# Appendix B: Site Investigation Report

Southern Testing
Environmental & Geotechnical

ST Consult
Environmental & Geotechnical

# Desk Study, Site Investigation & Risk Assessment Report

**Project Name:** Land at Mount Avenue

**Location:** Land at Mount Avenue, Chaldon, Caterham, CR3 5BB

**Client:** Sigma Homes Ltd.

**Project ID:** J15961

**Report Date:** 26th June 2025

**Report Issue:** 1

## SUMMARY

The site, which extends to approximately 1.45ha, comprises an approximately square shaped plot of land, utilised as a small grazing field for horses bounded by mature trees and brambles. At the time of the site investigation the soft landscaping appeared mostly to be flat, level and well maintained. It is proposed to develop the site with 30 No. residential properties including private gardens, associated infrastructure and public open spaces.

Geological records indicate the site to be underlain by superficial deposits of Clay-with-Flints over Bedrock of Lewes/Seaford/Newhaven Chalk Formation.

A desk study was carried out and indicates that the site has a history of open/agricultural usage.

A single phase of intrusive investigation was carried out, with most areas of the site accessible during the fieldwork, although the presence of an underground water main and use of the field for grazing horses, slightly limited the fieldwork.

The soils comprised a covering of Topsoil to depths of 0.1-0.2m, over variable Clay-with-Flints to depths of 6.3/6.7m, over Lewes/Seaford/Newhaven Chalk Formation.

Groundwater was not encountered during intrusive investigation.

At this stage, conventional strip foundations are likely to be acceptable for this site, with a preliminary allowable bearing capacity of 100kPa is recommended. NHBC edium Volume Change Potential precautions will apply. However, since this is a preliminary geotechnical investigation, further trial holes will be required across the site to confirm the bearing capacity and swelling/shrinkage recommendations etc.

The sulphate content of the natural soil was found to fall within Class DS-1. The ACEC classification for the site is AC-1s.

No significant groundwater conditions requiring de-watering of excavations are anticipated.

For this site, suspended ground floor slabs will be required in accordance with NHBC requirements where foundation depths in excess of 1.5m are required due to the influence of trees, or where made ground/disturbed soils are deeper than 600mm beneath the slabs. Outside of these areas, ground floor slabs can be either of ground bearing or suspended construction.

No evidence of any soil, groundwater or landfill gas contamination has been identified by these site investigation works. The topsoil and underlying shallow soils across the site would be considered uncontaminated, and therefore suitable to be retained on site post redevelopment.

The contamination screening values used are valid at the time of writing but may be subject to change and any such changes will have implications for the assessments based on them. Their validity should be confirmed at the time of site development.

As with any site, areas of contamination not identified during investigation works may come to light during the course of redevelopment. Accordingly, a discovery strategy must be in place during the redevelopment to ensure that any hitherto unknown contamination is identified and dealt with in an appropriate manner. Depending on the nature of any such contamination, it may prove necessary to reassess the remedial strategy for the site. The presence of contamination may affect the classification of waste soils, or the potential for their re-use.

The investigation was conducted and this report has been prepared for the sole internal use and reliance of Sigma Homes Ltd. and their appointed Engineers. This report shall not be relied upon or transferred to any other parties without the express written authorisation of Southern Testing Laboratories Ltd. If an unauthorised third party comes into possession of this report they rely on it at their peril and the authors owe them no duty of care and skill.

The findings and opinions conveyed via this investigation report are based on information obtained from a variety of sources as detailed within this report, and which Southern Testing Laboratories Ltd. believes are reliable. Nevertheless, Southern Testing Laboratories Ltd. cannot and does not guarantee the authenticity or reliability of the information it has obtained from others.

Southern Testing Laboratories Ltd. assumes no liability for any conditions not revealed in the records obtained in performance of the services in accordance with the limitations of the contract with the Client, or where variations occur between exploratory hole locations or below the depth of investigation.

The recommendations contained in this report are made in respect of the particular context of the investigation as described in the report and may not be appropriate to alternative development schemes. This report should be considered in its entirety and Southern Testing Laboratories Ltd. accepts no responsibility for and excludes liability in respect of any omission or alteration made by others, and any use of the report for any purpose other than that for which it was produced.

| | | |
|---|---|---|
| **Author** | C Lennard<br>BEng |  |
| | S Toms<br>BSc (Hons) MSc MIEnvSc PIEMA |  |
| **Check / Review** | J Race<br>BSc MSc CGeol FGS |  |

For and on behalf of Southern Testing Laboratories Limited

## DOCUMENT HISTORY AND STATUS

| Issue No. | Date | Purpose or Status | Author | Check / Review |
|---|---|---|---|---|
| 1 | 26/06/2025 | First Issue | CL/SKT | JNR |
| | | | | |
| | | | | |

# TABLE OF CONTENTS


| | | | |
|---|---|---|---|
| **A** | **INTRODUCTION** | | **1** |
| | 1 | Authority | 1 |
| | 2 | Location | 1 |
| | 3 | Proposed Construction | 1 |
| | 4 | Object | 1 |
| | 5 | Scope | 1 |
| **B** | **DESK STUDY AND WALKOVER SURVEY** | | **2** |
| | 6 | Desk Study | 2 |
| | 7 | Site Walkover Survey | 7 |
| **C** | **PRELIMINARY SITE MODELS** | | **8** |
| | 8 | Conceptual Engineering Geological Ground Model | 8 |
| | 9 | Conceptual Site Model | 9 |
| | 10 | Risk Estimation | 10 |
| **D** | **GROUND INVESTIGATION** | | **14** |
| | 11 | Strategy and Method | 14 |
| | 12 | Weather Conditions | 14 |
| | 13 | Soils as Found | 14 |
| | 14 | Groundwater Observations | 15 |
| **E** | **DISCUSSION OF GEOTECHNICAL TEST RESULTS AND RECOMMENDATIONS** | | **15** |
| | 15 | Geotechnical Laboratory Tests | 15 |
| | 16 | Soil Classification and Properties | 15 |
| | 17 | Groundwater Levels | 16 |
| | 18 | Swelling and Shrinkage | 16 |
| | 19 | Soakaways | 16 |
| | 20 | Sulphates and Acidity | 18 |
| | 21 | Foundations and Bearing Capacity | 18 |
| | 22 | Floor Slabs | 18 |
| | 23 | Excavations and Dewatering | 18 |
| | 24 | Pavement Construction | 19 |
| **F** | **DISCUSSION OF GEOENVIRONMENTAL TEST RESULTS AND RECOMMENDATIONS** | | **19** |
| | 25 | Analytical Framework | 19 |
| | 26 | Site Investigation – Soils | 20 |
| | 27 | Site Investigation – Waters | 22 |
| | 28 | Site Investigation – Ground Gas | 22 |
| | 29 | Summary of Identified Contamination | 23 |
| | 30 | Discussion and Conclusions | 23 |
| | 31 | General Guidance | 24 |

# TABLE OF APPENDICES

**APPENDIX A**
Site Plans, Exploratory Hole Logs & Photographs

**APPENDIX B**
Field Sampling and In-Situ Test Methods and Results

**APPENDIX C**
Geotechnical Laboratory Test Methods and Results

**APPENDIX D**
Contamination Laboratory Test Methods and Results

**APPENDIX E**
Historical Maps

**APPENDIX F**
Envirocheck Report

# A INTRODUCTION

## 1 Authority

Our authority for carrying out this work is contained in an email from Mr A Light of Sigma Homes Ltd, dated 11th March 2025 in relation to our quote ref. Q250241-2 (dated 7th March 2025).

## 2 Location

The site is located on the north side of Birchwood Lane, approximately 1.6km west of the centre of Caterham, as indicated on Figure 1 within Appendix A. The approximate National Grid Reference of the site is TQ 32110 55020.

## 3 Proposed Construction

It is proposed to construct 30 No. semi-detached and detached residential properties (assumed to be up to 2-storeys), together with associated gardens, areas of soft-landscaping and public open space in the northwest (see Figure 2 in Appendix A).

For the purposes of the contamination risk assessment, the proposed development land use is classified as Residential with consumption of Home-grown Produce CLEA Model Ref [1] / C4SL Report Ref [2].

The gas sensitivity of the proposed development is rated as High CIRIA C665 Ref [3].

## 4 Object

This is a Phase 1 Desk Study (including walkover) and a limited Phase II geotechnical & contamination (risk estimation and evaluation) investigation (Tier 1).

The primary object of the investigation was to assess the depth of Clay-with-Flints to establish the likely suitability for on site soakaway drainage. Limited/preliminary information is also included in relation to foundation bearing conditions and other soil parameters relevant to the proposed development. Additional shallow trial holes were also undertaken to assess the likely nature on the site.

## 5 Scope

This report presents our desk study findings, exploratory hole logs and test results and our interpretation of these data.

A UXO risk assessment was not requested within our brief for the investigation.

As with any site there may be differences in soil conditions between exploratory hole positions.

This report is not an engineering design and the figures and calculations contained in the report should be used by the Engineer, taking note that variations will apply, according to variations in design loading, in techniques used, and in site conditions. Our figures therefore should not supersede the Engineer's design.

The site investigation has been completed with reference to BS 5930 Ref [4] and BS 10175 Ref [5].

Waste Classification of soils has not been included within the brief for the investigation.

