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DCS18253-LIS-ZZ-F1-RP-G-0001

Metnor Construction

Factual Geotechnical Investigation

COLT Data Centre
Powergate Business Park
Volt Avenue
London
NW10 6PW

Report No: 21.02.026
April 2021

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DOCUMENT RECORD

Report Title	Factual Geotechnical Investigation Report
Development	Conversion of an existing Commercial Property
Project Address	COLT Data Centre, Powergate Business Park, Volt Avenue, London, NW10 6PW
Project Number	21.02.026
Client	Metnor Construction

	Signature	**Name and Qualifications**
Prepared By:		**Adam Jones** **Senior Geotechnical Engineer** **MGeol(Hons), FGS**
Checked and Approved By:		**Matt Johnston** **Associate Director** **BSc(Hons), FGS**

For and on behalf of ListersGeo, trading name of Listers Geotechnical Consultants Ltd

Issue No	Date	Status
1	8th April 2021	Draft
2	15th April 2021	Final

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CONTENTS

FACTUAL GEOTECHNICAL INVESTIGATION REPORT

INTRODUCTION

A Factual Geotechnical Investigation has been undertaken as part of the proposed conversion of an existing commercial property at the proposed COLT Data Centre, Powergate Business Park, Volt Avenue, London, NW10 6PW to accommodate a mezzanine floor and higher loadings on the existing floor slab. A Site Location Plan is provided in Appendix A. The Ordnance Survey National Grid reference for the approximate centre of the site is 520963, 182802.

Instructions to undertake the investigation were received from our client Metnor Construction in their e-mail dated 24th February 2021.

This report describes the work carried out by ListersGeo, the ground conditions encountered and provides a factual presentation of results.

To our knowledge, the site has not been subject to any previous investigations.

This report has been prepared for the sole use of the client and their professional advisors. This report shall not be relied upon by third parties without the express written authority of ListersGeo. If an unauthorised third-party comes into possession of this report, they must not rely on it and the authors owe them no duty of care and skill.

SCOPE OF THE INVESTIGATION

The scope of the investigation, as requested by Metnor Construction, was to undertake concrete coring through the existing floor slabs along with strength testing of the concrete cores. Beneath the slab hand augers were undertaken to confirm the make-up of the ground and in-situ testing was undertaken on the underlying subbase to derive equivalent California Bearing Ratio (CBR) and modulus of sub-grade reaction (MSR) values were requested along with a factual presentation of the results. In order to minimise disturbance to the existing slabs, tests were limited to relatively small diameter concrete cores and hand augers up to 0.25m diameter.

PROPOSALS

It is proposed to redevelop the existing building to accommodate a mezzanine floor, that is understood to be founded on piles, along with new equipment stored on the existing ground floor slab. It is understood that the new equipment will be for a new data centre and will have relatively high loads. An existing car park and external concrete slab will also be built over and used as part of the date centre.

The report is based upon the above development proposals and the existing ground levels. Should either of these alter significantly following issue of this report, then the contents will require re-evaluation.

SITE INFORMATION AND WALKOVER SURVEY

A walkover survey of the site and its immediate surrounds was undertaken on the 16th and 25th March 2021, preceding the fieldwork. A selection of site photographs is presented in Appendix A along with a plan showing the existing site layout.

The site lies in a predominantly industrial area and is currently occupied by a steel portal framed warehouse with offices on part of the first floor and an associated car park. The warehouse part of the building is currently unoccupied. The building continues towards the east and it is understood that the eastern end of the building is already developed with a data centre. To the south of the building is a car park that is partially covered with block paving and partially with cement-concrete. To the east of the car park is an outdoor area covered with concrete slabs which house generators and air conditioning units etc for the adjacent data centre.

The site consists of an irregular shaped parcel of land with covers half of the existing building and all of the external area to the south as shown on the plans in Appendix A.

The internal slab had locally been broken out and backfilled prior to ListersGeo attending site and generally appeared in good conditions. Expansion joints were noted between different parts of the floor slab. Some minor cracks were noted within the surface of the internal slab.

The external slab also appeared to have been cast in sections with the area around CC06 having kerb stones nearby and appearing different in texture to adjacent slabs to the east. Some of the slabs were used to house generators which were generally on around 0.30m high cement-concrete plinths.

UNEXPLODED ORDNANCE AND BOMB SITES

A Detailed Unexploded Ordnance (UXO) Risk Assessment, has been undertaken for the site by MACC International. The report identifies that the site is within a low risk area of encountering UXO and a copy of the report is provided in Appendix D.

GEOLOGY

Published Geology

Reference to online published geological information on the area indicates that the site is underlain by Bedrock geology, the London Clay Formation.

Given the existing development, Fill and Made Ground are anticipated from surface beneath the site, overlying the London Clay.

Bedrock

The London Clay Formation is generally represented by blue grey or grey brown silty clay which may contain cementstone nodules and disseminated pyrite.

EXPLORATION AND TESTING

A total of seven exploratory holes were formed at the site on the 16th and 25th March 2021. These included concrete cored holes at all locations, CC01 to CC07 except CC05, with hand augers and TRL-DCP tests below.

The positions of all exploratory holes undertaken at the site as part of this investigation can be seen on the Exploratory Hole Location Plans in Appendix A. The logs are provided in Appendix B and the results of the geotechnical laboratory testing are provided in Appendix C.

Elevation values have been extrapolated from the topographical survey reference Powergate DCS 17-174 Drawing Reference PWG01-HYP-XX-ZZ-DR-A_0100 rev T2 dated July 2019. Coordinates have been extracted from freely available aerial imagery and should be treated with an appropriate level of accuracy in the order of say ±5m.

Findings presented in this report are based on data obtained from these sources but it should be noted that variations, which affect these conclusions, may inevitably occur between and beyond the test locations. Also, water levels may vary seasonally and with other factors.

SAMPLING STRATEGY

The investigation was undertaken in accordance with the scope of works agreed with our client. The positions of the exploratory holes were selected by ListersGeo in discussion with Metnor Construction to provide a coverage across different areas of both the internal and external concrete slabs.

METHODOLOGY

Health and Safety

Prior to commencement of boring/testing, and in order to minimise the dangers from/to buried services, the proposed locations were scanned using a Cable Avoidance Tool.

Exploratory Holes

At positions located on the existing floor slab, the surfacing was cored out using an electric 250mm diameter concrete corer with CC01 to CC04 on the internal slab and CC06 and CC07 on the external slab. CC05 was located in an area of previously disturbed brick block paving. Hand excavated inspection pits were put down using insulated hand digging tool on the sub-base beneath the slab. Due to the density and presence of gravel and cobbles in the sub-base holes were terminated at between 0.30m and 0.70m bgl. Disturbed samples were taken at selected depths down to the base of the holes for subsequent laboratory testing and inspection. On completion, all pits were carefully backfilled with arisings, ensuring that excavated material was replaced in the same order as it had been removed. Each of the positions located in hardstanding were reinstated with cement-concrete.

In-situ Testing

TRL-DCP (DCP) testing was undertaken from immediately below the concrete floor slab, to enable an assessment of the CBR down to a to a maximum depth of around 0.75m. Where DCP tests refused at shallow depths, locally the pit was deepened before a repeat test was undertaken. All DCP tests were terminated in the Made Ground due to refusal of the DCP.

GROUND CONDITIONS

The intrusive investigation revealed that the general succession of strata was represented by a layer of cement-concrete hardstanding over Fill with Made Ground at depth. Locally some block paving was present across parts of the existing car park.

HARDSTANDING

All exploratory holes were located over cement-concrete floor slabs except CC05 with CC01 to CC04 being internal and CC06 and CC07 being external. CC05 was located in an area of brick block paving that had been previously broken out.

In CC05 the block paving extended down to 0.06m below ground level (bgl).

The cement-concrete ranged in thickness from 0.12m thick in one of the external slabs, CC06, to between 0.19m to 0.22m bgl in CC01 to CC04 and CC07. A black membrane was present at the base of the internal slab in CC01 to CC04.

Approximately 7mm diameter rebar was encountered in each concrete core except CC06. CC04 encountered two layers of reinforcement and was located close to an area of the floor slab that had a fine crack in the surface.

A kerb stone was located to the east of CC06 suggesting that this thinner, un-reinforced slab may have been a former pavement as opposed to an engineered slab. In the eastern half of CC06 a layer of buried concrete was resent which may be linked to the adjacent cement-concrete plinth.

FILL

A relatively thin layer of Fill was encountered beneath the internal slab with a 0.03 to 0.06m of yellow grey gravelly sand with gravel of cement-concrete and sandstone encountered down to depths of between 0.22m and 0.28m bgl.

A 0.04m thick layer of grey yellow sand was present beneath the block paving down to 0.10m bgl in CC05.

MADE GROUND

Made Ground was encountered beneath the Fill from depths of between 0.10m bgl and 0.28m bgl down to beyond the base of the investigation at a maximum depth of 0.70m bgl. All exploratory holes and tests were terminated in the Made Ground due to refusal on either cobbles or gravel within the Made Ground or the density of the soils. The Made Ground has not been classed as Fill given its variable composition but does appear to have been subject to compaction/engineering.

Made Ground generally comprised a silty/clayey sandy to very sandy gravel, locally very gravelly sand with a low cobble content. Gravel and cobbles were of brick, flint, cement-concrete, igneous aggregate and occasionally clinker. Soils were generally dense to very dense.

Laboratory testing revealed the following:

Parameter	Range	Comments
Portion <63mm and >2mm (%)	10 to 82	Gravel fraction
Portion <2mm and >63µm (%)	16 to 72	Sand fraction
Passing 63µm sieve (%)	3 to 18	Fines (silt/clay) fraction

GROUNDWATER

Groundwater was not encountered in any of the exploratory holes during the fieldwork down to 0.70m depth below the existing ground level, for the short time that the holes were open.

COMPRESSIVE STRENGTH OF CONCRETE CORES

Concrete core samples were submitted to a materials testing laboratory for compressive strength testing. A summary of the findings is presented below.

Pont Load Test Data

Exploratory Hole ID	Failure Load (kN)	Point Load (MN/m^2)	Point Load Index (MN/m^2)
CC03	10.46	1.25	1.64

Exploratory Hole ID	Failure Load (kN)	Compressive strength (N/mm^2)	Corrected in situ cube strength (N/mm^2)
CC01	379.4	54.7	56.8
CC02	297.7	42.9	43.2
CC06	315.8	41.9	42.8
CC07	237.8	43.5	43.5

CALIFORNIA BEARING RATIO (CBR) TESTS

In-situ testing was undertaken using a TRL probe to obtain equivalent CBR with depth profiles to around 0.70m bgl at all test locations. At some locations, two tests were taken at different start depths following further excavation where probes terminated at shallow depths. Graphs of the penetration rates with depth are provided in Appendix B.

CBR tests provides the ration of resistance to penetration developed by the soil tested to that of developed by a specimen of crushed rock. Further consideration to long term performance is required when evaluating

results. The results of the testing are summarised in the table below, together with derived approximate CBR values for the subgrade soils:

Stratum	Depth (m)	Equivalent CBR (%)	Notes
Fill / Made Ground	0.1 – 0.7	4 to >40	Generally, achieves a CBR in the order of 20% or greater

A CBR value of 20% has been used for design purposes with an Equivalent Modulus of Subgrade Reaction of $Ks_{(762)}$ of 80,873 kN/m^2/m.

It should be noted that TRL-DCP tests can provide higher values were coarse-grained materials are present.

SULPHATE AND pH TESTS

The results of the laboratory pH and water-soluble sulphate tests on samples of soil are summarised below:

Stratum	Water-soluble Sulphate SO_4 (g/l)	pH (pH units)	Number tested
Made Ground	0.06 to 0.38	8.1 to 12.0	6

RECOMMENDATIONS

Soil is a heterogeneous material and variations, which affect our conclusions, may inevitably occur between and beyond the test locations. Given the inherent nature of Made Ground soils, variations should be anticipated beneath the concrete slab given the potential for variations in the composition of the Made Ground and the level of compaction undertaken during formation. Variations external floor slab thicknesses between different areas along with the localised presence of re-bar should also be anticipated. The strength and thickness of concrete plinths for existing infrastructure has not been assessed.

In order to minimise this risk, consideration should be given to undertaking additional investigation across the site area to confirm the ground conditions and anticipated CBR and MSR values. This could be done following the removal of any hardstanding if it is not to be used in the final design. Should ground conditions vary noticeably from our Ground Model, then we recommend further assessment by a suitably qualified person.

At the time of this investigation, it was required to minimise disturbance to the existing flor slabs and infrastructure also limited access to some areas of the site. Therefore, at the request of the client, our works were limited to relatively small diameter holes in order to minimise disruption to site activities.

TRL-DCP tests can be impacted by the presence of coarse-grained soils and consideration should be given to undertaking plate load testing to provide further supportive soil parameters. Specialist reinstatement may be required to ensure any reinstated parts of the slab have the same performance and strength as the surrounding slabs.

REFERENCES

1. British Standards Institution (BSI), Site Investigations: Code of Practice, BS5930:2015+A1:2020, 2020
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7. BSI, Soils for Civil Engineering Purposes, BS 1377-1:2016, 2016
8. BRE, Concrete in Aggressive Ground, BRE Special Digest 1, 2005
9. BSI, Foundations, BS 8004:2015, 2015
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11. Transport and Road Research Laboratory (TRRL), The Structural Design of Bituminous Roads, Laboratory Report LR1132, 1984

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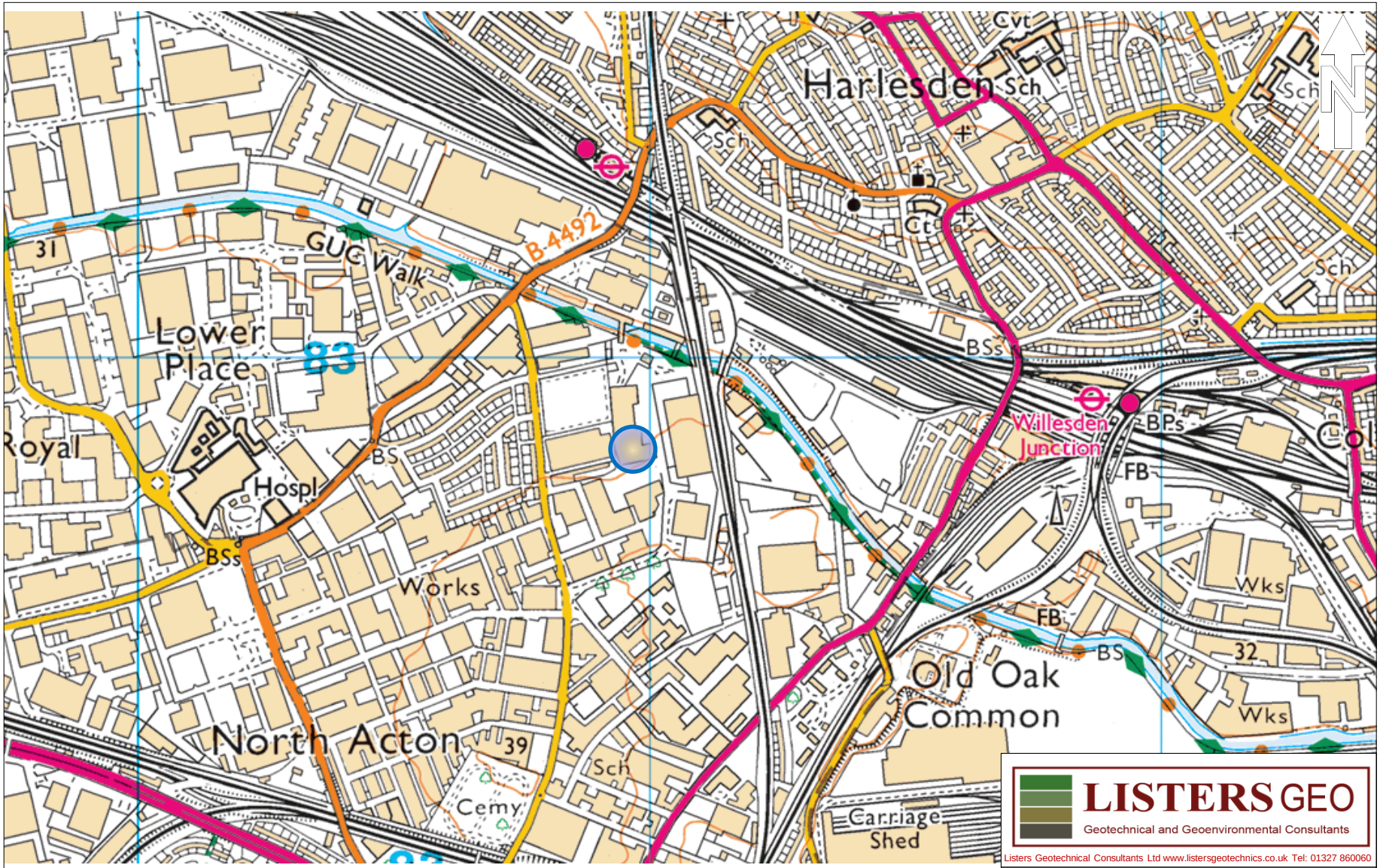
APPENDIX A
PLANS & PHOTOGRAPHS



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Listers Geotechnical Consultants Ltd www.listersgeotechnics.co.uk Tel: 01327 860060

