
DESK STUDY & GROUND INVESTIGATION REPORT

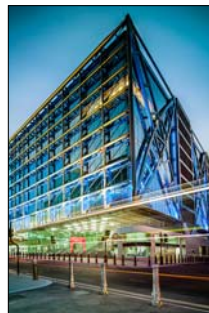
Royal Heights
Queen's Road
Reading

Client: Reading Heights Limited

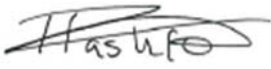
Engineer: Fluid Structures

J18003

March 2018



Document Control

Project title		Royal Heights, Queen's Road, Reading RG1 4BN		Project ref	J18003
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Issue No	Status	Amendment Details	Date	Approved for Issue	
1	Final		9 March 2018		

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This report is intended as a Ground Investigation Report (GIR) as defined in BS EN1997-2, unless specifically noted otherwise. The report is not a Geotechnical Design Report (GDR) as defined in EN1997-2 and recommendations made within this report are for guidance only.

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CONTENTS

EXECUTIVE SUMMARY

Part 1: INVESTIGATION REPORT

1.0	INTRODUCTION	1
1.1	Proposed Development	1
1.2	Purpose of Work	1
1.3	Scope of Work	1
1.4	Limitations	2
2.0	THE SITE	3
2.1	Site Description	3
2.2	Site History	4
2.3	Preliminary UXO Risk Assessment	5
2.4	Other Information	6
2.5	Geology	6
2.6	Hydrology and Hydrogeology	6
2.7	Preliminary Risk Assessment	7
3.0	EXPLORATORY WORK	8
3.1	Sampling Strategy	9
4.0	GROUND CONDITIONS	9
4.1	Made Ground	9
4.2	Superficial Deposits	10
4.3	Seaford Chalk Formation	10
4.4	Groundwater	10
4.5	Soil Contamination	11
4.6	Existing Foundations	13

Part 2: DESIGN BASIS REPORT

5.0	INTRODUCTION	14
6.0	GROUND MODEL	14
7.0	ADVICE AND RECOMMENDATIONS	15
7.1	Re-use of Existing Foundations	15
7.2	Piled Foundations	15
7.3	Shallow Excavations	16
7.4	Ground Floor Slab	16
7.5	Effect of Sulphates	16
7.6	Site Specific Risk Assessment	17
7.7	Waste Disposal	17
8.0	OUTSTANDING RISKS AND ISSUES	19

APPENDIX

EXECUTIVE SUMMARY

This executive summary contains an overview of the key findings and conclusions. No reliance should be placed on any part of the executive summary until the whole of the report has been read. Other sections of the report may contain information that puts into context the findings that are summarised in the executive summary.

BRIEF

This report describes the findings of a site investigation carried out by Geotechnical and Environmental Associates (GEA) on the instructions of Fluid Structures, on behalf of Reading Heights Limited, with respect to the conversion of the existing office building into residential units, which will include the addition of two storeys and the construction of a ten-storey extension. The purpose of the investigation has been to research the history of the site with respect to possible contaminative uses, to determine the ground conditions, to assess the extent of any contamination and to provide information to assist with the design of suitable foundations for the proposed development.

DESK STUDY FINDINGS

The desk study research has indicated that the site was developed prior to 1879 with terraced houses, fronting onto Watlington Street to the east and Queen's Road to the south, with gardens at the rear. It is possible that the former terraced houses had basements. A print works was present in the central western part of the site from some time between 1931 and 1957 map, present until the 1989 map, when the site had been cleared and replaced with the existing building in the south of the site and a car park in the north. It is understood that the existing building was formerly used as offices and is now vacant. The print works represents a potential source of contamination. Within 250 m of the site there have been saw mills, a timber yard, printing works, gas works, breweries, wharves, works and warehouses, which are potentially contaminative land uses. However, most of these sites have since been redeveloped and there are unlikely to be any ongoing sources of contamination. In addition, groundwater flow beneath the site is expected to be in a northeasterly direction and the site was located upstream of most of these contaminative uses. A tank has been shown on the 1991 immediately to the west of the site within the grounds of the Queen's Wharf apartment block. No landfills are recorded within 250 m of the site and made ground associated with demolition of the houses previously present on the site is likely to be predominantly inert demolition rubble, such that no potential sources of soil gas have been identified.

A preliminary UXO risk assessment has been carried and has concluded that there is minimal risk that items of UXO will be encountered on the site such that no further action is required.

GROUND CONDITIONS

The investigation has generally confirmed the expected ground conditions, in that beneath a moderate to significant thickness of made ground, a cover of Superficial Deposits was encountered, overlying the Seaford Chalk Formation which was proved to the maximum depth investigated of 30.00 m. The made ground extended to depths of between 0.80 m and 2.60 m, with the greatest thickness encountered in the east of the site, within the footprint of the former terraced houses. The Superficial Deposits extended to depths of between 1.75 m and 4.40 m and generally comprised soft brown clayey silt with occasional gravel composed of flint and chalk. The underlying Seaford Chalk Formation was highly weathered to a depth of about 6 m with a brown clay infill. The chalk was recovered predominantly as putty chalk (Grade Dm) to the maximum depth investigated, but this is a result of disturbance of the chalk by drilling. Groundwater was encountered within the chalk during drilling at a depth of approximately 4.00 m, rising to 2.00 m and subsequent monitoring has indicated groundwater at 2.00 m. Contamination testing has measured elevated lead and benzo(a)pyrene above the screening values for a residential end use with plant uptake.

RECOMMENDATIONS

Load changes for Clarendon House are proposed to be negligible and therefore no modifications should be necessary to the existing foundations. For the proposed ten-storey extension, loads are high and piled foundations will be required to support the new building.

Remedial measures in the form of imported clean soil will be required where any areas of soft landscaping are to be incorporated into the scheme to protect end users from the lead and benzo(a)pyrene contamination.

Part 1: INVESTIGATION REPORT

This section of the report details the objectives of the investigation, the work that has been carried out to meet these objectives and the results of the investigation. Interpretation of the findings is presented in Part 2.

1.0 INTRODUCTION

Geotechnical and Environmental Associates (GEA) has been commissioned by Fluid Structures, on behalf of Reading Heights Limited, to carry out a desk study and ground investigation at Royal Heights, Queens Road, Reading RG1 4BN.

1.1 Proposed Development

It is understood that it is proposed to convert the existing office building into residential units, which will include the addition of two extra storeys and a ten-storey extension on the eastern half of the car park. Some soft landscaped areas may be incorporated into the scheme.

This report is specific to the proposed development and the advice herein should be reviewed if the development proposals are amended.

1.2 Purpose of Work

The principal technical objectives of the work carried out were as follows:

- ❑ to determine the history of the site and surrounding area, particularly with respect to any previous or present potentially contaminative uses;
- ❑ to assess the risk from unexploded ordnance (UXO);
- ❑ to determine the ground conditions and their engineering properties;
- ❑ to determine the configuration of the existing foundations;
- ❑ to provide advice for the design of suitable foundations;
- ❑ to provide an indication of the degree of soil contamination present; and
- ❑ to assess the risk that any such contamination may pose to the proposed development, its users or the wider environment.