It should be recognised that site conditions can vary over time, in response to seasonal variations, prevailing weather conditions or other natural phenomena, and also in response to human activity on or near the site. These factors can influence both geotechnical and geoenvironmental characteristics, including soil moisture conditions, the occurrence of groundwater, and the behaviour of mobile contamination phases. Accordingly, the accuracy and reliability of the investigation findings may be affected. The findings and opinions conveyed via this investigation report are based on information obtained from a variety of sources as detailed within this report, and which Southern Testing Laboratories Ltd. believes are reliable. Nevertheless, Southern Testing Laboratories Ltd. cannot and does not guarantee the authenticity or reliability of the information it has obtained from others.

The investigation was conducted and this report has been prepared for the sole internal use and reliance of Sigma Homes Ltd. and their appointed Engineers. This report shall not be relied upon or transferred to any other parties without the express written authorisation of Southern Testing Laboratories Ltd. If an unauthorised third party comes into possession of this report they rely on it at their peril and the authors owe them no duty of care and skill.

The recommendations contained in this report are made in respect of the particular context of the investigation as described in the report and may not be appropriate to alternative development schemes. This report should be considered in its entirety and Southern Testing Laboratories Ltd. accepts no responsibility for and excludes liability in respect of any omission or alteration made by others, and any use of the report for any purpose other than that for which it was produced.

Detailed information on the proposed development, such as detailed final layout, loadings and serviceability limits was not provided. Accordingly, where geotechnical design advice is provided it is on the prescriptive basis allowed for by Eurocode 7: employing conventional and conservative design rules.

The contamination screening values used are valid at the time of writing but may be subject to change and any such changes will have implications for the assessments based on them. Their validity should be confirmed at the time of site development.

# B DESK STUDY AND WALKOVER SURVEY

## 6 Desk Study

A desk study has been carried out. Reference has been made to the following information sources.

- Online Geological Maps Ref [6] & Ref [7]
- Online Hydrogeological Maps Ref [8]
- Historical Ordnance Survey Maps
- Environmental Databases
- BGS Online Historical Borehole Records Ref [9]
- Search on Local Authority Planning Portal for planning history
- Environment Agency / Gov.UK Website Flood Risk Ref [11]
- UK Radon Ref [12] and BRE Radon Ref [13]
- Google Earth (for old aerial photographs)

The environmental databases search report compiled for this desk study contains site-specific environmental data drawn from data sets that comprise publicly available information together with data from third parties, some of which is under review. Accordingly, Southern Testing Laboratories Limited does not warrant its accuracy, reliability or completeness.

The full report is included in Appendix F, a summary of the salient features is included in the following sections of this report.

### 6.1 Geology

The British Geological Survey Map No. 286 Reigate (dated 1978) indicates that the site geology consists of superficial Clay-with-Flints over Upper Chalk (Seaford/Lewes/Newhaven Chalk Formation - undifferentiated).

#### 6.1.1 Clay-with-Flints

The Clay-with-Flints Formation is a residual superficial deposit formed from the dissolution, decalcification and cryoturbation of the Chalk Groups, Palaeogene formations and, in the west country, the Upper Greensand Formation. There is no bedding, and it is variable in its content. The clay content may range from about 35 – 75%. The formation predominantly comprises orangish brown to reddish brown sandy clays, with abundant gravel to cobbles of flint. Angular flints are derived from Chalk deposits; rounded flints, sand and clay are derived from Palaeogene deposits. The unit locally contains bodies of yellow fine to medium grained sands.

The unit is variable in thickness, and the interface with the underlying units is highly variable. Where the Clay-with-Flints Formation overlies the Chalk there may be solution features, particularly around the fringes of the formation.
Seaford Chalk Formation

The Seaford Chalk Formation comprises a fairly homogeneous white chalk with regular and conspicuous flint bands. These flints are commonly laterally very continuous and traceable over large distances. Some of the flints can be very large. A few marl seams are present within the lower parts of the formation.

### 6.1.2 Lewes Nodular Chalk Formation

The Lewes Nodular Chalk Formation is characterised by bands of orange-stained, hard, medium to very high density chalk interbedded with soft greyer low density chalk. There are some well-developed hardgrounds noted such as the Top Rock and Chalk Rock. A number of persistent marl and flint horizons are included within this formation. Fracturing is variable, although commonly steeply inclined and curvilinear in nature. Horizons of sub-horizontal sheet flints are also present.

### 6.1.3 Newhaven Chalk Formation

The Newhaven Chalk Formation is characterised by firm white chalk with common marl seams and widely spaced flint bands, and by numerous inclined conjugate shear fractures, normally slickensided and frequently containing sheet flint. In eastern Kent an overlying secondary unit, the Margate Chalk Member, is typically homogenous with no marl seams and few flints.

The White Chalk outcrop in particular is frequently highly fractured and highly permeable, and usually has good infiltration characteristics. On the other hand, Chalk Head, highly weathered Chalk and Chalk under a low permeability superficial cover may have very poor infiltration characteristics.

Chalk is slightly soluble in water and, while it has excellent bearing properties when unweathered, this solubility can lead to deep weathering and softening, and the upper layers of chalk often have an irregular boundary with overlying strata

The Chalk may be softened by solution to a depth of 5-15m and bearing capacities and engineering properties improve with depth. Where there is an outcrop of impermeable soil overlying the chalk there may be a dramatically increased solution effect due to concentrated surface water flow to the Chalk close to the outcrop boundary.

Solution features are common in the Chalk, and these can present significant difficulties to development on affected sites.

Man has also worked the chalk for flints, and for other purposes, for thousands of years and any signs of old workings should be carefully investigated.

## 6.2 Historical Borehole Records

A search of previous exploratory hole records both from the online British Geological Survey (BGS) database [9] and Southern Testing (STL) in-house records, revealed relatively limited records within 1km of this site, which proved the depth of superficial Clay-with-Flints overlying the chalk. Those which are available are summarised below.

| BH Reference | Final Depth (bgl) | Distance from site & Direction | Remarks |
|---|---|---|---|
| STL ref. J13126 | 30m | 675m NE | Clay-with- flints, with sandy bands to between 13 – 26m bgl.<br>Chalk to 30m<br>Groundwater not recorded |
| STL ref. J14962 | 15m | 980m W | Made Ground – very stiff sandy gravelly CLAY to 0.5m<br>Bands of reddish-brown sandy, gravelly CLAY and yellowish-brown weakly cemented fine to coarse SAND with ironstone and iron stained sandstone to 15m<br>Groundwater not recorded |

| BH Reference | Final Depth (bgl) | Distance from site & Direction | Remarks |
|---|---|---|---|
| BGS ref. TQ35NW12 | 140m | 815m N | Upper Chalk – chalk & flints to 18m<br>Middle Chalk – soft putty chalk/hard chalk and soft chalk to 105m<br>Melbourne Rock – chalk rock to 116m<br>Lower Chalk – blue clay/chalk marl to 140m<br>RWL 62.3m bgl.<br>GL 154m OD |

## 6.3 Geological Hazards and Mining Activities

Data from various sources relating to potential geological hazards at the site are summarized below. The Hazard Potentials listed for the BGS data are as presented in the Envirocheck report, derived from various generic BGS sources, **which are not considered as site-specific**. It is important that this information is considered in context of the actual site topography, ground conditions encountered during future investigation, and development proposals.

| Data Source | Hazard | Hazard Potential to Site | Remarks |
|---|---|---|---|
| BGS | Potential for Collapsible Ground Stability Hazard | Very Low | |
| | Potential for Compressible Ground Stability Hazard | No Hazard | |
| | Potential for Ground Dissolution Stability Hazard | Moderate | |
| | Potential for Landslide Ground Stability Hazard | Very Low | |
| | Potential for Running Sand Ground Stability Hazard | No Hazard | |
| | Potential for Swelling or Shrinkage Clay Ground Stability Hazard | Low | A Moderate hazard is considered more applicable within Clay-with-Flints deposits. |
| | Shallow Mining Hazard | Rare | |
| | BGS recorded mineral site | The closest record to the site is 135m to the SE – Chaldon Common Brick Field, an open cast operation for the extraction of clay and shale. It is recorded as having ceased operation.<br>No other records are listed within 0.5km. | |
| ARUP [Ref [14] ] | Mining Instability | The site is not located within a 1km grid square with any recorded features. | |
| CSS [Ref [15] ]<br>KURG [Ref [16] ] | Underground Openings | The only record within 1km are Secret Tunnels approximately 800m to the ESE of the site at Old Court Lodge. | |
| PBA | Mining Cavities | The closest recorded man-made mining cavity to the site is 559m to the SE and comprises a gravel pit/potential flint mine. | |
| | Natural Cavities | The closest natural cavities recorded are solution features 533m to the E, with other records for solution features 863m to the S and 994m to the SE. | |

## 6.4 Radon Risk

With reference to the Envirocheck report, UK Radon Ref [12] and BRE Radon Ref [13] guidance: no radon protection is required on this site.

The designer should take note of any measures specific to radon protection for basements (if proposed) as detailed in BR211 (2023) and ensure any recommendations are followed.

