



RIDGE

Property and Construction Consultants

Portsmouth City Council

Ground Condition Assessment
Land at Kingsclere Avenue,
Havant

August 2015

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Ground Condition Assessment

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Factual Report	
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Generic Quantitative Risk Assessment	
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Ground Condition Assessment

Contents

Section 1 – Introduction	4
1.1. Introduction	4
1.2. Legal Context	4
1.3. Methodology	4
1.4. Proposed Use	5
1.5. Previous Reports Reviewed	5
1.6. Report Scope and Limitation	6
Section 2 – Hazard Identification	7
2.1. Site Location and Description	7
2.2. Site History	7
2.3. Documented Ground Conditions	7
2.4. Environmental Data Search	8
2.5. Department of Environment – Industry Profiles	10
2.6. Preliminary Conceptual Site Model	10
Section 3 – Fieldwork Summary of Scope and Rationale	11
3.1. Rationale and Summary of Scope	11
3.2. Sampling	11
3.3. Monitoring	11
3.4. Site Investigation Standards	11
Section 4 – Ground Conditions Encountered	12
4.1. Soil Conditions	12
4.2. Obstructions	13
4.3. Groundwater Conditions	13
4.4. Visual/Olfactory Evidence of Contamination	13
Section 5 – Generic Risk Assessment	14
5.1. Contamination Assessment Methodology	14
5.2. Soil Assessment	16
5.3. Statistical Analysis	17
5.4. Ground Gas Assessment	18
Section 6 – Conceptual Site Model	19
6.1. Sources	19
6.2. Pathways	19
6.3. Receptors	19
Section 7 – Risk Assessment	20

Ground Condition Assessment

7.1. Risk Assessment Procedure	20
7.2. Pollutant Linkage Assessment	22
Section 8 – Geotechnical Assessment	23
8.1. Introduction	23
8.2. Geotechnical Tests	23
8.3. Geotechnical and Geological Parameters	23
8.1. Aggressive Ground Soil Chemistry	30
Section 9 – Foundation and Ground Engineering	32
9.1. Introduction	32
Section 10 – Conclusions and Recommendations	38
10.1. Contamination	38
10.2. Geotechnical	39
Figure 1 – Site Location Plan	41
Figure 2 – Investigation Location Plan	42
Figure 3 – SPT N v Depth	43
Figure 4 – Undrained Shear Strength v Depth	44
Appendix 1 – Report Conditions	45
Appendix 2 – Engineering Logs	47
Appendix 3 – Generic Assessment Criteria	48
Appendix 4 – Soil Screening Summary	49
Appendix 5 – Chemical Analysis Results	50
Appendix 6 – Monitoring Records	51
Appendix 7 – Geotechnical Test Certificates	52
Appendix 8 – Geotechnical Calculations	53
Appendix 9 – TRRL Results	54

Section 1 – Introduction

1.1. Introduction

Ridge and Partners LLP (Ridge) was commissioned by Portsmouth City Council in May 2015 to undertake a Ground Condition Assessment of a plot of land at Kingsclere Avenue, Havant, Hampshire.

The brief was to undertake a site investigation and assessment to identify any ground contamination issues and geotechnical conditions that may affect the proposed development. This report provides an assessment of the identified and potential ground conditions of the site, with regard to the proposed works in accordance with the Model Procedures for the Management of Land Contamination (CLR 11), published by the Environment Agency. In addition, the geotechnical sections of this report provide a detailed assessment of the materials present beneath the site and present characteristic parameters that should be used in design of all geotechnical facets of the proposed development.

This report is prepared in line with the agreed brief and is subject to the report conditions shown in Appendix 1.

1.2. Legal Context

Part IIA of the Environmental Protection Act 1990 (inserted by Section 57 of the Environment Act 1995) provides a regime for the control of specific threats to health or the environment from land contamination. In accordance with the Act and the statutory guidance document 'The Contaminated Land (England) Regulations 2000', the definition of contaminated land is intended to embody the concept of risk assessment. Within the meaning of the Act, land is only "contaminated land" where it appears to the Regulatory Authority, by reason of substances within or under the land, that:

- Significant harm is being caused, or there is a significant possibility of such harm being caused; or
- Pollution of controlled waters is being, or is likely to be, caused."

Inherent in this definition is the requirement for contamination risk assessment to be undertaken on a site specific basis, as the potential for harm is determined by the site's end use and its specific environmental setting.

The guidance defines "risk" as the combination of:

- The probability, or frequency, of occurrence of a defined hazard (for example, exposure of a property to a substance with the potential to cause harm); and
- The magnitude (including the seriousness) of the consequences.

1.3. Methodology

This report has been prepared in accordance with published Environment Agency guidance ('Model Procedures for the Management of Land Contamination – Contaminated Land Report (CLR) 11'). CLR 11 provides the technical framework for structured decision making about land contamination and builds on previous work carried out under the Contaminated Land Research Programme (of the former Department of the Environment). CLR 11 has adopted and refined the well recognised methodology and terminology that has been used in contaminated land risk assessment for a number of years.

Ground Condition Assessment

Pollutant Linkage Concept

In the context of land contamination, there are three essential elements to any risk:

- A **contaminant source** – a substance that is in, on or under the land and has the potential to cause harm or to cause pollution of controlled waters.
- A **receptor** – in general terms, something that could be adversely affected by a contaminant, such as people, an ecological system, property, or a water body.
- A **pathway** – a route or means by which a receptor can be exposed to, or affected by, a contaminant.

Each of these elements can exist independently, but they create a risk only where they are linked together, so that a particular contaminant affects a particular receptor through a particular pathway. This kind of linked combination of contaminant–pathway–receptor is described as a pollutant linkage.

Conceptual Model

An important thread throughout the overall process of risk assessment is the need to formulate and develop a conceptual model for the site, which supports the identification and assessment of pollutant linkages. A conceptual model represents the characteristics of the site in diagrammatic or written form that shows the possible relationships between contaminants, pathways and receptors (pollutant linkages).

Risk Assessment

CLR 11 advocates a phased approach to risk assessment comprising the following in order, as necessary:

Preliminary Risk Assessment – a desk study consisting of a review of documentary, anecdotal and site walk over evidence.

Generic Quantitative Risk Assessment (GQRA) - comparison of contaminant concentrations obtained from site investigation with generic assessment criteria.

Detailed Quantitative Risk Assessment (DQRA) - comparison of contaminant concentrations obtained from site investigation with site-specific assessment criteria.

This document constitutes a Preliminary Risk Assessment, Generic Quantitative Risk Assessment and a Geotechnical Design Report.

1.4. Proposed Use

It is currently understood that the site is proposed for low rise residential development. A change in the site use from that currently proposed may result in the need for re-assessment of risk criteria and the conclusions and recommendations resulting from the risk assessment could therefore significantly change.

1.5. Previous Reports Reviewed

An Environmental Desk Study was conducted for Portsmouth City Council by Omnia Environmental Consulting Ltd, in February of 2015; this report was reviewed as part of this assessment.

1.6. Report Scope and Limitation

This report is based upon a review of readily available historical and current information and the recent site investigation data detailed herein.

The report presents an interpretation of the borehole and laboratory data provided by the Ridge site investigation undertaken between the 4th and 12th June 2015. In addition, this report outlines the basic ground conditions encountered in the exploratory holes and the results of any monitoring of ground installations. This information has been collated, processed and used to provide an interpretation of the ground conditions, with recommendations on potential ground contamination risks for the proposed development.

The recommendations and opinions expressed in this report are based on the strata observed in the exploratory holes, the results of the site and laboratory tests, and information obtained as part of the desk study or provided by others. Ridge takes no responsibility for conditions that have not been revealed by the exploratory holes, or which occur between them. Whilst every effort has been made to interpret the conditions between investigation locations, such information is only indicative and liability cannot be accepted for its accuracy. Information provided from other sources is taken in good faith and Ridge cannot guarantee its accuracy.

The information contained in this report is intended for the use of Portsmouth City Council. Ridge can take no responsibility for the use of this information by any other party or for uses other than that described in this report.

Ground Condition Assessment

Section 2 – Hazard Identification

2.1. Site Location and Description

The site has an area of approximately 1.3ha, is roughly square in shape and comprises an open, level, grassed field, with a slightly elevated area in the north eastern corner. The northern and eastern boundaries are denoted by a number of fence lines, vegetation and trees, separating the site from Riders infant school. The southern limit of the eastern boundary meets a pedestrian entry point to the open space and a lockable vehicular access gate. The southern boundary is marked by a metal fence line set under a strip of mature trees. The western site limit meets a number of wooden fences at the rear of residential properties and two pedestrian access ways, leading to Kingsclere Avenue, marked by a low post and rail fence and bollards to restrict vehicular access.

The site is located between Dunsbury Way and Kingsclere Avenue in a predominantly residential area of Havant.

2.2. Site History

According to the Ordnance Survey maps provided and reviewed from 1866 to 2014 (scales 1:2,500, 1:10,000, 1:1,250, 1:10,560) the site appears to have remained as undeveloped farm land with a track way bisecting the site from the northwest to the southeast, approximately 80m to the west of what was previously known as Riders Lane Farm until 1956, when the area is shown to have been developed. The track is absent from mapping from the early 1950's and field boundaries in the area are altered. The area surrounding the site, as represented in mapping from 1956 is similar to that of current infrastructure and buildings in the area, with subsequent infilling of undeveloped areas in the 1970's. From 1956 through to 1959-1962 the site is split roughly east-west by a boundary line and a building is present in the west of the site. The nature of the building is not indicated. The site is indicated as playground and the building and boundary line absent from map from 1962 onward.

2.3. Documented Ground Conditions

Ground conditions recorded in readily available sources are summarised below.

Geology

Reference to the British Geological Survey (BGS) Map (Sheet 315, Southampton, Scale 1:50,000) indicates the site to directly overlie bedrock geology of the Bognor Sand Member, with the London Clay Formation within 50m of the southern limit of the site. No Artificial or Made Ground deposits are recorded as present on the site, however the site is surrounded by developed properties and it is considered likely that some Made Ground may be present.

Hydrogeology

The Environment Agency Groundwater Vulnerability Map (Sheet 52, Southern Hampshire, Scale 1:100,000) indicates that the site is underlain by a bedrock Secondary A Aquifer, interpreted as the Bognor Sand Member. The site lies to the north of an area of bedrock Unproductive Strata, interpreted as the London Clay Formation.

Ground Condition Assessment

Secondary A Aquifers are permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers. These are generally aquifers formerly classified as minor aquifers.

Unproductive Strata are rock layers or drift deposits with low permeability that have negligible significance for water supply or river base flow.

The site lies within a groundwater source protection zone (SPZ), recorded as 1C – Inner catchment within a confined aquifer, this is interpreted as the underlying deep Chalk Aquifer.

Hydrology

The nearest surface water feature to the site is a primary river 273m to the south east of the site.

Radon

Radon is a naturally occurring radioactive gas which may be harmful to human health. Radon is generally released into the atmosphere in areas underlain by granite and limestone. Harmful concentrations of radon may build up if it becomes trapped in an enclosed space such as a building.

National Radiological Protection Board data presented within the Landmark Envirocheck Report indicates that the percentage of houses exceeding the Action Levels for Radon in this area is 1-3%. Therefore the British Geological Survey recommends that no radon protective measures are necessary in the construction of new dwellings or extensions.

2.4. Environmental Data Search

A search of an environmental database was undertaken together with information from various other organisations as part of the desk study and is summarised in the following sections. The following summary is generally limited to locations within 250m of the site boundaries unless it is considered that installations or activities beyond that range could potentially have an impact on the site or be affected by the redevelopment of the site.

Table 2.1: Data search results

Discharge consents	There are no recorded active discharge consents within 250m of the site.
Pollution incidents	There are 3No. recorded pollution incidents to controlled waters within 250m of the site. All three of these relate to a fire fighting incident 158m to the south east of the site. Water, Land and Air Impacts are recorded as Category 3 (Minor) in each case.
Water abstractions	There are no recorded water abstractions within 500m of the site.
Fuel stations	There are no recorded fuel stations within 250m of the site.
Landfill sites	There are no recorded landfill sites within 250m of the site.

The site is located in an area which may not be affected by coal mining.

The following ground hazards were identified:

Ground Condition Assessment

- Compressible ground stability hazards – Negligible hazard
- Collapsible ground stability hazards – Very Low hazard
- Ground dissolution stability hazards – Negligible hazard
- Landslide ground stability hazard – Very Low hazard
- Shrinking or swelling clay ground stability hazard – Low hazard
- Running sand ground stability hazards – Low hazard

Ground Condition Assessment

2.5. Department of Environment – Industry Profiles

The Industry Profiles produced by the Department of the Environment do not cover the current or past uses of the site.

