

Project
London City Airport, Western Terminal Expansion

Title
Site Boundary

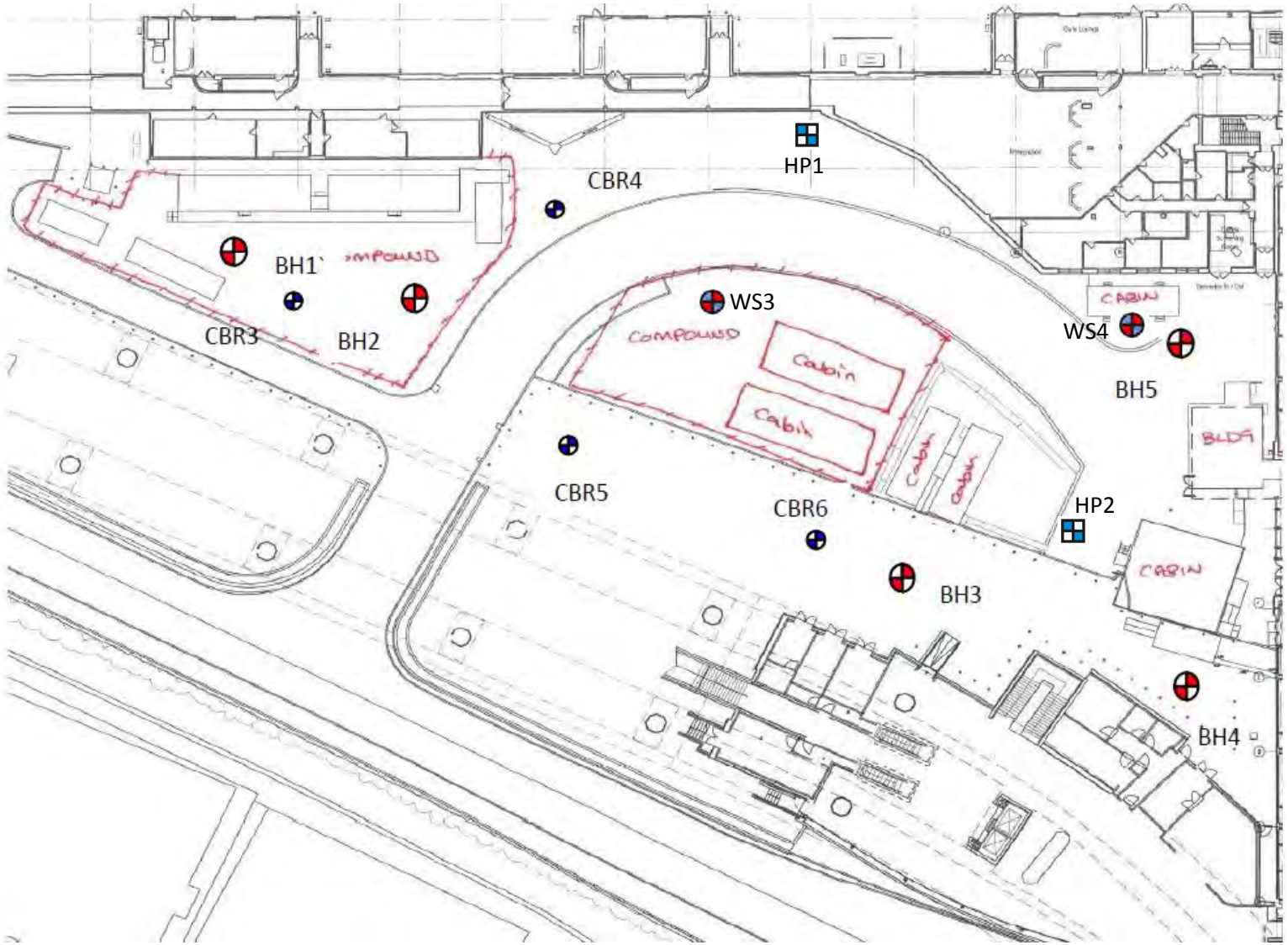
Original Scale	Drawn	Checked	Authorised	
NTS	CMC Date 03/03/17	CMC Date 03/03/17	EX Date 03/03/17	A4

Drawing Number
Figure 2

Rev
A

Drawing Number
Figure 2

Rev.
A



ATKINS

Legend

RPS 2013

- Window Sampling Location
- Hand Pit

RPS 2014

- Cable Percussive Borehole Location
- CBR Test Location

Rev.	Description	By	Date	Chk'd	Auth
	FOR INFORMATION / COMMENT	A			

Purpose of Issue	Rev	Date	Authorised

ATKINS
Consulting Engineers
Woodcote Grove,
Ashley Road,
Epsom, Surrey, England,
KT18 5BW
Fax (01372) 740055
Tel. (01372) 726140

Client: London City Airport

Project: London City Airport, Western Terminal Expansion

Title: Site Boundary

Original Scale	Drawn	Checked	Authorised	
NTS	CMC Date 03/03/17	CMC Date 03/03/17	EX Date 03/03/17	A4

Drawing Number: Figure 3 — Rev A

Drawing Number: Figure 3 — Rev. A

Appendices

Appendix A.Drawings

DO NOT SCALE

Millimetres 100 0 10

CRANE SLEW RESTRICTED
TO AVOID DLR AIRSPACE(5.0m
FROM DLR STRUCTURES)
CONTRACTOR TO PREPARE
DETAILED LIFTING PLAN

W14 9500 W13 9500 W12 9500 W11 9500 W10 9500 W9 9500 W8 9500 W7 9500 W6 9500 W5 9500 W4 9500 W3 9500 W2 9500 W1 14700 C1 9375 C2 9375 C3 7500

Departure Lounge Gate 5 · Departure Lounge Gate 4 · Departure Lounge Gate 3 · Gate Lounge Departure Lounge Gate 2C

Plant and Equipment Room

Airline Handling Agent

DLR ACCESS ROAD

EXISTING DNR SUBSTATION

Existing Fence

HOARDING

DLR PILECAP

GATE

LOW LOADER LORRY
DELIVERS PILING
RIG TO SITE

ENTECO E7050-CFA240
CONTINUOUS FLIGHT
AUGER RIG

CONCRETE
MIXER TRUCK

RIGID FLATBED
TRUCK

LIEBHERR LTB 1030-2.1
MOBILE CRANE OR
SIMILAR

SLEW ZONE

NO SLEW ZONE

5000

5000

DLR
SUBWAY

DLR APPROACH

ARP

SAFETY, HEALTH AND ENVIRONMENTAL INFORMATION

In addition to the hazards/risks normally associated with the types of work detailed on this drawing, note the following:

CONSTRUCTION

MAINTENANCE/CLEANING

It is assumed that all works will be carried out by a competent contractor working, where appropriate, to an approved method statement

KEY PLAN

Rev.	Date	Description	By	Chk'd	App'd
1	30/9/16	Planning Condition PCC 87 - First issue	CJB	RB	MDS

Drawing Status: WORK IN PROGRESS

Suitability: S0

ATKINS
Euston Tower
286 Euston Road
London
NE1 3AT
United Kingdom
Tel: 20 7121 2000
Fax: Atkins Limited
www.atkinsglobal.com

Client: London City Airport Get closer.

Project Title: LONDON CITY AIRPORT
CITY AIRPORT DEVELOPMENT
PROGRAMME

Drawing Title: SITE PLAN
PROPOSED WEC AND
WTE PILING
CONSTRUCTION PLANT

Scale	Designed	Drawn	Checked	Authorised
1:250	CJB	RK	RDB	MDS
Original Size	Date	Date	Date	Date
A1	30/9/16	30/9/16	30/9/16	30/9/16

Drawing Number

Proj.Code	Orig	Dis	Zone	Level	Type	Sub	Series / Num	Rev	Status
A400	ATK	S	00	L00	DR	GA	940-001	01	S0

DO NOT SCALE

Millimetres 0 10 100

9500 9500 9500 9500 9500 9500 9500 9500 9500 9500 9500 9500 9500 9500 14700 9375 9375 7500

DLR ACCESS ROAD

EXISTING DLR SUBSTATION

Existing Fence

Existing Fence

HOARDING

DLR PIER

BASEMENT SLAB

GATE

HOARDING

SCHWING S 34 X CONCRETE PUMP OR SIMILAR

CRANE SLEW

LIEBHERR LTM 1030-2,1 MOBILE CRANE OR SIMILAR

Rebar Truck

REBAR DELIVERED ON FLATBED TRUCK

5000

5000

DLR TICKET HALL

F&B

DLR APPROACH

Gate Lounge

ARR

SAFETY, HEALTH AND ENVIRONMENTAL INFORMATION

In addition to the hazards/risks normally associated with the types of work detailed on this drawing, note the following:

CONSTRUCTION

MAINTENANCE/CLEANING

It is assumed that all works will be carried out by a competent contractor working, where appropriate, to an approved method statement

KEY PLAN

Rev.	Date	Description	By	Chk'd	App'd
1	30/9/16	Planning Condition PCC 87 - First issue	CJB	RB	MDS

Drawing Status: WORK IN PROGRESS

Suitability: S0

ATKINS
Euston Tower
286 Euston Road
London
NW1 3AT
United Kingdom
Tel: 20 7121 2000
Fax: Atkins Limited
www.atkinsglobal.com

Client: London City Airport Get closer.

Project Title: LONDON CITY AIRPORT
CITY AIRPORT DEVELOPMENT PROGRAMME

Drawing Title: SITE PLAN
PROPOSED WEC AND WTE SUBSTRUCTURE CONSTRUCTION PLANT

Scale	Designed	Drawn	Checked	Authorised
1:250	CJB	RK	RDB	MDS
Original Size: A1	Date: 30/9/16	Date: 30/9/16	Date: 30/9/16	Date: 30/9/16

Drawing Number

Proj.Code	Orig	Dis	Zone	Level	Type	Sub	Series / Num	Rev	Status
A400-ATK-	S-	00-	L00-	DR-	GA-	940-	002-	01-	S0

Appendix B. Borehole log

BGS ID: 947108 : BGS Reference: TQ48SW466
British National Grid (27700) : 542020,180360
Report an issue with this borehole

TQ 48 SW/466
4202 8036

Location TQ 42048037
Record of BOREHOLE 52 (sheet 1 of 4)
150 to 36.00m
150 to 15.00m
Orientation
Ground level (m.O.D.) 4.75
Date commenced 20.10.77

Date and Depth (m)	DESCRIPTION OF STRATA	O.D. Level (m.O.D.)	Legend
20/10 0.30	FILL (clay and gravel)	4.45	
	FILL (fine gravel and sand)		
2.20		2.55	
	FILL (soft to firm brown to black, silty, locally peaty, CLAY with occasional gravel fragments in the upper part and bands of silty clay alternating with bands of peat below 4.00m with cinders and brick fragments)		
4.70		0.05	
	Soft mottled grey-green silty CLAY with traces of shell debris and organic matter	-0.75	
5.50	Soft dark grey silty CLAY	-1.25	
6.00	Bands of firm dark brown peaty CLAY and clayey PEAT		
7.50			
21/10 8.00		-3.25	
	Soft grey-green silty CLAY		
8.80		-4.05	
	Medium dense to very dense brown to black fine to coarse GRAVEL with a little brown sand		

1.20
1.50

and abbreviations see Notes, pages (i) and (ii)

SCALE 1 : 50

JUBILEE LINE STAGES 3 & 4

Fig. 1/64

BGS ID: 947108 : BGS Reference: TQ48SW466
British National Grid (27700) : 542020,180360
Report an issue with this borehole

TQ 48 SW /466
4202 8036

Location
Orientation
Record of BOREHOLE 52 (sheet 2 of 4)
Ground level (m.O.D.)
Date commenced

