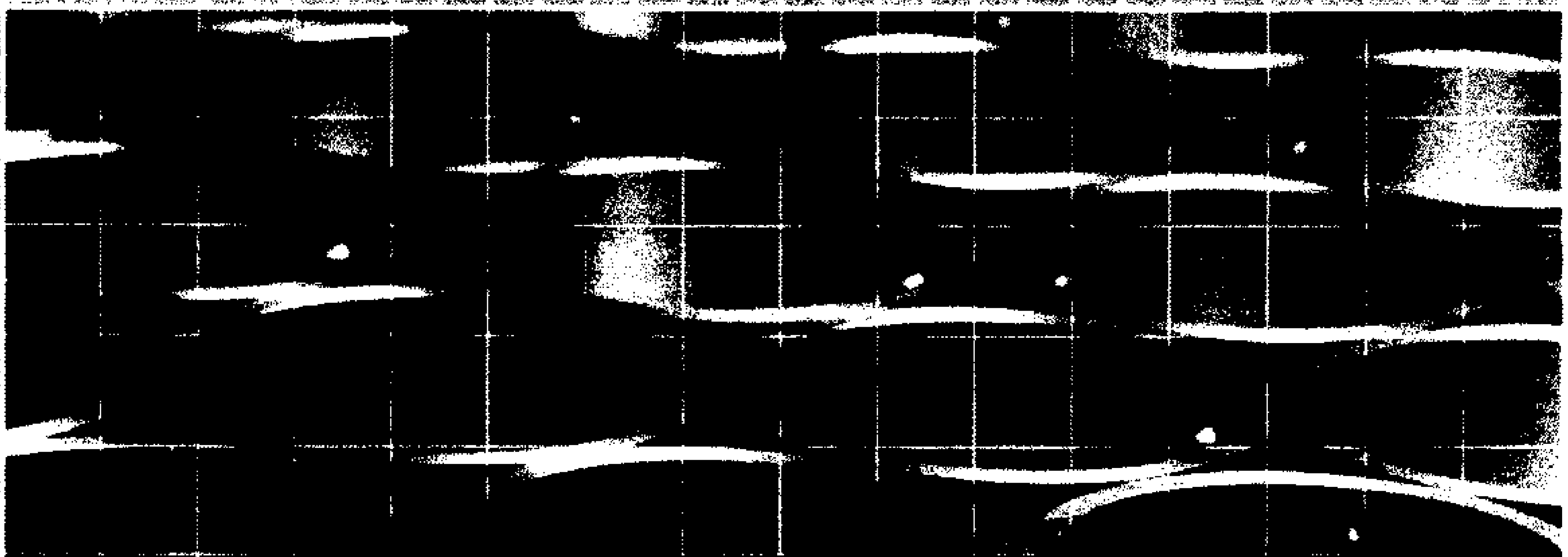

Phase II Geo-Environmental Assessment
Osnaburgh Street, London

M3 Consulting

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WSP

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Issue/revision	Issue 1	Revision 1	Revision 2	Revision 3
Remarks				
Date	January 2007			
Prepared by	R Melillo			
Signature				
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Project number	12040881			
File reference	001			

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Contents

Executive Summary

Client	M3 Consulting
Site Location	Osnaburgh Street, London NW1 3UP
Proposed Development	It is proposed to redevelop the site adjacent to Osnaburgh Street in central London. It is understood that re-development works at the site comprise demolition of the existing structures followed by construction of an 18 storey tiered residential tower with two basement levels and two 9 storey commercial buildings with one and two level(s) basements. Associated landscaping and hardstanding areas will form the areas between these three structures.
Ground Investigation	The investigation comprised the progression of five cable percussion boreholes to depths of between 25.0m and 50.40m bgl, eleven window sample boreholes to a maximum depth of 3.10m bgl, and seven hand excavated trial pits to a maximum depth of 2.65m bgl.
Ground conditions	The ground conditions at the site consist of Made Ground over River Terrace Gravels (Lynch Hill Gravels), London Clay, Lambeth Group deposits (Woolwich and Reading Beds), Thanet Sand and Upper Chalk. Localised deposits of Brickearth were encountered across the site of limited thickness.
Groundwater	Groundwater was encountered during the fieldworks and during the monitoring visits; groundwater was recorded at depths of between 5.36m and 6.91m bgl within the gravels. Groundwater was encountered within a sand deposit at 33.3m bgl (Lambeth Group), standing levels were recorded at 9.48m and 8.23m bgl.
Environmental Recommendations	No significant soil contamination was identified during this investigation, with the exception of four lead concentrations. However this does not elevate the risk rating of the site as this material will be removed as part of the basement excavation. The impact of any lead onsite can be mitigated by ensuring that construction workers are adequately protected and that a suitable health and safety management scheme is operated during construction activities.
Ground Gas	The site can be classified as Characterisation 1 based on the methodology of assessing the risk posed by ground gas from CIRIA guidance. According to this classification, gas protection measures are not required. Additional ground gas monitoring is recommended to fully characterise the site.
Foundations	It is recommended that the basement walls be constructed using embedded retaining walls. The basement slab will need to be designed for uplifting pressures resulting from both the groundwater and soil heave. Piled foundations are recommended for the basement.
Buried Concrete	The Design Sulphate class is DS-3 and the Aggressive Chemical Environment for Concrete Classification is AC-3.

