Star Land Realty UK Limited c/o LS Estates Limited

Former Barnes Hospital (Plot A), South Worple Way, SW14 8SU

Geo-environmental and Geotechnical Site Assessment

1920884 R01 (03)

RSK GEOSCIENCES

AUGUST 2021

RSK GENERAL NOTES

Project No.: 1920884 R01 (03)

Title: Geo-environmental and Geotechnical Site Assessment: Barnes Hospital, South Worple Way, SW14 8SU

Client: Star Land Realty UK Limited c/o LS Estate Limited, 1F/128, Cheapside, London, EC2V 6BT

Date: 13th August 2021

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Status: Rev02

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Revision control sheet

Revision reference	Date	Reason for revision
Rev 00	10-01-2020	Interim
Rev 01	25-02-2020	Final
Rev 02	22-04-2020	RBG review
Rev 03	13-08-2021	Updated architectural plans (Scott Brownrigg)

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EXECUTIVE SUMMARY

Commissioning and purpose of assessment	RSK Environment Limited (RSK) was commissioned by Star Land Realty UK Limited c/o LS Estates Limited ('Client') to carry out a geo-environmental and geotechnical site assessment of the land at Barnes Hospital (Plot A), off South Worple Way, in North Sheen, London. The overall aim of the project was to assess land contamination sources and geotechnical constraints to the current proposed development.
Site description	The Site is located to the west of Mortlake, to the south of the Richmond line on South Worple Way. It lies adjacent to Old Mortlake Burial Ground, which forms its western boundary. A number of hospital buildings occupy the immediate area to the east with South Worple Avenue beyond, and to the south the site is bounded by the gardens to the rear of residential properties along Grosvenor Avenue.
Proposed development	Based on the updated plans prepared by Scott Brownrigg, the proposed development will comprise a residential apartment block measuring three to four storeys in height with a single storey basement level car park in the western portion. A three-storey residential apartment block with an under-croft arrangement as part of the ground floor level will be situated in the eastern portion.
SI scope	The following works were completed: • Drilling of deep cable percussive boreholes; • Drilling of drive-in sampler boreholes; • Associated in-situ testing and sampling; • Laboratory analysis of soil samples; • Interpretation of data to develop a refined conceptual site model; • Generic quantitative risk assessment (GQRA) to evaluate potentially complete contaminant; • Identification of remedial strategy; • Interpretation of geotechnical data to provide preliminary recommendations with respect to foundations and infrastructure design; and • Preliminary assessment of the potential waste classification.

SI factual findings	The exploratory holes sunk during the investigation revealed that the site is underlain by a variable thickness of made ground ranging between 0.50 and 2.0m and comprised an initial surface layer of asphalt overlying a variable proportion of anthropogenic material in a granular matrix. Localised sandy clay with frequent inclusions of gravel sized brick fragments and brick cobbles was noted locally. Beneath this, Kempton Park Gravel was noted between 4.80 and 6.30 in thickness. The stratum consisted of slightly clayey gravelly fine to coarse sand/sandy gravel. The gravel fraction consisted of subangular to rounded fine to coarse quartzite. London Clay Formation was recorded at depth and comprised firm, becoming stiff with depth medium to high strength brown clay, over stiff to very stiff, high to very high strength, closely fissured dark grey/grey silty clay. Visual or olfactory evidence of contamination was limited to localised pockets of ash/bituminous rich materials in the made ground. No evidence of organic (i.e. free phase product)/inorganic contamination was identified in soils or groundwater. The findings of the monitoring data reflect a groundwater table in the underlying granular drift deposits at elevations between approximately 2.60 m AOD in the south and 3.08 m AOD in the west.
Refined conceptual site model and geo-environmental assessment	The investigation generally confirmed the predicted ground model. In view of the unsaturated zone beneath the drift deposits, the impermeable London Clay would attenuate any dissolve phase migration of contaminants into the deeper aquifer. However, the potential contamination linkage with respect to Controlled Waters may exist within the unconfined shallow aquifer (i.e. Kempton Park Gravel). With respect to ground gas, to generate large volumes of methane and carbon dioxide, a large mass of readily degradable organic content is required. The gas generated will depend on the volume of degradable material that is present in the soil. A review of the field records observed very little degradable material with low gas generating potential within the made ground. Furthermore, the presence of volatiles was not identified following the in-situ screening using a photo-ionisation detector(<1 ppm). However, in light of the credible sources (i.e. fuel storage tanks and adjacent cemetery) recorded within the CSM, potential risk may exist beneath the site. To provide an initial assessment, the chemical results recorded to date were conservatively assessed against adopted assessment criteria. The findings identified elevated concentrations of metals and polycyclic aromatic hydrocarbons within the made ground with the potential to pose an unacceptable risk to human health (via direct contact) and plants/vegetation. Leachate tests were carried out to assess mobile contaminants and conservatively compared with freshwater Environmental Quality Standards (EQS) due to the fact that the nearby Beverley Brook represents the most viable sensitive receptor with respect to groundwater contamination. Some exceedances were recorded (namely Lead and Zinc) however large proportion of the made ground may be removed to facilitate the construction of the proposed basement.

Geotechnical assessment	The ground conditions appear suitable for the adoption of conventional spread foundation for the proposed three storey development in the eastern portion of the site. Albeit, pile foundation/raft are deemed more suitable for the development in the western portion of the site. The excavation for the basement (assumed approximately 3 m with the anticipated FFL resting at ~3 m AOD) will take the formation level within the medium dense sandy gravel/gravelly sand and close to the groundwater levels. Subsequent new construction will be accompanied by a sequence of ground movements, including swelling heave on unloading, and longer term consolidation settlement on reloading. A detailed assessment of the potential ground movements will need to be undertaken once the foundation scheme has been finalised. For preliminary road pavement design, it is recommended a sub-grade soil CBR value of 5% used. This value assumes that during construction the formation level will be carefully compacted and any soft spots removed and replaced with well-compacted granular fill. Design Sulphate Class of DS-2, may be adopted. It has been assumed that groundwater conditions are mobile. From consideration of the characteristic pH value, an Aggressive Chemical Environment for Concrete classification of AC-2 may be assumed for design purposes.
Alleviation measures	The following recommendations are made for remediation of the site to address the risks identified: • Any fuel storage tanks present should be carefully emptied (If any residual fuel/oil be encountered) and removed off site in accordance with best industry practice. • A watching brief should be maintained during removal of the slab and subsequent excavation works; • Any impacted soils should be removed with the excavations determined from soils exhibiting visual /olfactory evidence of petroleum hydrocarbon contamination; • An allowance should be made to incorporate a minimum 450 mm clean cover (including 150 mm of topsoil) over a non-woven geotextile membrane through all areas of communal soft landscaping; • All underground services placed on the site should be laid within dedicated trenches. Clean granular fill shall be used as a bedding material for all services and as backfill material for all service trenches.
The information given in this summary is necessarily incomplete and is provided for initial briefing purposes only. The summary must not be used as a substitute for the full text of the report.	

1 INTRODUCTION

1.1 Commissioning

On the instructions of Robert Bird Group (RGB), acting on behalf of Star Land Realty UK Limited c/o LS Estates Limited ('Client'), RSK Environment Limited (RSK) has undertaken a geo-environmental and geotechnical site assessment of the land at Barnes Hospital (Plot A), off South Worple Way, in North Sheen, London.

The project was carried out to an agreed brief as set out in RSK's proposal (Ref. 1920884/T01/02, dated 9th October 2019.

This report is subject to the RSK service constraints given in **Appendix A** and limitations that may be described through this document.

1.2 Objectives

The objective of the work is:

- To supplement previous phases of investigation and address any data gaps/uncertainties raised, notably associated with the potential areas of concerns identified within the initial conceptual site model;
- To prove the geological sequence and obtain data for geotechnical and geo-environmental assessment; and
- To identify the need for any additional investigation or/and preliminary remediation works to render the site suitable for its proposed use.

1.3 Scope of works

The scope of this assessment has been developed by RGB and RSK, in general accordance with relevant British Standards and authoritative technical guidance as referenced through the report. The assessment of the contamination status of the site is in line with the technical approach presented in CLR 11 Model Procedures for the Management of Land Contamination (Environment Agency, 2004) and in general accordance with BS 10175: 2011 + A2 2017 (BSI, 2017).

In addition to the above, the investigation has been designed in line with the recommendations of BS5930: 2015 Code of practice for ground investigations (BSi, 2016).

The initial scope of works for the assessment comprised the following:

- Drilling of three (3No.) cable percussive boreholes up to maximum depth of 30 m;
- Drilling of eleven (11No.) drive-in sampler boreholes up to a maximum depth of 4 m;
- Associated in-situ testing and sampling;
- Laboratory analysis of soil samples;
- Interpretation of data to develop a refined conceptual site model (CSM);

- Generic quantitative risk assessment (GQRA) to evaluate potentially complete contaminant linkages identified in the refined CSM;
- Identification of the need for further action, e.g. supplementary intrusive investigations /monitoring, remediation works or other mitigation, if any;
- Interpretation of ground conditions and geotechnical data to provide preliminary recommendations with respect to foundations and infrastructure design;
- Preliminary assessment of the potential waste classification (hazardous/non-hazardous) implications of soil arisings; and
- Preparation of this factual and interpretative report with recommendations for further works (i.e. undertake a remedial options appraisal to identify appropriate mitigation measures) and/or remediation as necessary.

1.4 Existing reports

The site has been the subject of former phases of investigation, namely:

- Ove Arup and Partners Limited (Arup), Desktop Study, 247776-00, October 2018;
- RSK, Geo-environmental Site Assessment, 1920514-R01(00), March 2019; and
- 1rst Line Defence, Detailed UXO Risk Assessment, DA8245a-00, October 2019.

RSK have relied fully upon the contents of the existing documents for the purposes of the intrusive ground investigation detailed herein. Copies of the above reports are saved under **Appendix C** and salient information is summarised in the relevant section (**Section 3**).

1.5 Limitations

The comments given in this report and the opinions expressed are based on the ground conditions encountered during the site work and on the results of tests made in the field and in the laboratory. However, there may be conditions pertaining to the site that have not been disclosed by the investigation and therefore could not be taken into account. In particular, it should be noted that there may be areas of made ground not detected due to the limited nature of the investigation or the thickness and quality of made ground across the site may be variable. In addition, groundwater levels and ground gas concentrations and flows may vary from those reported due to seasonal, or other, effects and the limitations stated in the data should be recognised.

The initial CSM is based on third party data, and whilst RSK have undertaken a critical review of the information we cannot be held liable for the quality of the data provided and cannot offer any guarantees or warranties for the completeness or accuracy of information relied upon.

Asbestos is often present in soils in discrete areas. Whilst asbestos-containing materials was not encountered during the fieldworks or supporting laboratory analysis, the history of the site indicates that asbestos may be present in soils and could be encountered during more extensive ground works.

Preliminary geotechnical recommendations are presented and these should be verified in a Geotechnical Design Report once proposed construction and structural design proposals are confirmed.

The Remediation Method Statement (RMS) contains details of the procedures to be adopted for inspection and validation of the works. However, it should be noted that responsibility for the correct implementation of the strategy lies with the Principal Contractor. **RSK cannot be held responsible for any remedial works that are carried out without the agreed procedures involving either direct supervision by RSK, or inspection and verification of the works by a representative from RSK, or if suspect materials are not notified to RSK**.

2 SITE DETAILS

2.1 Site location

Site location details are presented in **Table 1** and a site location plan is provided on **Figure 1**.

Table 1 Site location details

Site name	Barnes Hospital
Full site address and postcode	Barnes Hospital, South Worple Way, SW14 8SU
National Grid reference (centre of site)	E521203, N175677

2.2 Surrounding land uses

The Site is situated south of the River Thames in a residential area between Richmond Park and Barnes Common.

The Site is located to the west of Mortlake, to the south of the Richmond line on South Worple Way. It lies adjacent to Old Mortlake Burial Ground, which forms its western boundary. A number of hospital buildings occupy the immediate area to the east with South Worple Avenue beyond, and to the south the site is bounded by the gardens to the rear of residential properties along Grosvenor Avenue.

An extract of the 1:50,000 Ordnance Survey map showing the location of the site is included in **Figure 1**.

2.3 Site description

The Site, measuring an approximate area of 0.8 Ha, is set within the western portion of the Barnes Hospital grounds and accommodates a number of redundant buildings, which historically provided mental health facilities including an administration building, a laundry and a generator house. The remainder of the Site is occupied by hardstanding providing car parking and associated soft landscaping. Mature trees of varying height and species are noted along the southern and western boundaries. The site is relatively flat with a gentle slope from 5.8 m AOD in the southwest to 6.5 m AOD in the east.

A site layout plan is presented as **Figure 2**.

2.4 Development plans

Based on the recent plans provided by Avison Young (August 2021), the proposed development will comprise the following:

- Western portion: two residential apartment blocks measuring three to four storeys in height with a single storey interconnecting basement level car park;

- Eastern portion: three-storey residential apartment block with an under-croft arrangement as part of the ground floor level.

Current plans and sections drawings, prepared by Scott Brownrigg, are shown in **Appendix B**.

3 SUMMARY OF PRECEDING REPORTS

3.1 Arup, Phase 1 Ground Contamination Desk Study

The initial desk based review was prepared in October 2018 aimed at identifying the potential geo-environmental liabilities beneath the site and the surrounding area. The findings concluded the possibility that some shallow made ground may exist on site associated with the historic and current development. In addition, the site has been used for hospital activities for more than 50 years and some releases of contamination may have occurred during that time. The most significant potential sources of contamination was considered attributable to the former/current site operations (i.e. storage fuel oils, spills/leaks associated with the electricity sub-station, laundry, plant rooms and handling of medical waste). However, the study alluded no direct evidence of ground contamination, which in its current form of development, is very unlikely to be acting as a source of potentially on-going contamination. A number of potential off-site sources of contamination were identified (including a garage, railway track and bus station). However, none were considered to pose a direct risk to the site.

3.2 RSK, Geo-environmental Site Assessment

The desk based assessment was supplemented with an intrusive ground investigation in March 2019 to assess the potential linkages beneath the western portion of the hospital grounds (referred to as 'Plot A'). This comprised a series of shallow boreholes with associated monitoring and laboratory analysis. The report confirmed the ground conditions to comprise a variable thickness of made ground over the superficial deposits of Kempton Park Gravel. No olfactory/visual evidence of contamination was recorded and no groundwater was noted during the course of the investigation. The results from chemical analysis identified elevated concentrations of Lead (Pb) and Polycyclic Aromatic Hydrocarbon (PAH) compounds locally within the made ground. However, it was considered that any potential risk will most likely be mitigated through encapsulation or excavation as part of the enabling works.

Given the nature of the investigation completed and spatial extent of the sampling locations, data gaps and uncertainties remain, notably associated with the potential areas of concern identified within the CSM prepared by Arup. A supplementary intrusive investigation was designed by RSK and submitted to the Local Authority for approval. The purpose of the supplementary investigations was to provide sufficient additional information to enable risks to be further assessed in relation to the proposed residential development.

3.3 1st Line Defence, Detailed UXO Risk Assessment

This Report has been produced in compliance with the Construction Industry Research and Information Association (CIRIA) C681 guidelines for a detailed assessment. In summary, the site was unaffected by bombing incidents with no evidence of damage.

4 SITE INVESTIGATION STRATEGY & METHODOLOGY

4.1 Introduction

RSK carried out intrusive investigation works between 9th and 20th December 2019 and subsequent monitoring of boreholes thereafter to further investigate the potential pollutant linkages outlined in the conceptual site model (CSM). Please note the monitoring is ongoing.

4.2 Objectives

The specific objectives of the investigation were as follows:

- To establish the ground conditions underlying the site including the extent and thickness of any made ground;
- To investigate specific potential sources of contamination identified in initial CSM;
- To determine groundwater depth;
- To determine the ground gas regime underlying the site;
- To assess geotechnical properties of soils for foundation design and concrete specification; and
- To determine preliminary waste implications.

4.3 Selection of investigation methods

The techniques adopted for the investigation were chosen with consideration of the objectives and site constraints, which are described below.

Cable percussion drilling was chosen based on the targeted drill depth, requirement for in-situ geotechnical data, the opportunity to collect both disturbed and undisturbed samples and install monitoring wells. This was supplemented by shallow dynamic sampling to obtain a greater coverage of the site and to install gas monitoring wells.

Prior to conducting intrusive works, utility service plans were obtained, and buried service clearance undertaken in line with RSK's health and safety procedures. Copies of statutory service records obtained by RSK as part of the agreed scope of works are contained in **Appendix E**.

4.4 Investigation strategy

The client presented RSK with a specification prepared by RGB (ref.4427, dated August 2019) at tender stage, which was amended during the course of the investigation.

The locations of the proposed exploratory holes and techniques adopted for the investigation were detailed within the specification and chosen with consideration of the objectives discussed above.

The deep borehole was advanced using a cable percussive technique due to time constraints and requirement for in-situ geotechnical data, the opportunity to collect both disturbed and undisturbed samples and install monitoring wells. This was supplemented by a series of shallow boreholes to obtain a higher number of investigation locations, achieve a greater understanding of the contamination status of the shallow Made Ground.

All exploratory hole positions are presented on **Figure 2**.

4.5 Investigation strategy

The ground investigation was carried out using intrusive ground investigation techniques in general accordance with the recommendations of BS5930: 2015 Code of practice for ground investigations. Whilst every attempt was made to record full details of the strata encountered in the boreholes, techniques of hole formation and sampling will inevitably lead to disturbance, mixing or loss of material in some soils and rocks.

The investigation strategy involved predominately targeted boreholes located by the RGB/RSK across the site area. Boreholes located within close vicinity of potential sources of contamination (as detailed within the CSM) were selected for additional chemical analysis of relevant potential determinants.

The constraints to the investigation were as follows:

- Live, underground services present across the site area and adjacent to existing buildings dictating the locations of some exploratory hole locations;
- Palisade fencing around the existing building restricting access to some areas, however in most cases these where removed; and
- Existing buildings present across 70% of the sites surface area, including an electrical substation to present to the south.

Details of the investigation locations, installations and rationale are presented in **Table 2**.

Table 2 Summary of activities and rationale

Investigation type	No.	Designation	Rationale
Deep Boreholes by cable percussive methods	4No	BH01 to BH04	To prove the geological succession beneath the site and obtain geotechnical data for foundation design. Also, to install groundwater wells within the Kempton Park Gravel.
Shallow Boreholes by windowless sampling methods	7No.	WS201, WS203, WS205, WS207, WS208, WS209 and WS211	To prove the geological succession and targeted assessment in the vicinity of the following areas of potential concern: • Laundry house, • Generator house and diesel tank (13,600 litre); • Plant room; • Electricity sub-station; and

Investigation type	No.	Designation	Rationale
			• Work shop and potential chemical storage area.
	4No.	WS202, WS204, WS206 and WS210	To assess the upper strata in non-targeted locations for the purpose of site coverage.
Standard Penetration Tests (SPT)	64No.	WS201 to WS211, BH01 to BH04	To determine the in-situ strength of the underlying soils at regular intervals (in accordance with part 9 of BS 1377:1990 (BSI, 1990)).
Vane shear tests	5No.	WS201, WS204, WS205 and WS208.	To determine the undrained shear strength of the underlying clays without disturbance.
Falling head tests	2No.	BH01 and BH03	To assess the infiltration characteristics of the underlying granular drift deposits.
Clegg hammer impact tests	3No.	CBR1 to CBR3	To determine the strength of the sub-grade material.
PID screening	n/a	WS201 to WS202	Detection of volatile organic compounds (headspace screening with a photo-ionisation detector fitted with a 10.2 eV bulb).
Groundwater monitoring	3No. visits	BH01 to BH05	Measurement of groundwater levels within the Kempton Park Gravel.
Ground gas monitoring		WS201, WS202, WS204, WS207, WS210 and WS211	Measurement of ground gas to asses possible on-site sources and zones of permeable geology.

4.5.1 Implementation of investigation works

The exploratory holes were logged by an engineer in general accordance with the recommendations of BS 5930:2015.

The monitoring well construction and associated response zones are detailed on the exploratory hole records in **Appendix G**.

The soil sampling and analysis strategy was designed to characterise each encountered soil strata, permit an assessment of the potential contaminant linkages identified and investigate the geotechnical characteristics. In addition, samples were taken to allow for geo-environmental and geotechnical testing to be undertaken.

Soils collected for laboratory analysis were placed in a variety of containers appropriate to the anticipated testing suite required. They were dispatched to the laboratory in cool boxes under chain of custody documentation. Samples were stored in accordance with the RSK quality procedures to maintain sample integrity and preservation and to minimise the chance of cross contamination.

4.6 Monitoring programme

4.6.1 Ground gas monitoring

Three monitoring rounds have been undertaken to provide data to support refining of the CSM.

An infrared gas meter was used to measure gas flow, concentrations of carbon dioxide (CO_2), methane (CH_4) and oxygen (O_2) in percentage by volume, while hydrogen sulphide (H_2S) and carbon monoxide (CO) were recorded in parts per million.

Initial and steady state concentrations were recorded. In addition, during the first monitoring round, all wells were screened with a PID to establish if there are any interferences and cross-sensitivity of other hydrocarbons with the infrared gas meter.

The atmospheric pressure before and during monitoring, together with the weather conditions, were recorded. The monitoring included periods of rising atmospheric pressures and after rainfall. Due to time restraints on the reporting deadline, a monitoring period of low atmospheric pressure was not achieved.

All ground gas monitoring results together with the temporal conditions are contained within **Appendix G**. Equipment calibration certificates are available on request.

4.6.2 Groundwater monitoring

Alongside the ground gas monitoring, groundwater depth was recorded. The monitoring records, including dates, are shown in **Appendix G**.

4.6.3 Chemical analysis of soil samples

The soil sampling strategy was designed to characterise made ground and natural strata typically within the upper 1.0 m of the ground profile whilst also characterising deeper strata and the potential for contaminant migration from relevant sources of identified within the preliminary CSM.

The programme of chemical tests undertaken on soil samples obtained from the intrusive investigation is presented in **Table 3**

Table 3 Summary of chemical testing of soil samples

Stratum	Tests undertaken	No. of tests
Made ground	Asbestos screening and ID	12
	Heavy metals	10
	PCBs	1
	Leachable metals (9No) to BS EN 12457-1(2:1)	3
	Speciated Polycyclic Aromatic Hydrocarbons (PAH)	10
	Speciated Total Petroleum Hydrocarbons (TPH CWG)	10
	Volatile organic compound	5
	Total organic carbon (TOC)	6

Stratum	Tests undertaken	No. of tests
Kempton Park Gravel	Heavy metals	2
	Speciated Polycyclic Aromatic Hydrocarbons (PAH)	2
	Speciated Total Petroleum Hydrocarbons (TPH CWG)	2
	Total Organic Carbon	3

4.6.4 Geotechnical analysis of soils

Where appropriate disturbed, bulk and undisturbed soil samples were taken for geotechnical classification testing with the depth and nature of samples detailed within the exploratory hole records.

Where appropriate, testing was undertaken in accordance with BS 1377:1990 Method of Tests for Soils for Civil Engineering Purposes or, where superseded, by the relevant part of BS EN ISO 17892:2014 Geotechnical investigation and testing - Laboratory Testing of Soil. Tests carried out in order to classify the concrete class required on-site have been undertaken following the procedures within BRE SD1:2005.

The programme of geotechnical tests undertaken on samples obtained from the intrusive investigation is presented in **Table 4**.

Table 4 Summary of geotechnical testing undertaken

Strata	Tests undertaken	No. of tests
	Sieve analysis	12
	BRE Non pyritic geology suite	7
London Clay Formation	Moisture content %	25
	Liquid/plastic limits	25
	Unconsolidated undrained triaxial	11
	BRE pyritic geology suite	11
	Sedimentation/sieve analysis	4
	BRE pyritic geology suite	1
Made Ground	BRE pyritic geology suite	3

5 SITE INVESTIGATION FACTUAL FINDINGS

The results of the intrusive investigation undertaken are detailed below. The descriptions of the strata encountered, notes regarding visual or olfactory evidence of contamination, list of samples taken, field observations of soil and groundwater, in-situ testing and details of monitoring well installations are included on the exploratory hole records presented in **Appendix G**.

5.1 Ground conditions encountered

The exploratory holes sunk during the investigation revealed that the site is underlain by a variable thickness of made ground over the Kempton Park Gravel with the London Clay Formation encountered at depth. This appears to confirm the stratigraphical succession described within the initial conceptual model prepared by Ove Arup and Partners (Ref. 247776-00, October 2018).

For the purpose of discussion, the ground conditions are summarised in **Table 5** and the strata discussed in subsequent subsections.

Table 5 General succession of strata encountered

Stratum	Exploratory holes encountered	Depth to top of stratum m bgl	Proven thickness (m)
Made ground (i.e. fill material)	WS201 to WS211 and BH1 to BH4	0.00 (GL)	0.50 to 2.00
Kempton Park Gravel	WS1 to WS11	0.50 to 1.20	Proven to the full depth of the investigation (4.45 m)
	BH1 to BH4	1.00 to 2.00	4.8 m to 6.30
London Clay Formation	BH1 to BH4	6.80 to 7.90	Proven to the full depth of the investigation (30 m bgl)

5.1.1 Made ground

The exploratory holes encountered a variable thickness of made ground ranging between 0.50 m and 2.0 m bgl. The Made Ground was heterogeneous in nature and reference should be made to the individual records. In general, it comprised an initial surface layer of asphalt overlying a variable proportion of anthropogenic material in a granular matrix. Localised sandy clay with frequent inclusions of gravel sized brick fragments and brick cobbles was noted in BH03.

On-site PID screening of disturbed samples indicated concentrations of volatile organic compounds (VOC) <1 ppm, indicating the absence of significant VOC within the samples.

5.1.2 Kempton Park Gravel

Soils recovered as the Kempton Park Gravel were encountered beneath the made ground, predominantly characterised by slightly clayey gravelly fine to coarse sand/sandy gravel. The gravel fraction consisted of subangular to rounded fine to coarse quartzite. Cohesive portion was recorded locally above the granular horizon in the north-western/northern portion of the site (WS1, WS2, WS201, WS204, WS205 and WS208), which typically comprised firm to stiff gravelly sandy clay with occasional silt lenses.

On-site PID screening of disturbed samples indicated concentrations of volatile organic compounds (VOC) <1 ppm, indicating the absence of significant VOC within the samples.

A summary of the in-situ and laboratory test results recorded in the stratum are presented in **Table 6** and **7**.

Table 6 Summary of in-situ and laboratory test results for cohesive unit

Soil parameters	Min. Value	Max. Value	Reference
Moisture content (%)	14		**Appendix I**
Modified moisture content (%)	16		-
Liquid limit (%)	43		**Appendix I**
Plasticity limit (%)	21		**Appendix I**
Plasticity index (%)	22		-
Modified plasticity index (%)	19.8		-
Plasticity term	Intermediate		-
Volume change potential	Low		-
SPT 'N' values	9	22[1)]	**Appendix G**
SPT 'N60' values (E_r 58%)	9	21	
Undrained shear strength inferred from SPT 'N' values (kN/m^2) based on a stroud factor of 5	45	110	-
Undrained shear strength measured by shear vane testing (kN/m^2)	42	75	**Appendix G**
Consistency term from field description	Firm to Stiff		**Appendix G**
Strength term (based on the undrained shear strength)	Medium to High		-

[1)] High readings considered attributable to gravel content

Table 7 Summary of in-situ and laboratory test results for granular unit

Soil parameters	Min. Value	Max. Value	Reference
SPT 'N' values	18	>50	**Appendix G**
SPT 'N60' values (E_r 68%)	20	>50	
SPT 'N60' values (E_r 67%)	36	49	

Soil parameters		Min. Value	Max. Value	Reference
Density term		Medium to Very Dense		**Appendix G**
Grading (%)	Silt/clay	1	4	**Appendix I**
	Sand	15	63	**Appendix I**
	Gravel	36	84	**Appendix I**
Uniformity coefficient (Cu)		5.2	57	**Appendix I**
Coefficient of curvature (Cc)		0.13	5	**Appendix I**

5.1.3 London Clay Formation

The London Clay Formation was encountered beneath the Kempton Park Gravel and proven to a maximum depth of 30 m. The London Clay Formation typically comprised an upper weathered portion, of initially firm, becoming stiff with depth medium to high strength brown clay, over stiff to very stiff, high to very high strength, closely fissured dark grey/grey silty clay.

A summary of the in-situ and laboratory test results recorded in the stratum are presented in **Table 8**.

Table 8 Summary of in-situ and laboratory test results for London Clay Formation

Soil parameters	Min. Value	Max. Value	Reference
Moisture content (%)	23	37	**Appendix I**
Modified moisture content (%)	23	38	**Appendix I**
Liquid limit (%)	68	80	**Appendix I**
Plasticity limit (%)	27	38	**Appendix I**
Plasticity index (%)	35	48	**Appendix I**
Modified plasticity index (%)	30.6	48	**Appendix I**
Plasticity term	High to Very High		-
Volume change potential	Medium to High		-
SPT ‘N’ values	19	>50	**Appendix G**
SPT ‘N60’ values (E_r 68%)	26	>50	-
SPT ‘N60’ values (E_r 67%)	21	21	
Undrained shear strength inferred from SPT ’N’ values (kN/m^2)* based on a stroud factor of 4.2	79.8	>210	-
Undrained shear strength measured by triaxial testing (kN/m^2)	69	204	**Appendix I**
Consistency term from field description	Firm to very stiff		**Appendix G**
Strength term (inferred from Triaxial testing)	Medium to very high		-

5.1.4 Visual/olfactory evidence of soil contamination

Visual or olfactory evidence of contamination was limited to localised pockets of ash/bituminous rich materials in the made ground. No evidence of organic (i.e. free phase product)/inorganic contamination was identified in soils or groundwater.

