Southern Testing
Environmental & Geotechnical

ST Consult
Environmental & Geotechnical

Geotechnical Site Investigation Report

Project Name: Land adjacent to Toddington Lane, Littlehampton

Location: Toddington Lane, Littlehampton, West Sussex, BN17 7PN

Client: Worthing Homes

Project ID: J14912

Report Date: 4 November 2021

Report Issue: 1

SUMMARY

The site, which extends to approximately 0.62 acres comprises a barn and vacant overgrown land. It is proposed to redevelop the site with residential housing.

Geological records indicate the site to be underlain by River Terrace Deposits/Brickearth over New Pit Chalk Formation

A Desk Study was not requested as part of this investigation.

An Unexploded Ordnance (UXO) risk assessment was undertaken by a specialist subcontractor as part of these works, showing the site to be at Low Risk of UXO.

A single phase of intrusive investigation was carried out. With the exception of the overgrown bank along the northern and north eastern edges of the site and the ground beneath the barn, all areas of the site were accessible during the fieldwork. The inaccessible areas will require further investigation once access is available. It should not be assumed that the same ground conditions would apply to these inaccessible areas.

The soils encountered comprised varying silty and sandy clays. These soils appeared desiccated.

Groundwater was not encountered during the initial fieldwork or subsequent groundwater monitoring visits.

Conventional foundations are recommended for this site. An allowable bearing pressure of 100kPa is recommended for foundations at a minimum depth of 2.00m. NHBC Low Volume Change Potential precautions will apply.

The sulphate content of the fill and 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.

Suspended floor slabs are advised.

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.

Author	J A Clifford BSc FGS		
Check / Review	P J Sugden MSc FGS		

For and on behalf of Southern Testing Laboratories Limited

DOCUMENT HISTORY AND STATUS

Issue No	Date	Purpose or Status	Author	Check / Review
1	4-Nov-2021	Geotechnical Site Investigation Report	JAC	PJS

TABLE OF CONTENTS

TABLE OF APPENDICES

A INTRODUCTION

1 Authority

Our authority for carrying out this work is contained in a Project Order Form approved by Kelly Male of MH Architects on behalf of Worthing Homes dated 1st September 2021.

2 Location

The site is located 1.8km north East of Littlehampton Railway station, and just to the south of Toddington Lane. The approximate National Grid Reference of the site is TQ 03400 03859. The site location is indicated on Figure 1 within Appendix A.

3 Proposed Construction

It is proposed to construct 10 No Residential units comprising 4 bedroom townhouses, 2 and 3 bedroom semi-detached houses and 2 bedroom flats.

Ground loadings have not been given. 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 II geotechnical investigation

The object of the investigation was to assess foundation bearing conditions and other soil parameters relevant to the proposed development, and to assess the likely nature and extent of soil, groundwater and soil gas contamination on the site.

5 Scope

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

A Preliminary UXO risk assessment was included within our brief for the investigation in advance of the investigation works being undertaken.

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

Contamination issues are not considered in this report.

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

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 Worthing Home 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 may not be appropriate to alternative development schemes.

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 was not requested as part of this Investigation.

6.1 Geology

The British Geological Survey Map No317/332 indicates that the site geology consists of River Terrace Deposits over Raised Beach Deposits over the New Pit Chalk Formation

6.1.1 River Terrace Deposits

The River Terrace Deposits are of fluviatile origin and were laid down by the Thames when the climate was much wetter and cooler than at present. The terraces consist of sheets of gravel and sand with an overlying deposit of Brickearth (really an ancient alluvium). Some variability in soils is to be expected at junctions with the various terraces, as riverbanks existed there. The remains of these former riverbanks can be soft and silty or contain clay.

6.1.2 Brickearth

Brickearth (loess deposit) is a recent deposit which is so called as it is suited to brick manufacture. It is predominantly an aeolian deposit; formed during cold, dry climatic conditions. There is evidence that brickearth has been reworked as part of 'sheet flooding' which helped incorporate flint gravels into the deposit. Brickearth consists mainly of ferruginous silty clay, which is often sandy and may contain some finely divided chalk, scattered flints and gravelly seams, or other locally derived material. It is usually poorly consolidated and may contain numerous hollow root tubes and worm burrows.

6.1.3 Raised Beach Deposits (South Coast)

There are four raised beaches on the south coast. These are:

1. The Higher Raised Beach (30m Beach, Goodwood Slindon Raised Beach).
2. The 15 20 m Beach.
3. The Sussex Low Raised Beach (The 7.5 m Raised Beach).
4. The 4 m Beach.

The principal beaches in Southeast England are the Higher and Low beaches, as described below:

The Higher Raised Beach (Goodwood-Slindon Raised Beach)

The higher beach is variously referred to as the 100 foot beach, the 30 m beach, the Goodwood Beach and the upper beach.

The beach deposits consist of uniformly graded, often buff, silty sand, which lie beneath a superficial cover of (usually) clayey gravel. They are above 4 m thick and are dated to the second warm interglacial period (the Hoxnian). They rest on a wave-cut platform which falls gently from its maximum elevation of just over 30 m AOD to about 25 m AOD over a distance of 1 to 2 km. Where the base platform is in chalk there is often a thin gravelly layer and the upper 150 mm or so of the chalk is hard and calcreted. At the interface between the chalk and the overlying beach large solution features may be found.

The northern margin of the beach is marked by a slight break in slope at about +45 m AOD - the beach deposits and overlying cover are about 15 m thick there. A "buried cliff" line may be found and intense reworking and variability of soils must be anticipated.

It is noted that coarse beach deposits are usually absent and it is not entirely clear whether the northern margin is a cliff line or a fault scarp.

Low Sand Beach (7.5 m Beach) (Sussex/Hampshire Low Raised Beach)

The Low Beach deposits comprise fine uniform silty sands with some gravel, which rest on a platform that falls from about +15 m AOD, to present sea level, over a distance of up to 15 km. They lie beneath a superficial cover of brickearth or Coombe deposits.

As the deposits are up to about 5 m thick, the ground level at the inland margin is about +20 m AOD, and a slight change in slope can sometimes be detected at this point. There is a former cliff at the margin, usually in soft Tertiary clays which have been highly degraded but which may have been up to 10 to 12 m high. Highly variable soil conditions must be anticipated in the region of the ancient cliffs.

The beaches were formed in a complex marine transgression which is traditionally considered to belong to the Ipswichian Interglacial (about 80,000 years ago) and there are also deep local cryoturbation and solution features.

6.1.4 New Pit Chalk Formation

The New Pit Chalk Formation typically comprises a blocky creamy white, smooth textured chalk with well-developed marl seams. Small finger shaped flint occurs sporadically in the lower part of the sequence. Conjugate fractures are usually clay-coated and slickensided, reflecting the presence of many clay-rich marl seams.