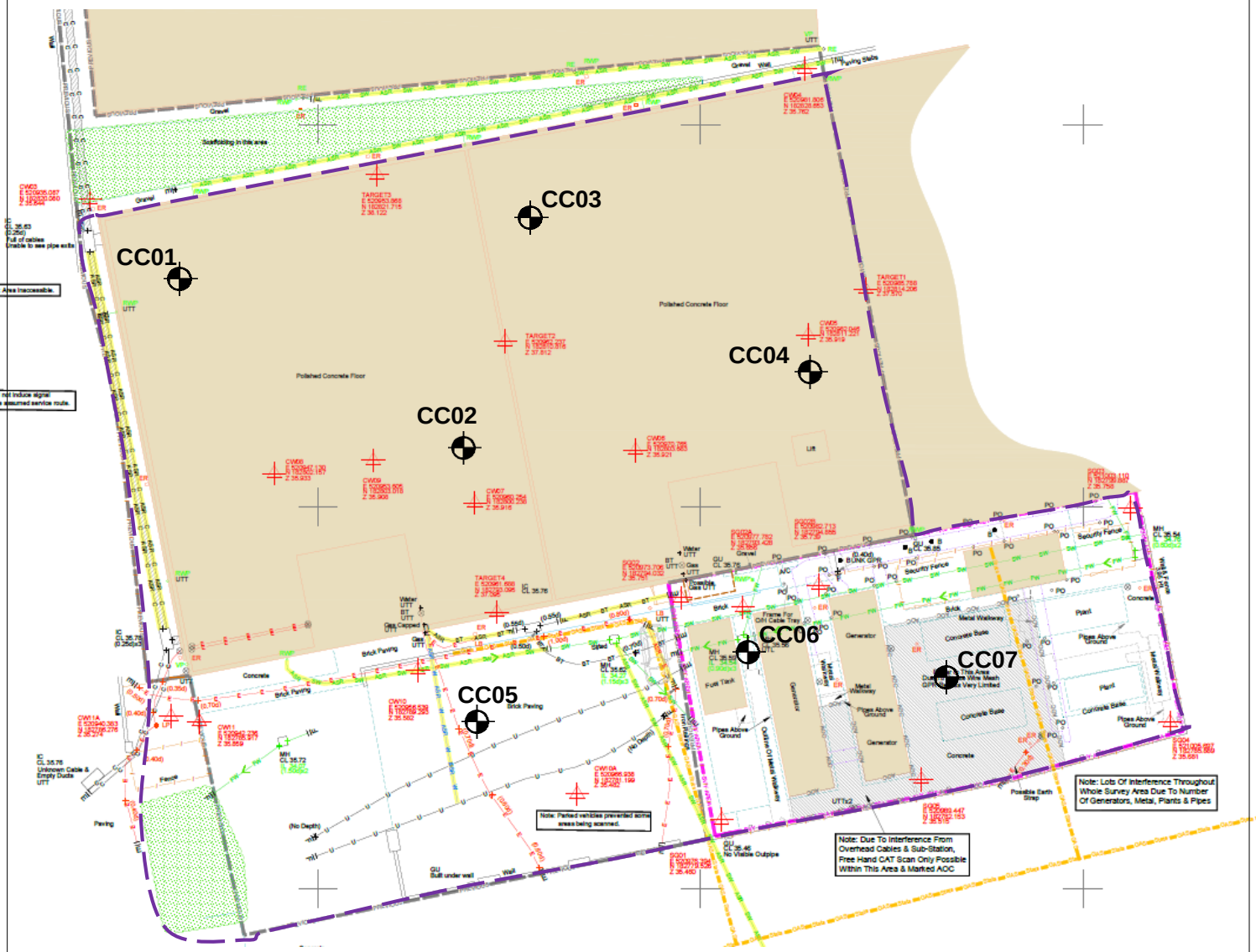
Title: Site Location Plan

Key:

Approximate site location

Site: COLT Data Centre, Powergate Business Park, Volt Avenue, London, NW10 6PW

Scale: NTS	Job Number: 21.02.026	Drawn By: AJ



(plan Extracted from Powergate DCS 17-174 Drawing Reference PWG01-HYP-XX-ZZ-DR-A_0100 rev T2 dated July 2019)

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Key:

Concrete core, inspection pit and TRL-DCP test location

Approximate site boundary

Title: Exploratory Hole Location Plan – Existing Site Layout

Site: COLT Data Centre, Powergate Business Park, Volt Avenue, London, NW10 6PW

Scale: NTS **Job Number**: 21.02.026 **Drawn By**: AJ

(plan Extracted from Sumo Services Ltd Drawing Reference SOR016349 Dwg 01 dated 24/10/2019)

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Key:

Concrete core, inspection pit and TRL-DCP test location

Approximate Site Boundary

Title: Exploratory Hole Location Plan – Proposed Site Layout

Site: COLT Data Centre, Powergate Business Park, Volt Avenue, London, NW10 6PW

Scale: NTS **Job Number**: 21.02.026 **Drawn By**: AJ

Photograph looking west towards CC05 and showing the exiting building and car park.

Photo 1

Photograph looking north east towards the adjacent part of the building and the current external slabs with associated generators etc.

Photo 2

SITE PHOTOGRAPHS

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Photograph showing the internal layout of the eastern half of the building.

Photo 3

Photograph showing the western half of the building with associated internal offices.

Photo 4

SITE PHOTOGRAPHS

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Photograph showing the nature of the concrete cores, sub-base and underlying Made Ground.

Photo 5

Photograph showing the concrete core in CC02.

Photo 6

SITE PHOTOGRAPHS

Report:
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Photograph showing the location of CC07 and the external slabs.

Photo 7

Photograph showing the location of CC06, post reinstatement.

Photo 8

SITE PHOTOGRAPHS

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APPENDIX B
FIELDWORK AND TESTING

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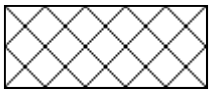
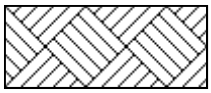
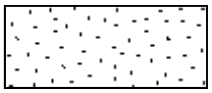
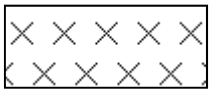
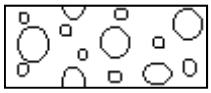
LEGEND - Soils

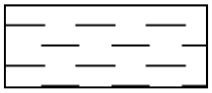

Made Ground

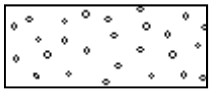

Topsoil

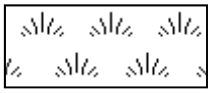

Sand


Silt

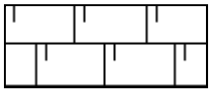

Boulders and Cobbles

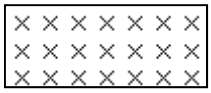

Clay

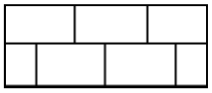

Gravel

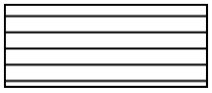

Peat

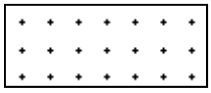
LEGEND - Rocks (Sedimentary)


Chalk


Siltstone


Limestone


Mudstone


Sandstone


Coal


Conglomerate


Breccia

LOG ABREVIATIONS

W	Water Sample	▽	Water Strike
B	Bulk Sample	▼	Water (Standing Level)
D	Disturbed Sample	PP	Pocket Penetrometer
J	Jar Sample	HV	Hand Vane
U	Undisturbed Sample	SPT	Standard Penetration Test
(No. of blows shown in brackets for U100 samples)		CPT	Cone Penetration Test
WAC	Waste Acceptance Criteria Sample	CBR	California Bearing Ratio
		*	Extrapolated Value

Pocket penetrometer testing provides values of unconfined compressive strength. The results have been converted to an approximate equivalent shear strength which should be used with due circumspection. As the pocket penetrometer tends to overestimate shear strength, we have used an appropriate reduction factor.

LOG KEY

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Trial Pit Log

Trial Pit No. CC 01

Project Location: COLT Data Centre, Powergate Business Park, Volt Avenue, London NW10 6PW

Co-ords: 520942E - 182815N

Level: 35.90 mAOD

Dates: 16/03/2021

Project Number: 21.02.026

Logged By: Adam Jones to BS 5930:2015

Water Strikes	Sample and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description	
	Depth (m)	Type	Result					
							FILL CEMENT-CONCRETE floor slab with 7mm diameter re-bar at 0.14m bgl and black membrane at base	
				0.19	35.71			
				0.25	35.65		FILL Yellow grey gravelly SAND (dense). Gravel is tabular angular to subangular of cement-concrete and sandstone	
	0.40	D					MADE GROUND Brown slightly silty sandy GRAVEL (dense). Gravel is angular to subangular of brick and cement-concrete *- with a low cobble content and becoming very dense from 0.40m bgl*	
				0.70	35.20		End of Trial Pit at 0.70m	1

Method of excavation: Concrete corer and hand digging tools **Dimensions:** 25cm

Stability: Sides Stable

Groundwater: None encountered

Remarks: Terminated at 0.70m bgl due to refusal in Made Ground
0.25m diameter concrete core taken from surface with hand excavated pit below
Elevation values and coordinates are approximate but have not been levelled in by a surveyor

ISO 9001 REGISTERED FIRM

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Trial Pit Log

Trial Pit No. CC 02

Project Location: COLT Data Centre, Powergate Business Park, Volt Avenue, London NW10 6PW

Co-ords: 520963E - 182802N

Level: 35.90 mAOD

Dates: 16/03/2021

Project Number: 21.02.026

Logged By: Adam Jones to BS 5930:2015

Water Strikes	Sample and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description
	Depth (m)	Type	Result				
							FILL CEMENT-CONCRETE floor slab with 7mm diamater rebar at 0.14m bgl and black membrane at base
				0.19	35.71		
				0.22	35.68		FILL Yellow grey gravelly SAND (dense). Gravel is tabular angular to subangular of cement-concrete and sandstone
				0.30	35.60		MADE GROUND Brown slightly clayey sandy GRAVEL (very dense) with a low cobble content. Gravel and cobbles are angular to subangular of brick and cement-concrete
							End of Trial Pit at 0.30m

1

Method of excavation: Concrete corer and hand digging tools **Dimensions:** 25cm

Stability: Sides Stable

Groundwater: None encountered

Remarks: Terminated at 0.30m bgl due to refusal in Made Ground
0.25m diameter concrete core taken from surface with hand excavated pit below

Elevation values and coordinates are approximate but have not been levelled in by a surveyor

ISO 9001 REGISTERED FIRM

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Trial Pit Log

Trial Pit No. CC 03

Project Location: COLT Data Centre, Powergate Business Park, Volt Avenue, London NW10 6PW

Co-ords: 520967E - 182820N

Level: 35.90 mAOD

Dates: 16/03/2021

Project Number: 21.02.026

Logged By: Adam Jones to BS 5930:2015

Water Strikes	Sample and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description
	Depth (m)	Type	Result				
							FILL CEMENT-CONCRETE floor slab with 7mm diamater rebar at 0.14m bgl and black membrane at base
				0.22	35.68		
	0.30	D		0.28	35.62		FILL Yellow grey slightly silty sandy GRAVEL (dense). Gravel is tabular angular to subangular of cement-concrete and sandstone
							MADE GROUND Brown very gravelly SAND (very dense) with a low cobble content. Gravel and cobbles are angular to subangular of brick and cement-concrete
				0.55	35.35		End of Trial Pit at 0.55m

1

Method of excavation: Concrete corer and hand digging tools **Dimensions:** 25cm

Stability: Sides Stable

Groundwater: None encountered

Remarks: Terminated at 0.55m bgl due to refusal in Made Ground
0.25m diameter concrete core taken from surface with hand excavated pit below
Elevation values and coordinates are approximate but have not been levelled in by a surveyor

ISO 9001 REGISTERED FIRM

AGS Association of Geotechnical & Geoenvironmental Specialists

LISTERS GEO
Geotechnical and Geoenvironmental Consultants

Trial Pit Log

Trial Pit No. CC 04

Project Location: COLT Data Centre, Powergate Business Park, Volt Avenue, London NW10 6PW

Co-ords: 520980E - 182808N

Level: 35.90 mAOD

Dates: 16/03/2021

Project Number: 21.02.026

Logged By: Adam Jones to BS 5930:2015

Water Strikes	Sample and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description
	Depth (m)	Type	Result				
	0.20	D		0.19	35.71		FILL CEMENT-CONCRETE with 6mm diamater rebar at 0.085m and 0.12m bgl and with black membrane at base
				0.23	35.67		FILL Yellow grey silty gravelly SAND (dense). Gravel is tabular angular to subangular of cement-concrete and sandstone
				0.30	35.60		MADE GROUND Brown very gravelly SAND (very dense) with a low cobble content. Gravel and cobbles are angular to subangular of brick and cement-concrete
							End of Trial Pit at 0.30m

1

Method of excavation: Concrete corer and hand digging tools **Dimensions:** 25cm

Stability: Sides Stable

Groundwater: None encountered

Remarks: Terminated at 0.30m bgl due to refusal in Made Ground
0.25m diameter concrete core taken from surface with hand excavated pit below
Elevation values and coordinates are approximate but have not been levelled in by a surveyor

ISO 9001 REGISTERED FIRM

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Geotechnical and Geoenvironmental Consultants

Trial Pit Log

Trial Pit No. CC 05

Project Location: COLT Data Centre, Powergate Business Park, Volt Avenue, London NW10 6PW

Co-ords: 520963E - 182785N

Level: 35.58 mAOD

Dates: 25/03/2021

Project Number: 21.02.026

Logged By: Adam Jones to BS 5930:2015

Water Strikes	Sample and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description
	Depth (m)	Type	Result				
				0.06	35.52		FILL BRICK paving
				0.10	35.48		FILL Grey yellow SAND
	0.20	D					MADE GROUND Brown clayey very sandy GRAVEL (very dense) with a low cobble content. Gravel and cobbles are angular to sub-angular of brick, flint and cement-concrete *... becoming clayey and dense below 0.30m bgl*
				0.50	35.08		MADE GROUND Yellow orange silty SAND (medium dense)
				0.55	35.03		
	0.60	D		0.60	34.98		MADE GROUND Dark grey slightly sandy GRAVEL (dense). Gravel is angular to subrounded of clinker, flint and brick End of Trial Pit at 0.60m

1

Method of excavation: Hand digging tools **Dimensions:** 25cm

Stability: Sides Stable

Groundwater: None encountered

Remarks: Terminated at 0.60m bgl due to refusal in Made Ground
Hand excavated inspection pit. Backfilled with arising upon completion
Elevation values and coordinates are approximate but have not

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Trial Pit Log

Trial Pit No.
CC 06

Project Location: COLT Data Centre, Powergate Business Park, Volt Avenue, London NW10 6PW

Co-ords: 520979E - 182791N
Level: 35.56 mAOD
Dates: 25/03/2021

Project Number: 21.02.026
Logged By: Adam Jones to BS 5930:2015

Water Strikes	Sample and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description
	Depth (m)	Type	Result				
							FILL CEMENT-CONCRETE
				0.12	35.44		MADE GROUND Grey brown sandy GRAVEL (very dense). Gravel is subangular to subrounded of igenous aggregate
				0.30	35.26		End of Trial Pit at 0.30m

1

Method of excavation: Concrete corer and hand digging tools
Dimensions: 25cm
Stability: Sides Stable
Groundwater: None encountered
Remarks: Terminated at 0.30m bgl due to refusal in Made Ground
0.25m diameter concrete core taken from surface with hand excavated pit below
Elevation values and coordinates are approximate but have not been levelled in by a surveyor

QMS ISO 9001 REGISTERED FIRM

AGS Association of Geotechnical & Geoenvironmental Specialists

LISTERS GEO
Geotechnical and Geoenvironmental Consultants

Trial Pit Log

Trial Pit No. CC 07

Project Location: COLT Data Centre, Powergate Business Park, Volt Avenue, London NW10 6PW

Co-ords: 520992E - 182789N

Level: 35.50 mAOD

Dates: 25/03/2021

Project Number: 21.02.026

Logged By: Adam Jones to BS 5930:2015

Water Strikes	Sample and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description
	Depth (m)	Type	Result				
							FILL CEMENT-CONCRETE ranging from 0.19m to 0.22m thick with 7mm diameter rebar at 0.07m bgl
				0.22	35.28		MADE GROUND Grey brown silty very sandy GRAVEL (very dense). Gravel is subangular to subrounded of flint, brick, cement-concrete and igneous aggregate
	0.40	D		0.40	35.10		End of Trial Pit at 0.40m

Method of excavation: Concrete corer and hand digging tools

Dimensions: 25cm

Stability: Sides Stable

Groundwater: None encountered

Remarks: Terminated at 0.40m bgl due to refusal in Made Ground
0.25m diameter concrete core taken from surface with hand excavated pit below
Elevation values and coordinates are approximate but have not been levelled in by a surveyor