Date and Depth (m)	DESCRIPTION OF STRATA	O.D. Level (m.O.D.)	Legend
13.50 24/10	(See previous sheet)		
17.70		-12.95	
7.60 17.00	Very dense brown-grey slightly silty fine SAND, increasingly silty with depth		

and abbreviations see Notes, pages (i) and (ii)

SCALE 1 : 50

JUBILEE LINE STAGES 3 & 4

Fig. 1/64 (CONT'D)

British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

BGS ID: 947108 : BGS Reference: TQ48SW466
British National Grid (27700) : 542020,180360
Report an issue with this borehole

<< < Prev Page 3 of 4 Next > >>

TQ 48 SW/466
4202 8036

Location
Orientation
Record of BOREHOLE 52 (sheet 3 of 4)
Ground level (m.O.D.)
Date commenced

Water Strikes	Date and Depth (m)	DESCRIPTION OF STRATA	O.D. Level (m.O.D.)	Legend
	24.00 24/10	(See previous sheet)		
	30.00		-25.25	

For abbreviations see Notes, pages (i) and (ii)

SCALE 1 : 50

JUBILEE LINE STAGES 3 & 4

Fig. 1/64 (CONT'D)

British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

BGS ID: 947108 : BGS Reference: TQ48SW466
British National Grid (27700) : 542020,180360
Report an issue with this borehole

<< < Prev Page 4 of 4 Next > >>

TQ 48 SW/466
4202 8036

Location
Orientation
Record of BOREHOLE 52
(sheet 4 of 4)
Ground level (m.O.D.)
Date commenced

Date and Depth (m)	DESCRIPTION OF STRATA	O.D. Level (m.O.D.)	Legend
	Very dense grey clayey fine SAND		
32.20		-27.45	
	Fine to coarse, occasionally green coated, FLINT GRAVEL with occasional cobbles in a matrix of sandy CLAY		
33.00		-28.25	
26/10	(Grade V - IV) structureless CHALK		
33.50		-28.75	
	Cream to white rubbly CHALK with visible bedding and/or jointing and a little structureless chalk (Grade IV) Flints at 33.40m 34.00m 35.00m and 35.40m		
36.00		-31.25	
	END OF BOREHOLE		

...e was started from an inspection pit. Water was added to assist boring below 1.50m. ... added to assist boring at 13.50m, 17.50m and 21.00m and stratum had a tendency to ...ity. Water was added to assist boring at 24.00m, 26.00m and 28.00m. ...m, the borehole was backfilled with bags of bentonite and cement to 25.00m ...nite pellet seal placed to 24.00m. A piezometer was installed at 23.90m within ...ter extending to 22.90m. The borehole was resealed and grouted, backfilled and ...with a 0.05m diameter steel pipe, with cap, set in concrete.

...ations and abbreviations see Notes, pages (i) and (ii) SCALE 1 : 50

JUBILEE LINE STAGES 3 & 4 Fig. 1/64 (CONT'D)

...REY LABORATORIES LIMITED

Appendix C.Screening Sheets

							BH2 (S)	BH3 (S)	BH4 (S)	WS03	WS04
Determinand	units	LOD	WQS	Min	Max	No of Excedances	20/11/2014	20/11/2014	20/11/2014	05/07/1905	05/07/1905
							Alluvium	Alluvium	Made Ground	Made Ground	Made Ground
Zinc, Dissolved	µg/l	1.25	7.9	4.02	490.0	4	8.65	4.02	12.2	490.0	50
Chromium, Dissolved	µg/l	0.25	0.6	0.36	23.0	3	1.2	<0.25	0.36	1.30	23
Aliphatic C5-C35	µg/l	10	10	12.00	55.0	2	12	55	<10	<10	<10
Arsenic, Dissolved	µg/l	0.16	10	2.00	40.0	2	16.00	2.00	5.10	9.20	40
Fluoranthene	µg/l	0.01	0.0063	0.03	0.1	2	0.03	<0.01	0.07	<0.1	<0.1
Lead, Dissolved	µg/l	0.09	1.3	0.11	32.0	2	0.34	<0.09	0.11	6.60	32
Sulphate as SO4	mg/l	0.1	250	209.00	977.0	2	250	320	230	977	209
Aliphatic C16-C21	µg/l	1	10	1.40	12.0	1	12	1.4	<1	<10	<10
Aliphatic C21-C35	µg/l	1	10	54.00	54.0	1	<1	54	<1	<10	<10
Benzo(a)pyrene	µg/l	0.01	0.00017	0.02	0.0	1	0.02	<0.01	<0.01	<0.1	<0.1
Benzo(b)fluoranthene	µg/l	0.01	0.017	0.02	0.0	1	0.02	<0.01	<0.01	<0.1	<0.1
Nickel, Dissolved	µg/l	0.5	8.6	6.60	20.0	1	6.6	7	7.1	20.0	7.8
Cadmium, Dissolved	µg/l	0.03	0.2	0.04	0.8	1	0.04	0.04	0.05	0.76	<0.1
Copper, Dissolved	µg/l	0.4	21	0.70	35.0	1	0.7	5	10	15.0	35
Selenium, Dissolved	µg/l	0.25	10	1.60	21.0	1	1.6	8.6	21	<4.0	<4.0
Aromatic C16-C21	µg/l	1	10	0.00	0.0	0	<1	<1	<1	<10	<10
Aromatic C21-C35	µg/l	1	10	0.00	0.0	0	<1	<1	<1	<10	<10
Aromatic C5-C35	µg/l	10	10	0.00	0.0	0	<10	<10	<10	<10	<10
Benzo(k)fluoranthene	µg/l	0.01	0.017	0.00	0.0	0	<0.01	<0.01	<0.01	<0.1	<0.1
Cyanide total	µg/l	40	1	0.00	0.0	0	<40	<40	<40	<10	<10
1,1,1,2-tetrachloroethane	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1		
1,1,1-trichloroethane	µg/l	1	100	0.00	0.0	0	<1	<1	<1		
1,1,2,2-tetrachloroethane	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1		
1,1,2-trichloroethane	µg/l	1	300	0.00	0.0	0	<1	<1	<1		
1,1-dichloroethane	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1		
1,1-dichloroethylene	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1		
1,1-dichloropropene	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1		
1,2,3-trichlorobenzene	µg/l	1	0.4	0.00	0.0	0	<1	<1	<1		
1,2,3-trichloropropane	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1		
1,2,4-trichlorobenzene	µg/l	1		0.00	0.0	0	<1	<1	<1		
1,2,4-Trichlorobenzene	µg/l	1	0.4	0.00	0.0	0	<1	<1	<1		
1,2,4-trimethylbenzene	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1		
1,2-dibromo-3-chloropropane	µg/l	1	1	0.00	0.0	0	<1	<1	<1		
1,2-dibromoethane	µg/l	1	0.4	0.00	0.0	0	<1	<1	<1		
1,2-dichlorobenzene	µg/l	1	20	0.00	0.0	0	<1	<1	<1		
1,2-dichloroethane	µg/l	1	3	0.00	0.0	0	<1	<1	<1		
1,2-dichloropropane	µg/l	1	40	0.00	0.0	0	<1	<1	<1		
1,2-Dinitrotoluene	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1		
1,3,5-trimethylbenzene	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1		
1,3-dichlorobenzene	µg/l	2	20	0.00	0.0	0	<2	<2	<2		
1,3-dichloropropane	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1		
1,3-Dinitrobenzene	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1		
1,4-dichlorobenzene	µg/l	1	20	0.00	0.0	0	<1	<1	<1		
1,4-Dinitrobenzene	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1		
2,2-dichloropropane	µg/l	2	No WQS	0.00	0.0	0	<2	<2	<2		
2,3,4,6-Tetrachlorophenol	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1		
2,3,5,6-Tetrachlorophenol	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1		
2,4,5-Trichlorophenol	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1		
2,4,6-Trichlorophenol	µg/l	1	200	0.00	0.0	0	<1	<1	<1		
2,4-Dichlorophenol	µg/l	1	0.42	0.00	0.0	0	<1	<1	<1		
2,4-Dimethylphenol	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1		
2,4-Dinitrotoluene	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1		
2,6-Dinitrotoluene	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1		
2-Chloronaphthalene	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1		
2-Chlorophenol	µg/l	1	50	0.00	0.0	0	<1	<1	<1		
2-chlorotoluene	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1		
2-Methylnaphthalene	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1		
2-Methylphenol	µg/l	1	100	0.00	0.0	0	<1	<1	<1		
2-Nitroaniline	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1		
3&4-Methylphenol	µg/l	1	100	0.00	0.0	0	<1	<1	<1		
3-Nitroaniline	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1		
4-Bromophenylphenylether	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1		
4-Chloro-3-methylphenol	µg/l	1	40	0.00	0.0	0	<1	<1	<1		
4-Chlorophenylphenylether	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1		
4-chlorotoluene	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1		
4-Nitroaniline	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1		
4-Nitrophenol	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1		
Acenaphthene	µg/l	0.01	No WQS	0.00	0.0	0	<0.01	<0.01	<0.01	<0.1	<0.1
Acenaphthylene	µg/l	0.01	No WQS	0.00	0.0	0	<0.01	<0.01	<0.01	<0.1	<0.1
Aliphatic C10-C12	µg/l	1	10	0.00	0.0	0	<1	<1	<1	<10	<10
Aliphatic C12-C16	µg/l	1	10	0.00	0.0	0	<1	<1	<1	<10	<10
Aliphatic C5-C6	µg/l	0.1	10	0.00	0.0	0	<0.1	<0.1	<0.1	<10	<10
Aliphatic C6-C8	µg/l	0.1	10	0.00	0.0	0	<0.1	<0.1	<0.1	<10	<10
Aliphatic C8-C10	µg/l	0.1	10	0.00	0.0	0	<0.1	<0.1	<0.1	<10	<10
Aniline	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1		
Anthracene	µg/l	0.01	0.1	0.00	0.0	0	<0.01	<0.01	<0.01	<0.1	<0.1
Aromatic C10-C12	µg/l	1	10	0.00	0.0	0	<1	<1	<1	<10	<10
Aromatic C12-C16	µg/l	1	10	0.00	0.0	0	<1	<1	<1	<10	<10
Aromatic C5-C7	µg/l	0.1	10	0.00	0.0	0	<0.1	<0.1	<0.1	<10	<10
Aromatic C7-C8	µg/l	0.1	10	0.00	0.0	0	<0.1	<0.1	<0.1	<10	<10
Aromatic C8-C10	µg/l	0.1	10	0.00	0.0	0	<0.1	<0.1	<0.1	<10	<10
Azobenzene	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1		
Benzene	µg/l	1	1	0.00	0.0	0	<1	<1	<1		
Benzene	µg/l	1	1	0.00	0.0	0	<1	<1	<1		
Benzo(a)anthracene	µg/l	0.01	No WQS	0.00	0.0	0	<0.01	<0.01	<0.01	<0.1	<0.1