5.2 Groundwater

5.2.1 Groundwater encountered during intrusive works

Groundwater strikes were encountered during the intrusive investigation works as detailed on the individual cable percussive field records in **Appendix G**. Resting groundwater levels within the Kempton Park Gravel recorded between 3.90 m (1.99 m AOD) and 4.90 m (1.31 m AOD). A further strike was noted within the claystone band locally within the London Clay Formation resting at 7.5 m (-1.605 m AOD).

5.2.2 Groundwater encountered during monitoring

Field data measurements are shown in **Appendix G** and summarised in **Table 9**.

Table 9 Groundwater results during investigation

WS Location	Response zone	Elevation (m AOD)	Groundwater monitoring m (m AOD)		
			19.12.19	06.01.20	20.01.20
BH1	Kempton Park Gravel	6.28	3.67 (2.61)	3.60 (2.68)	3.58 (2.70)
BH2	Kempton Park Gravel	6.20	3.18 (3.02)	3.12 (3.08)	3.10 (3.10)
BH3	Kempton Park Gravel	5.89	3.29 (2.60)	3.21 (2.68)	3.20 (2.69)
BH4	Kempton Park Gravel	6.34	3.51 (2.83)	3.50 (2.83)	3.48 (2.85)

The findings reflect a groundwater table in the underlying granular drift deposits at elevations between approximately 2.60 m AOD in the south and 3.08 m AOD in the west. The data from the initial monitoring visits has been used to construct a piezometric contour plans and these are presented in **Figure 3**. The data indicate groundwater flow in a westerly direction.

It should be noted that groundwater levels might fluctuate for a number of reasons including seasonal variations. On-going monitoring would be required to establish both the full range of conditions and any trends in groundwater levels.

5.2.3 Visual/olfactory evidence of groundwater contamination

No visual/olfactory evidence of contamination in groundwater during well development, monitoring was recorded.

5.3 Chemical laboratory results

The soil results are presented in **Appendix H** and discussed in the relevant subsection.

5.4 Geotechnical laboratory results

The results of the geotechnical testing are presented in **Appendix I**.

5.5 Ground gas monitoring

The results of the ground gas monitoring to date, are presented in **Appendix G** and discussed in **Section 5**.

5.6 Limitations

The following data gaps have been identified during the course of the investigation:

- The cable percussive borehole (BH03) was terminated at 12.5 m due to the density of the ground conditions and groundwater ingress. An additional borehole (ref. BH4) was advanced to a maximum depth 8 m in the western portion of the site upon request of RGB; and
- Shallow refusals were recorded within drive-in sampler boreholes due to the density of the Kempton Park Gravel.

6 GEO-ENVIRONMENTAL ASSESSMENT

6.1 Refinement of initial CSM

The investigation generally confirmed the predicted ground model, which was anticipated to comprise a variable thickness of made ground overlying superficial deposits (Kempton Park Gravel) with the London Clay Formation at depth. Groundwater was recorded within the superficial deposits (3.10 m and 3.67 m bgl) with localised perched water within the London Clay Formation. No visual/olfactory evidence of significant contamination was observed, with the exception of bituminous material noted locally within the made ground.

Given the considerable thickness of unsaturated zone beneath the drift deposits, the impermeable London Clay would attenuate any dissolve phase migration of contaminants into the deeper aquifer. However, the potential contamination linkage with respect to Controlled Waters may exist within the unconfined shallow aquifer (i.e. Kempton Park Gravel).

With respect to ground gas, to generate large volumes of methane and carbon dioxide, a large mass of readily degradable organic content is required. The gas generated will depend on the volume of degradable material that is present in the soil. A review of the field records observed very little degradable material with low gas generating potential within the made ground. Furthermore, the presence of volatiles was not identified following the in-situ screening using a photo-ionisation detector(<1 ppm). However, in light of the credible sources (i.e. fuel storage tanks and adjacent cemetery) recorded within the CSM, potential risk may exist beneath the site.

6.1.1 Linkages omitted on consideration of the initial CSM

Migration of dissolve phase contaminants to wider secondary aquifer body and surface water course has not been considered, due to the following;

- The site is not located in a sensitive area with respect to controlled waters. The nearest surface water body is situated 230 m south east (Beverley Brook) flowing in a north-easterly direction (i.e. towards River Thames);
- The piezometric surface plan shows that groundwater flow is to the west and therefore it is unlikely that groundwater will provide base flow to the brook;
- No visual/olfactory evidence of contaminants (e.g. NAPLs) within the groundwater; and
- No records of surface water abstraction licences within 2000 m of the site.

The potential pollutant linkages that require further assessment and/or remediation are shown in the subsection below.

6.2 Linkages for assessment

In line with CLR11 (Environment Agency, 2004), there are two stages of quantitative risk assessment, generic (GQRA) and detailed (DQRA). The GQRA comprises the comparison of soil, groundwater, soil gas and ground gas results with generic assessment

criteria (GAC) that are appropriate to the linkage being assessed. This comparison can be undertaken directly against the laboratory results or following statistical analysis depending upon the sampling procedure that was adopted.

Following the refinement of the initial CSM, the potentially complete contaminant linkages that require further assessment and the methodology of assessment are presented in **Table 10**.

Table 10 Linkages for GQRA

Potentially relevant contaminant linkage	Assessment method
Human Health	
1. Oral and dermal exposure with impacted soil by future residents ***(Linkage 1)***	Based on the recent information obtained from Avison Young, the proposal comprise a residential-led apartment block (measuring three-four storeys) with a single storey basement in the west and associated podium/communal gardens. To provide an initial assessment of the potential human health risk, the chemical results (together with the previous data collected in March 2019) have been conservatively assessed against the human health GACs (presented in **Appendix J**) under residential scenario (without home grown).
2. Inhalation exposure of future residents to asbestos fibres ***(Linkage 2)***	Due to uncertainty regarding risk (in particular appropriate toxicological criterion and soil to air relationships), no acceptable concentration of asbestos in soil exists. However, the potential for fibre release is likely to reflect the concentrations in soil, the soil type and surface cover, disturbance, the form and type of asbestos and the soil moisture content (CIRIA, C733, 2014). Qualitative assessment based on the asbestos minerals present, their form, concentration, location and the nature of the proposed development. A total of 12 samples of the near surface soil material (made ground) were screened in the laboratory for the presence of asbestos materials.
3. Inhalation exposure to soil vapours from contaminated soil ***(Linkage 3)***	In the absence of indoor inhalation data (mg/m3), the potential for volatile organic compounds in the ground (soil) has been conservatively assessed using soil chemical results against GACs (Appendix J) including an empirical approach to provide multiple lines of evidence to increase confidence of the assessment.
4. Exposure, explosion and asphyxiation of future residents/ground workers to carbon dioxide and methane. ***(Linkage 4)***	Gas screening values (GSV) have been calculated using maximum methane and carbon dioxide concentrations with maximum flow rates recorded at the site. The GSV have been compared with the revised Wilson and Card classification presented in BS8485.
Vegetation	

Potentially relevant contaminant linkage	Assessment method
5. Uptake of contaminants by vegetation potentially impacting plant growth (phytotoxicity) ***(Linkage 5)***	In the absence of other published GAC, the GAC have been obtained from legislation (UK and European) and guidance related to the use of sewage sludge on agricultural fields. Comparison of soil data was undertaken in accordance with Soil Code (1998) (**Appendix K**).
Potable Pipe	
6. Contaminants permeating potable water supply pipes. ***(Linkage 6)***	Comparison of chemical results against published data in general accordance with UKWIR (2010) guidance, 10/WM/03/21 (**Appendix L**). This technical guidance was introduced by UK water Industry Research to safeguard water quality by identifying suitable pipe materials to be used in potential contaminated ground.
Controlled Water (Secondary A Aquifer)	
7. Leaching of mobile contaminants potentially impacting the underlying confined aquifer (Kempton Park Gravel). ***(Linkage 7)***	Leachate analysis is not suitable for organics therefore the potential for leaching has been considered qualitatively using soil results. Comparison of leachate data against the target concentrations prescribed within **Appendix M**.

6.3 Methodology and assessment of results

The assessment has not taken into consideration the health and safety of construction workers. Risks may still be present to construction workers especially where works include the entry into excavations within the ground. Construction workers should undertake appropriate risk assessments and risks should be managed through health and safety procedures and safe systems of work.

6.3.1 Oral, dermal and inhalation exposure with impacted soil by future occupants/site users

In order to assess the soil results against the appropriate GAC, the soil results have been split into appropriate data. The datasets being considered in the assessment are:

- Data set 1 Made Ground; and
- Data set 2 Kempton Park Gravel.

As an initial assessment, all soil results in each dataset have been directly compared against the GAC for residential with home-grown produce end use.

6.3.1.1 Data set 1 – Made Ground

All made ground results have been compared with the aforementioned GAC. A soil organic matter (SOM) of 2.5% has been selected since laboratory results for total organic carbon (TOC) within the made ground range from 1.2% and 10.2%.

Assessment of the results indicates exceedances of the GAC for the contaminants shown in **Table 11**

Table 11 Data summary table – Data set 1 (Made Ground)

Determinand	No. of samples tested	GAC (mg/kg)	No of exceedances	Maximum concentration (mg/kg)	
				Value	Location / depth (m bgl)
Inorganic (Metals)					
Lead	16	200	7	380	WS1 @ 0.2[1)]
Arsenic	16	37	1	52	WS201 @ 1.00[2)]
Semi Volatile Organic Compounds (Poly-cyclic Aromatic Hydrocarbons)					
Benzo(a)anthracene	16	11	1	27.2	WS208 @ 0.2[2)]
Benzo(a)pyrene	16	5	1	18.5	WS208 @ 0.2[2)]
Benzo(b)fluoranthene	16	3.3	3	20.1	WS208 @ 0.2[2)]
Chrysene	16	22	1	29.2	WS208 @ 0.2[2)]
Dibenzo(ah)anthracene	16	0.28	3	0.62	WS2 @0.4[1)]
Total Petroleum Hydrocarbons (Aromatic Hydrocarbons)					
Aromatic >C16-C21	16	540	1	626	WS208 @ 0.20[2)]
Aromatic >C21-C35	16	1500	1	1640	WS208 @ 0.20[2)]

[1)] RSK Geo-environmental Site Assessment March 2019

[2)] RSK Supplementary Geo-environmental Site Assessment January 2020

In addition to the simple comparison of data to the adopted screening values, the CIEH document 'Guidance on Comparing Soil Contamination Data with a Critical Concentration', dated May 2008 recommends a statistical review should be conducted to demonstrate the site's 'suitability for use' with a defined level of confidence. Given the targeted nature of the investigation and the heterogenous nature of the made ground, it is not considered appropriate to conduct a statistical assessment.

On the basis of the above assessment it is considered that there are potentially significant risks associated with the soil contamination. However, there is no risk to human health via the inhalation pathway since Lead is not volatile, therefore the elevated concentrations of this determinant do not pose a risk to human health if encapsulated beneath hardstanding. With respect to the aromatic hydrocarbons, these compounds are generally associated with the higher chain hydrocarbon range and have a very low volatility. Thus, the vapour pathway is also not relevant and, similarly, not considered cause for concern if encapsulated beneath the hardstanding. Where areas of soft landscaping are proposed, further testing will be required to confirm the absence of contamination within the made ground soils. Alternatively, consideration will need to be given to incorporation of a clean capping layer to break the potential pollutant pathway.

6.3.1.2 *Data set 2 – Kempton Park Gravel*

All results have been compared with the aforementioned GAC. A soil organic matter (SOM) of 1% has been selected since laboratory results for total organic carbon (TOC) within the drift deposits ranged between 0.2% and 1.20%. Assessment of the results indicates that there were no exceedances of the GAC for the analytes tested.

6.3.2 Inhalation exposure of future occupants/site users to asbestos fibres

The visual inspection at the laboratory identified no materials suspected of potentially containing asbestos and the scheduled laboratory screening for asbestos found no detectable asbestos fibres within the samples of made ground.

6.3.3 Inhalation exposure to soil vapours

The following lines of evidence have been assessed in respect to the risk from VOC's:

- Chemical testing of soils largely detected concentrations of VOC below laboratory limits of detection (LOD);
- Detectable concentrations of Trimethylbenzene was recorded within WS205 (0.80 m), however, concentrations were below adopted assessment criteria value;
- Mercury and BTEX were recorded below laboratory of detection (LOD);
- No visual/olfactory evidence of volatiles (e.g. free phase product) recorded within soil and groundwater;
- The ground investigation indicated that the underlying residual made ground largely consists of inert material i.e. bituminous material, plastic, glass, clinker, flint, brick and concrete;
- Low emission rates have been recorded during the gas monitoring (<0.1 l/hr); and
- Negligible concentrations of methane and very low levels of carbon dioxide was recorded on three monitoring events.

Based on the above lines of evidence it is considered that the risk to future site users from VOC's is low.

6.3.4 Inhalation exposure, asphyxiation and explosion from ground gases

6.3.4.1 *Conceptual site model*

In summary, potential sources of ground gas have been identified in the initial desk study (Arup) and principally comprised made ground and the adjacent cemetery. Although, the sources of ground gas are considered to have a very low to negligible generation potential and therefore pose a very low risk to the site.

Gas primarily migrates via either pressure driven (advective) flow or via diffusive flow. In general, the predominant mechanism for migration of gases from aged landfill waste is diffusive, with no driving pressure. This is supported by the consistently negligible flow rates recorded during gas monitoring. Certain proportion of gases may remain dissolved

in groundwater, however the piezometric surface plan shows that groundwater is flowing in a westerly direction.

The anticipated development proposals will inherently introduce receptors to the site. These typically comprise future residents. Although, the main areas of risk are limited to restricted access/confined spaces. Given the proposed development, it is anticipated that a ventilated basement substructure (confirming to water proofing standards) will inherently provide suitable mitigation measures to address any potential risk.

6.3.4.2 Assessment of data

The risks to development from ground gases have been assessed in accordance with BS8485:2015+A1 2019, which provides guidance on ground gas (methane and carbon dioxide) characterisation and hazard assessment, as well as a framework for the prescription of protection measures within new buildings.

The process involves characterising the gas hazard from combining the qualitative assessment of risk (using the conceptual site model) with ground investigation data so that a 'characteristic situation' (CS) can be derived for the site. Characteristic situations range from CS1 to CS6, the higher the CS the higher the hazard potential. Protection measures within new buildings can be prescribed using a point scoring system, taking into consideration the CS and the proposed building type.

6.3.4.2.1 Empirical approach for assessing low degradable content

With respect to the low degradable organic content within the made ground as a potential source, an alternative framework can be used to characterise the ground gas regime. A significant amount of research into the relationship between the gas generation potential of soil material and the associated Total Organic Content (TOC) have been undertaken. This research has been published by CLAIRE, Reference Research Bulletin (RB) 17, November 2012 entitled 'A Pragmatic Approach to Ground Gas Risk Assessment' and recognised in BS8485:2015+A1 2019.

In total 6 No. individual TOC results were obtained from Made Ground as part of the soil chemical test analysis. These TOC results are summarised in **Table 12**.

Table 12 TOC data summary

Stratum (thickness)	No. of TOC tests	TOC range (%)	TOC geometric mean (%)
Made ground (<3m)	6	1.20 – 10.20	3.4

Consistent with the research presented in RB17, the results for the residual made ground equates to a site which is likely to be designated as conforming with Characteristic Situation (CS) 2 or 3 of the Modified Wilson and Card classification (CIRIA Report C665, Assessing Risks Posed by Hazardous Ground Gases to Buildings, 2007). However, the TOC content is considered most likely to reflect the ash/bituminous material content within the made ground much of which is generally not degradable and cannot produce carbon dioxide or methane.

6.3.4.2.2 Semi-quantitative Approach (Wilson and Card)

The empirical semi quantitative approach using gas monitoring data is based on calculations of the gas screening value (GSV). BS8485 defines the GSV as the *'flow rate (l/hr) of a specific hazardous gas representative of a site or zone, derived from assessment of borehole concentration and flow rate measurements and taking account of all other influencing factors, in accordance with a conceptual site model'.*

Once derived for both methane and carbon dioxide the GSVs are compared to the thresholds presented in Table 2 of BS8485, so that a CS can be determined for the site, or a zone. It is important to note that the GSV thresholds are guideline values and not absolute. The GSV thresholds may be exceeded in certain circumstances, if the site conceptual model indicates it is safe to do so. Similarly, consideration of additional factors such as very high concentrations of methane, should lead to consideration of the need to adopt a higher risk classification than the GSV threshold indicates.

The monitoring results are given in **Appendix G**. The steady state concentrations and flows are recorded in **Table 13**.

Table 13 Summary of ground gas results

Borehole	Number of monitoring visits	LEL (%)	Methane (%)	Carbon dioxide (%)	Oxygen (%)	Carbon monoxide (ppm)	hydrogen sulphide (ppm)	Flow rate (l/hr)	Atmospheric pressure (mbar)
WS201	3	0	<0.1	0.6-1.3	19.8-20.6	0	0	0.0	1000-1041
WS202	3	0	<0.1	0.1-0.9	19.9-21.0	2	0	0.0-0.2	1000-1041
WS204	3	0	<0.1	0.8-1.1	18.7-20.0	1	0	0.0	1000-1041
WS207	3	0	<0.1	0.1-0.2	19.7-21.1	1	0	0.0-0.1	999-1040
WS210	3	0	<0.1	0.1-1.8	20.0-20.8	0	0	0.0-0.1	999-1040
WS211	3	0	<0.1	0.2-0.3	20.0-20.7	1	0	0.0-0.1	999-1040

BS8485 suggests that the GSV should be derived by multiplying the worse credible (worst case) recorded flow value in any standpipe in that strata or zone with the maximum gas concentration in any other standpipe in that strata or zone. Further guidance is given in BS8485 section 6.3.

Based on the GSVs derived and the method for determining the CS presented within Table 2 of BS8485, the site has been characterised as CS1.

6.3.5 Uptake of contaminants by vegetation potentially inhibiting plant growth (phytotoxicity)

Table 14 Summary of soil results with respect to plant phytotoxicity effects

Determinant	Generic assessment criteria (mg/kg)				Concentrations of determinants in excess of assessment value
	pH 5.0 < 5.5	pH 5.5 < 6.0	pH 6.0 < 7.0	pH >7.0	
Zinc	200	200	200	300	None recorded
Copper	80	100	135	200	None recorded
Nickel	50	60	75	110	None recorded
Lead	300	300	300	300	WS1 at 0.20 (380 mg/kg)[1)] WS201 at 0.20 (350 mg/kg)[2)] WS211 at 0.40 (323 mg/kg)[2)]
Cadmium	3	3	3	3	None recorded
Mercury	1	1	1	1	WS1 at 0.20 (2.6 mg/kg)[1)] WS2 at 0.40 (2.0 mg/kg)[1)] WS201 at 0.20 (1.85 mg/kg)[2)] WS203 at 0.80 (1.21 mg/kg)[2)]
Note: Only compounds with assessment criteria documented within the Directive 86/278/EEC have been included, although criteria for 5 additional compounds have been presented within the 2006 CoP.					

[1)]RSK Geo-environmental Site Assessment March 2019

[2)]RSK Supplementary Geo-environmental Site Assessment January 2020

The results above indicate the potential for plant growth to be affected by the presence of contaminants within the ground. However, the made ground is not conducive to plant growth and consideration should be given to incorporating clean soil material suitable as a growing medium.

6.3.6 Impact of organic contaminants on potable water supply pipes

For initial assessment purposes, the results of the investigation have been compared with the GAC presented in **Appendix L** for this linkage, which are reproduced from *UKWIR Report 10/WM/03/21. Guidance for the Selection of Water Supply Pipes to be used in Brownfield Sites* (UKWIR, 2010).

Since water supply pipes are typically laid at a minimum depth of 750 mm below finished ground levels, sample results from depths between **0.75 m** and **1.35 m** below finished level were considered for assessing risks to water supply.

The results indicate that a relevant linkage may potentially exist associated with organic contaminants. Please note, at the time of this investigation the future routes of water supply pipes had not been established, hence the investigation and sampling strategy may not be fully compliant with UKWIR recommendations. It is recommended that a targeted assessment be undertaken to determine the remedial measures.

6.3.7 Leaching of contaminants to the underlying Secondary A Aquifer

Leachate samples were prepared from representative soil samples of the made ground to assess mobile contaminants (metals). The results of the leachate analyses have been conservatively compared with freshwater Environmental Quality Standards (EQS) due to the fact that the nearby Beverley Brook represents the most viable sensitive receptor with respect to groundwater contamination. Those results that have been found to exceed the target concentrations are summarised in **Table 15**.

Table 15 Summary of soil leachate results with respect to controlled waters

Substance classification[1)]	Determinant	Target concentration (µg/l)	Location	Depth (m)	Concentration (µg/l)
Hazardous substance	Lead (leachable)	1.2	WS201	0.20	203
			WS203	0.80	76
Non-hazardous pollutant	Zinc (leachable)	10.9	WS201	0.20	52
			WS203	0.80	12

1) Groundwater receptor

In view of the above, exceedances are present for Lead and Zinc, suggesting that leaching of contaminants to groundwater may be occurring. However, the assessment is considered to be very conservative as the target concentration corresponds to the bio-available fraction of the metal. Bio-available metal is not the same metric as dissolved metal as only a fraction of the dissolved metal will usually be bio-available. Furthermore, a large proportion of the made ground may be removed to facilitate the construction of the basement and the proposed layout will largely comprise hardcover greatly reducing the risk of infiltration. On this basis, the pollutant linkage with respect to leachable contamination is considered a low likelihood.

6.4 Uncertainty and data confidence

The review has identified a number of data confidence issues associated with the intrusive works completed to date. Key to the assessment of the pollutant linkages, the following are highlighted:

- Spatial extent of the investigation was limited by remnant structures (i.e. redundant hospital buildings), which currently occupy a large proportion of the site;
- The nature of the made ground (i.e. fill material) is not well defined, with insufficient information to characterise the nature of the waste deposits and/or the associated waste matrix; and

- The future routes of water supply pipes had not been established, hence the investigation and sampling strategy may not be fully compliant with UKWIR recommendations.

7 PRELIMINARY WASTE ASSESSMENT

In accordance with the definition provided in the Waste Framework Directive (WFD), materials are only considered waste if 'they are discarded, intended to be discarded or required to be discarded, by the holder'. Naturally occurring soils are not considered waste if reused on the site of origin for the purposes of development. Soils such as made ground that are not of clean and natural origin (irrespective of whether they are contaminated or not) and other materials such as recycled aggregate, do not become waste until the criteria above are met. Further background information is provided in **Appendix F**.

Excavation arisings from the development may therefore be classified as waste if surplus to requirements or unsuitable for reuse. The following assessments assume the material tested is classified subsequently as waste.

RSK recommends that a Sampling Plan be prepared to support any waste classifications and hazardous waste assessments, prior to any material being excavated. Given the level of data obtained, scale of the development and heterogeneity of the site soils, the following assessment should be considered **indicative** and further assessment should be undertaken following the preparation of a waste sampling plan.

7.1 Hazardous waste assessment

Technical Guidance WM3 (EA, 2018) sets out in Appendix D requirements for waste sampling. It is a legal requirement to correctly assess and classify waste. The level of sampling should be proportionate to the volume of waste and its heterogeneity. The preliminary assessment provided below is based only upon the available sample results and may not be sufficient to adequately classify the waste.

7.1.1 Chemical contaminants

Envirolab, an RSK company, has developed a waste soils characterisation assessment tool (HASWASTE), which follows the guidance within Technical Guidance WM3. At this stage, the body of the made ground is considered as a singular unit. The analytical results have been assessed using this tool to assess the hazardous properties to support potential off-site disposal of materials in the future. Note that it is ultimately for landfills to confirm what wastes they are able to accept within the constraints of their permit. The results are presented in **Table 16**.

Table 16 Results of waste soils characterisation assessment (HASWASTE)

Sample ref/ location	Depth (m)	Soil description	Hazardous property description	Contaminant generally driving hazardous assessment	Preliminary waste assessment
WS201	0.20	Made Ground (silty sand with rare brick fragments)	-	-	Not-hazardous
WS203	0.80	Made Ground (gravelly silty sand with gravel fraction comprising brick, concrete, ceramic fragments and frequent bituminous material)	-	-	Not-hazardous
WS204	0.40	Made Ground (silty sand with rare brick fragments)	-	-	Not-hazardous
WS205	0.80	Made Ground (sandy gravel of glass, flint, bituminous material)	-	-	Not-hazardous
WS207	0.40	Made Ground (silty sandy gravel of sandstone, brick, clinker and concrete)	-	-	Not-hazardous
WS208	0.20	Made Ground (gravelly sand with the gravel fraction comprising ash, clinker, concrete, limestone, flint)	Carcinogenic HP7 & Mutagenic HP11	Total TPH (2680 mg/kg)	Hazardous
			HP8 - Corrosive	pH (13.05)	Hazardous*
WS202	0.80	Made Ground (silty sand with rare brick fragments, glass, plastic and concrete)	-	-	Not-hazardous
WS209	0.15	Made Ground (silty sandy gravel of brick, glass, ceramic and flint)	-	-	Not-hazardous
WS210	1.00	Made Ground (sandy clayey gravel of sandstone, concrete and brick with low cobble	-	-	Not-hazardous

Sample ref/ location	Depth (m)	Soil description	Hazardous property description	Contaminant generally driving hazardous assessment	Preliminary waste assessment
		content and frequent pieces of plastic).			
WS211	0.40	Made Ground (gravelly silt with frequent inclusions of brick and concrete fragments).	-	-	Not-hazardous

From the above it can be seen that majority of the samples have been identified as 'not-hazardous'. WAC testing would be required to determine whether waste might be classified as 'inert or non hazardous'.

Whilst the sample of made ground obtained from WS208 exceeded the TPH and pH hazardous threshold limits, the recorded concentrations are anticipated to relate to presence of bituminous material. As such, the hazardous classification can be downgraded.

Notwithstanding the above, it is important to note that this initial assessment given in this report is for guidance only and it is always necessary to confirm the actual classification with prospective landfill operators prior to disposal.

It is recommended that further sampling and testing should be undertaken for waste characterisation purposes.

7.1.2 Asbestos within waste soils

Technical Guidance WM3 requires that within a mixed waste the separately identifiable wastes be assessed separately.

For instance, where waste soil contains identifiable pieces of asbestos (visible to the naked eye) the asbestos should, where feasible, be separated from the soil and classified separately. This should be disposed of within a hazardous, stable non-reactive hazardous waste landfill or a special cell in a non-hazardous waste landfill.

Samples of potential asbestos containing material were collected from site and analysed for the presence of asbestos, the results of which are presented in **Appendix F**. Analysis confirmed that asbestos is not present within samples tested. Visible asbestos containing material was not identified on-site.

7.1.3 Natural soils

Uncontaminated natural soils are automatically classed as an inert waste under European Waste Category (EWC) code 17 05 04. Therefore, natural soils arisings are considered suitable for disposal at an inert landfill or a site that has a valid exemption from the Environmental Permitting (England and Wales) Regulations 2016registered with the EA.

8 PRELIMINARY REMEDIATION METHOD STATEMENT

8.1 Remedial Objectives

The aim of the remediation works is to provide a site that is suitable for its subsequent redevelopment and does not pose a risk to future site users.

8.2 Phases of Remediation

8.2.1 Introduction

The overall remediation strategy for the site may be divided into the enabling and remediation phase, i.e. those works required to produce a suitable development platform, including the removal of floor slabs and removal of contamination hotspots, and the subsequent construction phase.

The sequence of works required under both phases is outlined in the following sections.

8.2.2 Enabling and Remediation Phase

The enabling and remediation phase works will be carried out in the following sequence:

8.2.2.1 Demolition and site clearance

Prior to demolition of the existing structures, an asbestos refurbishment / demolition survey shall be undertaken to confirm the presence or absence of asbestos containing materials within all structures present on site.

Where asbestos containing materials are encountered, removal works must be undertaken by an appropriately licensed contractor such that all identified asbestos containing materials are safely removed off-site to a suitably licensed facility in advance of demolition works commencing.

Copies of the relevant survey and clearance documents, including disposal records and air monitoring/clearance results should be made available for inclusion within the site verification report.

Demolition will comprise the removal of any existing buildings, including breaking out and removal of hardstanding and below ground structures (e.g. foundations, floor slabs, and redundant services).

Any fuel storage tanks present should be carefully emptied (If any residual fuel/oil be encountered) and removed off site in accordance with best industry practice.

A watching brief should be maintained during removal of the slab and subsequent excavation works (notably beneath the potential areas of concern, as shown in **Figure 6**). It will be the responsibility of the on-site manger to ensure watching briefs are undertaken and documented. A watching brief record will consist of the following:

- Observations of contamination made during the course of development by members of site staff, contractor or visitor;

- A photographic record of the key stages of development and occurrences including contamination found during the course of the development, the formation levels of excavations, any reduced level dig/mass excavation, formation of landscaped or garden areas, etc.; and
- Examples of observations that should be recorded as part of a watching brief and included within the Discovery Strategy detailed in **Appendix O** and discussed in the relevant subsection.

Following removal of these structures, the formation levels should be periodically inspected by a suitably qualified environmental consultant. Should the assessment provide evidence of potentially significant contamination requiring remediation, modifications will be made to the remedial works and will be agreed with the Local Authority.

Stockpiles of soils for re-use at the site should be tested for its chemical suitability at a frequency of five samples per stockpile or one sample every 250 m^3, whichever is greater, for general suite of contaminants, including metals, speciated TPH determinants, speciated PAH, pH and asbestos.

Stockpiles of crushed concrete will be visually inspected for the presence of asbestos.

On completion of this element of the works, the Principal Contractor (PC) shall provide the Environmental Consultant with an accurate survey drawing showing the locations of all removed structures and any structures remaining in situ.