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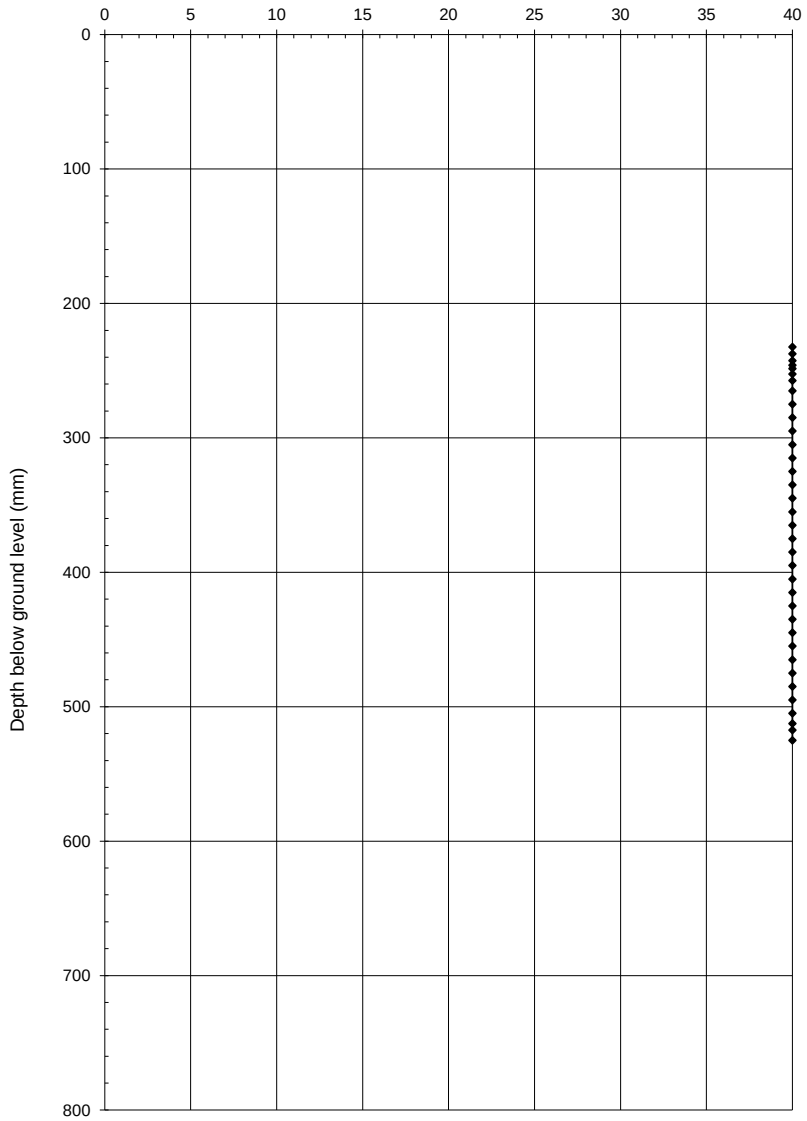
AGS Association of Geotechnical & Geoenvironmental Specialists

LISTERS GEO
Geotechnical and Geoenvironmental Consultants

Site :	COLT Data Centre, Powergate Business Park, Volt Avenue, London, NW10 6PW	Test No.:	CBR01
		Date tested:	16/03/2021

Blow Count	Penetration (mm)	mm per blow	Eq. CBR (%)
1	280	0	-
2	285	5.0	>40
3	290	5.0	>40
4	295	5.0	>40
5	297	2.0	>40
6	300	3.0	>40
11	305	1.0	>40
13	310	2.5	>40
16	320	3.3	>40
21	330	2.0	>40
25	340	2.5	>40
29	350	2.5	>40
33	360	2.5	>40
37	370	2.5	>40
40	380	3.3	>40
43	390	3.3	>40
46	400	3.3	>40
49	410	3.3	>40
52	420	3.3	>40
55	430	3.3	>40
57	440	5.0	>40
59	450	5.0	>40
62	460	3.3	>40
64	470	5.0	>40
67	480	3.3	>40
69	490	5.0	>40
72	500	3.3	>40
75	510	3.3	>40
78	520	3.3	>40
80	530	5.0	>40
83	540	3.3	>40
87	550	2.5	>40
93	560	1.7	>40
99	565	0.8	>40
109	570	0.5	>40
119	580	1.0	>40

Plot of Equivalent CBR (%) against Depth



Remarks:

Test commenced from base of concrete core at 0.23mbgl

Any data that equates to a CBR of >40% have been calculated and plotted to that value

Tested using 60 degree cone and calculated using the Kleyn & Van Heerden method:
Log10(CBR) = 2.632–1.28x Log10(mm/blow) and plotted at mid-point of each depth increment

TRL Dynamic Cone Penetrometer CBR Test

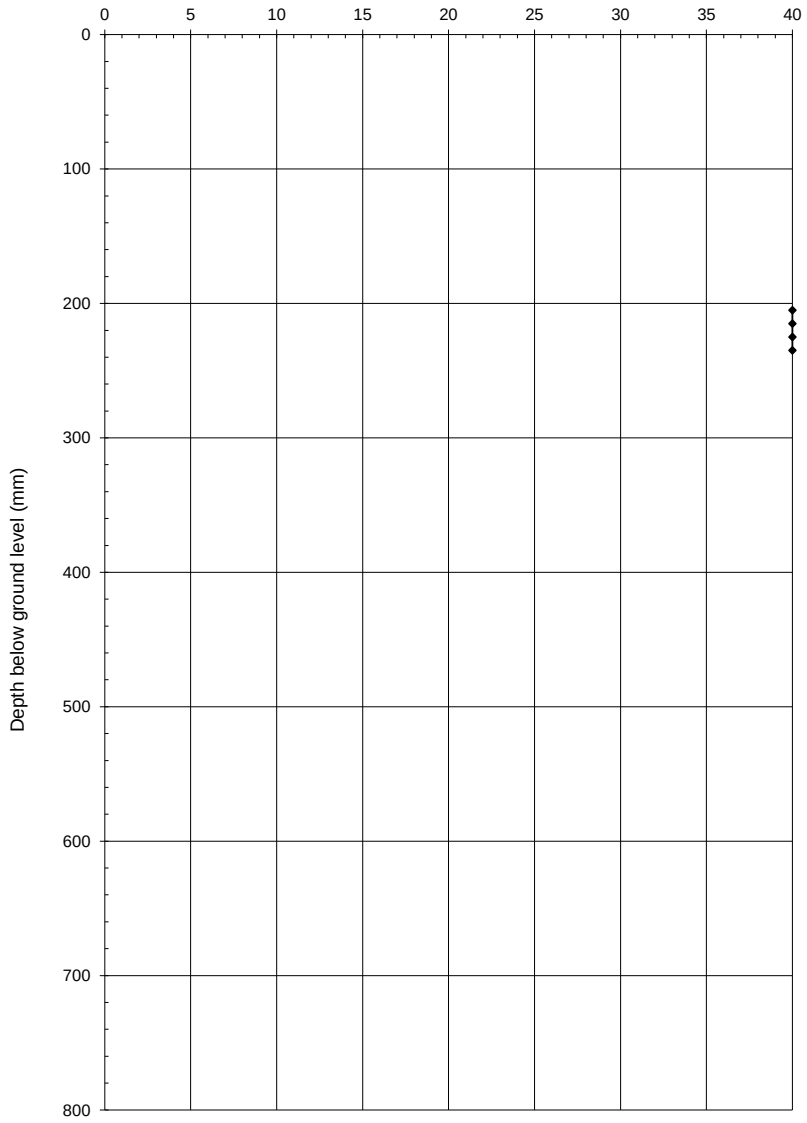
Report: **21.02.026**

LISTERS GEO
Geotechnical and Geoenvironmental Consultants

Site :	COLT Data Centre, Powergate Business Park, Volt Avenue, London, NW10 6PW	Test No.:	CBR02
		Date tested:	16/03/2021

Blow Count	Penetration (mm)	mm per blow	Eq. CBR (%)
0	280	0	-
3	290	3.3	>40
7	300	2.5	>40
13	310	1.7	>40
23	320	1.0	>40

Plot of Equivalent CBR (%) against Depth



Remarks:

Test commenced from base of concrete core at 0.20mbgl

Any data that equates to a CBR of >40% have been calculated and plotted to that value

Tested using 60 degree cone and calculated using the Kleyn & Van Heerden method:
Log10(CBR) = 2.632–1.28x Log10(mm/blow) and plotted at mid-point of each depth increment

TRL Dynamic Cone Penetrometer CBR Test

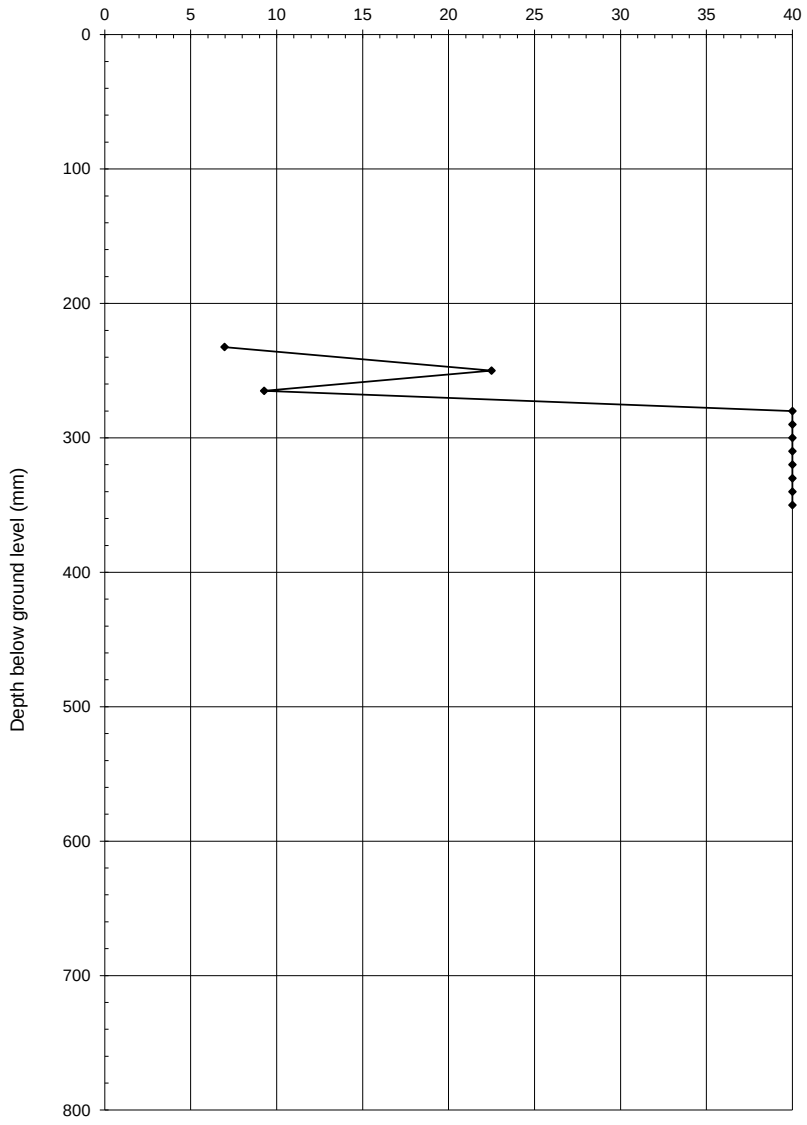
Report: **21.02.026**

LISTERS GEO
Geotechnical and Geoenvironmental Consultants

Site :	COLT Data Centre, Powergate Business Park, Volt Avenue, London, NW10 6PW	Test No.:	CBR03
		Date tested:	16/03/2021

Blow Count	Penetration (mm)	mm per blow	Eq. CBR (%)
0	255	0	-
1	280	25	7.0
2	290	10	22
3	310	20	9.3
6	320	3.3	>40
9	330	3.3	>40
13	340	2.5	>40
18	350	2.0	>40
23	360	2.0	>40
29	370	1.7	>40
32	380	3.3	>40
40	390	1.3	>40

Plot of Equivalent CBR (%) against Depth



Remarks:

Test commenced from base of concrete core at 0.22mbgl

Any data that equates to a CBR of >40% have been calculated and plotted to that value

Tested using 60 degree cone and calculated using the Kleyn & Van Heerden method:
Log10(CBR) = 2.632–1.28x Log10(mm/blow) and plotted at mid-point of each depth increment

TRL Dynamic Cone Penetrometer CBR Test

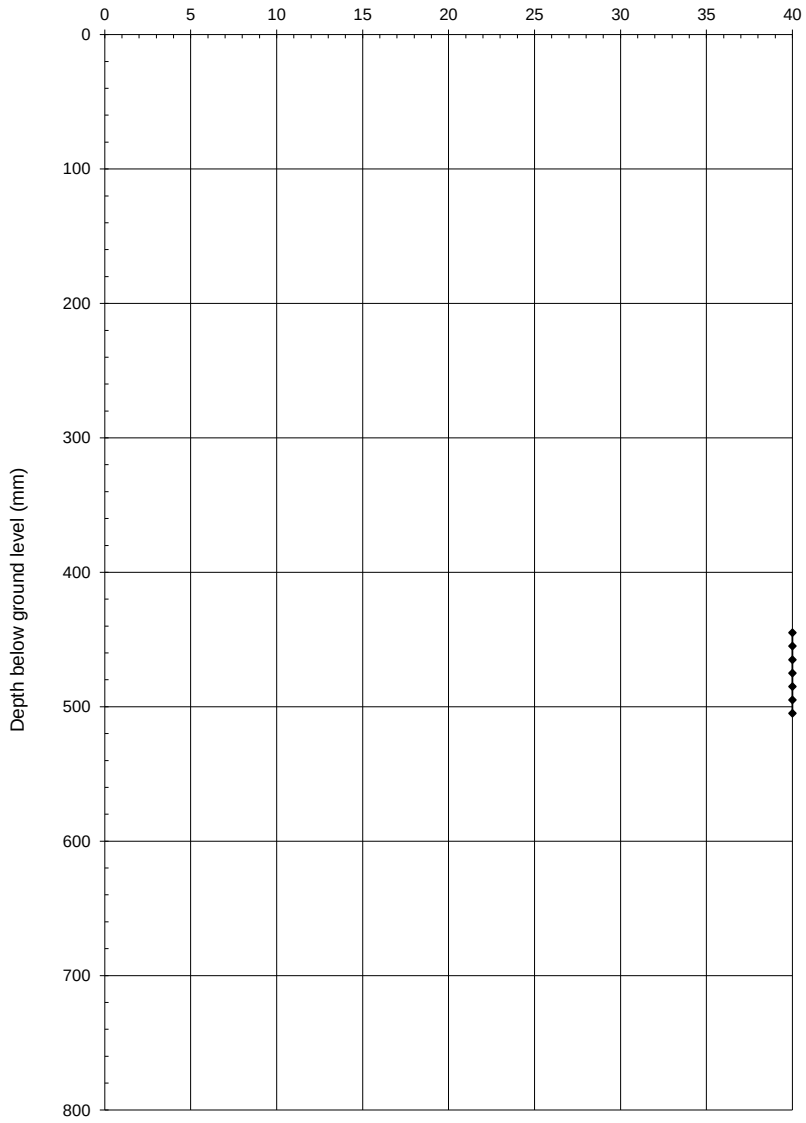
Report: **21.02.026**

LISTERS GEO
Geotechnical and Geoenvironmental Consultants

Site :	COLT Data Centre, Powergate Business Park, Volt Avenue, London, NW10 6PW	Test No.:	CBR03 (2)
		Date tested:	16/03/2021

Blow Count	Penetration (mm)	mm per blow	Eq. CBR (%)
0	470	0	-
2	480	5.0	>40
5	490	3.3	>40
10	500	2.0	>40
14	510	2.5	>40
19	520	2.0	>40
26	530	1.4	>40
36	540	1.0	>40

Plot of Equivalent CBR (%) against Depth



Remarks:

Test commenced from base of hand excavated pit at 0.44mbgl

Any data that equates to a CBR of >40% have been calculated and plotted to that value

Tested using 60 degree cone and calculated using the Kleyn & Van Heerden method:
Log10(CBR) = 2.632–1.28x Log10(mm/blow) and plotted at mid-point of each depth increment