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 to 15 metres 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 database [9] and Southern Testing in-house records, revealed only two records within the near vicinity of this site, both from the BGS source.

BH Reference	Final Depth (mbgl)	Distance from site (m) & Direction		Remarks
TQ00SW174 13.10.21 accessed BGS database	30.1	182m SE	0.00-4.60m 4.60-13m 13-30.1m	Brickearth and Alluvium deposits. Soft brown sandy CLAY and Flints. Weathered Chalk with grey marl bands and no flints (very unstable) Chalk became more block, no flint throughout.
TQ00SW49 31.10.21 Accessed BGS database	30	343m E	0.00 - 0.60m 0.60 – 3.04m 3.04 – 4.00m 4.00 – 30.00m	Topsoil Brown Clay Sand Chalk

6.3 UXO Risk Management

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.

A preliminary UXO risk assessment has been prepared by MACC International and is appended.

The risk assessment indicates that although the Littlehampton coast suffered multiple enemy bombing raids during WWII the Toddington area avoided most of the raids with the closest known bomb strike approximately 950m south west at Grand Avenue. No records were found to confirm a bomb strike within or immediately adjacent to the site boundary.

Consequently the risk assessment found the site to be at Low risk of unexploded Ordnance.

7 Site Walkover Survey

7.1 General Site Description and Boundaries

The site was roughly rectangular in shape measuring approximately 100m across in east west direction and 70m in a north south direction. The site comprised mostly vacant land overgrown with vegetation, with a part brick and part concrete agricultural barn measuring approximately 15m x 30m. This had a suspected asbestos cement pitched roof and sidings. The site was bound by Toddington Lane to the north east, residential houses to the south and commercial buildings and workshops to the west.

7.2 Topography and Drainage

The topography of the site was elevated in comparison to Toddington Lane to the north, south and east and overlooked the flat lying land to the north. The topography of the surrounding area is predominantly flat towards the coastline but rises steeply to the north towards Arundel.

7.3 Vegetation

The site was heavily vegetated with weeds and brambles with the northern and eastern boundaries being the most heavily vegetated. An ecological boundary fence was also in place along the southern boundary.

7.4 Buildings and Land Use on Site and Nearby

A single building was present on site and this comprised a part brick part concrete barn with concrete floor slab and suspected asbestos cement roof and sides that had partially collapsed in several places.

7.5 Inaccessible Site Areas

It was not possible to drill a borehole beneath the footprint of the barn nor was it possible to drill at the top of the sloping boundary along the northern part of the site due to dense vegetation.

7.6 Site Photographs

A series of photographs showing a general overview of the site is included in Appendix G.

C GROUND INVESTIGATION

8 Strategy and Method

The strategy adopted for the intrusive investigation comprised the following:

Activity / Method	Purpose	Max Depth Range (mbgl)	Installations / Notes
WLS1-5 Dynamic Windowless Sampling	Boreholes to investigate the shallow ground conditions within external areas. To allow SPTs and collection of samples for geotechnical & contamination testing. Installation of shallow groundwater monitoring wells.	3.0 - 5.0	50mm groundwater monitoring wells installed within WLS3 and WLS5.
(WLS1,2 and 3) Small scale falling head soakage tests	Soakage testing to provide indicative infiltration rates.	3.0 - 5.0	100mm diameter boreholes

Exploratory hole locations are shown in 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.

The presence of the barn buildings and dense vegetation the fieldwork. Additional fieldwork will be required once access to the entire site is available.

9 Weather Conditions

The fieldwork was carried out on the 15 September 2021 at which time the weather was generally warm, dry and sunny.

10 Soils as Found

The soils encountered are described in detail in the attached exploratory hole logs (Appendix A), but in general comprised a covering of Made Ground over silty sandy gravelly Clays (Terrace Deposits), over weathered Chalk. A summary is given below.

Depth	Thickness	Soil Type	Description
0.0-0.2/0.3m	0.20-0.30m	Made Ground	Brown red and grey silty sandy GRAVEL. Gravel is fine to coarse brick, limestone and concrete with geotextile membrane at base.
0.2/0.3-1.5/4.5m	1.20-4.20m	Silty sandy CLAY	Stiff to very stiff red/orange brown silty slightly fine sandy CLAY
1.5-2.2m (WLS01 only)	0.70m	Silty gravelly SAND	Medium dense orange brown silty gravelly SAND. Gravel is fine to coarse subangular flint sand is medium to coarse grained.
2.2-3.0m (WLS01 only)	Unproven	Silty sandy CLAY	Stiff to very stiff red/orange brown silty slightly fine sandy CLAY
2.3/3.5-5.0m	Unproven	Structureless Chalk	Recovered as: Structureless chalk comprising off white and brown silty gravelly CLAY. Gravel is fine to coarse chalk

These occurrences are discussed in Section E.

11 Groundwater Observations

Groundwater was not observed in the exploratory during drilling.

D DISCUSSION OF GEOTECHNICAL TEST RESULTS AND RECOMMENDATIONS

12 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	4	River Terrace Deposits/Brickearth
Atterberg Limit	4	River Terrace Deposits/Brickearth
Particle Size Distribution (Wet Sieve)	1	River Terrace Deposits/Brickearth
BRE SD1 Suite	6	River Terrace Deposits/Brickearth
Saturation Moisture Content of Chalk	2	New Pit Chalk

13 Soil Classification and Properties

13.1 Made Ground

Shallow surface hard standing (0.2 - 0.3m thick) in the form of a gravel comprising brick and concrete crushed material with an underlying geotextile membrane was encountered at each exploratory hole location.

13.2 River Terrace Deposits/Brickearth

These deposits were predominantly stiff to very stiff sandy clays with varying proportions of sand and flint gravel, not untypical of fluvial deposits. 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.

Six Atterberg Limit Tests were undertaken within the silty sandy clays which indicated a clay of low to intermediate plasticity, with a Liquid Limits in the range of 30-38%, a Plastic Limit of 11-21% and a Plasticity Index of 16- 21%, indicating Low to Medium Volume Change Potential.

The materials were found to be of low to medium density in nature with SPT N values in between 6 and 25.

A band of gravelly Sand was encountered in WLS01 between 1.5m and 2.2m which had the following range of particle size distribution results.

Hole ID / Depth (m)	Clay/Silt (%)	Sand (%)	Gravel (%)	Cobbles (%)
WLS01	13	74	13	0

13.3 New Pit Chalk

The chalk material recovered on site was recovered as Structureless chalk that appeared to be weathered. It was possible to select chalk gravel pieces suitably sized for laboratory testing.