2.6. Preliminary Conceptual Site Model

Table 2.2: Pollutant linkage assessment

Source	Pathway	Receptor
Potential ACM in Made Ground	Inhalation of fibres	Construction workers
		Future site users
Ground gas from natural strata	Vertical migration leading to accumulation and inhalation	Future site users

The preliminary risk assessment identified several potentially viable pollutant linkages that could present a significant risk, based on the proposed use. As such, an intrusive investigation was undertaken to further assess the potential risks.

Section 3 – Fieldwork Summary of Scope and Rationale

3.1. Rationale and Summary of Scope

Site investigation works were undertaken by Ridge between the 4th and 12th June 2015. The scope and rationale of the ground investigation are presented below.

- 7no. cable percussive boreholes (BH) to a maximum depth of 10.0mbgl.
- 10no. windowless sample boreholes (WS) to a maximum depth of 5.0mbgl.
- Collection of representative samples to undergo chemical and geotechnical laboratory testing as detailed in later sections of this report.
- Installation of 6no. gas / water monitoring standpipes.
- 6No. TRRL probe locations to allow calculations of CBR values.

It should be noted that additional sources of contamination may become apparent during any future investigation and development of the site.

Table 3.1: Exploratory hole location rationale

Location	Rationale	Max Depth (mbgl)
BH1-7	7no. cable percussive boreholes positioned across the proposed development area to assess the nature and stratigraphy of the subsurface materials and allow collection of representative samples for geotechnical and environmental analyses and installation of monitoring wells.	10.0
WS1-10	10no. windowless sample boreholes positioned across the proposed development area to assess the nature and stratigraphy of the subsurface materials and allow collection of representative samples for geotechnical and chemical environmental analysis	5.0

The layout of the exploratory positions is presented in Figure 2.

3.2. Sampling

Prior to the investigation it was determined that the primary receptors that would potentially be at risk on this site would be the future site users and construction workers with additional potential risk to the underlying Secondary Aquifer. It was therefore considered appropriate to target the near surface deposits, at a depth representative of the material that is likely to remain following site clearance for chemical analysis as this is the material most likely to be encountered by the receptor following the development of the site.

3.3. Monitoring

One groundwater level and ground gas monitoring round was undertaken on completion of the intrusive investigation works to provide an assessment of the ground gas regime at the site.

3.4. Site Investigation Standards

Methods employed during the investigation were generally undertaken in accordance with BS10175, BS EN 1997-2 and BS5930.

Ground Condition Assessment

Section 4 – Ground Conditions Encountered

4.1. Soil Conditions

Ground conditions encountered during the recent ground investigation were broadly consistent with those identified in the published literature and in summary comprised Topsoil overlying orange brown and grey silty fine to medium sands of the Bognor Sand Member in turn overlying clays of the London Clay Formation. Variations in strata thicknesses are summarised in Table 4.1 below, engineering logs are presented in Appendix 2.

Table 4.1: Summary of encountered ground conditions

Location	Topsoil / Made Ground		Bognor Sand Member		London Clay Formation	
	From (mbgl)	Thickness (m)	From (mbgl)	Thickness (m)	From (mbgl)	Thickness (m)
BH1	GL	0.10	0.10	>9.90	N/E	
BH2	GL	0.10	0.10	6.30	6.40	>3.60
BH3	GL	0.10	0.10	>9.90	N/E	
BH4	GL	0.10	0.10	5.90	6.00	>4.00
BH5	GL	0.10	0.10	5.70	5.80	>4.20
BH6	GL	0.10	0.10	5.80	5.90	>4.10
BH7	GL	0.10	0.10	5.90	6.00	>4.00
WS1	GL	0.35	0.35	>3.65	N/E	
WS2	GL	0.30	0.30	>3.70	N/E	
WS3	GL	0.40	0.40	>2.60	N/E	
WS4	GL	0.35	0.35	>2.65	N/E	
WS5	GL	0.30	0.30	>3.70	N/E	
WS6	GL	0.45	0.45	>3.55	N/E	
WS7	GL	0.10	0.10	>2.90	N/E	
WS8	GL	0.45	0.45	>2.55	N/E	
WS9	GL	0.30	0.30	>3.70	N/E	
WS10	GL	0.35	0.35	>3.65	N/E	

N/E Not Encountered

Ground Condition Assessment

Surfacing

The site comprises grassland. No other surfaced areas are present on site.

Topsoil

Topsoil was encountered in all locations and was recorded as light brown silty fine to medium sand with rootlets and locally flint gravel. Topsoil was recorded as having a thickness of 0.10 to 0.45m.

Made Ground

Made Ground was encountered in WS3 and comprised a light brown silty gravelly fine sand with frequent rootlets and coarse flint, brick and tile fragments from ground level to 0.40mbgl. Laboratory analysis on the samples revealed Amosite (Asbestos Board) within the sample taken from WS2 indicating that the material between ground level and 0.3m at this location is also Made Ground, although no anthropogenic inclusions were observed in this material during the investigation.

Bognor Sand Member

The Bognor Sand Member (BSM) was present immediately beneath the Topsoil / Made Ground at all locations and attained thicknesses of between 5.70 to >9.90m. The Bognor Sand Member comprised orange brown slightly gravelly fine Sand overlying orange brown and grey fine Sand becoming silty fine Sand with depth.

London Clay Formation

The London Clay Formation (LCF) was encountered immediately beneath the Bognor Sand Member in five of the CP Boreholes. The boundary between the LCF and the overlying BSM is gradational and difficult to locate precisely; however, in this Report it has been taken where the material becomes cohesive. The LCF comprised grey silty Clay and formed the basal unit of the investigation where encountered.

4.2. Obstructions

No obstructions were noted during works.

4.3. Groundwater Conditions

Water ingress was noted as a seepage in the intrusive investigation locations BH1,2,4 and 5. Seepages were recorded at shallow depths varying from 1.4mbgl and 3.7mbgl and at greater depth of 9.5mbgl. Two rounds of groundwater and gas monitoring were undertaken subsequent to installation of groundwater and gas monitoring piezometers in BH1 to BH7. Groundwater levels recorded during the monitoring are presented in Appendix 6 and were recorded at depths varying of 1.85mbgl to 2.06mbgl.

4.4. Visual/Olfactory Evidence of Contamination

No notable evidence of contamination was encountered.

Section 5 – Generic Risk Assessment

5.1. Contamination Assessment Methodology

In order to assess the human health and environmental risks posed by potential contaminants within the underlying soils and groundwater, Ridge undertook an initial screen of the laboratory results using generic assessment criteria. Generic assessment criteria (GAC) are conservative contaminant concentration values used for comparison purposes to assess the risk associated with contaminant concentrations found on site and are derived using non-site-specific information.

Soils

In order to assess the soil analyses results with regard to potential human health risks, Ridge has adopted the LQM/CIEH Suitable 4 Use Levels (S4ULs), generic assessment criteria (GACs) derived in accordance with the UK framework set out in the most recent CLR (Contaminated Land Report) documents using the Contaminated Land Exposure Assessment (CLEA) Model.

S4ULs have been published for an extensive suite of contaminants, with assessment criteria derived for each contaminant for four different land use scenarios namely:

- Residential with homegrown produce;
- Residential without homegrown produce
- Allotments; and
- Commercial and industrial.

A full list of the GACs together with an indication of the method used for their derivation is provided in Appendix 3. GACs applicable to residential end use have been used for the assessment of the site. Contaminant concentrations below the GACs are considered not to warrant further risk assessment. However, concentrations of contaminants above the GACs may require further consideration through statistical analysis, if appropriate, or further detailed assessment using site specific data.

This document does not constitute a Site Assessment Report (SAR) as outlined in the UKWIR Guidance for the Selection of Water Supply Pipes to be Used in Brownfield Sites (Ref: 10/WM/03/21, 2010). As such, the full generic suite of testing recommended in the UKWIR guidance may not have been undertaken for this site and may be required by some water companies. However, consideration has been given to the 'threshold' concentrations presented in Table 3.1 of the UKWIR guidance, where they are applicable to the analysis undertaken, to provide an indication of the potential risks to buried water supply pipes.

Assessment framework

In regards to human health, the CLEA model states that, 'the contamination is assumed to be at or within 1m of the surface' (CLR10 pg10). It is considered that at depths greater than 1m, the probability of human exposure via the direct contact pathways are significantly reduced, leaving inhalation of volatile compounds as the dominant pathway with regard to human health risks. Typically, volatile compounds only significantly affect the indoor inhalation pathway. Therefore, for the purposes of statistical analysis, data from the top 1.0 to 1.5m is used for assessment of risks to human health via direct contact pathways in accordance with the CLEA model, dependant on proposed future site levels.

Ground Condition Assessment

Statistical analysis

The CLEA guidelines state that for each contaminant, the upper 95th percentile confidence limit on the mean measured concentration (95%UCL) should be calculated and this value should be compared to the GAC. Maximum value tests should also be performed in accordance with the method outlined in Annex 1 of CLR7.

The objective of these tests is to decide whether the maximum concentration observed should be treated as an outlier or whether it can reasonably be considered to come from the same underlying population as the other samples.

Annex 1 of CLR 7 describes a simplistic method for calculation of the 95%UCL value based on the arithmetic mean of the sample distribution, assuming the contaminant concentrations fall within a normal distribution. However, it is known that contaminant concentrations often tend towards other distribution forms.

Therefore, in order to calculate what are considered to be more representative 95%UCL values, the contaminant concentrations have first been assessed to determine if each contaminant distribution is closer to a normal or another distribution. If a dataset was found to be normally distributed, the arithmetic mean was used to calculate the 95%UCL using the 'One sample t-test' as described in CLR 7. If the distribution was determined to be significantly removed from normal, the one-sided Chebychev Theorem was used to calculate the 95%UCL. Constituent non-detects were assigned a value equal to the reported analytical laboratory limit of detection, considered reasonably conservative in accordance with CLR principles. Any identified outliers are excluded from the datasets used in calculation of the 95%UCL value, with justification.

Groundwater

Groundwater analyses, where undertaken, shall be assessed by direct comparison with the freshwater Environmental Quality Standards (EQS), or, in the absence of EQSs, UK or WHO Drinking Water Standards or other appropriate guidance values. For certain compounds, the EQS is quoted as a range of values based on the alkalinity of the water, where the measured concentration lies within this range, the results are interpreted qualitatively. The guideline values selected as appropriate GACs for each contaminant are presented in Appendix 3.

Leachate

Leachate analyses, where undertaken, shall be assessed in the same manner as the groundwater samples. The guideline values selected as appropriate GACs for each contaminant are presented in Appendix 3.

Ground Gas

The criteria used to assess the ground gas monitoring results, where monitored, have been taken from the following guidance documents:

- Assessing risks posed by ground gases to buildings, CIRIA Report C665, 2007
- Code of practice for the characterisation and remediation from ground gas in affected developments, British Standard BS 8485, 2007

Ground Condition Assessment

The frequency and period of monitoring is assessed based on the gas generation potential of the source material and the sensitivity of the development, in accordance with Figure 6 of BS8576 and Table 5.5 of CIRIA C665. As BS8576 promotes a risk based approach to ground gas assessment, it recognises that ground gas monitoring might not be necessary if a viable pollutant linkages is not present, e.g. if a 'credible' source with significant ground gas generation potential and/or a 'credible' migration pathway are not present.

The typical monitoring recommendations present in BS8576 and CIRIA C665 vary between four sets of readings over a one month period for a commercial development and a very low generation potential source to 24 rounds over 24 months for a residential property and a very high generation potential source. However, these are recognised as typical recommendations that may require fewer or additional readings depending on site specific circumstances.

Where possible, monitoring rounds are undertaken during a range of atmospheric conditions to enable their influence on gas conditions to be assessed. As monitoring over the recommended periods is frequently impractical on development sites, the monitoring rounds undertaken are conducted during the worst case conditions (e.g. low and falling atmospheric pressure) during the time available, as far as reasonably practicable, in order to limit the level of uncertainty resulting from the reduced monitoring period. It may, however, be appropriate to raise the Characteristic Situation to account for uncertainties on a site by site basis.

The Characteristic Situation for a monitoring location is determined using the worst case gas screening value for methane or carbon dioxide from all of the monitoring rounds at that location. Following the precautionary principal, the most stringent of the Characteristic Situations for the monitoring locations within the Site is generally used to classify the Site as a whole.