Determinand	units	LOD	WQS	Min	Max	No of Excedances	BH2 (S) 20/11/2014 Alluvium	BH3 (S) 20/11/2014 Alluvium	BH4 (S) 20/11/2014 Made Ground	WS03 05/07/1905 Made Ground	WS04 05/07/1905 Made Ground
Benzo(g,h,i)perylene	µg/l	0.01	No WQS	0.00	0.0	0	<0.01	<0.01	<0.01	<0.1	<0.1
Benzyl Alcohol	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1		
Bis(2-chloroethoxy)methane	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1		
Bis(2-chloroisopropyl)ether	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1		
Bis(2-ethylhexyl)ether	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1		
Bis(2-ethylhexyl)phthalate	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1		
Boron	µg/l	10	1000	560.00	570.0	0				560	570
Bromobenzene	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1		
Bromochloromethane	µg/l	4	No WQS	0.00	0.0	0	<4	<4	<4		
Bromodichloromethane	µg/l	4	100	0.00	0.0	0	<4	<4	<4		
Bromoform	µg/l	1	100	0.00	0.0	0	<1	<1	<1		
Bromomethane	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1		
Butylbenzylphthalate	µg/l	1	0.75	0.00	0.0	0	<1	<1	<1		
Carbazole	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1		
Carbon tetrachloride	µg/l	1	3	0.00	0.0	0	<1	<1	<1		
Chlorobenzene	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1		
Chloroethane	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1		
Chloroform	µg/l	1	2.5	0.00	0.0	0	<1	<1	<1		
Chloromethane	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1		
Chrysene	µg/l	0.01	No WQS	0.00	0.0	0	<0.01	<0.01	<0.01	<0.1	<0.1
cis-1,2-dichloroethylene	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1		
cis-1,3-dichloropropene	µg/l	1	20	0.00	0.0	0	<1	<1	<1		
Dibenzo(a,h)anthracene	µg/l	0.01	No WQS	0.00	0.0	0	<0.01	<0.01	<0.01	<0.1	<0.1
Dibenzofuran	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1		
Dibromochloromethane	µg/l	1	100	0.00	0.0	0	<1	<1	<1		
Dibromomethane	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1		
Dichlorodifluoromethane	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1		
Diethylphthalate	µg/l	1	200	0.00	0.0	0	<1	<1	<1		
Dimethylphthalate	µg/l	1	800	0.00	0.0	0	<1	<1	<1		
Di-n-butylphthalate	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1		
Di-n-octylphthalate	µg/l	1	20	0.00	0.0	0	<1	<1	<1		
Diphenylamine	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1		
Ethylbenzene	µg/l	1	20	0.00	0.0	0	<1	<1	<1	<1	<1
Ethylbenzene	µg/l	1	20	0.00	0.0	0	<1	<1	<1	<1	<1
Fluorene	µg/l	0.01	No WQS	0.00	0.0	0	<0.01	<0.01	<0.01	<0.1	<0.1
Hardness	mg/l	0.1	No WQS	589.00	682.0	0	682	589	599		
Hexachlorobenzene	µg/l	1	0.05	0.00	0.0	0	<1	<1	<1		
Hexachlorobutadiene	µg/l	1	0.6	0.00	0.0	0	<1	<1	<1		
Hexachlorocyclopentadiene	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1		
Hexavalent Chromium	µg/l	10	0.6	0.00	0.0	0	<10	<10	<10		
Indeno(1,2,3-c,d)pyrene	µg/l	0.01	No WQS	0.00	0.0	0	<0.01	<0.01	<0.01	<0.1	<0.1
Isopropylbenzene	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1		
m+p-Xylene	µg/l	2	30	0.00	0.0	0	<2	<2	<2	<1	<1
Mercury, Dissolved	µg/l	0.01	0.07	0.00	0.0	0	<0.01	<0.01	<0.01	<0.1	<0.1
MTBE	µg/l	1	1.5	0.00	0.0	0	<1	<1	<1	<1	<1
Naphthalene	µg/l	0.01	2	0.00	0.0	0	<0.01	<0.01	<0.01	<0.1	<0.1
n-butylbenzene	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1		
n-propylbenzene	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1		
o-Xylene	µg/l	1	0.003	0.00	0.0	0	<1	<1	<1	<1	<1
PAH	µg/l	0.2	No WQS	0.00	0.0	0	<0.2	<0.2	<0.2		
Pentachlorophenol	µg/l	1	0.4	0.00	0.0	0	<1	<1	<1		
pH			9	7.20	7.9	0	7.6	7.3	7.2	7.3	7.9
Phenanthrene	µg/l	0.01	No WQS	0.04	0.0	0	<0.01	<0.01	0.04	<0.1	<0.1
Phenol	µg/l	1	7.7	0.00	0.0	0	<1	<1	<1	<10	<10
Phenol - Monohydric	µg/l	100	7.7	0.00	0.0	0	<100	<100	<100		
p-isopropyltoluene	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1		
Pyrene	µg/l	0.01	No WQS	0.03	0.0	0	0.03	<0.01	0.04	<0.1	<0.1
sec-butylbenzene	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1		
Styrene	µg/l	1	50	0.00	0.0	0	<1	<1	<1		
Sulphide	µg/l	10	No WQS	12.00	12.0	0	<10	<10	12	<5.0	<5.0
Tert-butylbenzene	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1		
Tetrachloroethylene	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1		
Toluene	µg/l	1	74	0.00	0.0	0	<1	<1	<1	<1	<1
Toluene	µg/l	1	74	0.00	0.0	0	<1	<1	<1	<1	<1
Total Organic Carbon	mg/l	1	No WQS	7.60	15.0	0	15	7.6	8.7		
Trans-1,2-dichloroethylene	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1		
trans-1,3-dichloropropene	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1		
Trichloroethylene	µg/l	1	10	0.00	0.0	0	<1	<1	<1		
Trichlorofluoromethane	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1		
Vinyl Chloride	µg/l	1	0.5	0.00	0.0	0	<1	<1	<1		
Xylene	µg/l	1	30	0.00	0.0	0	<1	<1	<1		

							BH2 (D)	BH3 (D)	BH4 (D)
Determinand	units	LOD	WQS	min	max	No of Excedances	20/11/2014	20/11/2014	20/11/2014
							RTD	RTD	RTD
Zinc, Dissolved	µg/l	1.25	7.9	26.50	73.8	3	26.5	73.8	43.9
Sulphate as SO4	mg/l	0.1	250	260.00	510.0	3	260	510	340
Aliphatic C16-C21	µg/l	1	10	16.00	21.0	2	16	21	<1
Aliphatic C21-C35	µg/l	1	10	110.00	640.0	2	110	640	<1
Aliphatic C5-C35	µg/l	10	10	130.00	670.0	2	130	670	<10
Chromium, Dissolved	µg/l	0.25	0.6	0.31	0.7	1	0.73	<0.25	0.31
Nickel, Dissolved	µg/l	0.5	8.6	6.20	9.8	1	6.2	6.7	9.8
Aromatic C16-C21	µg/l	1	10	18.00	18.0	1	<1	18	<1
Aromatic C21-C35	µg/l	1	10	560.00	560.0	1	<1	560	<1
Aromatic C5-C35	µg/l	10	10	580.00	580.0	1	<10	580	<10
Arsenic, Dissolved	µg/l	0.16	10	3.60	9.5	0	9.50	9.40	3.60
Cyanide total	µg/l	40	1	0.00	0.0	0	<40	<40	<40
Fluoranthene	µg/l	0.01	0.0063	0.00	0.0	0	<0.01	<0.01	<0.01
Benzo(b)fluoranthene	µg/l	0.01	0.017	0.00	0.0	0	<0.01	<0.01	<0.01
Benzo(k)fluoranthene	µg/l	0.01	0.017	0.00	0.0	0	<0.01	<0.01	<0.01
Benzo(a)pyrene	µg/l	0.01	0.00017	0.00	0.0	0	<0.01	<0.01	<0.01
Cadmium, Dissolved	µg/l	0.03	0.2	0.03	0.1	0	0.03	0.05	0.03
Hexavalent Chromium	µg/l	10	0.6	0.00	0.0	0	<10	<10	<10
Copper, Dissolved	µg/l	0.4	21	0.80	0.8	0	0.8	<0.4	<0.4
Lead, Dissolved	µg/l	0.09	1.3	0.00	0.0	0	<0.09	<0.09	<0.09
Mercury, Dissolved	µg/l	0.01	0.07	0.00	0.0	0	<0.01	<0.01	<0.01
Selenium, Dissolved	µg/l	0.25	10	1.00	2.2	0	1	2.2	1.4
pH			9	7.30	7.6	0	7.6	7.5	7.3
Hardness	mg/l	0.1	No WQS	661.00	854.0	0	661	843	854
Sulphide	µg/l	10	No WQS	12.00	12.0	0	<10	12	<10
Total Organic Carbon	mg/l	1	No WQS	4.80	22.0	0	22	8.6	4.8
Aliphatic C5-C6	µg/l	0.1	10	0.00	0.0	0	<0.1	<0.1	<0.1
Aliphatic C6-C8	µg/l	0.1	10	2.80	2.8	0	<0.1	2.8	<0.1
Aliphatic C8-C10	µg/l	0.1	10	0.00	0.0	0	<0.1	<0.1	<0.1
Aliphatic C10-C12	µg/l	1	10	0.00	0.0	0	<1	<1	<1
Aliphatic C12-C16	µg/l	1	10	0.00	0.0	0	<1	<1	<1
Aromatic C5-C7	µg/l	0.1	10	0.00	0.0	0	<0.1	<0.1	<0.1
Aromatic C7-C8	µg/l	0.1	10	0.00	0.0	0	<0.1	<0.1	<0.1
Aromatic C8-C10	µg/l	0.1	10	0.00	0.0	0	<0.1	<0.1	<0.1
Aromatic C10-C12	µg/l	1	10	0.00	0.0	0	<1	<1	<1
Aromatic C12-C16	µg/l	1	10	0.00	0.0	0	<1	<1	<1
Benzene	µg/l	1	1	0.00	0.0	0	<1	<1	<1
Toluene	µg/l	1	74	0.00	0.0	0	<1	<1	<1
Ethylbenzene	µg/l	1	20	0.00	0.0	0	<1	<1	<1
Xylene	µg/l	1	30	0.00	0.0	0	<1	<1	<1
MTBE	µg/l	1	1.5	0.00	0.0	0	<1	<1	<1
Naphthalene	µg/l	0.01	2	0.00	0.0	0	<0.01	<0.01	<0.01
Acenaphthylene	µg/l	0.01	No WQS	0.00	0.0	0	<0.01	<0.01	<0.01
Acenaphthene	µg/l	0.01	No WQS	0.00	0.0	0	<0.01	<0.01	<0.01
Fluorene	µg/l	0.01	No WQS	0.00	0.0	0	<0.01	<0.01	<0.01
Phenanthrene	µg/l	0.01	No WQS	0.00	0.0	0	<0.01	<0.01	<0.01

