



Phase 2 (Ground Investigation) Report

Land adjacent to 62 Water Gate, Quadring, Spalding

Produced for Mrs J Kane

February 2020

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Executive Summary

<i>Proposed works</i>	The proposed development comprises of the construction of up to four dwellings to be used as holiday lets with associated vehicular access, play park and soft landscaping.
<i>Site history</i>	Undeveloped agricultural land until around 1973 when two large buildings are present in the north along with three smaller buildings adjacent to the south west and a drain is present on the eastern boundary. By 2006, the buildings adjacent to the south west are no longer present and only one of the large buildings in the northern part of the site is still shown on-site. By 2009 no buildings are shown on site.
<i>Published geology</i>	Drift: Tidal Flat Deposits (clays and silts) Solid: Oxford Mudstone Formation
<i>Site description</i>	The site is currently an open field with grass as surfacing across the site. Small vegetation stockpiles were noted towards the east. There is a row of small trees in the centre part of the site. A thick concrete slab was noted in the west of the site and is thought to be associated with former agricultural buildings.
<i>Topography</i>	Relatively flat and level; c. 5m above Ordnance Datum
<i>Site works</i>	Three windowless sampler boreholes (WS1 to WS3) to maximum depth of 3.0m bgl. One hand dug pit to a maximum depth of 0.9m bgl. SHDCP testing was carried out to a maximum depth of 11m bgl.
<i>Revealed ground conditions</i>	Topsoil - ALL (except HD1) - Dark brown slightly sandy CLAY with occasional rootlets (0.1m bgl) Madeground - HD1 - Crushed concrete and brick fill with pockets of clay down to 0.4m bgl. (0.4m bgl) Tidal flat deposits (Cohesive silts and clays) - ALL - All boreholes found soft to firm brown slightly sandy silty clays at shallow depth (e.g. to 0.6m bgl) Tidal flat deposits (Granular silts) - ALL (except HD1) - Greyish brown (clayey) sandy silts Oxford Clay Formation (Mudstone) - mudstone was not uncovered during site investigation. However, it is estimated to be below 7m bgl based on SHDCP test results
<i>Groundwater</i>	Groundwater reported in WS1 at 0.58m bgl 2 hours after well installation and in WS2 at 0m bgl after well installation
<i>Contamination tests</i>	No elevated metals, PAHs or TPHs and no asbestos fibres were detected in any of the samples.
<i>Contamination assessment</i>	It is unlikely that there will be any significant risk of contamination within the site.
<i>Ground gas</i>	NHBC/RSK traffic light classification: Green
<i>Foundation design</i>	In-situ shallow TFD clays are of medium volume change potential Minimum required foundation depth should be 0.9m bgl
<i>Allowable net bearing pressures</i>	50kPa in loose sands and silt where present in sufficient thickness Deep stiff clay: an ultimate end bearing capacity of 900kPa below 8m bgl and of 1350kPa below 10m bgl.
<i>Heave protection & slab design</i>	Ground bearing slabs might not be suitable close to the locations of existing trees due to potential for heave. If heave is determined to be a problem, a suspended floor solution (e.g. beam and block) could be considered.
<i>Buried concrete</i>	A Design Sulphate class of DS-1 and an ACEC Class of AC-1 should be suitable.

1 Introduction

Under instruction from the client, Mrs Jenni Kane, a Phase 2 ground investigation for a proposed development on land adjacent 62 Water Gate, Quadring, Spalding has been undertaken by Humberside Materials Laboratory Limited (HML). The land will be hereinafter referred to as *the site*.

1.1 Aims

The aim of the investigation is to assess relevant geotechnical and geo-environmental aspects of the site in relation to proposed development works. This includes an evaluation of encountered ground conditions, relevant ground engineering issues and contamination issues.

1.2 Scope

The scope of the investigation includes:

- A review of available desk study information
- An intrusive borehole investigation with standard penetration testing (SPT)
- Geochemical and geotechnical laboratory testing
- A contamination conceptual site model and risk assessment
- Interpretation of findings to facilitate design/construction of proposed works
- Options for remediation or further works, if required

1.3 Conditions and limitations

This report is produced solely for the above client and should only be copied in full. When transmitted electronically, the definitive copy of the report is held by Humberside Materials Laboratory Ltd.

This report is prepared on the assumption that all facts have been disclosed.

The comments given in this report and the opinions expressed assume that conditions do not vary beyond the range revealed by this study and the information provided in the production of this report is complete and reliable.

2 Review of desk study information

The main source of desk study information to complete this report is a Delta-Simons Phase 1 Desk Study report dated November 2019 (Project number. 19-1425.01). The Phase 1 report contains a Landmark Envirocheck Report with historical maps dated October 2019 (Landmark ref.: 221642427_1_1).

2.1 The site

2.1.1 Location and size

The site is on land adjacent to number 62, Water Gate, Quadring, Spalding. The site is to the north of the town of Spalding with a national grid reference of (NGR) 522810, 333510.

The site occupies a roughly rectangular tract of land with a total area about 0.47 hectares.

A site location plan is included in Appendix A.

2.1.2 Site features

The site is currently an open field with grass as surfacing across the site. Small vegetation stockpiles were noted towards the east. Which are thought to be associated with dredging of the drains adjacent to the land. There is a row of small trees in the centre part of the site. A thick concrete slab was noted in the west of the site and is thought to be associated with former agricultural buildings. The boundaries are made up of hedgerows and trees to the north south and west, along with drains running along the eastern and western boundaries.

Outside of the site boundary to the south were discarded wooden pallets and doors along with a small plastic oil tank containing possible heating oil. This seemed to be new and stood on a concrete slab. No surface staining was noted below the tank.

2.1.3 Site topography

The site is generally level. The average ground level is estimated to be about 5m above Ordnance Datum (AOD).

2.1.4 Surrounding land use

The site is within a rural area about 9km north of Spalding, a town within Lincolnshire. The site is surrounded by the following features.

- North: Residential properties, beyond which is agricultural land.
- East: Water Gate, beyond which is agricultural land.
- South: Residential properties.
- West: Residential properties, beyond which is agricultural land.

2.2 Proposed development

The proposed development comprises of the construction of up to four dwellings to be used as holiday lets with associated vehicular access, play park and soft landscaping.

2.3 Site history

Historical mapping dated 1888 shows the site to be undeveloped agricultural land. The site remains undeveloped until around 1973 when two large buildings are present in the north along with three smaller buildings adjacent to the south west and a drain is present on the eastern boundary. These are possible farm buildings. By 2006, the buildings adjacent to the south west are no longer present and only one of the large buildings in the northern part of the site is still shown on-site. By 2009 no buildings are shown on site.

2.3.1 Made ground

Some reworked topsoil may be present at the site. Possible made ground in the locations of the former agricultural buildings.

2.4 Published Geology

2.4.1 Drift deposits

The local British Geological Survey (BGS) map shows superficial drift deposits of Tidal Flat Deposits (TFD).

2.4.2 Solid geology

BGS mapping indicates the underlying bedrock is Oxford Clay Formation – Mudstone.

2.5 Anticipated ground conditions

Based on inspected geological map information, the anticipated ground conditions are as shown below (in Table 1). These are subject to confirmation (or otherwise) by site works.

Table 1: Anticipated geology (subject to confirmation with site works)		
Strata	Description	Anticipated depth to base of stratum (m bgl)
Topsoil / made ground	Natural silts, sand and clays with occasional rootlets	0.2 – 0.4
Tidal Flat deposits	Clays and silts with occasional sands and gravels	10

Table 1: Anticipated geology (subject to confirmation with site works)		
<i>Strata</i>	<i>Description</i>	<i>Anticipated depth to base of stratum (m bgl)</i>
Oxford Clay Formation - Mudstone	Firm to stiff clays	+10
Groundwater table – unknown		

2.6 Hydrogeology

The underlying bedrock is classified as Unproductive strata. The site is not in a designated groundwater Source Protection Zone and there are no licensed groundwater abstraction within 1 km of the site.

The location of the groundwater table is unknown.

2.7 Hydrology

The nearest reported surface water feature is reported to be the drains to the east and west boundaries of the site. There is also a reservoir approximately 280m south east.

There are no reported *surface water abstractions* within 500m of the site.

2.8 Waste

There are no reported historic or present landfills within 1km of the site. Neither is there any reported potentially infilled land within 1km of the site

There is one waste management facility 945m south of the site.

2.9 Radon gas

With respect to *radon potential*, the site is in a Lower probability area with less than 1% of homes above the action level. No radon protection measures are therefore necessary for new homes.

3 Preliminary contamination assessment

The Delta-Simons Phase 1 (desk study) report included the development of a conceptual site model (CSM) based on the available desk study information. Further, a preliminary contamination risk assessment was carried out to identify potentially significant contamination linkages.

A summary of the initial CSM and preliminary risk assessment is as follows.

3.1 Initial conceptual site model

The Phase 1 conceptual site model identified potential sources of contamination at the site, as shown below (in Table 2).

Table 2: Potential sources of contamination						
Location	Source	Potential contaminants				
		Metals	PAHs	Asbestos	TPH	Ground gas
On-site	Possible former agricultural use including farming machinery	P	P	P	P	P
	Organic material in TFD					
	Possible madeground					
Off-site	Oil tank to the south	P			P	

Contamination pathways for consideration included absorption (via dermal contact), inhalation (i.e. indoor or outdoor dust or vapour) and migration (i.e. vertical/lateral movement through soil, rock, groundwater, building materials, voids and along services, including potable water supply pipes).

Identified receptors consisted of humans (e.g. future site users and ground workers), groundwater, wildlife, surface water, adjacent property and building materials.

3.2 Preliminary risk assessment

The Phase 1 risk assessment identified a number of possible pollution linkages as shown below (in Table 3). The below risk assessment is an adapted version from the Delta-Simons Phase 1 report.

Table 3: Initial conceptual site model and preliminary risk assessment

Potential source	Potential pathway	Potential receptor	Probability	Severity	Risk rating	Comments
Possible former agricultural use including farming machinery Possible madeground PAH, heavy metals, asbestos, TPH	Direct contact/ ingestion and inhalation of dust, vapours and asbestos fibres.	Future Site users. Groundworkers during the redevelopment or during any subsurface maintenance works.			Low	Limited potential sources of contamination have been identified at the Site associated with the Sites former agricultural use, the off-Site oil tank and off-Site allotment. A limited environmental investigation is recommended at the time of any geotechnical assessment to advise on the soil quality beneath the Site. Although not directly observed there is potential for ACMs to be present in the on-Site stockpiles. As such, it should be inspected by a suitably qualified contractor prior to removal. A 'hotspot' protocol should be in place during the redevelopment for ground workers to act upon should suspected contamination be identified. A clean layer of certified suitable for use topsoil will be required in landscaped areas. Current on-Site topsoil may be suitable for re-use subject to appropriate testing and approval from the Local Authority. Groundworkers should use appropriate personal protective equipment (PPE), including respiratory protective equipment (RPE), if required and maintain good standards of hygiene to be protected from any soil contamination which may be present.
	Leaching of contamination into groundwater. Vertical and lateral migration of contamination through permeable deposits below the Site.	Controlled waters.			Very low	Limited on-Site sources of contamination have been identified from the Site reconnaissance and desktop study. The Site is not within a groundwater source protection zone (SPZ). As such, the risk to controlled waters is considered very low. Additionally, the superficial and bedrock geology is classified as Unproductive Strata. A limited environmental investigation is recommended at the time of any geotechnical assessment to advise on the soil quality beneath the Site and the risk to controlled waters.
	Direct infiltration in water supply pipes.	Service conduits.			Low	The Local Water Authority should be consulted to advise on the requirements for potable water pipes.