1.3 Scope of Work

In order to meet the above objectives, a desk study was carried out followed by a ground investigation. The desk study comprised:

- ❑ a review of historical Ordnance Survey (OS) maps and environmental searches sourced from the Envirocheck database;
- ❑ a review of readily available geology maps;

- ❑ a preliminary UXO risk assessment (ref EP5854-00, dated 10 January 2018) commissioned from 1st Line Defence; and
- ❑ a walkover survey of the site carried out at the time of the fieldwork.

In the light of this desk study an intrusive ground investigation was carried out which comprised, in summary, the following activities:

- ❑ a single cable percussion borehole advanced to a depth of 30.00 m;
- ❑ two trial pits, mechanically excavated using a tracked mini-excavator to a depth of 1.50 m;
- ❑ four open-drive sampler boreholes, sampled to 5 m and extended by continuous probing to a depth of 8.15 m;
- ❑ standard penetration tests (SPTs) at regular intervals in the boreholes to provide quantitative data on the strength of the soils;
- ❑ installation of three standpipes to a depth of 5.00 m and two return groundwater monitoring visits;
- ❑ testing of selected soil samples for contamination and geotechnical purposes; and
- ❑ provision of a report presenting and interpreting the above data, together with our advice and recommendations with respect to the proposed development.

The report includes a contaminated land assessment which has been undertaken in accordance with the methodology presented in Contaminated Land Report (CLR) 11¹ and involves identifying, making decisions on, and taking appropriate action to deal with, land contamination in a way that is consistent with government policies and legislation within the United Kingdom. The risk assessment is thus divided into three stages comprising Preliminary Risk Assessment, Generic Quantitative Risk Assessment, and Site-Specific Risk Assessment.

The exploratory methods adopted in this investigation have been selected on the basis of the constraints of the site including but not limited to access and space limitations, together with any budgetary or timing constraints. Where it has not been possible to reasonably use an EC7 compliant investigation technique a practical alternative has been adopted to obtain indicative soil parameters and any interpretation is based upon engineering experience, local precedent where applicable and relevant published information.

1.4 Limitations

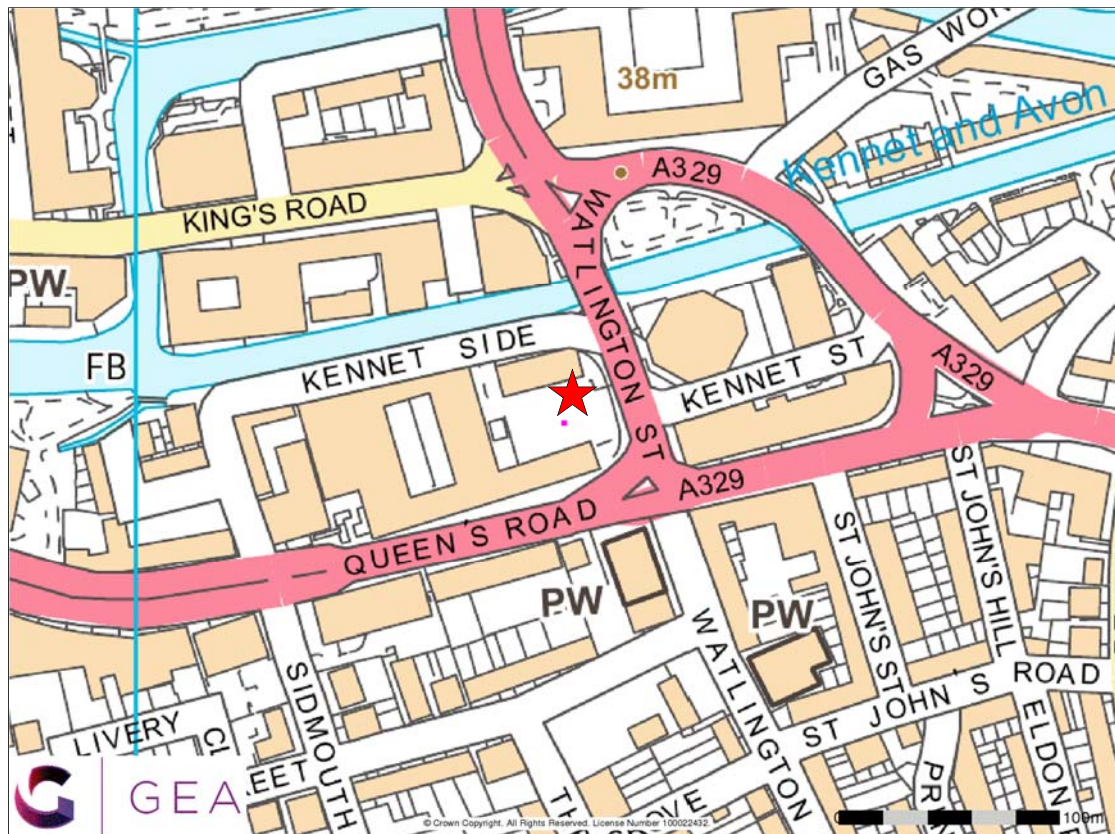
The conclusions and recommendations made in this report are limited to those that can be made on the basis of the investigation. The results of the work should be viewed in the context of the range of data sources consulted, the number of locations where the ground was sampled and the number of soil, gas or groundwater samples tested; no liability can be accepted for information in other data sources or conditions not revealed by the sampling or testing. Any comments made on the basis of information obtained from the client or other third parties are given in good faith on the assumption that the information is accurate; no independent validation of such information has been made by GEA.

1 *Model Procedures for the Management of Land Contamination* issued jointly by the Environment Agency and the Department for Environment, Food and Rural Affairs (DEFRA) Sept 2004

2.0 THE SITE

2.1 Site Description

The site is located approximately 920 m to the southeast of Reading railway station and fronts onto Queen's Road to the south. It is bounded to the east by Watlington Street, located at a higher level and supported by a retaining wall, to the north by a six-storey apartment block, called Grantley Heights and to the west by a seven-storey apartment block, known as Queen's Wharf.. The site may additionally be located by National Grid Reference 472190, 173290 and is shown on the map extract below.



A walkover survey was carried out by an engineer from GEA on 15 January 2018, prior to the fieldwork and selected photographs are included below. The site is irregular in shape and measures roughly 40 m north-south by 50 m east-west. It is essentially on a level plot and is currently occupied by Clarendon House, which fronts onto Queen's Road to the south. Clarendon House is a four-storey building with partial basement, formerly used as offices and currently vacant apart from live-in security personnel.

A tarmac car park is present to the north of the office building, with an area of soft landscaping in the southeastern corner, planted with bushes. The car park can be accessed via Kenet Side. At the time of the investigation the car park was not in use.

Hypodermic needles were noted at the rear of Clarendon House, in the southwestern corner of the car park.