8.2.2.2 Hydrocarbon Impacted Areas

Hydrocarbon impacted soils (unsaturated zone) may be encountered beneath potential areas of concern (i.e. the generator house to the west and suspected tank bases to the north).

Any impacted soils should be removed with the excavations determined from soils exhibiting visual/olfactory evidence of petroleum hydrocarbon contamination. The excavations should proceed by careful removal of the upper, un-impacted parts of the made ground. This material should be stockpiled separately. Following excavation of the contaminated materials, and validation of the excavations, backfilling of the excavations should occur with clean crushed concrete or similar.

Where laboratory testing is required to verify the adequacy of remediation, those excavations shall not be backfilled until the results of the testing are obtained and approval is given by the Environmental Consultant.

All excavations should be supervised and validated by a suitably qualified engineer. Validation samples should be taken from the base and sides of the excavations, and tested at a UKAS accredited laboratory for a speciated petroleum hydrocarbon suite to demonstrate that the soil objectives presented in RSK Soil Objectives (**Appendix P**) have been met.

8.2.2.3 Disposal of soil materials & licensing

For any materials destined for off-site removal, discrete mounds should be formed and where possible, resting on hardstanding, or alternatively on impermeable membranes. A

thick gauge membrane must be placed and secured over the stockpile to prevent rainwater ingress and potential leachate migration.

During excavation care will be taken to undertake segregation of made ground and natural underlying soils as works progress so as to avoid cross contamination of the natural soils by the made ground.

All strata should be segregated visually when excavated separately. Any strata exhibiting olfactory indications of contamination will be stockpiled, analysed and classified prior to removal from site.

Prior to disposal, the PC shall ensure the waste material is assessed in accordance with the EA's 'Technical Guidance WM3' (2015).

A record shall be kept of the location of temporary stockpiles, their chemical status and nature including origin of the materials.

All hauliers transporting waste soils from site will hold a **Waste Carriers Licence**. All facilities receiving waste soils from the site will either be licensed to accept the waste that they receive or hold an exemption that allows the waste to be received without a licence.

All vehicles transporting hazardous waste soils from site will be issued with a Consignment Note. A duplicate of the Consignment note will be retained by the PC.

All waste transfer notes and consignment notes must be signed prior to the vehicle leaving site.

All documentation should be supplied to the environmental consultant for inclusion in the validation report

8.2.2.4 Material of a suspect nature

It is possible that the enabling works will encounter different conditions (e.g. presence of asbestos construction materials) from those revealed by the site investigation that may require special treatment or other alleviation measures.

Where unexpected ground conditions or potentially suspect materials are encountered, the contractor shall immediately inform the Environmental Consultant who shall then carry out an inspection as soon as is reasonably practical. During or immediately following the inspection, the Environmental Consultant shall advise the Client of any requirements for additional investigations or possible modifications to the remediation strategy. In addition, Local Authority should be consulted if any substantially different conditions are encountered or modifications to the remedial works are required.

A discovery strategy, which sets out in principle the proposed methods for identifying and managing site specific risks in the event potential land contamination is uncovered during development, is included within **Appendix O**.

8.2.3 Construction Phase

8.2.3.1 Preparation of soft landscaped area

The development scheme proposed includes soft landscaped areas. All imported soil material required for the completion of the soft landscaped areas should comply with the following requirements:

- An allowance should be made to incorporate a minimum 450 mm clean cover (including 150 mm of topsoil) over a non-woven geotextile membrane through all areas of communal and private soft landscaping respectively;
- The Principal Contractor (PC) shall provide details of the provenance of the imported material to the Environmental Consultant **before importation** and use of the material on the site;
- Representative chemical test certificate(s) from source shall be provided by the supplier to confirm suitability of use (**before importation**) and a delivery note for each consignment detailing source and volume. The certificates must correspond in both age and source to the material delivered to site;
- Additional sampling shall be undertaken by the Environmental Consultant. Representative soil samples shall be collected from a body of material into a single homogenised (composite sample) for the purpose of chemical analysis;
- All samples tested should meet the soil assessment criteria set out in **Appendix P**; and
- Prior to importation, the PC should ensure all imported topsoil comply with British Standard **BS3882:2015**.

At completion of the above works, the Environmental Consultant shall produce a verification report to confirm suitability of use. The verification process is detailed in **Section 9**.

It should be noted, that the responsibility for the correct implementation of the remediation strategy lies with the PC. However, the remedial works shall be monitored, inspected and validated by the Environmental Consultant's experienced geo-environmental engineers with part time attendance on-site dependent on the operations being undertaken.

During periods of part time supervision, it will be the PC's responsibility to provide adequate notice of any key activities that will require the attendance of the Environmental Consultant.

8.2.3.2 Potable pipes

Potentially unacceptable risks to plastic water supply pipes may exist beneath the site, however the assessment carried out to date is not fully compliant with UKWIR/local water authority. It is recommended to carry out a targeted assessment. Alternatively, consideration maybe given to adopting barrier pipes.

Notwithstanding the above, all underground services placed on the site should be laid within dedicated trenches. Clean granular fill shall be used as a bedding material for all services and as backfill material for all service trenches.

9 WORKING PRACTICE AND VERIFICATION PLAN

9.1 Health and safety of site personnel

It is the responsibility of the PC and any appointed sub-contractors to enforce an appropriate health and safety regime for all site personnel. Full details regarding the proposed working practices in connection with the remediation works shall be agreed in advance of the commencement of the works with the Planning Supervisor and if appropriate with the Environmental Health Officer at London Borough of Richmond Upon Thames.

Measures will be necessary to protect the health and safety of site workers during the site works. The contractors will be under a statutory obligation to take reasonable care to protect the health and safety of their employees. The following measures are suggested to provide a minimum level of protection.

- All ground workers on-site should be issued with protective clothing, dust masks, footwear and gloves. These should not be removed from site, and advice should be given on when and how they are to be used;
- Care should be taken to minimise the amount of dust and mud generated on-site; and
- Good practices relating to personal hygiene should be adhered to on-site, i.e. food and drink should only be consumed within designated areas on the site and smoking should be prohibited in all working areas.

Reference should also be made to the Health and Safety Executive (HSE) document "Protection of Workers and the General Public during the Development of Contaminated Land".

Any health and safety measures noted in the Asbestos Removal Method Statement shall be adhered to.

9.2 Prevention of Pollution

9.2.1 General

The targets perceived to be potentially most at risk from pollution during the remediation of the site are the aquifer beneath the site, and workers on-site.

All contractors on-site shall adhere to environmental good practice as set out in CIRIA publication C650 (2005) and in particular those issues identified below.

9.2.2 Airborne Pollution (dust, etc.)

Care shall be taken by the contractor to minimise the amount of dust generated on-site during excavation, backfilling and trafficking. In the event that dry weather leads to excessive dust generation, exposed soils shall be damped down, but not flooded, with clean water.

The Contractor's method statement shall include a detailed dust control plan.

9.2.3 Surface Runoff

The PC shall implement appropriate procedures to prevent surface run-off, including forming bunds around any temporary stockpiles of contaminated soils.

In addition, so far as is practicable the works should be carried out during fine weather conditions, as a heavy rainstorm would potentially mobilise the contaminants in the shallow soils currently encapsulated below hardstanding.

9.2.4 Vehicles

Wheel cleaning/washing facilities shall be provided on-site if operations are likely to result in vehicles leaving site with potentially contaminated soil/mud clinging to them. Contaminated water on-site, including water and other liquid collected from vehicle washing facilities, shall be disposed of off-site in an approved manner with full regard to current legislation and good practice.

All vehicles leaving the site shall be clear of contaminated materials other than that contained within the load container, which shall be sheeted to prevent the loss of dust and other materials.

9.2.5 Re-contamination

The programme of works and any subsequent modifications shall be designed to avoid the potential re-contamination of areas already worked, i.e. site traffic shall be routed to avoid passing from contaminated to clean areas and contaminated soils shall not be stockpiled on clean areas.

9.3 Documentation

All contaminated materials removed off-site shall be transported to an approved licensed landfill for final disposal. The main contractor shall provide a full documentary record of this operation in accordance with the Duty of Care. Copies of the landfill documents shall be provided to the Environmental Consultant for inclusion in the verification report.

9.4 Verification of Remediation

9.4.1 Cover system validation

The requirements for the validation of cover systems are outlined in NHBC Standards Chapter 4.1 ‘Land Quality – Managing Ground Conditions’. The two main aspects to consider when validating cover systems are:

a) Confirmation that the designed thickness of the material has been placed; and
b) Confirmation that the materials comprising the cover system are themselves not contaminated, i.e. suitable for residential use.

To assess the thickness of the cover layer, it will be necessary to dig through the cover layer at selected locations to verify the post-compaction thickness of topsoil and subsoil.

In addition, the topsoil and subsoil (whether imported or site derived during earthworks or the subsequent construction phase) will be chemically validated by the collection and analysis of representative soil samples by an appropriately qualified environmental consultant. The frequency of testing for any site-derived or imported materials stockpiled

for re-use should be a minimum of one sample for every 100 m^3 for the following parameters:

- Metals: arsenic, cadmium, chromium, copper, nickel, lead, mercury, selenium and zinc and pH;
- Speciated TPH CWG (split into aliphatic and aromatic carbon bands) with BTEX compounds;
- Speciated 16 No. PAH; and
- Asbestos in soil (with identification where applicable).

It is acceptable to test stockpiled topsoil/subsoil intended for use in gardens and soft landscaped areas before placement, however the cover layer thickness will still require validation at a later date.

The groundworks contractor shall provide details of the provenance of any imported soil and evidence of compliance (i.e. chemical testing certificates representative of the type and volume of material) to the Environmental Consultant whose written approval will be required **before** importation and use of the material

At the completion of the remediation works the Environmental Consultant shall undertake the following:

- Confirmation of the capping layer thickness. The thickness shall be validated by excavating a trial hole in treated areas once the cover system has been placed;
- Soil sampling and subsequent chemical analysis of capping material. The results shall be assessed against the criteria set out in **Appendix P**. Where separate subsoil and topsoil materials are present, it will be necessary to confirm the chemical quality of both of these components;
- Testing of the cover shall be conducted at a sufficient rate to provide an adequate confidence regarding the depth and quality of the material used. In accordance with NHBC guidance, site fewer than 5 plots, testing shall be undertaken in every plot;
- Provision of a verification report detailing the following:
    - The source and volume of materials imported, including test certificates provided by the supplier and approvals from London Borough of Richmond Upon Thames;
    - The results of laboratory testing carried out prior and during the works;
    - A photographic record of the trial holes with a tape or a staff clearly showing the hole depth including the placement of the geo-marker layer;
    - Locations and number of trial holes; and
    - Collation of all other relevant documents, including consignment notes.

A copy of the report shall be forwarded to the Local Authority and NHBC for approval of the remediation works.

9.4.2 Hydrocarbon impacted area validation

A verification report shall be produced by the Environmental Consultant following the completion of the remediation works. This will include the following elements:

- The extent of works that have been carried out and formation levels, including a photographic record;
- The results of the in-situ testing (PID) and validation laboratory analysis undertaken following the excavation;
- Supporting chemical test records;
- Details of the backfill material used within the resultant voids; and
- Collation of all other relevant documents, including records of waste movements and consignment notes from the licensed waste carrier.

9.4.3 Potable pipe validation

Should the above be considered (subject to any supplementary ground investigation), the Principal Contractor shall provide details of the installation, including photographic record and letter of conformity to demonstrate the works undertaken and material used are in general accordance with Thames Water. The information shall be incorporated into the verification report prepared by the Environmental Consultant.

10 GEOTECHNICAL ASSESSMENT

10.1 Proposed development

As outlined in section 2.4, the development scheme is preliminary at this stage and consideration is being given to the following options:

Eastern Portion

- A single residential apartment block (measuring up to 3 storeys in height) with an undercroft car park at ground level.

Western Portion

- Two residential apartment blocks (measuring up to 3-4 storeys in height) with a single storey interconnecting basement level.

No specific information relating to the structural design or maximum imposed loads by the proposed building has been provided.

BS EN 1997-1 defines three different Geotechnical Categories that structures may fall into, which are summarised as follows:

- Category 1: Small and relatively simple structures for which it is possible to ensure that the fundamental requirements will be satisfied on the basis of experience and qualitative geotechnical investigations; with negligible risk;
- Category 2: Conventional types of structure and foundation with no exceptional risk or difficult ground or loading conditions; and
- Category 3: Structures or part of structures, which fall outside limits of Geotechnical Categories 1 and 2. Examples include very large or unusual structures; structures involving abnormal risks, or unusual or exceptionally difficult ground or loading conditions; structures in highly seismic areas; structures in areas of probable site instability or persistent ground movements that require separate investigation or special measures.

Different regimes for each category are adopted for inspection of the construction works, quality control, checking the exposed ground and groundwater conditions and performance of the works in relation to the design assumptions.

Based on the information provided above on the proposed development and in view of the anticipated ground conditions, a Geotechnical Category of 2 has been assumed for the purposes of assessment. This should be reviewed at all stages of the investigation and revised where necessary.

For Categories 2, measurements of the ground properties should be conducted, and additional ground investigations may be needed. Monitoring of performance in relation to the sequence of construction is required with measurements of displacements and appropriate ongoing analyses.

10.2 Key geotechnical hazards/development constraints

A summary of commonly occurring geotechnical hazards is given in **Table 17** together with an assessment of whether the site may be affected by each of the stated hazards.

Table 17 Summary of main potential geotechnical hazards that may affect site

Hazard category (excluding contamination issues)	Hazard status based on investigation findings and proposed development			Engineering considerations if hazard affects site
	Found to be present on site	Could be present but not found	Unlikely to be present and/or affect site	
Sudden lateral changes in ground conditions	✔	The variable composition and thickness of made ground and heterogeneity of the drift deposits (Kempton Park Gravel).		Likely to affect ground engineering and foundation design and construction
Shrinkable clay soils	✔	Low volume change potential (associated with the cohesive portion of the Kempton Park Gravel) and Medium to High (associated with the London Clay Formation), although the latter is unlikely to have effect due to its depth		Design to NHBC Standards Chapter 4 or similar
Highly compressible and low bearing capacity soils			✔	Likely to affect ground engineering and foundation design and construction
Silt-rich soils susceptible to loss of strength in wet conditions	✔	Variable silt content in the cohesive portion of the Kempton Park Gravel and inherent nature of the London Clay Formation.		Likely to affect ground engineering and foundation design and construction
Running sand at and below water table		✔	Could be present for excavation in granular soils below groundwater table	Likely to affect ground engineering and foundation design and construction
Karstic dissolution features (including ‘swallow holes’ in Chalk terrain)			✔	May affect ground engineering and foundation design and construction – refer to Section 4.1.2
Evaporite dissolution features and/or subsidence			✔	May affect ground engineering and foundation design and construction

Hazard category (excluding contamination issues)	Hazard status based on investigation findings and proposed development			Engineering considerations if hazard affects site
	Found to be present on site	Could be present but not found	Unlikely to be present and/or affect site	
Ground subject to or at risk from landslides			✔	Likely to require special stabilisation measures
Ground subject to peri-glacial valley cambering with gulls possibly present			✔	Likely to affect ground engineering and foundation design and construction
Ground subject to or at risk from coastal or river erosion			✔	Likely to require special protection/stabilisation measures
High groundwater table (including waterlogged ground)	✔	Groundwater recorded within the Kempton Park Gravel ranging between 3.10 and 3.67 m bgl.		May affect temporary and permanent works
Rising groundwater table due to diminishing abstraction in urban area	Relevant to exceptional structures (CIRIA Special Publication 69). The site does not lie within critical areas in which foundations and basements are at risk.			May affect deep foundations, basements and tunnels.
Underground mining			✔	Likely to require special stabilisation measures
Existing sub-structures (e.g. tunnels, foundations, basements, and adjacent sub-structures)	✔	Foundations to existing structures.		Likely to affect ground engineering and foundation design and construction
Filled and made ground (including embankments, infilled ponds and quarries)	✔	Made ground with variable thickness across the Site.		Likely to affect ground engineering and foundation design and construction
Adverse ground chemistry (including expansive slags and weathering of sulphides to sulphates)	✔	Geological strata most likely to have substantial sulphate concentrations within the London Clay Formation. This is further discussed in the sub-sections below.		May affect ground engineering and foundation design and construction
Note: Seismicity is not included in the above table as this is not normally a design consideration in the UK.				

10.3 Foundations

10.3.1 Foundation options

The ground conditions beneath the footprints of the proposed blocks derived from the two phases of investigative works reveal a variable depth of made ground, overlying interbedded superficial deposits of Kempton Park Gravel, typically characterised by firm gravelly sandy clay and medium dense to very dense locally clayey sandy gravel. The solid geology comprised the London Clay Formation of firm weathered silty clay, grading into stiff to very stiff dark grey/blueish grey silty clay. Groundwater levels recorded during the monitoring show resting levels within the Kempton Park Gravel, at a depth of between 3.10 and 3.67 m bgl. Groundwater strike were recorded was further recorded locally within claystone band in the London Clay Formation.

Given the presence of competent granular Kempton Park Gravel deposits at relatively shallow depths (0.50 m to 2.00 m below ground level) it is considered that traditional spread footings may be suitable in the eastern portion. Foundation excavations will, however, be locally relatively deep and may require further deepening due to any ground disturbance caused during the removal of remnant sub structures associated with the existing buildings on-site. Therefore, whilst recommendations for the design and construction of spread foundation is provided in **Section 10.3.2**, it is recommended that further investigations be conducted to provide greater confidence that traditional spread foundations will prove viable given the likely requirement to locally deepen and support foundation excavations. Alternatively, prior treatment, such as vibro-compaction/replacement may prove a more cost effective solution to enable the adoption of spread foundations or recourse to pile foundations. It is recommended that advice be sought from a ground improvement specialist to confirm suitability of the ground conditions for treatment and achievable bearing capacities.

With reference to western portion, piles are deemed the most suitable foundation option for the proposed development however, a rafted foundation can also be considered. The excavation for the basement (assumed approximately 3 m with the anticipated FFL resting at ~3 m AOD) will take the formation level within the medium dense sandy gravel/gravelly sand and close to the groundwater levels. Subsequent new construction will be accompanied by a sequence of ground movements, including swelling heave on unloading, and longer term consolidation settlement on reloading. The amounts of each component of movement will depend upon a number of factors, construction timetable and ultimate loadings. A detailed assessment of the potential ground movements will need to be undertaken once the foundation scheme has been finalised.

10.3.2 Spread foundations

It is envisaged that spread foundations founded within the Kempton Gravel Member at a minimum depth of 1.00 m below the existing ground level or at least 0.2 m into the medium dense gravels may be appropriate for this option. Design Approach 1 - Combination 2 results are summarised in **Table 18**.

Table 18 Comparison of ULS design resistance and SLS design pressures

Foundation Dimensions				DA1-C2 Design Resistance (kN/m²)	SLS (25 mm Settlement) (kN/m²)
Width (m)	Length (m)	Depth (m)	Area (m²)		
Strip/Trench Fill Foundations					
1.00	10.00	1.00	10.00	420	282
1.50	10.00		15.00	565	216
2.00	10.00		20.00	595	180
1.00	10.00	1.50	10.00	706	289
1.50	10.00		15.00	737	223
2.00	10.00		20.00	767	186
1.00	10.00	2.00	10.00	876	296
1.50	10.00		15.00	908	230
2.00	10.00		20.00	938	193
Pad Foundations					
1.50	1.50	1.00	2.25	523	328
2.00	2.00		4.00	546	271
3.00	3.00		9.00	570	233
1.50	1.50	1.50	2.25	702	335
2.00	2.00		4.00	726	277
3.00	3.00		9.00	750	240
1.50	1.50	2.00	2.25	882	341
2.00	2.00		4.00	906	284
3.00	3.00		9.00	929	247
Notes: Depth refers to depth below ground level or m bgl					

Consideration may need to be given to some form of excavation stabilisation/support as pumping from open sumps in non-cohesive soils can result in instability and general loosening of the soils at the base of the excavation.

Owing to the lateral and vertical variability of the founding strata, it is recommended that the foundations are constructed fully within the granular Kempton Park Gravel deposits, or alternatively consideration should be given to incorporating appropriate reinforcement into the strip foundations to minimise the risk of future differential foundation movements.

10.3.3 Basement raft

Based on the soil profile indicated above and the anticipated formation level of the proposed basement (3 m below the existing ground level), the basement raft would be

constructed within the medium dense, sandy gravel and locally firm sandy, gravelly clay (Kempton Park Gravel).

A net safe bearing pressure of 250 kN/m^2 (safety factor F_s=3.0) has been calculated for a raft foundation, however, pressures of this magnitude are likely to result in appreciable settlements. It will be necessary to check that the associated settlements are acceptable to the proposed structure and surrounding buildings.

The groundwater level beneath the site was recorded at the highest level of approximately 3.10 mbgl, i.e. below, but close to the anticipated basement formation level. Therefore, it would be prudent to allow for a potential for higher levels to occur at some point in the future and associated hydrostatic uplift pressures acting on the raft.

The proposed methods for basement construction should effectively produce a cut-off around the perimeter of the excavation, and therefore dewatering will not be required during the construction. Furthermore, suitable support to the excavation should be provided by the installation of the proposed sheet/secant/contiguous piles around the perimeter.

The basement structure will need to incorporate suitable waterproofing measures and reference should be made to BS 8102:2009 'Code of practice for protection of below ground structures against water from the ground' for further guidance.

10.3.4 Piled foundations

Recommendations for the design and construction of pile foundations in relation to the ground conditions are set out in **Table 19**.

Table 19 Design and construction of piled foundations

Design/construction considerations	Design/construction recommendations
Pile type	The construction of both bored and 'cfa' piles is considered technically feasible at this site
Possible constraints on choice of pile type	Given the close proximity of the site to other properties, it is considered that the use of driven piles may not be acceptable due to the vibration, noise and heave associated with pile driving. Driven piles are also likely to reach premature set in the 'dense' sands and gravels of the Kempton Park Gravel.
Temporary casing	Given the presence of groundwater within the Kempton Park Gravel, and the claystone bands in the London Clay Formation, bored piles will require temporary casing throughout their depth. Alternatively, the use of continuous-flight-auger (CFA) injected bored piles or driven piles usually overcomes this issue Groundwater adopted at 1.00 m bgl for preliminary design purposes
Man-made obstructions	The presence of buried sub-structures or other obstructions within made ground may lead to some difficulty during piling. Where buried obstructions are encountered, it will be necessary to either relocate the pile(s) or make allowance for removing the obstruction
Hard strata	An allowance should be made for the presence of 'rock' bands (claystone) within the London Clay Formation. Claystone bands were recorded locally within BH02 (13.70 m) and BH03 (12.20 m)

Design/construction considerations	Design/construction recommendations	
Limitations afforded by ground	For the purpose of assessing preliminary pile capacities the made ground/Kempton Park Gravel (cohesive portion) have been presumed not to contribute to the load-carrying capacity for the piles for the first approximately 3 m bgl. At this time, no negative skin friction has been considered	
Pile Design Parameters (bored piles)		
Kempton Park Gravel (granular)	Angle of internal friction (φ) based on average SPT 'N' value of 34	37
	Shaft friction factor (k_s.tan δ)	0.60
London Clay Formation	Undrained shear strength c_u (kN/m^2) for London Clay Formation	80 + 8.26z kN/m2 where z = depth
	Adhesion factor α	0.5
	End bearing factor (N_c)	9
General parameters	SLS check –factor on shaft friction	1.2
	Model factor (γ_{Rd})	1.4
	Maximum limiting shaft friction (kN/m^2)	140
Special precautions relating to bored pile shafts and bases	Bored pile concrete should be cast as soon after completion of boring as possible and in any event the same day as boring Prior to casting the base of the pile bore should be clean, otherwise a reduced safe working load will be required. Similarly, if the pile bore is left open the shaft walls may relax/soften, leading to a reduced safe working load	

The design resistance has been calculated in accordance with BS EN 1997-1 and the UK National Annex, using partial resistance factors for bored piles, given in **Table 20**.

Table 20 Partial resistance factors (γ_R)

Resistance	Set	
	DA1 C1	DA1 C2[1)]
Base - γ_b	1.0	2.0
Shaft (compression) - γ_s	1.0	1.6
Total (compression) - γ_t	1.0	2.0

[1)] no serviceability verification

The design procedure for piles varies considerably, depending on the proposed type of pile. However, for illustrative purposes **Table 19** give likely working pile loads (in compression) for traditional bored, cast-in-situ concrete piles of various diameters and lengths, based on the design parameters given in **Table 21**.

Table 21 Illustration of typical compressive design resistances for bored cast-in-situ piles

Compression												
Typical Design resistance for DA1 – Combinations C1 & C2 (kN)												
Depth of toe below ground (mbgl)	Pile diameter											
	300 mm			450 mm			600 mm			750 mm		
	C1	C2	SLS	C1	C2	SLS	C1	C2	SLS	C1	C2	SLS
10	228	137	152	375	222	229	545	318	305	737	426	382
12	307	185	212	500	298	319	720	423	425	965	562	532
14	398	241	282	643	385	423	918	543	564	1223	717	705
16	501	305	361	803	483	542	1139	678	722	1509	890	903
18	616	375	450	980	591	675	1383	826	900	1824	1081	1125
20	741	453	548	1175	711	822	1651	990	1097	2168	1289	1371
22	879	538	656	1387	841	984	1941	1167	1313	2541	1517	1641

From the above, it can be seen that pile loads are limited by the Combination 2 design resistances or serviceability limit state and the smaller of the two adopted.

It should be stressed that the above capacities do not take into consideration limiting concrete stress (to be verified by a separate load case as defined in EC2) nor pile group effects, the latter of which is more pronounced for a large number of closely spaced piles.

Notwithstanding the above, it is recommended that the detailed advice of a specialist-piling contractor be sought as to the most suitable type of pile for the prevailing ground conditions and as to their lengths and diameters to support the required design loads.

It should be stressed that the above capacities do not take into consideration pile group of piled raft effects which is more pronounced for a large number of closely spaced piles.

The presence of water-bearing strata may dictate the pile length, its type and the construction methods adopted. The ground investigation undertaken to date was limited and further investigations may be required to fully characterise the ground conditions.

10.4 Retaining wall design parameters

In order to facilitate the basement excavation, it will be necessary to construct an embedded retaining wall around the external basement perimeter. On the basis of the ground investigation information obtained to date, the following soil parameters in **Table 22** are recommended for retaining wall design purposes.

Table 22 Retaining wall design parameters

Soil type	N Value / Undrained Shear Strength c_u (kN/m^2)	Unit weight -γ_k (kN/m^3)	Short Term Characteristics		Long Term Characteristics	
			C_U (kN/m^2)	ϕ (°)	c' (kN/m^3)	ϕ' (°)
Made Ground (granular)	N = 9 to 32	18	0	30	0	30
Kempton Park Gravel (cohesive)	Cu = 42 to 75[2)]	19	42 to 75	0	0	25[1)]
Kempton Park Gravel (granular)	N = 18 to >50	20.0 (moist) 22.0 (saturated)	N/A	37	0	37
London Clay Formation	80 + 8.26z	20.0	80 + 8.26z	0	2[1)]	25[1)]

[1)] assumed parameters based on previous experience and in absence of site specific data

[2)] based on hand vane results

In order to prevent damage to adjacent structures, the design of the retaining wall and basement excavation must address the risk of excessive deformation of the wall. Bracing, both in the temporary and permanent condition will therefore be required, to ensure that the horizontal and vertical soil movement around and below the excavation remain within acceptable levels.

10.5 Roads and hardstanding

In the 1.0 m to 1.5 m below the proposed finished ground level the exploratory holes have revealed a soil profile comprising made ground over Kempton Park Gravel. The potentially poorest sub-grade material within this profile is the made ground.

In pavement design terms, the groundwater conditions are anticipated to comprise a low water-table, i.e. at least 1 m below the pavement formation level. The results of in-situ testing are summarised in **Table 23**.

Table 23 Summary of CBR values derived from in-situ Clegg Hammer tests

Test location	Depth (mbgl)	Material type	Minimum CBR value
CBR1	0.45	Made Ground (granular)	17%[1)]
CBR2	0.45	Made Ground (granular)	10%[1)]
CBR3	0.45	Made Ground (granular)	10%[1)]

1) High readings considered attributable to gravel content

For preliminary road pavement design, it is recommended a sub-grade soil CBR value of 5% used. This value assumes that during construction the formation level will be carefully compacted and any soft spots removed and replaced with well-compacted granular fill.

It is recommended that in situ plate bearing tests are completed on the final formation to confirm the final design CBR value.

The sub-grade soils can be regarded as non-frost-susceptible (PI <15%), based upon the criteria given in Appendix 1 of TRRL (1970) Report Road Note 29. When the sub-grade is frost-susceptible the thickness of sub-base must be sufficient to give a total thickness of non-frost-susceptible pavement construction over the soil of not less than 450 mm.

10.6 Chemical attack on buried concrete

This assessment of the potential for chemical attack on buried concrete is based on current BRE guidance. The desk study and site walkover indicate that, for the purposes of this assessment of the aggressive chemical environment, the site should be considered as a site where disturbance of pyrite bearing ground could result in additional sulphate. A summary of the results is presented below.