Table 3: Initial conceptual site model and preliminary risk assessment

Potential source	Potential pathway	Potential receptor	Probability	Severity	Risk rating	Comments
Organic material in TFD Ground gas	Accumulation of gas in enclosed spaces and subfloor voids.	Buildings and future Site users.			Low	Limited sources of ground gas have been identified at the site and in the surrounding area and are limited to Made Ground and possible organic Tidal Flat Deposits.

3.3 (Phase 2) Investigation recommendations

The Delta-Simons Phase 1 proposed the following scope of initial (Phase 2) site investigation works.

It is recommended that a limited environmental investigation is undertaken at the site following site clearance in order to assess the following:

- Presence, thickness and nature of any madeground, and in-situ geotechnical soil strength testing/laboratory testing, in order to inform proposed foundation design;
- Presence and concentration of substances of concern in shallow soils (including madeground) on-site; and
- Likelihood of significant ground gas and/or soil vapour intrusion into future site and off-site buildings.

Depending on the findings of the ground investigation the following may also need consideration:

- Preparation of a remediation method statement covering topics such as ground gas protection measures, upgraded water supply pipework and hotspot protocol;
- Preparation of a remediation verification report; and
- Although considered unlikely, a materials management plan or U1 exemption may be required for the movement, re-use or import of materials at the site.

4 Site Investigation Works

The procedures adopted for this site investigation are based on BS 5930 (2015) – Code of Practice for Site Investigations and BS 10175 (2011 + A2, 2017). The soils and rocks encountered have been described based on BS5930 (2015), BS EN ISO 14688-1 (2002) and BS EN ISO 14689-1 (2003).

4.1 Fieldwork

4.1.1 *Exploratory holes*

Fieldwork took place on the 27th January 2020.

Boreholes were drilled by HML at three locations (WS1 to WS3) around the site using a Dando Terrier windowless sampler rig down to 3m bgl.

The rig extracted 1m-long tubes of sub-strata and depths to sub-strata and groundwater were measured from ground level. The soils were logged by an HML engineer and samples from all holes were collected for contamination and geotechnical testing.

One hand dug pit (HD1) was excavated close to the location of the oil tank to the south of the site.

Standard penetrometer testing (SPT) was carried out at 1m-intervals in WS1-WS3.

Super heavy dynamic cone penetrometer (DCP) testing was carried out in WS1 and WS2 to a maximum depth of 11m bgl.

Approximate locations of all site works are shown in the exploratory hole location plan (in Appendix A).

Logs for the boreholes are presented later (in Appendix B).

4.2 Laboratory testing

Laboratory testing included both geotechnical and geochemical testing, as shown below (in Table 4).

Geotechnical testing was undertaken at the HML UKAS accredited laboratory. The scope of geotechnical testing comprised the following.

- 3 number plasticity index (PI) and moisture content (MC) tests
- 1 number particle size distribution (sedimentation) test

Geochemical testing was undertaken by Chemtech Environmental, a UKAS and MCERTS accredited laboratory. The scope of geochemical testing comprised the following.

- 2 number TRL sulphate suites
- 3 number PAH testing
- 3 number asbestos testing
- 3 number metal suites
- 1 number TPH

Results for all the laboratory testing undertaken are included later in this report (in Appendix C).

Table 4: Schedule of laboratory testing

Sample hole	Sample location	HML Sample ref. S/	Chemtech Sample ref.	Depth (m bgl)	PI	MC	Sulphate suite	Asbestos	Metals	PAH	TPH	Sedimentation
WS1	WS1-1	55216	84000-2	0.1-0.5				ü	ü	ü		
	WS1-2	55215	84000-1	1.25-2.0			ü					ü
WS2	WS2-1	55217	84000-3	0.1-0.5				ü	ü	ü		
	WS2-2	55212	-	0.5-0.95	ü	ü						
	WS2-3	55213	-	1.25-2.0	ü	ü						
WS3	WS3-2	55219	84000-5	0.6-1.0			ü					
	WS3-3	55214	-	1.5-2.0	ü	ü						
HD1	HD1-1	55218	84000-4	0.1-0.4				ü	ü	ü	ü	

5 Ground Conditions

5.1 Sequence of sub-strata

The sub-strata as revealed during the site works are summarised below (in Table 5). Copies of the borehole logs are presented later (in Appendix B).

Table 5: Summary of revealed ground conditions (during site works)				
Strata	Locations revealed	Summary description	Depth to base of stratum (m bgl)	
			Min	Max
Madeground	HD1	Concrete and brick fill	0.4	
Topsoil	ALL (except HD1)	Dark brown slightly sandy CLAY with occasional rootlets.	0.05	0.1
Tidal flat deposits (Cohesive silts and clays)	ALL	Soft to firm brown slightly sandy silty clays from around 0.1m bgl. Some firm clays were found slightly deeper from around 1.25m to 2m bgl.	0.6	1.25
Tidal flat deposits (Granular silts)	ALL (except HD1)	Greyish brown clayey sandy silts	+3	
Oxford clay mudstone	Mudstone was not uncovered during site investigation. However, is estimated to be at around 7m bgl based on SHDCP test results			

5.2 Topsoil

Topsoil was encountered in all three boreholes (WS1-WS3) to a depth of around 0.1m bgl. It mainly consisted of dark brown slightly sandy clay with occasional rootlets.

5.3 Made ground

Made ground was discovered at HD1 and consist of concrete and brick fill. This was in the location of the oil tank to the south of the site and was found to around 0.4m bgl. No other significant made ground was encountered across the site.

5.4 Tidal Flat Deposits (Cohesive silts and clays)

Soft to firm brown slightly sandy silts and clays were found in all the boreholes and hand dug pit to a depth of around 1.25m bgl. Some deeper silts and clays were revealed and logged as soft or very soft brown (slightly sandy) silty clays.

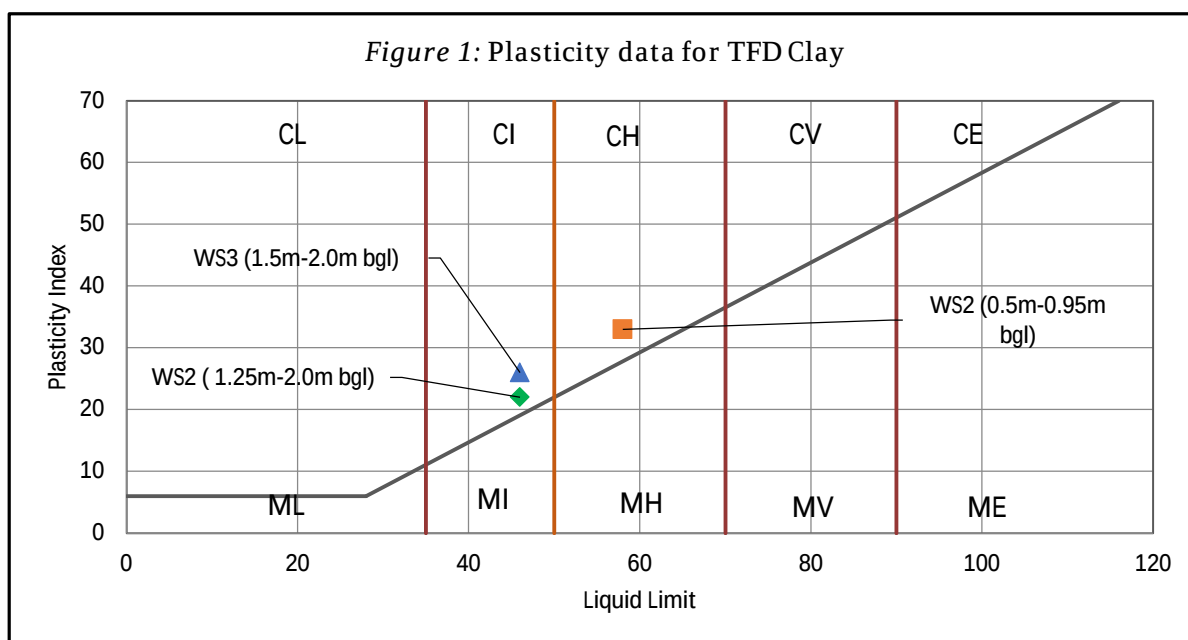
The top of the deeper softer clays was revealed at depths ranging between 1.25m (WS2) and 2.5m (WS1) bgl. It is common within Tidal Flat Deposits for deeper softer (wetter) clays to be overlain by a (1m to 2m thick) crust of firmer clay.

5.4.1 Plasticity and moisture content

The results of plasticity index and moisture content tests on samples of the tidal flat deposit silty clays are shown below (in Table 6). The natural moisture contents generally ranged between 32% and 43%. The plastic limits were between 20% and 25% and the liquid limits between 46% and 58%. The plasticity chart below (Figure 1) shows the fine-grained material (<0.425mm in diameter) within the TFD clay samples could be classified as intermediate to high plasticity clay.

Table 6: Plasticity tests on the TFD clay

Location	Soil	Depth (m bgl)	HML Sample reference S/	Natural moisture content (%)	Plastic limit (%)	Liquid limit (%)	Plasticity index (%)	% of sample passing 425 μ m sieve	Modified plasticity index (%)
WS2-2	Clay	0.5-0.95	55212	32	25	58	33	100	33
WS2-3	Clay	1.25-2.0	55213	32	24	46	22	100	22
WS3-3	Clay	1.5-2.0	55214	43	20	46	26	100	26

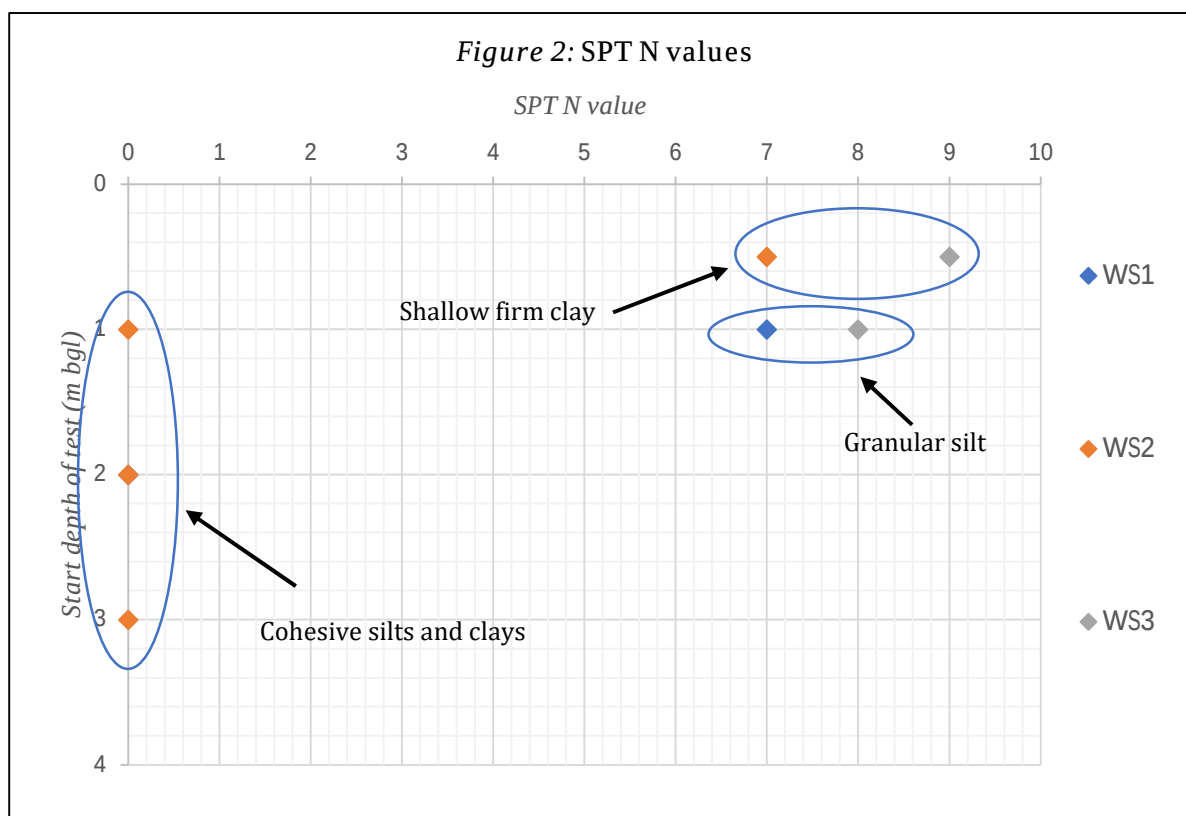


The calculated modified plasticity index (i.e. the plasticity index multiplied by the fraction of sample passing a 425 μ m sieve) of the TFD clay samples is between 22% and 33%. The three samples are shrinkable based on NHBC Standards (2018) and would be categorised as being of *medium volume change potential*.