One sample from WLS02 at 3.00m and one sample from WLS04 at 4.00m depth were selected for classification testing using the saturation moisture content method giving bulk density's in the range of 2.11-2.16 mg/m3, dry density of 1.74-1.82mg/m3 and saturation moisture content of 18-20%.

14 Groundwater Levels

Groundwater monitoring has been carried out at on one occasion following the site work. The table below details the findings and date of the visit. One more monthly monitoring visit is scheduled.

BH ID	Water level on 10.10.21	Water level on 1.11.21
WLS03	Dry @ 4m bgl	Dry @ 4.00m
WLS05	Dry @ 4.70m bgl	Dry @ 4.70m bgl

Although groundwater water was not encountered during the investigation it should be noted that 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. Long-term monitoring from boreholes or standpipes is required to assess the ground water regime and this was not possible during the course of this site investigation.

15 Swelling and Shrinkage

Shrinkable soils are subject to changes in volume as their moisture content is altered. Soil moisture contents vary from season to season and can be influenced by a number of factors including the action of roots. The resulting shrinkage or swelling of the soil can cause subsidence or heave damage to foundations, the structures they support and services.

The designer should be aware that precautions regarding swelling and shrinkage are applicable, and in this respect NHBC precautions provide a helpful guide with respect to minimum foundation depths and deepening particularly within the zone of influence of trees.

Assessment of foundation depths should take into account trees, hedgerow and shrubs which are to be removed, remaining or are proposed which may be allowed to reach maturity.

We would recommend that on balance a NHBC Low Volume Change Potential site classification be adopted for design purposes covering the silty sandy CLAY materials.

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

16 Desiccation

No single factor can be used to assess the degree of desiccation of soils but some of the more commonly used criteria are listed below:-

If the soils are below a moisture content of 0.5 x liquid limit, measured by the cone method, they can be considered desiccated, but heave will not necessarily occur when the tree is removed.

If the soils are below a moisture content of 0.4 x liquid limit1 then they are strongly desiccated and heave is likely after trees are removed.

A plot of moisture content and Atterberg Limit tests versus depth is included within Appendix D Figures 3 and 4.

Clay soils such as London Clay Formation are usually found to have a moisture content that is close to the Plastic Limit, below a depth of about 4.0m. Above that depth softening occurs and the moisture content rises to Plastic Limit +2 to 4% where the soil is unaffected by trees. A typical profile would be a moisture content of PL + 3% at 1.0m reducing to PL + 1% at 3.0m.

Where clay contains gravel such as the flint gravel found within the Brickearth/River Terrace deposits on this site the amount of shrinkage is reduced in direct proportion to the percentage of gravel in the mass, and because the interlocking effect of the gravel reduces volumetric shrinkage by causing small voids to form.

R Driscoll - The influence of vegetation on the swelling and shrinkage of clay in Great Britain - Geotechnique, June 1983

It should be noted that the clay materials have been recorded as containing sand and flint gravel and would be expected to have lower moisture contents and reduce the overall swelling and shrinkage properties of the soils when compared to a pure clay material. The desiccation plot (Figure 3 Appendix D) indicates the soils to be potentially desiccated to approximately 2.0m or 2.5m below ground level (bgl) Given the sand and gravel content within the clay it is not possible to categorically assess the level of desiccation on the site with the Atterberg limit data.

The hand penetrometer plot (Figure 4 Appendix D) also indicates the soils are desiccated. Again the results of the hand penetrometer can be affected by sand and gravel content within the sample and can artificially raise the readings achieved on site. However the results shown in figure 4 suggest the soils are desiccated to a depth of approximately 2.0m bgl.

Based on all the results above, soils appear desiccated to approximately 2.0m bgl.

17 Lateral Pressure & Heave

Where foundations are more than 1.5m deep, and are within the zone of influence of existing or removed trees, then precautions will also need to be taken against the effects of lateral swelling of soils beneath house units due to removal of trees, or cutting tree roots.

A helpful guide with respect to requirements for the relief of lateral pressure is set out in the NHBC Standards Ref [21], Chapter 4.2 to which the reader is referred. The basic requirement is that compressible material or void former should be installed on the inner face of external foundation walls. With piled foundations additional voids are required below ring beams.

18 Soakaways

Small scale falling head soakage testing was carried out in WLS01, WLS02 and WLS03. WLS01 and WLS03 indicated little or no infiltration; which was not unexpected given the low permeability clay soils encountered. WLS02 indicated good soakage as it was possible to repeat the test three times the same day. It is likely that infiltration in WLS02 was through the rubbly chalk encountered at the base of the borehole. Clay /chalk was encountered in WLS03, which did not soak. It is worth noting that the chalk is very variable and the amount of clay in the chalk will significantly affect soakage potential.

18.1 Soakage Test Results

The BRE paper DG365, Ref [22] describes a method for site testing to determine soil infiltration rates at the proposed site of a soakaway. The in-situ test method is described in Appendix B however this has been modified by testing within a borehole instead of a trial pit.

A total of three soakage tests were carried out across the site, at the locations WLS01, WLS02 and WLS03 shown on the attached site plan Figure 2, Appendix A. The full results of the soakage tests are presented within Appendix B.

The DG365 Ref [22], states that each pit should be allowed to drain three times to near empty, with filling on the same or consecutive days. It was only possible to test WLS02 three times the other two locations did not provided quick enough soakage to allow repeat tests to be carried out on the one day of site work allowed for.

The infiltration rate from each trial hole is summarised in the table below. The soakage rate in this report in expressed as ℓ/m²/minute, which is a convenient rate to use. The BRE use a unit of m/sec, which is the value in l/m²/minute divided by 60,000.

Test ID	Test Depth (mbgl)	Design Infiltration Rate		Notes
		ℓ/m²/minute	m/sec	
WLS01	3.0	0.120	2.0x10-6	
WLS02	3.0	0.527	8.8x10-6	3 fillings carried out
WLS03	5.0	0.034	5.7x10-7	

Note: The Design Infiltration Rate is the lowest of the three tests

Where three fillings have not been carried out, a reduction factor should be applied to the result to provide a design infiltration rate.

The results generally indicate that the silty sandy clay soils on site do not provide a good means of infiltration for water discharged below surface level.

On the basis of these test results and given the soil types present, the shallow soils are not considered suitable for shallow soakaway drainage. However some soakage may be possible in the rubbly chalk at depth but this strata is not consistent either in composition or depth. We would therefore recommend further testing within deeper boreholes penetrating the chalk.

At this stage a positive drainage system should be considered for all surface water disposal.

19 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 that is unlikely to contain pyrites.

Given the sample numbers tested the characteristic value for sulphate concentration has been determined from the highest measured concentration.