Table 24 Pyritic geology chemical tests (London Clay)

Test location	Depth	pH	Water soluble sulphate (2:1) mg/l	Acid soluble sulphate %w/w	Total Sulphur %w/w	Total potential sulphate %	Oxidisable Sulphides %
BH02	9	8.61	120	0.1	0.44	1.32	1.22
BH02	12	8.34	11	0.2	7.38	22.14	21.94
BH02	15	8.73	56	0.07	0.34	1.02	0.95
BH02	18	8.94	66	0.06	0.3	0.9	0.84
BH04	8	8.76	66	0.05	0.17	0.51	0.46
BH01	10.5	8.86	39	0.08	0.38	1.14	1.06
BH01	13.5	8.71	92	0.1	0.48	1.44	1.34
BH01	16.5	8.41	308	0.16	0.41	1.23	1.07
BH01	19.5	8.43	174	0.12	0.36	1.08	0.96
BH01	25.5	8.49	184	0.2	5.32	15.96	15.76
BH03	7.5	8.28	150	0.14	0.45	1.35	1.21
BH03	10.5	8.74	68	0.07	0.42	1.26	1.19

Table 25 Non-Pyritic geology chemical tests (Kempton Park Gravel)

Test location	Depth	pH	Water soluble sulphate (2:1) mg/l
BH02	6	8.45	<10
BH04	1.5	8.15	15
BH04	3.5	8.5	<10
BH04	5.5	8.29	<10

Test location	Depth	pH	Water soluble sulphate (2:1) mg/l
BH02	6	8.45	<10
BH04	1.5	8.15	15
BH01	2	8.42	<10
bh01	7	8.11	<10
BH03	5	8.17	<10

Table 26 Non-Pyritic geology chemical tests (Made Ground)

Test location	Depth	pH	Water soluble sulphate (2:1) mg/l
BH02	1.2	8.08	<10
BH04	0.5	7.92	<10
BH03	1.2	8.09	11

"Characteristic value" is the highest or mean of the two highest results if more than 5 readings from one area are available. For the purpose of this assessment, we have taken the highest result (308 mg/l) as a characteristic value. As this value is below the limiting value of 3.0 g/l consideration of magnesium is not required.

Based on Table C2 in the BRE guidance, Result one for Design Sulphate Class for the site is DS-1.

Although for the purposes of this assessment the site has been classified as brownfield, the pH is nowhere less than the limiting value of 5.5. The third assessment of Design Sulphate Class specific to brownfield sites is therefore not required in this case.

Due to the possible presence of sulphides in weathered London Clay, a calculation was made using the measured concentrations of Total Sulphur and Acid Soluble Sulphate content of the amount of Oxidisable Sulphide present. A maximum Oxidisable Sulphide content of 21.94% was calculated. Since this value is greater than 0.3% a Total Potential Sulphate (TPS) concentration of 22.14% has been calculated, which results in a Design Sulphate Class of DS-5. However, the classification is based on the assumption that significantly disturbed clays will come into contact with buried concrete. As such, concrete in pyritic ground which is initially low in soluble sulfate does not have to be designed to withstand a high potential Sulfate Class unless it is exposed to ground which has been 'disturbed' to the extent that contained pyrite might oxidise and the resultant sulfate ions reach the concrete.

Furthermore, the sulfate classification based on total potential sulfate is highly conservative as not all the pyrite in soil will be oxidised and only a part will be taken into solution.

In view of the above and assuming the adoption of pile foundation, Design Sulphate Class of DS-1, may be adopted. It has been assumed that groundwater conditions are mobile. From consideration of the characteristic pH value, an Aggressive Chemical Environment for Concrete classification of AC-1 may be assumed for design purposes. However,

should the proposals include the reuse of significantly disturbed clay (pile arisings, etc.) on site concrete structures, Design Sulphate Class of DS-5 and Aggressive Chemical Environment for Concrete classification of AC-5 should be adopted.

With respect to non-pyritic ground conditions (i.e. Kempton Park Gravel), consideration may be given to DS-1.

Please note, the above is preliminary and the data should be re-assessed once the development scheme and foundation type has been finalised.

10.7 Infiltration drainage

Falling head tests were performed in BH2 and BH3 to provide a preliminary assessment on the infiltration characteristics of the underlying soils. The results of which are summarised in **Table 27** below and shown in **Appendix G**.

Table 27 Summary of borehole soakaway results

Test location	Depth of test section (m)	Infiltration rate (m/s)	Strata
BH2	1.7-2.7	$4.0E10^{-6}$	Kempton Park Gravel
BH3	3-4	$1.46E10^{-4}$	Kempton Park Gravel

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FIGURES

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Project Title: BARNES HOSPITAL
PLOT A

Drawing Title: SITE LOCATION PLAN

Rev	Drawn	Date	Checked	Date	Approved	Date
01	SAY	20.01.20	HA	20.01.20	ZH	20.01.20

Dimensions	Scale	Original Size
m	1:25,000	A4

Project Number	Drawing File	Drawing Number
1920884 - R01 (00)	1920884 - SLP.dwg	FIGURE 1

LEGEND

- Site Boundary
- Borehole Location
- Window Sample Location

Rev.	Date	Amendment	Drawn	Chkd.	Appd.

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BARNES HOSPITAL
PLOT A

Drawing Title

SITE LAYOUT AND EXPLORATORY HOLE LOCATION PLAN

Drawn	Date	Checked	Date	Approved	Date
SAY	20.01.20	HA	20.01.20	ZH	20.01.20

Scale	Orig Size	Dimensions
1:600	A3	Metres

Project No.	Drawing File
1920884 (R01-00)	1920884 (R01-00) Fig 2.dwg

Drawing No.	Rev.
FIGURE 2	P1

Scale 1 : 600

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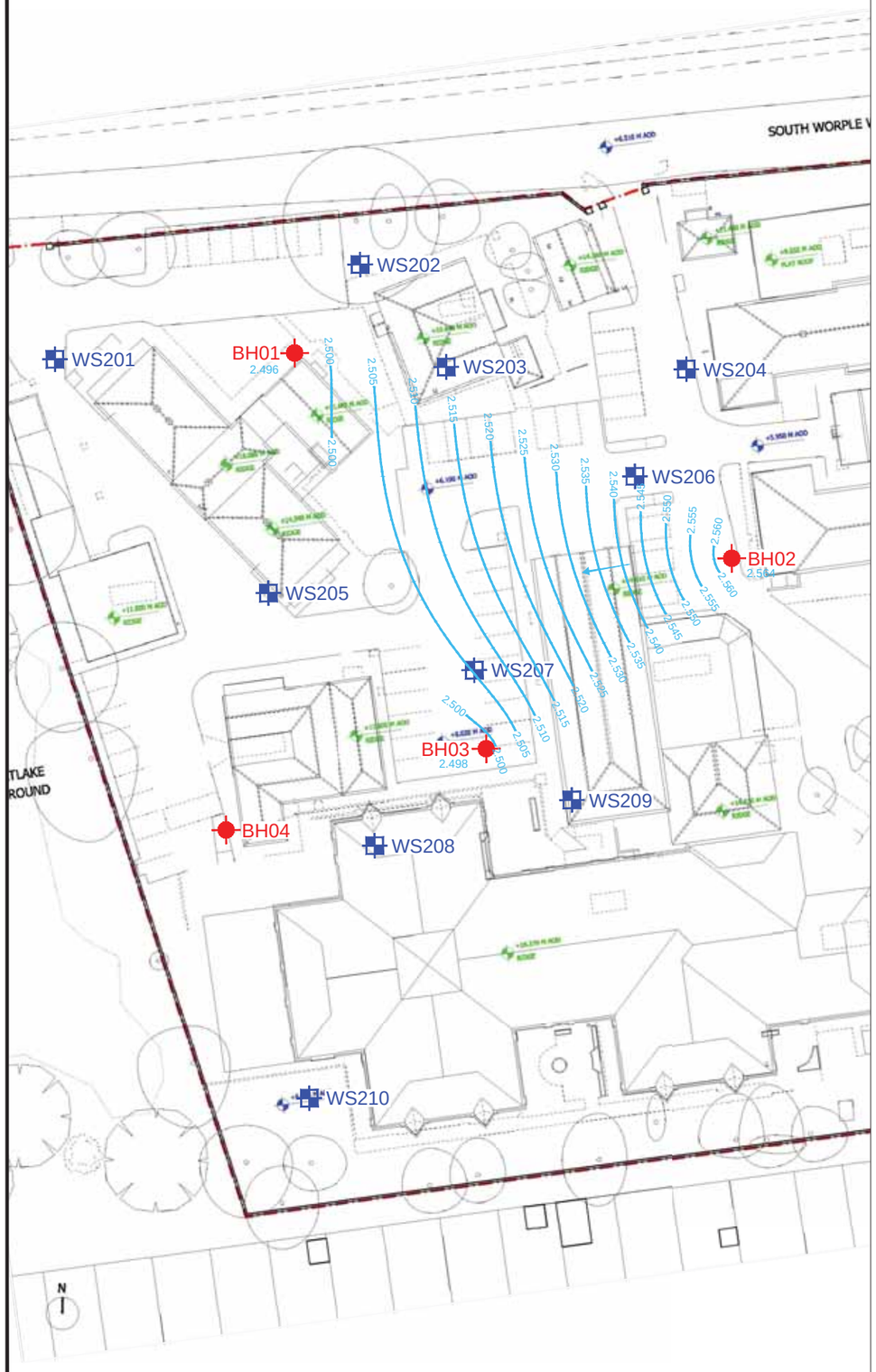

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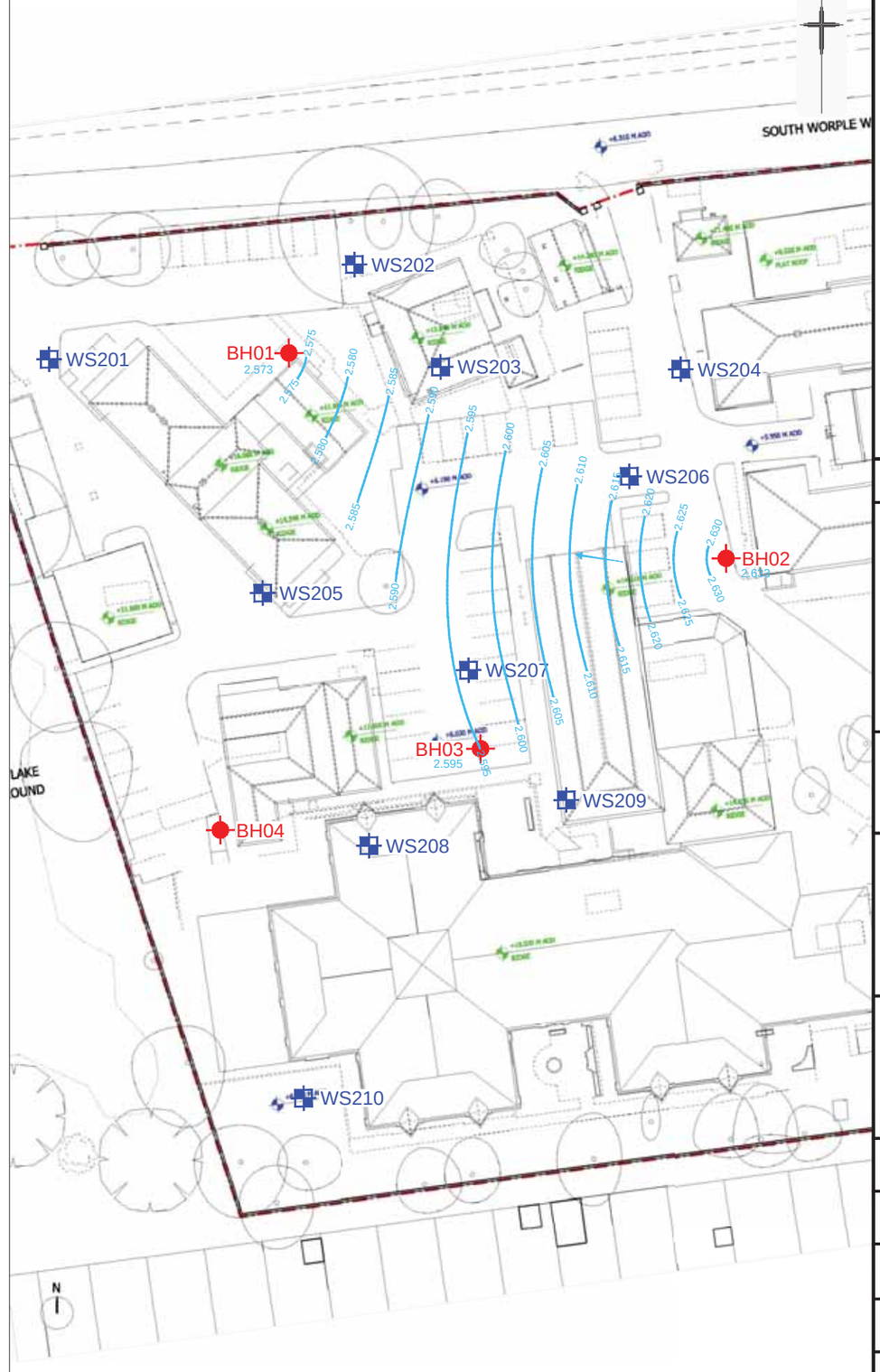

LEGEND

- Site Boundary
- Borehole Location
- Window Sample Location
- 6.943 Groundwater Level (mAOD)
- 7.05 Groundwater Contour (mAOD)
- Groundwater Flow Direction

Rev.	Date	Amendment	Drawn	Chkd.	Appd.

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BARNES HOSPITAL
PLOT A

Drawing Title

GROUNDWATER
PIEZOMETER PLAN

Drawn	Date	Checked	Date	Approved	Date
SAY	20.01.20	HA	20.01.20	ZH	20.01.20

Scale	Orig Size	Dimensions
1:600	A3	Metres

Project No.	Drawing File
1920884 (R01-00)	1920884 (R01-00) Fig 3.dwg

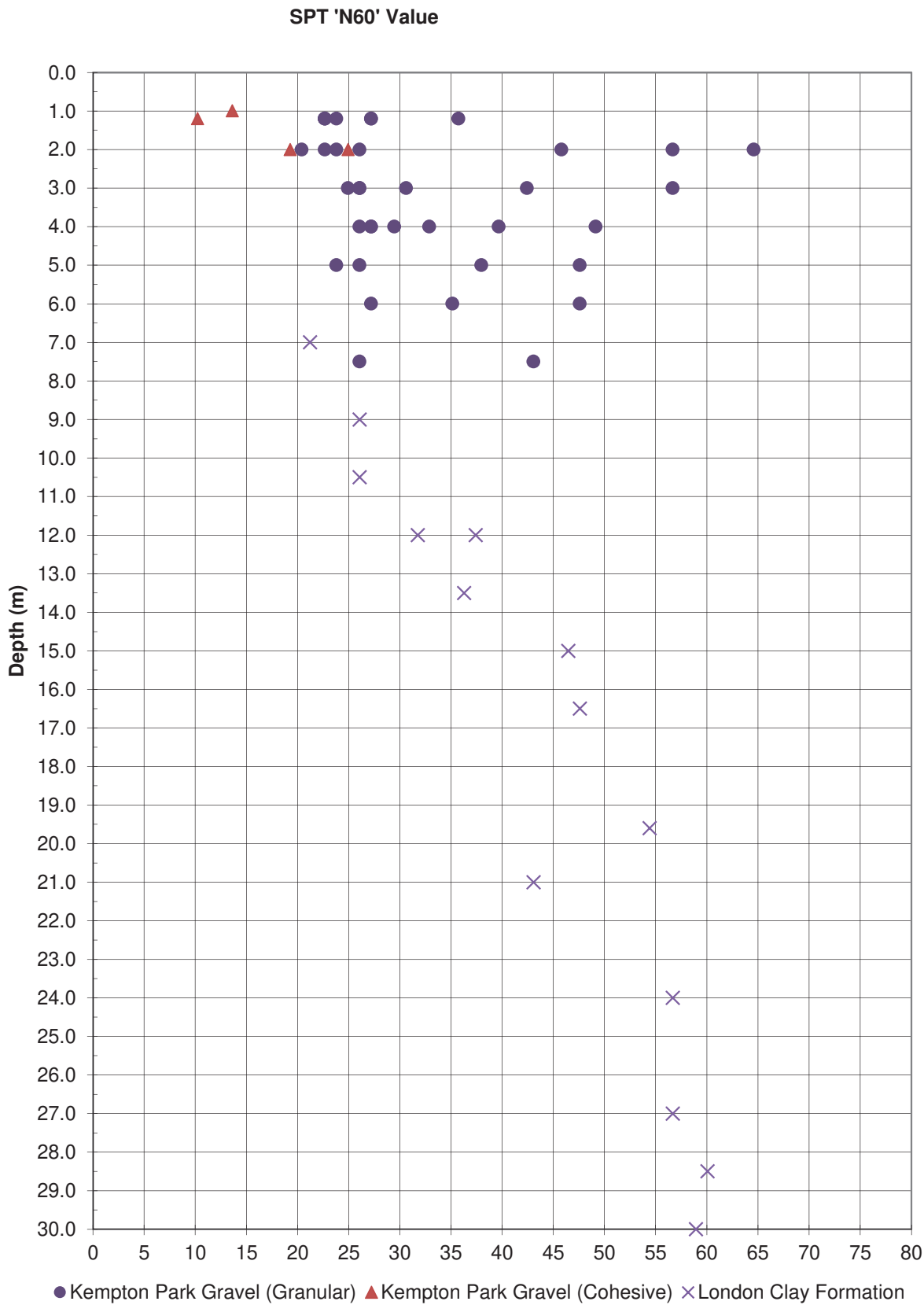
Drawing No.	Rev.
FIGURE 3	P1

Scale 1 : 600

0 8 16 24 32 40m

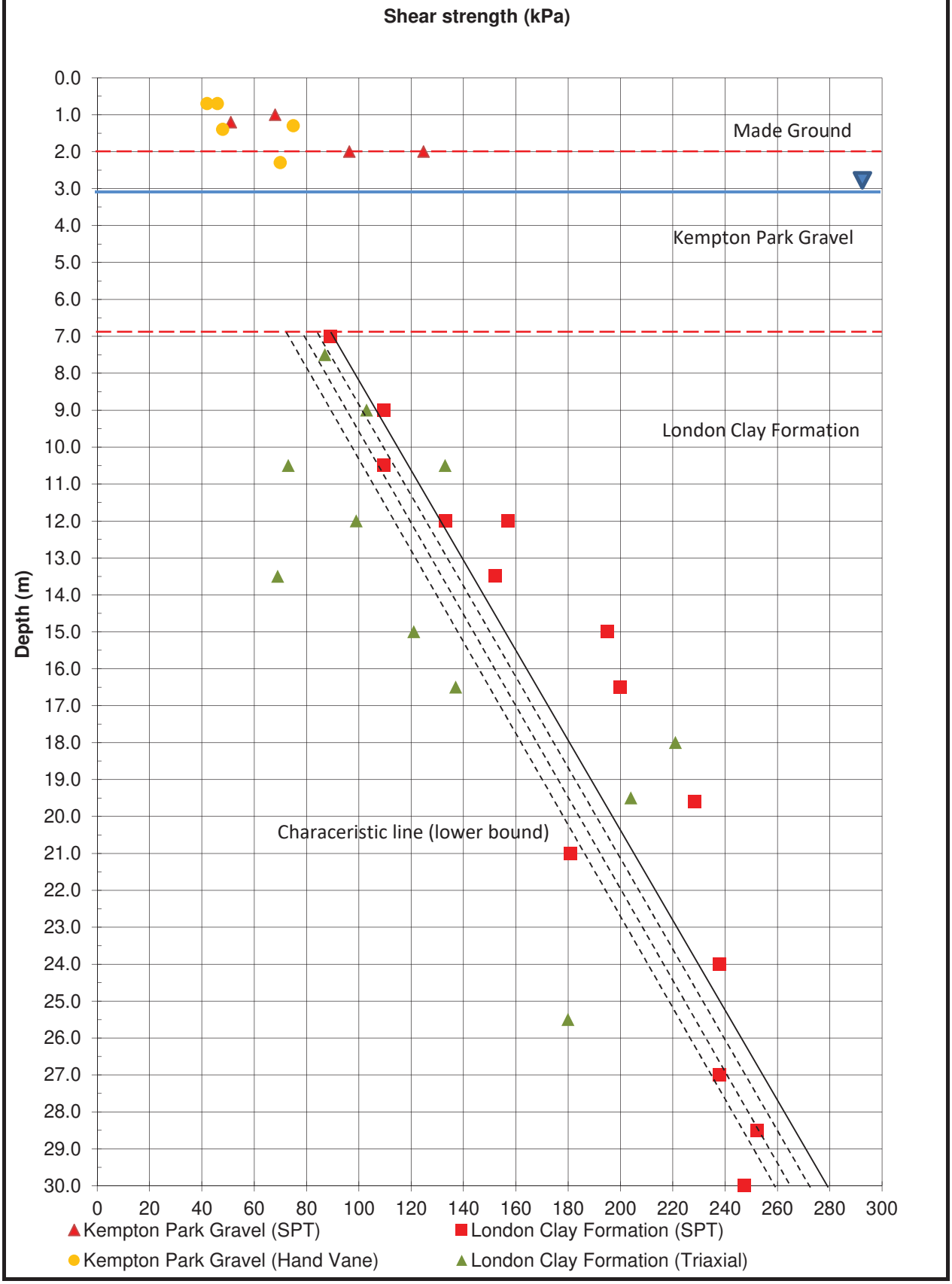
SPT 'N60' Value vs Depth (m)

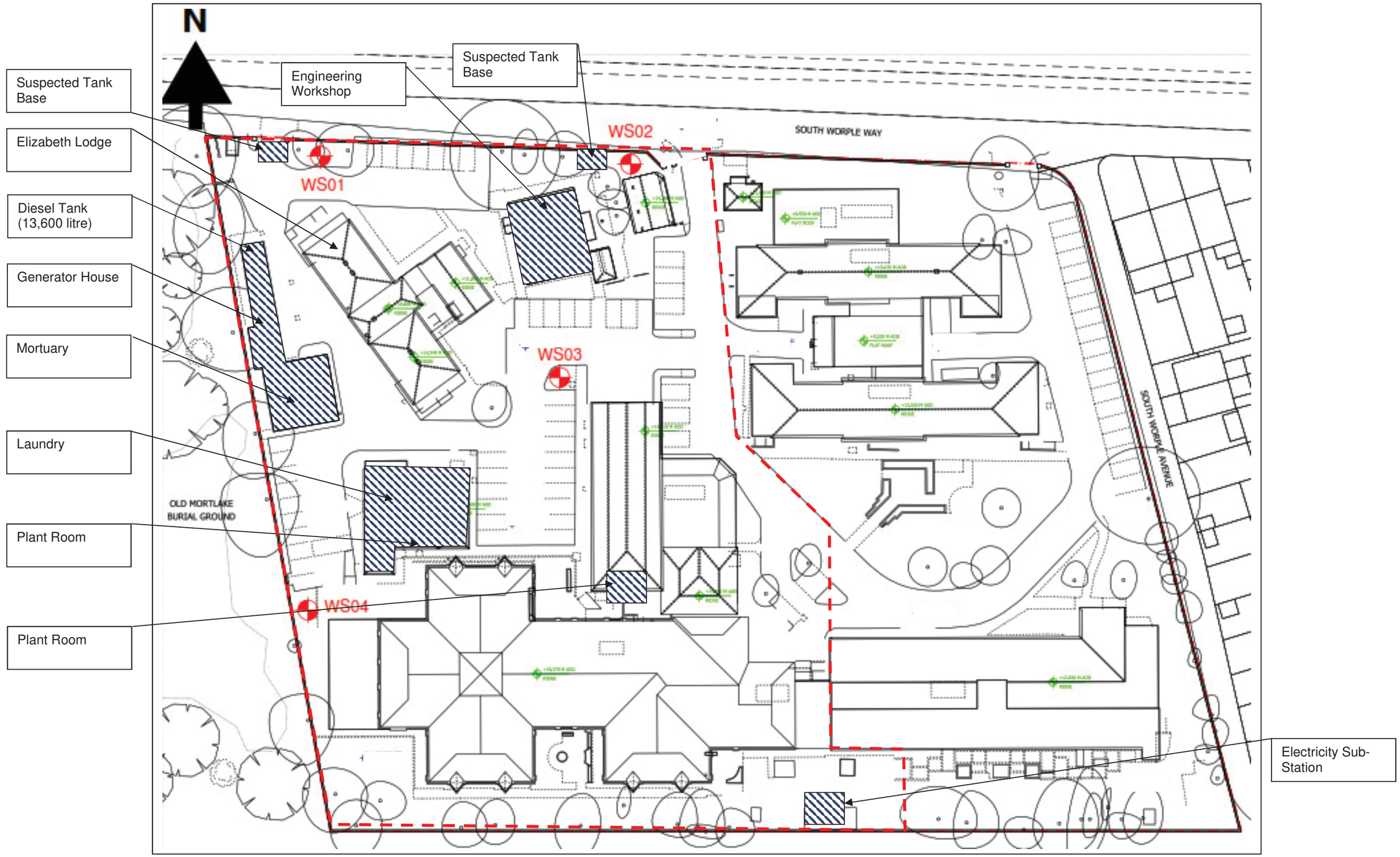
Site:	Client:	Job Number:	1920884
Barnes Hospital (Plot A)	Star Land UK Ltd c/o LS Estates Ltd	Figure:	4



Shear Strength vs Depth (m)

Site:	Client:	Job Number:	1920884
Barnes Hospital (Plot A)	Star Land UK Ltd c/o LS Estates Ltd	Figure:	5





RSK	**POTENTIAL AREAS OF CONCERN**	Client:	Star Land Realty UK Ltd c/o LS Estates Ltd	Figure No:	6
		Site:	Barnes Hospital (Plot A)	Job No:	1920884
		Scale:	NTS	Source:	RSK

APPENDIX A
SERVICE CONSTRAINTS

1. This report and the site investigation carried out in connection with the report (together the "Services") were compiled and carried out by RSK Environment Limited (RSK) for Star Land UK Ltd c/o LS Estates Ltd (the "Client") in accordance with the terms of a contract [RSK Environment Standard Terms and Conditions] between RSK and the Client. The Services were performed by RSK with the reasonable skill and care ordinarily exercised by an environmental consultant at the time the Services were performed. Further, and in particular, the Services were performed by RSK taking into account the limits of the scope of works required by the client, the time scale involved and the resources, including financial and manpower resources, agreed between RSK and the Client.
2. Other than that, expressly contained in paragraph 1 above, RSK provides no other representation or warranty whether express or implied, in relation to the Services.
3. Unless otherwise agreed in writing, the Services were performed by RSK exclusively for the purposes of the Client. RSK is not aware of any interest of or reliance by any party other than the Client in or on the Services. Unless expressly provided in writing, RSK does not authorise, consent or condone any party other than the client relying upon the Services. Should this report or any part of this report, or otherwise details of the Services or any part of the Services be made known to any such party, and such party relies thereon that party does so wholly at its own and sole risk and RSK disclaims any liability to such parties. **Any such party would be well advised to seek independent advice from a competent environmental consultant and/or lawyer.**
4. It is RSK's understanding that this report is to be used for the purpose described in the introduction to the report. That purpose was a significant factor in determining the scope and level of the Services. Should the purpose for which the report is used, or the proposed use of the site change, this report may no longer be valid and any further use of or reliance upon the report in those circumstances by the client without RSK 's review and advice shall be at the client's sole and own risk. Should RSK be requested to review the report after the date of this report, RSK shall be entitled to additional payment at the then existing rates or such other terms as agreed between RSK and the client.
5. The passage of time may result in changes in site conditions, regulatory or other legal provisions, technology or economic conditions which could render the report inaccurate or unreliable. The information and conclusions contained in this report should not be relied upon in the future without the written advice of RSK. In the absence of such written advice of RSK, reliance on the report in the future shall be at the Client's own and sole risk. Should RSK be requested to review the report in the future, RSK shall be entitled to additional payment at the then existing rate or such other terms as may be agreed between RSK and the client.
6. The observations and conclusions described in this report are based solely upon the Services which were provided pursuant to the agreement between the Client and RSK. RSK has not performed any observations, investigations, studies or testing not specifically set out or required by the contract between the client and RSK. RSK is not liable for the existence of any condition, the discovery of which would require performance of services not otherwise contained in the Services. For the avoidance of doubt, unless otherwise expressly referred to in the introduction to this report, RSK did not seek to evaluate the presence on or off the site of asbestos, invasive plants, electromagnetic fields, lead paint, heavy metals, radon gas or other radioactive or hazardous materials, unless specifically identified in the Services.
7. The Services are based upon RSK's observations of existing physical conditions at the Site gained from a visual inspection of the site together with RSK's interpretation of information, including documentation, obtained from third parties and from the Client on the history and usage of the site, unless specifically identified in the Services or accreditation system (such as UKAS ISO 17020:2012 clause 7.1.6):

    a. The Services were based on information and/or analysis provided by independent testing and information services or laboratories upon which RSK was reasonably entitled to rely.

    b. The Services were limited by the accuracy of the information, including documentation, reviewed by RSK and the observations possible at the time of the visual inspection.

    c. The Services did not attempt to independently verify the accuracy or completeness of information, documentation or materials received from the client or third parties, including laboratories and information services, during the performance of the Services.

    RSK is not liable for any inaccurate information or conclusions, the discovery of which inaccuracies required the doing of any act including the gathering of any information which was not reasonably available to RSK and

including the doing of any independent investigation of the information provided to RSK save as otherwise provided in the terms of the contract between the Client and RSK.

8. The intrusive environmental site investigation aspects of the Services are a limited sampling of the site at pre-determined locations based on the known historic / operational configuration of the site. The conclusions given in this report are based on information gathered at the specific test locations and can only be extrapolated to an undefined limited area around those locations. The extent of the limited area depends on the properties of the materials adjacent and local conditions, together with the position of any current structures and underground utilities and facilities, and natural and other activities on site. In addition, chemical analysis was carried out for a limited number of parameters (as stipulated in the scope between the client and RSK, based on an understanding of the available operational and historical information) and it should not be inferred that other chemical species are not present.