The moisture content of the TFD clays was found to remain constant with depth in WS2 with a moisture content of 32% between 0.5m and 2.0m bgl. However, the deeper sample from WS3 (1.5m-2.0m bgl) was found to be wetter (with 43% moisture content), as shown above (in table 6).

5.4.2 Engineering properties

SPT N values in the TFD clay appear to decrease with depth, as shown below (in Figure 2). At a starting depth of 0.5m bgl, the SPT N values vary between 7 and 9 (blows/300mm penetration). However, at starting depths of 1.0m or greater, N values of zero were measured.



The undrained shear strengths of the underlying TFD clay can be roughly correlated from SPT N values (e.g. using Stroud, 1976), as shown below (in Table 7). The shallower SPT N values between 0.5m and 1m bgl from all three boreholes were found to be higher than the deeper SPT N values.

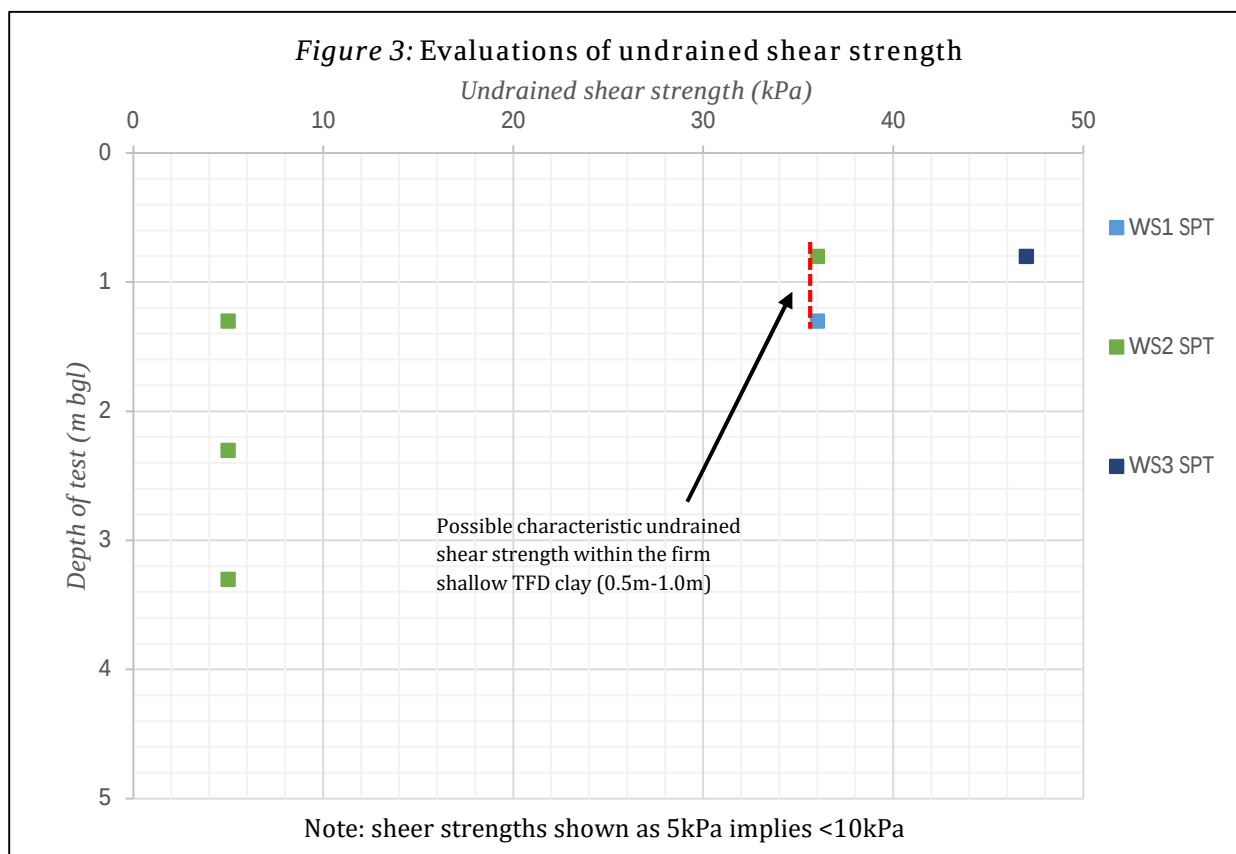
Table 7: Estimated undrained shear strength of TFD clays from SPT correlations

Average SPT depth (m bgl)	Test location	SPT N value	Estimated undrained shear strength (kPa)	Average SPT depth (m bgl)	Test location	SPT N value	Estimated undrained shear strength (kPa)
0.8	WS1	-	-	2.3	WS1	0	*
	WS2	7	36		WS2	0	<10
	WS3	9	47		WS3	-	-
1.3	WS1	7	36	3.3	WS1	-	-
	WS2	0	<10		WS2	0	<10
	WS3	8	*		WS3	-	-

Note: uses a factor of 5.2 x N value based on Stroud (1976). Average depth is 0.3m plus starting test depth.
Note: * indicates SPT in granular SILT

Overall, evaluations of the undrained shear strength of the shallow TFD clay suggest it is around 35kPa within the firm shallow TFD clays (in figure 3). However, below around 1m bgl this may not be the case as the ground conditions change becoming sandy silts which may not offer suitable bearing strata.

The SPT N value from WS1 at a depth of 1.3m bgl (7 blows/300mm penetration) may or may not reflect the TFD clay but may reflect the TFD silt as it crosses through two separate strata. However, for the sake of this report section it is assumed to be within the TFD clay.



5.5 Tidal Flat Deposits (Granular silts)

Tidal flat deposits of granular silts were found in all three boreholes (WS1-WS3). They were revealed to between 0.05m (in WS2) and 1.25m (in WS1) in thickness.

The granular silts were typically logged as “loose greyish brown sandy SILT”.

Results from particle size distribution (sedimentation) testing show that in a sample from WS1 (1.25m-2.0m bgl) of granular silt yielded 47.4% silt, 48.6% sand and 4.1% clay. This indicates that this stratum could be classified as sandy silt.

The relative density of the granular silts was found to range between very loose and loose. SPT N values were between 0 and 7 at depths of 1.0m and 2.0m bgl in the granular silts.

5.6 Oxford Clay (Mudstone)

Mudstone was not found during sampling. However, SHDCP testing indicated that mudstone may be found at approximately 7m bgl.

Calculations based on SHDCP testing in WS1 and WS2 indicates that the mudstone clays below 8m have an undrained shear strength of at least 100 kPa which is typical of stiff clay. Below depths of 10m bgl, this increases to at least 150kpa, which is typical of very stiff clay.

The results of the SHDCP testing are presented later (in Appendix B).

Determinations of undrained shear strength are presented later (in Appendix C).

5.7 Groundwater observations

Groundwater was recorded at WS1 at a depth of 0.58m bgl and WS2 at 0m bgl after well installation.

No groundwater was recorded elsewhere.

6 Analysis of soil contamination test data

Assessment criteria (in mg/kg) have been taken from the *generic assessment criteria* (GAC) published in the *Land Quality Management Ltd/Chartered Institute of Environmental Health suitable for use levels* (LQM/CIEH S4ULs) report (LQM/CIEH, 2015). The exception to this is the GAC for lead which is taken from the Category 4 Screening Level (C4SL) data published in a report by Defra (2014). All the GAC are based on the context of a *residential* development with the potential for consumption of home-grown produce (i.e. with plant uptake).

6.1 Metals and metalloids

Table 8 (below) gives the GAC for metal (and metalloid) contaminants considered for the site.

Table 8: Generic assessment criteria for metals - <i>Residential with plant uptake</i>	
<i>Element</i>	<i>(mg/kg)</i>
Arsenic	37
Boron	290
Cadmium	11
Chromium III	910
Chromium VI	6
Copper	2400
Lead**	200
Mercury element	1.2
Mercury inorganic	40
Mercury methyl	11
Nickel	130
Selenium	250
Vanadium	410
Zinc	3700
* from LQM/CIEH (2015) except: ** from Defra (2014)	

Two samples of near surface soils (from WS1 and WS2) and one sample of near surface made ground (from HD1) were subjected to a suite of metals and metalloids tests. These were sampled between depths ranging between 0.1m and 0.5m bgl. Test results indicate there are no elevated levels of metals above the GAC for a residential development with potential for plant uptake.

The maximum measured concentration of total chromium of 43mg/kg (from WS1) exceeded the GAC for chromium VI (of 6mg/kg). However, Chromium VI is typically only present in soils in the vicinity of industrial processes and waste deposition, which is not the case at this site. It is extremely unlikely that more than 14% of the measured total

chromium could be chromium VI. Therefore, it is unlikely that Chromium VI will have affected the site.

The complete test results are presented later (in Appendix C).

6.2 Polycyclic aromatic hydrocarbons (PAHs)

Table 9 (below) gives the GAC (from LQM/CIEH, 2015) for speciated PAH contaminants. These vary with soil organic matter (SOM) content. At this stage, the most onerous SOM of 1% is assumed, which should be reasonably conservative.

<i>Element</i>	<i>SOM of 1%</i>	<i>SOM of 2.5%</i>	<i>SOM of 6%</i>
Acenaphthene	210	510	1100
Acenaphthylene	170	420	920
Anthracene	2400	5400	11000
Benzo(a)anthracene	7.2	11	13
Benzo(a)pyrene	2.2	2.7	3
Benzo(b)fluoranthene	2.6	3.3	3.7
Benzo(k)fluoranthene	77	93	100
Benzo(ghi)perylene	320	340	350
Chrysene	15	22	27
Dibenzo(ah)anthracene	0.24	0.28	0.3
Fluoranthene	280	560	890
Fluorene	170	400	860
Indeno(123-cd) pyrene	27	36	41
Naphthalene	2.3	5.6	13
Phenanthrene	95	220	440
Pyrene	620	1200	2000
BaP as Surrogate marker	0.79	0.98	1.1

Two samples of near surface soils (from WS1 and WS2) and one sample of near surface madeground (from HD1) were subjected to a suite of speciated PAH tests. These were sampled between depths ranging between 0.1m and 0.5m bgl. The test results show that there are no elevated levels of PAH contamination. Some low-level concentrations of PAHs were found within the madeground sample from HD1. However, these were all well below GAC screening values.

The complete test results are presented later (in Appendix C).

6.3 Petroleum hydrocarbons (TPH & BTEX)

Table 10 (below) gives the GAC (from LQM/CIEH, 2015) for speciated TPH fractions. These vary with soil organic matter (SOM) content. At this stage, the most onerous SOM of 1% is assumed, which should be reasonably conservative.