The recorded pH values are in the range 5.4-8.0

The water soluble SO4 concentrations ranged from 17.9 - 65.5mg/l giving a mean concentration of 47.25mg/l

The Design Sulphate Class is DS-1. Groundwater should be assumed to be immobile. The ACEC site classification is AC-1s

20 Foundation 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. It should be noted that at the time of the investigation the natural clays appeared desiccated to approximately 2.0m bgl.

Taking this into account, we recommend that an allowable bearing pressure of 100kPa be adopted for traditional spread foundations placed at a minimum depth of 2.0m bgl to avoid desiccated soils.

Spread foundations should be kept between 600mm and 1.2m width.

Allowance should be made for nominal mesh reinforcement in all foundations to cater for differential movement where they span differing materials.

A minimum foundation depth of 900mm would normally be anticipated for NHBC Low Volume Change Potential soils however given the potential desiccation identified on site a minimum depth of 2.0m below existing ground level is recommended to avoid soil swelling in the wetter months. The designer should be aware that precautions regarding swelling and shrinkage are applicable and in this respect NHBC precautions provide a helpful guide with respect to minimum foundation depths and deepening particularly within the zone of influence of trees hedgerows or shrubs; existing, proposed or removed.

Noting that the site is very heavily 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.

Subject to the Engineers final design excessive foundation deepening may be required. Based on NHBC guidance, foundations below 2.5m must be designed individually by an engineer on an individual property basis taking into account soil desiccation, heave, lateral pressure, trench stability and workmanship. At depths in excess of 2.5m a piled foundation is usually the most appropriate foundation option.

Given the inherent variability of soil conditions, it is recommended that foundation inspections be undertaken during construction by a suitably qualified engineer to confirm that the recommendations within this report are appropriate to the foundations.

21 Floor Slabs

Due to the presence of clay soils fully suspended ground floor slabs are recommended.

22 Settlement

Based on the recommendations given above, settlement for the proposed structure should be within tolerable limits.

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 below the water table.

Where excavation is proposed in close proximity to existing structures care will need to be taken to avoid undermining existing foundations.

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), "Borehole Scans," [Online]. Available: hiip://www.bgs.ac.uk/data/boreholescans/home.html.

[7] CIRIA, "C681 Unexploded Ordnanace (UXO) A guide for the construction industry," 2009.

[8] NHBC, "NHBC Standards Plus," [Online]. Available: hiip://www.nhbc.co.uk/Builders/ProductsandServices/TechZone/nhbcstandards/.

[9] Building Research Establishment (BRE), "DG365 Soakaway Design," 2016.

[10] Building Research Establishment (BRE), "SD1 Concrete in aggressive ground," 2005.

[11] BSI Standards, "BS 3882:2015 Specification for Topsoil," 2015.

[12] CIRIA, "C574 Engineering in Chalk," 2002.

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

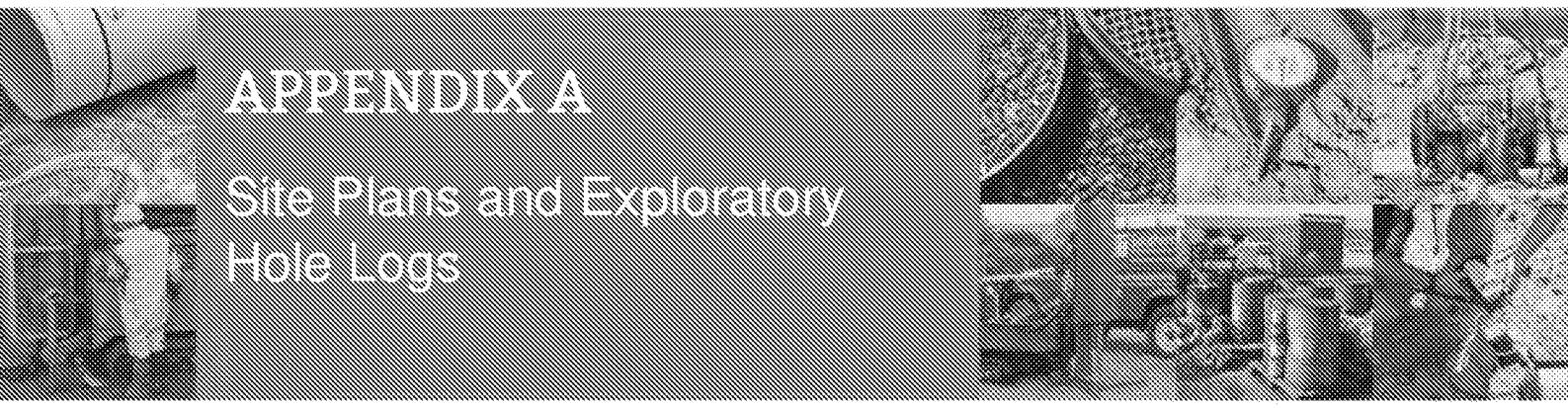
[14] BSI Standards, "BS EN ISO 22476-3:2005+A1:2011 Geotechnical investigation and testing. Field testing. Standard penetration test," 2011.