TRL Dynamic Cone Penetrometer CBR Test

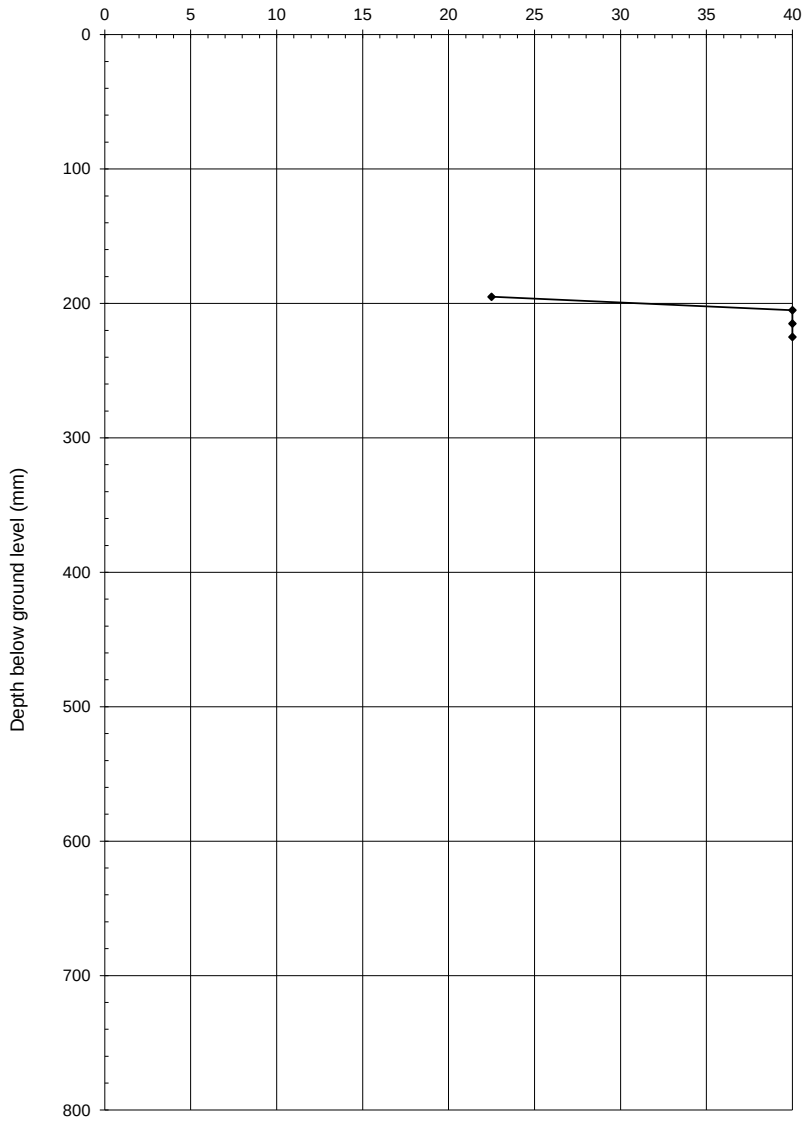
Report: **21.02.026**

LISTERS GEO
Geotechnical and Geoenvironmental Consultants

Site :	COLT Data Centre, Powergate Business Park, Volt Avenue, London, NW10 6PW	Test No.:	CBR04
		Date tested:	16/03/2021

Blow Count	Penetration (mm)	mm per blow	Eq. CBR (%)
0	240	0	-
1	250	10	22
4	260	3.3	>40
7	270	3.3	>40
17	280	1.0	>40

Plot of Equivalent CBR (%) against Depth



Remarks:

Test commenced from base of concrete core at 0.19mbgl

Any data that equates to a CBR of >40% have been calculated and plotted to that value

Tested using 60 degree cone and calculated using the Kleyn & Van Heerden method:
Log10(CBR) = 2.632–1.28x Log10(mm/blow) and plotted at mid-point of each depth increment

TRL Dynamic Cone Penetrometer CBR Test

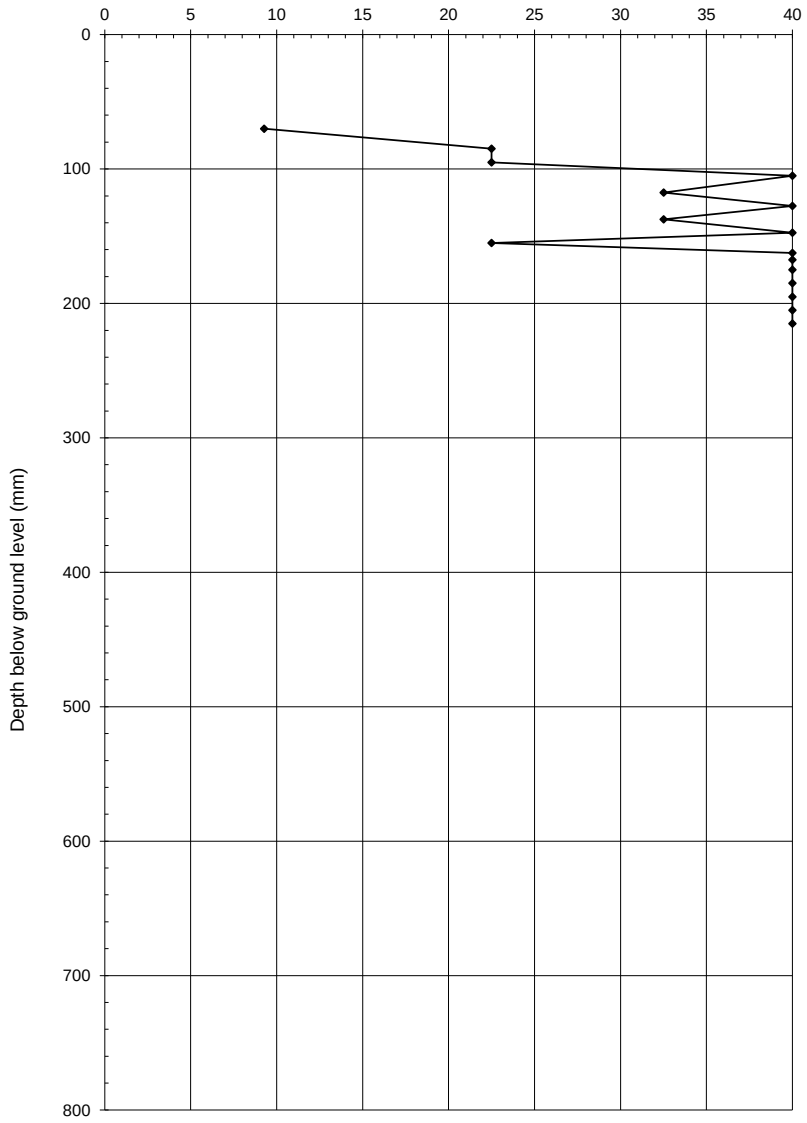
Report: **21.02.026**

LISTERS GEO
Geotechnical and Geoenvironmental Consultants

Site :	COLT Data Centre, Powergate Business Park, Volt Avenue, London, NW10 6PW	Test No.:	CBR05
		Date tested:	25/03/2021

Blow Count	Penetration (mm)	mm per blow	Eq. CBR (%)
0	120	0	-
1	140	20	9.3
2	150	10	22
3	160	10	22
5	170	5.0	>40
7	185	7.5	33
8	190	5.0	>40
10	205	7.5	33
11	210	5.0	>40
12	220	10	22
13	225	5.0	>40
15	230	2.5	>40
17	240	5.0	>40
20	250	3.3	>40
23	260	3.3	>40
25	270	5.0	>40
27	280	5.0	>40

Plot of Equivalent CBR (%) against Depth



Remarks:

Test commenced from base of hand excavated pit at 0.06mbgl

Any data that equates to a CBR of >40% have been calculated and plotted to that value

Tested using 60 degree cone and calculated using the Kleyn & Van Heerden method:
Log10(CBR) = 2.632–1.28x Log10(mm/blow) and plotted at mid-point of each depth increment

TRL Dynamic Cone Penetrometer CBR Test

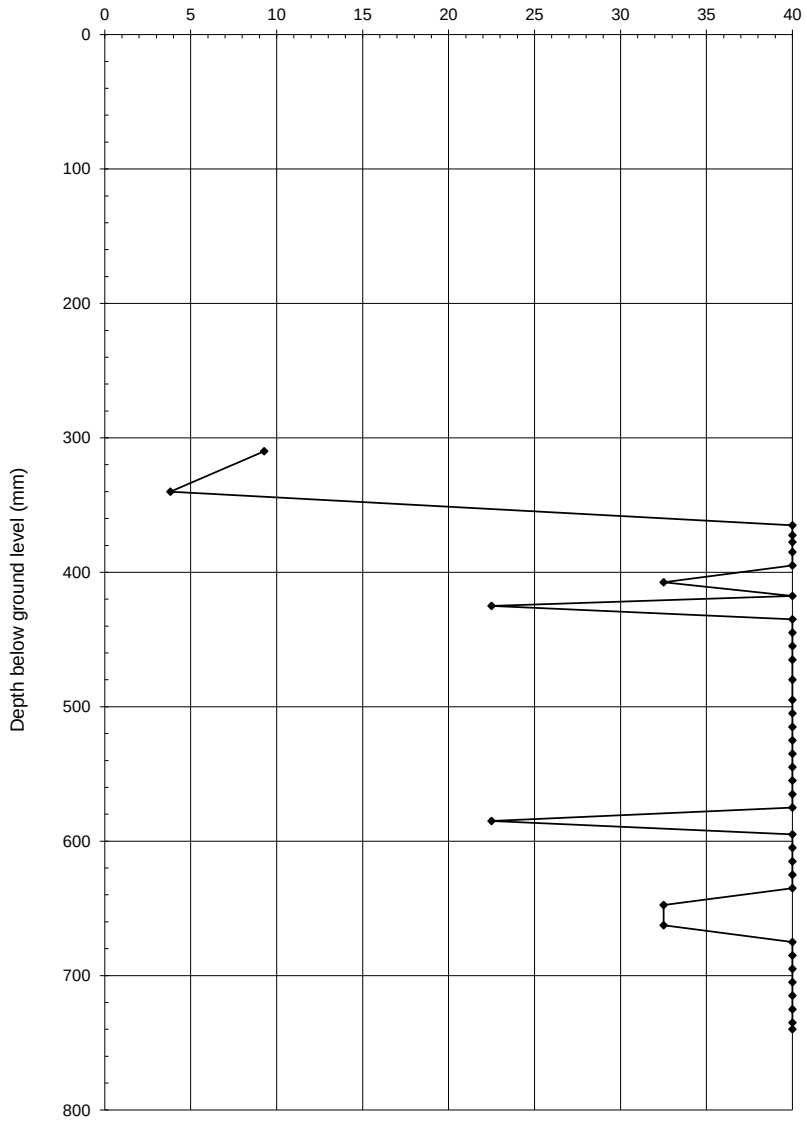
Report: **21.02.026**

LISTERS GEO
Geotechnical and Geoenvironmental Consultants

Site :	COLT Data Centre, Powergate Business Park, Volt Avenue, London, NW10 6PW	Test No.:	CBR05 (2)
		Date tested:	25/03/2021

Blow Count	Penetration (mm)	mm per blow	Eq. CBR (%)
	360	0	-
1	380	20	9.3
2	420	40	3.8
4	430	5.0	>40
6	435	2.5	>40
9	440	1.7	>40
14	450	2.0	>40
16	460	5.0	>40
18	475	7.5	33
19	480	5.0	>40
20	490	10	22
22	500	5.0	>40
25	510	3.3	>40
27	520	5.0	>40
30	530	3.3	>40
34	550	5.0	>40
36	560	5.0	>40
38	570	5.0	>40
41	580	3.3	>40
44	590	3.3	>40
47	600	3.3	>40
50	610	3.3	>40
52	620	5.0	>40
54	630	5.0	>40
56	640	5.0	>40
57	650	10	22
59	660	5.0	>40
61	670	5.0	>40
63	680	5.0	>40
65	690	5.0	>40
67	700	5.0	>40
69	715	7.5	33
71	730	7.5	33
73	740	5.0	>40
75	750	5.0	>40
77	760	5.0	>40
79	770	5.0	>40
82	780	3.3	>40
84	790	5.0	>40
87	800	3.3	>40
92	810	2.0	>40

Plot of Equivalent CBR (%) against Depth



Remarks:

Test commenced from base of hand excavated pit at 0.30mbgl

Any data that equates to a CBR of >40% have been calculated and plotted to that value

Tested using 60 degree cone and calculated using the Kleyn & Van Heerden method: Log10(CBR) = 2.632–1.28x Log10(mm/blow) and plotted at mid-point of each depth increment

TRL Dynamic Cone Penetrometer CBR Test

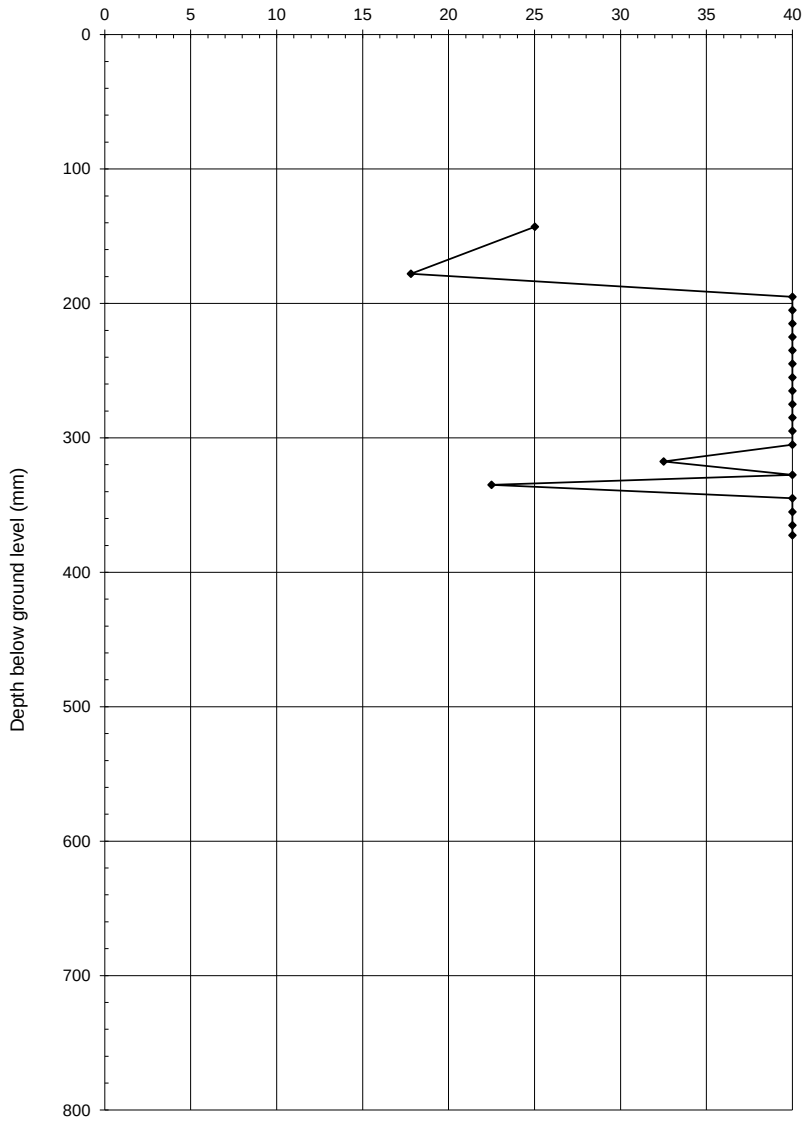
Report: **21.02.026**

LISTERS GEO
Geotechnical and Geoenvironmental Consultants

Site :	COLT Data Centre, Powergate Business Park, Volt Avenue, London, NW10 6PW	Test No.:	CBR06
		Date tested:	25/03/2021

Blow Count	Penetration (mm)	mm per blow	Eq. CBR (%)
0	170	0	-
5	216	9.2	25
7	240	12	18
9	250	5.0	>40
11	260	5.0	>40
14	270	3.3	>40
17	280	3.3	>40
20	290	3.3	>40
23	300	3.3	>40
26	310	3.3	>40
29	320	3.3	>40
31	330	5.0	>40
34	340	3.3	>40
37	350	3.3	>40
39	360	5.0	>40
41	375	7.5	33
42	380	5.0	>40
43	390	10	22
45	400	5.0	>40
47	410	5.0	>40
52	420	2.0	>40
57	425	1.0	>40

Plot of Equivalent CBR (%) against Depth



Remarks:

Test commenced from base of concrete core at 0.12mbgl

Any data that equates to a CBR of >40% have been calculated and plotted to that value

Tested using 60 degree cone and calculated using the Kleyn & Van Heerden method:
Log10(CBR) = 2.632–1.28x Log10(mm/blow) and plotted at mid-point of each depth increment

TRL Dynamic Cone Penetrometer CBR Test

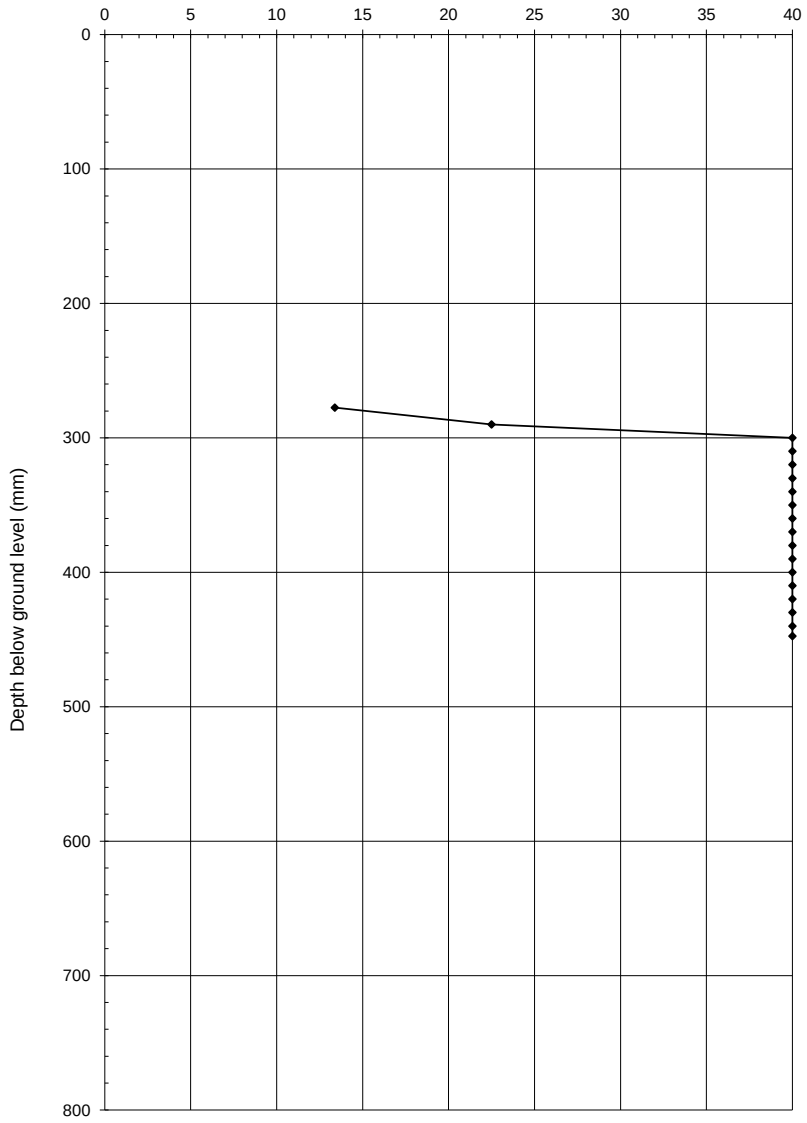
Report: **21.02.026**

LISTERS GEO
Geotechnical and Geoenvironmental Consultants

Site :	COLT Data Centre, Powergate Business Park, Volt Avenue, London, NW10 6PW	Test No.:	CBR07
		Date tested:	25/03/2021