No potential petroleum hydrocarbon contamination was identified during the site works. However, there was an above ground tank noted in the area just south of the site.

Table 10 - Total Petroleum hydrocarbons (TPHs) generic acceptance criteria – residential with plant uptake				
Compound		1% SOM	2.5% SOM	6% SOM
TPH Aliphatic	C5-6	42	78	160
	C6-8	100	230	530
	C8-10	27	65	150
	C10-12	130 (48)	330 (118)	760 (283)
	C12-16	1100 (24)	2400 (59)	4300 (142)
	C16-35	65000 (8.5)	92000 (21)	110000
	C35-44	65000 (8.5)	92000 (21)	110000
TPH Aromatic	C5-7	70	140	300
	C7-8	130	290	660
	C8-10	34	83	190
	C10-12	74	180	380
	C12-16	140	330	660
	C16-21	260	540	930
	C21-35	1100	1500	1700
BTEX	Benzene	0.087	0.17	0.37
	Toluene	130	290	660
	Ethylbenzene	47	110	260
	O-xylene	60	140	330
	M-xylene	59	140	320
	P-xylene	56	130	310
Note: values in parentheses indicate vapour saturation limit (v) or limit of solubility (s)				

One sample of shallow madeground (from HD1 0.1m to 0.4m bgl) was subjected to a suite of TPH tests. The results of TPH testing show that there are no exceedances above the GAC.

The complete test results are presented later (in Appendix C).

6.4 Asbestos

Three samples of near surface soil samples were subjected to tests for the presence of asbestos. Asbestos fibres were not detected in either of the samples.

7 Revised Contamination Assessment

7.1 Revised conceptual site model (CSM) and risk assessment

Based on initial assessment, findings of the site works and analysis of the contamination test data, a revised combined CSM and risk assessment has been developed, as shown below (in Table 11), based on a *source-pathway-receptor* consideration of potential pollution linkages.

Table 11: Revised risk assessment						
Potential source	Potential pathway	Potential receptor	Probability	Severity	Risk rating	Comments
Possible former agricultural use including farming machinery + nearby tank	Direct contact/ ingestion and inhalation of dust, vapours and asbestos fibres.	Future Site users. Groundworkers during the redevelopment or during any subsurface maintenance works.			Very low	No elevated levels of PAH, Metals or TPH were found. No asbestos detected
Possible made ground PAH, heavy metals, asbestos, TPH	Leaching of contamination into groundwater. Vertical and lateral migration of contamination through permeable deposits below the Site.	Controlled waters.			Very low	
	Direct infiltration in water supply pipes.	Service conduits.			Very low	
Organic material in TFD Ground gas	Accumulation of gas in enclosed spaces and subfloor voids.	Buildings and future Site users.			Very low	No significant organic materials were found in the TFD during investigation

A risk rating of *very low* or *low* is not considered significant while a rating of *moderate* / *low* (or greater) could be potentially hazardous and the associated source-pathway-receptor is taken to be a plausible contamination linkage and in need of further consideration.

The above risk assessment indicates that there is unlikely to be any significant risks from contamination within this site. The detected levels of metals, PAHs and TPHs are well below the residential GAC and no asbestos was detected. Similarly, no hazardous ground gas producing materials (highly organic materials) were revealed during site works. Therefore, it is unlikely that there will be any significant risk to human health and future site users.

The health risk to construction workers should be mitigated by suitable safe working practices. This includes the provision of personal protective equipment and hygiene facilities.

7.2 Contamination assessment

No further testing or remediation is anticipated at this stage.

Nevertheless, any unforeseen contamination (for example, hydrocarbon odours or staining) encountered during the development of the site should be monitored and reported to the local authority. Work should be halted in any area of the revealed potential contamination and the contamination investigated and assessed to the satisfaction of the local authority.

7.3 Ground gas risk assessment

No viable source of hazardous ground gas has been identified. There are no historic or present land fill sites recorded within 1km of the site. Similarly, there is no recorded potentially infilled land within 1km of the site. No radon gas is anticipated. No deep made ground or highly organic materials were recorded during site works.

No significant risk of hazardous ground gas has been identified. Therefore, an NHBC/RSK traffic light classification of Green should be appropriate which means that no ground gas protection measures should be required.

8 Engineering Issues

8.1 Foundations

All foundations should be designed by a competent engineer with consideration to all factors and the information within this report.

8.1.1 Influence of trees

The underlying shallow TFD clays are of *medium volume change potential*. Even before considering the influence of trees, the minimum required foundation depth (to NHBC Standards) in medium-shrinkability clays should be 0.9m bgl. However, the required foundation depth should also account for the influence of trees (existing, proposed or recently removed) and may need to be deepened to reach below the likely zone of shrinkage and swelling.

Site works noted a small row of trees located through the centre of the site. Soft landscaping of the proposed site may also include the planting of new trees. However, the species of trees present and proposed are unknown and it is recommended that details of the trees are used to confirm the required foundation depths.

The presence of existing (or recently removed) trees near proposed new buildings can also cause heave, i.e. swelling of the ground, after construction. The removal or severing of roots below a building footprint stops root desiccation (i.e. the drying out of the soil by roots) and the ground can swell as the underlying clays subsequently moisten. Foundations and floor slabs may need heave protection measures, typically in the form of voids or void formers that can accommodate swelling movement.

8.1.2 Shallow conventional foundations

The shallow ground conditions mainly comprise of firm clays. However, these only extend to a depth of approximately 1m bgl. Below this depth, the ground conditions appear to deteriorate.

Loose (becoming very loose) sandy silts have been found in some locations (e.g. WS1 and WS3) at slightly greater depths (e.g. at least 1.5m bgl). Shallow footings in such ground conditions might potentially be suitable for strip footings, if structural loads are low. Allowable bearing pressures of at least 50kPa are typically available in loose sandy silts.

However, the deeper ground conditions include some very soft clays. For example, very soft clays were found in WS3 below a depth of 1.5m bgl. Therefore, conventional shallow

footings might not be suitable. Raft foundations may also be subject to large settlements, subject to the results of further investigation. Accordingly, a deep foundation solution may be required.

8.1.3 Piled foundations

Piled foundations should be designed by a suitably experienced engineer.

The deeper mudstone clays have relatively good strength and stiffness properties and should be able to provide a suitable bearing stratum for deep foundations (i.e. piles). Below depths of around 8m bgl the stiff clays should be able to provide an ultimate end bearing capacity of about 900kPa. This increases at 10m bgl to approximately 1350kPa.

8.2 Slab design

Ground bearing slabs might not be suitable close to the locations of existing trees due to potential for heave. This can be confirmed with the results of a tree survey.

If heave is determined to be a potential problem, the answer could be a suspended floor solution (e.g. beam and block).

8.3 Buried concrete

The results of two sulphate (SO_4) and pH tests (full copies of which are included in Appendix C) provide information about the required sulphate resistance of buried concrete within the ground conditions at the site. The buried concrete should be designed in accordance with BRE Special Digest 1 (BRE, 2005) using these results.

Based on the results of site investigation works, groundwater seepages were observed. Therefore, it would be prudent to assume a *mobile* groundwater regime for the specification of buried concrete.

The maximum measured water-soluble sulphate concentration was only 26mg/kg. No significant oxidizable sulphides are present and the total potential sulphate is up to 0.10%.

The test results indicate that minimum sulphate resistance will be required for buried concrete. *A Design Sulphate class of DS-1 and an ACEC Class of AC-1 should be suitable.*

Table 12: Soil sulphate content										
Stratum	Sample location	HML sample ref. S/	Chemtech sample ref.	Depth (m bgl)	Water-soluble sulfate (mg/l)	pH	Total sulphur, [S _T] (%)	Total (acid-soluble) sulphate, [S _A] (%)	Total potential sulphate 3S _T (%)	Oxidisable sulphides [3S _T -S _A] (%)
TFD Clay	WS1-2	55215	84000-1	1.25-2	26	8.2	0.03	188	0.110	0.09
	WS3-2	55219	84000-5	0.6-1.0	11	8.1	0.02	158	0.077	0.06

8.4 Excavations and groundwater control

Standing groundwater was noted in both WS1 and WS2 to depths, ranging between ground 1cm and 5.8m bgl. Therefore, groundwater control measures may be required (e.g. sump pumping) during excavations.

Excavations in the firm TFD clays are likely to remain relatively stable, at least at shallow depths. Excavations within the silts below the water table could be unstable.

Suitable safety precautions should be taken with any open excavations, especially where man entry is required.

9 SUMMARY & CONCLUSIONS

9.1 Ground conditions

The findings of the investigation indicate the following general sequence of sub-strata at the site (in descending order).

- Topsoil - ALL (except HD1) - Dark brown slightly sandy CLAY with occasional rootlets (0.1m bgl)
- Madeground – HD1 – Crushed concrete and brick fill with pockets of clay down to 0.4m bgl. (0.4m bgl)
- Tidal flat deposits (Cohesive silts and clays) – ALL - All boreholes found soft to firm brown slightly sandy silty clays at shallow depth (e.g. to 0.6m bgl)
- Tidal flat deposits (Granular silts) - ALL (except HD1) - Greyish brown (clayey) sandy silts
- Oxford Clay Formation (Mudstone) - mudstone was not uncovered during site investigation. However, it is estimated to be below 7m bgl based on SHDCP test results

9.2 Geotechnical properties

The geotechnical properties of the encountered ground conditions based on engineering evaluations and estimations described herein are summarised below (in Table 13).

Table 13: Geotechnical properties			
<i>Stratum</i>	<i>Geotechnical property</i>	<i>Approximate depth (m bgl)</i>	<i>Measurement / Estimation</i>
TFD clays	Moisture content	0.5-2.0	32%-43%
	Modified plasticity index		22%-33%
	SPT N values	0.5-0.95	7-9 (blows/300mm)
		1.0 – 1.45	0-8 (blows/300mm)
	Estimated undrained shear strength in shallow firm clays	0.5-1	35kPa
Oxford clay	Estimated undrained shear strength in deeper stiff clays	>8	100kPa
		>10	>150kPa

9.3 Contamination test results

Three samples of near surface soils and one sample of near surface madeground were tested. No elevated levels of Metals, PAH or TPH contamination were detected. No asbestos fibres were found.

9.4 Contamination assessment

It is unlikely that there will be any significant risk to human health and future site users. Therefore, no further testing or remediation measures should be required.

Nevertheless, any unforeseen contamination (for example, hydrocarbon odours or staining) encountered during the development of the site should be monitored and reported to the local authority. Work should be halted in any area of the revealed potential contamination and the contamination investigated and assessed to the satisfaction of the local authority.

9.5 Ground gas protection measures

No viable source of hazardous ground gas has been identified so no significant risk of hazardous ground gas has been identified. Therefore, an NHBC/RSK traffic light classification of Green should be appropriate which means that no ground gas protection measures should be required.

9.6 Foundations

The underlying TFD clays are of medium volume change potential. The minimum required foundation depth should be 0.9m bgl. The required foundation depth should account for the influence of trees and may need to be deepened to reach below the likely zone of shrinkage and swelling. Accordingly, details of proposed/existing trees will be needed to confirm the required footing depths. The presence of existing (or recently removed) trees near proposed buildings can also cause heave, i.e. swelling of the ground, after construction.

9.6.1 *Shallow conventional foundations*

The revealed firm clays only extend to depths of around 1m bgl. Below this depth, the ground conditions deteriorate. Therefore, shallow footings might only be feasible in certain locations where structural loadings are low and the ground conditions are better (e.g. in WS3 where loose silts were revealed).