5.2. Soil Assessment

General

A total of 20no. near surface soil samples collected during the site investigation were submitted to a UKAS accredited laboratory for analysis for a suite of heavy metals, phenols, speciated polyaromatic hydrocarbons (PAHs), fractionated total petroleum hydrocarbons (TPH), BTEX compounds and several inorganic parameters. The results of the laboratory analyses are summarised in Appendix 4, in which they are compared to the relevant generic assessment criteria. A full set of all the laboratory test certificates is presented as Appendix 5.

The range of potentially hazardous contaminants present on the site can be wide and varied and the suite has been chosen to reflect both commonly found contaminants and others indicated by research to have a significant risk of being present. It is, however, possible that others may exist for which analyses have not been carried out or which were outside the scope of completed exploratory holes.

The decision to recommend acceptability or a requirement for remediation is based on the evaluation of a number of factors which when combined present a statutory or non-statutory risk that may require remedial action.

Ground Condition Assessment

Heavy metals

The heavy metals included in the analysis of the samples from the site were identified at concentrations well below the relevant GACs. Therefore heavy metals are not considered to present a significant source of contamination with regard to human health.

Petroleum hydrocarbons

Total petroleum hydrocarbon (TPH) concentrations were recorded to be well below GACs in all of the soil samples across the site with concentrations below the laboratory detection limits recorded in the majority of the samples. Therefore TPH is not considered likely to represent a significant source of contamination with regard to human health across the site.

Concentrations of TPH C11-C40 fractions were not recorded to exceed the UKWIR 'threshold' values for mineral oil. TPH is therefore considered unlikely to represent a potentially significant source of contamination to proposed water supply pipes. However, the designers of the water supply pipes for this site should review the data in this report to inform their decision making process.

Polyaromatic hydrocarbons (PAHs)

Polyaromatic hydrocarbon (PAH) compounds were recorded to be well below the relevant residential GACs in all of the soil samples across the site with concentrations below the laboratory detection limits recorded in the majority of the samples. Therefore PAHs are not considered to represent a significant source of contamination with regard to human health across the site.

BTEX compounds and MTBE

BTEX compounds and MTBE were generally not identified at concentrations in excess of the laboratory detection limits and were well below the relevant GACs in all of the samples from across the site. Therefore BTEX compounds and MTBE are not considered to represent a significant source of contamination with regard to human health.

Concentrations of BTEX and MTBE were not recorded to exceed the UKWIR 'threshold' values. BTEX and MTBE are therefore not considered to represent a significant source of contamination to proposed water supply pipes.

Inorganics

The concentrations of free cyanide fell below laboratory detection limits in all of the soil samples analysed.

The pH of the soil samples analysed was generally slightly acidic, falling within the 5-9 range.

Asbestos containing materials or fibres were identified in one sample taken from WS2 between 0.10 and 0.30mbgl, in the form of a fragment of board containing amosite.

5.3. Statistical Analysis

Statistical analysis was not considered to be appropriate on the analysis result for the samples from this site.

5.4. Ground Gas Assessment

The intrusive investigation of the site identified Topsoil and Made Ground of up to 0.40m thickness over Bognor Sand Member and London Clay Formation. No significant quantities of organic matter were observed within the natural soils during the investigation and the soil organic matter test data confirms the presence of moderately low organic content. With reference to Figure 6 of BS8576, the ground gas potential of the soils underlying the site is considered to be less than “very low”. Ground gas monitoring is therefore not considered to be necessary for the majority of the site.

However, to provide additional confidence to this assessment and to highlight any potential unexpected gas generation sources, an initial monitoring round of the three monitoring wells was undertaken. The presence and concentrations of ground gases in the installed monitoring wells were monitored in accordance with CIRIA C665 on 18th June 2015 to give a view of the ground gas regime at the site. The monitoring results are presented in Appendix 6.

During the gas monitoring round, flow rates of up to -1.2l/hr were recorded in monitoring wells. Typical steady state flow rates monitored in wells with water levels comfortably within the response zone were <0.1l/hr.

No significantly elevated concentrations of carbon dioxide or methane were recorded during the monitoring round. In all of the wells flammable gas as methane was recorded at a steady state of up to 0.1% by volume. Carbon dioxide was recorded as below 1.0% by volume in all locations.

The Gas Screening Values (GSVs) in all locations fell well below the boundary between Characteristic 1 and 2 (NHBC Green and Amber 1) in all six monitoring rounds.

Therefore, no ground gas protection measures are recommended for the site.

Section 6 – Conceptual Site Model

6.1. Sources

The conceptual model, based on information obtained as part of the generic risk assessment, identified the following potential contaminant sources:

On-site – Historic and Current

- Made Ground impacted with asbestos

It should be noted that additional sources of contamination may become apparent during any future investigation and development of the site.

Off-site – Historic and Current

- None

6.2. Pathways

The key environmental pathways and exposure routes by which potentially toxic substances can reach the identified potential receptors are considered to be:

Direct

- Inhalation of asbestos fibres.

6.3. Receptors

Receptors that may be affected by the potential contamination are:

Human

- Future construction workers
- Future residents of the site.

Section 7 – Risk Assessment

7.1. Risk Assessment Procedure

By considering the sources, pathways and receptors (pollutant linkages), an assessment of the human health/ environmental risks is made with reference to the significance and degree of the risk. This assessment is based on consideration of whether the source contamination can reach a receptor and hence whether it is of major or minor significance.

The risk assessment has been undertaken with reference to BS10175:2001 and CIRIA Document C552: Contaminated Land Risk assessment 'A Guide to Good Practice'. The risk assessment has been carried out by assessing the severity of the potential consequence, taking into account both the potential magnitude of the hazard and the sensitivity of the target, based on the categories given overleaf.

Table 7.1: Sensitivity of receptor

Category	Examples
High	Residential with gardens/Groundwater Source Protection Zone
Medium	Residential without gardens/Principal (Major) Aquifer/sensitive watercourse
Low	Commercial and industrial use/Secondary (Minor) Aquifer
Very Low	Construction and maintenance workers/non-sensitive watercourse

Table 7.2: Magnitude of impact

Category	Examples
Gross Impact	Heavily contaminated gasworks or industrial site, hazardous waste landfill
Moderate Impact	Major leaks and spills from fuel infrastructure (e.g. petrol stations), domestic waste landfills
Slight Impact	Minor leaks and spills from fuel infrastructure, 'inert' waste landfills

Table 7.3: Level of severity of potential hazard

Magnitude of impact	Sensitivity of receptor			
	High	Medium	Low	Very Low
Gross Impact	Severe	Medium	Mild	Minor
Moderate Impact	Medium	Mild	Minor	Minor
Slight Impact	Mild	Minor	Minor	Minor

The likelihood of an event (probability) takes into account both the presence of the hazard and target and the integrity of the pathway and has been assessed based on the categories given below.

Ground Condition Assessment

Table 7.4: Probability of risk definition

Category	Examples
High likelihood	Pollutant linkage may be present, and risk is almost certain to occur in long term, or there is evidence of harm to the receptor
Likely	Pollutant linkage may be present, and it is probable that the risk will occur over the long term
Low likelihood	Pollutant linkage may be present, and there is a possibility of the risk occurring, although there is no certainty that it will do so
Unlikely	Pollutant linkage may be present, but the circumstances under which harm would occur are improbable

The potential severity of the risk and the probability of the risk occurring have been combined in accordance with the following matrix in order to give a level of risk for each potential hazard.

Table 7.5: Level of risk for potential hazard definition

Probability of risk	Sensitivity of receptor			
	Severe	Medium	Mild	Minor
High likelihood	Very High	High	Moderate	Low/Moderate
Likely	High	Moderate	Low/Moderate	Low
Low likelihood	Moderate	Low/Moderate	Low	Very Low
Unlikely	Low/Moderate	Low	Very Low	Very Low

The assessment is discussed below in terms of plausible pollutant linkages. A complete assessment of the pollutant linkages is presented in Table 4.6.

A description of these risk classifications and likely action required are given in CIRIA 552 as:

Very high risk – High probability that severe harm could arise to a designated receptor from an identified hazard OR there is evidence that severe harm to a designated receptor is currently happening. This risk, if realised, is likely to result in substantial liability. Urgent investigation and remediation are likely to be required.

High risk – Harm is likely to arise to a designated receptor from an identified hazard. This risk, if realised, is likely to result in substantial liability. Urgent investigation is required and remedial works may be necessary in the short term and are likely over the long term.

Moderate risk – It is possible that harm could arise to a designated receptor from an identified hazard. However, it is either relatively unlikely that any such harm would be severe, or if any harm were to occur it is more likely that the harm would be relatively mild. Investigation is normally required to clarify risks and to determine potential liability. Some remedial works may be required in the long term.

Low risk – It is possible that harm could arise to a designated receptor from an identified hazard but it is likely that this harm, if realised, would at worst normally be mild.

Very low risk – It is a low possibility that harm could arise to a designated receptor. In the event of such harm being realised it is not likely to be severe.

Ground Condition Assessment

7.2. Pollutant Linkage Assessment

Table 7.6: Pollutant linkage assessment

Source	Pathway	Receptor	Severity	Likelihood	Risk Level
Asbestos in Made Ground	Inhalation of fibres	Construction workers	Medium	Low Likelihood	Low/ Moderate
		Future site users	Medium	Low Likelihood	Low/ Moderate

Asbestos in Made Ground

The main identified risk driver on the site is asbestos present in Made Ground. A fragment of asbestos board, containing amosite, was identified in the Made Ground in WS2. As Made Ground of up to 0.4m thickness was only encountered at two locations on the site, The quantity of Made Ground Present is not considered to be large but should be considered as impacted with asbestos containing materials unless it can be proven otherwise. Mitigation measures will therefore be required to address this risk as part of the development of the site.

Therefore, appropriate asbestos awareness training and vigilance are recommended for the personnel involved in the development of the site. If asbestos containing materials are identified during the works they should be appropriately disposed of and the risks reassessed. Mitigation measures such as dust suppression, PPE provision and possibly source removal to mitigate the risks to construction workers and source removal or an appropriately designed cover system in soft landscaped areas to mitigate the risks to future site users might be required, based on the findings of the reassessment.

Consideration will also need to be given to waste classification if Made Ground is to be disposed of off-site and may need to be supported by asbestos in soil quantification testing.

Ground Condition Assessment

Section 8 – Geotechnical Assessment

8.1. Introduction

The geotechnical assessment and the subsequent foundation design recommendations will use the findings of the ground investigation and the results of the in-situ and geotechnical testing carried out in the boreholes and on representative samples of the material encountered.

8.2. Geotechnical Tests

A programme of geotechnical laboratory testing was carried out on representative samples collected from the strata encountered during the ground investigation.

Details of the specific procedure used in each case are shown below in Table 8.1 and the geotechnical test certificates are presented in Appendix 7.

Table 8.1: Summary of Geotechnical Testing

Test	Standard (BS1377:1990) unless otherwise indicated	No.
Classification Tests		
Atterberg Limits	Part 2, Clauses 4.3, 5.3 & 5.4	3
PSD Wet Sieve	Part 2, Clause 9.2	12
Shear Strength Tests		
Quick Undrained Triaxial	Part 7, Clause 8.4	1
Chemical Tests		
BRE SD1	Various	2
Sulphate Content 2:1 soil water extract	Part 3, Clause 5.3	4
pH value	Part 3, Clause 9.0	4



8.3. Geotechnical and Geological Parameters

This section discusses the key geotechnical characteristics of each encountered stratum as determined from field observations, in-situ and laboratory geotechnical testing.

Topsoil / Made Ground

Topsoil

Topsoil was encountered at all locations and comprised 0.1 to 0.45m of brown clayey silty fine to medium sand with rootlets and locally flint gravel.

Ground Condition Assessment

Made Ground

Made ground was encountered in WS3 and differed from the Topsoil by the presence of brick and tile fragments. Asbestos was also encountered in the Shallow soils in WS1, however, the material appeared to be Topsoil.

No in-situ or geotechnical laboratory testing was carried out within the Topsoil / Made Ground as all foundations will be constructed beneath these superficial materials.

Bognor Sand Member

The Bognor Sand Member (BSM) was encountered immediately beneath the Topsoil / Made Ground and comprised an orange brown becoming grey fine sand with occasional gravel. The base of the BSM has been placed at the depth where the material becomes cohesive giving proven thicknesses of 5.70 to >9.90m in the cable percussive boreholes. In the windowless sample boreholes the full thickness of this stratum was not proven.

In-situ testing

Standard penetration testing (SPT) was carried out throughout the BSM. The distribution of SPT N and corrected N' values are shown in Table 8.2 and presented graphically in Figure 3.