## 6.5 Hydrology and Hydrogeology

Data from the Environment Agency and other information relating to controlled waters is summarised below.

| Data | | Remarks | Possible Hazard to/from Site (Y/ N) |
|---|---|---|---|
| Aquifer Designation | Superficial Deposits | Clay with flints – Unproductive strata | N |
| | Bedrock | Chalk – Principal aquifer. | Y |
| Groundwater Vulnerability | | High – productive bedrock aquifer. | Y |
| Abstractions | Surface Water | None recorded within 1km of the site. | N |
| | Groundwater | The closest groundwater abstraction to the site is 808m to the north at Surrey National Golf Club Ltd, and is for point abstraction for spray irrigation purposes. There are no potable water supply abstractions within 1km of the site. | N |
| Source Protection Zones | | Zone II (Outer Protection Zone) | Y |
| Surface Watercourses | | The Envirocheck report lists a “surface water feature” 263m to the SE. However, review of Ordnance Survey mapping does not show any significant surface watercourses within 0.5km of the site. | N |
| Surface Water Flood Risk* | | The site is not shown within/adjacent to an area mapped as being at risk. | N |
| Marine / Fluvial Flood Risk* | | The site is not shown within/adjacent to an area mapped as being at risk. | N |
| Discharge Consents | | The closest recorded discharge consent to the site is 305m to the south, and is for sewage discharge – final/treated effluent – not water company onto land. | N |

** These sections are provided for information only, this report does not constitute a formal flood risk assessment and specialist advice should be sought in relation to potential flooding issues.*

Whilst the superficial Clay-with-Flints, which are mapped beneath the site, are considered to be relatively impermeable (unproductive strata) the underlying chalk forms a highly permeable principal aquifer. The site is also situated within a groundwater source protection zone. Therefore, the groundwater beneath the site would be considered moderately sensitive. Depending on the thickness of the overlying superficial deposits, they should provide some protection to the aquifer, which is at potential risk from mobile contaminants arising from an on-site source. The site itself will also be at potential risk from the transmission of mobile contaminants from off-site sources.

The site is situated in an area classified as having a limited potential for groundwater flooding to occur. Given groundwater is likely to be at some considerable depth within the chalk aquifer, this likely refers to perched groundwater present within the superficial clay-with-flints.

### 6.5.1 Hydrogeology

Whilst there is limited data available for this location, based on BGS Hydrogeological mapping, groundwater within the chalk aquifer if likely to lie at approximately 250-300ft (AOD), ie. around 76-91mAOD. Therefore, with site ground levels of approximately 185mAOD, groundwater could be of the order of 100m below ground level.

## 6.6 Historical Ordnance Survey Maps

Copy extracts of historical Ordnance Survey plans dating from 1896 to 2024 were obtained and are presented in Appendix E. A summary of the salient features is presented below.

The earliest available map extract shows the site as open land, part of a larger field, to the north of an unnamed track. With the exception of the mapping of some woodland in the west/northwest of the site from 1912, the site has remained unchanged up until the present day.

The surrounding area remained largely undeveloped up until the 1930s when development for residential use began. This development continued up until the mid to late 1900s. The only historical notable features in the surrounding area are a small pond approximately 60m to the north from 1869 until 1973, which was subsequently developed with a residential property. Brick fields & pits were mapped present approximately 75m to the south and southeast from 1896 and appeared disused by the 1910/20s, part of this area was redeveloped with housing from 1930 onwards, with the other area appearing to remain open land. Based on the mapping, the brick fields/pits only appear to have been partially infilled. A plant nursery was present to the immediate west of the site, mapped from the mid 1900s up until the present day.

From Google Maps[1] it appears that the plant nursery is no longer in use, the land appearing to have been relatively recently redeveloped with a large detached house.

## 6.7 Environmental Databases

| Data Source | Distance (m) | Direction | Details | Possible Hazard to Site (Y/N) |
|---|---|---|---|---|
| Historical Industrial Land Use<br>(Within 250m of the site & identified from the historic mapping) | 0<br>0<br>75 | W<br>W<br>SE | Plant nursery (1965 – present)<br>Builders yard (1973 – present)<br>Brickfield (1896 – 1935) | N<br>N<br>N |
| Current Industrial Land Use<br>(Within 250m of the site) | 53 | E | Home furnishing manufacturer – inactive | N |
| Current and Historical Landfills | None recorded within 500m of the site. | | | N |
| Potentially Backfilled Land<br>(Within 250m of the site) | 75<br>60 | SE<br>N | Brickfield (1976)<br>Pond (1992) | N<br>N |
| Fuel Sites | None recorded within 500m of the site. | | | N |
| Pollution Incidents to controlled waters | None listed within 500m of the site. | | | N |
| IPPC/LAPPC Authorisations | None recorded within 1km of the site. | | | N |
| Hazardous Substances Consents | None recorded within 1km of the site. | | | N |

No significant contaminative uses features with the potential to affect the site have been identified from the environmental database.

[1] Accessed 10th April 2025

The potential risks associated with the proximity of potentially backfilled areas of land (a pond and former brick works) are discussed further in Section 6.9 below.

## 6.8 Planning Application History

A search of Tandrige District Councils[2] planning pages returned the following planning applications for the site.

| Application Number | Application Date | Proposal Details / Comments | Decision |
|---|---|---|---|
| 2000/911 | Sep. 2000 | Erection of two stables, hay barn and store. Widening existing access. | Refuse |

No other applications were listed for the site and the above does not indicate a significant potential source of contamination.

## 6.9 Ground Gas Risk

There are no current or historical landfill sites recorded within 500m of the site.

There are two areas of potentially backfilled land within 250m of the site. These comprise a former brickfield approximately 75m to the SE of the site and a pond 60m to the N of the site.

The brickfield is first shown on the 1896 historical map extract. By 1912 it appears from the mapping to be disused. By 1935 houses are present across the east of the former brickfield, with some of the former workings shown within their associated gardens and to the west. By the 1970s the excavations are no longer shown, with the area denoted as woodland. Given the age of the brickfield it is considered unlikely that it was particularly deep. Also, given its location, it is considered unlikely that it was used as a landfill and is not recorded as such. From the mapping, it appears most likely that the area was simply left and became overgrown.

A pond is shown around 60m to the N on the historical mapping from 1896–1992, by which time the location of the pond is occupied by a house.

On this basis, the above areas of potentially backfilled land are not considered to pose a potential risk from the generation and migration of ground gases to the subject, particularly given the anticipated negligible/very low permeability of the Clay-with-Flints soils.

## 6.10 UXO Risk Management

The agreed scope of work did not allow for either a preliminary or detailed UXO risk assessment.

However, by way of comment, preliminary risk mapping indicates the site to be within an area at moderate risk from UXO. The possibility of unexploded ordnance (UXO) being encountered on a site falls within the category of a potentially significant risk and should be addressed as a legal duty under the Construction (Design and Management) Regulations by the Client as early as possible in a project.

The CIRIA publication C681 Ref [17] has been developed to provide a consistent framework for the management of potential risks posed by UXO during site investigation and groundwork phases of construction. The process adopts a tiered approach, divided into four distinct stages; Preliminary risk assessment, Detailed risk assessment, Risk mitigation and Implementation.

# 7 Site Walkover Survey

## 7.1 General Site Description and Boundaries

The site comprises an open, approximately square field on the north side of Birchwood Lane, measuring around 120×110m. It is bounded to the east, north and west by residential properties/gardens. The land to the south of Birchwood Lane is undeveloped, and covered with grass and woodland. Within the site entrance in the south (off Birchwood Lane) the ground surface was noted to include fragments of brick/concrete rubble, which extended a short distance into the field.

[2] *Planning application search – accessed 09/04/2025*

### 7.2 Topography

The site is relatively flat and level in keeping with the surrounding area, with a slight fall of around 2-3m from the southeast towards the northwest. There is a slight gradual depression noted in the ground (<0.5m deep) towards the southeast corner. Similarly, the local area slopes gently towards the east/northeast at approximately 2-4°.

### 7.3 Vegetation

The majority of the site comprises a grassed field, and is currently used as grazing for horses. The site boundaries are quite heavily vegetated. The northern boundary comprises a post and wire fence, vegetated with brambles and a number of mature deciduous trees. The southern site boundary also comprises a post and wire fence and the site access gate, and is also lined with various semi-mature and mature deciduous trees. The eastern site boundary is heavily vegetated with dense brambles and scrub, which is encroaching onto the site in places. The western site boundary is slightly more open, with a post and wire fence along the boundary, with a number of semi-mature trees both along the boundary and forming a small wooded area extending out into the field.

### 7.4 Buildings and Land Use on Site and Nearby

The only structure on the site is a corrugated metal lean-to shed in the northwest corner of the site. Some limited machinery and materials were seen stored/discarded in the west/northwest of the site. It is understood that a water main runs north-south through the western part of the site (as shown on Sutton & East Surrey records), although the exact location of this pipe is unknown.

The surrounding area has a predominantly residential use, consisting of large, detached houses and their associated private gardens, with some areas of open land and woodland to the south and west.