The mudstone (inferred below 7m bgl) appears to provide a suitable bearing stratum for a piled foundation solution. End bearing capacities of at least 900kPa are anticipated below 8m bgl and at least 1350kPa below 10m bgl.

9.7 Slab design

Ground bearing slabs might not be suitable close to the locations of existing trees due to potential for heave. If heave is determined to be a potential problem, a suspended floor solution (e.g. beam and block) could be considered.

9.8 Buried concrete

A Design Sulphate class of DS-1 and an ACEC Class of AC-1 should be suitable for buried concrete.

9.9 Excavations and groundwater control

Standing groundwater was noted at depths between ground level and 0.58m bgl. Therefore, groundwater control measures may be required (e.g. sump pumping) during excavations.

- END OF REPORT -

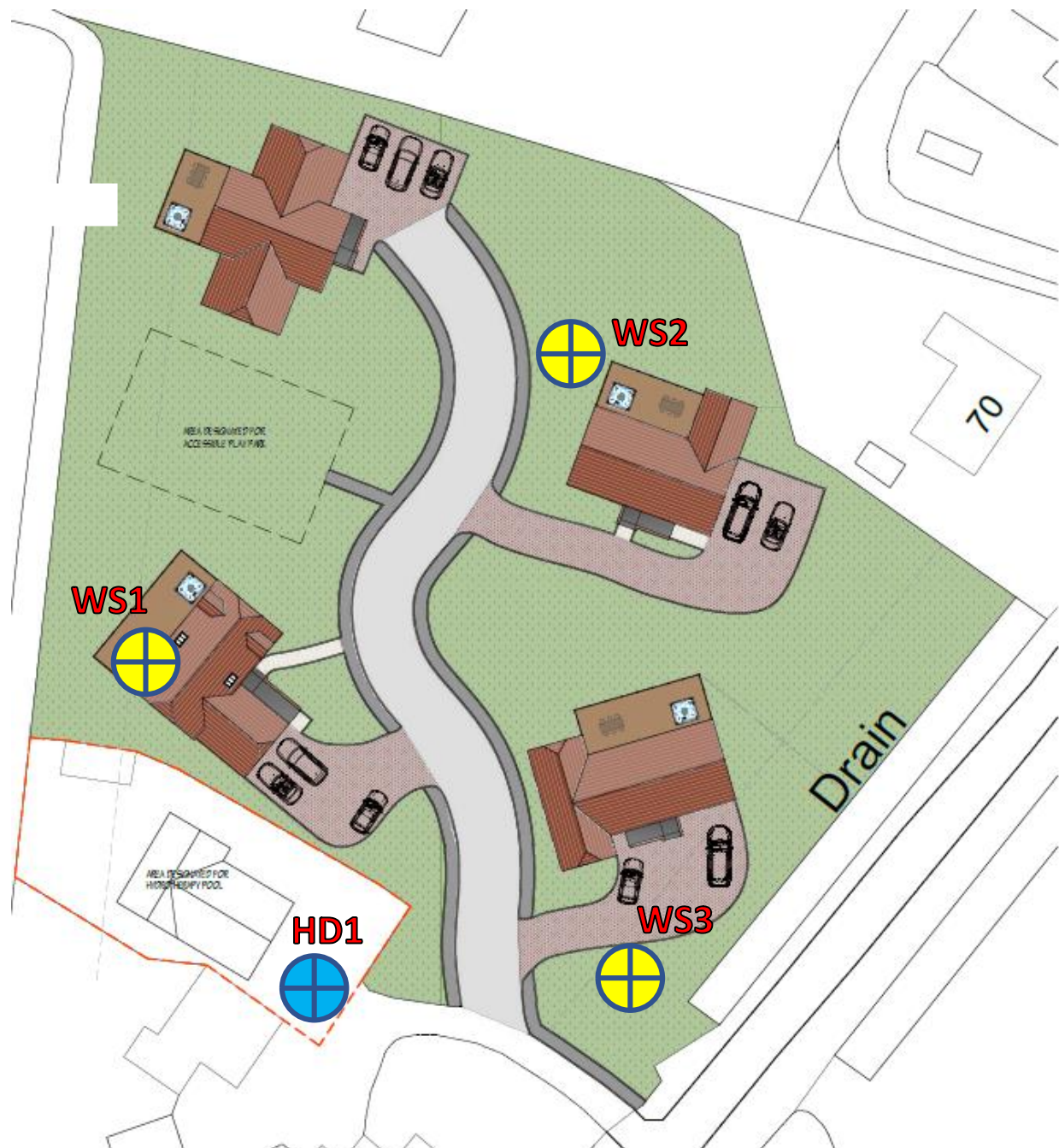
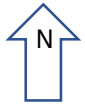
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Appendix A
Plans & Photographs

Notes:

1. Do not scale
2. Locations of all features are approximate only
3. Background image from JC Architectural Design (Drw No. 0152/19/04A)
4. Date of site works: 27th January 2020



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Drawing Title: Borehole location plan
Drawing No.: 1251/5048-P-P2-01 Revision: 0
Site: Quadring, Spalding
Client: Mrs J Kane
Project No.: 1251/5048/P/P2
Date: 07/02/2020



Site location (Screenshot from Open Street Maps)



Aerial view of site (Screenshot from Google Maps)



View facing west (Screenshot from Google Street View)

Appendix B
Exploratory hole logs



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BOREHOLE LOG

Borehole
No
WS1

Client :- Mrs J Kane

Site :- Quadring, Spalding

Project No :- 5048

Location :- see site plan

Date :- 27 January 2020

Coordinates E: N:

Elevation :-

Excavated by :- DANDO TERRIER

Drilled by :- DD+CC

Depth (m)	Lithology / Description / Depth (m)	Elevation	Thickness (m)	Samples	Water level & well	SPT	SH DCP	Notes
0	Soft dark brown slightly silty sandy CLAY with occasional fine to medium gravel of stone and brick fragments and occasional rootlets	0	0.10	WS1-1 D				
0.2		0.2						
0.4	Firm dark brown slightly silty sandy CLAY with occasional fine gravel and rootlets	0.4						
0.6		0.6	0.85					
0.8		0.8						
1	Soft greyish brown slightly silty sandy CLAY	1						
1.2		1.2	0.30					
1.4	Loose becoming very loose brown sandy SILT	1.4						
1.6		1.6		WS1-2 D				
1.8		1.8						
2		2	1.25					
2.2		2.2						
2.4		2.4						
2.6	Very soft to soft greyish brown sandy clayey SILT sand is fine	2.6		WS1-3 D				
2.8		2.8	0.40					
3	Soft dark greyish black silty CLAY	3		WS1-4 D				
3.2		3.2	0.10					
3.4		3.4						
3.6		3.6						
3.8		3.8						

Sample Key
B Bulk
D Disturbed
W Water
SS Split spoon
U undisturbed
DCP SHDCP
HV Hand Vane

Notes :-

Depth drilled :-3

Casing depth :-

File Ref :- 1251/ 5048
Logged by :- MBP



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BOREHOLE LOG

Borehole
No
WS1

Client :- Mrs J Kane

Site :- Quadring, Spalding

Project No :- 5048

Location :- see site plan

Date :- 27 January 2020

Coordinates E: N:

Elevation :-

Excavated by :- DANDO TERRIER

Drilled by :- DD+CC

Depth (m)	Lithology / Description / Depth (m)	Elevation	Thickness (m)	Samples	Water level & well	SPT	SH DCP	Notes
0	Soft dark brown slightly silty sandy CLAY with occasional fine to medium gravel of stone and brick fragments and occasional rootlets	0.1	0.10	WS1-1 D	0.58m bgl 2 hours after well install			SPT @ 1m: 1,2,2,2,1,2
1	Firm dark brown slightly silty sandy CLAY with occasional fine gravel and rootlets	0.95	0.30			7		
2	Soft greyish brown slightly silty sandy CLAY Loose becoming very loose brown sandy SILT	1.25	1.25	WS1-2 D		0		SPT @ 2m: 0,0,0,0,0,0
3	Very soft to soft greyish brown sandy clayey SILT sand is fine	2.5	0.40	WS1-3 D				
	Soft dark greyish black silty CLAY	2.9	0.10	WS1-4 D				
4		3						
5								
6								
7								
8								
9								
10								
11								
12								

Sample Key
B Bulk
D Disturbed
W Water
SS Split spoon
U undisturbed
DCP SHDCP
HV Hand Vane

Notes :-

Depth drilled :- 3

Casing depth :-

File Ref :- 1251/ 5048
Logged by :- MBP



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BOREHOLE LOG

Borehole
No
WS2

Client :- Mrs J Kane

Site :- Quadring, Spalding

Project No :- 5048

Location :- see site plan

Date :- 27 January 2020

Coordinates E: N:

Elevation :-

Excavated by :- DANDO TERRIER

Drilled by :- DD+CC

Depth (m)	Lithology / Description / Depth (m)	Elevation	Thickness (m)	Samples	Water level & well	SPT	SH DCP	Notes
0	Soft brown slightly sandy silty CLAY with occasional rootlets	0.05	0.05		0.0m bgl after well installation			
0.2	Firm brown slightly sandy silty CLAY with occasional rootlets			WS2-1 D				
0.4								
0.6			0.90			7		SPT @ 0.5m: 2,2,2,2,1,2
0.8				WS2-2 D				
1	Loose becoming very loose greyish brown sandy SILT. Sand is fine	0.95	0.05			0		SPT @ 1m: 0,0,0,0,0,0
1.2	Very soft to soft brown slightly sandy to sandy clayey SILT. Sand is fine	1.25	0.25					
1.4	Soft brown mottled grey silty CLAY							
1.6			0.85	WS2-3 D				
1.8								
2		2.1				0		SPT @ 2m: 0,0,0,0,0,0
2.2	none recovered							
2.4								
2.6			0.90					
2.8								
3		3				0		SPT @ 3m: 0,0,0,0,0,0
3.2								
3.4								
3.6								
3.8								
						0		

Sample Key
B Bulk
D Disturbed
W Water
SS Split spoon
U undisturbed
DCP SHDCP
HV Hand Vane

Notes :- Near
conifers
Depth drilled :-3
Casing depth :-

File Ref :- 1251/ 5048
Logged by :- MBP



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BOREHOLE LOG

Borehole
No
WS2

Client :- Mrs J Kane

Site :- Quadring, Spalding

Project No :- 5048

Location :- see site plan

Date :- 27 January 2020

Coordinates E: N:

Elevation :-

Excavated by :- DANDO TERRIER

Drilled by :- DD+CC

Depth (m)	Lithology / Description / Depth (m)	Elevation	Thickness (m)	Samples	Water level & well	SPT	SH DCP	Notes
0	Soft brown slightly sandy silty CLAY with occasional rootlets	0.05	0.05	WS2-1 D	0.0m bgl after well installation	7		SPT @ 0.5m: 2,2,2,1,2
	Firm brown slightly sandy silty CLAY with occasional rootlets	-0.90	0.90	WS2-2 D		0		SPT @ 1m: 0,0,0,0,0,0
1	Loose becoming very loose greyish brown sandy SILT. Sand is fine	0.95	0.05			0		
	Very soft to soft brown slightly sandy to sandy clayey SILT. Sand is fine	1.25	0.25			0		
2	Soft brown mottled grey silty CLAY	2.1	0.85	WS2-3 D		0		SPT @ 2m: 0,0,0,0,0,0
	none recovered	-0.90	0.90			0		
3		3				0		SPT @ 3m: 0,0,0,0,0,0
4		4						
5		5						
6		6						
7		7						
8		8						
9		9						
10		10						
11		11						
12		12						