Table 8.2: Distribution of SPT N Values in the Bognor Sand Member

BH No.	Depth (mbgl)	SPT N Value	N'	Major Constituent	BH No.	Depth (mbgl)	SPT N Value	N'	Major Constituent
BH1	1.70	12	28	Sand	BH3	1.20	11	30	Sand
	2.50	15	28			2.00	17	37	
	3.50	23	37			3.00	11	19	
	4.50	26	36			4.00	25	38	
	5.50	35	42			5.00	18	23	
	8.50	23	23			7.00	24	24	
	10.00	30	30						
BH2	1.20	37	>50	Sand	BH4	1.20	19	50	Sand
	2.00	23	49			2.00	29	50	
	3.00	25	44			3.00	26	50	
	4.00	28	42			4.00	31	47	
	5.00	29	36			5.00	50	>50	

Ground Condition Assessment

Table 8.2 Contd.

BH No.	Depth (mbgl)	SPT N Value	N'	Major Constituent	BH No.	Depth (mbgl)	SPT N Value	N'	Major Constituent	
BH5	1.20	11	30	Sand	WS4	1.00	25	>50	Sand	
	2.00	11	24			2.00	22	47		
	3.00	31	>50			3.00	>50	>50		
	4.00	29	43		WS5	1.00	21	>50	Sand	
	5.00	31	39			2.00	10	22		
BH6	1.20	14	38	Sand		3.00	35	>50		Sand
	2.00	11	24		4.00	>50	>50			
	3.00	5	9		WS6	1.00	24	50	Sand	
	4.00	28	42			2.00	25	50		
	5.00	32	40			3.00	27	47		
BH7	1.20	17	46	Sand	WS7	4.00	27	41	Sand	
	2.00	18	39			1.00	19	>50		Sand
	3.00	16	28			2.00	13	28		
	4.00	34	>50		3.00	50	>50	Sand		
	5.00	>50	>50		WS8	1.00	25		>50	Sand
WS1	1.00	18	50	Sand		2.00	16	34		
	2.00	18	39	3.00		>50	>50			
	3.00	7	12	WS9	1.00	16	44	Sand		
	4.00	>50	>50		2.00	20	43			
WS2	1.00	16	44		Sand		3.00		26	46
	2.00	10	22	WS10	4.00	50	>50	Sand		
	3.00	>50	>50		1.00	19	>50			
					2.00	23	49			
					3.00	40	>50			
								4.00	49	>50

*Values of N' derived in accordance with BS8002

Careful inspection shows no easily identifiable trend within the results with the majority of the data set falling in the range N=10 and N=30 (Figure 3).

Ground Condition Assessment

Classification Testing

Particle Size Distribution

Twelve representative samples of the BSM underwent laboratory determination of the particle size distribution using the wet sieve method of which five underwent sedimentation analyses to determine their clay and silt content. The results of these analyses are presented in Table 8.3 and copies of the grading envelopes and laboratory test certificates are located in Appendix 7.

Table 8.3: Results of the Particle Size Distribution Analyses – Bognor Sand Member

Sample	Depth (m)	Particle Size Distribution (%)					Clay & Silt Content (%)
		Gravel	Silt	Sand	Gravel	Clay	
BH1	0.50	25	20	12	42	0	NC
	1.70	11		86	3	0	NC
	5.50	22		78	0	0	NC
	8.00	27	34	39	0	0	NC
	9.50	72		28	0	0	NC
BH2	0.50	21	28	31	20	0	NC
	3.00	12		88	0	0	NC
	6.00	30		70	0	0	NC
WS2	2.00	9		91	0	0	1.9
WS5	3.00	13		87	0	0	NC
WS10	3.00	5	10	85	0	0	19
WS9	2.00	4	10	87	0	0	3.5

NC – Not Calculated

The results of the particle size distribution analyses have identified a stratigraphy within the BSM. The upper units comprise a gravelly sand / sandy gravel which is underlain by a slightly silty to silty fine to medium sand to a minimum depth of 5.50m whereupon the fine-grained content increases to form a gradational boundary with the London Clay Formation.

Where calculated the Uniformity Coefficient suggests the sand horizon to be generally even graded.

Ground Condition Assessment

Shear Strength

The strength of the BSM has been determined from the corrected SPT data. The peak and critical state shearing resistance have been calculated using the following equations:

The estimated peak angle of shearing resistance is:

$$\phi'_{\max} = 30 + A + B + C$$

The estimated critical state angle of shearing resistance is:

$$\phi'_{\text{crit}} = 30 + A + B$$

Where A is the angularity of the particles

B is the grading of the Sand/Gravel

C is the results of the corrected SPT N values.

Based on the above equations and the values for the A, B & C coefficients presented in BS8002, a peak angle of shearing resistance of 40° and a critical angle of shearing resistance of 35° are considered appropriate for BSM.

Other Geotechnical Parameters

Modulus of Deformation (E_k)

The deformation modulus for square and long strip foundations can be obtained by multiplying the static cone resistance by a factor of 2.5 or 3.5 respectively. Where only SPT data is available the static cone resistance q_c (in kg/cm²) can be obtained by multiplying the N value by an empirical factor. For clean fine to medium sands a value of 3.5 is recommended.

Table 8.4: Deformation Modulus for the Bognor Sand Member

Mean SPT N Value	Equivalent Static Cone Resistance (kg/cm ²)	Static Cone Resistance (MN/m ²)	Deformation Modulus E_k (MN/m ²)	
			Strip	Square
40	140	14	50	35

London Clay Formation

London Clay Formation (LCF) was encountered immediately below the BSM and persisted to the full depth of the ground investigation. The boundary between the BSF and LCF was gradational and has been taken to be where the material becomes cohesive. Based on this division of the strata the LCF comprised grey silty clay.

The full thickness of the LCF was not encountered in any borehole although a maximum proven thickness of > 4.20m was encountered in BH5.

Ground Condition Assessment

In-situ testing

Standard penetration testing (SPT) was carried out throughout the LCF. The distribution of SPT N and corrected N' values are shown in Table 8.5 and presented graphically in Figure 3.

Table 8.5: Distribution of SPT N Values in the River Terrace Deposits

BH No.	Depth (mbgl)	SPT N Value	N'	Major Constituent	BH No.	Depth (mbgl)	SPT N Value	N'	Weathered / Unweathered
BH2	6.50	20	20	Clay	BH5	8.00	21	21	Clay
	9.50	26	26		BH6	8.00	23	23	Clay
BH4	8.00	26	26	Clay	BH7	8.00	29	29	Clay

*Values of N' derived in accordance with BS8002

There is some evidence of an increase in undrained shear strength with depth; however the limited data set makes this difficult to confirm. Therefore no increase in SPT N will be used and a single characteristic value will be used to develop the undrained shear strength.

Classification Testing

Consistency Limits

Three Atterberg limits tests were carried out on a representative samples of the LCF. The results of these tests are shown in Table 8.6.

Table 8.6: Results of the Atterberg Limits Analyses – London Clay Formation

Location	Depth (mbgl)	Natural Moisture Content, w (%)	Liquid Limit w _L (%)	Plastic Limit w _P (%)	Plasticity Index I _P (%)	Corrected Plasticity Index (%)
BH2	7.50	22	41	20	21	21
	8.00	22	44	20	24	24
	9.50	21	46	18	28	26

The calculated plasticity indices range between 21 and 26% which is consistent with an intermediate plasticity clay. No correction to the indices were required as all the samples passed the 425µm sieve. Careful inspection of this limited data set suggests that the plasticity index increases with depth which is consistent with a decrease in silt /fine sand content with depth.

The consistency index is the numerical difference between the liquid limit and the natural moisture content expressed as a percentage ratio of the plasticity index, and can be written as:

$$I_C = \frac{w_L - w}{I_P}$$

Calculations based on the results of the Atterberg limits test (Table 8.6) give a range of consistency indices between 0.90 and 0.96 which are indicative of a stiff consistency.

Ground Condition Assessment

Shear Strength

Undrained Shear Strength

One representative sample of the LCF underwent laboratory quick undrained triaxial compression testing. The result of the laboratory testing are presented in Table 8.7; whilst the laboratory test certificate is located in Appendix 7.

Table 8.7: Results of the QU triaxial Compression Testing – London Clay Formation

Location	Depth (mbgl)	Bulk Density (Mg/m ³)	Cell Pressure (kN/m ²)	Undrained Shear Strength c_u (kN/m ²)
BH1	8.00	2.66	217	218

The result of the QU triaxial testing give c_{uk} values of 218kN/m² which is consistent with a very high strength material.

This laboratory test result has been augmented with c_{uk} values derived from the widely accepted empirical relationship:

$$c_u = f_1 \times SPTN$$

Where f_1 is a correlation factor based on the I_p

Using a correlation factor of 5, all the undrained shear strength data has been plotted and indicates that the laboratory test result is significantly higher than those achieved using the SPT correlation (Figure 4).

Based on the whole data set a conservative characteristic undrained shear strength of 125kN/m² is considered appropriate for the London Clay Formation.

Drained (Effective) Shear Strength

The widely accepted relationship between drained shear strength and plasticity index for remoulded clays has been used to determine the effective shear strength parameters. In terms of effective stress, the shear strength of a fine-grained soil can be considered as frictional, such that $c'_k = 0$ kN/m².

A characteristic plasticity index of 24% has been determined for the LCF suggesting that a characteristic effective angle of shearing resistance (ϕ'_k) of 25° is appropriate for this material.

Other Geotechnical Parameters

Modulus of Deformation (E_k)

Butler (1974) gives an E_{uk}/c_u ratio of 400 for London Clay giving an undrained modulus of 50MN/m². CIRIA R 143 suggests that the drained modulus (E'_k) should be taken as $0.75E_{uk}$. Therefore an E'_k of 37MN/m² is considered appropriate for the LCF.

Ground Condition Assessment

Coefficient of Volume Compressibility

The coefficient of volume compressibility (m_v) has been determined from the empirical relationship with the plasticity index (I_p), where:

$$m_v = \frac{1}{f_2 N}$$

Where f_2 is a correlation factor based on the characteristic I_p and N is the characteristic SPT- N value.

The above relationship gives an m_{vk} of $0.08\text{m}^2/\text{MN}$ which is indicative of a material of low to medium compressibility.

8.1. Aggressive Ground Soil Chemistry

Chemical testing was carried out on six samples of the encountered materials in accordance with Box C10, BRE Special Digest 1. The results are summarised in Tables 8.8 and 8.9.

Table 8.8: Summary of the Results of Chemical Testing for Concrete Classification

Test	BH1	BH1	BH2	WS5
	0.50	8.00	0.50	3.00
	BSM	BSM	BSM	BSM
pH	7.46	7.68	7.63	7.50
Soluble Sulphate (g/l)	0.46	0.99	0.59	0.27

Table 8.9: Summary of BRE SD1 Results

Test	BRE SD1	
	BH1	BH2
	9.50 (BSM)	7.50 (LCF)
pH	7.7	7.8
Total Sulphate (% SO ₄)	0.18	0.13
Total Sulphur (% S)	0.78	0.47
Water Soluble Sulphate (g/l) SO ₄)	0.65	0.45
Water Soluble Chloride (mg/kg)	<40	<40
Water Soluble Nitrate (mg/kg)	<40	<40
Ammonium (mg/kg)	<0.1	<0.1

The amounts of oxidisable sulphides have been determined following the procedure documented in Paragraph C5.1.2 of BRE SD1. The results indicate that pyrite is likely to be present in significant amounts. Based on the maximum determined total potential sulphate content Table C1 of BRE SD1 gives a Design Sulphate classification of DS4 and an Aggressive Chemical Environment for Concrete (ACEC) Class of AC-3s assuming static groundwater conditions in LCF.

Ground Condition Assessment

However, for shallow foundations placed entirely within the BSM the results indicate a Design Sulphate classification of DS-2 and ACEC of AC-2 assuming mobile groundwater in the BSM.

8.2. Characteristic Geotechnical Parameters

Based on the laboratory test results, in-situ testing and subsequent analysis a range of characteristic geotechnical parameters, which should be used in all subsequent geotechnical and foundation design calculations are presented in Table 8.10.