							BH2 (D)	BH3 (D)	BH4 (D)
Determinand	units	LOD	WQS	min	max	No of Excedances	20/11/2014	20/11/2014	20/11/2014
							RTD	RTD	RTD
Anthracene	µg/l	0.01	0.1	0.00	0.0	0	<0.01	<0.01	<0.01
Pyrene	µg/l	0.01	No WQS	0.00	0.0	0	<0.01	<0.01	<0.01
Benzo(a)anthracene	µg/l	0.01	No WQS	0.00	0.0	0	<0.01	<0.01	<0.01
Chrysene	µg/l	0.01	No WQS	0.00	0.0	0	<0.01	<0.01	<0.01
Benzo(g,h,i)perylene	µg/l	0.01	No WQS	0.00	0.0	0	<0.01	<0.01	<0.01
Dibenzo(a,h)anthracene	µg/l	0.01	No WQS	0.00	0.0	0	<0.01	<0.01	<0.01
Indeno(1,2,3-c,d)pyrene	µg/l	0.01	No WQS	0.00	0.0	0	<0.01	<0.01	<0.01
PAH	µg/l	0.2	No WQS	0.00	0.0	0	<0.2	<0.2	<0.2
Dichlorodifluoromethane	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1
Phenol - Monohydric	µg/l	100	7.7	0.00	0.0	0	<100	<100	<100
Chloromethane	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1
Vinyl Chloride	µg/l	1	0.5	0.00	0.0	0	<1	<1	<1
Bromomethane	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1
Chloroethane	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1
Trichlorofluoromethane	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1
1,1-dichloroethylene	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1
Trans-1,2-dichloroethylene	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1
1,1-dichloroethane	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1
cis-1,2-dichloroethylene	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1
2,2-dichloropropane	µg/l	2	No WQS	0.00	0.0	0	<2	<2	<2
Bromochloromethane	µg/l	4	No WQS	0.00	0.0	0	<4	<4	<4
Chloroform	µg/l	1	2.5	0.00	0.0	0	<1	<1	<1
1,1,1-trichloroethane	µg/l	1	100	0.00	0.0	0	<1	<1	<1
1,1-dichloropropene	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1
Carbon tetrachloride	µg/l	1	3	0.00	0.0	0	<1	<1	<1
Benzene	µg/l	1	1	0.00	0.0	0	<1	<1	<1
1,2-dichloroethane	µg/l	1	3	0.00	0.0	0	<1	<1	<1
Trichloroethylene	µg/l	1	10	0.00	0.0	0	<1	<1	<1
1,2-dichloropropane	µg/l	1	40	0.00	0.0	0	<1	<1	<1
Dibromomethane	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1
Bromodichloromethane	µg/l	4	100	0.00	0.0	0	<4	<4	<4
cis-1,3-dichloropropene	µg/l	1	20	0.00	0.0	0	<1	<1	<1
Toluene	µg/l	1	74	0.00	0.0	0	<1	<1	<1
trans-1,3-dichloropropene	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1
1,1,2-trichloroethane	µg/l	1	300	0.00	0.0	0	<1	<1	<1
Tetrachloroethylene	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1
1,3-dichloropropane	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1
Dibromochloromethane	µg/l	1	100	0.00	0.0	0	<1	<1	<1
1,2-dibromoethane	µg/l	1	0.4	0.00	0.0	0	<1	<1	<1
Chlorobenzene	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1
1,1,1,2-tetrachloroethane	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1
Ethylbenzene	µg/l	1	20	0.00	0.0	0	<1	<1	<1
m+p-Xylene	µg/l	2	30	0.00	0.0	0	<2	<2	<2
o-Xylene	µg/l	1	0.003	0.00	0.0	0	<1	<1	<1
Styrene	µg/l	1	50	0.00	0.0	0	<1	<1	<1
Bromoform	µg/l	1	100	0.00	0.0	0	<1	<1	<1

							BH2 (D)	BH3 (D)	BH4 (D)
Determinand	units	LOD	WQS	min	max	No of Excedances	20/11/2014	20/11/2014	20/11/2014
							RTD	RTD	RTD
Isopropylbenzene	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1
1,1,2,2-tetrachloroethane	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1
Bromobenzene	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1
1,2,3-trichloropropane	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1
n-propylbenzene	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1
2-chlorotoluene	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1
1,3,5-trimethylbenzene	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1
4-chlorotoluene	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1
Tert-butylbenzene	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1
1,2,4-trimethylbenzene	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1
sec-butylbenzene	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1
p-isopropyltoluene	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1
1,3-dichlorobenzene	µg/l	2	20	0.00	0.0	0	<2	<2	<2
1,4-dichlorobenzene	µg/l	1	20	0.00	0.0	0	<1	<1	<1
n-butylbenzene	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1
1,2-dichlorobenzene	µg/l	1	20	0.00	0.0	0	<1	<1	<1
1,2-dibromo-3-chloropropane	µg/l	1	1	0.00	0.0	0	<1	<1	<1
1,2,4-trichlorobenzene	µg/l	1		0.00	0.0	0	<1	<1	<1
Hexachlorobutadiene	µg/l	1	0.6	0.00	0.0	0	<1	<1	<1
1,2,3-trichlorobenzene	µg/l	1	0.4	0.00	0.0	0	<1	<1	<1
Phenol	µg/l	1	7.7	0.00	0.0	0	<1	<1	<1
Aniline	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1
2-Chlorophenol	µg/l	1	50	0.00	0.0	0	<1	<1	<1
Benzyl Alcohol	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1
2-Methylphenol	µg/l	1	100	0.00	0.0	0	<1	<1	<1
Bis(2-chloroisopropyl)ether	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1
3&4-Methylphenol	µg/l	1	100	0.00	0.0	0	<1	<1	<1
Bis(2-chloroethoxy)methane	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1
2,4-Dimethylphenol	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1
2,4-Dichlorophenol	µg/l	1	0.42	0.00	0.0	0	<1	<1	<1
1,2,4-Trichlorobenzene	µg/l	1	0.4	0.00	0.0	0	<1	<1	<1
4-Chloro-3-methylphenol	µg/l	1	40	0.00	0.0	0	<1	<1	<1
2-Methylnaphthalene	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1
1,2-Dinitrotoluene	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1
Hexachlorocyclopentadiene	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1
2,4,6-Trichlorophenol	µg/l	1	200	0.00	0.0	0	<1	<1	<1
2,4,5-Trichlorophenol	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1
2-Chloronaphthalene	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1
2-Nitroaniline	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1
2,4-Dinitrotoluene	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1
3-Nitroaniline	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1
4-Nitrophenol	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1
Dibenzofuran	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1
2,6-Dinitrotoluene	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1
2,3,4,6-Tetrachlorophenol	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1
Diethylphthalate	µg/l	1	200	0.00	0.0	0	<1	<1	<1

							BH2 (D)	BH3 (D)	BH4 (D)
Determinand	units	LOD	WQS	min	max	No of Excedances	20/11/2014	20/11/2014	20/11/2014
							RTD	RTD	RTD
4-Chlorophenylphenylether	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1
4-Nitroaniline	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1
Diphenylamine	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1
4-Bromophenylphenylether	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1
Hexachlorobenzene	µg/l	1	0.05	0.00	0.0	0	<1	<1	<1
Bis(2-ethylhexyl)ether	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1
Pentachlorophenol	µg/l	1	0.4	0.00	0.0	0	<1	<1	<1
Di-n-butylphthalate	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1
Butylbenzylphthalate	µg/l	1	0.75	0.00	0.0	0	<1	<1	<1
Bis(2-ethylhexyl)phthalate	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1
Boron	µg/l	10	1000	0.00	0.0	0			
Di-n-octylphthalate	µg/l	1	20	0.00	0.0	0	<1	<1	<1
1,4-Dinitrobenzene	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1
Dimethylphthalate	µg/l	1	800	0.00	0.0	0	<1	<1	<1
1,3-Dinitrobenzene	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1
2,3,5,6-Tetrachlorophenol	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1
Azobenzene	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1
Carbazole	µg/l	1	No WQS	0.00	0.0	0	<1	<1	<1

							BH1 (D)	BH5
Determinand	units	LOD	WQS	min	max	No of Excedances	20/11/2014 Thanet Sand	20/11/2014 Thanet Sand
x	x	x	x	x	x	x	x	x
Zinc, Dissolved	µg/l	1.25	7.9	48.10	413.0	2	48.1	413
Arsenic, Dissolved	µg/l	0.16	10	16.00	19.0	2	19.00	16.00
Sulphate as SO4	mg/l	0.1	250	220.00	390.0	1	390	220
Aliphatic C16-C21	µg/l	1	10	49.00	49.0	1	49	<1
Aliphatic C21-C35	µg/l	1	10	450.00	450.0	1	450	<1
Aliphatic C5-C35	µg/l	10	10	510.00	510.0	1	510	<10
Cyanide total	µg/l	40	1	89.00	89.0	1	89	<40
Fluoranthene	µg/l	0.01	0.0063	0.11	0.1	1	0.11	<0.01
Benzo(b)fluoranthene	µg/l	0.01	0.017	0.06	0.1	1	0.06	<0.01
Benzo(k)fluoranthene	µg/l	0.01	0.017	0.04	0.0	1	0.04	<0.01
Benzo(a)pyrene	µg/l	0.01	0.00017	0.07	0.1	1	0.07	<0.01
Chromium, Dissolved	µg/l	0.25	0.6	0.25	0.5	0	0.25	0.5
Nickel, Dissolved	µg/l	0.5	8.6	4.80	6.9	0	4.8	6.9
Aromatic C16-C21	µg/l	1	10	0.00	0.0	0	<1	<1
Aromatic C21-C35	µg/l	1	10	0.00	0.0	0	<1	<1
Aromatic C5-C35	µg/l	10	10	0.00	0.0	0	<10	<10
Cadmium, Dissolved	µg/l	0.03	0.2	0.03	0.1	0	0.08	0.03
Hexavalent Chromium	µg/l	10	0.6	0.00	0.0	0	<10	<10
Copper, Dissolved	µg/l	0.4	21	0.70	0.7	0	0.7	<0.4
Lead, Dissolved	µg/l	0.09	1.3	0.00	0.0	0	<0.09	<0.09
Mercury, Dissolved	µg/l	0.01	0.07	0.00	0.0	0	<0.01	<0.01
Selenium, Dissolved	µg/l	0.25	10	1.70	1.7	0	1.7	<0.25
pH			9	7.50	8.0	0	8	7.5
Hardness	mg/l	0.1	No WQS	708.00	965.0	0	965	708
Sulphide	µg/l	10	No WQS	11.00	11.0	0	11	<10
Total Organic Carbon	mg/l	1	No WQS	8.70	9.5	0	8.7	9.5
Aliphatic C5-C6	µg/l	0.1	10	0.00	0.0	0	<0.1	<0.1
Aliphatic C6-C8	µg/l	0.1	10	0.00	0.0	0	<0.1	<0.1
Aliphatic C8-C10	µg/l	0.1	10	0.00	0.0	0	<0.1	<0.1
Aliphatic C10-C12	µg/l	1	10	0.00	0.0	0	<1	<1
Aliphatic C12-C16	µg/l	1	10	2.10	2.1	0	2.1	<1
Aromatic C5-C7	µg/l	0.1	10	0.00	0.0	0	<0.1	<0.1
Aromatic C7-C8	µg/l	0.1	10	0.90	0.9	0	0.9	<0.1
Aromatic C8-C10	µg/l	0.1	10	0.00	0.0	0	<0.1	<0.1
Aromatic C10-C12	µg/l	1	10	0.00	0.0	0	<1	<1
Aromatic C12-C16	µg/l	1	10	0.00	0.0	0	<1	<1
Benzene	µg/l	1	1	0.00	0.0	0	<1	<1
Toluene	µg/l	1	74	0.00	0.0	0	<1	<1
Ethylbenzene	µg/l	1	20	0.00	0.0	0	<1	<1
Xylene	µg/l	1	30	0.00	0.0	0	<1	<1
MTBE	µg/l	1	1.5	0.00	0.0	0	<1	<1
Naphthalene	µg/l	0.01	2	0.00	0.0	0	<0.01	<0.01
Acenaphthylene	µg/l	0.01	No WQS	0.00	0.0	0	<0.01	<0.01