Blow Count	Penetration (mm)	mm per blow	Eq. CBR (%)
1	335	0	-
2	350	15	13
3	360	10	22
8	370	2.0	>40
13	380	2.0	>40
19	390	1.7	>40
23	400	2.5	>40
27	410	2.5	>40
30	420	3.3	>40
34	430	2.5	>40
37	440	3.3	>40
43	450	1.7	>40
47	460	2.5	>40
52	470	2.0	>40
58	480	1.7	>40
67	490	1.1	>40
74	500	1.4	>40
85	510	0.9	>40
95	515	0.5	>40

Plot of Equivalent CBR (%) against Depth



Remarks:

Test commenced from base of concrete core at 0.27mbgl

Any data that equates to a CBR of >40% have been calculated and plotted to that value

Tested using 60 degree cone and calculated using the Kleyn & Van Heerden method:
Log10(CBR) = 2.632–1.28x Log10(mm/blow) and plotted at mid-point of each depth increment

TRL Dynamic Cone Penetrometer CBR Test

Report: **21.02.026**

LISTERS GEO
Geotechnical and Geoenvironmental Consultants

APPENDIX C
LABORATORY TEST REPORTS

GroundTech Laboratories

Geotechnical Testing Facility

Slapton Hill Barn, Blakesley Road, Slapton, Towcester, Northants. NN12 8QD

Telephone:- 01327 860947/860060 Fax:- 01327 860430 Email: groundtech@listersgeotechnics.co.uk

PROJECT INFORMATION

Site Location:- COLT Data Centre
Powergate Business Park
Volt Avenue
London
NW10 6PW

Client Reference:- -

Date Samples Received:- 19th March 2021

Date Testing Completed:- 31st March 2021

The results relate only to the samples tested

SAMPLE INFORMATION

Laboratory Tests Undertaken:-

TEST TYPE	TEST METHOD	TESTED
Natural Water Contents (WC%)	(BS 1377:Part 2:1990 Clause 3.2)	
Liquid Limits (%)	(BS 1377:Part 2:1990 Clause 4.3)	
Plastic Limits (%)	(BS 1377:Part 2:1990 Clause 5.3)	
Plasticity Index (%)	(BS 1377:Part 2:1990 Clause 5.4)	
Linear Shrinkage (%)	(BS 1377:Part 2:1990 Clause 6.5)	
PSD - Wet Sieving	(BS 1377:Part 2:1990 Clause 9.2)	✓
Engineering Sample Descriptions	(BS 5930 : Section 6)	
Passing 425/63 (μm)	-	
Hydrometer	(BS 1377:Part 2:1990 Clause 9.5)	
Loss on Ignition (%)	-	
Soil Suctions (kPa)	BRE Digest IP 4/93, 1993	
Bulk Density (Mg/m^3)	(BS 1377:Part 2:1990 Clause 7.2)	
Strength Tests	(BS 1377:Part 7:1990 Clause 8 & 9)	
Soluble Sulphate Content (SO_4g/l)	(BS 1377:Part 3:1990 Clause 5.3)	✓
pH value	(BS 1377:Part 3:1990 Clause 9.4)	✓
California Bearing Ratios (CBR)	(BS 1377:Part 4:1990 Clause 7)	
Compaction Tests	(BS 1377:Part 4:1990 Clauses 3.0-3.6)	

Laboratory testing in accord with BS EN ISO/IEC 17025-2000 and Quality Management in accord with ISO 9001

Signed on behalf of GroundTech Laboratories:-_____ Technical Signatory

Quality Assured to ISO 9001

GEOTECHNICAL LABORATORY TEST RESULTS

Report No: 21.02.026

GroundTech Laboratories

Geotechnical Testing Facility

Slapton Hill Barn, Blakesley Road, Slapton, Towcester, Northants. NN12 8QD
Telephone: 01327 860947/860060 Fax: 01327 860430 Email: groundtech@listersgeotechnics.co.uk

Quality Assured to ISO 9001

SAMPLES				CLASSIFICATION TESTS							CLASSIFICATION TESTS							STRENGTH TESTS					CHEMICAL TESTS	
Test Location	Sample Type	Sample Depth -m	Test Type	WC %	LL %	PL %	PI %	Passing 425 µm %	Modified PI %	Class	Passing 63 µm %	WC/ LL	PL+ 2%	Liquidity Index	Loss on Ignition %	Soil Suction kPa	Bulk Density Mg/m³	Test Type	Cell Pressure kN/m²	Deviator Stress kN/m²	Apparent Cohesion kN/m²	ϕ	pH Value	Soluble Sulphate Content SO4 g/l
CC 01	D	0.40	PSD																				11.7	0.33
CC 03	D	0.30	PSD																				12.0	0.12
CC 04	D	0.20	PSD																				10.0	0.06
CC 05	D	0.20	PSD																				9.9	0.23
	D	0.60	PSD																				8.1	0.25
CC 07	D	0.40	PSD																				10.2	0.38

Symbols:

U	Undisturbed Sample	R	Remoulded	PI	Plasticity Index	T	Triaxial Undrained	L	100mm specimen
D	Disturbed Sample	63	Passing 63µm	F	Filter Paper Suction Tests	M	Multistage Triaxial	S	38mm specimen
B	Bulk Sample	H	Hydrometer	CC	Continuous Core	HP	Hand Penetrometer		
W	Water Sample	PSD	Wet Sieving			V	Vane Test		

LABORATORY TEST RESULTS

Project Reference
21.02.026

GroundTech Laboratories

Geotechnical Testing Facility

Slapton Hill Barn, Blakesley Road, Slapton, Towcester, Northants. NN12 8QD

Telephone: 01327 860947/860060 Fax: 01327 860430 Email: groundtech@listersgeotechnics.co.uk

Quality Assured ISO 9001

Site: COLT Data Centre, Powergate Business Park, Volt Avenue, London, NW10 6PW

Test Location: CC 01

Sample Depth: 0.40m

Sample Description:

Hydrometer No.:

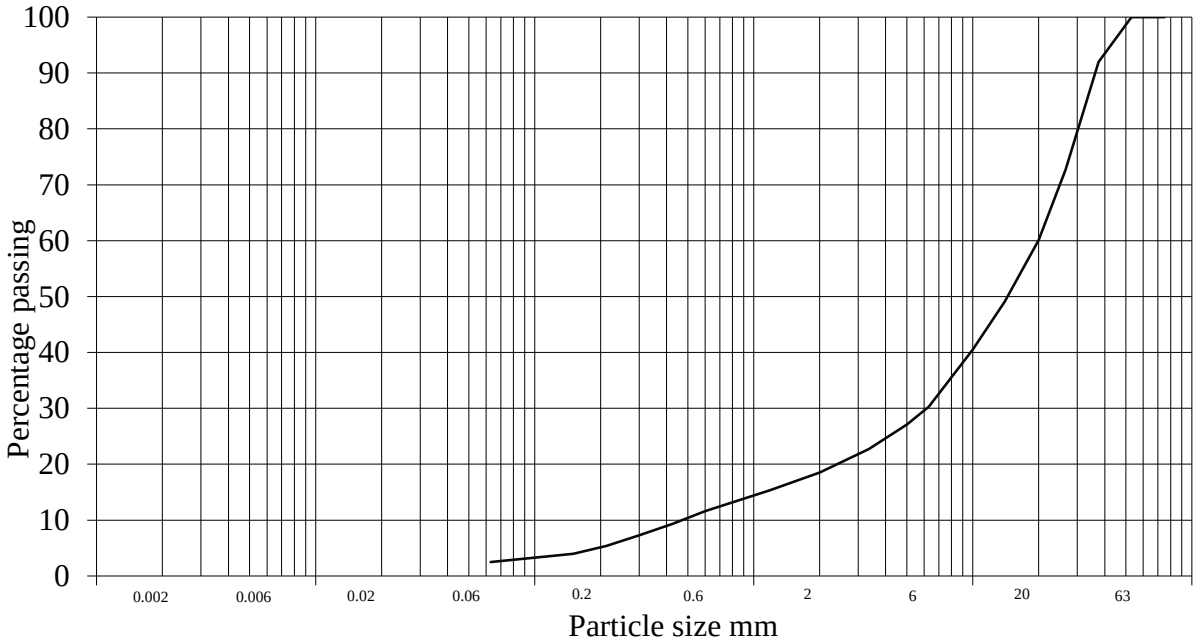
SG Gs:

Water Visc. (N):

Dry Mass of Soil after pretreatment (g):

Test Method: BS 1377 : Part 2 : 1990 : 9.2

BS test sieve	Cumulative Passing - %	Hydrometer Particle Diameter	Cumulative Passing - %
75mm	100.00		
63mm	100.00		
50mm	100.00		
37.5mm	92.00		
26.5mm	72.70		
20mm	60.10		
14mm	49.10		
10mm	40.50		
6.3mm	30.30		
5mm	27.10		
3.5mm	22.70		
2mm	18.50		
1.18mm	15.30		
600µm	11.60		
425µm	9.30		
300µm	7.30		
212µm	5.40		
150µm	4.00		
63µm	2.50		



CLAY	SILT			SAND			GRAVEL			COBBLES
	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse	
3%				16%			82%			0%

PARTICLE SIZE DISTRIBUTION

Project Reference
21.02.026

GroundTech Laboratories

Geotechnical Testing Facility

Slapton Hill Barn, Blakesley Road, Slapton, Towcester, Northants. NN12 8QD

Telephone: 01327 860947/860060 Fax: 01327 860430 Email: groundtech@listersgeotechnics.co.uk

Quality Assured ISO 9001

Site: COLT Data Centre, Powergate Business Park, Volt Avenue, London, NW10 6PW

Test Location: CC 03

Sample Depth: 0.30m

Sample Description:

Hydrometer No.:

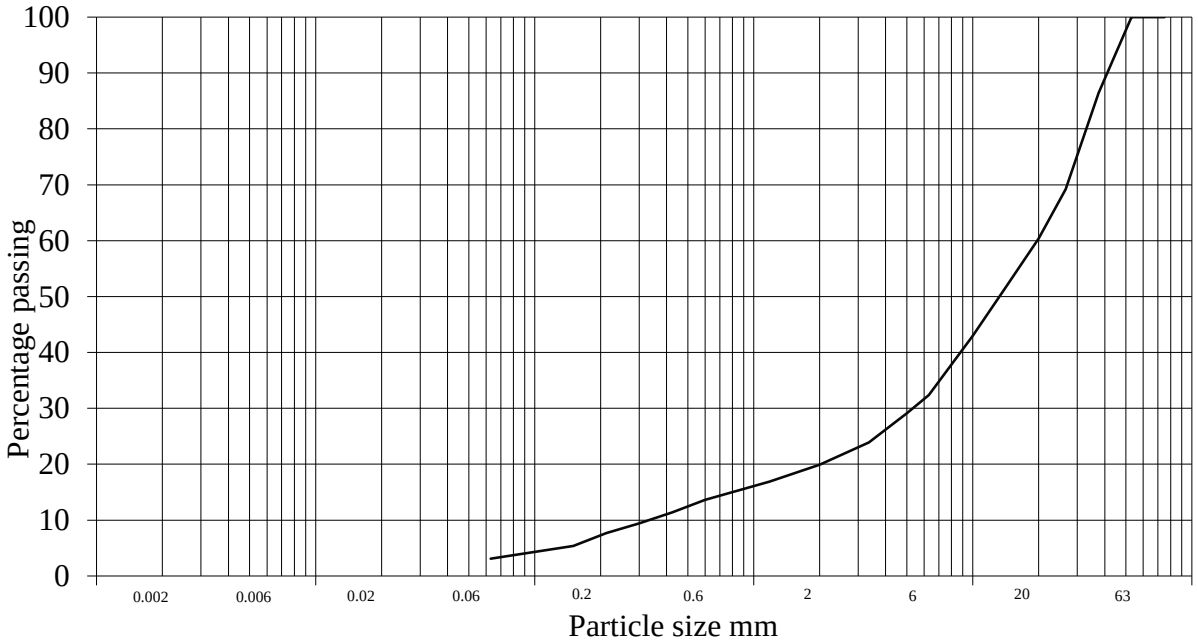
SG Gs:

Water Visc. (N):

Dry Mass of Soil after pretreatment (g):

Test Method: BS 1377 : Part 2 : 1990 : 9.2

BS test sieve	Cumulative Passing - %	Hydrometer Particle Diameter	Cumulative Passing - %
75mm	100.00		
63mm	100.00		
50mm	100.00		
37.5mm	86.40		
26.5mm	69.20		
20mm	60.40		
14mm	51.40		
10mm	43.00		
6.3mm	32.40		
5mm	29.10		
3.5mm	23.90		
2mm	19.90		
1.18mm	16.90		
600µm	13.60		
425µm	11.40		
300µm	9.40		
212µm	7.70		
150µm	5.40		
63µm	3.10		



CLAY	SILT			SAND			GRAVEL			COBBLES
	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse	
3%				17%			80%			0%

PARTICLE SIZE DISTRIBUTION

Project Reference
21.02.026

GroundTech Laboratories

Geotechnical Testing Facility

Slapton Hill Barn, Blakesley Road, Slapton, Towcester, Northants. NN12 8QD

Telephone: 01327 860947/860060 Fax: 01327 860430 Email: groundtech@listersgeotechnics.co.uk

Quality Assured ISO 9001

Site: COLT Data Centre, Powergate Business Park, Volt Avenue, London, NW10 6PW

Test Location: CC 04

Sample Depth: 0.20m

Sample Description:

Hydrometer No.:

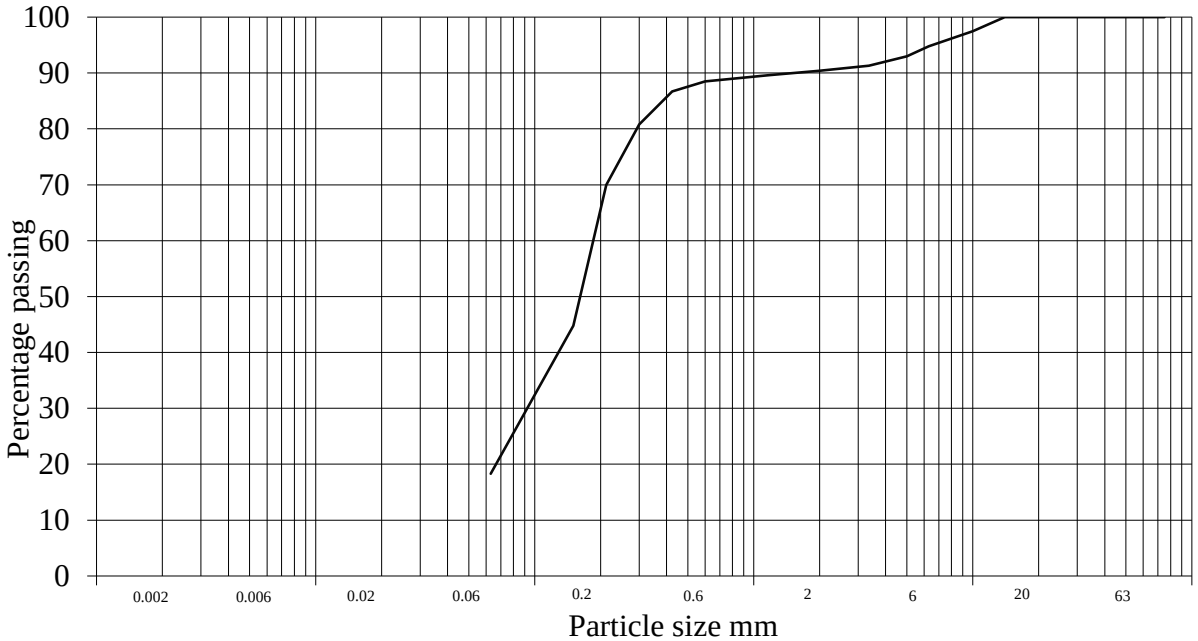
SG Gs:

Water Visc. (N):

Dry Mass of Soil after pretreatment (g):