Table 8.10: Characteristic Geotechnical Parameters

Stratum	Parameter		Source	Value		
Topsoil /Made Ground	All foundations to be constructed beneath Made Ground					
Bognor Sand Member	Unit Weight γ_k (kN/m ³)		BS8002	20kN/m ³		
	Shear Strength	c_k (kN/m ²)				
		ϕ_k (°)	BS8002	35°		
	Modulus of Deformation	E_k (MN/m ²)	Correlation with q _c	Pad	35MN/m ²	
				Strip	50 MN/m ²	
London Clay Formation	Unit Weight γ_k (kN/m ³)		BS8002	19kN/m ³		
	Undrained Shear Strength	c_{uk} (kN/m ²)	Laboratory QU Triaxial Testing & Correlation with SPT N	125kN/m ²		
		ϕ_{uk} (°)		0°		
	Drained Shear Strength	c'_k (kN/m ²)	Relationship with I _p	0kN/m ²		
		ϕ'_k (°)		25°		
	Modulus of Deformation	Undrained E_{uk} (MN/m ²)	400 x c _{uk}	50MN/m ²		
		Drained E'_k (MN/m ²)	0.75 x E_{uk}	37MN/m ²		
	Modulus of Volume compressibility	m_v (m ² /MN)	Relationship with SPT and I _p	0.08m ² /MN		

Section 9 – Foundation and Ground Engineering

9.1. Introduction

The geotechnical assessment below relates to the details of the proposed development. It is understood that the proposed development is to comprise a residential development. It is unclear at the time of writing if any of the proposed dwellings are to comprise multi-storey blocks of flats.

Seven cable percussive boreholes (BH1-7) and ten windowless sample boreholes (WS1-10) were undertaken on the site. The ground conditions encountered comprised Topsoil / Made Ground overlying Bognor Sand Member with London Clay Formation forming the basal unit in BHs 2, 4 - 7. The Bognor Sand Member comprised a gravelly Sand / sandy gravel overlying fine to medium Sand to approximately 5.00mbgl at which depth the fine – grained content gradually increases. The top of the London Clay Formation has been placed where stratigraphy becomes stiff grey silty clay.

Standing groundwater level recorded during the subsequent monitoring visit recorded the groundwater between 1.85 and 2.06mbgl across the site.

Shallow Foundations

Depth of Foundations

It is recommended that all foundations are constructed below the Made Ground / Topsoil within the BSM. Consideration should be given to the presence of medium volume change LCF beneath the site. NHBC Guidelines presents three conditions that should be assessed when considering the case of non-shrinkable soil over a shrinkable soil:

- ☐ Consistent soil conditions exist across each plot. This should be confirmed by the site investigation;
- ☐ The depth of the non-shrinkable soil is greater than $\frac{3}{4}$ depth X, where X is the foundation depth determined, assuming that all the soil is shrinkable;
- ☐ The thickness T of non-shrinkable soil below the foundation is equal to or greater than the width of the foundation B.

As all the above conditions are met it is appropriate to disregard the presence of the medium volume change potential LCF. Although Building Control may have their own minimum foundation depth requirements it is recommended that foundations are constructed at 0.75mbgl within the BSM.

Ground Condition Assessment

Ultimate Limit State Bearing Resistance

Bearing resistance analysis was carried out in order to check the Ultimate Limit State (ULS) bearing resistance of the Bognor Sand Member. The ground model and characteristic material properties used in the ULS analysis are presented in Table 9.1.

Table 9.1: Ground Model used in the ULS Bearing Resistance Calculations

Ground Model	Stratum	Thickness		Shear Strength Parameters			
		From (mbgl)	To (mbgl)	Total		Effective	
				c_{uk} (kN/m ²)	ϕ_{uk} (°)	c'_k (kN/m ²)	ϕ'_k (°)
GM1	Topsoil / Made Ground	GL	0.30	Not used			
	Bognor Sand Member	0.30	5.70	0	35	0	35
	London Clay Formation	5.70	>4.30	125	0	0	25

The UK has implemented Design Approach 1 (DA1) of BS EN1997-1:2004 (Eurocode 7: Geotechnical Design), which requires two design combinations to be satisfied:

Combination 1 (C1): A1 “+” M1 “+” R1

Combination 2 (C2): A2 “+” M2 “+” R1

Where A, M and R refer to groups of partial factors relating to actions, materials and resistance respectively.

Table 9.2: Partial Factors Applied to the Bearing Resistance Analysis

	Combination 1			Combination 2		
	A1	M1	R1	A2	M2	R2
Tangent of the Angle of Shearing Resistance ($\tan \phi$)		1.00			1.25	
Cohesion Intercept (c')		1.00			1.25	
Undrained Cohesion c_u		1.00			1.40	
Permanent Action	1.35					
Variable Action	1.50					
Resistance						1.00

The summary of the bearing checks are presented in Table 9.3 and the geotechnical calculation sheets are located in Appendix 8.

Ground Condition Assessment

Table 9.3: Summary of ULS Bearing Resistance Checks

GM	Foundation Type	Foundation Dimensions	Depth (mbgl)	DA1 Combination	Bearing Resistance (kN / m ²)
1	Strip	0.75m wide	.0.75	1	788
				2	374

These calculations indicate that combination 2 presents the most critical case. The results given represent the ultimate limit state that is the maximum load that can be supported by the soil without failure occurring within the soil mass.

The bearing resistances calculated indicate a ULS of 370kN/m² for a 0.75m wide strip foundation at a minimum depth of 0.75mbgl.

Serviceability Limit State

Eurocode 7 states that calculations of settlement must always be carried out on footings on soft clays - and should be carried out on footings on firm to stiff clays when the risk is anything other than negligible. However, for completeness an SLS settlement assessment has been carried out

Verification of serviceability limit state (SLS) is demonstrated by satisfying the inequality:

$$s_{Ed} = s_0 \leq s_{Cd}$$

where s_{Ed} is the total settlement; and
 s_{Cd} is the limiting value of that settlement

Without site / structure specific data a limiting value of settlement (s_{Ed}) of 25mm is considered appropriate for the type of construction under consideration. Partial factors for serviceability limit state analyses have all been taken as 1.

The settlement analysis has been carried out using the Rockscience software programme Settle 3D. The results are presented in Appendix 8 and précised in Table 9.4.

Table 9.4: Results of Settlement Analyses

Foundation Type	Depth (m)	Applied Foundation Loading (kN / m ²)	Founding Stratum	Immediate Settlement (mm)	Consolidation Settlement (mm)	Total Settlement (mm)
Strip	0.90	135	Bognor Sand Member	13	8	21

Ground Condition Assessment

The results of the settlement analyses show that if bearing pressures do not exceed 370kN/m² settlements will remain less 25mm.

The foundation design presented in the previous sections is considered appropriate for any two-storey dwellings. However, if multi storey blocks are to be constructed on the site the calculated bearing resistance may prove to be too restrictive.

If this proves to be the case it is recommended that a piled foundation is considered for these elements of the development.

9.2. Piled Foundations

The pile design has been carried out using the partial factors recommended in the UK National Annex to BSEN 1997.

Pile Calculations

Given the properties of the strata beneath the site, values for an axially loaded piles have been determined using the following relationships:

Characteristic Shaft Resistance – Bognor Sand Member

$$R_{sk} = \frac{K_s \sigma'_v \tan \delta}{\gamma_{rd}}$$

Characteristic Shaft Resistance – Fine-Grained London Clay Formation

$$R_{sk} = \frac{\alpha \times \bar{c}_{u,d} \times A_s}{\gamma_{rd}}$$

Characteristic End Bearing – London Clay Formation

$$R_{Bk} = \frac{N_c \times c_{u,d,B} \times A_B}{\gamma_{rd}}$$

Design Approach

The pile design has been carried out using the UK National Annex to EC7. The design approach and combination of partial factors and their values are presented in Table 9.5.

Table 9.5: Design Approach and Partial Factors used in Pile Design

CFA Pile								
Combination	Design Action Load	γ_G	Material Factors	All Partial Factors	Design Resistance	γ_b	γ_s	γ_{Rd}
1	A1	1.35	M1	1.00	R1	1.00	1.00	1.4
2	A2	1.00	M1	1.00	R4	2.00	1.60	1.4

Ground Condition Assessment

Although higher carrying capacities are often achieved by driven piles, however, as the use of driven piles can cause environmental issues (noise and vibration) the initial axial resistance calculations have been carried out on augured piles.

The ULS axial resistances of a 0.3, 0.4, and 0.5m diameter augured pile of varying length have been determined for the ground model presented in Table 9.1. The Geocentrix Repute Software programme has been used to calculate the axial resistances. The resultant calculation worksheets are presented in Appendix 8 and a précis of the results is shown in Table 9.6.

Table 9.6: Design Pile Resistances – Augured Pile

Pile Diameter (m)	Pile Length (m)	Combination	Design Pile Resistance (kN)			
			MG	Skin Friction (R_{sd})	End Bearing (R_{bd})	Design Axial Pile Resistance (kN)
0.30	5.00	C2	No input in Axial Resistance	55	5	60
	7.50			126	32	158
	10.00			206	33	239
0.40	5.00	C2	No input to Axial Resistance	73	8	81
	7.50			168	57	225
	10.00			274	59	333
0.50	5.00	C2	No input to Axial Resistance	88	12	100
	7.50			210	89	299
	10.00			343	93	436

The above pile axial resistances should be used as a guide only. It is recommended that if a piled foundation solution is the preferred option then the advice of an experienced piling contractor is sought.

When dimensioning a pile the applied load must be multiplied by the appropriate partial factor, γ_G (Table 9.5).

It must be remembered that the carrying capacity of a pile group is generally less than the sum of the individual piles. Therefore it is recommended that a pile group analysis is carried out once all the loads and serviceability limits are known.

Other Foundation Considerations

During the ground investigation groundwater seepages were reported in a number of the boreholes. The shallowest of these being at 1.40mbgl in BH2, subsequent groundwater monitoring placed the groundwater at between 1.85 and 2.06mbgl. As all these groundwater levels are below the proposed the foundation depth it is likely that foundation excavations will remain stable in the short term provided no perched groundwater is encountered.

Ground Condition Assessment

The ground investigation has shown that the depth of the medium volume change London Clay Formation is outside of the zone of influence of the foundation. Therefore ground bearing floor slabs are considered appropriate across the whole site.

9.3. Other Geotechnical Considerations

Accessways and Hardstandings

Californian Bearing Ratios were assessed at seven locations across the site using a TRRL probe. The results indicate a preliminary design CBR of 8% is appropriate for construction in the top 1.00m below existing ground level. A full set of TRRL probe data is resented in Appendix 9.

Chemical Attack on Buried Concrete

BRE testing of the Bognor Sand Member and London Clay Formation has shown it to be potentially pyritic at depth and it conforms to a Design Sulphate classification of DS-4 and an ACEC of AC-3s.

However, for shallow foundations constructed entirely within the BSM a Design Sulphate classification of DS-2 and ACEC of AC-2 is considered appropriate.

Section 10 – Conclusions and Recommendations

10.1. Contamination

The following sources of contamination were identified:

- Potential for localised asbestos containing material fragments

The risk of impact to identified receptors from the identified sources is generally considered to be **low/moderate**.

It is recommended that any Made Ground encountered on the site, particularly in the vicinity of WS2 should be considered to be impacted with asbestos containing materials. It is further recommended that this material is either removed from site or placed beneath suitable hard standing or an engineered cover system.

It is recommended that vigilance for asbestos containing material is maintained throughout the development of the site, with appropriate training for site staff, particularly in areas associated with tracks and access points.

General Notes

In order to mitigate the generic risks associated with development on potentially contaminated land the following mitigation measures are recommended:

- Preparation of a Discovery Strategy outlining the procedures to be followed in the event that unanticipated contamination is encountered during the development.
- Compliance with relevant Health and Safety procedures during construction works.
- Contractors on site should wear appropriate PPE to mitigate the risks from the chemical and physical impacts to the Made Ground at the site.
- The local authority should be informed if any sources of contamination are identified during the development that have not been assessed in this report. These sources should then be assessed and dealt with appropriately, with the agreement of the local authority.

These mitigation measures, as with any such mitigation or remedial measures, are subject to agreement with the regulatory authority, be it the Local Authority for human health related issues or the Environment Agency for environmental issues.

It is recommended that any removal and disposal of sub-soil arisings and/or groundwater from the site should be undertaken in a controlled manner to a licensed facility, with due regard to Duty of Care responsibilities. In addition, an appropriate degree of health and safety provision should be incorporated to protect both the site workers and the general public alike.

During any ground works, it is recommended that skin contact with soils is kept to a minimum in accordance with good working practice / specific control measures and the HSE guidance document 'Protection of Workers and the General Public During the Development of Contaminated Land', 1991.

Ground Condition Assessment

10.2. Geotechnical

10.3. Geotechnical

The ground investigation revealed ground conditions to comprise Topsoil /Made Ground overlying the Bognor Sand Member (BSM) which attained a minimum thickness of 5.70m (BH5). London Clay Formation was encountered immediately below the BSM to the full depth of the ground investigation. The boundary between the BSM and the LCF was gradational with an increase in the fine-grained component, the boundary between the two strata was placed where the material became cohesive.

Shallow Foundations

An Ultimate Limit State (ULS) bearing resistance analysis has been carried out on a 0.75m wide strip foundation constructed at 0.75mbgl within the Bognor Sand Member. The results indicate a ULS bearing resistance of 374kN/m².