9. Any site drawing(s) provided in this report is (are) not meant to be an accurate base plan but is (are) used to present the general relative locations of features on, and surrounding, the site. Features (intrusive and sample locations etc) annotated on site plans are not drawn to scale but are centred over the approximate location. Such features should not be used for setting out and should be considered indicative only.

10. The comments given in this report and the opinions expressed are based on the ground conditions encountered during the site work and on the results of tests made in the field and in the laboratory. However, there may be conditions pertaining to the site that have not been disclosed by the investigation and therefore could not be taken into account. In particular, it should be noted that there may be areas of made ground not detected due to the limited nature of the investigation or the thickness and quality of made ground across the site may be variable. In addition, groundwater levels and ground gas concentrations and flows, may vary from those reported due to seasonal, or other, effects and the limitations stated in the data should be recognised.

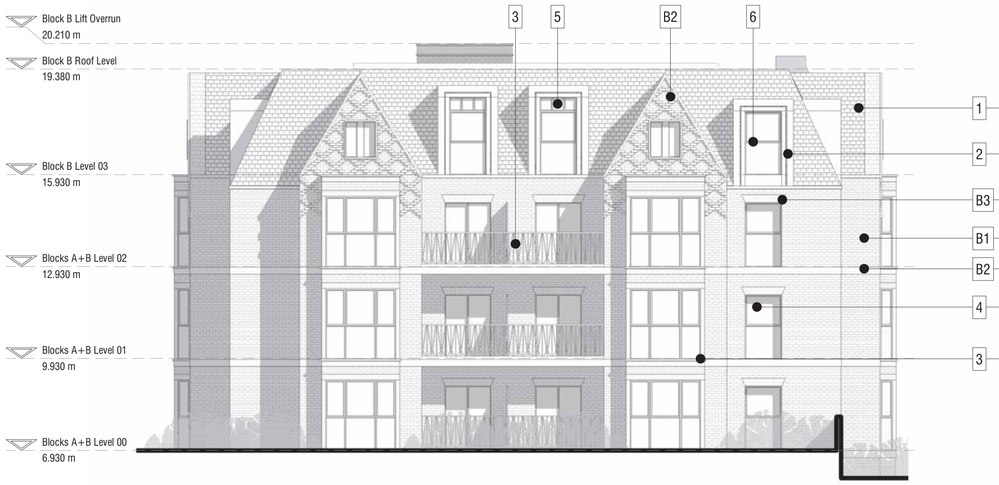
11. Asbestos is often observed to be present in soils in discrete areas. Whilst asbestos-containing materials may have been locally encountered during the fieldworks or supporting laboratory analysis, the history of brownfield and demolition sites indicates that asbestos fibres may be present more widely in soils and aggregates, which could be encountered during more extensive ground works.

12. Unless stated otherwise, only preliminary geotechnical recommendations are presented in this report and these should be verified in a Geotechnical Design Report, once proposed construction and structural design proposals are confirmed.

APPENDIX B
DEVELOPMENT DRAWINGS

1 Block B Elevation 1
1 : 100

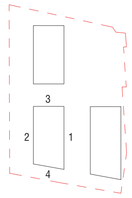
2 Block B Elevation 2
1 : 100



3 Block B Elevation 3
1 : 100

4 Block B Elevation 4
1 : 100

Figured dimensions only are to be taken from this drawing. All dimensions are to be checked on site before any work is put in hand.



Common Materials

- 1. Natural slate roof tiles
- 2. Zinc cladding
- 3. Brown-toned metalwork
- 4. Clear laminated glass
- 5. Grey backpainted glass panels
- 6. Black grey window frames

Block B Brickwork

- B1. Main brick
- B2. Lighter Accent Brick
- B3. Darker Accent Brick

DRAFT

Revision	Description	Date	Drawn	Checked
3	Update Desing Freeze	23/07/2021	FS	OM
2	Draft Planning Submission	09/07/2021	FS	OM
1	For Information	23/06/2021	FS	OM

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Client's Name
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Job Title
Barnes Hospital Site

Drawing Title
Block B Elevations

Scale
As indicated @A1

SBR Project No.
18387

SBR Project No. | Originator | Volume | Level | Type | Role | Number
18387-SBR-BB-XX-DR-A-84102

Suitability Code | Status | Rev
S0 - IN PROGRESS | **3**

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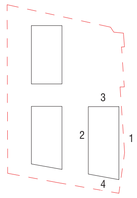


Common Materials

- 1. Natural slate roof tiles
- 2. Zinc cladding
- 3. Brown-toned metalwork
- 4. Clear laminated glass
- 5. Grey backpainted glass panels
- 6. Black grey window frames

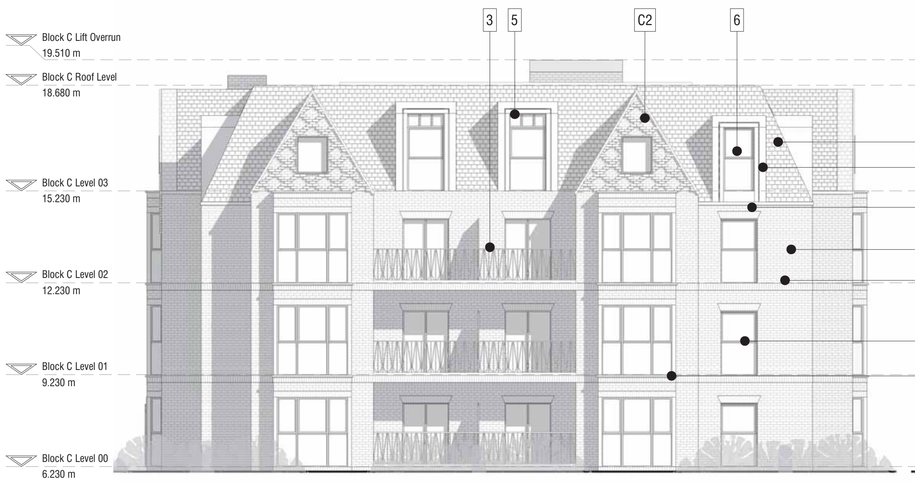
Block C Brickwork

- C1. Main brick
- C2. Lighter Accent Brick
- C3. Darker Accent Brick

DRAFT

1 Block C Elevation 1
1 : 100

2 Block C Elevation 2
1 : 100



3 Block C Elevation 3
1 : 100

4 Block C Elevation 4
1 : 100

Revision	Description	Date	Drawn	Checked
3	Update Desing Freeze	23/07/2021	FS	OM
2	Draft Planning Submission	09/07/2021	FS	OM
1	For Information	23/06/2021	FS	OM

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Drawing Title
Block C Elevations

Scale
As indicated @A1

SBR Project No.
18387

SBR Project No. | Originator | Volume | Level | Type | Role | Number
18387-SBR-BC-XX-DR-A-84103

Suitability Code | Status | Rev
S0 - IN PROGRESS | **3**

metres 5 10 15 20 25

SCALE BAR: 1:250

DRAFT

Revision	Description	Date	Drawn	Checked
12	Update Design Freeze	23/07/2021	FS	OM
11	Draft Planning Submission	09/07/2021	FS	OM
10	For Information	05/07/2021	FS	OM
9	For Information	23/06/2021	FS	OM
8	For Information	04/06/2021	FS	OM
7	For information	12/05/2021	FS	OM
6	For Information	10/05/2021	FS	OM
5	For Information	25/03/2021	FS	OM
4	Pre-App 2 Issue	25/02/2021	FS	OM
3	Building position update	08/02/2021	FS	OM
2	For Information	28/01/2021	FS	OM
1	For Information	14/01/2021	FS	OM

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Job Title
Barnes Hospital Site

Drawing Title
Proposed Site Plan

Scale
1 : 250 @A1

SBR Project No.
18387

SBR Project No.	Originator	Volume	Level	Type	Role	Number
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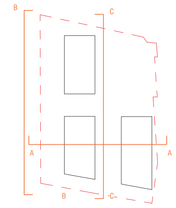
Suitability Code	Status	Rev
S0 -	WORK IN PROGRESS	12



1 **Site Section A**
1 : 500

2 **Site Section B**
1 : 500

3 **Site Section C**
1 : 500

DRAFT

Revision	Description	Date	Drawn	Checked
4	Update Desing Freeze	23/07/2021	FS	OM
3	Draft Planning Submission	09/07/2021	FS	OM
2	Building position update	08/02/2021	FS	OM
1	For Information	14/01/2021	FS	OM

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Job Title
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Drawing Title
Site Sections

Scale
As indicated @A1

SBR Project No.
18387

SBR Project No. | Originator | Volume | Level | Type | Role | Number
18387-SBR- ZZ-XX-DR-A-85001

Suitability Code | Status | Rev
S0 - WORK IN PROGRESS | **4**

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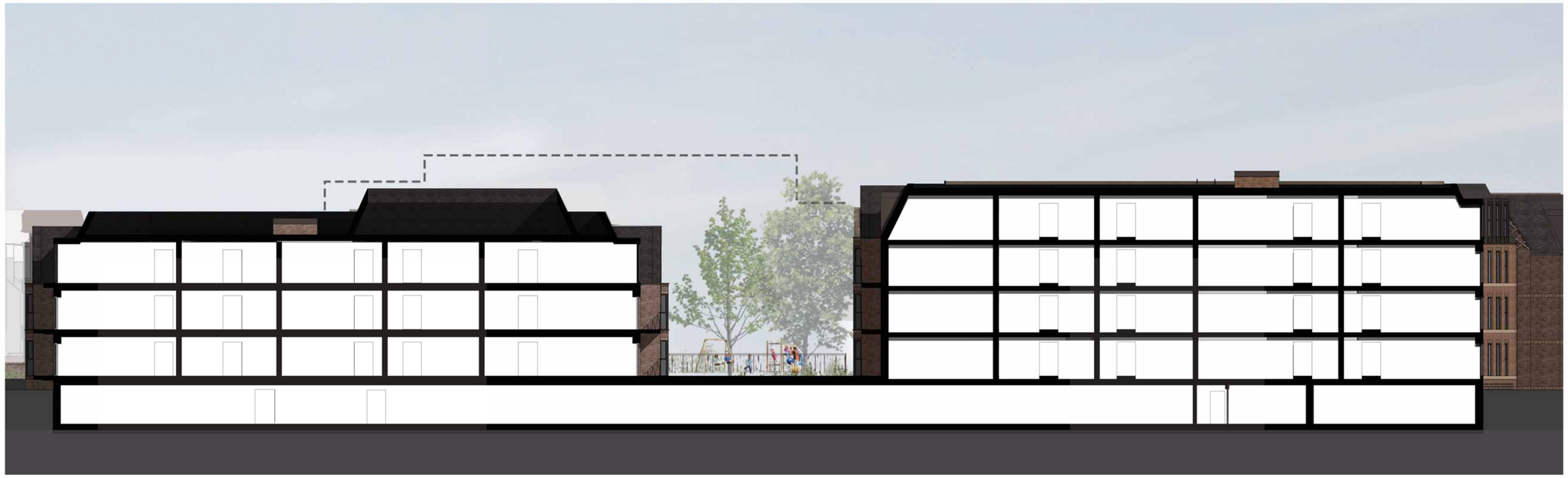

2 **Section B**
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DRAFT

Revision	Description	Date	Drawn	Checked
3	Update Desing Freeze	23/07/2021	FS	OM
2	Draft Planning Submission	09/07/2021	FS	OM
1	For Information	15/04/2021	FS	OM

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Star Land Realty UK Ltd.

Job Title
Barnes Hospital Site

Drawing Title
Site Sections

Scale
As indicated @A1

SBR Project No.
18387

SBR Project No. | Originator | Volume | Level | Type | Role | Number
18387-SBR- ZZ-XX-DR-A-85002

Suitability Code | Status | Rev
3

APPENDIX C
PREVIOUS SITE INVESTIGATION REPORTS

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Our Ref: 1920514-L01(00)

21st March 2019

LS Estates Limited
128 Cheapside,
London,
EC2V 6BT

For the attention of: Mr. M. Swetman

Dear Mark

RE: LAND AT BARNES HOSPITAL, SOUTH WORPLE WAY, LONDON, SW14 8SU

FURTHER GROUND GAS RISK ASSESSMENT

1. INTRODUCTION

The following letter presents an addendum to the ground investigation completed by RSK in March 2019 (Report No. 1920514-R01 00) and should be read in conjunction with this document.

Following the main fieldwork and subsequent single monitoring event, additional visits were undertaken within the dedicated 35mm diameter HDPE wells (designated WS1 to WS4).

An infrared gas meter was used to measure gas flow, concentrations of carbon dioxide (CO2), methane (CH4) and oxygen (O2) in percentage by volume, while hydrogen sulphide (H2S) and carbon monoxide (CO) were recorded in parts per million. Initial and steady state concentrations were recorded. In addition, during the first monitoring round, all wells were screened with a PID to establish if there are any interferences and cross-sensitivity of other hydrocarbons with the infrared gas meter.

This report is also subject to the service constraints given in the Appendix A of the previous report.

2. PROJECT BACKGROUND

A total of two investigations have been carried out with reference to the above site, namely:

- Ove Arup and Partners Limited (Arup): Phase 1 Ground Contamination Desk Study - Barnes Hospital, dated October 2018 (ref. 247776-00); and
- RSK Environment Ltd (RSK): Geo-environmental Site Assessment – Land At Barnes Hospital, South Worple Way, London, SW14 8SU, dated March 2019 (ref. 1920514-R01 00).

Information contained within the above reports pertinent to the gas assessment is referenced in the relevant subsections.

3. GROUND GAS CONCEPTUAL SITE MODEL (GGCSM)

3.1 ON-SITE SOURCES

A review of the site's historical land uses as part of previous phase of assessment has indicated the potential for contaminants to be present beneath the site. With particular reference to permanent ground gases, the initial conceptual site model (prepared by Arup) identified viable sources beneath the site, principally relating to made ground. To generate large volumes of methane and carbon dioxide, a large mass of readily degradable organic content is required. The gas generated will depend on the volume of degradable material that is present in the soil and the total volume. The soil profile recorded by RSK (ref.1920514-R01) confirmed a variable thickness of made ground (ranging between 0.50m and 2.3m bgl) overlying superficial deposits of the Kempton Park Gravel. Very little degradable material with low gas generating potential was observed within the made ground.

The presence of hydrocarbon contamination from historical fuel spills or leaks in locations such as the diesel tank (north-west) and suspected tank bases (north and north-west) may present a potential source. However, vapours are typically present due to volatilisation from contamination rather than biodegradation and therefore do not have a generation rate. Vapours volatilise very slowly but need careful consideration because adverse health effects occur at relatively low concentrations. Some volatile compounds can also migrate easily via groundwater due to relative high solubility. A qualitative assessment together with in-situ testing (i.e. screening of soil samples using photo-ionisation detector) was undertaken (as part of the assessment by RSK) to determine the potential risk from vapours, which was considered to be low. Furthermore, there was no visual evidence declared of gross hydrocarbon contamination during the course of the main fieldwork. It was recommended that further investigation is carried out in the vicinity of the former diesel tank and suspected tank bases so that the areas can be assessed in respect to possible 'hotspots'.

3.2 OFF-SITE SOURCES

Potential off-site sources of permanent ground gas include the following:

- Material deposited to the north within the former open cast quarry excavation; and
- Alluvium deposits, which are anticipated to the north of the site associated with the River Thames.

With regards to the off-site quarrying, available information suggest landfilling activities were undertaken to the north (c.440m) associated with Duke's Meadows and comprised the disposal of demolition waste, forming backfill to gravel extraction pits. The site is identified as being listed by the Environment Agency as an historic landfill. It is also considered that land raising may have occurred as part of the flood defences along the River Thames. There are two BGS borehole logs within the site boundary, one of which indicates no Made Ground present, with River Gravels logged from ground

level. The second indicates Made Ground from ground level to a depth of 4.9mbgl, which comprises predominantly brick and concrete rubble.

The available information and past land uses identified in and around the former landfill site and the anticipated ground conditions suggest a low potential for contamination based on the nature of the historic landfill/land raising activities.

Information obtained from the Duke's Meadows Trust website indicated that from the 1920s to the late 1930s, the land comprising Dukes Meadows was used by The Riverside Sand and Ballast Company. During this time, two million cubic yards of sand and gravel were reported to have been excavated from the area. The infill for the exhausted pits was brought from demolition sites. It is understood that filling was complete in the late 1930s and the topsoil which had been placed along side the railway line was returned for grassing.

Alluvium deposits are considered to have a very low gas generation potential and pose a very low risk to on-site development, with negligible risk of lateral migration.

Whilst, carbon dioxide can also be formed as decay products from the nearby cemetery, the risk of gas migrating beneath the site is considered to be low.

In conclusion, the potential off-site sources of permanent gas are not considered to be significant.

3.3 MIGRATION PATHWAYS

Gas primarily migrates via either pressure driven (advective) flow or via diffusive flow. In general, the predominant mechanism for migration of gases such as that encountered on this site is diffusive, with no driving pressure. This is supported by the negligible flow rates recorded during gas monitoring. As such, gas generated within the material identified across the site will diffuse through the soils forming a continuum between the source and ground level, with only minor concentrations of gas reaching ground level, and no perceivable flow.

Many ground gases are soluble in groundwater and can migrate within flowing groundwater. The solubility of all gases in water increases with increasing pressure and decreases with increasing temperature. It is possible for this mechanism to generate high concentrations in soil gas above the water table (partitioning is reversible, so equilibrium soil gas concentration is the same as partial pressure in the source), but mass transport rates are likely to be low. This mechanism may become more significant when considering geological sources at great depth and high pressure, because gases are much more soluble under these conditions.

Ground gases become most hazardous when they intrude into buildings and structures, such as utility access pits/inspection chambers, where they can accumulate at explosive or toxic concentrations, or form an asphyxiating atmosphere. Ground gas intrusion pathways into buildings are highly dependent upon building design and condition. For slab-on-ground construction, cracks, service penetrations and poorly filled construction joints provide the most likely pathways. Cavity wall vents may also allow ingress, particularly where convective currents occur due to a stack effect. Preferential pathways

formed by service ducts and trenches and drains are frequently present. Whilst diffusion is considered the primary mechanism for ground gas intrusion to buildings, pressure-driven flow may occur due to stack effects and wind-driven pressure gradients.

3.4 POTENTIAL RECEPTORS

The development proposals outlined for the site will inherently introduce receptors to the site. Receptors introduced to the site will typically comprise future residents. Detailed proposed layout has not been provided at the time of writing this report.

4. SUMMARY OF GROUND GAS DATASET

A total of three return visits were carried out (between 12th and 19th March) to undertake spot monitoring and take flow measurements. The monitoring data is presented in Appendix A and summarised below.

Table 1 Summary of gas monitoring results

Exp point	Monitoring days/ rounds	Range steady CO_2 (% vol/vol)	Range CH_4 (% vol/vol)	Range O_2 (% vol/vol)	Flow (l/hr)	Atmospheric pressure (mb)	Groundwater (m bgl)
WS1	3	0.1-4.3	<0.1	17.9-21.1	0.0-0.1	1006-1027	Dry
WS2	3	0.5-1.4	<0.1	20.0-21.2	0.0-0.2	1006-1027	Dry
WS3	3	<0.1-1.9	<0.1	19.8-21.0	0.0-0.2	1006-1027	Dry
WS4	3	<0.1-0.7	<0.1	20.0-21.0	0.0-0.2	1006-1027	Dry

5. ASSESSMENT OF DATA

The results have been assessed in accordance with the guidance provided in BS8485:2015+A1:2019 and CIRIA Report C665. In the assessment of risks and selection of appropriate mitigation measures, both reports highlight the importance of the conceptual site model. CIRIA C665 identifies two types of development, termed Situation A (modified Wilson and Card method), appropriate to all development excluding traditional low-rise construction, and Situation B (National House-Building Council, NHBC) only appropriate to traditional low-rise construction with ventilated sub-floor voids.

Both methods are based on calculations of the limiting borehole gas volume flow for methane and carbon dioxide, renamed as the gas screening value (GSV). The GSV (litres of gas per hour) is calculated by multiplying borehole flow rate (litres per hour) and gas concentration (percent by volume).

In both situations, it is important to note that the GSV thresholds are guideline values and not absolute. The GSV thresholds may be exceeded in certain circumstances, if the conceptual site model indicates it is safe to do so. Similarly, consideration of additional factors such as very high concentrations of methane, should lead to consideration of the need to adopt a higher risk classification than the GSV threshold indicates. Since the proposed development will comprise both apartment blocks, Situation A has been adopted for the flats.

As the data set is temporally/spatially limited, peak data was combined from more than one monitoring standpipe location, for each gas source. The gas monitoring data recorded to date has identified negligible concentrations of methane and a maximum concentration of carbon dioxide of 4.3%. A maximum gas flow rate of 0.2l/hr has been recorded. On this basis, the calculated GSV for methane is <0.0002 l/hr and the GSV for carbon dioxide is 0.0086l/hr.

Based on the GSVs, the site has been characterised as Situation CS1, indicating that a negligible gas regime has been identified and that gas protection measures are not considered necessary.

No construction details have been provided, however we have assumed reinforced concrete floor slabs will be adopted. BS8485:2015 indicates that a reinforced ground bearing slab with minimum surface penetrations as would afford some protection against the ingress of ground gas.

6. CONCLUSIONS

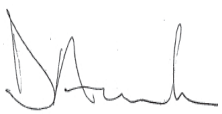
Based on the findings of this investigation, there is no significant source of ground gas below the site. The risk posed to the development and its occupiers by the presence of small volumes of gas is negligible. This is demonstrated by multiple lines of evidence:

1. The desk study has not identified any high risk sources of ground gas below or near the site.
2. There is no evidence of large volumes of degradable material contamination below the site.
3. The gas monitoring data shows very smalls volumes of gas.

It should be noted that the investigation was limited and therefore a detailed assessment is recommended to fully characterise the ground conditions in sufficient detail and increase the confidence in the preliminary assessment.

Yours sincerely
for **RSK Environment Limited - Geosciences**

Ziaul Hoque
Principal Geo-environmental Engineer



Dave Anchor
Director

Encl. Appendix A – Ground Gas Monitoring Data

APPENDIX A

IN-SITU GAS MONITORING RESULTS

	Start Date	End Date	[Pressures]	Previous	During	Start	End	Equipment Used & Remarks
Round 1	12/03/2019	12/03/2019		Constant	Constant	-	-	
Round 2	15/03/2019	15/03/2019		Constant	Constant	-	-	
Round 3	19/03/2019	19/03/2019		Constant	Constant	-	-	

Exploratory Position ID	Monitoring Round	Measured Installation Depth (mbgl)	Date & Time of Monitoring (elapsed time)	Borehole Pressure (mb)	Atmos Pressure (mb)	Gas Flow (l/hr)	Water Depth (mbgl)	Carbon Dioxide (% / vol)	Methane (% / vol)	Oxygen (% / vol)	LEL (%)	PID (ppm)	Carbon Monoxide (ppm)	Hydrogen Sulphide (ppm)	
WS1	1	---	12/03/2019	-	1008	$0.0_{(I)}$	DRY	0.1	0.0	21.1	0.0	0.0	0	0	
WS1	1	---	15 secs	-	1008	$0.0_{(SS)}$	DRY	0.1	0.0	21.0	0.0	0.0	0	0	
WS1	1	---	30 secs	-	1008	$0.0_{(SS)}$	DRY	0.2	0.0	19.9	0.0	0.0	0	0	
WS1	1	---	45 secs	-	1008	$0.0_{(SS)}$	DRY	0.2	0.0	19.9	0.0	0.0	0	0	
WS1	1	---	60 secs	-	1008	$0.0_{(SS)}$	DRY	0.1	0.0	20.0	0.0	0.0	0	0	
WS1	1	---	90 secs	-	1008	$0.0_{(SS)}$	DRY	0.1	0.0	20.0	0.0	0.0	0	0	
WS1	1	---	120 secs	-	1008	$0.0_{(SS)}$	DRY	0.1	0.0	20.0	0.0	0.0	0	0	
WS1	1	---	150 secs	-	1008	$0.0_{(SS)}$	DRY	0.1	0.0	20.0	0.0	0.0	0	0	
WS1	1	---	180 secs	-	1008	$0.0_{(SS)}$	DRY	0.1	0.0	20.0	0.0	0.0	0	0	
WS1	2 (2)	---	15/03/2019	-	1006	$0.0_{(I)}$	DRY	0.1	0.0	20.9	0.0	0.0	0	0	
WS1	2 (2)	---	15 secs	-	1006	$0.1_{(SS)}$	DRY	2.7	0.0	20.3	0.0	0.0	0	0	
WS1	2 (2)	---	30 secs	-	1006	$0.1_{(SS)}$	DRY	2.8	0.0	19.0	0.0	0.0	0	0	
WS1	2 (2)	---	45 secs	-	1006	$0.1_{(SS)}$	DRY	2.9	0.0	18.8	0.0	0.0	0	0	
WS1	2 (2)	---	60 secs	-	1006	$0.1_{(SS)}$	DRY	3.0	0.0	18.8	0.0	0.0	0	0	
WS1	2 (2)	---	90 secs	-	1006	$0.1_{(SS)}$	DRY	3.1	0.0	18.7	0.0	0.0	0	0	
WS1	2 (2)	---	120 secs	-	1006	$0.1_{(SS)}$	DRY	3.2	0.0	18.6	0.0	0.0	0	0	
WS1	2 (2)	---	150 secs	-	1006	$0.1_{(SS)}$	DRY	3.2	0.0	18.6	0.0	0.0	0	0	
WS1	2 (2)	---	180 secs	-	1006	$0.1_{(SS)}$	DRY	3.3	0.0	18.6	0.0	0.0	0	0	

Key: I = Initial, P = Peak, SS = Steady State. Note: LEL = Lower Explosive Limit = 5% v/v.

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Compiled By	Date	Checked By	Date	Contract Ref:
	20/03/19			**1920514**

Contract: **Barnes Hospital**

IN-SITU GAS MONITORING RESULTS

Exploratory Position ID	Monitoring Round	Installation Depth (mbgl)	Date & Time of Monitoring (elapsed time)	Borehole Pressure (mb)	Atmos Pressure (mb)	Gas Flow (l/hr)	Water Depth (mbgl)	Carbon Dioxide (% / vol)	Methane (% / vol)	Oxygen (% / vol)	LEL (%)	PID (ppm)	Carbon Monoxide (ppm)	Hydrogen Sulphide (ppm)	
WS1	3 (3)	---	19/03/2019	-	1027	$0.1_{(I)}$	DRY	0.1	0.0	20.9	0.0	0.0	0	0	
WS1	3 (3)	---	15 secs	-	1027	$0.1_{(SS)}$	DRY	2.5	0.0	19.7	0.0	0.0	0	0	
WS1	3 (3)	---	30 secs	-	1027	$0.1_{(SS)}$	DRY	2.8	0.0	19.2	0.0	0.0	0	0	
WS1	3 (3)	---	45 secs	-	1027	$0.1_{(SS)}$	DRY	3.0	0.0	18.9	0.0	0.0	0	0	
WS1	3 (3)	---	60 secs	-	1027	$0.1_{(SS)}$	DRY	3.1	0.0	18.7	0.0	0.0	0	0	
WS1	3 (3)	---	90 secs	-	1027	$0.1_{(SS)}$	DRY	3.3	0.0	18.5	0.0	0.0	0	0	
WS1	3 (3)	---	120 secs	-	1027	$0.1_{(SS)}$	DRY	3.5	0.0	18.5	0.0	0.0	0	0	
WS1	3 (3)	---	150 secs	-	1027	$0.1_{(SS)}$	DRY	4.0	0.0	18.0	0.0	0.0	0	0	
WS1	3 (3)	---	180 secs	-	1027	$0.1_{(SS)}$	DRY	4.2	0.0	17.9	0.0	0.0	0	0	
WS1	3 (3)	---	210 secs	-	1027	$0.1_{(SS)}$	DRY	4.3	0.0	17.9	0.0	0.0	0	0	
WS1	3 (3)	---	240 secs	-	1027	$0.1_{(SS)}$	DRY	4.3	0.0	17.9	0.0	0.0	0	0	
WS1	3 (3)	---	270 secs	-	1027	$0.1_{(SS)}$	DRY	4.3	0.0	17.9	0.0	0.0	0	0	
WS2	1	---	12/03/2019	-	1008	$0.2_{(I)}$	DRY	0.2	0.0	21.2	0.0	0.0	0	0	
WS2	1	---	15 secs	-	1008	$0.1_{(SS)}$	DRY	0.9	0.0	21.0	0.0	0.0	0	0	
WS2	1	---	30 secs	-	1008	$0.0_{(SS)}$	DRY	1.2	0.0	20.7	0.0	0.0	0	0	
WS2	1	---	45 secs	-	1008	$0.0_{(SS)}$	DRY	1.2	0.0	20.5	0.0	0.0	0	0	
WS2	1	---	60 secs	-	1008	$0.0_{(SS)}$	DRY	1.1	0.0	20.5	0.0	0.0	0	0	
WS2	1	---	90 secs	-	1008	$0.0_{(SS)}$	DRY	1.4	0.0	20.5	0.0	0.0	0	0	
WS2	1	---	120 secs	-	1008	$0.0_{(SS)}$	DRY	1.4	0.0	20.4	0.0	0.0	0	0	
WS2	1	---	150 secs	-	1008	$0.0_{(SS)}$	DRY	1.4	0.0	20.4	0.0	0.0	0	0	
WS2	1	---	180 secs	-	1008	$0.0_{(SS)}$	DRY	1.4	0.0	20.4	0.0	0.0	0	0	
WS2	2 (2)	---	15/03/2019	-	1006	$0.0_{(I)}$	DRY	0.1	0.0	20.9	0.0	0.0	0	0	
WS2	2 (2)	---	15 secs	-	1006	$0.0_{(SS)}$	DRY	1.0	0.0	20.6	0.0	0.0	0	0	
WS2	2 (2)	---	30 secs	-	1006	$0.0_{(SS)}$	DRY	1.0	0.0	20.3	0.0	0.0	0	0	

Key: I = Initial, P = Peak, SS = Steady State. Note: LEL = Lower Explosive Limit = 5% v/v.