This executive summary forms part of WSP Environmental Ltd Phase II Geo-Environmental Assessment (ref: 12040881 / 001). Under no circumstances is it to be used as an independent document.

1 Introduction

1.1 AUTHORISATION

At the request of M3 Consulting, WSP Environmental was instructed to undertake a Phase II Geo-environmental assessment at Osnaburgh Street, London. The investigation works were undertaken between the 20th November and 19th December 2006.

1.2 PROPOSED DEVELOPMENT

It is proposed to redevelop the site adjacent to Osnaburgh Street in central London. It is understood that re-development works at the site comprise demolition of the existing structures followed by construction of an 18 storey tiered residential tower with two basement levels and two 9 storey commercial buildings with one and two level(s) basements. The buildings will stand upon a common ground floor structure constructed over single and double level basements extending across the site. Associated landscaping and hardstanding areas will form the areas between these three structures.

1.3 OBJECTIVES

The objectives of the geo-environmental investigation were as follows:

- To determine an overview of the existing ground conditions at the site in relation to the proposed development;
- To establish geotechnical engineering parameters of the soil encountered;
- To provide preliminary geotechnical recommendations for the design and construction of foundation and basement, floor slabs, buried concrete, together with outline engineering and environmental risk control systems, which would be required;
- To confirm the groundwater and ground gas levels at the site; and
- To assess environmental aspects of the site and provide comments on risks during the construction phase as well as for the end use of the development.

1.4 PREVIOUS INVESTIGATIONS

WSP Environmental carried out a Geotechnical Desk Study of the site for WSP Buildings in November 2003 (Ref: 12040258, Geotechnical Desk Study, Osnaburgh Street, London Borough of Camden, dated November 2003).

The findings of this investigation have been included and adapted for use within this report.

1.5 SCOPE OF WORKS

The ground investigation was carried out between the 20th November and 19th December 2006. The following works were undertaken:

- Sub-surface utility search to allow the safe positioning of exploratory holes;
- Concrete coring at each borehole location;
- Two deep exploratory holes using a standard height rig to depths of 50.30m and 50.40m bgl (below ground level) in order to identify the deep ground conditions at the

site for design of piled foundations. Sampling and in-situ testing were undertaken in the holes as considered appropriate for design purposes. Ground water and ground gas monitoring installations were placed in both boreholes;

- Three exploratory holes using low headroom equipment to a maximum depth of 25.45m bgl to identify deep ground conditions for pile design in areas where the operational height is restricted. As above, sampling and in situ testing were undertaken as considered appropriate and ground water and ground gas monitoring installations were placed in each borehole. These holes were positioned in either existing car parks or buildings with low head room. One of the holes was drilled through a basement level.
- Eleven window sample boreholes across the site to assess the shallow ground conditions and recover disturbed samples for contamination testing;
- Seven hand excavated trial pits within the existing structures to determine shallow ground conditions and assess existing foundations. Two of these pits were requested by MoLAS, (Museum of London Archaeological Service);
- Laboratory testing to determine geotechnical properties of the soils;
- Chemical laboratory testing of soil and groundwater samples;
- Monitoring of ground gas (oxygen, carbon dioxide and methane) concentrations and groundwater levels on three occasions post completion of fieldwork;
- Interpretative reporting.

2 Environmental Setting

2.1 SITE DETAILS

Site Address:	Osnaburgh Street, London NW1 3UP
National Grid Reference:	TQ 289 822
Size:	0.9 Hectares approx.
Description of Site:	The site is located in the London Borough of Camden, approximately 200m north-east of Great Portland Tube station. The site is bounded by Longford Street to the north, Euston Road to the south and Osnaburgh Street to the west. The site currently comprises a number of existing 'works' buildings with courtyards and open areas, however these are generally limited. In addition, a number of existing basements are present and below ground car parking areas. The site slopes slightly from north to south, with ground levels just over +29mOD at the junction of Longford and Osnaburgh Streets, to just over +28mOD where Osnaburgh Street joins Euston Road. Surrounding areas are of similar levels with no major topological changes in the surrounding area.
Description of Surrounding Area:	The site is located in an area of mixed residential and commercial/office land uses. Residential properties are located immediately west of the site. Adjacent to the north eastern corner of the site is a large multi-storey electrical transformer station. Great Portland Street and Regents Park tube stations are both located within 300m south west of the site. Regents Park and Park Square are located approximately 250m to the west of the site.