Northern elevation of
Clarendon House



Queen's Wharf, looking west



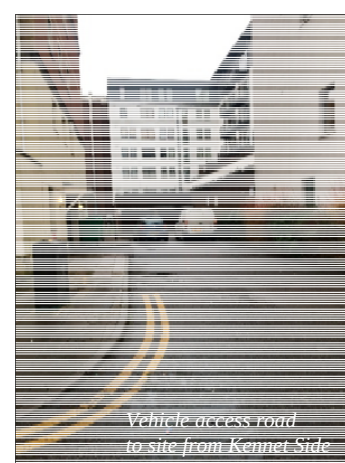
Grantley Heights on right



View of car park, looking
east towards Watlington Street



Western boundary of site
(Clarendon House, adjoined to
Queen's Wharf)



Vehicle access road
to site from Kennet Side

2.2 Site History

The site history has been researched by reference to historical Ordnance Survey (OS) maps obtained from the Envirocheck database and information submitted as part of previous planning applications, available on Reading Borough Council's website. This includes a Phase One Preliminary Risk Assessment carried out by RPS on behalf of a different client (report ref HLE153111/001R, dated June 2017).

The earliest map studied, dated, 1879, shows the site to already be developed with what appears to be terraced houses, fronting onto Watlington Street to the east and Queen's Road to the south. The immediate surrounding area also appears to be developed with terraced housing. A gas works was present 220 m to the northeast with a biscuit factory 160 m to the north. Within 250 m of the site was also wharves, breweries, printing works, two saw mills and a timber yard were present. The Kennet and Avon Canal had also been built by this time and was present 50 m to the north of the site.

By 1899, another biscuit factory had been constructed roughly 240 m to the southwest of the site and by 1912 this biscuit factory had relocated slightly to the east.

Between the 1931 and 1957 historical OS maps, a print works was located in the central western part of the site, with a warehouse shown 100 m to the west and a printing works 100 m to the east. During the period, the gas works appears to have been demolished.

By the 1989 map, the terraced houses on site and in the immediate surrounding area had been demolished, along with the print works and replaced with the existing office building of Clarendon House shown on this map in the south of the site. At some time between 1971 and 1989, the wharves, warehouses, factories, breweries and saw mill are removed and replaced.. On the 1991 map, a tank is first shown to the west of the site located within the grounds of Queen's Wharf, which is an apartment block. The tank has been shown on maps since 1991 and the contents of the tank is unknown.

A search of the planning applications relating to the site are available on Reading Borough Council' website and are summarised below;

Ref; 180156 (26/01/2018); Change of use of building from Class B1(a) (offices) to C3 (dwelling houses) to comprise 49 dwellings. No decision listed.

Ref 170905 (31/07/2017); Change of use of building from Class B1(a)(offices) to C3 (dwelling houses) to comprise 49 residential units. Approved.

Ref; 050013 (05/06/2005); Wall mounted air conditioning condenser unit on back of building. Permitted.

Ref; 010442 (04/05/2001); Installation of telecommunications apparatus consisting of 6 antennas, 3 m stub mast and radio equipment housing. No decision listed.

Ref 980612 (16/12/1998); Erection of 5/6 storey residential development comprising 24 apartments with associated car parking at ground/basement level. No decision listed.

Ref; 980251 (07/08/1998); Erection of 5/6 Storey residential development comprising 24 apartments with associated car parking at ground/basement level. Permitted.

Ref; 930087 (14/09/1993); Change of use from existing B1 consent to A2 consent. Permitted.

2.3 Preliminary UXO Risk Assessment

A preliminary UXO risk assessment has been carried out by 1st Line Defence and their report (ref EP5854-00, dated 10 January 2018) is included in the appendix. The risk assessment has been carried out in accordance with the guidelines provided by CIRIA, which state that the likelihood of encountering and detonating unexploded ordnance (UXO) below a site should be assessed along with establishing the consequences that may arise. The first phase comprises a preliminary risk assessment, which should be undertaken at an early stage of the development planning. If such an assessment identifies a high level of risk then a detailed risk assessment should be carried out by a UXO specialist, which will identify an appropriate course of action with regard to risk mitigation.

The preliminary UXO risk assessment indicated that there is no evidence in available historical ordnance survey maps that the site received any damage during WWII, such as areas of 'ruin(s)' or areas of missing buildings. During the war the site was occupied by residential and commercial properties and it is likely that the site received regular access and that evidence of bombs would have been noticed and recorded. The site was developed with the existing office block after the war, and the assessment concluded that there is a minimal risk that items of UXO will be encountered on the site and that no further research be carried out on the site.

2.4 Other Information

A search of public registers and databases has been made via the Envirocheck database and relevant extracts from the search are appended. Full results of the search can be provided if required.

The desk study research has indicated that there are no registered landfill, waste transfer, waste treatment, disposal or recorded infilled land sites within 250 m of the site. There are 26 pollution incidents to controlled waters within 250 m of the site, with the closest being 10 m northeast of the site, classed as category three (minor incident). This incident occurred in November 1994 and the pollutant was recorded as oils. Three discharge consents are recorded within 250 m of the site with the closest listed 176 m to the north. In total, there are 18 contemporary trade directory entries within 250 m of the site but there are no fuel station entries. The site is not listed as being within a Nitrate Vulnerable Zone or any other sensitive land use.

Reference to the National Radiological Protection Agency (NRPB, now part of the Health Protection Agency) Radon Atlas of England and Wales, indicates that the site falls within an area where less than 1% of homes are affected by radon emissions and therefore radon protective measures will not be necessary.

2.5 Geology

The British Geological Survey map of the area indicates that the site is directly underlain by River Terrace Deposits, overlying the Seaford Chalk Formation. Alluvium is shown to outcrop to the north of the site, associated with the River Kennet, and the Lambeth Group outcrops to the south of the chalk.

Chalk solution features are known to occur within the chalk close to the boundary with the Lambeth Group. A search of British Geological Survey records included in the Envirocheck report has indicated a very low risk of ground dissolution subsidence at the centre of the site, increasing to a high risk 72 m to the south of the centre of the site. There are no natural cavities recorded within 500 m of the site but there are seven within 500 m to 1000 m from the site.

The town of Reading is known for chalk mining and there are two recorded man-made cavities within 500 m of the site. The closest is located 189 m south of the centre of the site, with another 467 m to the southwest.

2.6 Hydrology and Hydrogeology

The River Terrace Deposits are classified as a Secondary 'A' Aquifer, defined by the Environment Agency (EA) as permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers. The underlying chalk is classified as a Principal Aquifer, defined as layers of rock or drift deposits that have high intergranular and / or fracture permeability.

A Groundwater Source Protection Zone is located 52 m northeast of the centre of the site, listed as Zone III. There are no recorded groundwater abstraction licences within 500 m of the site. The nearest surface water feature is the Kennet and Avon Canal, 49 m to the north of the site, and groundwater is expected to be flowing in a roughly northeasterly direction beneath the site.