### 7.5 Site Photographs

A series of photographs showing the site at the time of the walkover is included in Appendix A

# C PRELIMINARY SITE MODELS

## 8 Conceptual Engineering Geological Ground Model

From the desk study information and walkover undertaken at this site the following conceptual ground model has been formulated.

| Data Source | Comments |
|---|---|
| Geology | The recorded soils beneath the site comprise Lewes/Seaford/Newhaven Chalk Formation with a superficial covering of Clay-with-Flints. The Clay-with-Flints deposits are anticipated to be in the region of up to 10m in thickness. It is anticipated conventional foundations will be achievable (footing depths TBC) although piling may be required subject to the swelling/shrinkage classification. Excavations are likely to be stable in the very-short term, and unstable thereafter. |
| Former Site Use | Earliest available map extract shows the site as open land, part of a larger field, to the north of an unnamed track. With the exception of the mapping of some woodland on the western side of the site from 1912, the site has remained unchanged up until the present day. |
| Groundwater | The anticipated chalk formation on site is considered to be a productive aquifer. However, shallow groundwater is unlikely to be encountered within excavations, although some shallow seepages might be present within the clays during wet/winter weather. Allowances for de-watering is not considered to be required at this stage. Evaluation of this should be undertaken post groundwater monitoring. The site lies within Source Protection Zone II. |

| Data Source | Comments |
|---|---|
| Potential Geo-hazards | Shrinkage/swelling of clays is considered to be a moderate risk for this site. Although there are no records of solution features/mining within 0.5km of the subject site, due to the site geology, these cannot be completely ruled out altogether. |

On the basis of the available information the geotechnical categorisation for the proposed structure(s) is considered to fall within Geotechnical Category 2 – Conventional structure with no exceptional risk or difficult ground or loading conditions Eurocode 7 Ref [19].

# 9 Conceptual Site Model

In the context of this report, the conceptual model summarises the potential pollutant linkages identified for the site and forms the basis of the risk assessment for the site. The preliminary model comprises the potential sources of contamination, receptors that could be harmed and exposure pathways identified from the desk study and walkover survey. These potential linkages form the basis upon which the investigation is designed and reported.

## 9.1 Potential Sources of Contamination

The site has never been developed and is located within a largely residential area.

Given the history of the site and surrounding area, the potential sources of contamination are fairly limited, as discussed below.

### 9.1.1 On-Site Sources

| Potential Source | | Potential Contaminants |
|---|---|---|
| Historic Uses of the site | Open, undeveloped land | Limited potential for Made Ground in the vicinity of the site entrance and the lean-to structure in the northwest: variable, may include: Metals, non-metals, polyaromatic hydrocarbons (PAH) and asbestos containing materials (ACMs). |
| Current/Most Recent Uses of the site | Open, undeveloped land used for grazing horses | As above. |
| Ground and/or surface water | | No potential sources identified on site. |
| Ground Gases/Vapours | | No potential sources identified on site. |
| Radon | | No potential source. The site is mapped as in an area where 1–3% of homes are at or above the action level. |
| Sulphates (aggressive ground) | | No potential sources identified on site. |
| UXO | | Online mapping indicates the site to be within an area at moderate risk from UXO. |

On the basis of the available desk study information, the site has never been developed, with the exception of the lean-to structure in the northwest of the site. Therefore, there is considered to be a very limited potential for Made Ground to be present on the site.

The groundwater beneath the site would be considered moderately sensitive, due to the chalk forming a highly permeable principal aquifer. However, no potentially mobile, on site sources of potential contamination have been identified. Therefore, the site is not considered to pose a potential risk to groundwater, particularly given the overlying coverage of Clay-with-Flints (assumed to be of negligible permeability).

No potential on site sources of ground gases or vapours have been identified from the desk study and walkover survey.

### 9.1.2 Off-Site Sources

No significant potential off-site sources of contamination have been identified from the desk study and site walkover.

## 10 Risk Estimation

In order to evaluate the perceived contamination risks at this site, the severity of the risk in terms of the magnitude of the potential consequence of the linkage occurring has been compared with the likelihood of the linkage existing. A risk matrix with explanation of the probability, consequence and risk classification is included within Appendix D.

## 10.1 Risk Estimation Matrix

The table below summarises the risks for the possible potential pollutant linkages identified. This risk estimation assumes no mitigation has been undertaken.

| Source | | Pathway | Potential Receptor | | Prob | Con | Risk Category | Explanation |
|---|---|---|---|---|---|---|---|---|
| On site Sources of Contamination in Table 9.1.1 | **Affects Soils:** Heavy metals, non-metals, PAHs, asbestos & petroleum hydrocarbons | **Inhalation, Ingestion Dermal Contact & Plant uptake** | **Humans** | Construction Workers | Low | Minor | Very Low | The desk study and site walkover has not identified any significant source of potential contamination on site. However, there is a risk that more onerous contamination could be discovered during redevelopment. |
| | | | | Future Site Workers and Maintenance workers | Unlikely | Minor | Very Low | The desk study and site walkover has not identified any significant source of potential contamination on site. It is considered unlikely to pose a significant risk following redevelopment of the site. |
| | | | | Future Site Residents | Low | Mild | Low | The desk study and site walkover has not identified any significant source of potential contamination on site. However, intrusive investigation should be undertaken to confirm this, and enable the design of appropriate remedial measures (if required), given the sites proposed residential end use. |
| | | **Run-Off Leaching Direct Contact** | **Controlled Waters** | Groundwater:<br>Superficial deposits – Unproductive Strata.<br>Bedrock – Principal Aquifer.<br>Private or Public Drinking water supplies – none recorded | Unlikely | Minor | Very Low | Whilst the site is situated on a Principal Aquifer, the overlying relatively impermeable superficial deposits will provide protection from the migration of mobile contaminants arising at the site surface. Furthermore, no sources of mobile contamination have been identified on, or in the vicinity of the site. |
| | | | | Surface water - None | N/A | N/A | N/A | There are no surface water courses near enough to site to be considered a risk. |
| | | **Direct Contact** | **Property** | **Infrastructure -** Water Supply Pipes | Unlikely | Minor | Very Low | Organic contaminants (PAH & petroleum hydrocarbons) may affect plastic pipes. |
| | | | | **Structures -** Substructures/ foundations | Unlikely | Minor | Very Low | The soils underlying the site are not anticipated to contain high level of sulphates.<br>No potential sources of ground gases have been identified. |
| Off Site Sources of Contamination Table 9.2.1 | None Identified | **N/A** | | **N/A** | N/A | N/A | N/A | N/A |

| Very Low | Low | Moderate/ Low | Moderate | High | Very High |
|---|---|---|---|---|---|

## 10.2 Preliminary Relevant Pollution Linages

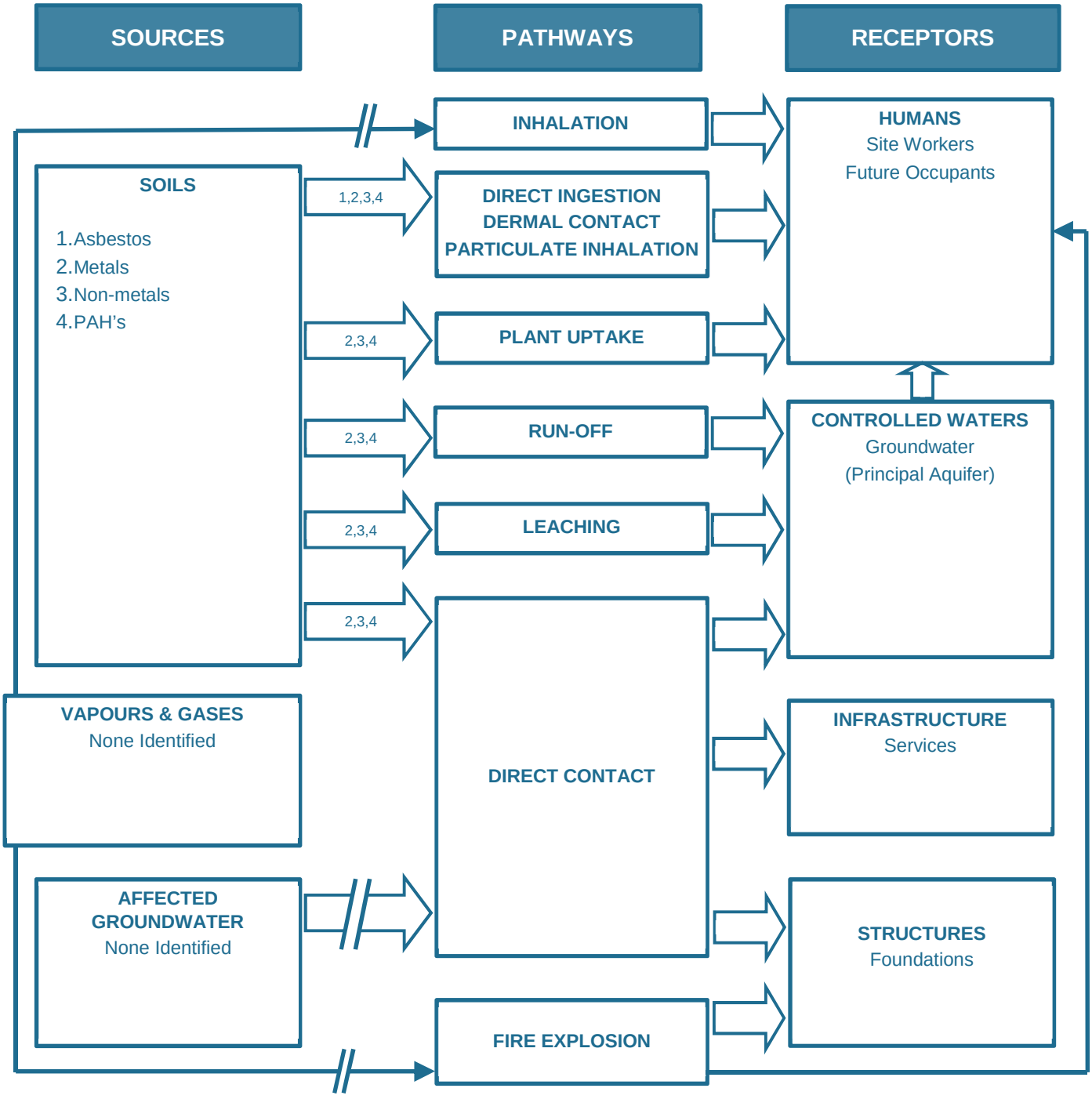
Those potential sources which have been identified as potential relevant are summarise in the table below:

| Sources | | Pathway | Receptors | Risk Category |
|---|---|---|---|---|
| **Human Heath** | Asbestos | • Inhalation of dust. | • Construction Workers<br>• Intrusive Maintenance Workers<br>• Future Site Residents | **Low** |
| | Heavy metals, non-metals, PAHs & petroleum hydrocarbons | • Ingestion of soil and/ or dust.<br>• Inhalation of soil and/ or dust.<br>• Plant Uptake | • Future Site Residents | **Low** |
| **Controlled Water** | Heavy metals, non-metals, PAHs & petroleum hydrocarbons | • Leaching<br>• Direct Contact | • Low permeability superficial deposits over Principal Aquifer<br>• No nearby surface water features | **Very Low** |
| **Property** | Organic contaminants (PAH & petroleum hydrocarbons) | • Direct Contract. | • Underground Utilities | **Very Low** |
| | Sulphates | • Direct Contact. | • Buildings – underground structures | **Very Low** |

| Very Low | Low | Moderate/ Low | Moderate | High | Very High |
|---|---|---|---|---|---|

## 10.3 Pollutant Linkages and Conceptual Site Model Summary

The following diagram shows the potential pollutant linkages identified for the site and summarises the preliminary conceptual model:




// Denotes potential pollutant linkage not complete.

## 10.4 Risk of Soil Contamination

Given the site history and current use of the site, there is considered to be a very low risk of contamination. However, there is some potential for localised contamination. Sampling and laboratory analysis of the shallow soils across the site should be undertaken given the sites proposed residential end use.

## 10.5 Risk of Groundwater Contamination

No risk to groundwater has been identified at this stage, and there are no surfaces water bodies within the vicinity of the site. Therefore, no further assessment is considered necessary, unless any significant mobile contamination is identified on site.

## 10.6 Risk from Ground Gases

No potential gas risk has also been identified either on site or locally. As such, no further assessment of land gas risk is considered necessary.

# D GROUND INVESTIGATION

## 11 Strategy and Method

The strategy adopted for the intrusive investigation comprised the following:

| Activity / *Method* | Purpose | Max Depth Range (bgl) | Installations / Notes |
|---|---|---|---|
| BH1 & BH2<br>*Cable Percussive (150mm)* | Boreholes to assess deeper ground conditions and allow SPT's and samples for geotechnical testing. | 20.0m | With full-depth 50mm groundwater monitoring wells installed. |
| HA01–HA06<br>*Hand Auger* | Shallow hand excavated trial holes to obtain samples of the shallow soils for contamination testing purposes. | 1.0m | |

The presence of an underground (PVC) water main, which crosses the site, limited the fieldwork since the exact location was unknown and could not be traced. In addition, the boreholes/monitoring wells were also positioned close to the periphery of the field, which was being used for horses. The exploratory hole locations are shown on Figure 2 in Appendix A.

In-situ test and sampling methods descriptions employed are given in Appendix B together with the test results.

SPT Energy Ratio certificates and a Summary Table of SPT N Values is provided within Appendix B.

## 12 Weather Conditions

The fieldwork was carried out between 1st and 4th April 2025, at which time the weather was generally dry. According to Southern Water rain-fall data, the weather across the UK was noted to be drier than the long term predicted average for the months of February and March, with 77.3% and 13% worth of the long-term average expected rainfall across the south of the UK.

## 13 Soils as Found

The soils encountered, which are described in detail in the attached exploratory hole logs (Appendix A), were broadly in accordance with those anticipated from geological records.

The soils comprised a covering of Topsoil to depths of 0.1-0.2m, over variable Clay-with-Flints to depths of 6.3/6.7m, over Lewes/Seaford/Newhaven Chalk Formation.

The Clay-with-Flints comprised an interbedded sequence of firm to stiff, gravelly clay, sandy clay, clayey sand or sandy/gravelly clay with cobbles.

### 13.1 Visual and Olfactory Evidence of Contamination

No visual or olfactory evidence of significant contamination was noted within the trial holes undertaken as part of this investigation.

The results of the laboratory analysis undertaken to date are discussed in Section F.

## 14 Groundwater Observations

Groundwater was not encountered within any of the trial holes undertaken. Most notably, groundwater was not struck during drilling of BH1 and BH2 during the investigation on the 1st-4th April 2025. Subsequently, during 1 No. return groundwater monitoring visit (undertaken on 7th May 2025), the monitoring wells installed in the boreholes were also found to be dry (also see Section 17).

# E DISCUSSION OF GEOTECHNICAL TEST RESULTS AND RECOMMENDATIONS

## 15 Geotechnical Laboratory Tests

The following geotechnical laboratory testing was carried out on selected samples in order to aid material classification and characterise soil properties. The test method references and results are given in Appendix C.

| Laboratory Test | Number of Samples Tested | Stratum |
|---|---|---|
| Moisture Content | 6 | Clay-with-Flints |
| Atterberg Limit | 6 | Clay-with-Flints |
| Particle Size Distribution (Wet Sieve) | 3 | Clay-with-Flints |
| BRE SD1 Suite | 2 | Clay-with-Flints |
| Saturated Moisture Content (Chalk) | 4 | Lewes/Seaford/Newhaven Chalk Formation |

## 16 Soil Classification and Properties

### 16.1 Clay-with-Flints

The Clay-with-Flints encountered at this site were seen to be variable with soils ranging from firm sandy clays to medium dense sands. The distribution of individual soil types across the site is not predictable and rapid changes in soil type should be anticipated both vertically and laterally.

Atterberg test was undertaken on samples of sandy clay and sandy gravelly clay, which indicated clays of Low, Intermediate, High and Very plasticity (CL, CI, CH,& CV). The Liquid Limits are in the range 24-82%, Plastic Limits of 13-26% and Plasticity Indices of 9-57% (mean of 37.3%).

The clayey sand materials were found to be medium dense in nature with SPT N values of N=10. SPT N values in the predominantly cohesive soils ranged between N=8-16 N indicating firm to stiff clays.

The Clay-with-Flints soils had the following range of particle size distribution results.

| Sample ID | Clay/Silt Fines (%) | Sand (%) | Gravel (%) | Cobbles (%) |
|---|---|---|---|---|
| BH1 (2.0m) | 48 | 51 | 1 | 0 |
| BH2 (1.0m) | 77 | 19 | 4 | 0 |
| BH2 (3.0m) | 19 | 80 | 0 | 0 |

Cohesive soils (clays and silts) usually present an aquatard with lower permeability rate. All of the samples tested had medium to high fines content and are likely to be low/negligible permeability.

The predominantly cohesive soils within the Clay-with-Flints Formation are likely to have medium to high compressibility characteristics, the more granular soils will have lower compressibility.

## 16.2 Lewes/Seaford/Newhaven Chalk Formation

The chalk at this site was generally recovered (from destructive cable percussive drilling) as structureless clast dominated off-white chalk. Clasts were recorded as extremely to moderately weak.

Dry density measurements for chalk samples were seen within the range of 1.56-1.65Mg/m$^3$, indicating Medium density.

# 17 Groundwater Levels

Groundwater levels vary considerably from season to season and year to year, often rising close to the ground surface in wet or winter weather, and falling in periods of drought. Groundwater levels measured in Winter months may be significantly higher than those that might be experienced in dry or Summer months and the possibility of a requirement for dewatering or alternative foundation solution that may not have initially been considered should not be overlooked.

According to BGS survey records and readings from neighbouring boreholes, groundwater is considered to vary between 80 -100m AOD depending on the season/period of wetter weather.

Long-term monitoring from boreholes or standpipes is required to assess the ground water regime. The effects of climate change, particularly the increased likelihood of significant rainfall events and warmer, wetter winters may mean groundwater levels in the future could be higher than those measured during site investigation works.

Groundwater monitoring was undertaken on 7$^{th}$ May 2025. Groundwater was not encountered in either borehole during the monitoring visit.

# 18 Swelling and Shrinkage

Atterberg Limit tests were carried out on a total of six samples of the Clay-with-Flints soils recovered from boreholes BH1 and BH2, which were found to be highly variable. The unmodified plasticity indices for the samples were recorded in the range 9-57%, with a mean of 37.3%.

When these results are amended to allow for the coarse soil particles (64-100% passing the 425µm sieve), then the modified plasticity indices reduce to the range of 8.0-44.5%, with a mean modified plasticity index of 30.4%.

Based on these results, 1 No. sample is classified as negligible plasticity, 4 No. samples are classified as Medium Volume Change Potential (VCP), with 1 No. sample classified as High VCP.

At this stage, we would recommend that on balance a NHBC Medium Volume Change Potential site classification be adopted for preliminary foundation design purposes. In addition, based on the results of three particle size distribution results (see Section 16.1), a further 3 No. samples tested from BH1 & BH2 contained 19-77% clay/silt size particles.