Serviceability Limit State settlement analyses have been carried out and reveal that foundations constructed within the BSM with foundation loads equivalent to the ULS bearing resistance will undergo less than 25mm settlement. Furthermore, given the granular nature of the BSM much of the predicted settlement will be immediate and therefore largely built out during construction.

Piled Foundations

It is unclear at the time of reporting whether any multi-storey blocks are to form part of this development. If this is the case it is possible that the calculated bearing resistance may be too restrictive. Therefore, ULS axial pile resistances have been calculated for a range of diameters and lengths of augured pile. However, when sizing piles from these results all applied actions must be factored in accordance with the UK National Annex to Eurocode 7.

It should be noted that the carrying capacity of a pile group is usually less than the sum of the individual piles. Therefore it is recommended that a detailed pile group analysis is carried out when all loads and serviceability limits are known.

Other Foundation Considerations

Groundwater was encountered at a minimum of 1.40mbgl during the ground investigation. During subsequent monitoring visits the groundwater level at the same location was recorded at 1.90mbgl suggesting that there is some perched groundwater bodies on the site as a result of change in the vertical permeability of the ground. Foundation excavations undertaken with the BSM should be above the standing water levels and the water strike levels and therefore it is anticipated they will remain stable in the short term.

Ground bearing floor slabs are considered appropriate across the whole site.

Other Geotechnical Considerations

The Californian Bearing Ratio (CBR) was determined for the top 1.00m of the site using a TRRL probe. The results indicate a preliminary design CBR of 8% is appropriate for the site.

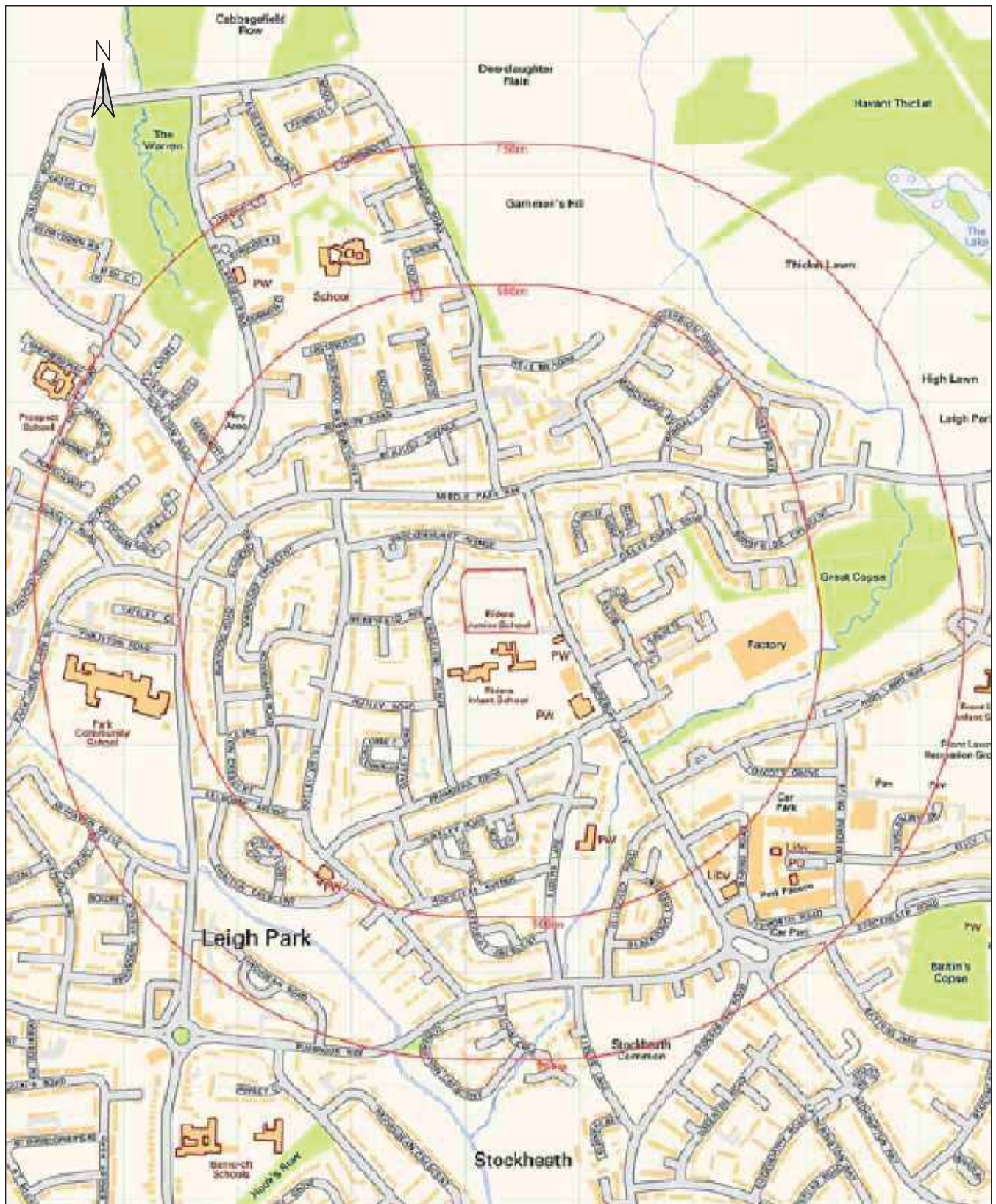
Ground Condition Assessment

Concrete Aggressivity

Chemical tests carried out on the Bognor Sand Member at shallow depths show the material to conform to Design Sulphate Class 2. Based on the mobile groundwater conditions in the Bognor Sand Member an ACEC classification AC-2 should be adopted.

If a deep foundation solution is adopted then BRE SD1 tests indicate the stratigraphy at depth to be potentially pyritic having Design Sulphate Classification of DS4 and based on static groundwater in the LCF an ACEC of AC-3s.

Figure 1 – Site Location Plan



-	20.07	PRELIMINARY	DAP	AP
REF	DATE	REVISION	DRAWN	CHECKED

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HAMPSHIRE, SO23 7R
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DRAWING

151240 - SITE LOCATION

SCALE
NTS @ A4

DATE
20.07.15

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FIGURE 1

REV

Figure 2 – Investigation Location Plan



KEY:

-  BOREHOLE LOCATION
-  WINDOW SAMPLE LOCATION
-  TRL PROBE LOCATION

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151240 - SITE INVESTIGATION LOCATIONS

SCALE
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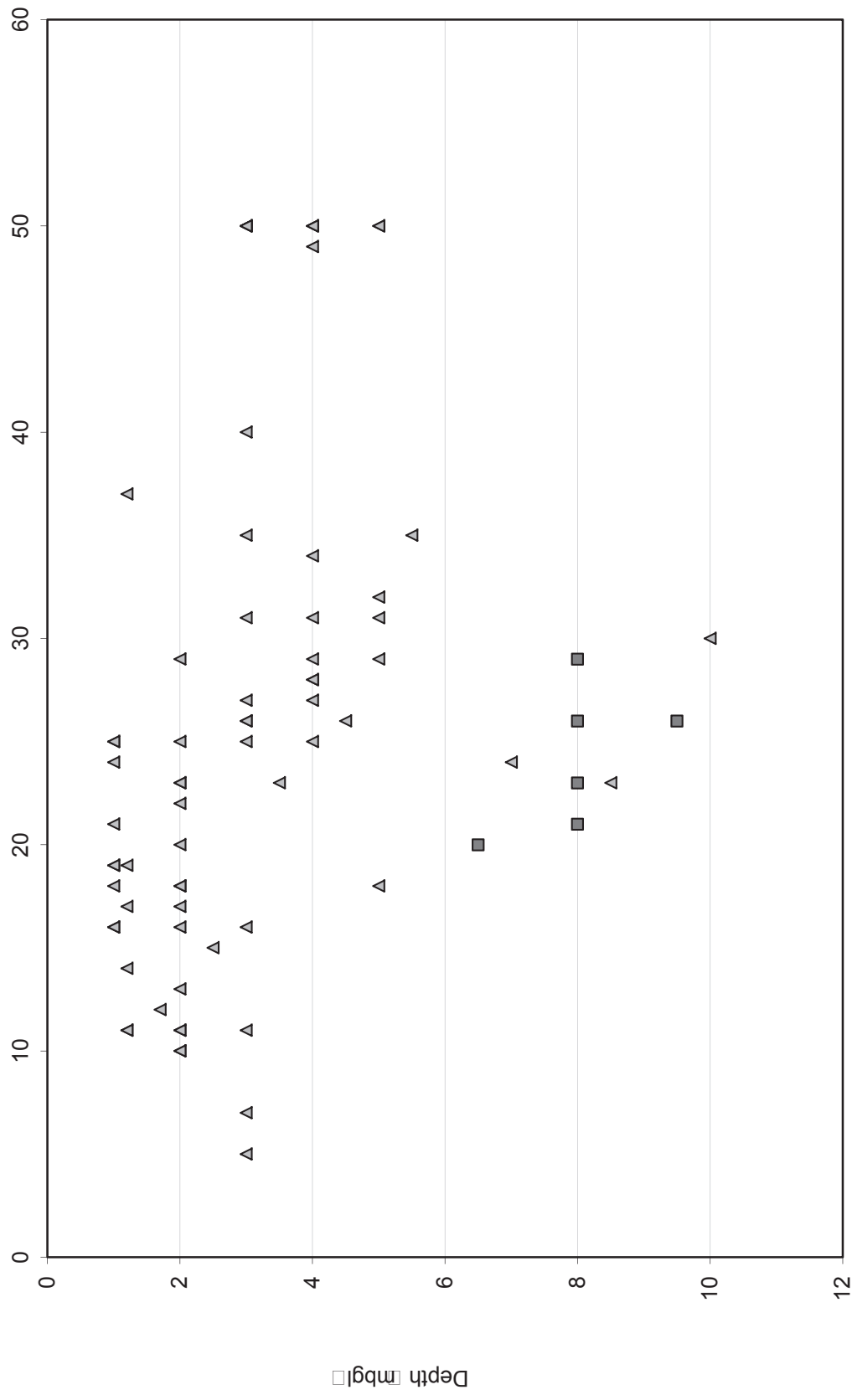
FIGURE 2