The Environment Agency indicates the site to be located within an area at risk from flooding from rivers or sea (Zone III) and is identified to be at risk from groundwater flooding. A flood risk assessment has been completed by RPS as part of a previous application (report ref; HLEF53150/001R, dated June 2017) and a copy of this report is publicly available to view on Reading Borough Council's planning website.

2.7 Preliminary Risk Assessment

Part IIA of the Environmental Protection Act 1990, which was inserted into that Act by Section 57 of the Environment Act 1995, provides the main regulatory regime for the identification and remediation of contaminated land. The determination of contaminated sites is based on a "suitable for use" approach, which involves managing the risks posed by contaminated land by making risk-based decisions. This risk assessment is carried out on the basis of a source-pathway-receptor approach.

2.7.1 Source

The site was previously developed by terraced housing prior to 1879. A print works was present in the central western part of the site from some time between 1931 and 1957. All of the buildings on site were demolished between 1971 and 1989 and replaced with the existing office building and car park.

The former print works is a potentially contaminative use, although there is no ongoing source of contamination. The print works was located in the western half of the car park, which is currently not planned to be developed. The relevant DoE industry profile² indicates the main groups of potential contaminants associated with this site use to be metals and metalloids, inorganic ions, acids and organics, including solvents, with hydrocarbon fuels in fuel storage areas.

Demolition of the buildings previously present on the site is likely to have resulted in the presence of a moderately significant thickness of made ground, including a possibility of backfilled basements beneath the terrace houses. This would mostly be inert rubble but is likely to include small quantities of contaminants such as lead, present in paintwork and other metals. Asbestos is likely to have been present in building fabric/insulation.

Within 250 m of the site there have been saw mills, timber yard, gas works, breweries, wharves, works and warehouses, which are potentially contaminative land uses. However, most of these sites have been redeveloped and there are no ongoing sources of contamination. In addition, groundwater flow beneath the site is expected to be in a northeast direction and the site was located upstream and contamination is unlikely to have migrated onto the site.

A tank is present immediately to the west of the site within the grounds of Queen's Wharf. The tank has been shown on maps since 1991 and the contents of the tank are unknown and may represent a potential source of contamination.

The desk study has not identified any evidence of landfills within the vicinity of the site and made ground associated with demolition of the houses previously present on the site is likely to be predominantly inert demolition rubble. No potential sources of soil gas have, therefore, been identified.

² Great Britain. Department of Environment (1996). *Profile of Miscellaneous Industries, incorporating charcoal works, dry-cleaners, fibreglass and fibreglass resins manufacturing works, glass manufacturing, photographic processing industries and printing and book works.* (DOE Industry Profile)

2.7.2 Receptor

The proposed redevelopment of the site for residential purposes will result in the end users, together with vegetation in garden areas, representing relatively high sensitivity receptors. Buried services are likely to come into contact with any contaminants present within the soils through which they pass and site workers are likely to come into direct contact with any contaminants present in the soil during construction. The site is considered to be underlain by a Secondary 'A' Aquifer and therefore groundwater may be considered to be a high sensitive receptor. The chalk beneath the site is a Principal Aquifer and, as such, also represents a highly sensitive receptor.

2.7.3 Pathway

Within the site, end users will be isolated from direct contact with any contaminants present within the near surface soils by the presence of the building and the extent of the hardstanding, thus limiting potential contaminant exposure pathways. The construction will not create any new pathways for existing contaminants in the ground to reach end users, unless soft landscaped areas are to be incorporated.

The site is likely to be directly underlain by a Secondary 'A' Aquifer, overlying the Chalk which is a Principal Aquifer and a pathway may exist for groundwater through granular soils of the Secondary 'A' Aquifer to the Principal Aquifer of the chalk. considered likely to exist to both aquifers. Buried services may be exposed to any contaminants present within the soil through direct contact and site workers will come into contact with the soils during construction works. There is thus considered to be a low potential for a contaminant pathway to be present between any potential contaminant source and a target for the particular contaminant.

2.7.4 Preliminary Risk Appraisal

On the basis of the above it is considered that there is a LOW risk of there being a significant contaminant linkage at this site that would result in a requirement for major remediation work. As there is no evidence of filled ground within the vicinity of the site and no landfill sites, there is not considered to be a significant potential for hazardous soil gas to be present on or migrating towards the site.

3.0 EXPLORATORY WORK

In order to meet the objectives described in Section 1.2, a single cable percussion borehole was drilled to a depth of 30.00 m in the car park. This borehole was supplemented with four open-drive sampler boreholes advanced to a depth of up to 5 m, continued to 8.15 m by continuous probing, in view of the initial low blow counts in the top of the chalk. Standard Penetration Tests (SPTs) were carried out at regular intervals in the boreholes to provide additional quantitative data on the strength of the soils.

Standpipes (50 mm diameter) were installed into Borehole Nos 1, 2 and 3 to a depth of 5.00 m and groundwater monitoring has been carried out on two occasions to date, approximately two weeks and three weeks after installation.

Two trial pits were mechanically excavated, using a tracked mini-excavator, to a depth of 1.50 m to determine the configuration of the existing foundations of Nos 59 to 75 Queen's Road (Clarendon House) and Nos 1 to 24 Kennet Side (Grantley Heights).

All of the above work was carried out under the supervision of a geotechnical engineer from GEA.

A selection of the samples recovered from the boreholes and trial pits was submitted to a soil mechanics laboratory for a programme of geotechnical testing and an analytical laboratory for a programme of contamination testing.

The borehole records and results of the laboratory analyses are appended together with a site plan indicating the exploratory positions.

3.1 Sampling Strategy

The scope of the works was specified by the consulting engineers, with input from GEA.

The borehole and trial pit locations were agreed on site between the structural engineer and GEA on the morning of the fieldwork.

At the request of the client, concrete bollards were removed at two entrances to the site, using a mini-excavator.

Five samples of the made ground were subjected to analysis for a range of common industrial contaminants and contamination indicative parameters. For this investigation, the analytical suite for the soil included a range of metals, speciation of total petroleum hydrocarbons (TPH), polycyclic aromatic hydrocarbons (PAH), total cyanide and monohydric phenols. In addition, the samples were screened for asbestos as a precautionary measure.

The soil samples were selected to provide a general view of the chemical conditions of the soils that are likely to be involved in a human exposure or groundwater pathway and to provide advice in respect of re-use or for waste disposal classification.

The contamination analyses were carried out at an MCERTs accredited laboratory with the majority of the testing suite accredited to MCERTS standards. Details of the MCERTs accreditation and test methods are included in the Appendix together with the analytical results.

A number of samples recovered from the boreholes were submitted to a geotechnical laboratory for a programme of testing that included soluble sulphate and pH level analysis. Selected samples of the chalk were also tested to determine their intact density and moisture content.

4.0 GROUND CONDITIONS

The investigation has generally confirmed the expected ground conditions, in that beneath a moderate to significant thickness of made ground, a cover of Superficial Deposits was encountered, overlying the Seaford Chalk Formation which was proved to the maximum depth investigated of 30.00 m.