Given that this is a preliminary geotechnical investigation, and these recommendations are based on limited laboratory testing from only two locations, it is recommended that further investigation from trial pits and additional classification laboratory testing is undertaken to finalise the recommendations.

Full details of protective measures are given in NHBC Standards Ref [21], Chapter 4.2 to which the reader is referred.

# 19 Soakaways

No shallow soakaway testing has been carried out on this site due to the predominantly clay nature of the soils, which were anticipated to extend to a significant depth, precluding the use of such drainage.

Based on the soils found within the boreholes undertaken, comprising Clay-with-Flints to depths of 6.3/6.7m, preliminary constant-head soakage tests were undertaken in each open borehole, with subsequent falling-head tests carried out within the 50mm groundwater monitoring wells installed.

## 19.1 Test Results (Constant-Head Tests)

Once each borehole had reached the target depth of 20m, a preliminary constant-head soakage test was undertaken in the open boreholes. The results of the discharge rates are summarised below.

- BH1 – 180L/min
- BH2 – 240L/min

At the above discharge rates, the water levels during testing did not rise up significantly in either borehole. Immediately after ceasing each test, borehole BH1 was dry, while the water level in borehole BH2 was at 15.6m(bgl). Therefore, it is likely that higher discharge rates will be achievable.

## 19.2 Test Results (Falling-Head Tests)

A return visit was made to site on 9th May 2025. A total of 3 No. falling-head tests were undertaken in each borehole. Due to the limited pipe diameter (50mm) installed in the boreholes, it was not possible to measure the water level at the same time as filling with water and, therefore, constant-head tests were not possible at this time.

The results of the falling-head tests are summarised below.

| BH ID | BH Depth (bgl) | Test No. | Starting Water Level (bgl) | Falling-Head Test (m/sec)* |
|---|---|---|---|---|
| BH1 | 20.0m | 1 | 12.67m | $1.0\times10^{-5}$ |
| | | 2 | 7.80m | $1.1\times10^{-5}$ |
| | | 3 | 8.25m | $1.2\times10^{-5}$ |
| BH2 | 20.0m | 1 | 9.10m | $7.8\times10^{-6}$ |
| | | 2 | 12.98m | $1.4\times10^{-5}$ |
| | | 3 | 13.50m | $1.0\times10^{-5}$ |

** BS22282 does not appear to satisfactorily cater for undertaking calculations for falling-head tests in chalk/rock soils, where water flows through fissures/fractures, rather than permeating through the whole soil mass (as it might do in a uniform soil strata such as sand). Therefore, these results are based on the methodology/calculation contained within BS5930.*

Due to the fast soakage rates, the water level did not rise up to anywhere near ground level and rapidly fell to around 8-13m below ground for the first dip measurement of each falling-head test.

As above, with the constant-head tests, it is considered likely that higher rates will be achievable.

## 19.3 General Guidance on Design of Borehole Soakaways

Based on the Dry Density results undertaken to date for the chalk strata from limited locations (see Section 16.2), which reported medium density, soakaways should be kept a minimum of 5m away from buildings/foundations etc. However, the chalk density/classification should be reassessed during future ground investigations to provide final recommendations.

Any borehole soakaway scheme will require the approval of the Environment Agency, and may require Building Control and Highways Authority approval.

Risk of pollution to the quality of groundwater must be considered as part of the design.

Generally, roof and surface run-off should not significantly impact on groundwater quality and subject to appropriate approvals from the Environment Agency could be discharged directly to borehole soakaways. However, although again subject to approvals from the Environment Agency, paved surface run-off for larger trafficked areas should generally be passed through a suitable form of oil interception device prior to discharge to the soakaway.

Care must be taken to ensure that the discharge of large volumes of surface run-off into the soil does not disrupt the existing sub-surface drainage patterns. Similarly in areas of sloping topography, consideration should be given to the siting of soakaways to avoid potential discharge and or flooding of down slope areas.

Further restrictions apply in areas where chalk strata is present depending on the chalk density.

In areas susceptible to geohazards that are sensitive to concentrated water flows, the use of borehole soakaways should be very carefully considered. In particular, borehole soakaways are often used instead of conventional shallow soakaways in areas susceptible to chalk solution features due to the anticipated reduced risk of surface expression or collapse due to inundation. It should be remembered that the use of borehole soakaways in such areas would be considered a risk *reduction* measure rather than a risk *removal* measure, even where detailed ground investigation had revealed an absence of solution features in the investigated areas. Published stand-off distances from buildings to soakaways relate to the horizontal, rather than vertical distance.

## 20 Sulphates and Acidity

Chemical analysis of the underlying soils has been undertaken to establish the aggressive chemical environment for concrete in accordance with the BRE Special Digest 1, Ref [23]. The site category determined is that of a natural ground location except those that contain pyrites, as the underlying soils form part of Clay-with-Flints.

Based on the sulphate results included within the shallow contamination test results, given the sample numbers tested (7 No.) the characteristic value for sulphate concentration has been determined from the mean of the two highest measured concentrations.

The recorded pH values are in the range of 5.8 to 7.5. The sulphate concentrations are in the range 5.7-19.9mg/ℓ, therefore, the Design Sulphate Class is DS-1. Groundwater should be assumed to be static and, therefore, the ACEC site classification is AC1s.

## 21 Foundations and Bearing Capacity

All loadings should be transferred beneath any fill or made ground, topsoil, soft or disturbed soils and be placed within the underlying natural clay soils. Based on the limited results from the 2 No. boreholes undertaken as part of this investigation, a preliminary allowable bearing capacity of 100kN/m$^2$ could be adopted for foundations set within the natural soils of the Clay-with-Flints Formation at a minimum depth of 0.9m. However, since this is a preliminary geotechnical investigation, further trial holes will be required across the site for the design of shallow traditional strip foundations etc.

In addition, further assessment of the variability of the clay/sand/gravel content will be required to establish whether reinforcement is required within foundations to cater for any potential differential movement/settlement.

Noting that the site boundary is fairly vegetated, allowance should be made for undertaking a detailed survey prior to any vegetation clearance with the location, height and species of all trees, saplings and shrubs accurately recorded.

Should piled foundations be required, the information contained within this report (ie. in-situ and laboratory test results) can be used for preliminary design purposes. Additional boreholes may be required, subject to the locations and/or number of units requiring piling.

## 22 Floor Slabs

For this site suspended ground floor slabs will be required in accordance with NHBC requirements where foundation depths in excess of 1.5m are required due to the influence of trees, or where made ground/disturbed soils are deeper than 600mm beneath the slabs. Outside of these areas, ground floor slabs can be either of ground bearing or suspended construction.

## 23 Excavations and Dewatering

Statutory support will be required in all excavations where personnel must work.

The clay materials will be prone to instability in open excavations during wet weather or where seepages are encountered and will soften rapidly if exposed to moisture or the elements.

The sand materials will run and be highly unstable in excavations or boring operations where significant water is encountered. Given the depth of the water table in this area any significant water is likely to be limited to seepages during heavy rainfall etc. Significant inflows of groundwater into excavations would not be anticipated nor would the requirement for specialist de-watering activities.

Where narrow diameter boreholes are used as the investigation technique, long-term stability can only be crudely estimated from soil type, strength and/or density but cannot be visually assessed. In addition, NHBC Chapter 4.3.9 requires that for strip and trench-fill foundations *'unless otherwise designed by an engineer in accordance with Technical Requirement R5, trench sides and steps should be, as near as possible, vertical'.*

Trial trenches would be advisable prior to the main excavation works to help assess trench stability, groundwater ingress and the requirement for any trench support.

## 24 Pavement Construction

Based on the available data, it is anticipated that the formation to proposed pavement areas will comprise sandy gravelly clays of the Clay-with-Flints formation.

The results of Atterberg Limit tests on the clay materials indicate variable plasticity indices in the range of 9-57%, with an average value of 37.3%. On the basis of guidance in the DMRB Ref [24] a preliminary CBR value of about 2.5-3.0% is estimated for a thin pavement construction for poor construction conditions with a low water table.

However, given that the soils are likely to be disturbed by construction plant during demolition and construction it would be suggested that the CBR value is reassessed as construction progresses. Further sampling and laboratory testing may be necessary to satisfy Local Highway Authority design guidance, in terms of frequency and types of testing, if roads are to be submitted for adoption.

The most important element of any road construction is drainage and attention must be given not only to the drainage of the subsoil but to the various layers of construction. To this end, the formation should be shaped to a camber or crossfall to allow water movement out of the sub-base. Silty soils soften extremely quickly if allowed to become wet and this softening can give rise to a very substantial increase in costs.

Sub-base and coarse capping materials tend to segregate during placing operations, particularly when end tipped. On soft clay subgrades this can lead to punching and softening of the formation. The use of an appropriate geotextile or geofabric, laid in accordance with manufacturer's recommendations / guidance, should help to minimise this.

The formation should be proof-rolled in a manner appropriate to the subgrade soils, and any soft spots found should be excavated and replaced with compacted granular material. The surface of the formation should then be appropriately compacted, prior to laying the capping layer and/or sub-base.

Construction traffic should be kept off formations and it is often advisable to leave a protective layer of soil above formation level until the last moment before reducing to formation level and placing the capping and/or sub-base.

At this stage, the formation should be considered potentially frost-susceptible (subject to further assessment).