REV

-

Figure 3 – SPT N v Depth

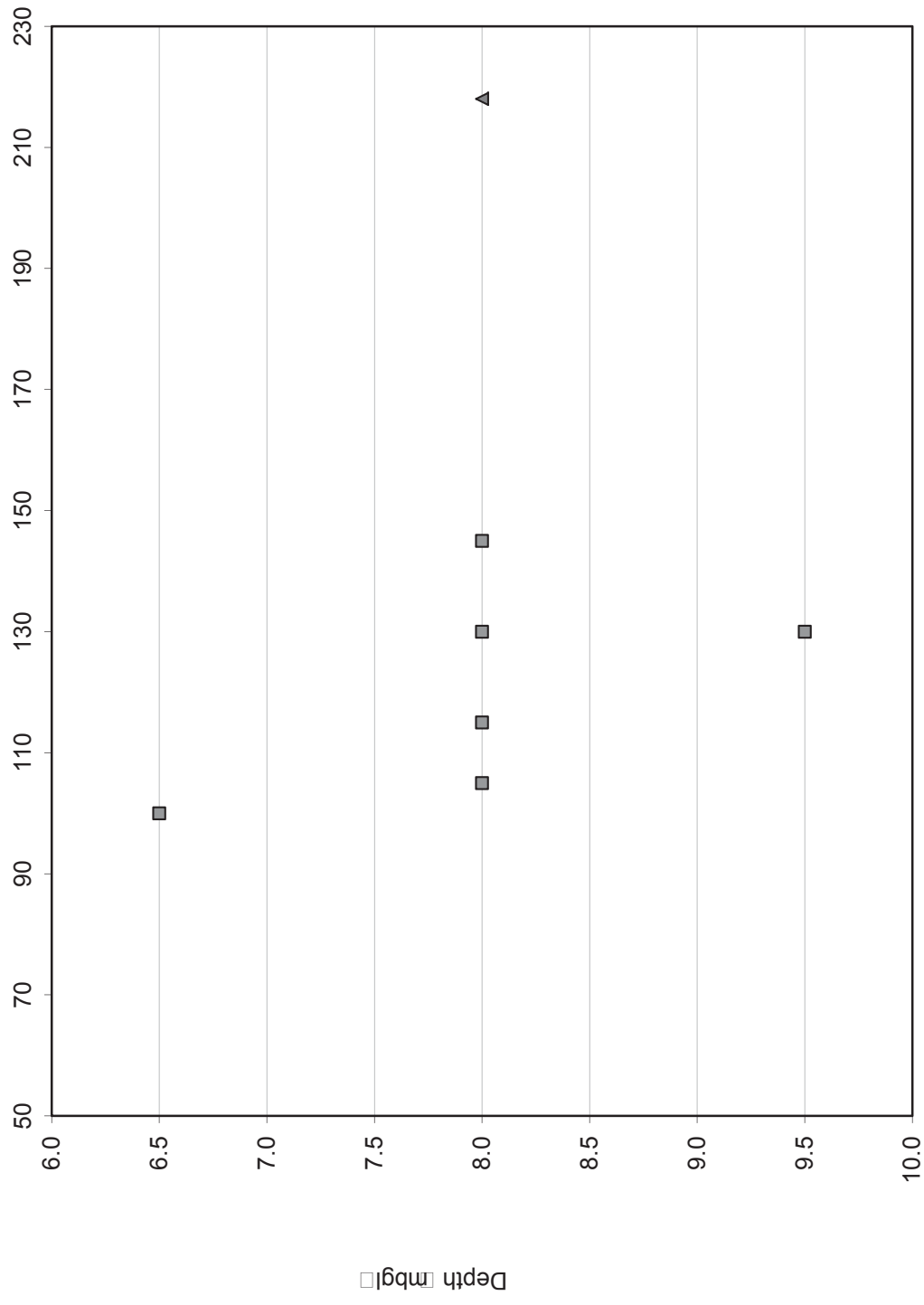
SPT N Value



△BSM ■LCF

Figure 4 – Undrained Shear Strength v Depth

Undrained Shear Strength $\square$ kN/m² $\square$



▲ Lab Test $\square$ SPT Correlation

Appendix 1 – Report Conditions

Ground Condition Assessment

This report is produced solely for the benefit of **Portsmouth City Council** and no liability is accepted for any reliance placed on it by any other party unless specifically agreed in writing otherwise.

This report refers, within the limitations stated, to the condition of the site at the time of the inspections. No warranty is given as to the possibility of future changes in the condition of the site.

This report is based on a visual site inspection, study of readily accessible referenced historical records, information supplied by those parties noted in the text and preliminary discussions with local and Statutory Authorities. Some of the opinions are based on unconfirmed data and information and are presented in good faith without exhaustive clarification. Where ground contamination is suspected but no physical site test results are available to confirm this, the report must be regarded as initial advice only, and further assessment should be undertaken prior to detailed activities related to the site. Where test results undertaken by others have been made available these can only be regarded as a limited sample. The possibility of the presence of contaminants, not revealed by this research cannot be discounted.

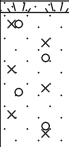
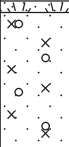
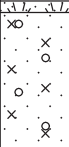
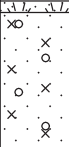
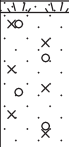
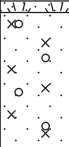
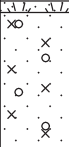
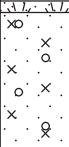
Whilst confident in the findings detailed within this report because there are no exact UK definitions of these matters, being subject to risk analysis, we are unable to give categorical assurances that they will be accepted by Authorities or Funds etc. without question, as such bodies may have unpublished, often more stringent objectives. This report is prepared for the proposed uses stated in the report and should not be used in a different context without reference to Ridge and Partners LLP. In time improved practices or amended legislation may necessitate a re-assessment.

The report is necessarily limited to those aspects of land contamination specifically reported on and no liability is accepted for any other aspect especially concerning gradual or sudden pollution incidents that may occur. The opinions expressed cannot be absolute due to the limitations of time and resources within the context of the agreed brief and the possibility of unrecorded previous use and abuse of the site and adjacent sites. The report concentrates on the site as defined in the report and provides an opinion on surrounding sites. If migrating pollution or contamination (past or present) exists this can only practically be better assessed following extensive on and off site intrusive investigations and monitoring.

Appendix 2 – Engineering Logs

BOREHOLE LOG

Project Kingsclere Ave				BOREHOLE No BH1
Job No 151240	Date 04-06-15 04-06-15	Ground Level (m)	Co-Ordinates ()	
Contractor DJ DRILLING				Sheet 1 of 1

SAMPLES & TESTS			Water	STRATA			Geology	Instrument/ Backfill			
Depth	Type No	Test Result		Reduced Level	Legend	Depth (Thickness)			DESCRIPTION		
0.30	D1	N12			0.10	Light brown silty clayey fine SAND with frequent rootlets					
0.30	ESA				(1.20)	Brown to orange brown silty slightly sandy slightly gravelly fine SAND.					
0.50-0.70	B2				1.30						
1.20	B3	N15				(2.40)	Brown to orange brown fine SAND				
1.70	D4										
1.70											
2.50	D5	N23					(0.90)	Grey to orange brown fine SAND			
2.50											
3.50	D6										
3.50		N26						4.60	Dark grey silty fine SAND		
4.50	D7										
4.50											
5.50	D8	N35							(2.10)	Dark grey silty clayey fine SAND	
5.50											
6.50	D9										
6.50		60 blows							(3.30)	Dark grey silty clayey fine SAND	
7.00-7.35	U10										
7.35	D11										
8.00	D12	N23							10.00		
8.50	D13										
8.50											
9.50	D14	N30									
10.00	D15										
10.00											

[illegible]

All dimensions in metres Scale 1:65.625	Client PCC	Method/ Plant Used	Logged By
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Report ID: AGS4 UK BH || Project: KINGSLERE AVENUE.GPJ || Library: GINT STD AGS 4 0.GLB || Date: July 21, 2015

BOREHOLE LOG

Project Kingsclere Ave				BOREHOLE No BH2
Job No 151240	Date 04-06-15 05-06-15	Ground Level (m)	Co-Ordinates ()	
Contractor DJ DRILLING				Sheet 1 of 1

SAMPLES & TESTS			Water	STRATA			Geology	Instrument/ Backfill
Depth	Type No	Test Result		Reduced Level	Legend	Depth (Thick-ness)		
0.30 0.50-0.70	D1 B2	N37			0.10	Brown silty fine SAND with frequent rootlets		
					(1.30)	Brown silty gravelly fine SAND. Gravel is of fine to coarse angular to sub rounded flint		
1.20-1.70 1.20	B3	N23			1.40			
					1.80	Orange brown silty gravelly SAND. Gravel is of fine to coarse angular flint		
2.00-2.45 2.00	D4	N25				Brown to orange and grey fine SAND		
					(2.40)			
3.00-3.45 3.00	D5	N28			4.20			
						Grey silty clayey SAND		
5.00-5.45 5.00	D7	N29			(2.20)			
					6.40			
6.00	D8	N20				Firm grey silty CLAY		
6.50-6.95 6.50	D9				(3.60)			
7.50	D10	65 blows						
8.00-8.35	U11							
8.35	D12	N26						
9.00	D13				10.00			
9.50-9.95 9.50	D14							

Boring Progress and Water Observations						Chiselling			Water Added		GENERAL REMARKS
Depth	Date	Time	Casing Depth	Casing Dia. mm	Water Depth	From	To	Hours	From	To	
All dimensions in metres Scale 1:65.625						Client PCC			Method/ Plant Used		Logged By

BOREHOLE LOG

Project Kingsclere Ave				BOREHOLE No BH3
Job No 151240	Date 08-06-15 09-06-15	Ground Level (m)	Co-Ordinates ()	
Contractor DJ DRILLING				Sheet 1 of 1

SAMPLES & TESTS			Water	STRATA				Geology	Instrument/ Backfill	
Depth	Type No	Test Result		Reduced Level	Legend	Depth (Thickness)	DESCRIPTION			
0.30 0.50-0.70	D1 B2	N11			0.10	Brown silty slightly clayey fine SAND with frequent rootlets				
					0.40	Light brown silty gravelly fine SAND. Gravel is of fine to coarse angular to sub rounded flint				
					(0.60) 1.00	Light brown very gravelly fine to medium SAND. Gravel is of fine to coarse angular to sub angular flint				
1.20-1.65 1.20	D3			N11		(0.50) 1.50	Light brown slightly silty gravelly fine SAND. Gravel is of fine to coarse angular to sub rounded flint			
2.00-2.45 2.00					D4	N17			(2.70)	Grey brown fine SAND
3.00-3.50 3.00										
4.00-4.45 4.00	D6			N25						
5.00-5.45 5.00					D7	N18				
6.00							U8	60 blows		
6.50-6.90	D9									
6.90 7.00				D10	N24					
7.50						D11				
8.00-8.45	D12									
9.00				D13						
9.50-9.90					U14	70 blows				
9.90	D15									

Boring Progress and Water Observations						Chiselling			Water Added		GENERAL REMARKS
Depth	Date	Time	Depth	Casing Dia. mm	Water Depth	From	To	Hours	From	To	
All dimensions in metres Scale 1:65.625		Client PCC				Method/ Plant Used					Logged By

Report ID: AGS4 UK BH || Project: KINGSCLERE AVENUE.GPJ || Library: GINT STD AGS4 0.GLB || Date: July 21, 2015

BOREHOLE LOG

Project Kingsclere Ave				BOREHOLE No BH4
Job No 151240	Date 11-06-15 11-06-15	Ground Level (m)	Co-Ordinates ()	
Contractor DJ DRILLING				Sheet 1 of 1

SAMPLES & TESTS			Water	STRATA			Geology	Instrument/ Backfill		
Depth	Type No	Test Result		Reduced Level	Legend	Depth (Thick- ness)			DESCRIPTION	
0.30	D1	N19			0.10	Light brown silty fine SAND with frequent rootlets				
0.50-0.70	B2				(0.50) 0.60	Light brown silty gravelly fine SAND. Gravel is of fine to medium angular to sub angular flint				
0.50	ESA				(0.50) 1.10	Orange brown silty fine SAND				
1.20	B3	N29			(3.10)	Brown fine SAND				
1.20										
2.20	D4	N26				(4.00)	Firm to stiff grey silty CLAY			
2.20										
3.10	D5	N31					6.00	Firm to stiff grey silty CLAY		
3.10										
4.00	D6	N50						(1.20)	Firm to stiff grey silty CLAY	
4.00										
4.80	D7	55 blows							6.00	Firm to stiff grey silty CLAY
5.00	D8									
5.00										
6.00	D9	N26							(4.00)	Firm to stiff grey silty CLAY
6.50-9.95	U10									
6.95	D11									
7.50	D12	70 blows							10.00	Firm to stiff grey silty CLAY
8.00	D13									
8.00										
9.00	D14									
9.50-9.95	U15									
9.95	D16									

[illegible]

All dimensions in metres Scale 1:65.625	Client PCC	Method/ Plant Used	Logged By
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Report ID: AGS4 UK BH || Project: KINGSLERE AVENUE.GPJ || Library: GINT STD AGS 4 0.GLB || Date: July 21, 2015

BOREHOLE LOG

Project Kingsclere Ave				BOREHOLE No BH5
Job No 151240	Date 11-06-15 11-06-15	Ground Level (m)	Co-Ordinates ()	
Contractor DJ DRILLING				Sheet 1 of 1

SAMPLES & TESTS			Water	STRATA				Geology	Instrument/ Backfill
Depth	Type No	Test Result		Reduced Level	Legend	Depth (Thickness)	DESCRIPTION		
0.30	D1					0.10	Light brown silty fine SAND with frequent rootlets		
0.30	ESA					0.50	Light orange brown silty gravelly fine SAND. Gravel is of fine to medium angular to sub angular flint		
0.50-0.70	B2					(0.90)	Light orange brown silty fine SAND locally slightly clayey		
1.20	D3	N11				1.40	Brown slightly silty fine SAND		
1.20	D4								
1.60	D5								
2.00	D5	N11							
2.00						(2.80)			
3.00	D6	N31							
3.00									
4.00	D7	N29				4.20	Grey slightly silty fine SAND		
4.00									
5.00	D8	N31				(1.60)			
5.00									
5.80	D9					5.80	Firm grey silty CLAY		
6.50-6.95	U10	50 blows				(1.30)			
6.95	D11					7.10	Stiff to very stiff grey silty CLAY with mudstone		
7.10-7.60	B12					(0.50)			
8.00	D13	N21				(2.40)	Firm to stiff grey silty CLAY		
8.00									
9.00	D14								
9.50-9.95	U15	70 blows				10.00			
9.95	D16								

Boring Progress and Water Observations						Chiselling			Water Added		GENERAL REMARKS
Depth	Date	Time	Casing Depth	Casing Dia. mm	Water Depth	From	To	Hours	From	To	
All dimensions in metres Scale 1:65.625						Client PCC			Method/ Plant Used		Logged By