A site location plan and aerial photograph are presented in **Appendix A**.

2.2 SUMMARY OF GEOTECHNICAL DESK STUDY

The following summary is obtained from the Geotechnical Desk Study of the site undertaken by WSP in November 2003 (Ref: 12040258). For detailed information reference should be made to the original report.

2.2.1 Geology

The British Geological Survey (BGS) geological map for the area (North London, Sheet 256, Solid & Drift, 1:50 000 scale) indicates that the site is underlain by the Lynch

Hill Gravels, London Clay, Lambeth Group deposits (Woolwich and Reading Beds), Thanet Sand and Upper Chalk.

2.2.2 Hydrogeology & Hydrology

The Environment Agency Groundwater Vulnerability Map (1:100,000 Series, Sheet 39) classifies the Lynch Hill Gravel Deposit as a minor groundwater aquifer of high leaching potential. The underlying London Clay is classified as a non-aquifer.

Water levels from the adjacent Arup site of Regents Place/Triton Square indicates perched groundwater levels of approximately +23mOD to +23.2mOD.

No significant hydrological features are present within 1000m of the site.

2.2.3 Former Land Uses

At present the subject site comprises a variety of medium rise structures ranging from 2 to 8 storeys in height with various basement levels, and an area in the southern half of the site including a basement car parking area. Several small areas of concrete hardstanding and tarmac are present on site. The current site occupancy consists of a mix of residential, office and light industrial businesses.

Historically, early 1800's, the site has possibly been exploited for Brickearth, following which the site has generally been occupied by residential and light industrial structures. Potential historical contaminative uses include a nursing home/hospital, optical instruments, a tyre and car accessory fitting business, wrought iron works, wood and cabinet fitters and a stable yard. Off site sources include a sheet metal works and an electricity board depot.

The surrounding area is generally characterised by a range of activities including office, residential and light industrial. The site directly adjacent to the east is the recently developed Regent's Place / Triton Square, comprising several multi-storey office complexes and associated multi-levelled basements, one car parking basement is closely located to the south eastern site boundary. Effects of the existing foundations / basements will need to be considered in foundation design for the subject site.

2.2.4 Underground services

Services from London Electricity, British Telecom, British Gas, Mercury Communication plc, Thames Water, Sewerage and Cable London all have services within Triton Square and the surrounding area and may be affected by the proposed development works. The Metropolitan and Circle Tube lines run along the southern side of Euston Road, with a large electrical transformer adjacent to the eastern site boundary.

2.2.5 Regulatory Information & Consultations

Regulatory consultations have not highlighted significant geological or environmental concerns pertaining to the site or its locality.

3 Conceptual Site Model

3.1 INTRODUCTION

The objectives of the hazard assessment process are to:

- Determine the sources of contamination (if present);
- Identify specific chemicals of potential concern (if present);
- Identify possible contaminant migration pathways;
- Identify possible receptors (e.g. soil, groundwater, humans, third parties) which could be affected, including their relative potential sensitivity to contaminants given their nature of exposure; and
- Construct a conceptual model for the site which clarifies the mechanisms by which the site may present a risk, highlighting those sources of risk which will require further assessment and those which can be eliminated.

The conceptual model, which is revised and developed in light of investigation findings, provides a description of three elements i.e.

- The actual and probable nature, extent and location of contaminants, i.e. the SOURCE term;
- The potential existing and reasonably foreseeable future on-site and off-site RECEPTORS to contamination; and
- The likely migration PATHWAYS by which contaminants may reach such receptors.

Such information enables the development of plausible POLLUTANT LINKAGES between sources of contamination and receptors, and thus an estimation of the risks that may be present. These aspects are summarised in **Table 3.1**.

3.2 PLAUSIBLE POLLUTANT LINKAGE

The pollutant linkages listed in **Table 3.1** are considered to be plausible and could therefore potentially represent a significant risk of harm to human health and the pollution of Controlled Waters. The investigation and assessment have therefore focused on these linkages.

Table 3.1 **Summary of Plausible Linkages**

Potential Contamination Sources	Associated Contaminants	Potential Migration Pathways	Sensitive Receptors
Onsite: ▪ Nursing Home/Hospital; ▪ Optical Instruments; ▪ Tyre &Accessory Fitting business; ▪ Wrought Iron Works; ▪ Wood & Cabinet Fitting; ▪ Stable Yard. Off site: ▪ Sheet Metal works; ▪ Electricity Board Depot.	▪ Organic compounds (TPH, PAH's); ▪ Metals (vanadium, arsenic, cadmium, chromium, copper, mercury, nickel, lead, zinc); ▪ Asbestos; ▪ Water soluble sulphate and sulphide; ▪ pH; ▪ Cyanide; ▪ Boron; ▪ Nitrate; ▪ Phenols; ▪ PCB's.	▪ Leaching to groundwater; ▪ Surface water run-off; ▪ Inhalation, dermal contact, ingestion; and ▪ Volatilisation to air.	▪ Future Site Users; ▪ Groundwater (underlying aquifers); ▪ Construction & Maintenance personnel.