Test Method: BS 1377 : Part 2 : 1990 : 9.2

BS test sieve	Cumulative Passing - %	Hydrometer Particle Diameter	Cumulative Passing - %
75mm	100.00		
63mm	100.00		
50mm	100.00		
37.5mm	100.00		
26.5mm	100.00		
20mm	100.00		
14mm	100.00		
10mm	97.50		
6.3mm	94.80		
5mm	93.00		
3.5mm	91.30		
2mm	90.40		
1.18mm	89.60		
600µm	88.50		
425µm	86.70		
300µm	80.80		
212µm	70.00		
150µm	44.80		
63µm	18.30		



CLAY	SILT			SAND			GRAVEL			COBBLES
	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse	
18%				72%			10%			0%

PARTICLE SIZE DISTRIBUTION

Project Reference
21.02.026

GroundTech Laboratories

Geotechnical Testing Facility

Slapton Hill Barn, Blakesley Road, Slapton, Towcester, Northants. NN12 8QD

Telephone: 01327 860947/860060 Fax: 01327 860430 Email: groundtech@listersgeotechnics.co.uk

Quality Assured ISO 9001

Site: COLT Data Centre, Powergate Business Park, Volt Avenue, London, NW10 6PW

Test Location: CC 05

Sample Depth: 0.20m

Sample Description:

Hydrometer No.:

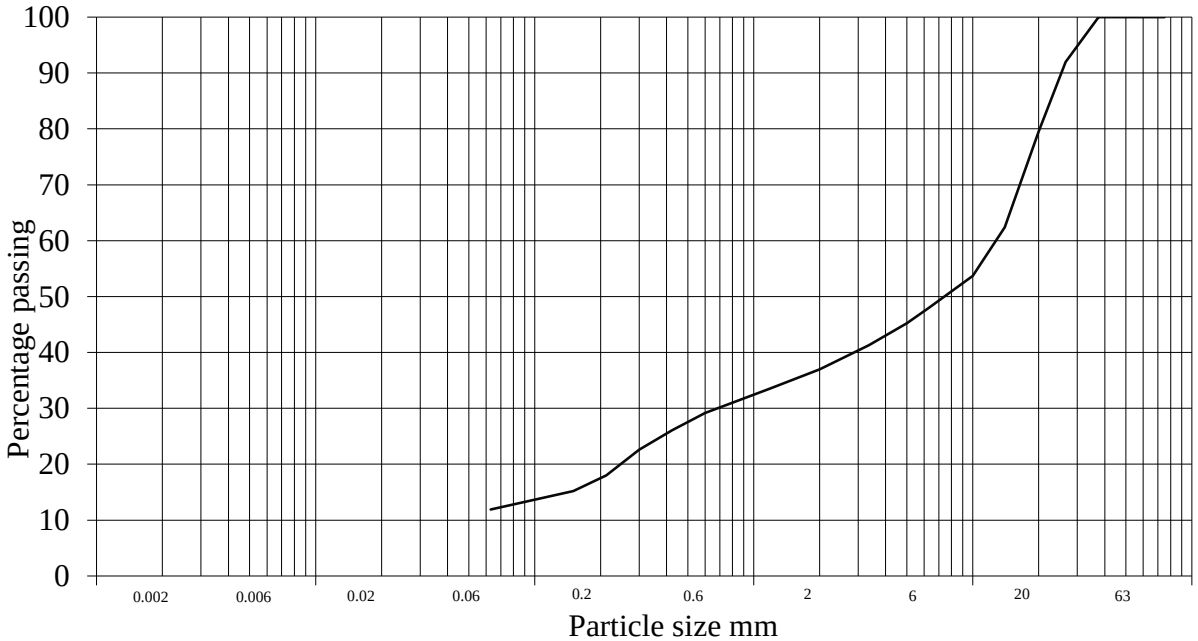
SG Gs:

Water Visc. (N):

Dry Mass of Soil after pretreatment (g):

Test Method: BS 1377 : Part 2 : 1990 : 9.2

BS test sieve	Cumulative Passing - %	Hydrometer Particle Diameter	Cumulative Passing - %
75mm	100.00		
63mm	100.00		
50mm	100.00		
37.5mm	100.00		
26.5mm	92.00		
20mm	79.50		
14mm	62.40		
10mm	53.70		
6.3mm	48.00		
5mm	45.20		
3.5mm	41.30		
2mm	37.00		
1.18mm	33.50		
600µm	29.20		
425µm	26.10		
300µm	22.60		
212µm	18.00		
150µm	15.20		
63µm	11.90		



CLAY	SILT			SAND			GRAVEL			COBBLES
	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse	
12%				25%			63%			0%

PARTICLE SIZE DISTRIBUTION

Project Reference
21.02.026

GroundTech Laboratories

Geotechnical Testing Facility

Slapton Hill Barn, Blakesley Road, Slapton, Towcester, Northants. NN12 8QD

Telephone: 01327 860947/860060 Fax: 01327 860430 Email: groundtech@listersgeotechnics.co.uk

Quality Assured ISO 9001

Site: COLT Data Centre, Powergate Business Park, Volt Avenue, London, NW10 6PW

Test Location: CC 05

Sample Depth: 0.60m

Sample Description:

Hydrometer No.:

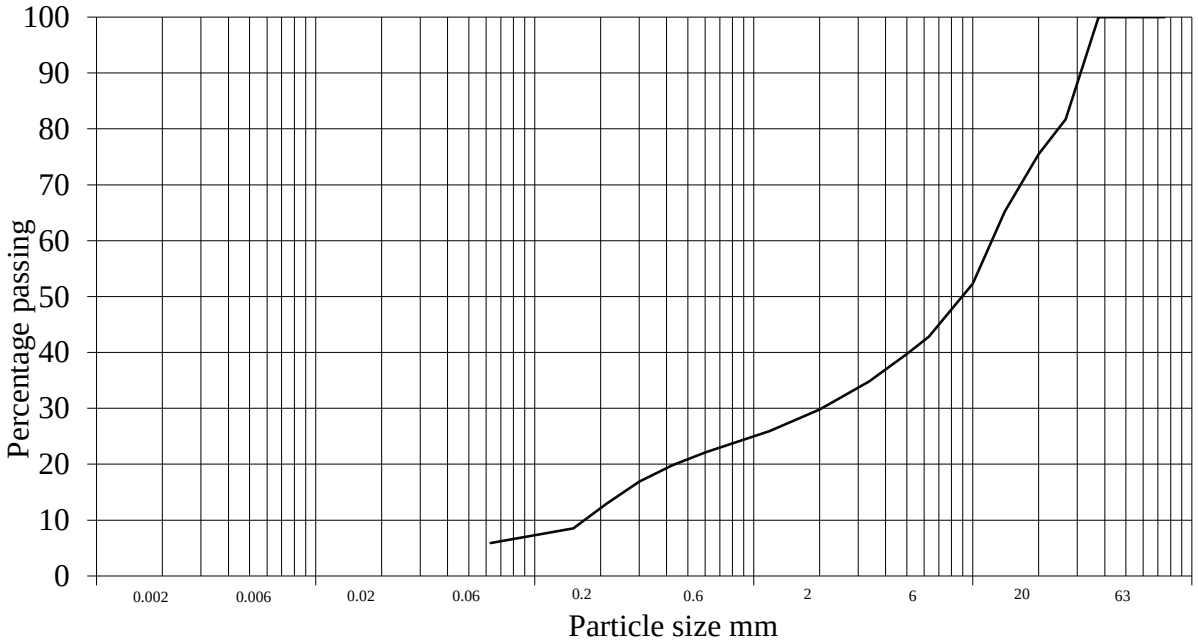
SG Gs:

Water Visc. (N):

Dry Mass of Soil after pretreatment (g):

Test Method: BS 1377 : Part 2 : 1990 : 9.2

BS test sieve	Cumulative Passing - %	Hydrometer Particle Diameter	Cumulative Passing - %
75mm	100.00		
63mm	100.00		
50mm	100.00		
37.5mm	100.00		
26.5mm	81.70		
20mm	75.50		
14mm	65.20		
10mm	52.30		
6.3mm	42.80		
5mm	39.70		
3.5mm	34.80		
2mm	29.80		
1.18mm	25.90		
600µm	22.10		
425µm	19.80		
300µm	16.90		
212µm	12.90		
150µm	8.50		
63µm	5.90		



CLAY	SILT			SAND			GRAVEL			COBBLES
	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse	
6%				24%			70%			0%

PARTICLE SIZE DISTRIBUTION

Project Reference
21.02.026

GroundTech Laboratories

Geotechnical Testing Facility

Slapton Hill Barn, Blakesley Road, Slapton, Towcester, Northants. NN12 8QD

Telephone: 01327 860947/860060 Fax: 01327 860430 Email: groundtech@listersgeotechnics.co.uk

Quality Assured ISO 9001

Site: COLT Data Centre, Powergate Business Park, Volt Avenue, London, NW10 6PW

Test Location: CC 07

Sample Depth: 0.40m

Sample Description:

Hydrometer No.:

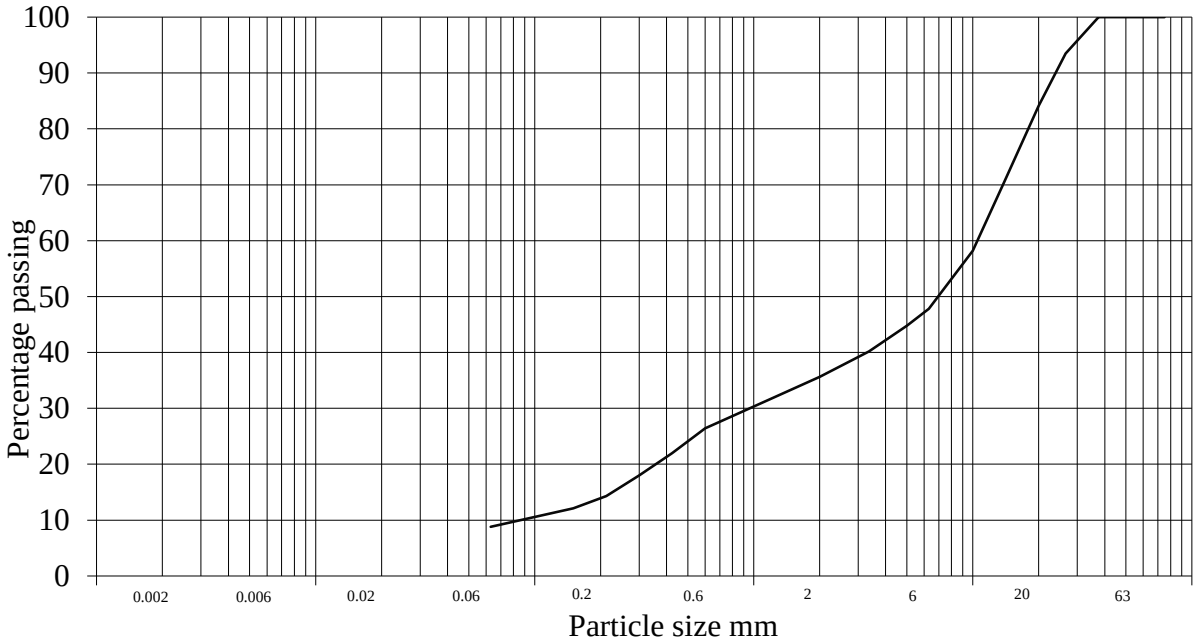
SG Gs:

Water Visc. (N):

Dry Mass of Soil after pretreatment (g):

Test Method: BS 1377 : Part 2 : 1990 : 9.2

BS test sieve	Cumulative Passing - %	Hydrometer Particle Diameter	Cumulative Passing - %
75mm	100.00		
63mm	100.00		
50mm	100.00		
37.5mm	100.00		
26.5mm	93.50		
20mm	84.10		
14mm	70.70		
10mm	58.20		
6.3mm	47.80		
5mm	44.80		
3.5mm	40.20		
2mm	35.60		
1.18mm	31.60		
600µm	26.40		
425µm	22.00		
300µm	18.00		
212µm	14.30		
150µm	12.10		
63µm	8.80		



CLAY	SILT			SAND			GRAVEL			COBBLES
	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse	
9%				27%			64%			0%

PARTICLE SIZE DISTRIBUTION

Project Reference
21.02.026

STRUCTURAL SOILS LTD

TEST REPORT

Report No. 584477-01 (00) 1774

Date 25-March-2021 Contract Powergates

Client RSK Materials and Structures
Address 18 Frogmore Rd
Apsley
Hemel Hempstead
Hertfordshire
HP3 9RT
For the Attention of Clive Rayner

Samples submitted by client	22-March-2021	Client Reference	1282878
Testing Started	22-March-2021	Client Order No.	N/A
Testing Completed	25-March-2021	Instruction Type	Written

Tests marked 'Not UKAS Accredited' in this report are not included in the UKAS Accreditation Schedule for our Laboratory.

UKAS Accredited Tests

10.06 Point Load Index ISRM:2007

* This clause of BS1377 is no longer the most up to date method due to the publication of ISO17892

Please Note: Remaining samples will be retained for a period of one month from today and will then be disposed of .
Test were undertaken on samples 'as received' unless otherwise stated.
Opinions and interpretations expressed in this report are outside the scope of accreditation for this laboratory.

Structural Soils Ltd 18 Frogmore Rd Hemel Hempstead HP3 9RT Tel.01442 416661 e-mail dimitris.xirouchakis@soils.co.uk

TESTING VERIFICATION CERTIFICATE

UKAS TESTING
1774

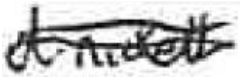
The test results included in this report are certified as:-

ISSUE STATUS: **FINAL**

In accordance with the Structural Soils Ltd Laboratory Quality Management System, results sheets and summaries of results issued by the laboratory are checked by an approved signatory. The integrity of the test data and results are ensured by control of the computer system employed by the laboratory as part of the Software Verification Program as detailed in the Laboratory Quality Manual.

This testing verification certificate covers all testing compiled on or before the following datetime: **25/03/2021 12:33:15**.

Testing reported after this date is not covered by this Verification Certificate.



Approved Signatory
David Nickells (Laboratory Technician)

(Head Office)
Bristol Laboratory
Unit 1A, Princess Street
Bedminster
Bristol
BS3 4AG

Castleford Laboratory
The Potteries, Pottery Street
Castleford
West Yorkshire
WF10 1NJ

Hemel Laboratory
18 Frogmore Road
Hemel Hempstead
Hertfordshire
HP3 9RT

Tonbridge Laboratory
Anerley Court, Half Moon Lane
Hildenborough
Tonbridge
TN11 9HU

STRUCTURAL SOILS LTD	Contract: **Powergates**	Job No: **584477**

DETERMINATION OF POINT LOAD STRENGTH

In accordance with ISRM 1974-2006

Exploratory Position ID	Sample Ref	Depth (m)	Type of Test	Width or Length (W or L) (mm)	Platen Separation (D) (mm)	Failure Load (P) (kN)	Equivalent Diameter (D_e) (mm)	Point Load (I_s) (MN/m^2)	Size Factor (F)	Point Load Index ($I_{s(50)}$) (MN/m^2)	Water Content (%)	Rock Type	Lab location
1	3	0.00	A	95	69	10.466	91	1.25	1.31	1.64 (✓)	3.9	CONCRETE	**H**

Results

$I_s(50)$ Mean Axial tests = **1.64** MN/m^2
Unable to calculate $I_a(50)$ Strength Anisotropy Index from this dataset.
Note:Size Correction Factor (F) calculated using $F = (D_e/50)^{0.45}$ (where D_e is equivalent core diameter).

Key

Type of Test column:, A = Axial, D = Diametral, I = Irregular, B = Block, L = Parallel, P = Perpendicular, [NS] denotes Non-standard Test.
Point Load Index column: (✓) = included in mean calculations, (✗) = excluded from mean calculations
Lab location: B = Bristol (BS3 4AG), C = Castleford (WF10 1NJ), H = Hemel Hempstead (HP3 9RT), T = Tonbridge (TN11 9HU)

STRUCTURAL SOILS
18 Frogmore Road
Hemel Hempstead
Hertfordshire
HP3 9RT

Compiled By		Date	Contract Ref:
	DAVID NICKELLS	**25.03.21**	**584477**
Contract: **Powergates**			

RSK Environment Ltd
Tel: +44 (0) 1442 437500
Fax: +44 (0) 1442 437550
Email: info2@rsk.co.uk
Web: www.rsk.co.uk

Materials & Structures
18 Frogmore Road
Hemel Hempstead
Hertfordshire
HP3 9RT

UKAS TESTING 0278

Compressive Strength of Concrete Cores
BS EN 12504-1: 2009

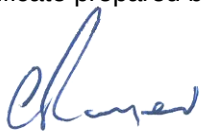
1282878 Powergate

Client Details			
Listers Geotechnical Consultants Limited Slapton Hill Barn Blakesley Road Towcester Northamptonshire NN12 8QD			
Contact name	Adam Jones		
Order reference	21.02.026/796	Order date	18/03/2021

Sample Details			
Sample type	Concrete cores	Cast date	Not advised
Sampled by	Client	Sampling date	Not advised
Age at test	Not advised	No of samples	2
RSK batch No	19346	Preparation method	Grinding
Receipt date	18/03/2021	Test date	23/03/2021

Methods	
Test	The test was carried out in accordance with BS EN 12504-1. BS EN 12504-1 permits cores to be tested in either a saturated or air-dried condition. The samples were tested dry Samples were recored from larger supplied samples. The procedures given in BS EN 12504-1 NA.3 have been followed to derive the corrected *in situ* cube strength, which assumes that the limitations on core location given in BS 6089 are applied. Density was determined by water displacement in accordance with BS EN 12390-7.
Notes	The nominal minimum designated size of a cylindrical or core test specimen stated in BS EN 12390 is 100 mm. Results obtained from smaller test specimens should be treated with caution, especially where the ratio of maximum aggregate size to core diameter is greater than about 1:3. The corrected *in situ* cube strength is only valid for cores with a length/diameter ratio of between 1.0 and 1.2.
Deviations	None.