IN-SITU GAS MONITORING RESULTS

Exploratory Position ID	Monitoring Round	Installation Depth (mbgl)	Date & Time of Monitoring (elapsed time)	Borehole Pressure (mb)	Atmos Pressure (mb)	Gas Flow (l/hr)	Water Depth (mbgl)	Carbon Dioxide (% / vol)	Methane (% / vol)	Oxygen (% / vol)	LEL (%)	PID (ppm)	Carbon Monoxide (ppm)	Hydrogen Sulphide (ppm)	
WS2	2 (2)	---	45 secs	-	1006	$0.0_{(SS)}$	DRY	0.9	0.0	20.3	0.0	0.0	0	0	
WS2	2 (2)	---	60 secs	-	1006	$0.0_{(SS)}$	DRY	0.8	0.0	20.3	0.0	0.0	0	0	
WS2	2 (2)	---	90 secs	-	1006	$0.0_{(SS)}$	DRY	0.9	0.0	20.5	0.0	0.0	0	0	
WS2	2 (2)	---	120 secs	-	1006	$0.0_{(SS)}$	DRY	1.3	0.0	20.6	0.0	0.0	0	0	
WS2	2 (2)	---	150 secs	-	1006	$0.0_{(SS)}$	DRY	1.1	0.0	20.2	0.0	0.0	0	0	
WS2	2 (2)	---	180 secs	-	1006	$0.0_{(SS)}$	DRY	0.5	0.0	20.4	0.0	0.0	0	0	
WS2	3 (3)	---	19/03/2019	-	1027	$0.0_{(I)}$	DRY	0.1	0.0	20.9	0.0	0.0	0	0	
WS2	3 (3)	---	15 secs	-	1027	$0.0_{(SS)}$	DRY	0.3	0.0	20.5	0.0	0.0	0	0	
WS2	3 (3)	---	30 secs	-	1027	$0.0_{(SS)}$	DRY	0.5	0.0	20.1	0.0	0.0	0	0	
WS2	3 (3)	---	45 secs	-	1027	$0.0_{(SS)}$	DRY	0.5	0.0	20.0	0.0	0.0	0	0	
WS2	3 (3)	---	60 secs	-	1027	$0.0_{(SS)}$	DRY	0.5	0.0	20.0	0.0	0.0	0	0	
WS2	3 (3)	---	90 secs	-	1027	$0.0_{(SS)}$	DRY	0.5	0.0	20.0	0.0	0.0	0	0	
WS2	3 (3)	---	120 secs	-	1027	$0.0_{(SS)}$	DRY	0.5	0.0	20.0	0.0	0.0	0	0	
WS2	3 (3)	---	150 secs	-	1027	$0.0_{(SS)}$	DRY	0.5	0.0	20.0	0.0	0.0	0	0	
WS2	3 (3)	---	180 secs	-	1027	$0.0_{(SS)}$	DRY	0.5	0.0	20.0	0.0	0.0	0	0	
WS3	1	---	12/03/2019	-	1008	$0.2_{(I)}$	DRY	0.1	0.0	21.0	0.0	0.0	0	0	
WS3	1	---	15 secs	-	1008	$0.1_{(SS)}$	DRY	0.5	0.0	20.5	0.0	0.0	0	0	
WS3	1	---	30 secs	-	1008	$0.1_{(SS)}$	DRY	1.1	0.0	19.9	0.0	0.0	0	0	
WS3	1	---	45 secs	-	1008	$0.1_{(SS)}$	DRY	1.9	0.0	19.8	0.0	0.0	0	0	
WS3	1	---	60 secs	-	1008	$0.1_{(SS)}$	DRY	1.9	0.0	19.8	0.0	0.0	0	0	
WS3	1	---	90 secs	-	1008	$0.1_{(SS)}$	DRY	1.9	0.0	19.8	0.0	0.0	0	0	
WS3	1	---	120 secs	-	1008	$0.1_{(SS)}$	DRY	1.8	0.0	19.8	0.0	0.0	0	0	
WS3	1	---	150 secs	-	1008	$0.1_{(SS)}$	DRY	1.9	0.0	19.8	0.0	0.0	0	0	
WS3	1	---	180 secs	-	1008	$0.1_{(SS)}$	DRY	1.9	0.0	19.8	0.0	0.0	0	0	

Key: I = Initial, P = Peak, SS = Steady State. Note: LEL = Lower Explosive Limit = 5% v/v.

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Contract: **Barnes Hospital**

IN-SITU GAS MONITORING RESULTS

Exploratory Position ID	Monitoring Round	Installation Depth (mbgl)	Date & Time of Monitoring (elapsed time)	Borehole Pressure (mb)	Atmos Pressure (mb)	Gas Flow (l/hr)	Water Depth (mbgl)	Carbon Dioxide (% / vol)	Methane (% / vol)	Oxygen (% / vol)	LEL (%)	PID (ppm)	Carbon Monoxide (ppm)	Hydrogen Sulphide (ppm)	
WS3	2 (2)	---	15/03/2019	-	1006	$0.1_{(I)}$	DRY	0.1	0.0	20.9	0.0	0.0	0	0	
WS3	2 (2)	---	15 secs	-	1006	$0.2_{(SS)}$	DRY	0.0	0.0	20.8	0.0	0.0	0	0	
WS3	2 (2)	---	30 secs	-	1006	$0.2_{(SS)}$	DRY	0.0	0.0	20.6	0.0	0.0	0	0	
WS3	2 (2)	---	45 secs	-	1006	$0.2_{(SS)}$	DRY	0.0	0.0	20.6	0.0	0.0	0	0	
WS3	2 (2)	---	60 secs	-	1006	$0.2_{(SS)}$	DRY	0.0	0.0	20.6	0.0	0.0	0	0	
WS3	2 (2)	---	90 secs	-	1006	$0.2_{(SS)}$	DRY	0.0	0.0	20.6	0.0	0.0	0	0	
WS3	2 (2)	---	120 secs	-	1006	$0.2_{(SS)}$	DRY	0.0	0.0	20.6	0.0	0.0	0	0	
WS3	2 (2)	---	150 secs	-	1006	$0.2_{(SS)}$	DRY	0.0	0.0	20.7	0.0	0.0	0	0	
WS3	2 (2)	---	180 secs	-	1006	$0.2_{(SS)}$	DRY	0.1	0.0	20.8	0.0	0.0	0	0	
WS3	3 (3)	---	19/03/2019	-	1027	$0.1_{(I)}$	DRY	0.1	0.0	20.9	0.0	0.0	0	0	
WS3	3 (3)	---	15 secs	-	1027	$0.1_{(SS)}$	DRY	0.1	0.0	20.7	0.0	0.0	0	0	
WS3	3 (3)	---	30 secs	-	1027	$0.1_{(SS)}$	DRY	0.1	0.0	20.5	0.0	0.0	0	0	
WS3	3 (3)	---	45 secs	-	1027	$0.1_{(SS)}$	DRY	0.1	0.0	20.5	0.0	0.0	0	0	
WS3	3 (3)	---	60 secs	-	1027	$0.1_{(SS)}$	DRY	0.1	0.0	20.5	0.0	0.0	0	0	
WS3	3 (3)	---	90 secs	-	1027	$0.1_{(SS)}$	DRY	0.1	0.0	20.5	0.0	0.0	0	0	
WS3	3 (3)	---	120 secs	-	1027	$0.1_{(SS)}$	DRY	0.1	0.0	20.5	0.0	0.0	0	0	
WS3	3 (3)	---	150 secs	-	1027	$0.1_{(SS)}$	DRY	0.1	0.0	20.5	0.0	0.0	0	0	
WS3	3 (3)	---	180 secs	-	1027	$0.1_{(SS)}$	DRY	0.1	0.0	20.5	0.0	0.0	0	0	
WS4	1	---	12/03/2019	-	1008	$0.1_{(I)}$	DRY	0.0	0.0	21.0	0.0	0.0	0	0	
WS4	1	---	15 secs	-	1008	$0.0_{(SS)}$	DRY	0.5	0.0	20.8	0.0	0.0	0	0	
WS4	1	---	30 secs	-	1008	$0.0_{(SS)}$	DRY	0.7	0.0	20.7	0.0	0.0	0	0	
WS4	1	---	45 secs	-	1008	$0.0_{(SS)}$	DRY	0.8	0.0	20.5	0.0	0.0	0	0	
WS4	1	---	60 secs	-	1008	$0.0_{(SS)}$	DRY	0.6	0.0	20.5	0.0	0.0	0	0	
WS4	1	---	90 secs	-	1008	$0.0_{(SS)}$	DRY	0.6	0.0	20.1	0.0	0.0	0	0	

Key: I = Initial, P = Peak, SS = Steady State. Note: LEL = Lower Explosive Limit = 5% v/v.

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Compiled By	Date	Checked By	Date	Contract Ref:
	20/03/19			**1920514**

Contract: **Barnes Hospital**

IN-SITU GAS MONITORING RESULTS

Exploratory Position ID	Monitoring Round	Installation Depth (mbgl)	Date & Time of Monitoring (elapsed time)	Borehole Pressure (mb)	Atmos Pressure (mb)	Gas Flow (l/hr)	Water Depth (mbgl)	Carbon Dioxide (% / vol)	Methane (% / vol)	Oxygen (% / vol)	LEL (%)	PID (ppm)	Carbon Monoxide (ppm)	Hydrogen Sulphide (ppm)	
WS4	1	---	120 secs	-	1008	$0.0_{(SS)}$	DRY	0.6	0.0	20.1	0.0	0.0	0	0	
WS4	1	---	150 secs	-	1008	$0.0_{(SS)}$	DRY	0.6	0.0	20.0	0.0	0.0	0	0	
WS4	1	---	180 secs	-	1008	$0.0_{(SS)}$	DRY	0.6	0.0	20.1	0.0	0.0	0	0	
WS4	2 (2)	---	15/03/2019	-	1006	$0.1_{(I)}$	DRY	0.1	0.0	20.9	0.0	0.0	0	0	
WS4	2 (2)	---	15 secs	-	1006	$0.2_{(SS)}$	DRY	0.0	0.0	20.8	0.0	0.0	0	0	
WS4	2 (2)	---	30 secs	-	1006	$0.2_{(SS)}$	DRY	0.0	0.0	20.6	0.0	0.0	0	0	
WS4	2 (2)	---	45 secs	-	1006	$0.2_{(SS)}$	DRY	0.0	0.0	20.6	0.0	0.0	0	0	
WS4	2 (2)	---	60 secs	-	1006	$0.2_{(SS)}$	DRY	0.0	0.0	20.6	0.0	0.0	0	0	
WS4	2 (2)	---	90 secs	-	1006	$0.2_{(SS)}$	DRY	0.0	0.0	20.6	0.0	0.0	0	0	
WS4	2 (2)	---	120 secs	-	1006	$0.2_{(SS)}$	DRY	0.0	0.0	20.6	0.0	0.0	0	0	
WS4	2 (2)	---	150 secs	-	1006	$0.2_{(SS)}$	DRY	0.1	0.0	20.7	0.0	0.0	0	0	
WS4	2 (2)	---	180 secs	-	1006	$0.2_{(SS)}$	DRY	0.1	0.0	20.6	0.0	0.0	0	0	
WS4	3 (3)	---	19/03/2019	-	1027	$0.0_{(I)}$	DRY	0.1	0.0	20.9	0.0	0.0	0	0	
WS4	3 (3)	---	15 secs	-	1027	$0.0_{(SS)}$	DRY	0.5	0.0	20.7	0.0	0.0	0	0	
WS4	3 (3)	---	30 secs	-	1027	$0.0_{(SS)}$	DRY	0.5	0.0	20.6	0.0	0.0	0	0	
WS4	3 (3)	---	45 secs	-	1027	$0.0_{(SS)}$	DRY	0.6	0.0	20.5	0.0	0.0	0	0	
WS4	3 (3)	---	60 secs	-	1027	$0.0_{(SS)}$	DRY	0.7	0.0	20.5	0.0	0.0	0	0	
WS4	3 (3)	---	90 secs	-	1027	$0.0_{(SS)}$	DRY	0.7	0.0	20.5	0.0	0.0	0	0	
WS4	3 (3)	---	120 secs	-	1027	$0.0_{(SS)}$	DRY	0.7	0.0	20.5	0.0	0.0	0	0	
WS4	3 (3)	---	150 secs	-	1027	$0.0_{(SS)}$	DRY	0.7	0.0	20.5	0.0	0.0	0	0	
WS4	3 (3)	---	180 secs	-	1027	$0.0_{(SS)}$	DRY	0.7	0.0	20.5	0.0	0.0	0	0	

Key: I = Initial, P = Peak, SS = Steady State. Note: LEL = Lower Explosive Limit = 5% v/v.

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Compiled By	Date	Checked By	Date	Contract Ref:
	20/03/19			**1920514**

Contract: **Barnes Hospital**

LS Estates Limited

Land at Barnes Hospital, South Worple Way, East Sheen, London, SW14 8SU

Geo-environmental Site Assessment

1920514-R01(00)

MARCH 2019

RSK GENERAL NOTES

Project No.: 1920514-R01(00)

Title: Geo-environmental Site Assessment: Land at Barnes Hospital, South Worple Way, East Sheen, London, SW14 8SU

Client: LS Estates Limited

Date: 13th March 2019

Office: RSK Environment Limited, 18 Frogmore Road, Hemel Hempstead, HP3 9RQ
Contact: Ziaul Hoque, Tel: 01442 416682.

Status: Rev 00

Author	Ziaul Hoque	**Technical reviewer**	Dave Anchor
Signature		Signature	
Date:	13th March 2019	Date:	13th March 2019
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Signature		Signature	
Date:	13th March 2019	Date:	13th March 2019

Revision control sheet

Revision reference	Date	Reason for revision
Rev 00	13th March 2019	First issue

Where field investigations have been carried out, these have been restricted to a level of detail required to achieve the stated objectives of the work.

This work has been undertaken in accordance with the quality management system of RSK Environment Ltd.

CONTENTS

FIGURES

APPENDICES

1 INTRODUCTION

1.1 Commissioning

On the instruction of the Richard Bird Group, acting on behalf of LS Estates Limited (''the Client''), RSK Environment Limited (RSK) has undertaken a geo-environmental site assessment of the land at Barnes Hospital, off South Worple Way, in East Sheen, hereafter referred to as 'the Site'.

The project was commissioned to obtain and collate information on the ground conditions with respect to its contamination status.

This report is subject to the RSK service constraints given in **Appendix A** and limitations that may be described through this document.

1.2 Project background

The site has been the subject of a previous desktop study carried out by Ove Arup and Partners Limited (Arup) in October 2018 (ref. 247776-00) and made available for review. The report provided a preliminary risk assessment aimed at identifying the potential geo-environmental liabilities associated with the site.

Salient information from the above report is summarised in the relevant section (**Section 3**).

1.3 Proposed development

The precise development plans are yet unknown, however it is understood that it is likely to be of a residential nature.

1.4 Scope of works

The project was carried out to an agreed brief as set out in RSK's proposal (ref. 1920514-T01(00), dated February 2019). The scope of works for the assessment included:

- Drilling of four shallow boreholes using drive-in sampler techniques to a maximum depth of 3.0m bgl;
- Associated sampling and on-site testing including the use of a photo ionisation detector for the purpose of screening for the presence of volatile organic compounds (VOC);
- A programme of environmental laboratory testing;
- Ground gas and groundwater monitoring across a period of two to three weeks;
- Development of a refined conceptual site model followed by generic quantitative risk assessment (GQRA) to assess complete pollutant linkages that may require the implementation of mitigation measures to facilitate redevelopment; and
- Identification of outline mitigation measures for complete pollutant linkages or recommendations for further work.

1.5 Limitations

The comments given in this report and the opinions expressed are based on the ground conditions encountered during the site work and on the results of tests made in the field and in the laboratory. However, there may be conditions pertaining to the site that have not been disclosed by the investigation and therefore could not be taken into account. In particular, it should be noted that there may be areas of made ground not detected due to the limited nature of the investigation or the thickness and quality of made ground across the site may be variable. In addition, groundwater levels and ground gas concentrations and flows may vary from those reported due to seasonal, or other, effects and the limitations stated in the data should be recognised.

2 SITE DETAILS

2.1 Site location and surrounding area

The Site, which is located at National Grid Reference 521212^{E}, 175677^{N}, is situated south of the River Thames in a residential area between Richmond Park and Barnes Common.

The Site is located to the west of Mortlake, to the south of the Richmond line on South Worple Way. It lies adjacent to Old Mortlake Burial Ground, which forms its western boundary. A number of hospital buildings occupy the immediate area to the east with South Worple Avenue beyond, and to the south the site is bounded by the gardens to the rear of residential properties along Grosvenor Avenue.

An extract of the 1:50,000 Ordnance Survey map showing the location of the site is included in **Figure 1**.

2.2 Site description

The Site, measuring an approximate area of 0.8Ha, is set within the Barnes Hospital grounds and accommodates a number of redundant buildings, which historically provided mental health facilities. The remainder of the Site is occupied by hardstanding providing car parking and associated soft landscaping.

A site layout plan is presented as **Figure 2**.

3 SUMMARY OF PRECEDING REPORT

3.1 General

As outlined in **Section 1**, the site has been subject to a previous assessment as part of wider desk-based assessment encompassing the parcel of land to the east of the site.

In October 2018, Ove Arup and Partners Limited were commissioned by South West London and St George's Mental Health NHS Trust to assess the ground conditions in relation to the client's proposal to redevelop the hospital grounds for a mixed-use development. The information presented below in Section 3 is taken from the desk-based report (Ref. 247776-00 Issue 4).

3.1.1 Historical site setting and surrounding area

The earliest historical map edition identified the site to comprise a section of a larger field dissected by a footpath. In the late 1800s, Barnes Hospital was initially developed in the western half of its current boundaries, bordering onto the eastern boundary of Old Mortlake Burial Ground. The hospital is shown on the OS map of 1896 as consisting of a fever or isolation hospital with three buildings to the north of the main building and a mortuary in the northeast corner.

By the early 1900s, the hospital increased in size, extending across the entire site footprint. Ancillary buildings and footpaths were constructed to the eastern extension of Barnes Hospital including a Lodge facing onto South Worple Way and another Mortuary in the northeast corner of the Site. More facilities were added by 1935 and the Mortuary moved to one smaller building to the east of the entrance Lodge. In the 1940s, the hospital joined the new National Health Service and became known by its recent name of Barnes Hospital in 1949-50.

No significant changes were observed in the subsequent years until the 1990s, by which time a number of buildings had been demolished and an electricity substation constructed along the site's southern boundary.

In the late 1700s, the surrounding area was largely occupied by open fields. The footpath passing diagonally through the site from Priests Bridge remains today to the southeast of the hospital site. Residential development to the northeast and southwest of the site had occurred in the late 1800s with the addition of the railway constructed to the immediate north. Mortlake Cemetery was established in the 1850s extending to the west to its current western limit at Lodge Avenue in the 1890s.

By the early 1930s, a garage is noted to the southeast of site c.20m and an omnibus depot is shown c.120m to the northwest.

Little or no significant changes were observed until the 1990s, by which time the Omnibus Depot was relabelled as the 'Bus Station'.

3.1.2 Geological, hydro-geological and hydrological setting

The published geological record (1:50,000 geological map sheet 256, North London) indicates that the site is underlain by superficial deposits of the Kempton Park Gravel (River Terrace Deposits) overlying the London Clay formation.

The Environment Agency designates the River Terrace Deposits as a Secondary A aquifer. The London Clay is considered unproductive.

The report has identified records for two groundwater abstractions within 1km of the site. The closest abstraction is listed as historical, 660m north of the site for use in spray irrigation at Dukes Meadows. The other abstraction listed is active, 860m northwest and also for spray irrigation at Dukes Meadows Golf Club. The site is not situated within a Source Protection Zone (SPZ) for potable water supply.

The nearest surface water feature is Beverley Brook, c.230m southeast of the site. The River Thames is approximately 340m north of the site, and there is also an enclosed culvert linking Beverley Brook to the River Thames running along White Hart Lane around 100m east of the site. There are no EA recorded pollution incidents to Controlled Waters within 500m of the site.

3.1.3 Arup's Preliminary Conceptual Site Model (CSM)

Based on the desk study, the findings identified the possibility that some shallow made ground may exist on site associated with the historic and current development of the site. In addition, the site has been used for hospital activities for more than 50 years and some releases of contamination may have occurred during that time. The most significant potential sources of on-site contamination are associated with the former/current site operations (i.e. storage fuel oils, spills/leaks associated with the electricity sub-station, laundry, plant rooms and handling of medical waste). However, the study has identified no direct evidence of ground contamination on the site, which in its current form of development, is very unlikely to be acting as a source of potentially on-going contamination.

A number of potential off-site sources of contamination have been identified (including a garage, railway track and bus station). However, none are considered to pose a direct risk to the site.

4 UNEXPLODED ORDNANCE

This assessment was undertaken to assess the likely potential of encountering unexploded ordnance (UXO) in general accordance with CIRIA C681. The assessment involves the consideration of the basic factors that affect the potential for UXO to be present at a site as outlined in Stage One of the UXO risk management process.

During WWII, the wider surrounding area sustained high density bomb damage. Mapping of the area indicates several incidents of bombing across the site area, including both HE and incendiary bombing on numerous occasions during the war.

It is recommended a detailed assessment is undertaken to enable an estimate to be made of the likelihood of creating a UXO hazard on site, giving due consideration to the proposed development type and construction methods to be employed.

A copy of the risk assessment report is presented in **Appendix B**.

5 SITE INVESTIGATION STRATEGY & METHODOLOGY

5.1 Introduction

RSK carried out an intrusive investigation 07th March 2019 and subsequent ground gas monitoring to further characterise the ground conditions as per the scope determined by Robert Bird Group (RBG).

5.2 Selection of investigation methods

The techniques adopted for the investigation have been chosen considering the anticipated ground conditions and the existing land use.

5.2.1 Health, safety and environment considerations

The site work was undertaken in line with RSK's Safety, Health, Environmental and Quality Management System (SHEQMS), which is accredited to ISO9001: 2008 (Quality Management System standard) and ISO14001:2004 (Environmental Management System standard).

A site-specific health and safety plan was completed in advance of the intrusive works and all available buried utilities plans were consulted. Copies of statutory service records obtained by RSK are contained in **Appendix C**.

All locations were scanned with a cable avoidance tool (CAT) and Ground Penetrating Radar (GPR) techniques. Furthermore, risk mitigation measures (in the form of a magnetometer survey) were adopted with respect to the potential UXO risk.

As an extra precautionary measure, inspection pits were excavated by hand to 1.2m depth at all borehole locations prior to the commencement of drilling.

5.3 Investigation strategy

The site work comprised the activities summarised in **Table 1** along with a justification for each exploratory location.

The investigation and the soil descriptions were carried out in general accordance with 'BS 5930:2015 Code of Practice for Ground Investigations'. The exploratory hole records and other site work records are presented in **Appendix D**. Whilst every attempt was made to record full details of the strata encountered in the boreholes, techniques of hole formation and sampling will inevitably lead to disturbance, mixing or loss of material in some soils and rocks.

Table 1 Exploratory hole and monitoring well location rationale

Investigation Type	Exploratory hole number	Rationale
Shallow drive-in sampler boreholes.	WS1 to WS4	To prove the geological succession and obtain data for the purpose of contamination assessment in the vicinity of diesel tank, suspected tank base and plant rooms.
		To enable installation of monitoring wells.
Monitoring wells	WS1 to WS4 (3No. Return Visits)	Measurement of ground gas emission rates and groundwater depths.

5.3.1 Soil sampling, in-situ testing and laboratory analysis

The sampling strategy was designed to characterise the shallow soils and locally underlying strata. Testing was primarily targeted towards the upper ground profile in order to test the environmental status of the made ground as well as the natural superficial deposits. Selected soil samples were placed in polythene bags for headspace screening with a photo-ionisation detector (PID) fitted with a 10.2 eV bulb.

Soils collected for laboratory analysis were recovered in a variety of containers appropriate to the anticipated testing suite required. Samples were stored in accordance with the RSK quality procedures to maintain sample integrity and preservation and to minimise the chance of cross-contamination.

Representative samples were taken and are recorded together with their depths and the PID screening results on the exploratory hole records in **Appendix D**.

The samples were transported to the laboratory in chilled cool boxes. Laboratory chain of custody forms can be provided if required. The rationale for soil sample chemical analysis is presented in **Table 2**.

Table 2 Scheduled analysis – soil

Exploratory hole no. and sample depth (m bgl)	Analyte	Rationale
WS1 (0.20m), WS2 (0.40m), WS3 (0.80m), WS4 (0.30m), WS4 (0.80m).	Basic contamination suite (includes heavy metals, speciated PAH's, TPH CWG, total sulphate, WS sulphate, Total organic carbon and asbestos soil screen.	To assess the suitability of made ground for use within a residential setting.
WS1 (0.60m), WS2 (1.50m), WS4 (1.50m).	Basic contamination suite (includes heavy metals, speciated PAH's, TPH CWG, total sulphate, WS sulphate, Total organic carbon.	To assess the underlying natural strata.
Notes: PAH – Polycylic aromatic hydrocarbons, TPH – Total petroleum hydrocarbons		

Test results are given on the borehole records presented in **Appendix D**. Disturbed samples were taken from each stratum encountered for potential future testing requirements. Geotechnical testing and the classification of the site soils for geotechnical purposes was outside the scope of this investigation.

5.3.2 Ground gas and groundwater monitoring

Subsequent to the installation of ground water monitoring wells within the borehole locations (WS1 to WS4) depths to groundwater were recorded using an electronic dip meter.

An infrared gas meter was used to measure gas flow, concentrations of carbon dioxide (CO_2), methane (CH_4) and oxygen (O_2) in percentage by volume, while hydrogen sulphide (H_2S) and carbon monoxide (CO) were recorded in parts per million. Initial and steady state concentrations were recorded. In addition, during the first monitoring round, all wells were screened with a PID to establish if there are any interferences and cross-sensitivity of other hydrocarbons with the infrared gas meter.

Monitoring results recorded to date are contained within **Appendix F**.

6 SITE INVESTIGATION FACTUAL FINDINGS

6.1 Ground conditions encountered

The descriptions of the strata encountered, notes regarding visual or olfactory evidence of contamination, list of samples taken, field observations of soil and groundwater, in-situ testing and details of monitoring well installations are included on the exploratory hole records presented in **Appendix F**.

The exploratory holes revealed that the site is underlain by a variable thickness of made ground over superficial deposits of the Kempton Park Gravel. This appears to confirm the stratigraphical succession described within the Arup desk study report.

For the purpose of discussion, the ground conditions encountered during the fieldworks are summarised in **Table 3** with the strata discussed in subsequent subsections.

Table 3 General succession of strata encountered

Stratum	Exploratory holes encountered	Depth to top of stratum m bgl	Proven thickness (m)
Made ground	WS1 to WS4	0.00 (GL)	0.50 to 2.30
Kempton Park Gravel	WS1 to WS4	0.50 to 2.30	Proven to the full depth of the investigation (3.00m)

6.1.1 Made ground

The exploratory holes encountered a variable thickness of made ground ranging between 1.00m and 2.30m bgl. The Made Ground was heterogeneous in nature and reference should be made to the individual records. In general, it comprised variable proportions of anthropogenic material in a granular matrix. Sandy clay portion with frequent inclusions of gravel sized brick fragments and brick cobbles.

No significant visual/olfactory evidence of contamination was encountered during the investigation. On-site PID screening of disturbed samples indicated concentrations of volatile organic compounds (VOC) <1ppm, indicating the absence of significant VOC within the samples.

6.1.2 Kempton Park Gravel

Soils recovered as the Kempton Park Gravel were encountered beneath the made ground, characterised by gravelly fine to coarse sand. The gravel fraction consisted of fine to coarse flint. Cohesive portion was recorded locally (WS1 and WS2) above the granular deposits, which typically comprised gravelly sandy clay.

No significant visual/olfactory evidence of contamination was encountered during the investigation. On-site PID screening of disturbed samples indicated concentrations of volatile organic compounds (VOC) <1ppm, indicating the absence of significant VOC within the samples.

6.2 Groundwater

Groundwater was not encountered during the investigation works or subsequent monitoring (carried out to date).

It should be noted that groundwater levels might fluctuate for a number of reasons including seasonal variations. On-going monitoring would be required to establish both the full range of conditions and any trends in groundwater levels.

6.3 Ground gas monitoring

The gas monitoring results recorded to date has identified a negligible concentration of methane (<0.1% v/v), maximum carbon dioxide concentration of 1.9% v/v and minimum oxygen concentrations of 19.8%vol with maximum flow rate of 0.2l/hr recorded. Atmospheric pressure was recorded at 1008mbar.

The results from the individual monitoring wells are presented in **Appendix D** and discussed further in **Section 7**.

6.4 Uncertainty

The spatial extent of the investigation and the density of sampling regime was limited due to the scope of works determined by RGB and on-site constraints (i.e. the presence of existing buildings and restricted areas to the north). Furthermore, there is uncertainty as to the groundwater table within the River Terrace Deposits.

7 GENERIC QUANTITATIVE AND QUALITATIVE RISK ASSESSMENT

7.1 Refinement of initial CSM

The investigation generally confirmed the predicted ground model which comprised a variable thickness of made ground overlying the superficial deposits of the Kempton Park Gravel. No visual or olfactory signs of contamination were observed.