Considering the above and the proposed development works the principal receptors of concern are site workers and future site workers.

To identify the likely contaminants present on the site, reference has been made to DEFRA / Environment Agency R & D Publication CLR 8: Potential Contaminants for the Assessment of Land (2002). This publication identifies typical contaminants associated with numerous land uses.

It is possible that contaminants may have been released as a result of historic site activities or surrounding uses. Such contaminants can migrate via groundwater and surface water run off.

The conceptual site model is developed further in the risk assessment discussed in more detail in Section 11.

4 Site Investigation

4.1 INVESTIGATION RATIONALE

The ground investigation has been designed to provide information on the general ground and groundwater conditions at the site together with specific information on potential contamination sources. The rationale behind the location of each exploratory hole is summarised in **Table 4.1**.

Before work commenced, all exploratory hole locations were surveyed to confirm the absence of underground services.

Chemical testing has been scheduled in accordance of **Table 3.1** to investigate those contaminants considered most likely to be present after review of historical map data.

Geotechnical testing was scheduled to provide details on the characteristics of the soils to enable foundation design.

Exploratory hole location plans are presented in **Appendix B**.

Table 4.1 Summary of Exploratory Hole Rationale

Potential Issue	Exploratory Holes
General site coverage including general groundwater quality	Cable percussion
Environmental soil sampling.	Window sample boreholes, trial pit, and cable percussion borehole
Determination of shallow ground conditions	Window sample borehole, trial pit, cable percussion borehole
Determination and assessment (quality, strength) of deeper ground conditions for the design of foundations and the retaining structures associated with the construction of the basement	Cable percussion boreholes
Geotechnical data for the design of the new structure and basement	BH101 to BH106 (Cable percussion boreholes)
Determination of existing foundations	TP1 to TP5 (Hand Dug Trial Pits)

4.2 SITE REQUIREMENTS

Full health and safety documentation, method statements and risk assessments were submitted and all contractors were suitably inducted in advance of the commencement of the site works.

In addition whilst on site all engineers and contractors had to wear the following personal protective equipment (PPE) as a minimum.

- Hard Hat;
- High Visibility Vest or Jacket;
- Steel Toecap Boots; and
- Gloves (when appropriate).

4.3 FIELD WORK

The ground investigation commenced on the 20th November 2007 and was completed on the 19th December 2007. The ground investigation comprised:

- Two cable percussion boreholes to a maximum depth of 50.40m bgl.
- Three cable percussion boreholes to a maximum depth of 25.45 bgl.
- Eleven window sample holes to a maximum depth of 3.10m bgl.
- Five hand dug trial pits to a maximum depth of 2.65m bgl.
- Two hand dug archaeological trial pits to a maximum depth of 1.80m bgl.

A summary of the scope of the ground investigation is outlined in **Table 4.2.**

The ground investigation was undertaken in accordance with techniques outlined in BS5930: 1999 Code of Practice for Site Investigations, BS1377: 1990 Methods of Testing of Soils for Civil Engineering purposes, BS10175: 2001 Investigation of Potentially Contaminated Sites, and The Construction (Health, Safety & Welfare) Regulations (S4) as appropriate, at the positions shown on the exploratory hole location plans presented in **Appendix B.** The exploratory hole records are presented in **Appendix B.**

The investigation was carried out under the supervision of an engineer from WSP Environmental UK Limited.

Table 4.2 Summary of Ground Investigation Works

Investigation Method	No.	Max Depth (m)	Sampling Regime	Monitoring Wells	Backfilling and Reinstatement
Hand Excavated Trial Pits	7	2.65	(1)	N/A	Backfilled with arisings.
Window Sample Boreholes	11	3.10	(1) & (2)	1 (WS7)	Arisings. Where monitoring wells, installations surrounded with gravel or bentonite.
Cable Percussion Boreholes	5	50.40	(1) & (2)	6 (Double installation in BH101)	Bentonite. Where monitoring wells, installations surrounded with gravel or bentonite.

Notes
(1) Plastic tubs, amber glass jars and 40ml glass volatile vials
(2) Plastic tubs, U100's, bulk samples

4.4 WINDOW SAMPLING BOREHOLES

Eleven window sampling holes (WS1 to WS11) were advanced to a maximum depth of 3.10m bgl.

All window sampling holes were located in hard standing areas. Window sampling holes WS1, WS2, WS5, WS8, WS9 WS10 and WS11 were positioned within basements or basement car parks.