Results
The results are reported on page 2 of this certificate.

Certification			
Certificate prepared by  Clive Rayner Principal Technician		Certificate reviewed and authorised by  Dr Ian G Blanchard Associate Director	
Testing by	CR	Certificate issue date	24/03/2021

The results given in this certificate relate only to those samples submitted and specimens tested and to any materials properly represented by those samples and specimens. Any opinions and interpretations expressed herein are outside the scope of our UKAS accreditation.

RSK Environment Ltd
Tel: +44 (0) 1442 437500
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Email: info2@rsk.co.uk
Web: www.rsk.co.uk

Materials & Structures
18 Frogmore Road
Hemel Hempstead
Hertfordshire
HP3 9RT

UKAS TESTING 0278

Sample Details		
RSK reference	**Client reference / Location**	**Abnormalities/observations noted on visual inspection**
C1	CC01	None
C2	CC02	None

Results		
RSK reference	C1	C2
Estimated voidage (%)	1.0	1.0
Estimated maximum aggregate size (mm)	20	20
Mass in air (g)	1667	1541
Mass in water (g)	950	900
As-received length, max/min (mm)	178/169	177/169
Portion tested in relation to as-received length (mm)	50-150	50-150
Mean diameter (mm)	94.0	94.0
Mean prepared length (mm)	103.6	95.8
Surface moisture condition at test	Dry	Dry
Failure load (kN)	379.4	297.7
Type of failure	Satisfactory	Satisfactory
Reinforcement (Y/N)	No	No
Total mass of reinforcement (g)	N/A	N/A
Compressive strength (N/mm^2)	54.7	42.9
Saturated Density (kg/m^3)	2320	2400
Corrected *in situ* cube strength (N/mm^2)	56.8	43.2
Length/diameter ratio	1.1	1.0
Distribution of steel in core (if present)		
Diameter of 1st bar (mm)		
Distance from end of core (mm)		
Diameter of 2nd bar (mm)		
Distance from end of core (mm)		
Diameter of 3rd bar (mm)		
Distance from end of core (mm)		

End of Certificate

RSK Environment Ltd
Tel: +44 (0) 1442 437500
Fax: +44 (0) 1442 437550
Email: info2@rsk.co.uk
Web: www.rsk.co.uk

Materials & Structures
18 Frogmore Road
Hemel Hempstead
Hertfordshire
HP3 9RT

UKAS TESTING 0278

Compressive Strength of Concrete Cores
BS EN 12504-1: 2009

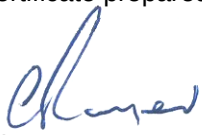
1282878 Powergate

Client Details			
Listers Geotechnical Consultants Limited Slapton Hill Barn Blakesley Road Towcester Northamptonshire NN12 8QD			
Contact name	Adam Jones		
Order reference	21.02.026/796	Order date	18/03/2021

Sample Details			
Sample type	Concrete cores	Cast date	Not advised
Sampled by	Client	Sampling date	Not advised
Age at test	Not advised	No of samples	2
RSK batch No	19346	Preparation method	Grinding
Receipt date	25/03/2021	Test date	07/04/2021

Methods	
Test	The test was carried out in accordance with BS EN 12504-1. BS EN 12504-1 permits cores to be tested in either a saturated or air-dried condition. The samples were tested in a dry condition. The procedures given in BS EN 12504-1 NA.3 have been followed to derive the corrected *in situ* cube strength, which assumes that the limitations on core location given in BS 6089 are applied. Density was determined by water displacement in accordance with BS EN 12390-7.
Notes	The nominal minimum designated size of a cylindrical or core test specimen stated in BS EN 12390 is 100 mm. Results obtained from smaller test specimens should be treated with caution, especially where the ratio of maximum aggregate size to core diameter is greater than about 1:3. The corrected *in situ* cube strength is only valid for cores with a length/diameter ratio of between 1.0 and 1.2.
Deviations	None.

Results
The results are reported on page 2 of this certificate.

Certification			
Certificate prepared by  Clive Rayner Principal Technician		Certificate reviewed and authorised by  Dr Ian G Blanchard Associate Director	
Testing by	CR	Certificate issue date	07/04/2021

The results given in this certificate relate only to those samples submitted and specimens tested and to any materials properly represented by those samples and specimens. Any opinions and interpretations expressed herein are outside the scope of our UKAS accreditation.

RSK Environment Ltd
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Web: www.rsk.co.uk

Materials & Structures
18 Frogmore Road
Hemel Hempstead
Hertfordshire
HP3 9RT

UKAS TESTING 0278

Sample Details		
RSK reference	**Client reference / Location**	**Abnormalities/observations noted on visual inspection**
C6	CC06	None
C7	CC07	None

Results		
RSK reference	C6	C7
Estimated voidage (%)	1.5	0.5
Estimated maximum aggregate size (mm)	20	20
Mass in air (g)	1784	1746
Mass in water (g)	1009	1007
As-received length, max/min (mm)	123/120	197/191
Portion tested in relation to as-received length (mm)	20-120	85-185
Mean diameter (mm)	98.0	98.0
Mean prepared length (mm)	103.6	98.4
Surface moisture condition at test	Dry	Dry
Failure load (kN)	315.8	327.8
Type of failure	Satisfactory	Satisfactory
Reinforcement (Y/N)	No	No
Total mass of reinforcement (g)	N/A	N/A
Compressive strength (N/mm^2)	41.9	43.5
Saturated Density (kg/m^3)	2300	2360
Corrected *in situ* cube strength (N/mm^2)	42.8	43.5
Length/diameter ratio	1.1	1.0
Distribution of steel in core (if present)		
Diameter of 1st bar (mm)		
Distance from end of core (mm)		
Diameter of 2nd bar (mm)		
Distance from end of core (mm)		
Diameter of 3rd bar (mm)		
Distance from end of core (mm)		

End of Certificate

LISTERS GEO
Geotechnical and Geoenvironmental Consultants

APPENDIX D
DESK STUDY INFORMATION

LISTERS GEO
Geotechnical and Geoenvironmental Consultants

DCS18253-LIS-ZZ-ZZ-RP-G-0001

Metnor Construction

Detailed UXO Risk Assessment

COLT Data centre
Powergate Business Park
Volt Avenue
London
NW10 6PW

Report No: 21.02.026
March 2021

DETAILED UNEXPLODED ORDNANCE RISK ASSESSMENT

COLT Data Centre
Powergate Business Park
Volt Avenue, London, NW10 6PW

Prepared for: Listers Geotechnical Consultants Ltd

Project Number: 6987

Version: 1.0

Dated: 09/03/2021

DISTRIBUTION

Project Number: 6987

Version: Issue version 1.0

Dated: 09/03/2021

Copy 1 LISTERS GEOTECHNICAL CONSULTANTS LTD

Copy 2 MACC INTERNATIONAL LTD

MACC International Limited
Camilla Court
Nacton Ipswich
IP10 0EU

Telephone Number: 01473 655127

Email: macc@macc-eod.com

Registered in England Company Registration Number 3014471

CONTENTS

REFERENCES

Publications

Sources of information used in the compilation of this study included:

German Air Raids on Britain 1914-18. Morris 1925

Unexploded Ordnance (UXO) – A guide for the Construction Industry. CIRIA C681

Dangerous Energy. Cocroft 2000

The Blitz Then and Now Volumes 1 to 3. Ramsey 1987

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Fields of Deception & Anti Aircraft Command. Dobinson 1988

Target Reconnaissance Photography. Luftwaffe 1939-44

Battle Stations Volume 3 DJ Smith 1980

National & Local Archive Reports, Accounts and Bomb Census Maps (where available)

Internet Information

Additional information was provided through the following credible internet sites, their assistance is credited where appropriate:

Army EOD Incidents

RAF EOD Incidents & Air Situation Reports 1939-45

Luftwaffe Strategy & Tactics

Luftwaffe Bomber Specifications

WO Defence Arrangements 1939-45

News Reports Witness Accounts 1939-45

Latest News Reports

Project Information

Site and project information was provided by Listers Geotechnical Consultants Ltd.

TERMS AND DEFINITIONS

Anti-Aircraft Ammunition (AAA)
High Explosive shells ranging from 30mm to 155mm used by air defence batteries to attack or deter enemy air attack.

Air Dropped Munition
A bomb or container dropped from an aircraft which is designed to detonate at a pre determined altitude, on impact or using a delay mechanism; after impact.

Air Dropped Sub-Munitions (Bomblet)
Small sub-munitions dispensed from a larger carrier which may be fixed to the aircraft or dropped as a single container munition which was designed to open above the target spreading its contents over a large area. Some designs are extremely dangerous and fitted with anti-handling devices.

Area Clearance
This is the term used for the systematic clearance of explosive ordnance from land, including military property, firing and bombing ranges, airfields and training areas. When the land is a former wartime battle ground, the term used is Battle Area Clearance (BAC)

Blast Zone
This term refers to the area around an explosive detonation where the explosive overpressure (Blast) can cause damage, injury or death.

Explosive Ordnance (EO)
All manufactured or improvised items designed to contain explosive, propellant, pyrotechnic and fissionable material or biological or chemical agents or pre-cursers which when coupled with an initiation or dispersal system are designed to cause damage, injury or death.

Explosive Ordnance Disposal (EOD)
A series of recognised procedures and protocols which are used by specialists in the detection, identification, evaluation, risk assessment, render safe, recovery and disposal of any item of explosive ordnance or improvised explosive device.

Fragmentation Zone
This is the term which refers to the danger area in which a piece of an item of explosive ordnance will travel on detonation. This zone is normally greater than the blast zone.

Geophysical Survey
The use of magnetometers, ground penetrating radar or other geophysical data gathering systems, which is then used for evaluation, risk assessment and to quantify further mitigation requirements.

High Explosive (HE)
High explosives react/detonate at a rate of around 9,000 metres per second, to all intents and purposes, instantaneously.

Imperial War Museum (IWM)
Wartime records source based in Lambeth Road London.

Incendiary Bomb (IB)

Incendiary bombs ranged from 1kg in size to 500kg the larger sizes were designated as Oil Bombs. Fills range from Thermite mixtures, Phosphorus, Kerosene or other pyrotechnic mixtures.

Intrusive Search

This term refers to the process of introducing a specialist magnetometer by pushing or drilling the sensor in to the ground to a pre determined depth, thus allowing construction activities such as: piling, soil testing and deep intrusive ground works to be conducted safety.

Land Service Ammunition (LSA)

LSA is a term that refers to all items containing explosives, pyrotechnic or noxious compounds which are placed, thrown or projected during land battles.

Local Records Office (LRO)

Wartime records source charged with maintaining the records for the Region, County, Borough or City.

National Archive (NA)

Wartime records source housed in Kew Gardens London.

Oil Bomb (OB)

Large airdropped bomb or modified ordnance container containing flammable material and accelerant, these weapons normally range in weight from 250 – 500kg.

Parachute Mine (PM)

Air-dropped mine designed to detonate at a pre set altitude above the ground. Essentially a large blast bomb with an explosive content of 1600 kg commonly fitted with anti-handling or anti-removal fuzes.

Unexploded Bomb (UXB)

Any air dropped bomb that has failed to function as designed.

Unexploded Ordnance (UXO)

Explosive ordnance that has been primed, fused, armed or otherwise prepared for use or used. It may have been fired, dropped, launched or projected yet remains unexploded either through malfunction or design or for any other cause.

War Office (WO)

This was the United Kingdom Government department responsible for defence of the realm, forerunner of the Ministry of Defence (MoD).

White Phosphorus (WP)

Munitions filled with WP_4 are designed for signalling, screening and incendiary purposes. They achieve their effect by dispersing WP, which burns on contact with the air.

World War One or Two (WWI or WW2)

Period of multi-national conflict, specifically: WW1; 1914-1918 or WWII; 1939-1945.

1 INTRODUCTION

1.1 Instruction & Scope

MACC International Ltd was commissioned by Listers Geotechnical Consultants Ltd to conduct a Detailed Unexploded Ordnance (UXO) Risk Assessment for COLT Data Centre, Powergate Business Park, Volt Avenue, London, NW10 6PW (See Annex A-1). The scope of the assessment is to determine the likelihood of an encounter with UXO within the context of the execution of ground investigations and any subsequent development works.

1.2 Methodology & Purpose

The methodology used in the assessment complies with the United Nations (IMAS) standards for UXO/Mine Level 1 Survey (Desk Top Study), the CIRIA C681 “Unexploded Ordnance (UXO) – A guide for the Construction Industry” and the recognised best practice advocated by the Health and Safety Executive (HSE). The quality and environmental aspects of the assessment comply with UKAS Accredited ISO 9001:2015 and ISO 14001:2015 standards. The purpose of the assessment is that of evaluation and to provide an aid in decision making by our client.

2 DETERMINING THE LIKELIHOOD OF ENCOUNTER

2.1 Aim, Research Restrictions & Indemnity

This risk assessment has drawn upon archive records which are within the public domain; however, these are acknowledged to be incomplete. Consequently, some incidents may have occurred where the records no longer exist or could not be located. The Secretary of State of the United Kingdom and MACC International Ltd does not accept responsibility for the accuracy or completeness of the information contained within the records. Some records regarding the UXO situation on some sites may not yet be within the public domain. Consequently, such information was not available for evaluation by MACC International Ltd. Research of the site history, regarding military usage, bombing raids and bomb impacts has been undertaken to establish the following:

- Frequency and location of enemy bombing raids and damage sustained to the site.
- The potential for UXO to remain on the site.
- Records of UXO removal activities and encounters.

2.2 Relevant Publications & Credible Internet Information

Published sources of information used in the compilation of this assessment are listed within the reference section including those provided by the client. Additional information was provided through credible internet sites; their assistance is credited where appropriate and details are listed within the reference section of this report.

3 THE SITE

The site footprint is located at Volt Avenue, London Borough of Ealing and is centred at approximate grid reference 520969, 182795. The site is currently occupied by the COLT Data Centre. During WWII, the site footprint was located within a large industrial complex at Park Royal consisting of various industrial works including Willesden Power Station to the north of the site, commercial property to the south and considerable railway infrastructure to the east. The site footprint has undergone a significant level of post-war development.

4 FUTURE INTENTIONS

Future intentions for the site were not disclosed. It has however been assumed that geo-environmental investigations will be conducted prior to the commencement of any subsequent development works.

5 HISTORICAL INFORMATION

5.1 British Archives

Prior to 1942 the United Kingdom did not operate a national recording system for EO/UXO incidents or military use of land. The records compiled during 1939-1942 were conducted under local arrangements and were only as detailed and accurate as the availability of time, personnel and the ease of access to information would allow. In April 1942, the Ministry of Home Security instigated a training programme for all personnel maintaining bomb census records, these standardised national records and greatly improved the accuracy of the information. Lack of exact bomb strike positions were most common where bombs fell on open ground well away from structures or buildings.

5.2 Manned Air Raids & Unmanned Rocket Attack Reports

WWI: Although the area did suffer enemy bombing during this period, no records were found to confirm a bomb strike within the site footprint or adjacent land. Consequently, this source of UXO contamination is considered to be highly unlikely.

WWII: The Municipal Borough of Acton suffered a high level of enemy bombing during WWII. The site footprint was located within a large industrial complex consisting of various industrial works including Willesden Power Station to the north of the site, commercial property to the south and considerable railway infrastructure to the east. Luftwaffe photography of the area highlights the large industrial area and adjacent railway infrastructure to be targets of strategic importance. Willesden Power Station to the north of the site was also identified as a bombing target.

Bomb Census Mapping for the area (TNA Ref: HO 193 series) was found to indicate that several bomb strikes fell in the immediate area of the site, although a bomb strike within the site footprint itself was not confirmed. The nearest recorded HE bomb strikes occurred approximately 110m to the south-east of the site near the main railway line, 120m to the south-east of the site near the present day Volt Avenue and 130m to the south-west near Chase Road. A further HE strike was recorded approximately 170m to the north-west of the site at North Acton Road.

Further records were found to verify that the Chase Factory Estate suffered a significant level of damage as a result of enemy bombing during September and November 1940. Post-war aerial imagery of the area shows potential bombing damage to commercial property to the south-west of the site at Chase Road. Records also indicate that a V1 Flying Bomb fell an estimated 140m to the north-west of the site at Wesley Playing Fields in June 1944.

Despite the significant level of enemy bombing recorded in the immediate surrounding area, no records were found to confirm a bomb strike within the site footprint. Given the significant level of post-war development that has taken place within much of the site footprint, this source of UXO contamination is on balance considered to be unlikely.

5.3 Airdropped Sub-Munitions' Reports

Records were found to indicate that the industrial area surrounding the site footprint did suffer enemy cluster/incendiary bombing during WWII. However, no records were found to confirm strikes within the site footprint. Given the low ground penetration potential for such weapons and the significant level of post-war development that has taken place within the site footprint, this source of UXO contamination is on balance considered to be unlikely.