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

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

Southern Testing
Environmental & Geotechnical

ST Consult
Environmental & Geotechnical

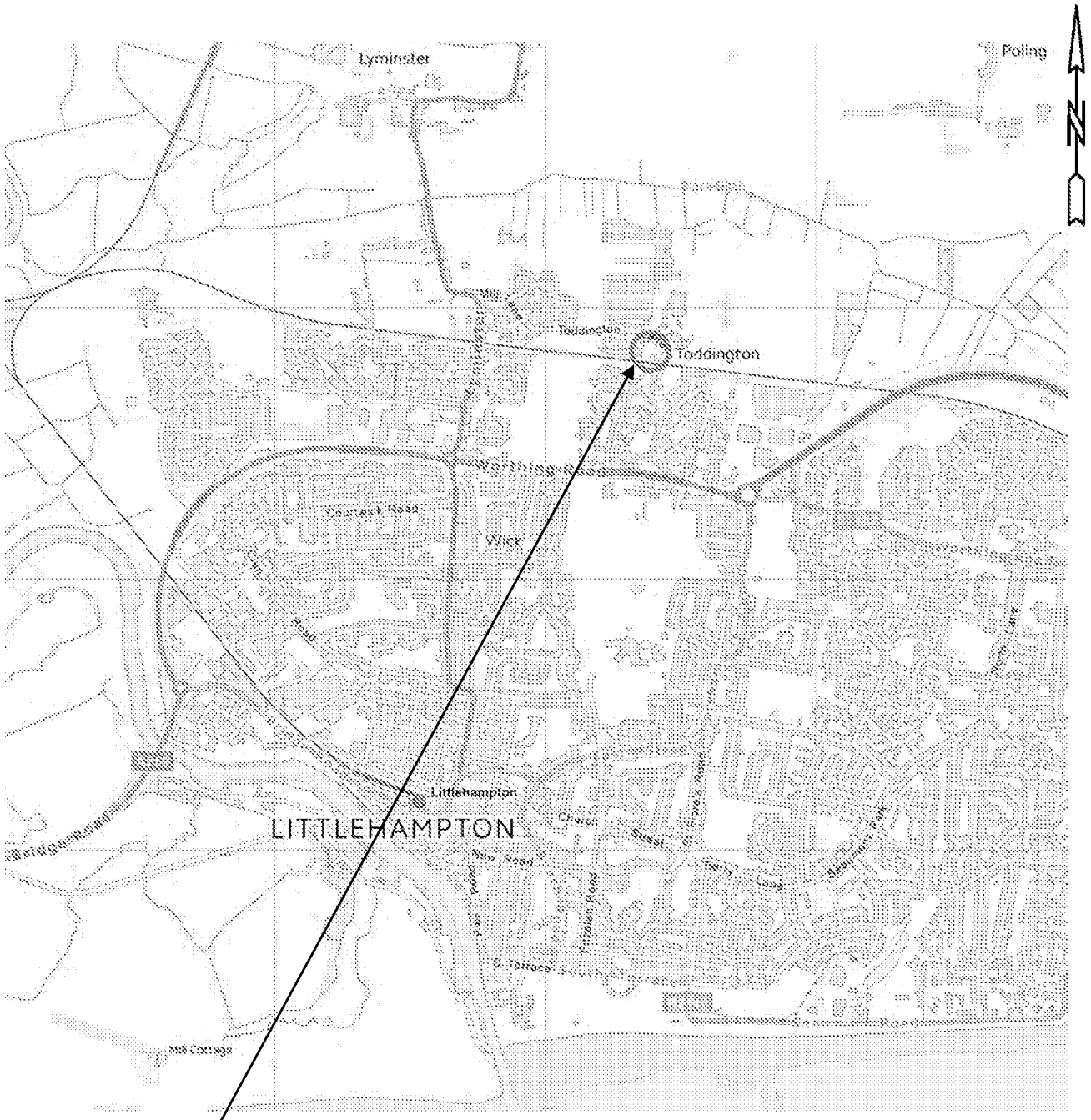


APPENDIX A

Site Plans and Exploratory Hole Logs

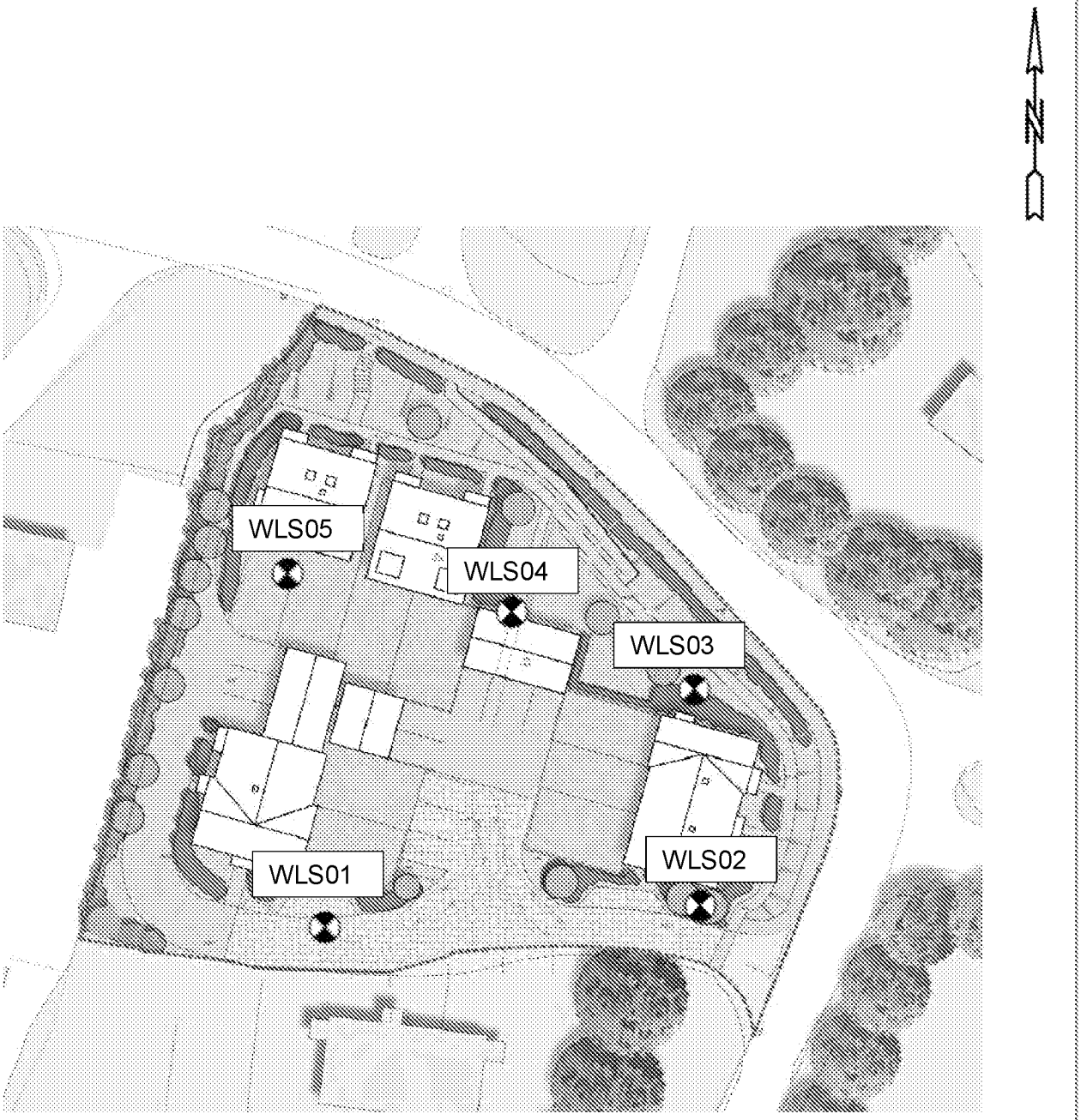
Southern Testing
Environmental & Geotechnical

ST Consult
Environmental & Geotechnical



Contains Ordnance Survey Data © Crown Copyright and Database Right 2019

Site:	Land at Toddington Lane, Littlehampton, BN17 7PN	Project ID	J14912
Figure 1	Site Location Plan	Date:	02/09/2021



NB: Positions of exploratory holes / test positions are only indicative unless dimensioned.