Window sampling was attempted within Jellico House basement car park. However coring of the basement concrete slab was unsuccessful due to the thickness, recorded in excess of 300mm and the presence of reinforcement.

On completion of the drilling, a monitoring standpipe was installed in one of the window sample holes (WS7) to monitor shallow ground gas and groundwater conditions. The standpipe response zones were placed within the Made Ground. **Table 4.3** shows the standpipe installation details.

Table 4.3 Monitoring Installation Details

Window Sample Hole	Tip Depth (m bgl)	Response Zone Strata
WS7	2.50	Made Ground

The installation consists of 50mm diameter plain pipe from ground level to 0.5m bgl, and slotted pipe over the Made Ground layer. A bentonite seal was provided over the section of plain pipe. A gravel filter was placed around the response zone (slotted section of pipe). Each installation was completed with a lockable steel cover at ground level.

Where possible, pocket penetrometer readings were taken on suitable cohesive soil samples recovered from the window samples.

Descriptive logs of the window sample boreholes with details of installation depths, sample type and depths are shown on the borehole records presented in **Appendix B**.

4.5 CABLE PERCUSSIVE BOREHOLES

Five light cable percussion boreholes (BH101, BH102, BH103, BH105 and BH106) were formed at the site to a maximum depth of 50.40m below ground level (bgl).

In cohesive strata alternating Standard Penetration Tests (SPT) and undisturbed (U_{100}) sampling (at 1.0m intervals) were undertaken from ground level to the base of all the cable percussion boreholes. In granular deposits where undisturbed sampling was inappropriate SPT's were taken at 1.0m intervals. Disturbed samples were also recovered for subsequent laboratory analysis.

All boreholes were installed on completion with monitoring standpipes to monitor ground gas and groundwater conditions. The slotted section of the pipe was covered with 'geowrap' material to prevent the fine particles from entering and silting up at the base of the installation. The standpipes were designed to allow the monitoring of the groundwater below the site within River Terrace Deposits, London Clay and Thanet Sands. **Table 4.4** shows the standpipe installation details for both boreholes.

Table 4.4 Monitoring Installation Details

Borehole	Tip Depth (m bgl)	Response Zone Strata
BH101a	50.40	Thanet Sands

BH101b	6.10	River Terrace Deposits
BH102	33.30	Lambeth Group
BH103	6.00	River Terrace Deposits
BH105	21.00	London Clay
BH106	7.70	River Terrace Deposits

The standpipe installations in BH101b, BH103 and BH106 comprise 50mm diameter plain pipe from ground level to a maximum depth of 2m bgl and slotted pipe within the River Terrace Deposits. The installation within BH101a comprise 50mm diameter plain pipe to a depth of 47.20m bgl and slotted pipe to a depth of 50.20m bgl. The installation within BH102 is comprised of 19mm diameter plain pipe to a depth of 33.0m bgl and a peizo tip at 33.30m bgl with a sand filter surround. Finally the installation in BH105 is comprised of 50mm diameter plain pipe to a depth of 15m bgl and slotted pipe to a depth of 21m bgl.

A bentonite seal was provided over the section of plain pipe. A gravel filter was placed around the response zone (slotted section of pipe). The installations were completed at ground level with a flush lockable steel cover.

Descriptive logs of the boreholes with details of installation depths, sample types, in-situ test result and depths are shown on the borehole records presented in **Appendix B.**

4.6 HAND EXCAVATED TRIAL PITS

A total of seven hand excavated trial pits (TP1 to TP5 and TPM1 to TPM2) were excavated across the site to a maximum depth of 2.65m bgl by a 3 man crew with hand tools. Samples were taken for environmental and geotechnical analysis. Trial pits allowed a visual inspection and logging of the ground conditions and the recording or existing foundations. On completion of the logging and sampling the trial pits were reinstated with arisings.

Descriptive logs and drawings of the trial pits with details of sample type and depths are shown on the borehole records presented in **Appendix B**.

4.7 GROUNDWATER AND GROUND GAS MONITORING

Three site visits were undertaken to monitor the borehole installations for groundwater and ground gas, (5th January 2007, 12th January 2007 and 26th January 2007). Gas flow readings were taken from the borehole using an electronic flow pod attached to the gas monitoring instrumentation. Atmospheric pressure readings were recorded during the monitoring. Monitoring of the ground gas concentrations and flows were undertaken using calibrated instrumentation.

Groundwater levels were measured from the standpipe using an electrical contact dip meter.

Measurements of ground water levels and gas concentrations made in the monitoring standpipes are presented in **Appendix D**.

5 Laboratory Testing

5.1 CONTAMINATION TESTING

Selected soil and groundwater samples were submitted for chemical analysis at the UKAS/MCERTS accredited WSP Environmental laboratory in Nottingham & Alcontrol Technichem Ltd. The results of the contamination testing are presented in **Appendix C**.