Sample Key
B Bulk
D Disturbed
W Water
SS Split spoon
U Undisturbed
DCP SHDCP
HV Hand Vane

Notes :- Near
conifers
Depth drilled :-3
Casing depth :-

File Ref :- 1251/ 5048
Logged by :- MBP



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BOREHOLE LOG

Borehole
No
WS3

Client :- Mrs J Kane

Site :- Quadring, Spalding

Project No :- 5048

Location :- see site plan

Date :- 27 January 2020

Coordinates E: N:

Elevation :-

Excavated by :- DANDO TERRIER

Drilled by :- DD+CC

Depth (m)	Lithology / Description / Depth (m)	Elevation	Thickness (m)	Samples	Water level & well	SPT	SH DCP	Notes
0	Soft brown slightly sandy silty CLAY with occasional rootlets	0	0.05					
0.2	Firm slightly sandy silty CLAY with occasional rootlets	0.2	0.55	WS3-1 D				
0.4		0.4						
0.6	Loose greyish brown sandy SILT sand is fine with occasional rootlets	0.6				9		SPT @ 0.5m: 2,3,2,2,2,3
0.8		0.8		WS3-2 D				
1		1	0.90			8		SPT @ 1m: 2,1,2,2,2,2
1.2		1.2						
1.4		1.4						
1.6	Ver soft brown slightly sandy silty CLAY	1.6	0.50	WS3-3 D				
1.8		1.8						
2		2						
2.2		2.2						
2.4		2.4						
2.6		2.6						
2.8		2.8						
3		3						
3.2		3.2						
3.4		3.4						
3.6		3.6						
3.8		3.8						

Sample Key
B Bulk
D Disturbed
W Water
SS Split spoon
U undisturbed
DCP SHDCP
HV Hand Vane

Notes :-

Depth drilled :-2

Casing depth :-

File Ref :- 1251/ 5048
Logged by :- MBP



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BOREHOLE LOG

Borehole
No
HD1

Client :- Mrs J Kane

Site :- Quadring, Spalding

Project No :- 5048

Location :- see site plan

Date :- 27 January 2020

Coordinates E: N:

Elevation :-

Excavated by :- DANDO TERRIER

Drilled by :- DD+CC

Depth (m)	Lithology / Description / Depth (m)	Elevation	Thickness (m)	Samples	Water level & well	SPT	SH DCP	Notes
0	Crushed concrete and brick fill with occasional pockets of clay	0						
0.2		0.2	0.40	HD1-1 D				
0.4	Firm brown slightly sandy silty CLAY	0.4						
0.6		0.6	0.50	HD1-2 D				
0.8		0.8						
0.9		0.9						
1		1						
1.2		1.2						
1.4		1.4						
1.6		1.6						
1.8		1.8						
2		2						
2.2		2.2						
2.4		2.4						
2.6		2.6						
2.8		2.8						
3		3						
3.2		3.2						
3.4		3.4						
3.6		3.6						
3.8		3.8						

Sample Key
B Bulk
D Disturbed
W Water
SS Split spoon
U undisturbed
DCP SHDCP
HV Hand Vane

Notes :-

Depth drilled :- 0.9

Casing depth :-

File Ref :- 1251/ 5048
Logged by :- MBP

Appendix C
Test results



HUMBERSIDE MATERIALS LABORATORY LTD

Atherton Way, Brigg
North Lincolnshire, DN20 8AR
Tel /Fax 01652 652753
e-mail info@humbersidematerialslab.co.uk



SOIL CLASSIFICATION TESTS

Page 1 of 1

Sample Ref S 55212

Client Jenni Kane
62 Water Gate
Quadrang
Spalding

PE11 4PY

Site	Land adjacent 62 Water Gate, Quadrang, Spalding		
Location	WS2-2		
Date/Time sampled	27/01/20		
Client sample No	WS2-2		
Sampled by	DD & CC	Sample point	
Trial pit / Bore hole No	2		
Depth of sample	0.5-0.95	m	Sample type Small Bulk
Description	Stiff, dark brown grey mottled SILT/CLAY with occasional fine rootlets		
comments			

Determination of moisture content

Test method BS 1377 Part 2 1990 - Clause 4.4 Single Point / Definitive Method Clause 4.3 (As Below)

Portion No 02
Method Oven dried

% Moisture 32

Determination of liquid limit, Plastic limit and Plasticity index

Test method BS 1377 Part 2 1990

Portion No 01
Test condition Sieved
Method Single point cone pen
% retained 0.425mm sieve 0

Liquid limit 58

% passing 0.425mm sieve 100

Plastic limit 25

Plasticity Index 33

File ref 1251 5048 / P
Date tested 29/01/20
Date reported 30/01/20
Date received 27/01/20

Signed :- M.J. Green C. Driver
Director

Certificates of sampling when submitted are retained by the Laboratory and is available upon request
Samples will normally be kept for 14 days from the date reported



HUMBERSIDE MATERIALS LABORATORY LTD

Atherton Way, Brigg
North Lincolnshire, DN20 8AR
Tel /Fax 01652 652753
e-mail info@humbersidematerialslab.co.uk



SOIL CLASSIFICATION TESTS

Page 1 of 1

Sample Ref S 55213

Client Jenni Kane
62 Water Gate
Quadrang
Spalding

PE11 4PY

Site	Land adjacent 62 Water Gate, Quadrang, Spalding		
Location	WS2-3		
Date/Time sampled	27/01/20		
Client sample No	WS2-3		
Sampled by	DD & CC	Sample point	
Trial pit / Bore hole No	2		
Depth of sample	1.25-2.0	m	Sample type Small Bulk
Description	Soft light brown silty CLAY		

comments

Determination of moisture content

Test method BS 1377 Part 2 1990 - Clause 4.4 Single Point / Definitive Method Clause 4.3 (As Below)

Portion No 02
Method Oven dried

% Moisture 32

Determination of liquid limit, Plastic limit and Plasticity index

Test method BS 1377 Part 2 1990

Portion No 01
Test condition Sieved
Method Single point cone pen
% retained 0.425mm sieve 0

Liquid limit 46

% passing 0.425mm sieve 100

Plastic limit 24

Plasticity Index 22

File ref 1251 5048 / P
Date tested 29/01/20
Date reported 30/01/20
Date received 27/01/20

Signed :- M.J. Green C. Driver
Director

Certificates of sampling when submitted are retained by the Laboratory and is available upon request
Samples will normally be kept for 14 days from the date reported



HUMBERSIDE MATERIALS LABORATORY LTD

Atherton Way, Brigg
North Lincolnshire, DN20 8AR
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e-mail info@humbersidematerialslab.co.uk



SOIL CLASSIFICATION TESTS

Page 1 of 1

Sample Ref S 55214

Client Jenni Kane
62 Water Gate
Quadrang
Spalding

PE11 4PY

Site	Land adjacent 62 Water Gate, Quadrang, Spalding		
Location	WS3-3		
Date/Time sampled	27/01/20		
Client sample No	WS3-3		
Sampled by	DD & CC	Sample point	
Trial pit / Bore hole No	3		
Depth of sample	1.5-2.0	m	Sample type Small Bulk
Description	Very soft, silty/sandy CLAY		

comments

Determination of moisture content

Test method BS 1377 Part 2 1990 - Clause 4.4 Single Point / Definitive Method Clause 4.3 (As Below)

Portion No 02
Method Oven dried

% Moisture 43

Determination of liquid limit, Plastic limit and Plasticity index

Test method BS 1377 Part 2 1990

Portion No 01
Test condition Sieved
Method Single point cone pen
% retained 0.425mm sieve 0

Liquid limit 46

% passing 0.425mm sieve 100

Plastic limit 20

Plasticity Index 26

File ref 1251 5048 / P
Date tested 29/01/20
Date reported 06/02/20
Date received 27/01/20

Signed :- M.J. Green C. Driver
Director

Certificates of sampling when submitted are retained by the Laboratory and is available upon request
Samples will normally be kept for 14 days from the date reported

HUMBERSIDE MATERIALS LABORATORY LTD

Atherton Way, Brigg
North Lincs, DN21 4DT
Tel & Fax 01652 652753

Particle Size Distribution

Page 1 of 1

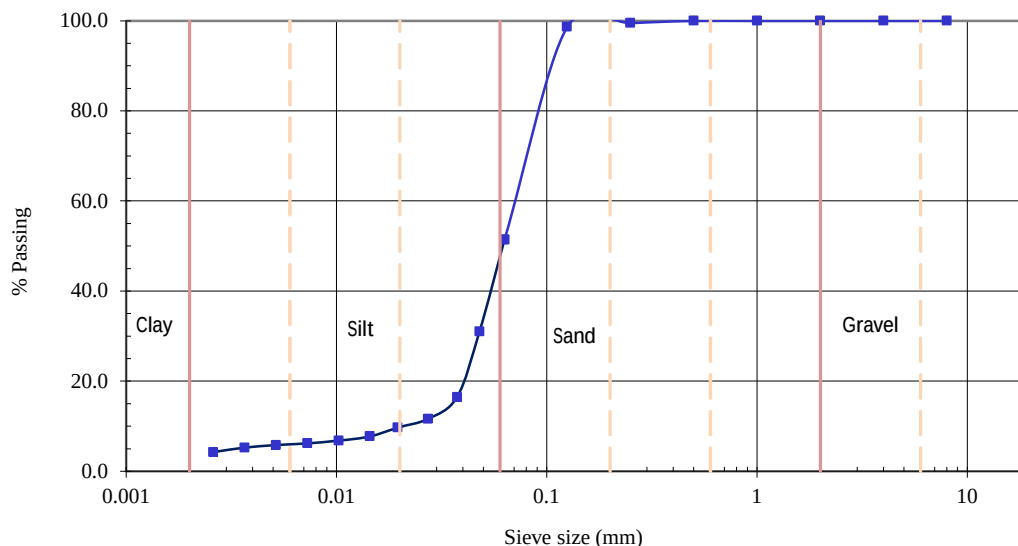
Sample Ref S/55215/02

Client Jenni Kane
Spalding

Site	Land adjacent 62 Water Gate, Quadring		
Location	WS1-2		
Material	Ssilt / Clay		
Date sampled	27/01/2020	TP/BH	WS1
Client sample No	2	Depth	1.25-2.0
Sampled by	D. Driver	Sample Type	Bulk

Determination of Particle size distribution - Sedimentation method

Test method BS 1377 Part 2 1990



	(%)
Clay	4.1
Silt	47.4
Sand	48.6
Aggregate	0.0

Comments

File ref 1251/5048/P
Date tested 03/02/2020
Date reported 06/02/2020

Signed M.J. Green C. Driver
Director

Certificate of sampling when submitted is retained by the Laboratory and available upon request
Samples will normally be kept for 14 days from the date reported

HUMBERSIDE MATERIALS LABORATORY LTD.