Site:	Land off Toddington Lane, Littlehampton	Project ID	J14912
Figure 2	Site Investigation Layout Plan	Date:	19.10.21

Southern Testing
Environmental & Geotechnical

ST Consult
Environmental & Geotechnical

Key to Exploratory Hole Logs, Plans and Sections

Backfill Symbols		Pipe Symbols		Principal Soil Types		Principal Rock Types		Drilling Records	
Arisings		Plain Pipe		Topsoil		Mudstone		Water Strike	
Concrete		Slotted Pipe		Made Ground		Claystone		Depth Water Rose	
Blacktop		Piezometer		Clay		Siltstone		Total Core Recovery (%) [TCR]	
Bentonite		Piezometer Tip		Silt		Sandstone		Solid Core Recovery (%) [SCR]	
Gravel Filter		Filter Tip		Sand		Limestone		Rock Quality Index (%) RQD]	
Sand Filter		Extensometer		Gravel		Chalk		Fracture Index (fractures / m) [FI]	
		Inclinometers		Peat					

All soil and rock descriptions are in general accordance with BS5930 2015, BS EN ISO 14688-1:2002+A1:2013 and BS EN ISO 14689-1:2003. Chalk descriptions are also based on CIRIA C574 and "Logging the Chalk – R.N. Mortimer 2015". The Geology Code is only provided where a positive identification of the sample strata has been made.

Location / Method Identifiers	
BH	Borehole (undefined)
CP	Cable Percussive
RC	Rotary Core
RO	Rotary Open Hole
ODC	Rotary Odex/Symmetrix drilling cased
CP+RC	Cable Percussive to Rotary Core
SNC	Sonic
CFA	Continuous Flight Auger
FA	Flight Auger
VC	Vibro Core
WLS+RC	Windowless (Dynamic) Sampler to Rotary Core
WLS	Windowless Sampler
WS	Window Sampler
HA	Hand Auger
C	Road / Pavement Core
IP	Inspection Pit (Hand Excavation)
TP	Trial Pit (Machine Excavated)
OP	Observation Pit (Supported Excavation Hand or Machine)

In-Situ Test Location / Method	
DP	Dynamic Probe
CPT	Cone Penetration Test
CBR	In-situ CBR Test
DCP	CBR using Dynamic Cone Penetrometer
CBRT	CBR using TRL Probe
PB	Plate Bearing Test
SPT (S)	Standard Penetration Test (Split Barrel Sampler)
SPT (C)	Standard Penetration Test (Solid Cone)
N	SPT Result
-/-	Blows/Penetration (mm) after seating drive
-*/-	Total Blows / Penetration (mm)
( )	Extrapolated Value
PPT	Perth Penetration (In-House Method - Equivalent N Value)
HP / UCS	Strength from Hand Penetrometer (kN/m^2)
IVN	Strength from Hand Vane ((kN/m^2) P = peak, R = residual
PID	Photo Ionisation Detector (ppm)
MEXE	Mexi-Cone CBR (%)

Samples / Test Type	
B	Bulk Sample
BLK	Block Sample
C	Core Sample
CBRS	CBR Mould Sample
D	Small Disturbed Sample
ES	Environmental Sample (Soil)
EW	Environmental Sample (Water)
GS	Environmental Sample (Gas)

Samples / Test Type	
SPTLS	Standard Penetration Test Split Barrel Sample
TW	Thin Wall Push In Sample (e.g. Shelby Sampler)
U	Undisturbed Open Drive Sample (blows to take)
UT	Thin Wall Undisturbed Open Drive Sample (blows to take)
W	Water Sample (Geotechnical)
SP	Sample from Stockpile
P	Piston Sample
AMAL	Amalgamated Sample

Southern Testing ST Consult

www.southerntesting.co.uk [redacted] www.stconsult.co.uk [redacted]

Start - End Date	Project ID:	Hole Type:	WLS01
15/09/2021	J14912	WLS	Sheet 1 of 1

Project Name:	Land off Toddington Lane, Littlehampton	**Remarks:**	**Co-ordinates:**	**Level:** / **Logger:** JAC
Location:	Land off Toddington Lane, Littlehampton			
Client:	Worthing Homes			

Well	Water Strikes	Samples and Insitu Testing: Depth (m bgl)	Type	Results	Level (m AOD)	Thickness (m)	Legend	Depth (m bgl)	Stratum Description
						(0.30)			Brown, red and grey silty sandy GRAVEL. Gravel is fine to coarse with cobbles of brick, limestone, concrete and brick., geotextile membrane at base. (MADE GROUND)
		0.30	HP	UCS(kPa)=400				0.30	
		0.50	HP	UCS(kPa)=300					Very stiff reddish brown silty fine sandy CLAY with occasional rootlets.
		0.75	HP	UCS(kPa)=300					
						(1.20)			
		1.00	HP	UCS(kPa)=300					
			SPT(S)	N=8 (1,1/1,1,3,3)					
		1.20	HP	UCS(kPa)=150					
		1.40	HP	UCS(kPa)=150					
								1.50	Medium dense orange brown silty gravelly SAND. Gravel is fine to coarse subangular flint. Sand is medium to coarse grained.
						(0.70)			
		2.00	SPT(S)	N=19 (5,6/5,5,5,4)					
								2.20	Stiff to very stiff orange brown silty very sandy CLAY. Sand is fine to coarse grained.
		2.50	HP	UCS(kPa)=250					
						(0.80)			
		2.75	HP	UCS(kPa)=300					
		3.00	HP	UCS(kPa)=300				3.00	End of Borehole at 3.00m

Hole Details		Casing Details		Waterstrike (m bgl)						Standing/Chiselling (m bgl)			
Depth (m bgl)	Dia. (mm)	Depth (m bgl)	Dia. (mm)	Date	Depth Strike	Depth Casing	Depth Sealed	Rose to:	Time (mins)	From	To	Time	Remarks

ARUN DISTRICT COUNCIL LU/246/24/PL

Southern Testing ST Consult

www.southerntesting.co.uk [redacted] www.stconsult.co.uk [redacted]

Start - End Date	Project ID:	Hole Type:	WLS02
15/09/2021	J14912	WLS	Sheet 1 of 1

Project Name:	Land off Toddington Lane, Littlehampton	Remarks:	Co-ordinates:	Level:	Logger:
Location:	Land off Toddington Lane, Littlehampton				JAC
Client:	Worthing Homes				