5.1.1 Chemical Testing Strategy

The chemical testing suite has been designed to achieve the following:

- Characterise near surface contamination levels to provide an assessment of the risks associated with direct contact with soils on site in its current state and facilitate CLEA statistical analysis;
- Provide information on the general contamination levels in the various topsoil types and natural ground across the site;
- Assess risks to buildings and buried utilities from aggressive chemicals;
- Provide information on the potential for on-site migration of contamination; and
- Provide information on the potential for off-site migration of contamination.

5.1.2 Soils – Contaminants

Selected samples were tested for contaminants indicated in **Table 3.1**.

5.2 GEOTECHNICAL TESTING

Selected soil samples were submitted for geotechnical analysis at the laboratory of WSP Environmental Ltd and ELE International, both of which are UKAS accredited.

Laboratory analysis certificates for geotechnical testing are included in **Appendix E**.

5.2.1 Geotechnical Testing Strategy and Parameters

Geotechnical laboratory testing work was carried out on selected soil samples by WSP Environmental to determine the physical characteristics of the underlying soils to provide details for the design of foundations and retaining structure. Soil samples were selectively analysed for the following range of parameters;

- Moisture contents;
- Atterberg limits;
- Undrained triaxial tests; and
- Particle size distribution / Sieve analysis.

In addition to the sulphate determinations carried out as part of the contamination related testing, water-soluble sulphate and pH determinations were undertaken. The purpose of these was to assess the soil chemistry with respect to sulphate attack on buried concrete.

The geotechnical testing was carried out in accordance with BS1377: 1990, The Testing of Soils for Civil Engineering Purposes.

Laboratory analysis certificates for geotechnical testing are included in **Appendix E**.

6 Ground Conditions

6.1 GENERAL

The ground conditions encountered in the exploratory holes broadly confirmed the geological sequence as described in the British Geological Survey. A summary of the ground conditions encountered is presented in **Table 6.1**. Records from the exploratory holes are presented in Appendix B.

Table 6.1 Summary of Ground Conditions

Stratum Description	Typical Thickness (m)	Depth to Top of Strata (m bgl)	SPT 'N' Values	Exploratory Holes in which strata encountered
Hardstanding: Tarmac and Concrete.	0.05–0.45	0.00	N/A	All Exploratory Holes
Basement Void:	3.30	0.30	N/A	BH106 only
Void:	0.25	0.12	N/A	WS3 only
Made Ground: Generally cohesive with brick and concrete fragments.	0.11–2.63	0.05–3.70	N/A	All Exploratory Holes
Brickearth: Firm to stiff orange brown slightly sandy clay.	0.15-1.80	0.35-2.5	6 - 9	BH101, BH102, BH103, BH105, TP4-5, TPM2, WS4, WS6-7 & WS10
River Terrace Deposits: Medium dense to dense orange brown sandy gravel.	3.10-4.10	1.40-4.20	18-64	BH101, BH102, BH103, BH105, BH106, TP1–4, WS1-2, WS4-6 & WS8-9
London Clay: Stiff to very stiff dark grey clay.	26.70-29.40	5.55-7.30	7-52	BH101, BH102, BH103, BH105 & BH106
Lambeth Group: Very stiff multicoloured clay.	12.50-14.90	33.00-35.50	43-68	BH101 & BH102
Thanet Sands: Very dense grey silty sand.	ND	47.90-48.00	50-86	BH101 & BH102

ND Not determined

Geotechnical data plots of SPT 'N' values and undrained shear strength versus depth are presented in **Appendix F**.

Cross-sections of the ground conditions across the site are presented in **Appendix F**.

6.2 HARDSTANDING

A hardstanding surface of concrete, tarmac and paving was encountered across the site. The hardstanding extended to depths of 0.45m bgl.

6.3 VOIDS

Borehole BH106 was situated above a basement, a pilot hole was placed in the ceiling and the borehole progressed through the base of the basement, levels were read from street level as shown on the log.

Window sample hole WS3 encountered a void beneath the concrete slab located in an outdoor courtyard. The void extended to a depth of 0.37m bgl, it was not possible to determine the lateral extent of the void. It is possible that the area may be a backfilled basement and the refusal of the window sampling hole at 3.00m bgl may be the floor of the basement.

6.4 MADE GROUND

Made Ground was encountered in all exploratory holes to a maximum depth of 4.20m bgl within borehole BH106, the greatest thickness of Made Ground was encountered in window sample hole WS3 of 2.63m.

The Made Ground ranged from gravelly clay to clayey sandy gravel comprised of brick and concrete fragments, along with flint and occasionally ash. Crushed brick and concrete was also found to be present as a sub-base for the concrete floors and basements, typically the thickness ranged from 0.10 to 0.15m.

In trial pit TPM2 the depth of the Made Ground could not be determined due to unstable pit walls, the fill material consisted of whole and partial brick fragments and may have been a backfilled basement or court yard.