							BH1 (D)	BH5
Determinand	units	LOD	WQS	min	max	No of Excedances	20/11/2014	20/11/2014
							Thanet Sand	Thanet Sand
Acenaphthene	µg/l	0.01	No WQS	0.00	0.0	0	<0.01	<0.01
Fluorene	µg/l	0.01	No WQS	0.00	0.0	0	<0.01	<0.01
Phenanthrene	µg/l	0.01	No WQS	0.11	0.1	0	0.11	<0.01
Anthracene	µg/l	0.01	0.1	0.00	0.0	0	<0.01	<0.01
Pyrene	µg/l	0.01	No WQS	0.15	0.2	0	0.15	<0.01
Benzo(a)anthracene	µg/l	0.01	No WQS	0.05	0.1	0	0.05	<0.01
Chrysene	µg/l	0.01	No WQS	0.03	0.0	0	0.03	<0.01
Benzo(g,h,i)perylene	µg/l	0.01	No WQS	0.00	0.0	0	<0.01	<0.01
Dibenzo(a,h)anthracene	µg/l	0.01	No WQS	0.00	0.0	0	<0.01	<0.01
Indeno(1,2,3-c,d)pyrene	µg/l	0.01	No WQS	0.00	0.0	0	<0.01	<0.01
PAH	µg/l	0.2	No WQS	0.65	0.7	0	0.65	<0.2
Dichlorodifluoromethane	µg/l	1	No WQS	0.00	0.0	0	<1	<1
Phenol - Monohydric	µg/l	100	7.7	0.00	0.0	0	<100	<100
Chloromethane	µg/l	1	No WQS	0.00	0.0	0	<1	<1
Vinyl Chloride	µg/l	1	0.5	0.00	0.0	0	<1	<1
Bromomethane	µg/l	1	No WQS	0.00	0.0	0	<1	<1
Chloroethane	µg/l	1	No WQS	0.00	0.0	0	<1	<1
Trichlorofluoromethane	µg/l	1	No WQS	0.00	0.0	0	<1	<1
1,1-dichloroethylene	µg/l	1	No WQS	0.00	0.0	0	<1	<1
Trans-1,2-dichloroethylene	µg/l	1	No WQS	0.00	0.0	0	<1	<1
1,1-dichloroethane	µg/l	1	No WQS	0.00	0.0	0	<1	<1
cis-1,2-dichloroethylene	µg/l	1	No WQS	0.00	0.0	0	<1	<1
2,2-dichloropropane	µg/l	2	No WQS	0.00	0.0	0	<2	<2
Bromochloromethane	µg/l	4	No WQS	0.00	0.0	0	<4	<4
Chloroform	µg/l	1	2.5	0.00	0.0	0	<1	<1
1,1,1-trichloroethane	µg/l	1	100	0.00	0.0	0	<1	<1
1,1-dichloropropene	µg/l	1	No WQS	0.00	0.0	0	<1	<1
Carbon tetrachloride	µg/l	1	3	0.00	0.0	0	<1	<1
Benzene	µg/l	1	1	0.00	0.0	0	<1	<1
1,2-dichloroethane	µg/l	1	3	0.00	0.0	0	<1	<1
Trichloroethylene	µg/l	1	10	0.00	0.0	0	<1	<1
1,2-dichloropropane	µg/l	1	40	0.00	0.0	0	<1	<1
Dibromomethane	µg/l	1	No WQS	0.00	0.0	0	<1	<1
Bromodichloromethane	µg/l	4	100	0.00	0.0	0	<4	<4
cis-1,3-dichloropropene	µg/l	1	20	0.00	0.0	0	<1	<1
Toluene	µg/l	1	74	0.00	0.0	0	<1	<1
trans-1,3-dichloropropene	µg/l	1	No WQS	0.00	0.0	0	<1	<1
1,1,2-trichloroethane	µg/l	1	300	0.00	0.0	0	<1	<1
Tetrachloroethylene	µg/l	1	No WQS	0.00	0.0	0	<1	<1
1,3-dichloropropane	µg/l	1	No WQS	0.00	0.0	0	<1	<1
Dibromochloromethane	µg/l	1	100	0.00	0.0	0	<1	<1
1,2-dibromoethane	µg/l	1	0.4	0.00	0.0	0	<1	<1
Chlorobenzene	µg/l	1	No WQS	0.00	0.0	0	<1	<1
1,1,1,2-tetrachloroethane	µg/l	1	No WQS	0.00	0.0	0	<1	<1

							BH1 (D)	BH5
Determinand	units	LOD	WQS	min	max	No of Excedances	20/11/2014	20/11/2014
							Thanet Sand	Thanet Sand
Ethylbenzene	µg/l	1	20	0.00	0.0	0	<1	<1
m+p-Xylene	µg/l	2	30	0.00	0.0	0	<2	<2
o-Xylene	µg/l	1	0.003	0.00	0.0	0	<1	<1
Styrene	µg/l	1	50	0.00	0.0	0	<1	<1
Bromoform	µg/l	1	100	0.00	0.0	0	<1	<1
Isopropylbenzene	µg/l	1	No WQS	0.00	0.0	0	<1	<1
1,1,2,2-tetrachloroethane	µg/l	1	No WQS	0.00	0.0	0	<1	<1
Bromobenzene	µg/l	1	No WQS	0.00	0.0	0	<1	<1
1,2,3-trichloropropane	µg/l	1	No WQS	0.00	0.0	0	<1	<1
n-propylbenzene	µg/l	1	No WQS	0.00	0.0	0	<1	<1
2-chlorotoluene	µg/l	1	No WQS	0.00	0.0	0	<1	<1
1,3,5-trimethylbenzene	µg/l	1	No WQS	0.00	0.0	0	<1	<1
4-chlorotoluene	µg/l	1	No WQS	0.00	0.0	0	<1	<1
Tert-butylbenzene	µg/l	1	No WQS	0.00	0.0	0	<1	<1
1,2,4-trimethylbenzene	µg/l	1	No WQS	0.00	0.0	0	<1	<1
sec-butylbenzene	µg/l	1	No WQS	0.00	0.0	0	<1	<1
p-isopropyltoluene	µg/l	1	No WQS	0.00	0.0	0	<1	<1
1,3-dichlorobenzene	µg/l	2	20	0.00	0.0	0	<2	<2
1,4-dichlorobenzene	µg/l	1	20	0.00	0.0	0	<1	<1
n-butylbenzene	µg/l	1	No WQS	0.00	0.0	0	<1	<1
1,2-dichlorobenzene	µg/l	1	20	0.00	0.0	0	<1	<1
1,2-dibromo-3-chloropropane	µg/l	1	1	0.00	0.0	0	<1	<1
1,2,4-trichlorobenzene	µg/l	1		0.00	0.0	0	<1	<1
Hexachlorobutadiene	µg/l	1	0.6	0.00	0.0	0	<1	<1
1,2,3-trichlorobenzene	µg/l	1	0.4	0.00	0.0	0	<1	<1
Phenol	µg/l	1	7.7	0.00	0.0	0	<1	<1
Aniline	µg/l	1	No WQS	0.00	0.0	0	<1	<1
2-Chlorophenol	µg/l	1	50	0.00	0.0	0	<1	<1
Benzyl Alcohol	µg/l	1	No WQS	0.00	0.0	0	<1	<1
2-Methylphenol	µg/l	1	100	0.00	0.0	0	<1	<1
Bis(2-chloroisopropyl)ether	µg/l	1	No WQS	0.00	0.0	0	<1	<1
3&4-Methylphenol	µg/l	1	100	0.00	0.0	0	<1	<1
Bis(2-chloroethoxy)methane	µg/l	1	No WQS	0.00	0.0	0	<1	<1
2,4-Dimethylphenol	µg/l	1	No WQS	0.00	0.0	0	<1	<1
2,4-Dichlorophenol	µg/l	1	0.42	0.00	0.0	0	<1	<1
1,2,4-Trichlorobenzene	µg/l	1	0.4	0.00	0.0	0	<1	<1
4-Chloro-3-methylphenol	µg/l	1	40	0.00	0.0	0	<1	<1
2-Methylnaphthalene	µg/l	1	No WQS	0.00	0.0	0	<1	<1
1,2-Dinitrotoluene	µg/l	1	No WQS	0.00	0.0	0	<1	<1
Hexachlorocyclopentadiene	µg/l	1	No WQS	0.00	0.0	0	<1	<1
2,4,6-Trichlorophenol	µg/l	1	200	0.00	0.0	0	<1	<1
2,4,5-Trichlorophenol	µg/l	1	No WQS	0.00	0.0	0	<1	<1
2-Chloronaphthalene	µg/l	1	No WQS	0.00	0.0	0	<1	<1
2-Nitroaniline	µg/l	1	No WQS	0.00	0.0	0	<1	<1

							BH1 (D)	BH5
Determinand	units	LOD	WQS	min	max	No of Excedances	20/11/2014	20/11/2014
							Thanet Sand	Thanet Sand
2,4-Dinitrotoluene	µg/l	1	No WQS	0.00	0.0	0	<1	<1
3-Nitroaniline	µg/l	1	No WQS	0.00	0.0	0	<1	<1
4-Nitrophenol	µg/l	1	No WQS	0.00	0.0	0	<1	<1
Dibenzofuran	µg/l	1	No WQS	0.00	0.0	0	<1	<1
2,6-Dinitrotoluene	µg/l	1	No WQS	0.00	0.0	0	<1	<1
2,3,4,6-Tetrachlorophenol	µg/l	1	No WQS	0.00	0.0	0	<1	<1
Diethylphthalate	µg/l	1	200	0.00	0.0	0	<1	<1
4-Chlorophenylphenylether	µg/l	1	No WQS	0.00	0.0	0	<1	<1
4-Nitroaniline	µg/l	1	No WQS	0.00	0.0	0	<1	<1
Diphenylamine	µg/l	1	No WQS	0.00	0.0	0	<1	<1
4-Bromophenylphenylether	µg/l	1	No WQS	0.00	0.0	0	<1	<1
Hexachlorobenzene	µg/l	1	0.05	0.00	0.0	0	<1	<1
Bis(2-ethylhexyl)ether	µg/l	1	No WQS	0.00	0.0	0	<1	<1
Pentachlorophenol	µg/l	1	0.4	0.00	0.0	0	<1	<1
Di-n-butylphthalate	µg/l	1	No WQS	0.00	0.0	0	<1	<1
Butylbenzylphthalate	µg/l	1	0.75	0.00	0.0	0	<1	<1
Bis(2-ethylhexyl)phthalate	µg/l	1	No WQS	0.00	0.0	0	<1	<1
Boron	µg/l	10	1000	0.00	0.0	0		
Di-n-octylphthalate	µg/l	1	20	0.00	0.0	0	<1	<1
1,4-Dinitrobenzene	µg/l	1	No WQS	0.00	0.0	0	<1	<1
Dimethylphthalate	µg/l	1	800	0.00	0.0	0	<1	<1
1,3-Dinitrobenzene	µg/l	1	No WQS	0.00	0.0	0	<1	<1
2,3,5,6-Tetrachlorophenol	µg/l	1	No WQS	0.00	0.0	0	<1	<1
Azobenzene	µg/l	1	No WQS	0.00	0.0	0	<1	<1
Carbazole	µg/l	1	No WQS	0.00	0.0	0	<1	<1

Elizabeth Waterfall
Atkins
Woodcote Grove
Ashley Road
Epsom
KT18 5BW

Elizabeth.Waterfall@atkinsglobal.com +44 1372 75 6745

City Airport Development Programme (CADP)

Piling Risk Assessment: Eastern Energy Centre and Multi Storey Car Park

London City Airport

22 December 2017

Notice

This document and its contents have been prepared and are intended solely for London City Airport's information and use in relation to the proposed piling works for the Eastern Energy Centre and Multi Storey Car park.

Atkins assumes no responsibility to any other party in respect of or arising out of or in connection with this document and/or its contents.

This document has 28 pages including the cover.

Document history

Job number: 5151383			**Document ref:**			
Revision	Purpose description	Originated	Checked	Reviewed	Authorised	Date
Rev 1.0	Draft	Dan Welch	Bala Palananthakumar	Jonathan Steeds	RM	19/10/2017
Rev 1.1	Draft	Dan Welch	FM	FM/VD/MH	RM	20/10/2017
Rev 2.0	Final	Dan Welch	Bala Palananthakumar	Jonathan Steeds	RM	22/12/2017

Client signoff

Client	London City Airport
Project	City Airport Development Programme (CADP)
Document title	Piling Risk Assessment: Eastern Energy Centre and Multi Storey Car Park
Job no.	5151383
Copy no.	
Document reference	

Table of contents

Tables

Figures

1. Introduction

1.1. General

The Airport submitted a Construction Phasing Plan to LBN pursuant to Condition 4 of the CADP1 permission in February 2017. It was proposed to build out CADP1 as a single uninterrupted period of construction over 5 years split into two distinct phases. Consistent with terminology used in the UES, the two phases were referred to as the 'Interim Works' and the 'Completed Works' – each delivering different parts of the CADP infrastructure. The Interim Works would be delivered first and would be immediately followed by the Completed Works. This Construction Phasing Plan was approved by LBN in March 2017 (ref. 17/00500/AOD) and the details pursuant to Condition 39 for the 'Interim Works' were also approved at the same time (ref. 17/00975/AOD).