5.4 Anti-Aircraft Ammunition (AAA) Reports

Local fixed and mobile Anti-Aircraft defences were positioned in the area to defend against air attack, the nearest of which was a Heavy Anti-Aircraft Battery located approximately 1.6km to the south-east of the site. It is considered reasonable to assume that test firing and combat engagements with enemy aircraft did take place during WWII. Consequently, this source of UXO contamination is considered to be credible, albeit unlikely given the distances involved.

5.5 Abandoned Bomb Reports

No records were found to confirm or otherwise indicate that an unexploded bomb was abandoned within the site footprint.

5.6 Migration of UXO

It is considered possible; albeit unlikely, that a bomb was imported onto the site from other bomb sites. Additionally, where land ground levels have been increased or in-filled using Marine Dredged Aggregates there is a high potential for the aggregate to contain items of UXO. Consequently, these must be considered to have the potential to represent an additional source of UXO contamination.

5.7 Bombing Decoys

There were no bombing decoys located in the immediate area of the site. Consequently, these are not considered to be a credible source of additional UXO contamination.

5.8 **Military Use**

Although there was a military presence in the area during WWII, no records were found to confirm military use of the site footprint. Consequently, potential UXO contamination as a result of military activity is not considered to be credible.

5.9 **Downed / Crashed Military Aircraft**

No records were found to indicate that an armed aircraft crashed within the site footprint.

6 DETERMINING THE NATURE OF RISK

6.1 General

While HE warheads are very unlikely to detonate if left undisturbed they remain inherently dangerous and may function if subjected to suitable stimuli. The most common of these stimuli is shock, friction or heat which may cause the fuze to function or unstable explosive materials such as Picric Acid (2-4-6 Trinitrophenol (TNP)) to explode. However, in the case of incendiary bombs containing White Phosphorus (WP_4) exposure of the WP to the oxygen in the air will result in its violent ignition and combustion which may cause any HE content within the munition to detonate.

6.2 German Bombing Tactics

The tactics employed by the German Air Force during WWII show that they had a wide variety of bombs at their disposal. The most common ranged in weight from 50 kg through to 500 kg. Some models in this range of bombs were designed to be “carrier” bombs. These containers could hold potentially hundreds of smaller sub-munitions (anti personnel or incendiary bomblets). Although dropped in lesser quantities, the German arsenal also included larger bombs and parachute mines up to 1,400 kg in weight. Unmanned attacks were also mounted by the Germans using V1 Rockets and V2 Missiles, each with a warhead around 1,000 kg in weight.

6.3 Bomb Trajectory & Ground Penetration

During WWII, the Ministry of Home Security undertook a major study on bomb penetration depths using 1,328 actual bomb impact events to provide statistical analysis of penetration potential. As a result, they determined the expected behaviour of a range of bomb weights through different geological strata around the Capital. Their findings remain the only empirical gained figures to have been gathered to date for England. A summary of their findings can be found in Table 1 of this study. A number of factors will influence the behaviour of a bomb on impact with the target and its trajectory through the ground. Relevant factors include: Height and speed of release of the bomb, aerodynamic qualities of the bomb, the angle of flight and impact and the nature of impact surface and sub soil.

6.3.1 In determining the potential bomb penetration depths into the ground, using the historic geotechnical information, other factors considered were: Release height 4,545 metres (15,000 ft). Most common GP Bomb used of 500 kg in weight and an impact Angle Range of 90° (tail vertical) to 0° (tail horizontal).

6.3.2 Table 1. Extract of Ministry of Home Security Bomb Penetration Study

	Bomb Weights			
Sub Soil Type	50kg	250kg	500kg	1000kg
Soft Rock or Made Ground	2.442	5.016	6.006	7.062
Gravel	2.442	5.016	6.006	7.062
Dry Clay	3.7	7.6	9.1	10.7
Average Offset (m)	0.8-1.6	1.6-3.7	3-4.5	3.4-5.3

6.3.3 Bombs on penetration of the surface do not tend to follow a straight line trajectory, due to a number of factors, shape, angle of entry, weight and speed; they tend to arc or curve; known as a “J” curve. With the horizontal distance from the entry point to the resting point known as the offset. The typical offset is generally taken to be $^{1}/_{3}^{rd}$ of the penetration depth. However, this distance can vary greatly if the bomb strikes an obstacle just below the surface. With this mechanism of offset, it is therefore a possibility that a bomb could enter the ground outside a building and come to rest within its footprint. Having reviewed the bomb penetration information and having provided a reasonable safety factor it is considered that:

- The maximum bomb penetration depth is estimated at 10.5 metres from the 1941 ground level. The expected offset from impact point is estimated to be 3.5 metres.
- The maximum ground penetration for an AA Artillery Shell is estimated at 1.5 metre below the 1941 ground level.

7 ENVIRONMENTAL IMPACT FROM UXO

7.1 Ground Contamination & Health Risk vectors

The amount of explosive material within the most common bombs is not considered sufficient to pose a significant widespread environmental risk. Nevertheless, it should be noted that the following components are commonly used in the manufacture of a high explosive bomb and may pose a localised contamination risk to health:

- Lead (Pb)
- Zinc (Zn)
- Copper (Cu)
- Iron (Fe)
- Mercury (Hg)
- Silver Fulminate (AgCNO)
- Aluminium (Al)
- Trinitrophenol ($C_6H_3N_3O_7$)
- Trinitrotoluene ($C_7H_5N_3O_6$)
- Trimethylene ($N(CH_3)_3$)
- Trinitramine ($C_3H_6N_6O_6$)
- Ammonium (NH_4)
- Sodium Nitrate ($NaNO_3$)
- Nitro-glycerine ($C_3H_5N_3O_9$)
- White Phosphorus (WP_4). This chemical may pose a significant immediate risk of spontaneously combusting when exposed to the oxygen in the air. WP will generate large quantities of toxic white smoke when ignited.

7.2 It is recommended that specialist environmental and medical advice be sought to identify any health or other risks posed by these and other chemical compounds.

8 RISK ASSESSMENT

8.1 Risk Source

Although the area suffered a significant level of enemy bombing during WWII, no records were found to confirm a bomb strike within the site footprint. Records are acknowledged to be incomplete and include errors; the possibility that items of UXO may have found their way onto the site and remain to the present day is considered credible.

8.2 Risk Pathway

The risk pathway is considered to be ground intrusive investigations and earth works.

8.3 Consequence

The consequences of a UXB detonation on site during construction works are considered to be a factor of the size of the blast and the proximity of assets and individuals to the point of detonation. These will include potential to kill or seriously injure personnel destroy or damage high value site assets, nearby public, private property and infrastructure.

8.4 Risk Rating

H = A figure derived from assessing the history of the site weighing up factors such as recorded bomb damage, threat weapon type, military use and the scope of any post conflict development.

W = A figure derived from assessing the type of the process to be undertaken without putting in place any UXO mitigation measures. A low figure is assigned where the process is relatively nonaggressive (minimal ground or point shock). A high figure is used where the work is considered aggressive (significant ground or point shock).

L = A figure derived by multiplying figures H and W to provide an overall likelihood of an encounter with UXO.

S = A figure derived by assessing the scope or extent of the works; a low figure is assigned where the volume of risk material is limited. A high figure is used where for example the volume of risk material is considerable such as “bulk digs” or shafting.

P = A Figure derived from assessing the result of an explosion, including primary and secondary risk pathways and receptors. A high figure is attributed for example in a gas works while a low figure is applied to a remote, rural open space.

C = A figure derived by multiplying figures S and P to provide an overall consequence of an encounter with UXO.

8.5 Table 2 Risk Level – From all potential UXO contamination sources

UXO RISK RATING (Post War Worked Ground)			
Activity	Likelihood (H x W = L)	Consequence (S x P = C)	Risk Rating (L x C = R)
Hand dug excavations	1 x 1 = 1	1 x 5 = 5	1 x 5 = 5
Limited mechanical excavations or trenching	1 x 2 = 2	2 x 5 = 10	2 x 10 = 20
Drilling, sampling, bulk excavations or piling	1 x 3 = 3	3 x 5 = 15	3 x 15 = 45
UXO RISK RATING (Post War Un-Worked Ground)			
Activity	Likelihood (H x W = L)	Consequence (S x P = C)	Risk Rating (L x C = R)
Hand dug excavations	2 x 1 = 2	1 x 5 = 5	2 x 5 = 10
Limited mechanical excavations or trenching	2 x 2 = 4	2 x 5 = 10	4 x 10 = 40
Drilling, sampling, bulk excavations or piling	2 x 3 = 6	3 x 5 = 15	6 x 15 = 90
1= Minimal 5=significant	LOW 0-100	MEDIUM 100-200	HIGH 200+

9 STUDY FINDINGS

9.1 Risk Levels

The risk assessment has determined the UXO risk within the site boundary. The UXO risk is considered to be lowest in post war worked ground increasing within the un-worked post war ground for some processes. When viewed from likelihood versus consequence standpoint; it is considered prudent to recommend a suitable degree of UXO mitigation to permit the work to proceed in the safest “acceptable” manner in compliance with current legislation and best practices.

9.2 Determining Acceptable Level of Risk

The meaning of the term “acceptable” in the context of this assessment is considered to be in keeping with the Health & Safety Executive directive which identifies the acceptable level as that which is; “As Low as Reasonably Practicable” (ALARP) to achieve.

10 RECOMMENDATIONS FOR RISK MITIGATION

All Risk Levels

- Risk Communication & Safety Planning: Stakeholders should be made aware of the UXO risk levels within the project boundary and the possible impact an encounter may have on the project and third parties. Consequently, a UXO Safety Plan should be drawn up and included within the overall project safety planning.

- Safety Training: In keeping with CDM Regulations concerning all sub-surface hazards, UXO Safety Induction Training should be provided to everyone working or visiting the site. The training should be commensurate with the individual's responsibilities and duties on site. The training should be provided by a competent individual (preferably a trained EOD Engineer) and delivered as a separate module of the Site Safety Induction Course or as a Toolbox Talk.

11 POST MITIGATION RISK

11.1 Overview

Prudent execution of the recommended risk mitigation strategy will reduce the risk however, it is emphasised that zero risk is not achievable given the possible variables. The assessment has confirmed the UXO risk level based on the nature of the work to be undertaken and has recommended suitable mitigation. An effective risk mitigation strategy will require detailed scoping to achieve its desired results in providing an acceptable level of risk. For further information concerning any part of this assessment please contact MACC International Ltd.

11.2 Intent & Use

This document has been produced in the United Kingdom by MACC International Limited and meets the requirements of CIRIA C681 “Unexploded Ordnance (UXO) – A guide for the Construction Industry”. It has been provided solely for the purpose of assessment and evaluation. It is not intended to be used by any person for any purpose other than that specified. Any liability arising out of use by a third party of this document for purposes not wholly connected with the above shall be the responsibility of that party, who shall indemnify MACC International Limited against all claims, costs, damages and losses arising out of such use.

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Annex A

SITE MAPPING

Site Boundary

Annex B

EXPLOSIVE ORDNANCE SAFETY INFORMATION

1 UNEXPLODED ORDNANCE

Since WWII the number of incidents in the UK where EO has detonated has been minimal, though a significant number of bombs have been discovered and safely disposed of without serious consequences. More commonly on mainland Europe (France, Germany and Belgium) incidents have occurred where ground workers have been killed or injured as a result of striking buried UXO or mishandling items of UXO found during excavation and piling work.

The threat to any proposed investigation or development on the site may arise from the effects of a partial or full detonation of a bomb or item of ordnance. The major effects are typically; ground shock, blast, heat and fragmentation. For example, the detonation of a 50kg buried bomb could damage brick/concrete structures up to 16m away and unprotected personnel on the surface up to 70m away from the blast. Larger ordnance is obviously more destructive. Table B-1 shows the MOD's recommended safe distance for UXO. However, it should be noted that the danger posed by primary and secondary fragmentation may be significantly greater. Almost 60% of civilian casualties sustained in London during the blitz were the result of flying glass.

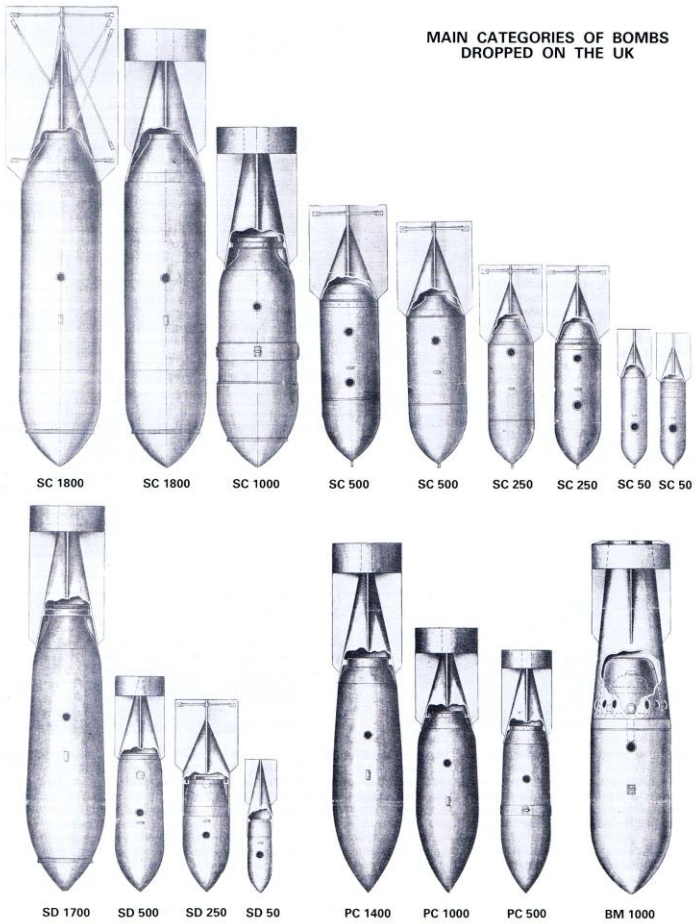
TABLE B-1 SAFETY DISTANCES FOR PERSONNEL

	Safety Distances (m)			
	Surface UXO		Buried UXO	
UXO (Kg)	Protected	Unprotected	Protected	Unprotected
2	20	200	10	20
10	50	400	20	50
50	70	900	40	70
250	185	1100	120	185
500	200	1250	140	200
1000	275	1375	185	275
3000	450	1750	300	450
5000	575	1850	400	575

Explosives rarely become inert or lose effectiveness with age. Over time some explosive materials can become more sensitive and therefore more prone to detonation. This applies equally to items that have been submersed in water or embedded in silt, clay, peat or similar materials.

2 TYPES OF GERMAN AIRDROPPED BOMBS & MINES

2.1 HE Bombs



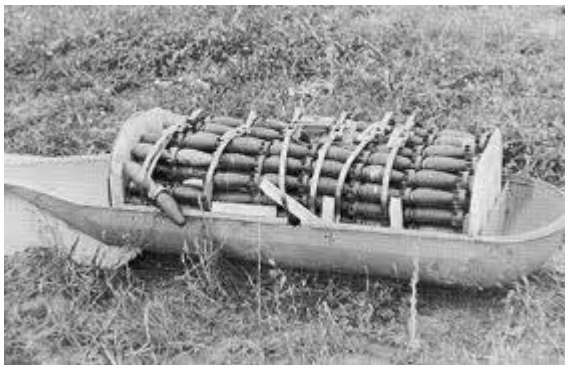
German 250kg Bomb found by MACC below a pre-war cellar floor in Bethnal Green London 10 August 2015

2.2 Incendiary, Anti-Personnel Bombs & Parachute Landmines

1kg incendiary Bomblet (Top as found today)

Flam c500, c250 & c50 Oil Bombs

SD1 Anti-Personnel Bomblets

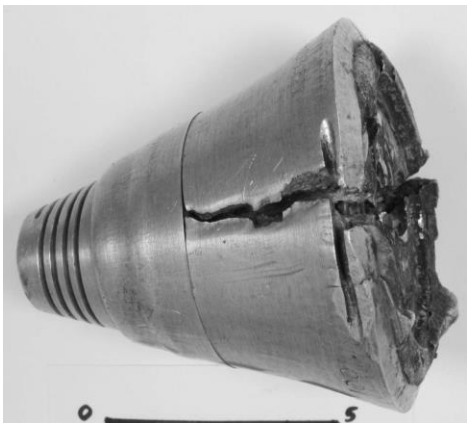


SD1 Container Bomb

Parachute Mines

2.3 British Anti-Aircraft Shells & Rockets

Examples of British Anti-Aircraft shells, rockets and components can be seen below.



Typical shell and rocket fuzes (Above left Proximity Fuzes found by MACC in 2017)

Typical shells (Above left 3.7” Shell found by MACC in 2017)

Typical rockets

3 UXO ENCOUNTER SAFETY PROCEDURE

3.1 All site personnel should be instructed on what action to take if they find an unidentified item which they suspect may be unexploded ordnance. The following actions are recommended until expert advice can be sought:

- **Stop Work**
- **Do not Touch**
- **Alert those around you and Evacuate the vicinity**
- **Call the UXO Specialist or Police (Dial 999)**

3.2 Where appropriate safety posters can be used to remind personnel of the safety procedure, an example can be seen below.

3.3 Where an item of UXO is found on site all work should be suspended until the UXO risk has been reassessed and if appropriate, suitable mitigation measures put in place.