4.1 Made Ground

The boreholes found the made ground to extend to depths of between 0.80 m and 2.60 m. In Borehole Nos 1, 3 and 4, the made ground extended to depths of 0.80 m, 1.35 m and 1.40 m respectively, with the greatest thicknesses of made ground in Borehole Nos 2 and 5, in the eastern half of the site, extending to depths of 2.60 m and 2.40 m respectively. These boreholes were located within area of the former terraced houses, which may have had basements.

A total of five samples were sent for contamination testing and the results are presented in Section 4.5.

4.2 Superficial Deposits

This stratum was encountered in all exploratory locations directly below the made ground and varied in thickness from 0.15 m to 2.30 m, extending to depths of between 1.75 m and 4.40 m. The Superficial Deposits generally comprised soft brown clayey silt with occasional gravel composed of flint and chalk. In Borehole No 4, between 1.40 m and 2.30 m, light brown gravelly fine sand was encountered.

Atterberg limit tests were carried out on three samples, which indicate these soils to be non-plastic.

These soils were observed to be free of any evidence of soil contamination.

4.3 Seaford Chalk Formation

On the basis of the inspection of recovered samples, the chalk has been classified in accordance with CIRIA Report C574 (2002), *Engineering in Chalk* with the chalk from the boreholes recovered as structureless chalk, composed of off-white with rare light brown staining gravelly slightly sandy silt with rare flint gravel (Grade Dm). The chalk was highly weathered to a depth of about 5 m with a brown clay infill noted. The sampling will however have resulted in disturbance of the material and the recovered samples are unlikely to be indicative of the insitu condition.

In situ testing from the boreholes has indicated either zero or low blow counts to depths of between 5 m and 6 m in the chalk and poor or no recovery of the chalk was noted in the open-drive sampler boreholes from depths of 2 m to 5 m. Further details on this are included on the borehole records in the appendix. Below a depth of about 6 m, the N values generally increase with depth and the N60 values in the cable percussion borehole range from 11 at a depth of 6.00 m to 102 at a depth of 29.50 m.

The results of laboratory analysis on three samples of chalk recovered from the cable percussion borehole at depths of 4.00 m, 17.50 m and 26.50 m indicate the chalk to be of low density and medium density with intact dry densities of between 1.55 Mg/m³ and 1.56 Mg/m³ and natural moisture contents of 27 % and 28 %.

No visual and olfactory evidence of contamination was observed within these natural soils.

4.4 Groundwater

Groundwater was not encountered during excavation of the foundation pits to depths of 1.50 m. However, groundwater was encountered during drilling in all five boreholes from within the chalk, generally at depths of between 3.90 m to 4.00 m and the water level rapidly rose up to depths of between 2.07 m and 2.38 m. Standpipes were installed in Borehole Nos 1, 2 and 3 to a depth of 5.00 m and the results of the groundwater monitoring on two occasions, roughly two weeks and three weeks after installation are shown in the table overleaf.

Date	Borehole No	Depth to water (m)
30/01/2018	1	1.98
	2	2.16
	3	2.12
05/02/2018	1	2.00
	2	2.18
	3	2.14

4.5 Soil Contamination

The following table sets out the values measured within five samples of made ground analysed. All concentrations are in mg/kg unless otherwise stated.

Determinant	BH2: 0.80- m	BH3: 0.80 m	BH4: 0.70 m	BH5: 0.60 m	TP2: 0.50m
pH	10.3	8.3	8.2	9.1	8.8
Arsenic	5.7	26	21	9.9	13
Cadmium	<0.2	<0.2	<0.2	0.6	<0.2
Chromium	10	22	21	83	23
Lead	45	260	190	290	62
Mercury	<0.3	1.0	1.1	0.4	<0.3
Selenium	<1.0	<1.0	<1.0	<1.0	<1.0
Copper	6.8	92	52	250	18
Nickel	9.5	26	21	14	11
Zinc	39	240	170	230	75
Total Cyanide	<1.0	<1.0	<1.0	<1.0	<1.0
Total Phenols	<1.0	<1.0	<1.0	<1.0	<1.0
Total PAH	55.5	10.6	4.30	<0.80	5.07
Sulphide	<1.0	1.1	<1.0	1.3	1.3
Benzo(a)pyrene	5.3	1.1	0.53	<0.05	0.55
Naphthalene	0.21	<0.05	<0.05	<0.05	<0.05
Total TPH (C10-C40)	260	62	<10	160	<10
Total Organic Carbon	0.3	2.0	1.4	0.7	0.5
Asbestos	Not-detected	Not-detected	Not-detected	Not-detected	Not-detected

Note: Figure in bold indicates concentration in excess of risk-based soil guideline values, as discussed in Part 2 of this report

4.5.1 Generic Quantitative Risk Assessment

The use of a risk-based approach has been adopted to provide an initial screening of the test results to assess the need for subsequent site-specific risk assessments. Contaminants of concern have values in excess of generic human health risk based guideline values which are either the CLEA³ Soil Guideline Value where available, or a Generic Screening Value calculated using the CLEA UK Version 1.06⁴ software assuming a residential end use with plant uptake, or based on the DEFRA Category 4 Screening values⁵. The key generic assumptions for this end use are as follows:

- ❑ that groundwater will not be a critical risk receptor;
- ❑ that the critical receptor for human health will be a young female child aged 0 to 6 years old;
- ❑ that young children will not have prolonged exposure to the site;
- ❑ that the exposure duration will be six years;
- ❑ that the critical exposure pathways will be direct soil and indoor dust ingestion, skin contact with soils and dust, and inhalation of dust and vapours; and
- ❑ that the building type equates to a two-storey small terraced house.

It is considered that these assumptions are acceptable for this generic assessment of this site. The tables of generic screening values derived by GEA and an explanation of how each value has been derived are included in the Appendix.

Where contaminant concentrations are measured at concentrations below the generic screening value it is considered that they pose an acceptable level of risk and thus further consideration of these contaminant concentrations is not required. However, where concentrations are measured in excess of these generic screening values there is considered to be a potential that they could pose an unacceptable risk and thus further action will be required which could include;

- ❑ additional testing to zone the extent of the contaminated material and thus reduce the uncertainty with regard to its potential risk;
- ❑ site specific risk assessment to refine the assessment criteria and allow an assessment to be made as to whether the concentration present would pose an unacceptable risk at this site; or
- ❑ soil remediation or risk management to mitigate the risk posed by the contaminant to a degree that it poses an acceptable risk.

This assessment is based upon the potential for risk to human health, which at this site is considered to be the critical risk receptor.