Ahead of the commencement of construction of CADP1, the Airport's Delivery Partner have identified a number of programme efficiencies and improvements to the 5 year build which would reduce the duration of the construction programme by 16 months and deliver the full CADP1 infrastructure in an accelerated single phase (2017 Accelerated Construction Phasing Plan), without the need to build and operate the Temporary Coaching Facility and Temporary Out Bound Baggage (OBB) system until the Completed Works are delivered.

The new 2017 Accelerated Construction Phasing Plan has been submitted to LBN pursuant to Condition 4 under separate cover and results in an overall construction programme of approximately 3 years 8 months (44 months), compared to 5 years (60 months) under the previously approved Construction Phasing Plan (March 2017).

As part of the details pursuant to Condition 39: Contamination, Atkins Limited (Atkins) has been commissioned by London City Airport (LCA) to produce this piling risk assessment (PRA) and to propose appropriate mitigation measures in accordance with the Environment Agency guidance document 'Piling into Contaminated Sites' (Environment Agency, 2002). This PRA is provided as an appendix to the overarching Condition 39 report prepared by RPS (on behalf of LCA) and to satisfy the requirements of the Environment Agency.

This PRA is based on current Environment Agency guidance for piling within brownfield land (Environment Agency, 2001) and focuses on the following two elements of the CADP1 Works:

- Eastern Energy Centre (EEC); and
- Multi Storey Public Passenger Car Park (MSCP).

The foundations of the EEC and MSCP will require piles as shown in Drawings A400-ATK-S-09-L00-DR-GA-247-001-02-S2 and A400-ATK-A-32-XXX-DR-GA-200-001-01-S2, included in Appendix A. This assessment is based on current pile designs, which are provisional and may be subject to change upon appointment of the Piling Contractor, although the principle of preventing pollution of the underlying aquifers shall be retained. Accordingly, this assessment may need to be revised following any changes to design and resubmitted to the Environment Agency and London Borough of Newham (LBN).

The proposed EEC is a single storey building with raft slab (32 m x 12 m), which will be supported by 27 no. piles, 600 mm in diameter extending to 20 -25 m below ground level (bgl). The MSCP is a steel framed structure (220 m x 43 m) with 153 no. piles, 450mm in diameter extending up to 25 m bgl for foundation support.

The piles are expected to be installed by Continuous Flight Auger (CFA). However, Rotatory Bored (RB) piles with temporary casing (extending into the Alluvium) may be considered if necessary (particularly if obstructions are encountered). As such, the suitability of both piling methods is evaluated in this assessment.

This PRA addresses the potential risks to controlled waters only from the proposed piling activities associated with the foundations of the EEC and MSCP. The PRA assesses potential risk posed by the proposed piling methods by reviewing various Source-Pathway-Receptors (SPR) linkages associated with controlled waters and whether or not mitigation or control measures are required to manage these risks. The PRA does not seek to replace any method statements, or health and safety plans for the test piling or piling, but should be used as an informative document to support such plans.

The following relevant information was made available to Atkins for the purposes of this report:

- RPS (2013a) City Airport Development Programme. London City Airport, Phase 1: Preliminary Risk Assessment Report, dated May 2013 (reference HLEI19695/001R);
- RPS (2013b) City Airport Development Programme. London City Airport, Phase 2: Environmental Site Investigation Report, dated April 2013 (reference HLEI24974/001R);
- TPS (2013). Piling Risk Assessment Report, London City Airport Development, dated May 2013;
- Soils Ltd (2014) Ground Investigation Report, New Immigration Facility, London City Airport, dated March 2014 (reference 14113/GIR);
- RPS (2014). London City Airport, Western Terminal Extension. Phase 2: Environmental and Geotechnical Site Investigation, dated December 2014 (reference HLEI32363/001R);
- Atkins (2015). London City Airport, West Apron Extension. Piling Risk Assessment, dated June 2015 (reference 5087877/West Pier PRA);
- RPS (2017) City Airport Development Programme, Submission under condition 39 of planning Permission 13/01228/FUL – Contaminated Land assessment and Outline Remediation Strategy, dated March 2017 (reference HLEI45199/001R);
- Atkins (2017). City Airport Development Programme. Western Energy Centre and Western Terminal Extension, Piling Risk Assessment, dated March 2017(reference A400-ATK-C-00-XXX-DC-RP-915-001);
- Concept (2017). London City Airport. Digital Air Traffic Control Tower (DATCT), Site Investigation Report, dated May 2017 (reference 16/2900- FR 01, Issue 01); and
- Atkins (2017) City Airport Development Programme (CADP1), Pre-commencement Condition 87: Construction, Design and Method Strategy.

1.2. Scope of Report

This PRA has been prepared in accordance with the Environment Agency's guidance (Environment Agency, 2001 and 2002) in order to assess the potential risks to controlled waters associated with the proposed piling techniques, and to recommend mitigation measures as appropriate. The scope of the assessment includes:

- Review of available background information on the environmental setting including the hydrogeological / hydrological regime;
- Identification and assessment of the Source Pathway Receptor (SPR) linkages associated with the proposed piling works;
- Qualitative assessment of risks from SPR linkages based on CIRA Report 552 (CIRIA, 2002);
- Review and discussion of the various potential pollution scenarios, in line with Environment Agency guidance (2001 and 2002); and
- Identification of mitigation measures, if required, in order to minimise impacts associated with piling and ground improvement methods.

This PRA focuses on the risks to controlled waters receptors (i.e. surface water and groundwater) as it is understood that the Contractor will adopt safe methods of working to mitigate human health risks from potentially contaminated soils and water arisings during construction, as required by Condition 39 and associated legislation. Potential risks to human health including from ground gases are addressed separately by RPS in the main volume of the report prepared in order to discharge Planning Condition 39.

1.3. Assumptions and Limitations

This report is based on the following assumptions and limitations:

- the document has been prepared based on available ground investigation data, for soil and groundwater, provided by third parties;
- the pile specifications have been based upon the current known piling designs and could be subject to change;
- this document covers matters in connection with risks to controlled waters associated with ground contamination only and does not seek to replace the Method Statement or Health and Safety Plan for the piling works as a whole. Separate detailed method statements covering wider issues will be produced by the Contractor prior to the commencement of piling works;
- human health, built structures and ecological receptors have not been considered within this piling risk assessment as the focus is the assessment of controlled waters risks; and
- the information presented is in part a summary of works undertaken by others and provided by the Client, and the sources of such data and the accuracy of the data provided are assumed to be correct and have not been verified by Atkins.

2. Site Location, History and Environmental Setting

2.1. Site Location and Description

The site is located within the curtilage of London City Airport (LCA), south of the existing terminal building, at approximate National Grid Reference (NGR) 543015E, 180335N. Drawings in Appendix A shows the site location and boundary.

The LCA site occupies an area of approximately 11,000 square metres and is predominately covered by hardstanding, comprising a long stay passenger car park and LCA's "King George V House" Business Services and Training Centre.

The surrounding land uses are:

- North: King George V Dock;
- East: Warehouse and LCA Taxi Feeder Rank;
- South: Hartmann Road, with residential dwellings of North Woolwich beyond; and
- West: LCA long stay car park.

2.2. Site History

The following site history has been taken directly from RPS (2017). From available historical maps, the area of the EEC and MSCP comprised undeveloped marshland at the time of the 1869 mapping with residential dwellings of "North Woolwich" present along the southern boundary. It is understood from RPS (2017) that by c.1898, the Royal Albert Dock had been constructed to the north of the site, followed by construction of the King George V Dock immediately to the north between 1912 and 1921. A wharf was constructed in the area of the EEC and MSCP during the late 1920's/ early 1930's.

Available mapping from c.1938 indicates that the site was occupied by warehouse buildings with increased residential dwelling density in the area of North Woolwich to the south. No significant changes were noted in the immediate area of the EEC and MSCP between 1938 and 1991 mapping editions.

At present, only one original warehouse building remains to the east of the site. The other warehouses have been cleared for the purpose of creating car parking for LCA and construction of King George V House since 1991.

2.3. Previous Ground Investigations

2.3.1. RPS, 2013

The site investigation was carried out by RPS between 11th and 19th February 2013: The investigation consisted of the following:

- 21 No. window sampler boreholes (WS1 - WS23) advanced to depths between 0.5 m and 5.0 m bgl with the installation of groundwater and gas monitoring wells. Soil and groundwater samples were taken for laboratory analysis; and
- Seven No. hand dug pits (HP1 – HP7) with depths between 0 to 0.5 m bgl, in which soakaway infiltration tests were carried out.

Only two locations (WS13 and HP6) of the RPS 2013 ground investigation were within the EEC and MCPS site boundary.

2.3.2. RPS, 2014

The site investigation was carried out by RPS between 22nd October and the 6th November 2014. The investigation comprised the drilling of five cable percussion boreholes (BH1 to BH5), approximately 500m west of the site in the area of the Western Terminal Extension, to depths ranging from 20m bgl to 25m bgl. In situ geotechnical testing, the installation of groundwater and ground gas monitoring wells and California Bearing Ratio (CBR) testing was undertaken in four locations (BH1, BH2, BH3 and BH4). These are dual installations, with shallow (Made Ground and Alluvium) and deep response zones (River Terrace Deposits and Thanet Sands). Soil samples and groundwater samples were taken for laboratory testing. There were also three gas monitoring rounds.

2.3.3. Soils, 2014

The aim of the investigation was to ascertain the geotechnical information on soils beneath the site so that foundations could be designed to support a relocated column within the existing terminal building. The ground investigation consisted of drilling one borehole to a depth of 10m bgl using cable percussion methods in a location within the existing terminal. A groundwater monitoring well was installed to a depth of 9m bgl, screened within the Made Ground and Alluvium. No environmental analysis for potential contaminants of concern was carried out as part of this investigation.

2.3.4. Concept, 2017

The site investigation was completed between 24th January and 10th February 2017. It comprised the drilling of two cable percussion boreholes to maximum depth of 30m bgl and one machine excavated trial pit to a depth of 3.5m bgl in an area immediately west of the proposed MCPS.

2.4. Geology

The published geology for the site (BGS, 2017) indicates the presence of superficial deposits of Alluvium and Shepperton Gravel Member / River Terrace Deposits (RTD) and deeper strata comprising the Thanet Sand Formation which overlies the Chalk Group.

A summary of the geology encountered during the intrusive works summarised in Section 2.3 is presented below, together with data from five BGS borehole scans (TQ48SW60 to TQ48SW64 inclusive), which are located either side of the site, parallel to King George V Dock. The BGS borehole logs are included in Appendix B.

Table 2-1 Summary of Geology.