# F DISCUSSION OF GEOENVIRONMENTAL TEST RESULTS AND RECOMMENDATIONS

## 25 Analytical Framework

There is no single methodology that covers all the various aspects of the assessment of potentially contaminated land and groundwater. Therefore, the analytical framework adopted for this investigation is made up of a number of procedures, which are outlined below. All of these are based on a Risk Assessment methodology centred on the identification and analysis of Source – Pathway – Receptor linkages.

The CLEA model Ref [1], provides a methodology for quantitative assessment of the long-term risks posed to human health by exposure to contaminated soils. Toxicological data is used to calculate a Soil Guideline Value (SGV) for an individual contaminant, based on the proposed site use; these represent minimal risk concentrations and may be used as screening values.

In the absence of any published SGVs for certain substances, Southern Testing have derived or adopted Tier 1 screening values for initial assessment of the soil, based on available current UK guidance including the LQM/CIEH S4UL's Ref [25] and CL:AIRE Soil Generic Assessment Criteria Ref [26]. In addition, in 2014, DEFRA Ref [27] published the results of a research programme to develop screening values to assist decision making under Part 2A of the Environmental Protection Act. Category 4 screening levels were published for 6 substances, with reference to human health risk only. This guidance includes revisions of the CLEA exposure parameters, presenting parameters for public open space land use scenarios, and also of the toxicological approach. The screening levels represent a low risk scenario, based on a 'Low Level of Toxicological Concern' rather than the 'Minimal Risk' of CLEA. Category 4 screening levels for further substances have been published subsequently. The analytical results of this investigation may be considered relative to these levels.

Site-specific assessments are undertaken wherever possible and/or applicable.

CLEA requires a statistical treatment of the test results to take into account the normal variations in concentration of potential contaminants in the soil and allow comparisons to be made with published guidance.

**The contamination screening values used are valid at the time of writing but may be subject to change and any such changes will have implications for the assessments based upon them. Their validity should be confirmed at the time of site development.**

# 26 Site Investigation – Soils

## 26.1 Sampling Regime

The number of sample locations was limited and was intended to provide general coverage.

The presence of a water main (exact location unknown), which crosses the site limited the fieldwork.

## 26.2 Testing

The preliminary conceptual model did not identify any significant risk of potential contamination on the site. Therefore, the following tests were selected, in order to confirm that the shallow soils would be suitable to be retained on site post redevelopment.

| Test Suite | Number of Samples | Soil Tested |
|---|---|---|
| STL Key Contamination Suite | 4<br>3 | Topsoil<br>Natural Subsoil |
| Asbestos Screen | 4<br>3 | Topsoil<br>Natural Subsoil |

The test results are presented in full in Appendix D. A summary and discussion of the significance of the results and identified contamination sources is given below.

## 26.3 Test Results and Identified Contamination Sources

### 26.3.1 General Contaminants

The results of the key contaminant tests have been analysed in accordance with the CLEA methodology. The samples have been grouped into two populations comprising topsoil and natural subsoil. For each parameter in each population the sample mean is calculated and compared to a Tier 1 screening value. If the sample mean exceeds the screening value, the soil may be regarded as contaminated and further assessment may be required. If neither the sample mean nor any single value exceeds the screening value, the soil may be regarded as not contaminated, though further confirmatory assessment may be required. Where any single parameter value exceeds the screening value but the sample mean does not, further statistical analysis may be applied to that parameter if the available data is suitable. Such analysis would include an assessment of the Normality of the distribution of the data, consideration of the presence of outliers, and the calculation of a UCL estimate of the mean.

Summary data is presented in the tables below and the laboratory analysis is included in Appendix D. The screening values and source notes are presented in Table 1 "Tier 1 Screening Values" at the front of Appendix D.

***Soil Type: Topsoil***

| Contaminants | Units | HA01 (0.1m) | HA02 (0.1m) | HA03 (0.1m) | HA05 (0.1m) | Residential with Home-grown Produce Consumption Tier 1 Screening Values |
|---|---|---|---|---|---|---|
| Arsenic (As) | mg/kg | 8.6 | 5.3 | 10 | 7.6 | 37 |
| Cadmium (Cd) | mg/kg | 0.3 | 0.2 | 0.3 | 0.3 | 11 |
| Trivalent Chromium (CrIII)* | mg/kg | 19 | 13 | 23 | 19 | 910 |
| Hexavalent Chromium (CrVI) | mg/kg | <1.8 | <1.8 | <1.8 | <1.8 | 6 |
| Lead (Pb) | mg/kg | 36 | 28 | 41 | 41 | 200 |
| Mercury (Hg) | mg/kg | <0.3 | <0.3 | <0.3 | <0.3 | 7.6-11 |
| Selenium (Se) | mg/kg | <1.0 | <1.0 | <1.0 | <1.0 | 250 |
| Nickel (Ni) | mg/kg | 10 | 5.8 | 11 | 8.3 | 130 (60 – 110) |
| Copper (Cu) | mg/kg | 12 | 12 | 17 | 14 | 2,400 (100 – 200) |
| Zinc (Zn) | mg/kg | 52 | 37 | 60 | 42 | 3,700 (200 – 300) |
| Phenol | mg/kg | <1.0 | <1.0 | <1.0 | <1.0 | 120-380 |
| Benzo(a)pyrene (BaP) | mg/kg | 0.13 | 0.18 | <0.05 | <0.05 | 1.7-2.4 |
| Naphthalene | mg/kg | <0.05 | 0.05 | 0.05 | 0.05 | 2.3-13 |
| Total PAHs (16) | mg/kg | 1.31 | 1.8 | <0.80 | 1.8 | / |
| Total Cyanide (CN) | mg/kg | <1.0 | <1.0 | <1.0 | <1.0 | / |
| Acidity (pH values) | / | 6.3 | 7.3 | 6.3 | 7.3 | / |
| Soil Organic Matter | % | 3.7 | 4 | 2.6 | 4 | / |

** Assumed as Total Cr minus CrVI*

() Screening values shown in brackets are the screening values (for the phytotoxic metals) as given in the British Standard for Topsoil (BS3882:2015).

On the basis of the above laboratory analysis, the topsoil across the site would be considered chemically suitable for retention and reuse on site within proposed garden and soft landscaped areas.

The concentrations of the potentially phytotoxic metals (copper, nickel and zinc) are below the values given in the British Standard for topsoil, and therefore the concentrations of these metals are not considered to be potentially detrimental to plant health.

***Soil Type*: Natural Subsoil**

| Contaminants | Units | HA02 (0.4m) | HA04 (0.3m) | HA05 (0.3m) | Residential with Home-grown Produce Consumption Tier 1 Screening Values |
|---|---|---|---|---|---|
| Arsenic (As) | mg/kg | 6 | 8.3 | 7.3 | 37 |
| Cadmium (Cd) | mg/kg | <0.2 | 0.3 | <0.2 | 11 |
| Trivalent Chromium (CrIII)* | mg/kg | 15 | 22 | 21 | 910 |
| Hexavalent Chromium (CrVI) | mg/kg | <1.8 | <1.8 | <1.8 | 6 |
| Lead (Pb) | mg/kg | 17 | 24 | 16 | 200 |
| Mercury (Hg) | mg/kg | <0.3 | <0.3 | <0.3 | 7.6-11 |
| Selenium (Se) | mg/kg | <1.0 | <1.0 | <1.0 | 250 |
| Nickel (Ni) | mg/kg | 6.5 | 10 | 7.4 | 130 |
| Copper (Cu) | mg/kg | 7.1 | 19 | 7.4 | 2,400 |
| Zinc (Zn) | mg/kg | 27 | 43 | 26 | 3,700 |
| Phenol | mg/kg | <1.0 | <1.0 | <1.0 | 120-380 |
| Benzo(a)pyrene (BaP) | mg/kg | <0.05 | <0.05 | <0.05 | 1.7-2.4 |
| Naphthalene | mg/kg | <0.05 | <0.05 | <0.05 | 2.3-13 |
| Total PAHs (16) | mg/kg | <0.80 | <0.80 | <0.80 | / |
| Total Cyanide (CN) | mg/kg | <1.0 | <1.0 | <1.0 | / |
| Acidity (pH values) | / | 6.6 | 6.7 | 7.5 | / |
| Soil Organic Matter | % | 0.9 | 1.5 | 0.9 | / |

** Assumed as Total Cr minus CrVI*

On the basis of the above laboratory analysis the natural subsoil would be considered chemically suitable for retention and within proposed garden and soft landscaped areas.

### 26.3.2 Asbestos Containing Materials

No asbestos containing materials were detected in the samples analysed and none were observed in the exploratory holes. However, it should be noted that the exploratory holes are of small size relative to the area investigated and the investigation was slightly constrained by the presence of a water main. Therefore, the samples obtained may not reflect the full composition of the soils on the site.

## 27 Site Investigation – Waters

Groundwater was not encountered during the intrusive site investigation works, or subsequent groundwater monitoring.

The site investigation works undertaken to date have not identified any potential sources of mobile contamination, or significant soil contamination.

Therefore, given the overlying clay-with-flints, and the anticipated depth to groundwater, the potential risk to the groundwater beneath the site from leaching or mobile sources of contaminants on the site is considered to be negligible.

## 28 Site Investigation – Ground Gas

No potential gas risk has been identified either on site or locally. As such, no further assessment of land gas risk is considered necessary.