Atherton Way, Brigg
North Lincolnshire DN20 8AR
Tel Fax 01652 652753

DETERMINATION OF UNDRAINED SHEAR STRENGTH (c_u) FROM SUPER HEAVY DYNAMIC PROBE TEST RESULTS

Site: Quadring Spalding

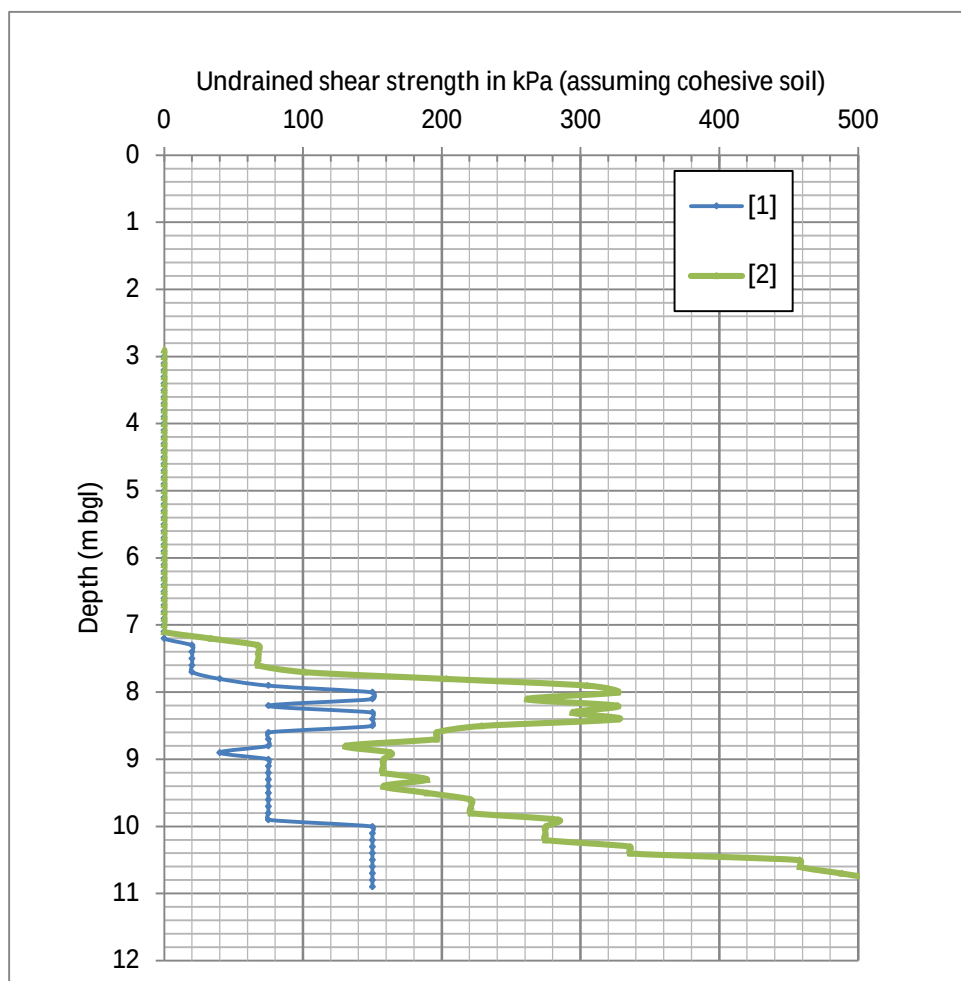
Client: Jenni Kane

Borehole: WS1

Date Tested: 27/01/2020

Minimum c_u (based on Huntley*, 1990): [1]

Stiff clay (based on Butcher, 1996): [2]



Huntley, S.L. (1990) Use of a dynamic penetrometer as a ground investigation and design tool in Hertfordshire, from Field Testing in Engineering Geology. Geological Society Engineering Geology Special Publication No. 6

Butcher, A. P. McElmeel, K. and Powell, J. J. M. (1996) Dynamic probing and its use in clay soils. Advances in site investigation practice. Thomas Telford, London, 1996

* assuming relationship between consistency and undrained shear strength based on BS5930 (1999)

File ref: 1251/5048/P/P2

Reporting date: 07-Feb-20

Signed M.J. Green C. Driver
Director

HUMBERSIDE MATERIALS LABORATORY LTD.

Atherton Way, Brigg
North Lincolnshire DN20 8AR
Tel Fax 01652 652753

DETERMINATION OF UNDRAINED SHEAR STRENGTH (c_u) FROM SUPER HEAVY DYNAMIC PROBE TEST RESULTS

Site: Quadring Spalding

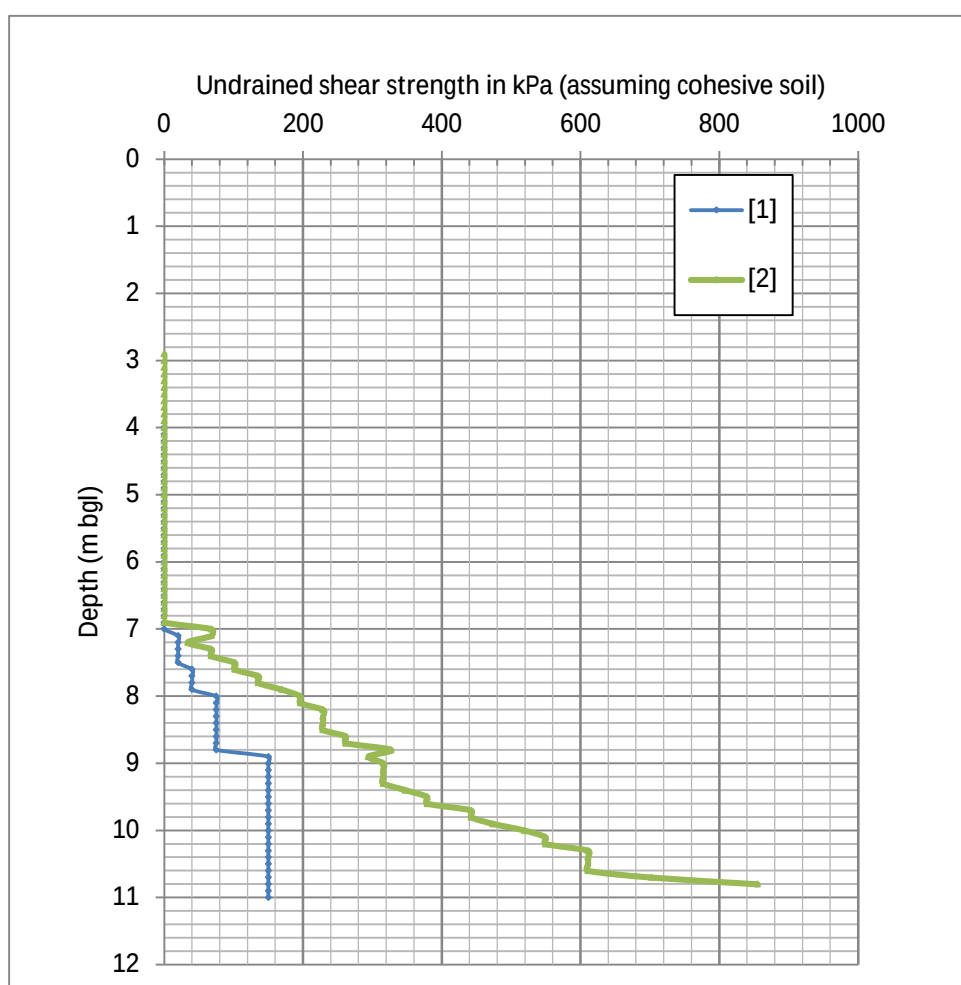
Client: Jenni Kane

Borehole: WS2

Date Tested: 27/01/2020

Minimum c_u (based on Huntley*, 1990): [1]

Stiff clay (based on Butcher, 1996): [2]



Huntley, S.L. (1990) Use of a dynamic penetrometer as a ground investigation and design tool in Hertfordshire, from Field Testing in Engineering Geology. Geological Society Engineering Geology Special Publication No. 6

Butcher, A. P. McElmeel, K. and Powell, J. J. M. (1996) Dynamic probing and its use in clay soils. Advances in site investigation practice. Thomas Telford, London, 1996

* assuming relationship between consistency and undrained shear strength based on BS5930 (1999)

File ref: 1251/5048/P/P2

Reporting date: 07-Feb-20

Signed M.J. Green C. Driver
Director



ANALYTICAL TEST REPORT

Contract no: 84000

Contract name: Land Adjacent 62 Water Gate, Quadring, Spalding

Client reference: 1251/5048/P

Clients name: Humberside Materials Laboratory

Clients address: Atherton Way
Brigg
North Lincolnshire
DN20 8AR

Samples received: 30 January 2020

Analysis started: 30 January 2020

Analysis completed: 06 February 2020

Report issued: 06 February 2020

Notes: Opinions and interpretations expressed herein are outside the UKAS accreditation scope.
Unless otherwise stated, Chemtech Environmental Ltd was not responsible for sampling.
All testing carried out at Unit 6 Parkhead, Stanley, DH9 7YB, except for subcontracted testing.
Methods, procedures and performance data are available on request.
Results reported herein relate only to the material supplied to the laboratory.
This report shall not be reproduced except in full, without prior written approval.
Samples will be disposed of 6 weeks from initial receipt unless otherwise instructed.

Key: U UKAS accredited test
M MCERTS & UKAS accredited test
\$ Test carried out by an approved subcontractor
I/S Insufficient sample to carry out test
N/S Sample not suitable for testing
NAD No Asbestos Detected

Approved by:

Dave Bowerbank
Customer Support Hero

Chemtech Environmental Limited

SAMPLE INFORMATION

MCERTS (Soils):

Soil descriptions are only intended to provide a log of sample matrices with respect to MCERTS validation. They are not intended as full geological descriptions. MCERTS accreditation applies for sand, clay and loam/topsoil, or combinations of these whether these are derived from naturally occurring soils or from made ground, as long as these materials constitute the major part of the sample. Other materials such as concrete, gravel and brick are not accredited if they comprise the major part of the sample.

All results are reported on a dry basis. Samples dried at no more than 30°C in a drying cabinet.

Analytical results are inclusive of stones.

Lab ref	Sample id	Depth (m)	Sample description	Material removed	% Removed	% Moisture
84000-1	S/55215	1.25-2.00	Clayey Sand with Gravel	-	-	20.8
84000-2	S/55216	0.10-0.50	Clay with Gravel	-	-	19.0
84000-3	S/55217	0.10-0.50	Clay with Gravel	-	-	18.1
84000-4	S/55218	0.10-0.40	Clayey Sand with Gravel	-	-	15.8
84000-5	S/55219	0.60-1.00	Clayey Sand with Gravel	-	-	18.4