BOREHOLE LOG

Project Kingsclere Ave				BOREHOLE No BH6
Job No 151240	Date 12-06-15 12-06-15	Ground Level (m)	Co-Ordinates ()	
Contractor DJ DRILLING				Sheet 1 of 1

SAMPLES & TESTS			Water	STRATA			Geology	Instrument/ Backfill
Depth	Type No	Test Result		Reduced Level	Legend	Depth (Thickness)		
0.30 0.30-0.50 0.50-0.70	D1 ESA B2	N14			0.10 (0.50) 0.60	Brown silty slightly clayey fine SAND with frequent rootlets		
					(0.50) 1.10	Light brown silty gravelly fine SAND. Gravel is of fine to coarse angular to sub rounded flint		
					(0.50) 1.10	Orange brown silty fine SAND		
1.20 1.20	D3	N11			(3.10)	Light brown fine SAND		
2.00 2.00	D4							
3.00 3.00	D5	N5						
4.00 4.00	D6	N28			4.20 (0.60) 4.80	Grey fine SAND		
5.00 5.00	D7	N32			(1.10) 5.90	Grey silty fine SAND		
6.00 6.50-6.85 6.85	D8 U9 D10	55 blows			(4.10)	Firm to stiff grey silty CLAY with occasional pockets of fossil fragments		
7.50	D11							
8.00 8.00	D12							
9.00	D13	N23						
9.50								
	U14	70 blows			10.00			

[illegible]

All dimensions in metres
Scale 1:65.625

Client	PCC
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Method/ Plant Used

Logged By

BOREHOLE LOG

Project Kingsclere Ave				BOREHOLE No BH7	
Job No 151240	Date 12-06-15 15-06-15	Ground Level (m)	Co-Ordinates ()		
Contractor DJ DRILLING				Sheet 1 of 1	

SAMPLES & TESTS			Water				STRATA	Geology	Instrument/ Backfill
Depth	Type No	Test Result		Reduced Level	Legend	Depth (Thick- ness)	DESCRIPTION		
0.30 0.50-0.70	D1 B2				0.10	Soft brown sandy CLAY with frequent rootlets			
					0.40	Light orange brown gravelly fine SAND. Gravel is of fine to coarse sub angular to sub rounded flint			
1.20-1.70 1.20	B3	N17			(0.90)	Orange brown silty sandy gravelly CLAY. Gravel is of fine to coarse angular to sub angular flint			
					1.30	Brown fine to medium SAND			
2.00-2.45 2.00	D4	N18			(2.90)				
3.00-3.45 3.00	D5	N16							
4.00-4.45 4.00	D6	N34			4.20	Grey fine to medium SAND			
5.00-5.40 5.00	D7	N50/ 290 mm			(1.80)				
6.00	D8				6.00	Soft to firm grey silty CLAY			
6.50-6.95	U9	65 blows							
6.95	D10								
7.50	D11								
8.00-8.45 8.00	D12	N29			(4.00)				
9.00	D13								
9.50-9.90	U14	75 blows							
9.90	D15				10.00				

Boring Progress and Water Observations						Chiselling			Water Added		GENERAL REMARKS
Depth	Date	Time	Casing Depth	Casing Dia. mm	Water Depth	From	To	Hours	From	To	

All dimensions in metres Scale 1:65.625	Client PCC	Method/ Plant Used	Logged By
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BOREHOLE LOG

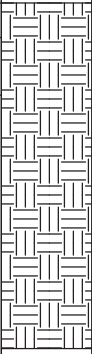
Project Kingsclere Ave				BOREHOLE No WS1
Job No 151240	Date 03-06-15 03-06-15	Ground Level (m)	Co-Ordinates ()	
Contractor DJ DRILLING				Sheet 1 of 1

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Boring Progress and Water Observations						Chiselling			Water Added		GENERAL REMARKS
Depth	Date	Time	Casing Depth	Casing Dia. mm	Water Depth	From	To	Hours	From	To	
All dimensions in metres Scale 1:65.625		Client PCC				Method/ Plant Used					Logged By

BOREHOLE LOG

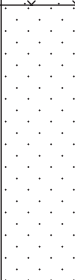
Project Kingsclere Ave				BOREHOLE No WS2	
Job No 151240	Date 03-06-15 03-06-15	Ground Level (m)	Co-Ordinates ()		
Contractor DJ DRILLING				Sheet 1 of 1	

SAMPLES & TESTS			Water	Reduced Level	Legend	Depth (Thick-ness)	STRATA	Geology	Instrument/Backfill
Depth	Type No	Test Result					DESCRIPTION		
0.10-0.30	ES1	N16				0.30	Light brown silty fine SAND with frequent rootlets		
						(0.50) 0.80	Stiff light brown silty gravelly CLAY. Gravel is of medium to coarse angular to sub angular flint		
0.90-1.00 1.00	ES2						Wet grey to orange fine to medium SAND		
2.00-3.00 2.00	B3	N10				(3.20)			
3.00		N50/ 205 mm				4.00			

Boring Progress and Water Observations						Chiselling			Water Added		GENERAL REMARKS
Depth	Date	Time	Casing Depth	Dia. mm	Water Depth	From	To	Hours	From	To	
All dimensions in metres Scale 1:65.625			Client PCC			Method/ Plant Used			Logged By		

BOREHOLE LOG

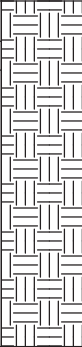
Project Kingsclere Ave				BOREHOLE No WS3	
Job No 151240	Date 03-06-15 03-06-15	Ground Level (m)	Co-Ordinates ()		
Contractor DJ DRILLING				Sheet 1 of 1	

SAMPLES & TESTS			Water	STRATA				Geology	Instrument/ Backfill
Depth	Type No	Test Result		Reduced Level	Legend	Depth (Thick- ness)	DESCRIPTION		
0.10-0.30	ES1					0.40	Light brown silty gravelly fine SAND with frequent rootlets. Gravel is of fine to coarse angular to rounded flint, brick and tile. Firm to stiff orange brown silty sandy gravelly CLAY. Gravel is of fine to coarse angular to sub rounded flint Wet orange to grey fine to medium SAND		
						0.60			
0.70-0.90	ES2					(2.40)			
2.00-3.00	B3		3.00						
				</					

Boring Progress and Water Observations						Chiselling			Water Added		GENERAL REMARKS
Depth	Date	Time	Casing Depth	Casing Dia. mm	Water Depth	From	To	Hours	From	To	
All dimensions in metres Scale 1:65.625						Client PCC			Method/ Plant Used		Logged By

BOREHOLE LOG

Project Kingsclere Ave				BOREHOLE No WS4	
Job No 151240	Date 03-06-15 03-06-15	Ground Level (m)	Co-Ordinates ()		
Contractor DJ DRILLING				Sheet 1 of 1	

SAMPLES & TESTS			Water	STRATA				Geology	Instrument/ Backfill
Depth	Type No	Test Result		Reduced Level	Legend	Depth (Thick- ness)	DESCRIPTION		
0.10-0.30	ES1	N25				0.35	Light brown silty slightly gravelly fine SAND with frequent rootlets		
						0.60	Firm orange brown silty gravelly CLAY. Gravel is of medium sub rounded flint.		
0.70-0.90	ES2						Wet orange brown orange and grey fine SAND		
1.00-2.00	B3								
1.00		N22			(2.40)				
2.00									
3.00		N50/ 220 mm			3.00				

Boring Progress and Water Observations						Chiselling			Water Added		GENERAL REMARKS
Depth	Date	Time	Casing Depth	Casing Dia. mm	Water Depth	From	To	Hours	From	To	

All dimensions in metres Scale 1:65.625	Client PCC	Method/ Plant Used	Logged By
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BOREHOLE LOG

Project Kingsclere Ave				BOREHOLE No WS5
Job No 151240	Date 03-06-15 03-06-15	Ground Level (m)	Co-Ordinates ()	
Contractor DJ DRILLING				Sheet 1 of 1

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All dimensions in metres Scale 1:65.625	Client PCC	Method/ Plant Used	Logged By
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Report ID: AGS4 UK BH || Project: KINGSLERE AVENUE.GPJ || Library: GINT STD AGS 4 0.GLB || Date: July 21, 2015

BOREHOLE LOG

Project Kingsclere Ave				BOREHOLE No WS6
Job No 151240	Date 03-06-15 03-06-15	Ground Level (m)	Co-Ordinates ()	
Contractor DJ DRILLING				Sheet 1 of 1

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Boring Progress and Water Observations						Chiselling			Water Added		GENERAL REMARKS
Depth	Date	Time	Casing Depth	Casing Dia. mm	Water Depth	From	To	Hours	From	To	
All dimensions in metres Scale 1:65.625		Client PCC				Method/ Plant Used					Logged By

Report ID: AGS4 UK BH || Project: KINGSLERE AVENUE.GPJ || Library: GINT STD AGS 4 0.GLB || Date: July 21, 2015

BOREHOLE LOG

Project Kingsclere Ave				BOREHOLE No WS7	
Job No 151240	Date 03-06-15 03-06-15	Ground Level (m)	Co-Ordinates ()		
Contractor DJ DRILLING				Sheet 1 of 1	

SAMPLES & TESTS			Water	STRATA			Geology	Instrument/ Backfill
Depth	Type No	Test Result		Reduced Level	Legend	Depth (Thick- ness)		
0.80-1.00 1.00	ES2	N19			0.10	Firm brown silty sandy CLAY with frequent rootlets		
					0.55	Firm to stiff orange brown silty slightly sandy slightly gravelly CLAY. Gravel is of fine to medium angular to sub angular flint		
					0.70	Firm to stiff orange brown gravelly CLAY. Gravel is of fine to coarse angular to sub angular flint		
						Wet orange brown and grey silty fine SAND		
2.00		N13			(2.30)			
3.00		N50			3.00			

Boring Progress and Water Observations						Chiselling			Water Added		GENERAL REMARKS
Depth	Date	Time	Casing Depth	Casing Dia. mm	Water Depth	From	To	Hours	From	To	
All dimensions in metres Scale 1:65.625						Client PCC			Method/ Plant Used		Logged By

BOREHOLE LOG

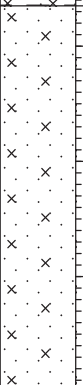
Project Kingsclere Ave				BOREHOLE No WS8	
Job No 151240	Date 04-06-15 04-06-15	Ground Level (m)	Co-Ordinates ()		
Contractor DJ DRILLING				Sheet 1 of 1	

SAMPLES & TESTS			Water	STRATA				Geology	Instrument/ Backfill
Depth	Type No	Test Result		Reduced Level	Legend	Depth (Thick- ness)	DESCRIPTION		
0.10-0.30	ES1	N25							

Boring Progress and Water Observations						Chiselling			Water Added		GENERAL REMARKS
Depth	Date	Time	Casing Depth	Casing Dia. mm	Water Depth	From	To	Hours	From	To	
All dimensions in metres Scale 1:65.625						Client PCC			Method/ Plant Used		Logged By

BOREHOLE LOG

Project Kingsclere Ave				BOREHOLE No WS9	
Job No 151240	Date 04-06-15 04-06-15	Ground Level (m)	Co-Ordinates ()		
Contractor DJ DRILLING				Sheet 1 of 1	

SAMPLES & TESTS			Water				STRATA	Geology	Instrument/ Backfill
Depth	Type No	Test Result		Reduced Level	Legend	Depth (Thick- ness)	DESCRIPTION		
0.10-0.30	ES1	N16			0.30	Light brown silty slightly gravelly fine SAND with frequent rootlets. Gravel is of fine to medium sub rounded flint			
0.70-0.90	ES2			0.65	Firm orange brown silty slightly sandy slightly gravelly CLAY. Gravel is of fine to coarse angular to sub angular flint				
1.00					Orange to grey silty fine SAND				
2.00-3.00	B3	N20			(3.35)				
2.00									
3.00		N26							
4.00		N50			4.00				
				</					

Boring Progress and Water Observations						Chiselling			Water Added		GENERAL REMARKS
Depth	Date	Time	Casing Depth	Casing Dia. mm	Water Depth	From	To	Hours	From	To	
All dimensions in metres Scale 1:65.625						Client PCC			Method/ Plant Used		Logged By

BOREHOLE LOG

Project Kingsclere Ave				BOREHOLE No WS10
Job No 151240	Date 04-06-15 04-06-15	Ground Level (m)	Co-Ordinates ()	
Contractor DJ DRILLING				Sheet 1 of 1

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All dimensions in metres Scale 1:65.625	Client PCC	Method/ Plant Used	Logged By
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