With respect to ground gas, very little degradable material with low gas generating potential was observed within the made ground. Therefore, the made ground is unlikely to be a significant source of ground gas.

With respect to ground gas, to generate large volumes of methane and carbon dioxide, a large mass of readily degradable organic content is required. The gas generated will depend on the volume of degradable material that is present in the soil and the total volume of the source. A review of the field records observed very little degradable material with low gas generating potential within the made ground. Furthermore, the presence of volatiles was not identified following the in-situ screening using a photo-ionisation detector (<1ppm). However, in light of the credible sources recorded within the CSM, potential risk may exist in the vicinity of the fuel storage diesel tank and suspected tank base.

Whilst a groundwater table, predicted within the Kempton Park Gravel, was not fully established during the ground investigation and subsequent monitoring to date, the pollution linkage was further assessed qualitatively. In addition, the permeable granular deposits within the made ground/Kempton Park Gravels will allow potential contaminants to laterally migrate into the nearby surface watercourse to the southeast.

7.2 Linkages for assessment

In line with CLR11 (Environment Agency, 2004), there are two stages of quantitative risk assessment, generic (GQRA) and detailed (DQRA). The GQRA comprises the comparison of soil, groundwater, soil gas and ground gas results with generic assessment criteria (GAC) that are appropriate to the linkage being assessed. This comparison can be undertaken directly against the laboratory results or following statistical analysis depending upon the sampling procedure that was adopted.

Following the refinement of the initial CSM, the potentially complete contaminant linkages that require further assessment and the methodology of assessment are presented in **Table 4**.

Table 4 Linkages for GQRA

Potentially relevant contaminant linkage	Assessment method
1. Direct contact with impacted soil and dust by future residents	No precise details have been provided at this stage however, it is understood that the proposed development will be of a residential nature. We have assumed low-rise residential apartment blocks with associated communal landscaping. To provide an initial assessment of the potential human health risk, the chemical results have been directly compared against generic assessment criteria values under a residential scenario (**Appendix H**) as these are considered to be the most conservative guidelines to protect the most critical targets from contaminants. Chemical analyses have been performed on a total of 8 No. soil samples to the maximum depth of 1.50 m bgl.
2. Inhalation exposure of future residents to asbestos fibres	Due to uncertainty regarding risk assessment (in particular appropriate toxicological criterion and soil to air relationships), no acceptable concentration of asbestos in soil exists. However, the potential for fibre release is likely to reflect the concentrations in soil, the soil type and surface cover, disturbance, the form and type of asbestos and the soil moisture content (CIRIA, C733, 2014). Qualitative assessment based on the asbestos minerals present, their form, concentration, location and the nature of the proposed development. A total of six samples of the near-surface soil material (made ground) were screened in the laboratory for the presence of asbestos materials.
3. Inhalation exposure of future residents to contaminants in the vapour phase	In the absence of indoor inhalation data (mg/m^3), the vapour pathway particularly in areas where the vapour pathway is the predominant pathway (i.e. in the vicinity of the infilling in the north), has been assessed qualitatively and by the comparison of soil data against residential GACs as above.
4. Uptake of contaminants by vegetation potentially impacting plant growth (phytotoxicity) from contaminated soils and via site run-off/ drainage/ dust deposition	Several compounds can inhibit plant growth; hence it is important to have generic assessment criteria (GAC) to promote healthy plant growth. In the absence of other published GAC, the GAC have been obtained from legislation (UK and European) and guidance related to the use of sewage sludge on agricultural fields. The specified limits (designed to protect plant growth) of concentrations of selected elements in soil are outlined in updated 2nd Edition of the DoE Code of Practice and are presented in **Appendix I**.
5. Contaminants permeating potable water supply pipes, and the potential for chemical attack.	Comparison of soil data to GAC in **Appendix J** for plastic water supply pipes using UKWIR (2010) guidance.

Potentially relevant contaminant linkage	Assessment method
6. An assessment on ground gas regime. Concentrations of methane and carbon dioxide in ground gas entering and accumulating in enclosed spaces or small rooms in new buildings, which could affect future residents. In the case of methane this could create a potentially explosive atmosphere, while death by asphyxiation could result from carbon dioxide.	Gas screening values (GSV) have been calculated using maximum methane and carbon dioxide concentrations with maximum flow rates recorded at the site. Owing to the proposed development, the GSV have been compared with the Wilson and Card classification presented in C665 and BS8485:2015+A1:2019.
7. Leaching of soil contaminants and dissolved phase migration to the underlying Secondary A and nearby surface water course (Beverley Brook c.230m south-east).	In the absence of any leachate and groundwater/surface chemical data, the pollutant linkage has been assessed qualitatively.

7.3 Methodology and assessment of soil results

The analysis of laboratory results relating to soil samples submitted for testing, including leachate analysis, is included in the following sections.

7.3.1 Direct contact via oral and dermal exposure with impacted soil by future occupants/site users

In order to assess the soil results against the appropriate GAC, the soil results have been segregated into appropriate data sets. The datasets being considered in the assessment are:

- Data set 1 Made Ground
- Data set 2 Kempton Park Gravel (cohesive and granular portion)

7.3.1.1 Data set 1 – Made Ground

All made ground results have been compared with the aforementioned GAC. A soil organic matter (SOM) of 2.5% has been selected since laboratory results for total organic carbon (TOC) within the made ground (ranging between 0.1% to 2.4%). Only those determinants where exceedances have been reported are included within **Table 5**.

Table 5 Data summary table – Data set 1 (Made Ground)

Determinand	No. of samples tested	GAC (mg/kg)	No of exceedances	Maximum concentration (mg/kg)	
				Value	Location / depth (m bgl)
Lead	6	310	1	380	WS1@0.20
Dibenzo(ah)anthracene (polycyclic aromatic hydrocarbon)	6	0.32	3	0.34	WS1@0.20
				0.62	WS2@0.40
				0.46	WS4@0.80

In addition to the simple comparison of data to the adopted screening values, the CIEH document 'Guidance on Comparing Soil Contamination Data with a Critical Concentration', dated May 2008 recommends a statistical review should be conducted to demonstrate the site's 'suitability for use' with a defined level of confidence. Given the targeted nature of the investigation, it is not considered appropriate to conduct a statistical assessment.

Whilst contamination has been identified within discrete areas, we have assumed the anticipated finished floor level will mitigate the potential risk via source removal. Furthermore, should the proposed development predominantly comprise hardcover, as such the risk driving pathway considered will be outdoor vapour inhalation. PAH compounds have a very low volatility and therefore the vapour pathway is also not relevant and similarly not considered cause for concern if encapsulated beneath the hardstanding. The source of the recorded PAH compounds is most likely associated with bituminous material recorded and therefore not considered of any significant concern. With respect to Lead, there is no risk to human health via the inhalation pathway since it is not volatile, therefore the elevated concentrations of lead are not considered to pose a risk to human health if encapsulated beneath hardstanding.

Where areas of soft landscaping are proposed, further testing will be required to confirm the absence of contamination within the made ground soils. Alternatively, consideration will need to be given to incorporation of a clean capping layer to break the potential pollutant pathway.

Detectable concentrations of Total Petroleum Hydrocarbons were noted, however, the results indicate that the concentrations are generally associated with the higher chain hydrocarbon range (Aliphatic C_{16}-C_{21} and C_{21}-C_{35}) and below the adopted threshold limits. Whilst soil concentrations exceeded the corresponding theoretical saturation limits (Aliphatic C_{16}-C_{21}, C_{21}-C_{35}), which indicates the potential presence of free phase product within the unsaturated zone, no direct evidence of non-aqueous phase liquids (NAPL) were observed during the course of the investigation.

7.3.1.2 *Data set 2 – Kempton Park Gravel*

The results have been compared with the aforementioned GAC. A soil organic matter (SOM) of 1% has been selected since laboratory results for total organic carbon (TOC) within the drift deposits ranged between 0.2% and 1.4%.

Assessment of the results indicates that there were no exceedances of the GAC for the analytes tested.

7.3.2 Inhalation exposure of future residents to asbestos fibres

The visual inspection at the laboratory identified no materials suspected of potentially containing asbestos and the scheduled laboratory screening for asbestos found no detectable asbestos fibres within the samples of made ground.

7.3.3 Inhalation exposure of future residents to contaminants in the vapour phase

The following lines of evidence have been assessed in respect to the risk from VOC's:

- The ground investigation indicated that the underlying residual made ground largely consists of inert material i.e. bituminous material, clinker, flint, brick and concrete.
- Petroleum hydrocarbons were recorded below the assessment criteria. The detectable concentrations generally represent higher chain hydrocarbons consistent with degraded petroleum products (C_{16}-C_{21} and C_{21}-C_{35}) with low volatility rates; and
- Low emission rates have been recorded during the gas monitoring of up to 0.2 l/hr.

Based on the above lines of evidence it is considered that the risk to future site users from VOC's is low. However, it is recommended that further investigation is carried out in the vicinity of the former diesel tank and suspected tank base so that the areas can be assessed in respect to possible 'hotspots'.

7.3.4 Uptake of contaminants by vegetation potentially inhibiting plant growth

For this linkage, the results were conservatively assessed against the GAC derived from the DoE Code of Practice. The results are summarised in the table below.

Table 6 Summary of soil results with respect to plant phytotoxicity effects

Determinant	Generic assessment criteria (mg/kg)				Concentrations of determinants in excess of assessment value
	pH 5.0 < 5.5	pH 5.5 < 6.0	pH 6.0 < 7.0	pH >7.0	
Zinc	200	200	200	300	None recorded

Determinant	Generic assessment criteria (mg/kg)				Concentrations of determinants in excess of assessment value
	pH 5.0 < 5.5	pH 5.5 < 6.0	pH 6.0 < 7.0	pH >7.0	
Copper	80	100	135	200	None recorded
Nickel	50	60	75	110	None recorded
Lead	300	300	300	300	WS1 at 0.20 (380mg/kg)
Cadmium	3	3	3	3	None recorded
Mercury	1	1	1	1	WS1 at 0.20 (2.6mg/kg) WS2 at 0.40 (2.0mg/kg)
Note: Only compounds with assessment criteria documented within the Directive 86/278/EEC have been included, although criteria for 5 additional compounds have been presented within the 2006 CoP.					

As shown above, elevated concentrations of lead and mercury have been recorded above the assessment criterion in the made ground at WS1 and WS2. However, the made ground is not conducive to plant growth and consideration should be given to incorporating clean soil material suitable as a growing medium.

7.3.5 Impact of organic contaminants on potable water supply pipes

Since water supply pipes are typically laid at a minimum depth of 750 mm below finished ground levels, sample results from depths between **0.5m and 1.5m** below finished level were considered for assessing risks to water supply.

The results indicate that a relevant linkage is unlikely to exist associated with organic contaminants and therefore pollutant polyethylene (PE) and/or polyvinyl chloride (PVC) water supply pipes are expected to be suitable for use on the development.

It should be noted that at the time of this investigation the future routes of water supply pipes had not been established, hence the investigation and sampling strategy may not be fully compliant with UKWIR recommendations. Consequently, a targeted investigation and specific sampling/analytical strategy may be required at a later date once the route(s) of the supply pipe(s) are known. In addition, it is recommended that the relevant water supply company be contacted at an early stage to confirm its requirements for assessment, which may not necessarily be the same as those recommended by UKWIR.

7.3.6 An assessment of ground gas regime

7.3.6.1 General

The three mechanisms which permit gas to flow through the ground are advective flow (pressure driven), diffusion flow (along a concentration gradient) and/or dissolved in solution. Typically, advection and diffusion flows are considered to be the most critical mechanisms for gas migration. Migration of gas could occur within the made ground on site via the matrix of the fill material.

The anticipated development proposals will inherently introduce receptors to the site. These typically comprise future residents. Although, the main areas of risk are limited to restricted access/confined spaces.

7.3.6.2 Assessment of data

The results have been assessed in accordance with the guidance provided in BS8485:2015+A1:2019 and *CIRIA Report C665*. In the assessment of risks and selection of appropriate mitigation measures, both reports highlight the importance of the conceptual site model.

CIRIA C665 identifies two types of development, termed Situation A (modified Wilson and Card method), appropriate to all development excluding traditional low-rise construction, and Situation B (National House-Building Council, NHBC) only appropriate to traditional low-rise construction with ventilated sub-floor voids.

Both methods are based on calculations of the limiting borehole gas volume flow for methane and carbon dioxide, renamed as the gas screening value (GSV). The GSV (litres of gas per hour) is calculated by multiplying borehole flow rate (litres per hour) and gas concentration (percent by volume).

In both situations, it is important to note that the GSV thresholds are guideline values and not absolute. The GSV thresholds may be exceeded in certain circumstances, if the conceptual site model indicates it is safe to do so. Similarly, consideration of additional factors such as very high concentrations of methane, should lead to consideration of the need to adopt a higher risk classification than the GSV threshold indicates.

Since the proposed development will comprise both apartment blocks, Situation A has been adopted for the flats.

As the data set is temporally/spatially limited, peak data was combined from more than one monitoring standpipe location, for each gas source.

The gas monitoring data recorded to date has identified negligible concentrations of methane and a maximum concentration of carbon dioxide of 1.9%. A maximum gas flow rate of 0.2l/hr has been recorded. On this basis, the calculated GSV for methane is <0.0002 l/hr and the GSV for carbon dioxide is 0.0038l/hr.

Based on the GSVs, the site has been characterised as Situation CS1, indicating that a negligible gas regime has been identified and that gas protection measures are not considered necessary.

Assuming removal of the fuel storage tank in the north-west of the site, the potential for ground gas generation is considered very low. However, to increase data confidence and establish a ‘worst case’ scenario (i.e. during low or falling barometric pressure periods), it is recommended that monitoring is continued. It should be noted that further monitoring has been scheduled and will be reported as an addendum to this report.

7.3.7 Leaching and dissolved phase migration of contaminants to controlled waters

No significant sources of contamination have been identified to drive the need for a detailed assessment of this potential pollution linkage. Whilst marginally elevated concentrations were recorded locally, the anticipated presence of hardcover will restrict

any infiltration. As such, no major pathways via which contamination may migrate and impact groundwater are present. Furthermore, the anticipated thickness of the unsaturated zone will provide a significant medium for natural attenuation and the site is not situated within a groundwater Source Protection Zone.

It is recommended that further assessment of groundwater quality be conducted beneath the site to confirm the absence of any impact.

7.4 Environmental assessment conclusions

Owing to the nature of the investigation and the restrictions encountered, sufficient information is not currently available to determine fully the necessary mitigation measures. However, at this stage consideration should be given to the points listed out in **Table 7**.

Table 7 Outline of Recommended Contamination Alleviation Measures

Potential Alleviation Measures	Area(s) of Site Likely to be Affected		Development Considerations
	Whole Site	Targeted Areas	
Removal of fuel storage tank located in the north/north-eastern portion of the site		✔	Fuel/oil storage should be carefully emptied, made safe and removed off site in accordance with best industry practice with any hydrocarbon impacted soil to a suitably licensed waste management facility. The resulting remedial excavation will have to be validated by the Environmental Consultant prior to backfilling with 'clean' material.
Specialist demolition	✔		Prior to demolition of the existing buildings it is recommended that a hazardous materials survey is carried out and all necessary measures stemming from the survey implemented.
Remove/seal existing drains/services	✔		To close off any existing drains/services ducts that could provide a pathway for contaminant migration

Potential Alleviation Measures	Area(s) of Site Likely to be Affected		Development Considerations
	Whole Site	Targeted Areas	
Provision of clean soil cover for all soft landscaped areas	✔		In areas of proposed soft landscaping (i.e. eastern portion of the site), further sampling should be undertaken to confirm the absence of any contamination. Alternatively, provisions should be made to incorporate a clean capping layer. Dependent on the proposed finished levels, this may involve the excavation and removal of some or all of the Made Ground. Any residual contamination may be isolated below a suitable thickness of subsoil and topsoil cover (**450mm** recommended), which will also provide a suitable growing medium.
Use only validated sources of imported materials for clean soil cover.	✔		Proposed imported materials from each individual source should be validated with appropriate chemical test certificates and approved in advance of materials being delivered to site.
Selection of appropriate materials for buried water pipes in contact with the made ground.	✔		Where passing through potentially contaminated ground, buried services should be placed in a service corridor and surrounded with clean uncontaminated material.

Notwithstanding the alleviation measures detailed above, which are likely to be required within the proposed residential development, data gaps remain, which will require further assessment to fully establish the potential pollutant linkages requiring mitigation.

Of particular concern is the remaining uncertainty regarding the potential areas of concern recorded by Arup. Additional sampling/testing is considered essential to determine the implications for the health and safety of construction workers, waste classification and scope of remediation to protect the health of future residents.

8 CONCLUSIONS AND RECOMMENDATIONS

Based on the findings from the intrusive investigation, the site is generally underlain by a variable thickness of made ground over the superficial deposits of Kempton Park Gravel. No olfactory/visual evidence of contamination was recorded. No groundwater was identified during the course of the investigation and subsequent monitoring to date. Furthermore, no degradable material was noted within the underlying soil material.

Whilst elevated concentrations of lead and PAH compounds were noted locally, any potential risk may be mitigated through encapsulation or excavation. In areas of soft landscaping it is recommended further sampling is undertaken to determine its contamination status.

Given the nature of the investigation and spatial extent of the sampling locations, data gaps and uncertainties remain, notably associated with the potential areas of concern identified within the CSM prepared by Arup.

It should be noted that the gas monitoring is on-going, and the results shall be provided under a separate cover.

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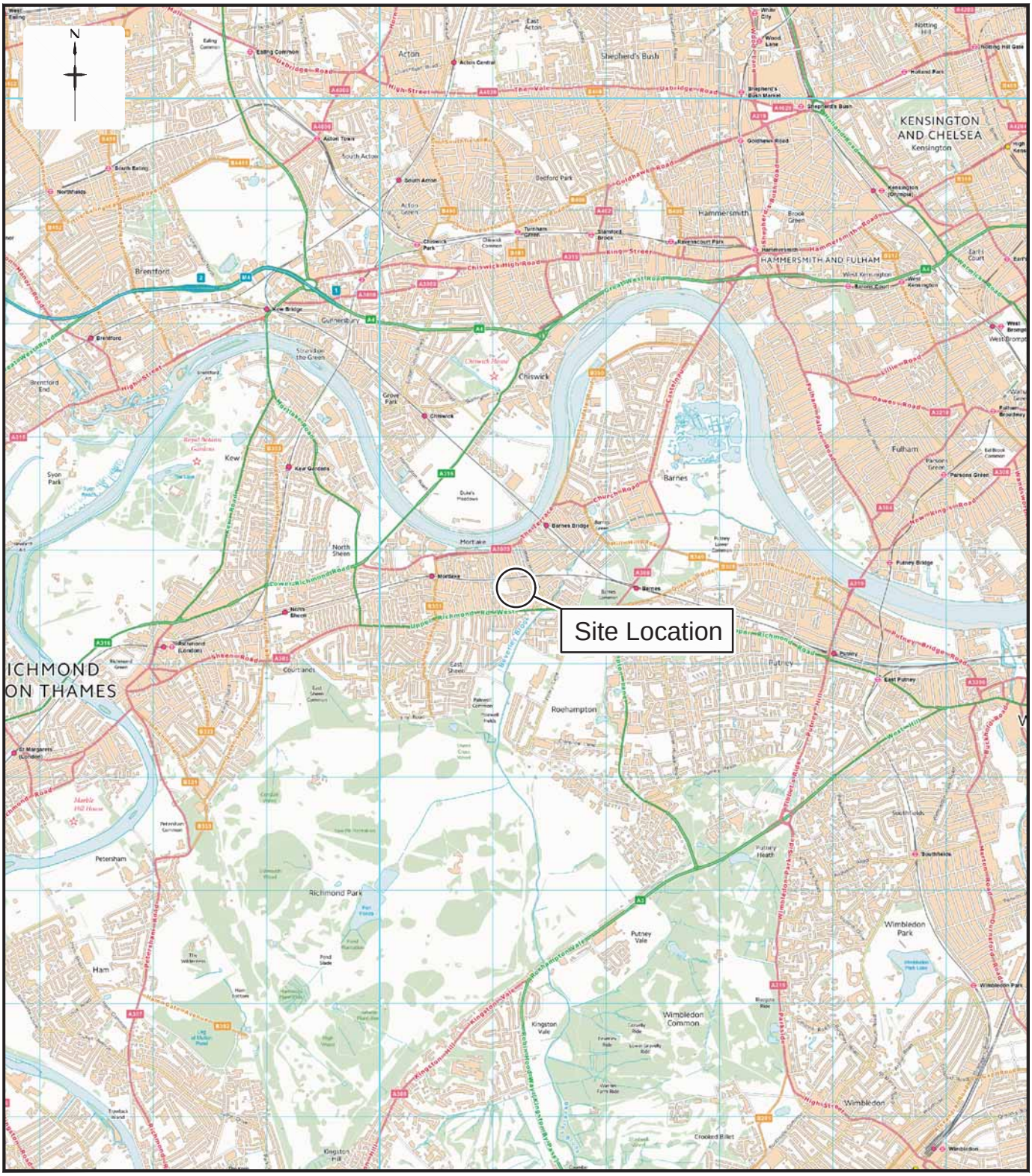
FIGURES



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Project Title: BARNES HOSPITAL

Drawing Title: SITE LOCATION PLAN

Rev	Drawn	Date	Checked	Date	Approved	Date
01	ASC	11.03.19	HE	11.03.19	ZH	11.03.19

Dimensions	Scale	Original Size
m	1:50,000	A4

Project Number	Drawing File	Drawing Number
1920514 - R01 (00)	1920514 - SLP.dwg	FIGURE 1

LEGEND

- Site Boundary
- Window Sample Location

Rev.	Date	Amendment	Drawn	Chkd.	Appd.

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Client

LS ESTATES LTD

Project Title

BARNES HOSPITAL

Drawing Title

EXPLORATORY HOLE LOCATION PLAN

Drawn	Date	Checked	Date	Approved	Date
ASC	11.03.19	HE	11.03.19	HE	11.03.19

Scale	Orig Size	Dimensions
1:600	A3	m

Project No.	Drawing File
1920514 - R01 (00)	1920514 (R01-00) Fig 2.dwg

Drawing No.	Rev.
FIGURE 2	P1

Scale 1 : 600

0 8 16 24 32 40m

APPENDIX A
SERVICE CONSTRAINTS

1. This report and the site investigation carried out in connection with the report (together the "Services") were compiled and carried out by RSK Environment Limited (RSK) for LS Estates Limited (the "client") in accordance with the terms of a contract [RSK Group Standard Terms and Conditions] between RSK and the "client", dated 14th February 2019. The Services were performed by RSK with the skill and care ordinarily exercised by a reasonable environmental consultant at the time the Services were performed. Further, and in particular, the Services were performed by RSK taking into account the limits of the scope of works required by the client, the time scale involved and the resources, including financial and manpower resources, agreed between RSK and the client.

2. Other than that, expressly contained in paragraph 1 above, RSK provides no other representation or warranty whether express or implied, in relation to the Services.

3. Unless otherwise agreed in writing the Services were performed by RSK exclusively for the purposes of the client. RSK is not aware of any interest of or reliance by any party other than the client in or on the Services. Unless expressly provided in writing, RSK does not authorise, consent or condone any party other than the client relying upon the Services. Should this report or any part of this report, or otherwise details of the Services or any part of the Services be made known to any such party, and such party relies thereon that party does so wholly at its own and sole risk and RSK disclaims any liability to such parties. Any such party would be well advised to seek independent advice from a competent environmental consultant and/or lawyer.

4. It is RSK's understanding that this report is to be used for the purpose described in the introduction to the report. That purpose was a significant factor in determining the scope and level of the Services. Should the purpose for which the report is used, or the proposed use of the site change, this report may no longer be valid and any further use of or reliance upon the report in those circumstances by the client without RSK 's review and advice shall be at the client's sole and own risk. Should RSK be requested to review the report after the date of this report, RSK shall be entitled to additional payment at the then existing rates or such other terms as agreed between RSK and the client.

5. The passage of time may result in changes in site conditions, regulatory or other legal provisions, technology or economic conditions which could render the report inaccurate or unreliable. The information and conclusions contained in this report should not be relied upon in the future without the written advice of RSK. In the absence of such written advice of RSK, reliance on the report in the future shall be at the client's own and sole risk. Should RSK be requested to review the report in the future, RSK shall be entitled to additional payment at the then existing rate or such other terms as may be agreed between RSK and the client.

6. The observations and conclusions described in this report are based solely upon the Services which were provided pursuant to the agreement between the client and RSK. RSK has not performed any observations, investigations, studies or testing not specifically set out or required by the contract between the client and RSK. RSK is not liable for the existence of any condition, the discovery of which would require performance of services not otherwise contained in the Services. For the avoidance of doubt, unless otherwise expressly referred to in the introduction to this report, RSK did not seek to evaluate the presence on or off the site of asbestos, invasive plants, electromagnetic fields, lead paint, heavy metals, radon gas or other radioactive or hazardous materials, unless specifically identified in the Services.

7. The Services are based upon RSK's observations of existing physical conditions at the Site gained from a visual inspection of the site together with RSK's interpretation of information, including documentation, obtained from third parties and from the client on the history and usage of the site, unless specifically identified in the Services or accreditation system (such as UKAS ISO 17020:2012 clause 7.1.6):

    a. the Services were based on information and/or analysis provided by independent testing and information services or laboratories upon which RSK was reasonably entitled to rely

    b. the Services were limited by the accuracy of the information, including documentation, reviewed by RSK and the observations possible at the time of the visual inspection

    c. the Services did not attempt to independently verify the accuracy or completeness of information, documentation or materials received from the client or third parties, including laboratories and information services, during the performance of the Services.

RSK is not liable for any inaccurate information or conclusions, the discovery of which inaccuracies required the doing of any act including the gathering of any information which was not reasonably available to RSK and including the doing of any independent investigation of the information provided to RSK save as otherwise provided in the terms of the contract between the client and RSK.

8. The intrusive environmental site investigation aspects of the Services is a limited sampling of the site at pre-determined locations based on the known historic / operational configuration of the site. The conclusions given in this report are based on information gathered at the specific test locations and can only be extrapolated to an undefined limited area around those locations. The extent of the limited area depends on the properties of the materials adjacent and local conditions, together with the position of any current structures and underground utilities and facilities, and natural and other activities on-site. In addition, chemical analysis was carried out for a limited number of parameters [as stipulated in the contract between the client and RSK] [based on an understanding of the available operational and historical information,] and it should not be inferred that other chemical species are not present.

9. Any site drawing(s) provided in this report is (are) not meant to be an accurate base plan, but is (are) used to present the general relative locations of features on, and surrounding, the site. Features (intrusive and sample locations etc) annotated on-site plans are not drawn to scale but are centred over the approximate location. Such features should not be used for setting out and should be considered indicative only.

APPENDIX B
PRELIMINARY UXO RISK ASSESSMENT

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Express Preliminary UXO Risk Assessment

Client	RSK
Project	Barnes Hospital
Site Address	Barnes Hospital, South Worple Way, London, SW14 8SU
Report Reference	EP8245-00
Date	20/02/19
Originator	JS

Assessment Objective

This preliminary risk assessment is a qualitative screening exercise to assess the likely potential of encountering unexploded ordnance (UXO) at the Barnes Hospital site. The assessment involves the consideration of the basic factors that affect the potential for UXO to be present at a site as outlined in Stage One of the UXO risk management process.

Background

This assessment uses the sources of information available in-house to 1st Line Defence Ltd to enable the placement of a development site in context with events that may have led to the presence of German air-delivered or Allied military UXO. The report will identify any immediate necessity for risk mitigation or additional research in the form of a Detailed UXO Risk Assessment. It makes use of 1st Line Defence's extensive historical archives, library and unique geo-databases, as well as internet resources, and is researched and compiled by UXO specialists and graduate researchers.

The assessment directly follows CIRIA C681 guidelines "Unexploded Ordnance, a Guide for the Construction Industry". The document will therefore assess the following factors:

- Basic Site Data
- Previous Military Use
- Indicators of potential aerial delivered UXO threat
- Consideration of any Mitigating Factors
- Extent of Proposed Intrusive Works
- Any requirement for Further Work

It should be noted that the vast majority of construction sites in the UK will have a low or negligible risk of encountering UXO and should be able to be screened out at this preliminary stage. The report is meant as a common sense 'first step' in the UXO risk management process. The content of the report and conclusions drawn are based on basic, preliminary research using the information available to 1st Line Defence at the time this report was produced. It should be noted that the only way to entirely negate risk from UXO to a project would be to support the works proposed with appropriate UXO risk mitigation measures. It is rarely possible to state that there is absolutely 'no' risk from UXO to a project.