Strata	Description	Base of Strata (m bgl)	Thickness of Strata (m)
Made Ground (MG)	Asphalt and concrete over, loose, light brown very sandy GRAVEL. Gravel comprises angular to well-rounded fine to coarse flint and concrete fragments. Sand is fine to coarse. Soft, light grey to greenish grey silty gravelly CLAY with organic odour.	3.4 - 6.5	3.4 - 6.5
Alluvium (ALV)	Soft, light grey locally gravelly silty CLAY with organic odour and occasional dark grey staining. Gravel is angular to subangular fine to coarse flint. Soft, dark brown fibrous very clayey PEAT with organic odour, frequent wood and plant fragments.	8.5 - 9.6	2.0 – 6.0
River Terrace Deposits (RTD)	Dark grey to brown sandy angular to well- rounded fine to coarse flint GRAVEL with hydrocarbon odour. Sand is fine to coarse.	15.5 – 22.3	7.0 – 12.7
Thanet Sand (TS)	Dense, light grey silty fine SAND, locally clayey. Basal dense, dark grey clayey silty angular to subangular fine to coarse black rounded flint GRAVEL.	24.0 – 32.2*	8.5 – 23.3*
Chalk	White CHALK recovered as: silty angular to subangular fine to coarse GRAVEL. Gravel is weak, medium density chalk fragments and locally black rounded flint	Base not proven	

*Based on data from TQ48SW466

2.5. Hydrogeology

The Environment Agency website (Environment Agency, 2017) indicates that the Alluvium (superficial deposits) is a Secondary Undifferentiated Aquifer and that the RTD (superficial deposits) and Thanet Sand Formation (bedrock) are Secondary A Aquifers. The Chalk is a Principal Aquifer.

The aquifers within the RTD, Thanet Sand and Chalk are considered to be in hydraulic continuity as there is no confining layer separating the three aforementioned units.

According to information provided on the Environment Agency website, the site does not lie within a Source Protection Zone. There is no licensed groundwater abstraction within 1km of the site.

The ground investigation by Concept (2017) identified water present within the Made Ground, perched above the Alluvium, with levels varying from approximately 1.5 m to 1.8 m above Ordnance Datum (AOD) (3.73 m to 4.20 m bgl). The perched water did not display any tidal influence as the water levels measured during three monitoring rounds were reasonably constant.

The deep boreholes associated with the ground investigation by RPS (2014) indicated that the Alluvium was acting as confining layer with groundwater levels rising to 5 – 6 m bgl from 8.6 – 9.6 m bgl in 20 minutes after entry into the RTD during drilling. The results of the groundwater monitoring suggest that the RTD and the Thanet Sands are a continuous water body with the water levels ranging from -1.85 to 1.6m AOD (4.1 m to 2.7 m bgl). No evidence of hydrocarbon free product was encountered during the monitoring. Groundwater level loggers were not used in this investigation to assess tidal influence on groundwater levels.

2.6. Hydrology

King George V Dock is situated to the east of the terminal and the Royal Albert Dock is situated adjacent to the northern boundary of the airport. It is understood that the docks are lined to maintain the impounded water level of 4.5 m above AOD. The River Thames is located approximately 460m to the south. It is tidally influenced and generally flows in an easterly direction.

There are records of two licensed surface water abstractions within 1km of the site. These both relate to abstractions from the River Thames by Tate and Lyle Sugars Ltd and the abstractions are recorded as being located approximately 375m and 480m south of the site (Environment Agency, 2017).

2.7. Potential Contaminants

The Phase 1 Preliminary Risk Assessment (RPS, 2014) identified a number of on-site and off-site potential sources of contamination associated with current and past land use.

2.7.1. On Site

Current and historical on-site potential sources of contamination are limited to the presence of Made Ground beneath the site, associated with the development of the nearby docks and airport. Potential contaminants of concern associated with Made Ground include metals, hydrocarbons, asbestos and ground gas.

2.7.2. Off-Site

Potentially contaminative historical land uses in the immediate surrounding area have included a white lead works, distilleries, foundries, breweries, a drugs mill and an engineering works. Current potentially contaminative land uses in the immediate surrounding area include two disused underground diesel tanks beneath the courtyard to the east of the site. Potential contaminants of concern associated with these land uses include metals, hydrocarbons and solvents.

2.8. Summary of Relevant Previous Contamination Assessments

2.8.1. RPS, 2013

A total of thirty samples of soil collected from Made Ground were submitted for chemical analysis for a broad range of potential contaminants. None of (including two soil samples analysed from WS13 which was located within the EEC and MCPS site boundary) were found to contain concentrations of contaminants of concern above the RPS derived Assessment Criteria (AC) for human health (commercial site user).

A total of nine perched groundwater samples, collected from nine boreholes (including one from WS13) screened within the Made Ground, were submitted for analysis, one round of groundwater sampling was carried out. There were no TPH or PAH's detected in the groundwater samples above laboratory method detection limits. No leachate samples were taken.

Assessment of ground gas results from three rounds of ground gas monitoring for a period of five weeks (between January and March 2013) classified the site as characteristic situation (CS) 2 or 'low risk', based on current UK guidance. A CS2 classification requires certain ground gas protection measures for new structures.

Waste Acceptance Criteria (WAC) testing was undertaken on one soil sample from Made Ground in WS13 (1.30m depth) and, as a result of which, this was considered likely to be suitable for disposal as inert waste.

2.8.2. RPS 2014

A total of five groundwater samples from the five locations (BH1 to BH5) screened across the RTD and Thanet Sand were analysed and screened against the DWS. Sulphate, selenium, cyanide, TPH CWG and PAH were recorded at concentrations in excess of their relevant DWS. However, none of boreholes are located within the site boundary.

2.8.3. Concept, 2017

A total of three soil-leachate samples from the three investigation locations (BH01, TP02 and BH02) within the Made Ground and five perched groundwater samples from two locations installed within the Made Ground were analysed. The results have been evaluated in the following section (Section 2.8.4).

2.8.4. Controlled Waters Assessment

The analytical results of soil leachate and groundwater from the Concept (2017) site investigations have been screened by Atkins against appropriate water quality standards (WQS), based on statutory Environmental Quality Standards (EQS) for coastal (marine) surface water as a conservative preference. Where these are not available, non-statutory EQS for coastal (marine) surface water were adopted. In the absence of a specific EQS for coastal (marine) surface water, either an equivalent EQS for fresh surface water, or, UK Drinking Water Standards (DWS) were adopted based on:

- The Water Framework Directive (Standards and Classification) Directions 2015; and
- Water Supply (Water Quality) Regulations 2016.

Where none of the above limits existed, the WQS were based on World Health Organisation (WHO) drinking water guidelines.

Leachate Assessment

Soil leachate tests provide an indication of the concentrations at which contaminants could leach from unsaturated materials and potentially affect controlled waters receptors. The exceedances in soil leachate are summarised in Table 2-2. The soil-leachate screening sheet can be found in Appendix C.

Table 2-2 Summary of Leachate Exceedances

Determinand	Units	No. Samples	No. Detections	Maximum Concentration	Location of Maximum.	WQS	No. of Exceedances
Ammoniacal Nitrogen (as N)	mg/l	3	3	0.80	BH01	0.39	2
Fluoranthene	µg/l	3	3	0.03	TP02	0.0063	3
Benzo(ghi)perylene	µg/l	3	1	0.01	TP02	0.00082	1
Total TPH (>C5-C40) Ali/Aro	µg/l	3	2	12.3	TP02	10	1

Groundwater Assessment

Perched groundwater data from the Concept (2017) ground investigations were screened by Atkins against appropriate WQS as per above section.

Contaminant exceedances have been noted in the perched groundwater samples for metals, ammoniacal nitrogen, TPH and PAHs. A summary table summarising the exceedances in perched groundwater has been provided in Table 2-3. The perched groundwater screening sheet can be found in Appendix C.

Table 2-3 Summary of Perched Groundwater Exceedances

Determinand	Units	No. Samples	No. Detections	Maximum Concentration	Location of Maximum.	WQS	No. of Exceedances
Aluminium	µg/l	4	1	333.00	BH02	200	1
Arsenic	µg/l	5	3	114.00	BH01	10	3
Iron	µg/l	4	2	44900.00	BH01	200	2
Mercury	µg/l	5	1	0.10	BH02	0.07	1
Nickel	µg/l	5	5	20.00	WS13	8.6	3
Lead	µg/l	5	1	4.20	WS13	1.3	1
Selenium	µg/l	5	2	12.00	BH02	10	2
Zinc	µg/l	5	5	58.00	BH01	6.8	5
Chloride	mg/l	4	4	2340.00	BH02	250	4
Sulphate	mg/l	5	5	361.00	BH02	250	2
Ammoniacal Nitrogen (as N)	mg/l	4	4	21.00	BH01	0.39	2
Free ammonia (NH_3)	mg/l	4	4	30.00	BH01	0.021	4
Fluoranthene	µg/l	5	4	0.14	BH01	0.0063	4
Benzo (b) fluoranthene	µg/l	5	3	0.06	BH01	0.0017	3
Benzo (k) fluoranthene	µg/l	5	3	0.05	BH02	0.0017	3
Benzo (a) pyrene	µg/l	5	3	0.04	BH02	0.00017	3
Benzo(ghi)perylene	µg/l	5	3	0.05	BH02	0.00082	3
>C21-C35 Aliphatic	µg/l	5	4	94.20	BH02	10.0	4
>C21-C35 Aromatic	µg/l	5	3	59.30	BH02	10.00	3

3. Pile Design

The piling design is in accordance with the Environment Agency guidance (Reference (Environment Agency, May 2001) & (Environment Agency, February 2002.) and takes into consideration potentially contaminated soils and groundwater.

All concrete and steel used for the piles will be specified and designed based upon site specific ground investigation results so as to resist chemical attack associated with aggressive ground conditions, where relevant.

The locations and layout of the piles are shown on Drawings A400-ATK-S-09-L00-DR-GA-247-001-02-S2 and A400-ATK-A-32-XXX-DR-GA-200-001-01-S2. The design of the piles is at a provisional stage but the current specification is summarized in Table 3-1, below.

Table 3-1 Provisional piling design and construction details

Location/ description	Type	Number of Piles (See note 2)	Design depth (m bgl) (See note 2)	Diameter (mm) (See note 2)
Multi Storey Car Park	CFA (See note 1)	153	Up to 25	450
Eastern Energy Centre	CFA (See note 1)	27	Up to 25	600

Notes

1: Pile type is expected to be continuous flight auger (CFA). Final pile design will be undertaken by the Contractor so may vary from the design considered in this assessment. Other bored pile techniques may be used, particularly if obstructions are encountered. A 5m temporary casing will be used depending on piling method and the ground encountered, particularly if a bored cast in situ technique is required.

2: Detailed pile design will be performed by a specialist piling contractor after contract award.

The proposed construction method for the piles is Continuous Flight Auger (CFA), which is discussed in more detail below along with the alternative method, rotary bored piles with temporary casing.

The rotary bored pile technique may be used in the event that CFA cannot penetrate the ground due to unforeseen obstructions.

3.1. Continuous Flight Auger Bored Piles

CFA is the chosen method for installing the piles. CFA is a non-displacement technique which relies on the retention of soil on the auger flights to provide support to the surrounding soil until the auger is withdrawn and the concrete or grout intruded. CFA piles are considered to present a low risk piling solution where contamination is present as material is brought to the surface and not driven down into lower units / groundwater as with driven techniques.

It is vital to the CFA technique that the intruded material (concrete) is placed under pressure at a rate consistent with that of the withdrawal of the auger to ensure that the hole is supported. This can be difficult to achieve near to the surface. Care has to be taken to ensure that water and concrete pressures are balanced in order to minimise concrete losses in permeable horizons.

3.2. Rotary Bored Piles

Rotary boring will be used in the event that an obstruction is encountered. The rotary bored piles are installed by drilling a borehole, which is stabilised using temporary casing. The temporary casing inhibits the creation of a groundwater pathway by preventing inflow into the borehole and maintains the stability of the soils around the borehole.

The hole is bored to the desired depth, concrete mixture, which will form the pile, is then pumped into the annulus within minutes of the pile being drilled, as the temporary casing is (generally) removed.