The contamination results indicate slightly elevated lead above the screening values for a residential end use with plant uptake in two of the five samples of made ground tested. In

3 Updated Technical Background to the CLEA Model (Science Report SC050021/SR3) Jan 2009 and Soil Guideline Value reports for specific contaminants; all DEFRA and Environment Agency.
4 Contaminated Land Exposure Assessment (CL|EA) Software Version 1.06 Environment Agency 2009
5 CL:AIRE (2013) *Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination* Final Project Report SP1010 and DEFRA (2014) *Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination* Policy Companion Document SP1010

addition, benzo(a)pyrene was also slightly elevated in a single sample. No other contaminants were noted to be above the screening values and no asbestos was detected during routine laboratory screening. The significance of these results are discussed in Part 2 of this report.

4.6 Existing Foundations

A total of two trial pits were excavated to expose the foundations of the existing buildings and the findings are summarised in the table below. Trial pit records are included within the appendix.

Trial Pit No	Structure	Foundation Detail	Bearing Stratum
1	Neighbouring building	Concrete Top: 0.50 m Base: 1.38 m Lateral projection: 550 mm	Soft orange-brown silty sandy clay with rare coarse subangular flint gravel – possibly made ground
2	Office building	Concrete Top: GL Base: 1.46 m Lateral projection: 600 mm	Appears to be bearing on weathered chalk

Part 2: DESIGN BASIS REPORT

This section of the report provides an interpretation of the findings detailed in Part 1, in the form of a ground model, and then provides advice and recommendations with respect to the proposed extension.

5.0 INTRODUCTION

It is understood that it is proposed to convert the existing office building into residential units and add an extra two storeys at roof level. It is understood from the structural engineers that the loads changes associated with this conversion and roof extension will be negligible.

It is also proposed to construct a ten-storey extension in the eastern half of the car park which will need to be supported on piled foundation with loads expected to be around 3000 kN for external columns and 6000 kN for internal columns.

6.0 GROUND MODEL

The desk study has revealed that the site was previously developed with terraced houses with rear gardens, prior to 1879. A print works was located in the central western part of the site from some time between 1931 and 1957. The site was redeveloped by 1989 with the existing office building and car park to the rear. Within close proximity of the site, there has been works, factories, wharves, breweries, warehouse and printing works, which have subsequently been redeveloped. On the basis of the fieldwork, the ground conditions at this site can be characterised as follows.

- ❑ Beneath a nominal thickness of made ground, Superficial Deposits overlies the Seaford Chalk Formation and was proved to the maximum depth investigated of 30.00 m;
- ❑ the made ground extends to depths of between 0.80 m and 1.40 m in the central and western half of the proposed new building, with a greater thickness of made ground encountered in the east, close to Watlington Street and extends to depths of 2.40 m and 2.60 m;
- ❑ directly below the made ground, Superficial Deposits comprising soft brown clayey silt with occasional gravel, composed of chalk and flint was generally encountered, which extends to depths of between 1.75 m and 4.40 m;
- ❑ the chalk was highly weathered to a depth of about 6 m with a brown clay infill and SPT blow counts recorded between zero and two;
- ❑ the SPT 'N' values in the chalk show an increase with depth;
- ❑ groundwater was encountered during drilling at a depth of approximately 4.00 m from within the chalk, rising to 2.00 m;
- ❑ subsequent groundwater monitoring has measured water to be standing in the standpipes at a depth of about 2.00 m; and
- ❑ contamination testing has measured elevated lead and benzo(a)pyrene above the screening values for a residential end use with plant uptake.

7.0 ADVICE AND RECOMMENDATIONS

Given the proposed loadings of the new ten-storey building, piled foundations extending into the chalk will be required. Consideration will need to be given to the possibility of variations in the level and quality of the chalk for the design of piles.

It is also proposed to add an extra two-storeys to the existing office building of Clarendon House, which is supported on concrete footings at a depth of 1.46 m bearing on what appears to be chalk. The load changes are understood to be negligible and it should be possible to make the load changes without any modifications to the existing foundations. If there is an increase in load, a check should be undertaken to confirm that settlements will remain acceptable and in any case additional trial pits would be prudent to check the bearing stratum.

If solution features or anomalous ground conditions are encountered, work should be halted until reviewed by a suitably qualified geotechnical engineer.

7.1 Re-use of Existing Foundations

It is understood that the proposed alterations to the existing office building and extra two-storeys will not result in load changes to the existing foundations. There does not appear to be any indication of movement of the existing foundations or structural distress of the building. The office building was constructed by 1989 and the settlement that would occur as a result of the loading from the foundations of both buildings may be assumed to be complete.

7.2 Piled Foundations

For the ground conditions encountered at the site, some form of bored pile is likely to be the most suitable. The following parameters, based upon the guidance provided by CIRIA⁶ for piles in chalk, are considered suitable for the preliminary design of straight-shafted bored piles installed using cfa techniques.

The following table of ultimate coefficients may be used for the preliminary design of bored piles, based on the measured SPT / depth graph in the appendix. Groundwater has been assumed to be present at a depth of 2.00 m and the chalk is assumed to be fully saturated.

Stratum	Depth m	kN / m ²
Skin Friction		
Made Ground / Superficial Deposits	-	Ignore
Chalk ($\beta = 0.45$)	4.40 to 30.00	Increasing linearly from 8 to 115
End Bearing		
Chalk ($N \times 200$)	10.00 to 25.00	Increasing from 4000 to 10,000*(limit)

* the limiting value will need to be checked based on a limiting allowable bearing pressure for individual pile loads in accordance with CIRIA C574

The following pile capacities have been estimated and are presented in the table below, based on an overall factor of safety of 2.5.

6 Engineering in Chalk CIRIAC574 (2002)

Pile Diameter (mm)	Pile Depth (m)	Approximate Safe Working Load (kN)
450	25	1100
600	25	1650
750	25	2385

The above examples are not intended to constitute any form of recommendation with respect to pile size or type and the advice of specialist piling contractors should be consulted in this respect.

As with any site underlain by chalk, variations in the level and quality of the chalk may occur and the piling method should be able to deal with any such variations.

7.3 Shallow Excavations

On the basis of the trial pit findings, it is considered that shallow excavations for foundations and services that extend through the made ground and into the natural soils are likely to remain relatively stable in the short term. However, should deeper excavations be considered or if excavations are to remain open for prolonged periods it is recommended that provision be made for battered side slopes or lateral support. Where personnel are required to enter excavations, a risk assessment should be carried out and temporary lateral support or battering of the excavation sides considered in order to comply with normal safety requirements.

Significant groundwater inflows into shallow excavations of less than 2 m in depth are not generally anticipated, although seepages may be encountered from perched water tables within the made ground, particularly within the vicinity of existing foundations; such inflows should, however, be suitably controlled by sump pumping.

7.4 Ground Floor Slab

Following the removal of the made ground a ground bearing floor slab may be adopted on the Superficial Deposits or chalk, following a proof rolling exercise and the infilling of any soft spots with suitably compacted granular fill or lean mix concrete. If chalk is exposed at formation level, ground floor slabs of unheated or poorly insulated buildings should be constructed over a layer of well compacted, free draining material of at least 300 mm thickness. In heated well insulated buildings, ground floor slabs can be constructed directly on chalk although the formation should not be exposed during construction for more than five consecutive days if the mean daily air temperature is below freezing.