Risk Assessment Considerations	
Site location and description/current use	The area of works is located in the London Borough of Richmond upon Thames. The proposed site boundary encompasses an area of land off within the grounds of the Barnes Hospital. Several multi-tiered structures associated with the hospital occupy the site area, whilst several roadways provide access across the site area. Open areas of undeveloped land are seldom present across the site of works, save for pockets of vegetation across the southern and western perimeters of the site boundary.  The northern perimeter of the site is defined by South Worple Way whilst South Worple Avenue forms the eastern border of the site. Residential properties run across the southern periphery of the site boundary. The site is approximately centred on the OS grid reference: TQ 2121975700
Are there any indicators of current/historical military activity on/close to the site?	At this stage, in-house records do not indicate that the site footprint had any former military use. No features such as WWII defensive positions, encampments or firing ranges are recorded to have been located at the site. In addition, no information of ordnance being stores, produced, or disposed of within the proposed site boundary could be found. The closest Heavy Anti-Aircraft (HAA) batteries was situated approximately 1.6km to the south-west of the site. The conditions in which unexploded anti-aircraft ordnance may have fallen unrecorded are analogous to that of aerial delivered German bombs - see the sections below for further information.
What was the pre- and post-WWII history of the site?	Research indicates that the site area has been situated within hospital grounds since the opening of The Barnes Isolation Hospital in 1889. The original purpose of the institution is understood to have been concerned with the treatment and care for patients with diseases such as diphtheria and scarlet fever, which reflects of OS map editions prior to the war that specify the institution was a *Hospital (Infectious Diseases)*. Prior to WWII, an OS map edition 1934 – 1936 indicates several structures across the northern and western sections of the site that appear to correlate to the present day structures on-site. A *mortuary* structure is specified in the northern section of the site across South Worple Way, whilst a *lodge* was situated adjacent to the west; all other structures are not specified in this map edition. Residential properties and their respective roads bound the site to the south and east, whilst *Mortlake Cemetry* neighboured the site to the west. Post-WWII OS mapping indicates that the hospital complex on-site was no longer explicitly concerned with infectious diseases; the hospital was now specified as the *Barnes Hospital*. An OS map edition dated 1952 – 1953 indicates that, within the south-eastern section of the site, two pre-war structures adjacent were cleared. Aside from this, no other substantial changes to the structural composition of the occupying areas is visible on this map edition, nor are any other areas of clearance visible (save for an area of clearance at a point where Priests Bridge meets with White Hart Lane, approximately 100m south-east).

Was the area subject to bombing during WWII?	During WWII, the site was situated within the Municipal Borough of Barnes. According to Home Office statistics, this district sustained a high density of bombing with an average of 114 items dropped per 1,000 acres. This consisted of 240 High Explosive (HE), 3 parachute mines, 15 oil bombs, 15 phosphorous bombs, 1 fire pot, 9 V-1 pilotless aircraft and 3 long-range rocket bombs across 12,599 acres of land. Consulted bomb mapping covering Barnes indicates several incidents of bombing across the site area, including both HE and incendiary bombing on numerous occasions during the war.
Is there any evidence of bomb damage on/close to the site?	Whilst consulted OS mapping does not explicitly record any structures are ruinous, the clearance of two structures between pre- and post-WWII map editions in the south-east of the section is of concern given that it is known that the site sustained several incidents of bombing during the war.
To what degree would the site have been subject to access?	It is anticipated that the site generally would have been accessed frequently during the war by hospital staff and patient alike, thus increasing the initial access and observation levels favourable to the detection of evidence of UXO across the site. However, of concern is the clearance shown on post-war historic OS mapping of two structures in the south-eastern section of the site, which appear to corroborate with incidents of bombing plotted on relevant bomb census maps for the area. Should this indicate that structures on-site were removed due to enemy action, it is considered likely that for a period during the war this area of the site would have been accessed less frequently, and signs of UXO could have been missed.
To what degree has the site been developed post-WWII?	Several structures on historical OS map editions appear to correspond to the present-day structures across the site area, save for development and extension works that have been carried out post-WWII.
What is the nature and extent of the intrusive works proposed?	The nature and extent of works proposed was not available at the time of writing.

Summary and Conclusions

During WWII, the site was situated within the Municipal Borough of Barnes. According to Home Office statistics, this district sustained a high density of bombing with an average of 114 items dropped per 1,000 acres. Consulted bomb mapping covering Barnes indicates several incidents of bombing across the site area, including both HE and incendiary bombing on numerous occasions during the war. The approximate locations of these incidents of bombing corresponds with areas of structural clearance indicated between pre- and post-WWII OS map editions consulted for the purposes of this assessment.

Damaged structures and associated debris possess the ability to conceal evidence of UXO, such as UXO entry holes, and impede access across the site to carry out post-raid inspections. As a result, the risk that UXO remains cannot be discredited at a preliminary stage.

Recommendations

Given the findings of this preliminary report, it is recommended that **further research** should be conducted in the form of a **Detailed UXO Risk Assessment**. This would allow for the cross-referencing of any available sources, and would involve archive visits to consult any local bomb mapping and written records. Further research would also include the consultation of WWII-era aerial photography, which would assist with the understanding of the wartime composition and conditions of the site. Any other available relevant historical records will be utilised to assess the risk on site.

Based on the conditions identified at this preliminary stage, it is anticipated that, following the acquisition of such information, it is possible that the risk from UXO could be lowered in certain areas and the site 'zoned' in the form of a risk map.

Prior to or in lieu of a Detailed Assessment, it is recommended that appropriate UXO Risk Mitigation Measures are provided for intrusive works proposed.

If the client has any anecdotal or empirical evidence of UXO risk on site, please contact 1st Line Defence.

APPENDIX C
UTILITY SERVICE RECORDS

Asset location search

Thames Water Property Searches

RSK Environment Limited
18

HEMEL HEMPSTEAD
HP3 9RT

Search address supplied

Barnes Hospital
South Worple Way
London
SW14 8SU

Your reference 28836

Our reference ALS/ALS Standard/2019_3954752

Search date 18 February 2019

Keeping you up-to-date

Notification of Price Changes

From 1 September 2018 Thames Water Property Searches will be increasing the price of its Asset Location Search in line with RPI at 3.23%.

For further details on the price increase please visit our website: www.thameswater-propertysearches.co.uk
Please note that any orders received with a higher payment prior to the 1 September 2018 will be non-refundable.

Thames Water Utilities Ltd
Property Searches, PO Box 3189, Slough SL1 4WW
DX 151280 Slough 13

searches@thameswater.co.uk
www.thameswater-propertysearches.co.uk

0845 070 9148

searchcode

Asset location search

Thames Water Property Searches

Search address supplied: Barnes Hospital, South Worple Way, London, SW14 8SU

Dear Sir / Madam

An Asset Location Search is recommended when undertaking a site development. It is essential to obtain information on the size and location of clean water and sewerage assets to safeguard against expensive damage and allow cost-effective service design.

The following records were searched in compiling this report: - the map of public sewers & the map of waterworks. Thames Water Utilities Ltd (TWUL) holds all of these.

This searchprovides maps showing the position, size of Thames Water assets close to the proposed development and also manhole cover and invert levels, where available.

Please note that none of the charges made for this report relate to the provision of Ordnance Survey mapping information. The replies contained in this letter are given following inspection of the public service records available to this company. No responsibility can be accepted for any error or omission in the replies.

You should be aware that the information contained on these plans is current only on the day that the plans are issued. The plans should only be used for the duration of the work that is being carried out at the present time. Under no circumstances should this data be copied or transmitted to parties other than those for whom the current work is being carried out.

Thames Water do update these service plans on a regular basis and failure to observe the above conditions could lead to damage arising to new or diverted services at a later date.

Contact Us

If you have any further queries regarding this enquiry please feel free to contact a member of the team on 0845 070 9148, or use the address below:

Thames Water Utilities Ltd
Property Searches
PO Box 3189
Slough
SL1 4WW

Email: searches@thameswater.co.uk
Web: www.thameswater-propertysearches.co.uk

Waste Water Services

Please provide a copy extract from the public sewer map.

Enclosed is a map showing the approximate lines of our sewers. Our plans do not show sewer connections from individual properties or any sewers not owned by Thames Water unless specifically annotated otherwise. Records such as "private" pipework are in some cases available from the Building Control Department of the relevant Local Authority.

Where the Local Authority does not hold such plans it might be advisable to consult the property deeds for the site or contact neighbouring landowners.

This report relates only to sewerage apparatus of Thames Water Utilities Ltd, it does not disclose details of cables and or communications equipment that may be running through or around such apparatus.

The sewer level information contained in this response represents all of the level data available in our existing records. Should you require any further Information, please refer to the relevant section within the 'Further Contacts' page found later in this document.

For your guidance:

- The Company is not generally responsible for rivers, watercourses, ponds, culverts or highway drains. If any of these are shown on the copy extract they are shown for information only.
- Any private sewers or lateral drains which are indicated on the extract of the public sewer map as being subject to an agreement under Section 104 of the Water Industry Act 1991 are not an ‘as constructed’ record. It is recommended these details be checked with the developer.

Clean Water Services

Please provide a copy extract from the public water main map.

Enclosed is a map showing the approximate positions of our water mains and associated apparatus. Please note that records are not kept of the positions of individual domestic supplies.

For your information, there will be a pressure of at least 10m head at the outside stop valve. If you would like to know the static pressure, please contact our Customer Centre on 0800 316 9800. The Customer Centre can also arrange for a full flow and pressure test to be carried out for a fee.

For your guidance:

- Assets other than vested water mains may be shown on the plan, for information only.
- If an extract of the public water main record is enclosed, this will show known public water mains in the vicinity of the property. It should be possible to estimate the likely length and route of any private water supply pipe connecting the property to the public water network.

Payment for this Search

A charge will be added to your suppliers account.

Further contacts:

Waste Water queries

Should you require verification of the invert levels of public sewers, by site measurement, you will need to approach the relevant Thames Water Area Network Office for permission to lift the appropriate covers. This permission will usually involve you completing a TWOSA form. For further information please contact our Customer Centre on Tel: 0845 920 0800. Alternatively, a survey can be arranged, for a fee, through our Customer Centre on the above number.

If you have any questions regarding sewer connections, budget estimates, diversions, building over issues or any other questions regarding operational issues please direct them to our service desk. Which can be contacted by writing to:

Developer Services (Waste Water)
Thames Water
Clearwater Court
Vastern Road
Reading
RG1 8DB

Tel: 0800 009 3921
Email: developer.services@thameswater.co.uk

Clean Water queries

Should you require any advice concerning clean water operational issues or clean water connections, please contact:

Developer Services (Clean Water)
Thames Water
Clearwater Court
Vastern Road
Reading
RG1 8DB

Tel: 0800 009 3921
Email: developer.services@thameswater.co.uk

Asset Location Search Sewer Map - ALS/ALS Standard/2019_3954752

The width of the displayed area is 500 m and the centre of the map is located at OS coordinates 521196,175690

The position of the apparatus shown on this plan is given without obligation and warranty, and the accuracy cannot be guaranteed. Service pipes are not shown but their presence should be anticipated. No liability of any kind whatsoever is accepted by Thames Water for any error or omission. The actual position of mains and services must be verified and established on site before any works are undertaken.

NB. Levels quoted in metres Ordnance Newlyn Datum. The value -9999.00 indicates that no survey information is available

Manhole Reference	Manhole Cover Level	Manhole Invert Level
3901	6.71	.7
39TX	n/a	n/a
09XZ	n/a	n/a
09ZV	n/a	n/a
1911	6.04	4.46
1904	6.05	3.89
19XS	n/a	n/a
181A	n/a	n/a
19YP	n/a	n/a
1705	6.43	4.6
0701	6	3.72
0708	5.92	4.73
1703	6.45	5.02
07WR	n/a	n/a
17YZ	n/a	n/a
171A	n/a	n/a
17YW	n/a	n/a
17ZT	n/a	n/a
17ZV	n/a	n/a
171B	n/a	n/a
07WW	n/a	n/a
07WQ	n/a	n/a
17YY	n/a	n/a
071E	n/a	n/a
17ZP	n/a	n/a
18TZ	n/a	n/a
18XZ	n/a	n/a
18YS	n/a	n/a
0801	5.76	3.32
181C	n/a	n/a
181B	n/a	n/a
1805	6.23	4.77
081B	n/a	n/a
1801	6.15	4.65
18XP	n/a	n/a
18YT	n/a	n/a
07YP	n/a	n/a
07XQ	n/a	n/a
08ZQ	n/a	n/a
08YZ	n/a	n/a
08YY	n/a	n/a
08YW	n/a	n/a
08YV	n/a	n/a
9802	5.7	3.13
08YS	n/a	n/a
08YR	n/a	n/a
0803	5.69	4.61
08YP	n/a	n/a
08XZ	n/a	n/a
08XX	n/a	n/a
08XW	n/a	n/a
98KC	n/a	n/a
081C	n/a	n/a
08XT	n/a	n/a
081A	n/a	n/a
08XS	n/a	n/a
98KE	n/a	n/a
9804	5.62	4.66
08XQ	n/a	n/a
0802	5.58	4.55
08XP	n/a	n/a
98KJ	n/a	n/a
981A	n/a	n/a
08WY	n/a	n/a
061A	n/a	n/a
961D	n/a	n/a
971F	n/a	n/a
97MJ	n/a	n/a
97MK	n/a	n/a
97MN	n/a	n/a
071A	n/a	n/a
971G	n/a	n/a
9707	6.64	2.63
9710	6.67	4.13
0710	6.43	4.6
9703	6.11	n/a
0702	4.09	3.43
9709	5.94	4.62
0709	5.88	4.98
07ZP	n/a	n/a
07YT	n/a	n/a
07ZV	n/a	n/a
07YQ	n/a	n/a
071D	n/a	n/a
071C	n/a	n/a
071B	n/a	n/a
07YZ	n/a	n/a
07YS	n/a	n/a
07XX	n/a	n/a
07ZT	n/a	n/a
07YY	n/a	n/a

Manhole Reference	Manhole Cover Level	Manhole Invert Level
97MD	n/a	n/a
96KJ	n/a	n/a
96LH	n/a	n/a
96MD	n/a	n/a
971E	n/a	n/a
96LF	n/a	n/a
96LE	n/a	n/a
991B	n/a	n/a
9801	5.44	2.75
091A	n/a	n/a
09WS	n/a	n/a
09WT	n/a	n/a
08ZS	n/a	n/a
08ZT	n/a	n/a
08WX	n/a	n/a
0906	5.45	2.91
081D	n/a	n/a
4509	6.06	4.3
4402	6.55	3.02
48WT	n/a	n/a
4707	6.42	4.87
49WT	n/a	n/a
48WY	n/a	n/a
481I	n/a	n/a
4805	5.91	3.67
48XT	n/a	n/a
4804	5.93	2.88
481D	n/a	n/a
48YP	n/a	n/a
3604	6.01	1.49
3611	6.19	4.93
4604	6.23	1.28
4602	n/a	n/a
47XV	n/a	n/a
4705	5.56	2.48
47XS	n/a	n/a
4708	5.67	5.05
47WR	n/a	n/a
461B	n/a	n/a
46VQ	n/a	n/a
46VV	n/a	n/a
46TT	n/a	n/a
46SV	n/a	n/a
38ZQ	n/a	n/a
38YZ	n/a	n/a
3809	6.18	5.17
38WR	n/a	n/a
3806	5.96	2.62
38WZ	n/a	n/a
38XX	n/a	n/a
38XS	n/a	n/a
38XW	n/a	n/a
38VV	n/a	n/a
38VW	n/a	n/a
38YP	n/a	n/a
391C	n/a	n/a
381B	n/a	n/a
48VW	n/a	n/a
48XQ	n/a	n/a
49YQ	n/a	n/a
48WP	n/a	n/a
4906	6.29	3.2
48XP	n/a	n/a
481F	n/a	n/a
49YT	n/a	n/a
48WX	n/a	n/a
48WR	n/a	n/a
49WS	n/a	n/a
49YV	n/a	n/a
48WS	n/a	n/a
3606	6.46	3.37
3605	5.9	2.58
36WQ	n/a	n/a
36WZ	n/a	n/a
36WV	n/a	n/a
36XT	n/a	n/a
36XX	n/a	n/a
36VS	n/a	n/a
36YQ	n/a	n/a
36TW	n/a	n/a
36YV	n/a	n/a
36SZ	n/a	n/a
36YZ	n/a	n/a
36TY	n/a	n/a
36VR	n/a	n/a
36SX	n/a	n/a
36TR	n/a	n/a
36TV	n/a	n/a
36TS	n/a	n/a
36TP	n/a	n/a
36ZR	n/a	n/a
36TQ	n/a	n/a
36TT	n/a	n/a

Manhole Reference	Manhole Cover Level	Manhole Invert Level
36ZV	n/a	n/a
3610	6.2	5.62
3601	6.2	4.44
37ZQ	n/a	n/a
37WW	n/a	n/a
37XW	n/a	n/a
371H	6.1	3.77
37YV	n/a	n/a
37ZT	n/a	n/a
37YW	n/a	n/a
27YZ	n/a	n/a
37XT	n/a	n/a
371G	6.24	4.02
37XV	n/a	n/a
3712	6.27	5.41
3711	6.14	4.64
3705	6.09	5.41
37XR	n/a	n/a
37XS	n/a	n/a
37YZ	n/a	n/a
37WR	n/a	n/a
37ZP	n/a	n/a
37YY	n/a	n/a
37XP	n/a	n/a
27YQ	n/a	n/a
371E	n/a	n/a
37XQ	n/a	n/a
371N	6.24	4.24
37XX	n/a	n/a
37VZ	n/a	n/a
371F	n/a	n/a
37WY	n/a	n/a
371J	6.34	4.39
37WZ	n/a	n/a
3709	6.31	5.4
27ZX	n/a	n/a
37XZ	n/a	n/a
371I	n/a	n/a
471A	n/a	n/a
3708	6.48	5.03
3710	6.24	5.07
2704	6.26	1.81
3701	6.59	1.2
3702	6.75	1.06
371B	6.6	.9
3707	5.84	5.02
4701	n/a	n/a
4706	5.81	4.98
2707	6.46	4.9
2703	6.59	4.61
4702	5.62	4.2
371C	n/a	n/a
3706	6.44	.43
381A	n/a	n/a
48SS	n/a	n/a
3802	n/a	n/a
3805	6.46	.69
3810	6.38	5.12
3811	6.29	2.76
381E	n/a	n/a
38ZS	n/a	n/a
381D	n/a	n/a
2810	n/a	n/a
2805	6.31	4.2
381C	n/a	n/a
381F	n/a	n/a
2806	n/a	n/a
2811	6.35	5.21
3804	6.51	.86
3808	6.48	4.55
381H	n/a	n/a
381G	n/a	n/a
281B	n/a	n/a
281A	n/a	n/a
38TZ	n/a	n/a
3807	n/a	n/a
3803	6.5	.7
38TW	n/a	n/a
281D	n/a	n/a
2919	6.44	4.9
2912	6.54	4.58
3903	6.65	3.86
391A	n/a	n/a
29YS	n/a	n/a
2920	n/a	n/a
2601	6.22	4.41
2509	6.24	4.87
26YP	n/a	n/a
26XW	n/a	n/a
26XR	n/a	n/a
26WY	n/a	n/a
25ZY	n/a	n/a
251B	n/a	n/a

Manhole Reference	Manhole Cover Level	Manhole Invert Level
3609	6.23	4.62
3613	6.21	n/a
3607	5.99	3
3612	5.86	5.07
3608	5.86	1.72
36VV	n/a	n/a
36VW	n/a	n/a
36VX	n/a	n/a
3505	5.73	4.38
461A	n/a	n/a
4516	5.72	4.35
4502	5.89	1.74
451A	n/a	n/a
4515	5.83	4.3
4610	6.05	4.73
451B	n/a	n/a
4605	6.11	1.44
4611	6.05	4.88
4510	4.01	4.31
4614	5.94	4.58
1501	6.37	4.36
1409	6.12	2.62
1406	6.22	4.09
151A	n/a	n/a
151B	n/a	n/a
1507	6.41	4.97
1405	6.14	4.64
15QQ	n/a	n/a
15QR	n/a	n/a
16ZX	n/a	n/a
2411	n/a	n/a
2410	n/a	n/a
26WV	n/a	n/a
25QT	n/a	n/a
25QP	n/a	n/a
2401	n/a	n/a
2502	6.41	4.72
2507	6.37	5.05
2501	6.41	4.63
26ZV	n/a	n/a
2508	6.39	5.03
26ZR	n/a	n/a
25QW	n/a	n/a
25QR	n/a	n/a
26YY	n/a	n/a
26YT	n/a	n/a
171G	n/a	n/a
18TR	n/a	n/a
18TT	n/a	n/a
18VR	n/a	n/a
171C	n/a	n/a
1802	6.15	5.19
171F	n/a	n/a
1803	6.12	5.11
18VP	n/a	n/a
1701	5.89	4.72
17ZW	n/a	n/a
1704	6.04	5.28
1702	6.43	2.63
28YP	n/a	n/a
28XX	n/a	n/a
28XS	n/a	n/a
2801	6.24	4.11
28WZ	n/a	n/a
2808	6.23	4.87
2706	6.43	4.98
2701	6.55	4.59
281C	n/a	n/a
281F	n/a	n/a
2814	n/a	n/a
2804	n/a	n/a
2708	6.33	5.67
2702	8.05	5.57
28YS	n/a	n/a
2809	6.29	5.6
2803	6.29	5.6
1804	6.32	3.73
281E	n/a	n/a
2802	6.23	4.63
2918	6.23	4.97
1913	6.26	4.55
2905	6.32	3.87
2917	6.23	4.97

The position of the apparatus shown on this plan is given without obligation and warranty, and the accuracy cannot be guaranteed. Service pipes are not shown but their presence should be anticipated. No liability of any kind whatsoever is accepted by Thames Water for any error or omission. The actual position of mains and services must be verified and established on site before any works are undertaken.

ALS Sewer Map Key

Public Sewer Types (Operated & Maintained by Thames Water)

Foul: A sewer designed to convey waste water from domestic and industrial sources to a treatment works.

Surface Water: A sewer designed to convey surface water (e.g. rain water from roofs, yards and car parks) to rivers or watercourses.

Combined: A sewer designed to convey both waste water and surface water from domestic and industrial sources to a treatment works.

Trunk Surface Water

Trunk Foul

Storm Relief

Trunk Combined

Vent Pipe

Bio-solids (Sludge)

Proposed Thames Surface Water Sewer

Proposed Thames Water Foul Sewer

Gallery

Foul Rising Main

Surface Water Rising Main

Combined Rising Main

Sludge Rising Main

Proposed Thames Water Rising Main

Vacuum

Sewer Fittings

A feature in a sewer that does not affect the flow in the pipe. Example: a vent is a fitting as the function of a vent is to release excess gas.

Air Valve

Dam Chase

Fitting

Meter

Vent Column

Operational Controls

A feature in a sewer that changes or diverts the flow in the sewer. Example: A hydrobrake limits the flow passing downstream.

Control Valve

Drop Pipe

Ancillary

Weir

End Items

End symbols appear at the start or end of a sewer pipe. Examples: an Undefined End at the start of a sewer indicates that Thames Water has no knowledge of the position of the sewer upstream of that symbol, Outfall on a surface water sewer indicates that the pipe discharges into a stream or river.

Outfall

Undefined End

Inlet

Other Symbols

Symbols used on maps which do not fall under other general categories

Public/Private Pumping Station

Change of characteristic indicator (C.O.C.I.)

Invert Level

Summit

Areas

Lines denoting areas of underground surveys, etc.

Agreement

Operational Site

Chamber

Tunnel

Conduit Bridge

Other Sewer Types (Not Operated or Maintained by Thames Water)

Foul Sewer

Surface Water Sewer

Combined Sewer

Gulley

Culverted Watercourse

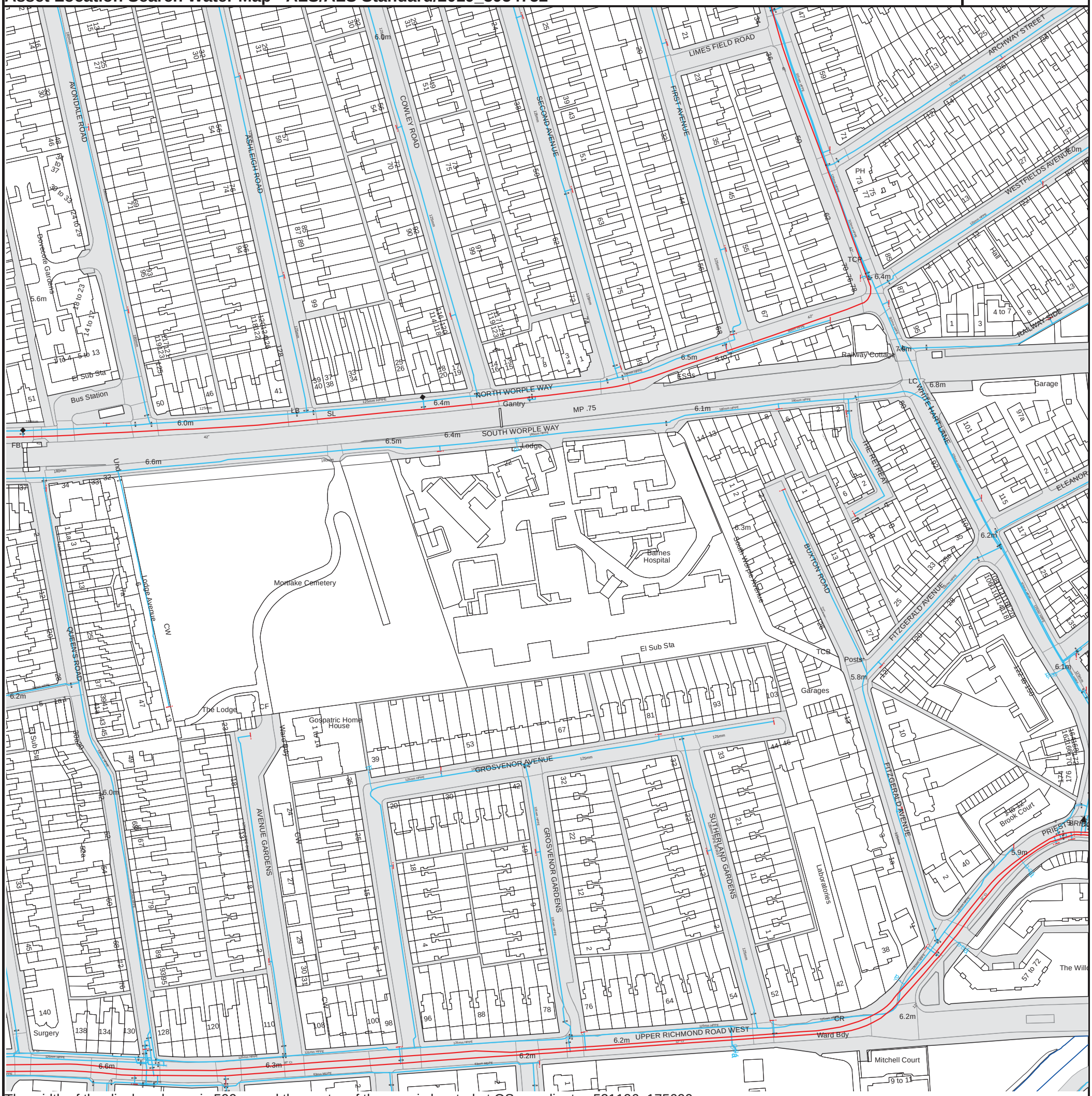
Proposed

Abandoned Sewer

Notes:

1) All levels associated with the plans are to Ordnance Datum Newlyn.
2) All measurements on the plans are metric.
3) Arrows (on gravity fed sewers) or flecks (on rising mains) indicate direction of flow.
4) Most private pipes are not shown on our plans, as in the past, this information has not been recorded.
5) 'na' or '0' on a manhole level indicates that data is unavailable.
6) The text appearing alongside a sewer line indicates the internal diameter of the pipe in milimetres. Text next to a manhole indicates the manhole reference number and should not be taken as a measurement. If you are unsure about any text or symbology present on the plan, please contact a member of Property Insight on 0845 070 9148.

Asset Location Search Water Map - ALS/ALS Standard/2019_3954752



The width of the displayed area is 500 m and the centre of the map is located at OS coordinates 521196, 175690.

The position of the apparatus shown on this plan is given without obligation and warranty, and the accuracy cannot be guaranteed. Service pipes are not shown but their presence should be anticipated. No liability of any kind whatsoever is accepted by Thames Water for any error or omission. The actual position of mains and services must be verified and established on site before any works are undertaken.

ALS Water Map Key

Water Pipes (Operated & Maintained by Thames Water)

4"

Distribution Main: The most common pipe shown on water maps. With few exceptions, domestic connections are only made to distribution mains.

16"

Trunk Main: A main carrying water from a source of supply to a treatment plant or reservoir, or from one treatment plant or reservoir to another. Also a main transferring water in bulk to smaller water mains used for supplying individual customers.

3" SUPPLY

Supply Main: A supply main indicates that the water main is used as a supply for a single property or group of properties.

3" FIRE

Fire Main: Where a pipe is used as a fire supply, the word FIRE will be displayed along the pipe.

3" METERED

Metered Pipe: A metered main indicates that the pipe in question supplies water for a single property or group of properties and that quantity of water passing through the pipe is metered even though there may be no meter symbol shown.

Transmission Tunnel: A very large diameter water pipe. Most tunnels are buried very deep underground. These pipes are not expected to affect the structural integrity of buildings shown on the map provided.

Proposed Main: A main that is still in the planning stages or in the process of being laid. More details of the proposed main and its reference number are generally included near the main.

Valves

- General Purpose Valve
- Air Valve
- Pressure Control Valve
- Customer Valve

Hydrants

- Single Hydrant

Meters

- Meter

End Items

Symbol indicating what happens at the end of a water main.

- Blank Flange
- Capped End
- Emptying Pit
- Undefined End
- Manifold
- Customer Supply
- Fire Supply

Operational Sites

- Booster Station
- Other
- Other (Proposed)
- Pumping Station
- Service Reservoir
- Shaft Inspection
- Treatment Works
- Unknown
- Water Tower

Other Symbols

- Data Logger

PIPE DIAMETER	DEPTH BELOW GROUND
Up to 300mm (12")	900mm (3')
300mm - 600mm (12" - 24")	1100mm (3' 8")
600mm and bigger (24" plus)	1200mm (4')

Other Water Pipes (Not Operated or Maintained by Thames Water)

Other Water Company Main: Occasionally other water company water pipes may overlap the border of our clean water coverage area. These mains are denoted in purple and in most cases have the owner of the pipe displayed along them.

Private Main: Indiates that the water main in question is not owned by Thames Water. These mains normally have text associated with them indicating the diameter and owner of the pipe.