Well	Water Strikes	Samples and Insitu Testing: Depth (m bgl)	Type	Results	Level (m AOD)	Thickness (m)	Legend	Depth (m bgl)	Stratum Description
						(0.30)		0.30	Brown sandy GRAVEL. Gravel is fine to coarse subangular to sub rounded concrete, flint and brick over geotextile membrane. (MADE GROUND)
		0.50	HP	UCS(kPa)=200					Stiff brown and orange brown silty sandy CLAY with occasional rootlets.
		0.75	HP	UCS(kPa)=250					
		1.00	HP	UCS(kPa)=250		(1.20)			
			SPT(S)	N=6 (1,1/1,2,1,2)					
		1.30	HP	UCS(kPa)=200					
		1.50	HP	UCS(kPa)=400				1.50	Very stiff orange brown silty slightly sandy CLAY.
		1.75	HP	UCS(kPa)=400					
		2.00	SPT(S)	N=7 (1,1/2,1,2,2)					
		2.20	HP	UCS(kPa)=300		(1.30)			
		2.50	HP	UCS(kPa)=300					
		2.70	HP	UCS(kPa)=300					
						(0.20)		2.80	Recovered as structureless chalk comprising Off white silty GRAVEL. Gravel is fine to medium subangular chalk.
								3.00	End of Borehole at 3.00m

Hole Details		Casing Details		Waterstrike (m bgl)						Standing/Chiselling (m bgl)			
Depth (m bgl)	Dia. (mm)	Depth (m bgl)	Dia. (mm)	Date	Depth Strike	Depth Casing	Depth Sealed	Rose to:	Time (mins)	From	To	Time	Remarks

ARUN DISTRICT COUNCIL LU/246/24/PL

Southern Testing ST Consult	Start - End Date	Project ID:	Hole Type:	WLS03
www.southerntesting.co.uk [redacted] www.stconsult.co.uk [redacted]	15/09/2021	J14912	WLS	Sheet 1 of 1

Project Name:	Land off Toddington Lane, Littlehampton	**Remarks:**	**Co-ordinates:**	**Level:** / **Logger:**
Location:	Land off Toddington Lane, Littlehampton			JAC
Client:	Worthing Homes			

Well	Water Strikes	Samples and Insitu Testing: Depth (m bgl)	Type	Results	Level (m AOD)	Thickness (m)	Legend	Depth (m bgl)	Stratum Description
						(0.30)		0.30	Brown and grey silty sandy GRAVEL. Gravel is fine to coarse with cobbles brick, concrete, and tile fragments Geotextile membrane at base. (MADE GROUND)
		0.50	HP	UCS(kPa)=500					Very stiff brown becoming orange brown silty slightly fine sand CLAY.
		0.75	HP	UCS(kPa)=400					
									0.80m becoming stiff.
		1.00	HP	UCS(kPa)=350					
			SPT(S)	N=6 (1,1/1,1,2,2)					
		1.30	HP	UCS(kPa)=200					
		1.50	HP	UCS(kPa)=200					
		1.75	HP	UCS(kPa)=200					
						(3.20)			
		2.00	HP	UCS(kPa)=200					
			SPT(S)	N=6 (1,1/1,1,2,2)					
		2.30	HP	UCS(kPa)=200					
		2.50	HP	UCS(kPa)=250					
		2.70	HP	UCS(kPa)=300					
		3.00	HP	UCS(kPa)=300					
			SPT(S)	N=17 (2,2/2,3,6,6)				3.50	Very stiff yellowish brown mottled orange brown silty CLAY.
		4.00	SPT(S)	N=8 (1,1/2,2,2,2)		(1.00)			
								4.50	Recovered as structureless chalk comprising off white and brown silty gravelly CLAY. Gravel is fine to coarse subangular chalk with orange brown staining.
						(0.50)			
		5.00	SPT(S)	N=19 (5,5/6,4,4,5)				5.00	End of Borehole at 5.00m

Hole Details		Casing Details		Waterstrike (m bgl)						Standing/Chiselling (m bgl)			
Depth (m bgl)	Dia. (mm)	Depth (m bgl)	Dia. (mm)	Date	Depth Strike	Depth Casing	Depth Sealed	Rose to:	Time (mins)	From	To	Time	Remarks

ARUN DISTRICT COUNCIL LU/246/24/PL

Southern Testing ST Consult	Start - End Date	Project ID:	Hole Type:	WLS04
www.southerntesting.co.uk [redacted] www.stconsult.co.uk [redacted]	15/09/2021	J14912	WLS	Sheet 1 of 1

Project Name:	Land off Toddington Lane, Littlehampton	**Remarks:**	**Co-ordinates:**	**Level:** / **Logger:**
Location:	Land off Toddington Lane, Littlehampton			
Client:	Worthing Homes			

Well	Water Strikes	Samples and Insitu Testing: Depth (m bgl)	Type	Results	Level (m AOD)	Thickness (m)	Legend	Depth (m bgl)	Stratum Description
						(0.30)		0.30	Brown and grey sandy GRAVEL. Gravel is fine to coarse subangular to subrounded flint, brick and concrete with membrane at base (MADE GROUND)
		0.40	HP	UCS(kPa)=300					Stiff to very stiff orange brown slightly fine sandy CLAY.
		0.60	HP	UCS(kPa)=300					
		0.80	HP	UCS(kPa)=400					
		1.00	HP	UCS(kPa)=400					
			SPT(S)	N=16 (1,1/3,4,4,5)					
		1.30	HP	UCS(kPa)=300					
		1.50	HP	UCS(kPa)=300					*1.40-1.50m orange brown silty clayey SAND.*
		1.75	HP	UCS(kPa)=300		(2.90)			*1.75 occasional black speckles and fine subangular flint gravel.*
		2.00	HP	UCS(kPa)=300					
			SPT(S)	N=9 (2,2/3,2,2,2)					
		2.20	HP	UCS(kPa)=200					
		2.50	HP	UCS(kPa)=200					
		2.75	HP	UCS(kPa)=200					
		3.00	HP	UCS(kPa)=200					
			SPT(S)	N=25 (1,3/4,7,7,7)				3.20	Very stiff brown and off white silty gravelly CLAY. Gravel is fine to medium subangular chalk fragments.
		4.00	SPT(S)	N=18 (2,2/4,4,4,6)		(1.80)			
		5.00	SPT(S)	N=35 (8,8/9,11,8,7)				5.00	End of Borehole at 5.00m

Hole Details		Casing Details		Waterstrike (m bgl)						Standing/Chiselling (m bgl)			
Depth (m bgl)	Dia. (mm)	Depth (m bgl)	Dia. (mm)	Date	Depth Strike	Depth Casing	Depth Sealed	Rose to:	Time (mins)	From	To	Time	Remarks

ARUN DISTRICT COUNCIL LU/246/24/PL

Southern Testing ST Consult	Start - End Date	Project ID:	Hole Type:	WLS05
www.southerntesting.co.uk [redacted] www.stconsult.co.uk [redacted]	15/09/2021	J14912	WLS	Sheet 1 of 1