7.5 Effect of Sulphates

Elevated concentrations of sulphate are not normally found in chalk soils. Sulphate and pH tests were undertaken on five samples of made ground and three samples of Superficial Deposits. The results have measured a sulphate class for the made ground generally in Class DS-1 with an ACEC class of AC-1, however the sample tested from Borehole No 2, falls into DS-3, with an ACEC class of AC-3, which assumes mobile water. Testing of natural samples indicate a sulphate class of DS-1 and ACEC class of AC-1, assuming mobile groundwater. The guidelines contained in BRE Special Digest 1 Part C (2005) should be followed in the design of foundation concrete.

7.6 Site Specific Risk Assessment

The site was developed by terraced housing prior to 1879. A print works was present in the central western part of the site from some time between 1931 and 1957, and represents a potential source of contamination. The site was redeveloped by 1989 with the existing office building and car park. Off-site there have been saw mills, a timber yard, gas works, factories, breweries, wharves, works and warehouses, which are potentially contaminative uses. A tank of unknown contents has been located from 1991 until the present day within the grounds of Queen's Wharf and may represent a source of contamination.

Contamination testing was carried out on five samples from five different locations, within the footprint of the proposed new extension. The contamination results have measured slightly elevated lead above the screening values for a residential end use with plant uptake in two of the five samples of made ground tested. Lead concentrations have been measured at 260 mg/kg and 290 mg/kg, above the screening value of 200 mg/kg. In addition, benzo(a)pyrene was also slightly elevated in a single sample above the screening value of 4.4 mg/kg at 5.3 mg/kg. No other contaminants were noted to be above the screening values and no asbestos was detected during routine laboratory screening.

The source of the lead and benzo(a)pyrene is likely to be attributable to extraneous fragments of burnt coal and ash. The lead and benzo(a)pyrene are considered to be non-volatile or of a low volatility and does not thus present a significant vapour risk. In addition, these compounds are considered likely to be of low solubility and a risk to groundwater has not been identified. The contamination could, however, pose an unacceptable risk to human health within areas of soft landscaping or through direct contact, accidental ingestion or inhalation of soil or soil derived dust. Within any proposed soft landscaped areas clean topsoil should be imported for the planters to protect end users and to provide a suitable medium for plant growth. The thickness of the topsoil required will depend on the plant type and should be specified by a landscape architect. A geoenvironmental engineer should be consulted with regard to sourcing suitable topsoil and validating the remedial measures.

7.6.1 Site Workers

Site workers should be made aware of the lead and benzo(a)pyrene contamination and a programme of working should be identified to protect workers handling any soil. The method of site working should be in accordance with guidelines set out by HSE and CIRIA and the requirements of the Local Authority Environmental Health Officer. A watching brief should also be maintained during the groundwork, and if suspicious soils are encountered then a suitably qualified engineer should inspect the soils and further testing carried out if required.

7.7 Waste Disposal

Under the European Waste Directive, waste is classified as being either Hazardous or Non-Hazardous and landfills receiving waste are classified as accepting hazardous or non-hazardous wastes or the non-hazardous sub-category of inert waste in accordance with the Waste Directive. Waste classification is a staged process and this investigation represents the preliminary sampling exercise of that process. Once the extent and location of the waste that is to be removed has been defined, further sampling and testing may be necessary. The results from this ground investigation should be used to help define the sampling plan for such further testing, which could include WAC leaching tests where the totals analysis indicates the soil to be a hazardous waste or inert waste from a contaminated site. It should however be noted that the Environment Agency guidance WM3⁷ states that landfill WAC analysis, specifically leaching test results, must not be used for waste classification purposes.

7 Environment Agency 2015. *Guidance on the classification and assessment of waste*. Technical Guidance WM3 First Edition

Any spoil arising from excavations or landscaping works, which is not to be re-used in accordance with the CL:AIRE⁸ guidance, will need to be disposed of to a licensed tip. Waste going to landfill is subject to landfill tax at either the standard rate of £86.10 per tonne (about £155 per m³) or at the lower rate of £2.70 per tonne (roughly £5 per m³). However, the classifications for tax purposes and disposal purposes differ and currently all made ground and topsoil is taxable at the 'standard' rate and only naturally occurring soil and stones, which are accurately described as such in terms of the 2011 Order, would qualify for the 'lower rate' of landfill tax.

Based upon the technical guidance provided by the Environment Agency it is considered likely that the soils encountered during this ground investigation, as represented by the five chemical analyses carried out on samples of shallow soils, would be generally classified as shown in the table below.

Soil Type	Waste Classification (Waste Code)	WAC Testing Required Prior to Landfill Disposal?	Comments
Made ground	Non-hazardous (17 05 04)	No	
Natural Soils	Inert (17 05 04)	Should not be required but confirm with receiving landfill	-

Under the requirements of the European Waste Directive, all waste needs to be pre-treated prior to disposal. The pre-treatment process must be physical, thermal, chemical or biological, including sorting. It must change the characteristics of the waste in order to reduce its volume, hazardous nature, facilitate handling or enhance recovery. The waste producer can carry out the treatment but they will need to provide documentation to prove that this has been carried out. Alternatively, the treatment can be carried out by an approved contractor. The Environment Agency has issued a position paper⁹ which states that in certain circumstances, segregation at source may be considered as pre-treatment and thus excavated material may not have to be treated prior to landfilling if the soils can be segregated onsite prior to excavation by sufficiently characterising the soils insitu prior to excavation.

The above opinion with regard to the classification of the excavated soils is provided for guidance only and should be confirmed by the receiving landfill once the soils to be discarded have been identified.

The local waste regulation department of the Environment Agency (EA) should be contacted to obtain details of tips that are licensed to accept the soil represented by the test results. The tips will be able to provide costs for disposing of this material but may require further testing.

⁸ CL:AIRE March 2011. *The Definition of Waste: Development Industry Code of Practice* Version 2
⁹ Environment Agency 23 Oct 2007 *Regulatory Position Statement Treating non-hazardous waste for landfill - Enforcing the new requirement*

8.0 OUTSTANDING RISKS AND ISSUES

This section of the report aims to highlight areas where further work is required as a result of limitations on the scope of this investigation, or where issues have been identified by this investigation that warrant further consideration. The scope of risks and issues discussed in this section is by no means exhaustive but covers the main areas where additional work is considered to be required.

The ground is a heterogeneous natural material and variations will inevitably arise between the locations at which it is investigated. This report provides an assessment of the ground conditions based on the discrete points at which the ground was sampled, but the ground conditions should be subject to review as the work proceeds to ensure that any variations from the Ground Model are properly assessed by a suitably qualified person.

It would be prudent to consult the building control officer to determine if the local council have any records of solution features close to the site and if they have any specific requirements for foundation construction.

These areas of doubt should be drawn to the attention of prospective contractors and further investigation will be required or sufficient contingency should be provided to cover the outstanding risk.