The option of temporary casing will assist in preventing migration of contamination from the perched water in the Made Ground into the borehole (clean drilling technique used on contaminated site) and entering the RTD Formation (Secondary A aquifer) and potentially subsequently to the River Thames.

4. Conceptual Site Model

The conceptual site model (CSM) describes the relationship between contamination which may be present from past and current activities on a site (and any off-site activities which may affect the site), and receptors of that contamination. As part of the CSM development, three elements are considered:

- a source of contamination (potentially contaminative activity) and associated contaminants;
- a receptor, or receptors, of that contamination; and
- a pathway to connect the two.

This assessment considers only controlled waters receptors (surface water and groundwater) as described in Section 1.2.

A risk to controlled waters can only be present if all three aforementioned elements are present, which is described as a potential pollutant linkage (PPL).

A preliminary conceptual site model (PCSM) has been developed to enable an assessment of the potential risks posed to controlled waters, and constraints which may be imposed on the proposed piling works.

4.1. Sources

Based on historical investigations completed at the site, the following contaminants in soil leachate from the Made Ground was in excess of WQS:

- general inorganics – ammonium;
- PAH - benzo(ghi)perylene and fluoranthene; and
- TPH – total Aliphatic/ Aromatic C5-C40.

There is perched water present in the Made Ground with the following contaminants above WQS:

- general inorganics – ammonium, chloride and sulphate;
- metals,/metalloids – aluminium, arsenic, iron, mercury, nickel, lead, selenium and zinc;
- PAH - benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, benzo(ghi)perylene and fluoranthene; and
- TPH - Aliphatic C21-C35, Aromatic C21-C35.

4.2. Receptors

The identified sources and contaminants may affect the following receptors:

- groundwater in the Secondary A (RTD and Thanet Sands) and Principal aquifers (Chalk); and
- saline surface water (principally King George V Dock and the River Thames).

The aquifers within the RTD, Thanet Sand and Chalk are considered to be in hydraulic continuity as there is no confining layer separating them. Further, sulphate, selenium, cyanide, TPH and PAH were recorded at concentrations in excess of their relevant DWS, within groundwater samples collected from the RTD and Thanet Sand formation in the vicinity of the site.

4.3. Pathways

The potential pathways associated with the installation of piled foundations, to controlled waters receptors, are considered in terms of construction and post-construction (long term impact) phases, as follows:

- pathway created by the action of the piling driving material downwards from the Made Ground into the RTD (Secondary A Aquifer), Thanet Sands (Secondary A Aquifer) and Chalk (Principal Aquifer);
- perched water from Made Ground/Alluvium migrating downwards via a preferential pathway created by the piling operations into the underlying aquifers; and
- subsequent migration of impacted groundwater to surface water features (i.e. King George V Dock and River Thames).

4.4. Risk to Controlled Waters

Table 4-1 summarises the CSM for the concrete piles and assigns a risk rating to the identified controlled waters receptors. The risk rating definitions are in general accordance with those provided in CIRIA Report C552 (Ref. (CIRIA, 2001)) following consideration of the potential consequence and likelihood of exposure occurring at each piling location, as summarised below:

Very High Risk: There is a high probability that severe harm could arise to a designated receptor or there is evidence that severe harm to a designated receptor is currently happening. This risk, if realised, is likely to result in a substantial liability.

High Risk: Harm is likely to arise to a designated receptor. Realisation of the risk is likely to present a substantial liability.

Medium Risk: It is possible that harm could arise to a designated receptor. However, it is either relatively unlikely that any such harm would be severe, or if any harm were to occur it is more likely that the harm would be relatively mild.

Low Risk: It is possible that harm could arise to a designated receptor, but it is likely that this harm, if realised, would be mild.

Very Low Risk: The possibility of harm to the designated receptor is either not plausible or, if the possibility of harm is plausible, risk is considered to be very unlikely with attenuation along the exposure pathway.

Table 4-1 Pile Specification, Conceptual Site Model and Controlled Waters Risk Rating

Pile Reference	Specifications					Conceptual Site Model					
	Type	No. of Piles	Pile Depth (m bgl)	Pile diameter/ width, mm)	Temporary casing (toe) Depth	Contamination Present?	Underlying Geology	Controlled Waters Receptors	Pile Toe Corresponding Geology	SPZ	Controlled Waters Risk
MSCP	Continuous flight auger / rotary bored with 5m temporary casing	153	25	450	Made Ground or top of Alluvium	Yes in perched water and Made Ground	Made Ground, Alluvium, River Terrace, Thanet Sand, Chalk	Superficial Deposits (Secondary A Aquifer), Bedrock Deposits (Secondary A Aquifer and Principal Aquifer), Saline surface water (principally King George V Dock and the River Thames).	Thanet Sand or top of Chalk	No	Low
EEC	Continuous flight auger / rotary bored with temporary casing	27	25	600	Made Ground or top of Alluvium	Yes in perched water and Made Ground	Made Ground, Alluvium, River Terrace, Thanet Sand, Chalk		Thanet Sand or top of Chalk	No	Low

5. Pollution Scenarios and Mitigation Measures

5.1. Introduction

The Environment Agency guidance document *Piling and Penetrative Ground Improvement Methods on Land Affected by Contamination: Guidance on Pollution Prevention*, (Environment Agency, 2001), presents initial technical guidance on the potential impact that intrusive ground improvement and piling techniques can have on the environment, focusing on the potential for pollution of groundwater and risks to human health.

In accordance with the Environment Agency (2002), potential Pollution Scenarios have been considered below, based on the CSM presented in Section 4. Mitigation measures have been outlined, where relevant, for any of the Pollution Scenarios.

5.2. Pollution Scenario 1

Creation of preferential pathways through an aquitard to allow potential contamination of an aquifer

The geology at the site typically comprises Made Ground directly overlying superficial deposits comprising Alluvium (Unproductive Strata) and RTD (Secondary A Aquifer). The low permeability Alluvium is considered to act as an aquitard which prevents or mitigates the downward movement of contaminated groundwater to the underlying RTD, Thanet Sand (Secondary A Aquifer) and Chalk (Principal Aquifer). It is likely the RTD, Thanet Sands and the Chalk are hydraulically connected and this hypothesis is supported by similar concentrations of determinants in groundwater identified within the RTD and Thanet Sands during the previous ground investigations across the wider LCA site (RPS, 2014).

The proposed drilling method, CFA or rotary bored with temporary casing, will minimise the movement of perched water (present in the Made Ground) down into the RTD or deeper groundwater from the Made Ground.

During CFA drilling the downward migration of material is prevented. Material is carried out on the flights of the auger, which also support the borehole walls. As the auger is withdrawn, concrete is injected into the borehole. As concrete is more dense than water it prevents the ingress of water into the borehole, which also stops the downward migration of water.

Considering the use of non-displacement techniques such as CFA or rotary bored with temporary casing, the piling is unlikely to result in any additional impact on the groundwater in either the RTD or Thanet Sands.

5.3. Pollution Scenario 2

Creation of preferential pathways through a low permeability surface layer, allowing migration of ground gas or contaminant vapours to the surface

This pollution scenario is outside the scope of this document. It should be noted that RPS (2013b) has undertaken a ground gas assessment for the site which indicates that CIRIA Characteristic Situation 2 is applicable, whereby ground gas protection measures are required.

5.4. Pollution Scenario 3

Direct contact of site workers and others with contaminated soil arising that have been brought to the surface

This pollution scenario is outside the scope of this document. According to the available investigation data, contamination is present in the Made Ground, perched water and RTD groundwater within the vicinity of the

piling locations. Specific construction related risks will be considered by the Contractor as part of the health and safety risk assessment process. The Contractor should ensure that suitable working practices and the use of appropriate personal protective equipment (PPE) are maintained so as to minimise exposure to potentially harmful pile arisings.

5.5. Pollution Scenario 4

Direct contact of the piles with contaminated soil or leachate, contaminated perched water/shallow groundwater and NAPL (if present) causing degradation of materials

The concrete and steel used in the proposed piles may come into direct contact with contaminated soil, contaminated groundwater, waste or leachate in aggressive conditions. The Building Research Establishment (BRE) Special Digest document states that some contaminants or constituents of contaminated soil or leachate may be aggressive to materials used in piles causing degradation of piles, reducing or eliminating their load carrying capacity, and possibly creating further migration pathways.

All concrete and steel used in the piles shall be specified, using site specific ground investigation data, to be resistant to contamination and naturally occurring aggressive ground conditions e.g. high sulphate concentrations.

5.6. Pollution Scenario 5

Forced movement of solid contaminants down into an underlying aquifer during pile driving

Movement of contaminated material into the underlying aquifer would have a moderate consequence. However, the proposed piling method CFA or rotary bored with a sleeved pile solution, is non-displacement piling where the soil is extracted and replaced with a pile. The piling method will not cause forced movement of solid contaminants into the underlying aquifers as the piling rig brings contaminated materials to surface.

5.7. Pollution Scenario 6

Contamination of groundwater and subsequently surface waters by concrete, cement paste or grout

Any void created by the proposed piling method is likely to be limited both in its extent and the duration to which it will remain open before a rapid setting cement grout mixture is poured to ensure contamination of the groundwater is unlikely. Any migration or contamination resulting from wet concrete, cement paste or grout would be limited in extent and duration meaning that the consequence would be mild. Assuming that the piles are designed to current authoritative guidance to reduce this risk and retarder additives and good working practices are used during construction, the risk of Pollution Scenario 6 occurring is considered to be very low.

5.8. Other Scenarios

Impact on ground- and surface water flow

The proposed piles are not contiguous. There are significant gaps between the piles as such groundwater, confined by the Alluvium, will be able to move freely around the piles within the underlying permeable aquifers (RTD, Thanet Sand, Chalk), meaning any impact is unlikely. Flow will not be significantly reduced to the River Thames.

Unexploded ordnance

Although outside the scope of this report it is considered that risks may be present from unexploded ordnance (UXO). As the docklands was a target for bombing raids an appropriate UXO risk assessment must be done before intrusive works and mitigation measures adopted if considered to be necessary.

6. Conclusions and Recommendations

Based on the available ground investigation data and the proposed piling methodology, the assessment has shown that there is a low risk to controlled waters receptors (groundwater and surface water).

Perched water from the Made Ground should not be allowed to pass through the Alluvium into the RTD groundwater during the piling activities and so the use of CFA or rotary bore piles with temporary casing is recommended. Should another technique be employed it should also satisfy this requirement.

Based on the findings of this piling risk assessment, no additional environmental monitoring or risk mitigation measures are considered necessary for the proposed piling operations (CFA or rotary bored piles with sleeved pile solution).

7. References

BGS (2017). Geology of Britain Viewer. [Online] http://mapapps.bgs.ac.uk/geologyofbritain/home.html.

CIRIA (2002). C552 Contaminated Land Risk Assessment – A Guide to Good Practice. IBN 0 86017 552 9.

Environment Agency (2001). Piling and Penetrative Ground Improvement Methods on Land Affected by Contamination: Guidance on Pollution Prevention. National Groundwater & Contaminated Land Centre report NC/99/73. May 2001.

Environment Agency (2002). Piling into contaminated sites. ISBN 1 85705 803 8. February 2002.

RPS (2013a) London City Airport Western Terminal Extension, Phase 1 Preliminary Risk Assessment Report, HLEI32363/001R.

RPS (2013b) London City Airport Environmental Site Investigation Report, HLEI24974/001R (Ref. (4))

RPS (2014). London City Airport Western Terminal Extension, Phase 2: Environmental and Geotechnical Site Investigation, HLEI32363/001R.

RPS (2017) City Airport Development Programme, Submission under condition 39 of planning Permission 13/01228/FUL – Contaminated Land assessment and Outline Remediation Strategy. HLEI45199/001R.

Appendices

Appendix A. Drawings