## 29 Summary of Identified Contamination

On the basis of the findings of the desk study and intrusive site investigation works, the site is not considered to be at risk from contamination.

### 29.1 Revised Conceptual Model

The preliminary site model has been refined in light of the findings of this investigation and is summarised below.

| Metals | Non-metals | Polyaromatic Hydrocarbons | Land Gas | Asbestos | Pathways | Receptors |
|---|---|---|---|---|---|---|
| N | N | N | n/a | N | Ingestion/inhalation of contaminated soil & dust | Human Health |
| N | N | N | n/a | n/a | Dermal contact with contaminated soil & dust | |
| n/a | N | N | N | n/a | Inhalation of vapours or gases | |
| N | N | N | n/a | n/a | Uptake into edible fruit and vegetables | |
| n/a | n/a | n/a | n/a | n/a | Surface water run-off into surface water features | Water Environment |
| N | N | N | n/a | n/a | Migration through ground into surface water or groundwater | |
| N | N | N | n/a | n/a | Off-site migration of contaminated groundwater | |
| N | N | N | N | n/a | Vegetation on site growing in contaminated soil | Flora and Fauna |
| n/a | n/a | n/a | n/a | n/a | Aquatic life in affected waters | |
| N | N | N | n/a | n/a | Contact with contaminated soils | Building materials / buried services |
| n/a | n/a | N | N | n/a | Fire or explosion | |

*Key:*

*Y* *Pollutant linkage likely*
*N* *Pollutant linkage not likely*
*P* *Pollutant linkage possible*
*n/a* *Pathway not applicable to contaminant*

### 29.2 Relevant Pollutant Linkages

No Relevant Pollutant Linkages for which remedial action will be required have been identified in the revised conceptual model.

## 30 Discussion and Conclusions

The topsoil and underlying shallow soils across the site would be considered uncontaminated, and therefore suitable to be retained on site post redevelopment.

In order to maintain the structure and composition of the topsoil, care should be taken when stripping, stockpiling and handling this soil. Further guidance is given in the Construction Code of Practice for the Sustainable Use of Soils on Construction Site (DEFRA 2009). Care should also be taken to avoid compaction of the subsoil; where this occurs, it should be rectified by rotavating or similar, prior to the placement of topsoil.

As with any site, areas of contamination not identified during site investigation works may come to light in the course of redevelopment. Accordingly, a discovery strategy must be in place during the redevelopment to ensure that any hitherto unknown contamination is identified and dealt with in an appropriate manner. Depending on the nature of any such contamination, it may prove necessary to reassess the remedial strategy for the site.

The existing monitoring wells on the site should be decommissioned, to prevent the upward migration of downward migration of contamination to the groundwater.

## 31 General Guidance

Allowance should be made for experienced verification of any remedial works.

It may be that specific local requirements apply to this site, of which we are not aware at this time.

In general terms, the workforce and general public should be protected from contact with contaminated material. There is a range of relevant documents published by the Health and Safety Executive, and organisations such as CIRIA, and the BRE.

## 31.1 Soil Waste Management

### 31.1.1 Re-use of Soils

It is anticipated that the arisings from groundworks on this site will comprise topsoil and underlying natural clay and chalk soils.

Clean natural arisings from groundworks may be re-used on site without further testing, where there is a definite use for such materials, e.g. raising levels or construction of landscaping layers or bunds as set out in the approved plans for the development.

Treated contaminated soils may be reused on site under an appropriate Materials Management Plan, where certain criteria are met, in accordance with the CL:AIRE Definition of Waste Code of Practice, Ref [31].

### 31.1.2 Disposal of Soils

Some soils will require removal from site and disposal to suitably licensed landfills. Different guidelines and charges will apply to different waste classifications. As waste producers, the Developer holds responsibilities under the various governing regulations, particularly the Waste Duty of Care Code of Practice under the Environmental Protection Act 1990, Ref [32].

The chemical analyses appended to this report can be used to inform the initial classification of the soils as either Hazardous or Non-Hazardous, and derive the appropriate EWC code, for offsite disposal or transfer. Waste Acceptance Criteria (WAC) testing may be needed for confirmation of the material's classification, and will be required to demonstrate an inert classification.

There are strict requirements in place for the accurate description of wastes using EWC codes and, therefore, it is essential that materials that would be given different descriptions (e.g. blacktop, made ground and natural soils), as well as those with different classifications, are carefully segregated during excavation and storage on site. This will also ensure the most cost effective disposal. Mixing these materials can give rise to significant difficulties in disposal and also substantially increase costs.

Soil arisings may be transferred to other development sites under a Materials Management Plan, where certain criteria are met, in accordance with the CL:AIRE Definition of Waste Code of Practice Ref [31].

All soils leaving site will need to be pre-treated. Waste minimisation by selective excavation is a recognised form of pre-treatment.

# REFERENCES

[1] Environment Agency, “Updated technical background to the CLEA model,” 2009.

[2] Contaminated Land: Applications in Real Environments (CL:AIRE), “Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination,” 2014.

[3] CIRIA, “C665 Assessing risks posed by hazardous ground gases to buildings,” 2007.

[4] BSI Standards, “BS 5930 Code of practice for ground investigations,” 2015.

[5] BSI Standards, “BS10175 Investigation of potentially contaminated sites – Code of practice,” 2013.

[6] British Geological Survey (BGS), “Scanned Maps Portal,” [Online]. Available: http://www.bgs.ac.uk/data/maps/home.html.

[7] British Geological Survey (BGS), “Geology of Britain Viewer,” [Online]. Available: http://www.bgs.ac.uk/discoveringGeology/geologyOfBritain/viewer.html.

[8] British Geological Survey (BGS), “Hydrogeology Maps of the UK,” [Online]. Available: http://www.bgs.ac.uk/research/groundwater/datainfo/hydromaps/hydro_maps_scanviewer.html.

[9] British Geological Survey (BGS), “Borehole Scans,” [Online]. Available: http://www.bgs.ac.uk/data/boreholescans/home.html.

[10] Environment Agency (GOV.UK website), “Long Term Flood Risk Information,” [Online]. Available: https://flood-warning-information.service.gov.uk/long-term-flood-risk/.

[11] Public Health England, “UK Radon Maps,” [Online]. Available: http://www.ukradon.org/information/ukmaps.

[12] Building Research Establishment (BRE), “BR211 Radon Guidance on protective measures for new buildings,” 2015.

[13] Ove Arup on behalf of the Department of Environment, “Review Of Mining Instability In Great Britain,” 1990.

[14] Chelsea Spelaeological Society, “Various Records, Journals and Special Publications”.

[15] Kent Underground Research Group, “Various Records, Journals and Special Publications”.

[16] CIRIA, “C681 Unexploded Ordnanace (UXO) A guide for the construction industry,” 2009.

[17] BSI Standards, “Eurocode 7 Geotechnical Design,” 2013.

[18] NHBC, “NHBC Standards Plus,” [Online]. Available: http://www.nhbc.co.uk/Builders/ProductsandServices/TechZone/nhbcstandards/.

[19] Building Research Establishment (BRE), “SD1 Concrete in aggressive ground,” 2005.

[20] Highways England, “Pavement Design CD 225 Design for new pavement foundations (Rev 1) (formerly IAN 73/06 revision 1 (2009), HD 25/94).”.

[21] C. Nathanail, C. McCaffrey, A. Gillett and R. &. N. J. Ogden, “The LQM/CIEH S4ULs for Human Health Risk Assessment,” Land Quality Press, Nottingham, 2015.

[22] EIC/AGS/CL:AIRE, “Soil Generic Assessment Criteria for Human Health Risk Assessment,” 2010.

[23] DEFRA, “SP1010 Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination,” 2014.

[24] CL:AIRE, “CL:AIRE Definition of Waste Code of Practice,” [Online]. Available: http://www.claire.co.uk/projects-and-initiatives/dow-cop.

[25] Environment Agency, “Waste duty of care code of practice,” [Online]. Available: https://www.gov.uk/government/publications/waste-duty-of-care-code-of-practice.

[26] BSI Standards, “BS 3882:2015 Specification for Topsoil,” 2015.

[27] CIRIA, “C574 Engineering in Chalk,” 2002.

[28] R. N. Mortimore, Logging the Chalk, 2014.

[29] BSI Standards, “BS EN ISO 22476-3:2005+A1:2011 Geotechnical investigation and testing. Field testing. Standard penetration test,” 2011.

[30] BSI Standards, “BS EN ISO 22475-1:2006 Geotechnical investigation and testing. Sampling methods and groundwater measurements. Technical principles for execution.,” 2006.

[31] BSI Standards, “BS ISO 18400-100:2017 Soil quality. Sampling. Guidance on the selection of sampling standards,” 2017.

[32] BSI Standards, “BS ISO 18400-101:2017 Soil quality. Sampling. Framework for the preparation and application of a sampling plan,” 2017.

[33] BSI Standards, “BS ISO 18400-103:2017 Soil quality. Sampling. Safety,” 2017.

[34] BSI Standards, “BS ISO 18400-105:2017 Soil quality. Sampling. Packaging, transport, storage and preservation of samples,” 2017.

[35] BSI Standards, “BS ISO 18400-107:2017 Soil quality. Sampling. Recording and reporting,” 2017.

[36] BSI Standards, “BS EN ISO 22282-2:2012 Geotechnical investigation and testing. Geohydraulic testing. Water permeability tests in a borehole using open systems,” 2012.