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SOILS

Lab number Sample id Sample location Depth (m) Date sampled			84000-1 S/55215 WS1-2 1.25-2.00 27/01/2020	84000-2 S/55216 WS1-1 0.10-0.50 27/01/2020	84000-3 S/55217 WS2-1 0.10-0.50 27/01/2020	84000-4 S/55218 HD1-1 0.10-0.40 27/01/2020	84000-5 S/55219 WS3-2 0.60-1.00 27/01/2020
Test	Method	Units					
Arsenic (total)	CE127 ^M	mg/kg As	-	11	11	17	-
Beryllium (total)	CE127 ^U	mg/kg Be	-	1.2	<1	<1	-
Boron (water soluble)	CE063 ^M	mg/kg B	-	1.3	1.2	<0.5	-
Cadmium (total)	CE127 ^M	mg/kg Cd	-	<0.2	<0.2	0.4	-
Chromium (total)	CE127 ^M	mg/kg Cr	-	43	38	20	-
Copper (total)	CE127 ^M	mg/kg Cu	-	19	14	20	-
Lead (total)	CE127 ^M	mg/kg Pb	-	56	29	110	-
Mercury (total)	CE127 ^M	mg/kg Hg	-	<0.5	<0.5	<0.5	-
Nickel (total)	CE127 ^M	mg/kg Ni	-	33	26	16	-
Selenium (total)	CE127 ^M	mg/kg Se	-	1.0	0.9	0.6	-
Vanadium (total)	CE127 ^M	mg/kg V	-	58	59	36	-
pH	CE004 ^M	units	8.2	-	-	-	8.1
Magnesium (2:1 water soluble)	CE061	mg/l Mg	5.1	-	-	-	3.9
Chloride (2:1 water soluble)	CE049 ^U	mg/l Cl	4.3	-	-	-	3.2
Nitrate (2:1 water soluble)	CE049 ^U	mg/l NO ₃	1.8	-	-	-	<1
Nitrite (2:1 water soluble)	CE049	mg/l NO ₂	<1	-	-	-	<1
Sulphate (2:1 water soluble)	CE049 ^U	mg/l SO ₄	26	-	-	-	11
Sulphate (total)	CE154	mg/kg SO ₄	188	-	-	-	158
Sulphur (total)	CE127	mg/kg S	368	-	-	-	259
PAH							
Naphthalene	CE087 ^M	mg/kg	-	<0.02	<0.02	<0.02	-
Acenaphthylene	CE087 ^M	mg/kg	-	<0.02	<0.02	<0.02	-
Acenaphthene	CE087 ^M	mg/kg	-	<0.02	<0.02	0.03	-
Fluorene	CE087 ^U	mg/kg	-	<0.02	<0.02	0.03	-
Phenanthrene	CE087 ^M	mg/kg	-	<0.02	0.05	0.72	-
Anthracene	CE087 ^U	mg/kg	-	<0.02	<0.02	0.15	-
Fluoranthene	CE087 ^M	mg/kg	-	0.03	0.11	1.87	-
Pyrene	CE087 ^M	mg/kg	-	<0.02	0.11	1.65	-
Benzo(a)anthracene	CE087 ^U	mg/kg	-	<0.02	<0.02	0.84	-
Chrysene	CE087 ^M	mg/kg	-	<0.03	<0.03	1.06	-
Benzo(b)fluoranthene	CE087 ^M	mg/kg	-	<0.02	0.04	1.58	-
Benzo(k)fluoranthene	CE087 ^M	mg/kg	-	<0.03	<0.03	0.67	-
Benzo(a)pyrene	CE087 ^U	mg/kg	-	<0.02	<0.02	1.15	-
Indeno(123cd)pyrene	CE087 ^M	mg/kg	-	<0.02	<0.02	0.36	-
Dibenz(ah)anthracene	CE087 ^M	mg/kg	-	<0.02	<0.02	<0.02	-
Benzo(ghi)perylene	CE087 ^M	mg/kg	-	<0.02	<0.02	0.33	-
Coronene	CE087	mg/kg	-	<0.02	<0.02	<0.02	-
PAH (total of 17)	CE087	mg/kg	-	<0.36	<0.36	10	-

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SOILS

Lab number			84000-1	84000-2	84000-3	84000-4	84000-5
Sample id			S/55215	S/55216	S/55217	S/55218	S/55219
Sample location			WS1-2	WS1-1	WS2-1	HD1-1	WS3-2
Depth (m)			1.25-2.00	0.10-0.50	0.10-0.50	0.10-0.40	0.60-1.00
Date sampled			27/01/2020	27/01/2020	27/01/2020	27/01/2020	27/01/2020
Test	Method	Units					
TPH							
VPH Aromatic (>EC5-EC7)	CE067	mg/kg	-	-	-	<0.01	-
VPH Aromatic (>EC7-EC8)	CE067	mg/kg	-	-	-	<0.01	-
VPH Aromatic (>EC8-EC10)	CE067	mg/kg	-	-	-	<0.01	-
EPH Aromatic (>EC10-EC12)	CE068	mg/kg	-	-	-	<1	-
EPH Aromatic (>EC12-EC16)	CE068	mg/kg	-	-	-	<1	-
EPH Aromatic (>EC16-EC21)	CE068	mg/kg	-	-	-	5	-
EPH Aromatic (>EC21-EC35)	CE068	mg/kg	-	-	-	7	-
EPH Aromatic (>EC35-EC44)	CE068	mg/kg	-	-	-	1	-
VPH Aliphatic (>C5-C6)	CE067	mg/kg	-	-	-	<0.1	-
VPH Aliphatic (>C6-C8)	CE067	mg/kg	-	-	-	<0.1	-
VPH Aliphatic (>C8-C10)	CE067	mg/kg	-	-	-	<0.1	-
EPH Aliphatic (>C10-C12)	CE068	mg/kg	-	-	-	<4	-
EPH Aliphatic (>C12-C16)	CE068	mg/kg	-	-	-	5	-
EPH Aliphatic (>C16-C35)	CE068	mg/kg	-	-	-	105	-
EPH Aliphatic (>C35-C44)	CE068	mg/kg	-	-	-	23	-
Subcontracted analysis							
Asbestos (qualitative)	\$	-	-	NAD	NAD	NAD	-

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METHOD DETAILS

METHOD	SOILS	METHOD SUMMARY	SAMPLE	STATUS	LOD	UNITS
CE127	Arsenic (total)	Aqua regia digest, ICP-MS	Dry	M	1	mg/kg As
CE127	Beryllium (total)	Aqua regia digest, ICP-MS	Dry	U	1	mg/kg Be
CE063	Boron (water soluble)	Hot water extract, ICP-OES	Dry	M	0.5	mg/kg B
CE127	Cadmium (total)	Aqua regia digest, ICP-MS	Dry	M	0.2	mg/kg Cd
CE127	Chromium (total)	Aqua regia digest, ICP-MS	Dry	M	1	mg/kg Cr
CE127	Copper (total)	Aqua regia digest, ICP-MS	Dry	M	1	mg/kg Cu
CE127	Lead (total)	Aqua regia digest, ICP-MS	Dry	M	1	mg/kg Pb
CE127	Mercury (total)	Aqua regia digest, ICP-MS	Dry	M	0.5	mg/kg Hg
CE127	Nickel (total)	Aqua regia digest, ICP-MS	Dry	M	1	mg/kg Ni
CE127	Selenium (total)	Aqua regia digest, ICP-MS	Dry	M	0.3	mg/kg Se
CE127	Vanadium (total)	Aqua regia digest, ICP-MS	Dry	M	1	mg/kg V
CE004	pH	Based on BS 1377, pH Meter	As received	M	-	units
CE061	Magnesium (2:1 water soluble)	Aqueous extraction, ICP-OES	Dry		1	mg/l Mg
CE049	Chloride (2:1 water soluble)	Aqueous extraction, IC-COND	Dry	U	1	mg/l Cl
CE049	Nitrate (2:1 water soluble)	Aqueous extraction, IC-COND	Dry	U	1	mg/l NO ₃
CE049	Nitrite (2:1 water soluble)	Aqueous extraction, IC-COND	Dry		1	mg/l NO ₂
CE049	Sulphate (2:1 water soluble)	Aqueous extraction, IC-COND	Dry	U	10	mg/l SO ₄
CE154	Sulphate (total)	Acid extraction, ICP-MS	Dry		100	mg/kg SO ₄
CE127	Sulphur (total)	Aqua regia digest, ICP-MS	Dry		100	mg/kg S
CE087	Naphthalene	Solvent extraction, GC-MS	As received	M	0.02	mg/kg
CE087	Acenaphthylene	Solvent extraction, GC-MS	As received	M	0.02	mg/kg
CE087	Acenaphthene	Solvent extraction, GC-MS	As received	M	0.02	mg/kg
CE087	Fluorene	Solvent extraction, GC-MS	As received	U	0.02	mg/kg
CE087	Phenanthrene	Solvent extraction, GC-MS	As received	M	0.02	mg/kg
CE087	Anthracene	Solvent extraction, GC-MS	As received	U	0.02	mg/kg
CE087	Fluoranthene	Solvent extraction, GC-MS	As received	M	0.02	mg/kg
CE087	Pyrene	Solvent extraction, GC-MS	As received	M	0.02	mg/kg
CE087	Benzo(a)anthracene	Solvent extraction, GC-MS	As received	U	0.02	mg/kg
CE087	Chrysene	Solvent extraction, GC-MS	As received	M	0.03	mg/kg
CE087	Benzo(b)fluoranthene	Solvent extraction, GC-MS	As received	M	0.02	mg/kg
CE087	Benzo(k)fluoranthene	Solvent extraction, GC-MS	As received	M	0.03	mg/kg
CE087	Benzo(a)pyrene	Solvent extraction, GC-MS	As received	U	0.02	mg/kg
CE087	Indeno(123cd)pyrene	Solvent extraction, GC-MS	As received	M	0.02	mg/kg
CE087	Dibenz(ah)anthracene	Solvent extraction, GC-MS	As received	M	0.02	mg/kg
CE087	Benzo(ghi)perylene	Solvent extraction, GC-MS	As received	M	0.02	mg/kg
CE087	Coronene	Solvent extraction, GC-MS	As received		0.02	mg/kg
CE087	PAH (total of 17)	Solvent extraction, GC-MS	As received		0.36	mg/kg
CE067	VPH Aromatic (>EC5-EC7)	Headspace GC-FID	As received		0.01	mg/kg
CE067	VPH Aromatic (>EC7-EC8)	Headspace GC-FID	As received		0.01	mg/kg
CE067	VPH Aromatic (>EC8-EC10)	Headspace GC-FID	As received		0.01	mg/kg
CE068	EPH Aromatic (>EC10-EC12)	Solvent extraction, GC-FID	As received		1	mg/kg
CE068	EPH Aromatic (>EC12-EC16)	Solvent extraction, GC-FID	As received		1	mg/kg
CE068	EPH Aromatic (>EC16-EC21)	Solvent extraction, GC-FID	As received		1	mg/kg
CE068	EPH Aromatic (>EC21-EC35)	Solvent extraction, GC-FID	As received		1	mg/kg

Chemtech Environmental Limited

METHOD DETAILS

METHOD	SOILS	METHOD SUMMARY	SAMPLE	STATUS	LOD	UNITS
CE068	EPH Aromatic (>EC35-EC44)	Solvent extraction, GC-FID	As received		1	mg/kg
CE067	VPH Aliphatic (>C5-C6)	Headspace GC-FID	As received		0.1	mg/kg
CE067	VPH Aliphatic (>C6-C8)	Headspace GC-FID	As received		0.1	mg/kg
CE067	VPH Aliphatic (>C8-C10)	Headspace GC-FID	As received		0.1	mg/kg
CE068	EPH Aliphatic (>C10-C12)	Solvent extraction, GC-FID	As received		4	mg/kg
CE068	EPH Aliphatic (>C12-C16)	Solvent extraction, GC-FID	As received		4	mg/kg
CE068	EPH Aliphatic (>C16-C35)	Solvent extraction, GC-FID	As received		4	mg/kg
CE068	EPH Aliphatic (>C35-C44)	Solvent extraction, GC-FID	As received		10	mg/kg
\$	Asbestos (qualitative)	HSG 248, Microscopy	Dry	U	-	-

Chemtech Environmental Limited

DEVIATING SAMPLE INFORMATION

Comments

Sample deviation is determined in accordance with the UKAS note "Guidance on Deviating Samples" and based on reference standards and laboratory trials.

For samples identified as deviating, test result(s) may be compromised and may not be representative of the sample at the time of sampling.

Chemtech Environmental Ltd cannot be held responsible for the integrity of sample(s) received if Chemtech Environmental Ltd did not undertake the sampling. Such samples may be deviating.

Key

N	No (not deviating sample)
Y	Yes (deviating sample)
NSD	Sampling date not provided
NST	Sampling time not provided (waters only)
EHT	Sample exceeded holding time(s)
IC	Sample not received in appropriate containers
HP	Headspace present in sample container
NCF	Sample not chemically fixed (where appropriate)
OR	Other (specify)

Lab ref	Sample id	Depth (m)	Deviating	Tests (Reason for deviation)
84000-1	S/55215	1.25-2.00	N	
84000-2	S/55216	0.10-0.50	N	
84000-3	S/55217	0.10-0.50	N	
84000-4	S/55218	0.10-0.40	N	
84000-5	S/55219	0.60-1.00	N	