APPENDIX

Borehole Records

SPT Summary Sheet

Trial Pit Records

Laboratory Geotechnical Test Results

Chemical Analyses (soil)

Generic Risk-Based Soil Guideline Values

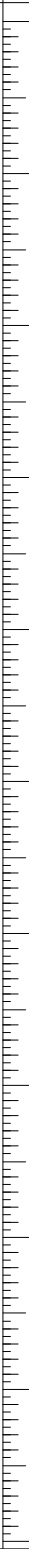
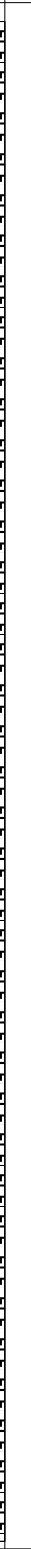
Envirocheck Extracts

Historical Maps

Preliminary UXO Risk Assessment

Site Plan

 Geotechnical & Environmental Associates Widbury Barn Widbury Hill Ware SG12 7QE						Site Royal Heights, Queen's Road, Reading, RG1 4BN		Borehole Number BH1	
Boring Method Cable Percussion		Casing Diameter 150mm cased to 29.50m		Ground Level (mOD)		Client Reading Heights Limited		Job Number J18003	
		Location				Dates 16/01/2018-17/01/2018		Engineer Fluid Structures	
Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
0.40	D1					0.07 (0.33)	MADE GROUND (macadam)		
						0.40 (0.40)	MADE GROUND (granular sub-base)		
0.80	D2					0.80	MADE GROUND (brown mottled orange-brown silty sandy clay with occasional flint gravel and rare chalk gravel, fragments of brick and rare ash)		
1.20-1.65 1.20	SPT(C) N60=32 B3	1.20	DRY	1,3/7,7,8,8			Soft orange-brown clayey sandy SILT with abundant fine to coarse subangular to subrounded flint gravel and rare medium subangular chalk gravel		
2.00-2.45 2.00	SPT(C) N60=11 B4	2.00	DRY	1,2/2,3,2,3		(2.30)			▼1
3.00-3.45 3.00	SPT(C) N60=9 B5	3.00	DRY	1,1/2,2,2,2		3.10	CHALK recovered as structureless chalk, composed of off-white with rare light brown staining gravelly slightly sandy SILT with brown clay infill. Gravel is very weak and weak, low density and medium density, off-white with rare blacks (Grade Dm)		▽1
4.00 4.00 4.00-4.45	B6 D7 SPT N60=3	4.00	3.50	Fast(1) at 3.90m, rose to 2.20m in 20 mins, not sealed. 1,0/1,1,1,0		4.00	CHALK recovered as structureless chalk, composed of off-white with rare light brown staining gravelly slightly sandy SILT. Gravel is very weak and weak, low density and medium density, off-white with rare black specks Grade Dm)		
5.00-5.45 5.00	SPT N60=4 D8	5.00	3.70	1,1/0,1,1,2					
6.00-6.45 6.00	SPT N60=11 D9	6.00	3.20	1,1/1,4,3,2					
7.50-7.95 7.50	SPT N60=15 D10	7.50	3.30	2,2/3,4,3,4			...rare fine subangular flint gravel		
9.00-9.45 9.00	SPT N60=18 D11	9.00		1,2/3,3,5,6			...rare medium to coarse subangular flint gravel		
Remarks Standpipe installed to a depth of 5.00 m Groundwater measured at a depth of 1.98 m on 30/01/2018 and 2.00 m on 05/02/2018								Scale (approx) 1:50	Logged By HD
								Figure No. J18003.BH1	

 GEA Geotechnical & Environmental Associates Widbury Barn Widbury Hill Ware SG12 7QE						Site Royal Heights, Queen's Road, Reading, RG1 4BN		Borehole Number BH1	
Boring Method Cable Percussion		Casing Diameter 150mm cased to 29.50m		Ground Level (mOD)		Client Reading Heights Limited		Job Number J18003	
		Location		Dates 16/01/2018-17/01/2018		Engineer Fluid Structures		Sheet 2/3	
Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
10.50-10.95 10.50	SPT N60=17 D12	10.50		3,3/3,4,4,5		 (26.00)	...rare medium to coarse subangular flint gravel		
12.00-12.45 12.00	SPT N60=18 D13	12.00		3,2/4,3,5,5					
13.50-13.95 13.50	SPT N60=22 D14	13.50		3,3/5,5,6,5			...rare medium to coarse subangular flint gravel		
15.00-15.45 15.00	SPT N60=26 D15	15.00		3,4/4,6,7,7			...rare medium to coarse subangular flint gravel		
				16/01/2018: 17/01/2018:3.00m					
16.50-16.95 16.50	SPT N60=36 D16	16.50	3.50	8,8/8,8,8,10			...rare coarse subangular flint gravel		
17.50	B17								
18.00-18.45 18.00	SPT N60=46 D18	18.00	3.20	8,8/9,11,12,11			...rare fine subangular flint gravel		
19.50-19.95 19.50	SPT N60=51 D19	19.50	4.10	8,7/9,9,15,15					
Remarks Standpipe installed to a depth of 5.00 m Groundwater measured at a depth of 1.98 m on 30/01/2018 and 2.00 m on 05/02/2018								Scale (approx) 1:50	Logged By HD
								Figure No. J18003.BH1	

 GEA Geotechnical & Environmental Associates Widbury Barn Widbury Hill Ware SG12 7QE							Site Royal Heights, Queen's Road, Reading, RG1 4BN		Borehole Number BH1
Boring Method Cable Percussion		Casing Diameter 150mm cased to 29.50m		Ground Level (mOD)		Client Reading Heights Limited		Job Number J18003	
		Location		Dates 16/01/2018-17/01/2018		Engineer Fluid Structures		Sheet 3/3	
Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
20.50	B20						...rare fine subangular flint gravel		
21.00-21.45 21.00	SPT N60=47 D21	21.00	4.70	7,7/8,10,12,14			...rare coarse subangular flint gravel		
22.50-22.95 22.50	SPT N60=42 D22	22.50	4.40	5,7/4,8,9,18					
23.50	B23								
24.00-24.45 24.00	SPT N60=59 D24	24.00	5.20	9,8/10,12,15,18					
25.50-25.53	SPT 35*/25	25.50	5.30	35/					
26.50	B25						...rare coarse subangular flint gravel and rare cobbles		
27.00-27.45 27.00	SPT N60=84 D26	27.00	6.00	8,11/13,15,24,27			...rare medium to coarse subangular flint gravel		
28.50-28.95 28.50	SPT N60=84 D27	28.50	6.80	10,10/14,18,22,25			...rare fine subangular flint gravel		
29.50-29.95 29.50	SPT N60=102 D28	29.50	7.00	11,16/15,22,26,33 17/01/2018:7.00m		30.00			
Remarks Standpipe installed to a depth of 5.00 m Groundwater measured at a depth of 1.98 m on 30/01/2018 and 2.00 m on 05/02/2018								Scale (approx) 1:50	Logged By HD
								Figure No. J18003.BH1	