There were no SPT 'N' values recorded within the Made Ground.

Chemical analysis of the Made Ground indicates the pH to be between 8.1 and 11.2, and the water soluble sulphate content to vary between 0.03g/l and 2.10g/l.

6.4.1 Asbestos

Asbestos was not observed within the Made Ground; however the presence and removal of asbestos from the existing buildings suggest the possible presence of asbestos within the Made Ground. As a result nine soil samples from the Made Ground were scheduled for asbestos identification. The results were negative for the presence of asbestos.

6.5 RIVER TERRACE DEPOSITS (LYNCH HILL GRAVEL)

Deposits of River Terrace Gravel were encountered across the site area extending to depths of between 5.55m and 7.30m bgl. These deposits were overlain by a thin deposit of Brickearth that, where encountered, varied in thickness from 0.15m to 1.80m.

The Brickearth comprised a soft to firm or firm orange brown sandy gravelly clay. The sand and gravel content was variable within this material. SPT 'N' values within this material varied from 6 to 9 suggesting the deposit to be firm. Chemical analysis of the Brickearth indicates the pH to be between 6.4 and 8.4, and the water soluble sulphate content to vary between 0.025g/l and 0.43g/l.

Geotechnical test results within the Brickearth indicate moisture contents of between 16% and 27%, a liquid limit of 37% and 39%, a plastic limit of 17% and 25% and a plasticity index of 14% and 20%, the results of a single triaxial test indicate a bulk density of 1.95 Mg/m^3 and a dry density of 1.54 Mg/m^3 and an undrained shear strength of 11 kPa.

The particle size distribution (PSD) results of the River Terrace Gravel deposits indicate the material to be generally a very gravelly sand or sandy to very sandy gravel, being slightly clayey to clayey in places. This confirms the visual descriptions.

The River Terrace Gravel comprised a variably graded fine to coarse sand and fine to coarse predominantly subangular flint gravel. A plot of SPT 'N' values within this deposit is presented in **Appendix F**. This plot indicates a scatter of results typically between 20 and 60. A value of 30 is considered to be a moderately conservative assessment of this parameter. The peak angle of shearing resistance can be assessed from; $\phi_{pk} = 30 + A + B + C$ where A, B and C are dependent upon the nature of the gravel. A is a function of the angularity, B is a function of the grading and C is dependent upon the SPT 'N' value. Based upon this assessment, the peak angle of shearing resistance is expected to be in the order of 38 degrees.

The Young's Modulus (E) stiffness of the gravel has been assessed from the SPT 'N' values through the relationship E = 2000N kN/m^2. This suggests that the Young's Modulus of the gravel will be in the order of 60 MPa.

Chemical analysis of the River Terrace Deposits indicates the pH to be between 8.2 and 8.5, and the water soluble sulphate content to vary between 0.020g/l and 0.065g/l.

6.6 LONDON CLAY

The full extent of the London Clay was proven in boreholes BH101 and BH102 where the deposit extended to depths of between 35.50m and 33.30m bgl respectively. This results in a thickness of between 26.70m and 29.40m.

The London Clay is typically blue grey fissured clay of variable lithology. The most obvious signs of the variation in lithology are the presence of sand, sand lenses and partings within the basal beds of the London Clay. This was typically observed at depths of 30.20m and 29.75m bgl respectively in the two deep boreholes. Initially the deposit appeared weathered / reworked and was brown in colour and locally reworked with the overlying sand and gravel.

The geotechnical test results indicate moisture contents of between 21% and 31%, a liquid limit of between 57% to 89%, a plastic limit of between 19% to 29% and a plasticity index of 29% to 64%, a bulk density of between 1.94 Mg/m^3 and 2.11 Mg/m^3 and a dry density of 1.50 Mg/m^3 and 1.73 Mg/m^3.

Chemical testing indicates a pH of between 7.0 and 7.9, and a sulphate content to vary between 0.25g/l to 2.61g/l.

Plots of SPT 'N' values versus depth and laboratory triaxial results are included in **Appendix F**. SPT's are undertaken within clay soils as it is normally possible to correlate these with the undrained shear strength by multiplying the SPT 'N' values by a suitable factor. Within this area of London, a factor of 5 is normally adopted.

The resulting undrained shear strength profile for the London Clay is;

Cu = 60 kN/m^2 at 6m bgl

Cu = 120 kN/m^2 at 10m bgl

Cu = 240 kN/m^2 at 35m bgl

This profile is in good agreement with that adopted for the adjacent site that showed an increase in undrained shear strength from 80 kN/m^2 at the top of the London Clay to 230 kN/m^2 at 25m into the London Clay. (Ref: 12040258)

For routine settlement calculations, the drained and undrained values of Young's Modulus have been related to the undrained shear strength through the following published relationships;

E' = 240 Cu

Eu = 400 Cu

For retaining wall analysis where ground movements are expected to be small, the above relationships are likely to be conservative.

Several of the deep Unconfined Undrained Triaxial results were not available at the time of writing this report and these will be issued by separate cover.

6.7 LAMBETH GROUP BEDS

The Lambeth Group Beds extended to depths of 48.00m and 47.90m bgl in boreholes BH101 and 102 respectively. The deposit primarily comprised a layer of multi coloured fissured clay. Within both boreholes, a layer of very dense gravely sand was present at the base of the Lambeth Group Beds.

The thickness of the Lambeth Group Beds varied between 12.50m and 14.90m in the two deep boreholes. The layer of multicoloured clay was between 11.70m and 13.50m thick with the underlying sand layer varying in thickness between 0.80m and 1.40m.

The multicoloured clay is typically of the Lambeth Group deposits. With depth, this material became sandy and very sandy. This material was very friable when recovered from the boreholes.

The geotechnical test results indicate moisture contents of between 11% and 25%, a liquid limit of between 43% and 95%, a plastic limit of between 17% and 29%, and a plasticity index of 26% to 70%.

The SPT 'N' values suggest that the strength of the Lambeth Group clays remains constant to a depth of 38m bgl and equivalent to the strength at the base of the London Clay (240 kN/m^2). Thereafter, the undrained shear strength appears to increase to 500 kN/m^2 at 47m bgl.

A single PSD result of the basal bed of the Lambeth Group (BH102 at 47.0mbgl), also called Upnor Formation, indicate the material to be a clayey gravelly sand which confirms the visual description.

For routine settlement calculations, the drained and undrained values of Young's Modulus have been related to the undrained shear strength through the following published relationships;

E' = 240 Cu

Eu = 400 Cu

The sand deposits at depth are very dense with SPT 'N' values of between 100 and 200 typically recorded. These deposits are assumed to be essentially rigid.

Chemical testing indicates a pH of between 9.0 and 9.4, and a sulphate content to vary between 0.01g/l to 0.02g/l.

6.8 THANET SANDS

The Thanet Sands were encountered at depths of between 48.00m and 47.90mbgl in boreholes BH101 and BH102 respectively and extended to the base of the boreholes.

The Thanet Sands were recovered from the boreholes as a locally clayey, silty fine sand.

A plot of SPT 'N' values is presented in **Appendix F** and indicates the deposits to be very dense, with extrapolated SPT 'N' values varying between 200 and 500.

A single PSD result of the Thanet Sands (BH101 at 49.2mbgl) indicates the material to be slightly clayey fine sand which confirms the visual description. A single sample was tested for Atterberg Limits which resulted in a liquid limit of 53%, a plastic limit of 19% and a plasticity index of 34%, the moisture content ranged from 7% to 27%.

Chemical testing indicates a pH of 6.4, at the time of writing this report a single sulphate content result is outstanding.

6.9 GROUNDWATER

6.9.1 Groundwater Strikes

Groundwater strikes were encountered within all cable percussion boreholes. Seepages were noted within the River Terrace Deposits but due to the addition of water to aid drilling it was not possible to monitor the inflow.

Possible seepage within the London Clay was noted in borehole BH105, along a band of Siltstone at a depth of 17.05m bgl.

Groundwater was encountered at the top of the Lambeth group in a layer of very dense sand at a depth of 33.3m bgl, the water rose to 23.40m bgl within 20 minutes.

6.9.2 Groundwater Monitoring

After installation of the monitoring standpipes the standing groundwater levels were monitored on three separate occasions (5^{th} January 2007, 12^{th} January 2007 and 26^{th} January 2007). Due to ongoing site works and demolition, access to all the monitoring wells on every site visit was not possible, additional monitoring of the instrumentation is recommended.

Standpipe readings from the instruments installed at the site are presented in **Appendix D**. These suggest a groundwater level within the River Terrace Gravels of between 5.3m and 6.9m bgl, suggesting that this perched groundwater is present towards the base of the deposit. A single installation within the London Clay indicates ground water levels in continuity with the perched waters within the gravels, levels were recorded from 5.28m to 5.37m bgl.

A standpipe peizometer installed at a depth of 33.30m bgl within a sand band at the top of the Lambeth Group, has recorded ground water levels of 8.23m and 9.48m bgl, this indicates a maximum head of water to be 25.07m.

The installation within the Thanet Sands recorded on a single occasion standing ground water at 50.03m with the tip at 50.40m bgl. However the base of the installation remains only damp.

This may indicate that the Thanet Sands are underdrained by the Chalk aquifer and the hydrostatic profile of the Lambeth Group is sub-hydrostatic.

6.10 VISUAL AND OLFACTORY EVIDENCE OF CONTAMINATION

No visual and olfactory evidence of contamination were observed during site works, with the exception trace amounts of ash within the Made Ground.