Project Name:	Land off Toddington Lane, Littlehampton	**Remarks:**	**Co-ordinates:**	**Level:** / **Logger:**
Location:	Land off Toddington Lane, Littlehampton			JAC
Client:	Worthing Homes			

Well	Water Strikes	Samples and Insitu Testing: Depth (m bgl)	Type	Results	Level (m AOD)	Thickness (m)	Legend	Depth (m bgl)	Stratum Description
						(0.20)		0.20	Brown and grey silty sandy GRAVEL. Gravel is fine to coarse subangular to subrounded brick, plastic and glass. Geotextile membrane at base. (MADE GROUND)
		0.30	HP	UCS(kPa)=500					Very stiff brown silty sandy CLAY.
		0.60	HP	UCS(kPa)=550					
		0.80	HP	UCS(kPa)=550					
		1.00	HP	UCS(kPa)=550					
			SPT(S)	N=9 (1,1/2,2,2,3)					
		1.20	HP	UCS(kPa)=200		(2.10)			*1.30m becoming sandy and stiff with occasional fine subrounded flint.*
		1.50	HP	UCS(kPa)=200					
		1.75	HP	UCS(kPa)=200					
		2.00	HP	UCS(kPa)=200					
			SPT(S)	N=13 (2,2/2,4,4,3)				2.30	Recovered as Structureless chalk comprising off white gravelly CLAY. Gravel is fine to coarse subangular chalk with yellowish staining and black speckles.
		3.00	SPT(S)	N=18 (4,4/4,5,4,5)		(2.70)			
		4.00	SPT(S)	N=16 (3,3/4,4,4,4)					
		5.00	SPT(S)	N=9 (2,2/2,2,2,3)				5.00	End of Borehole at 5.00m

Hole Details		Casing Details		Waterstrike (m bgl)						Standing/Chiselling (m bgl)			
Depth (m bgl)	Dia. (mm)	Depth (m bgl)	Dia. (mm)	Date	Depth Strike	Depth Casing	Depth Sealed	Rose to:	Time (mins)	From	To	Time	Remarks

Southern Testing
Environmental & Geotechnical

ST Consult
Environmental & Geotechnical

APPENDIX B

Field Sampling and In-Situ Test Methods and Results

B

Soil and Rock Descriptions

All soil and rock descriptions are in general accordance with BS5930 Ref [4].

Anthropogenic soils ('Made Ground' or 'fill') describe materials which have been placed by man and can be divided into those composed of reworked natural soils and those composed of or containing man-made materials. 'Fill' is used to describe material placed in a controlled manner and 'Made Ground' is used to describe materials placed without strict engineering control.

The classification of materials such as topsoil is based on visual description only and should not be interpreted to mean that the material complies with criteria used in BS 3882 Ref [33].

Chalk descriptions are based on CIRIA C574 Ref [34] and Mortimore Ref [35].

The geology code is only provided on logs where a positive identification of the sample strata has been made.

Inspection Pit

Inspection pits are hand excavated from the surface (maximum depth 1.2 – 1.5m) using appropriate tools to locate and avoid existing buried services at exploratory hole positions. They are also regularly used as part of investigations on existing structures to expose and determine foundation detail.

Dynamic Sampling - Window or Windowless

Window sampling is carried out by driving hollow steel tubes incorporating a longitudinal access slot (window) and a cutting shoe into the ground using a percussive 'breaker'. This enables recovery of a continuous soil sample for examination and sub-sampling.

Windowless samplers are designed for taking disturbed, continuous soil samples to depths up to 10 metres (depending on ground conditions). The samplers comprise steel tubes of about 50-100mm diameter with a rigid plastic liner (no window) and are driven into the ground with a sliding hammer mounted on a tracked purpose-designed soil sampling rig. After driving and extracting the sampler from the ground, the plastic liner is extracted together with the enclosed soil sample. The sample can then either be extracted, split and sub-sampled or plastic end caps may be fitted, the tube labelled and transported for future examination and sub-sampling.

Soil samples are disturbed by the driving process with both techniques and can be regarded as being between Class 5 up to Class 3 samples at best (in favourable ground).

The major advantage of using windowless samplers is that the plastic liner greatly reduces the possibility of cross-contamination between successive samples.

An equivalent in-situ test to the Standard Penetration Test can be carried out with the windowless sampler rig.

Standard Penetration Test (SPT)

The Standard Penetration Test (SPT) is specified in BS EN ISO 22476-3 Ref [36]. In this test, an open-ended tube is driven into the ground by blows from a free-falling hammer (with specified sizes, weights and distances).

The tube is seated by driving to a penetration of 150mm, or by 25 blows, whichever occurs first. It is then driven for a maximum of a further 300mm and the number of blows is termed the penetration resistance (N). If 300mm penetration cannot be achieved in 50 blows, the test drive is terminated and penetration depth is recorded.

When testing in gravels, a conical end piece is attached to the tube. The test is then called an SPT(C).

A classification of relative density descriptions as used on borehole logs, based upon uncorrected SPT N values, is given within BS5930 Ref [4] and set out as follows:

Classification based on uncorrected SPT N Value	Term
0 - 4	Very Loose
4 - 10	Loose
10 – 30	Medium Dense
30 – 50	Dense
Over 50	Very Dense

Hand Penetrometer Test

The handheld soil penetrometer consists of a spring loaded and calibrated plunger which is forced into cohesive soil. A reading of unconfined compression strength (equal to twice cohesion) is given on a calibrated scale. The average of a set of three readings shall be recorded.

In common with other hand methods of strength assessment it does not give an accurate indication of bearing capacity in stiff or fissured soils, because of the small test area.

Disturbed Samples

Disturbed samples were taken from exploratory holes in general accordance with BS 5930 [4] and BS EN ISO 22475-1 Ref [41] as required and stored in appropriately labelled containers. Details of the type, size and depth of sample will be recorded within the exploratory hole record. Such samples can be regarded as being between Class 5 up to Class 3 quality depending upon their method of sampling.

Monitoring Well

A groundwater and/or ground gas monitoring well consists of a perforated pipe, which is installed in the ground. The standpipe is typically 50mm nominal in diameter and is installed in a lined borehole. It is perforated from the base with a sand/gravel surround through the soil horizon of interest to an appropriate depth below ground level. Above this there is a bentonite seal with solid pipework and is provided with an end cap or a gas valve at the top as appropriate.

Gas monitoring is carried out via the gas tap. Water sampling/purging can be undertaken by removing the gas tap and bung.

The well is usually completed at the surface with a flush cast iron cover or raised lockable cover.

Groundwater Monitoring – Dip Meter

The dip meter is used to measure standing water levels within boreholes. The probe is lowered into the borehole until the meter detects the groundwater with an audible 'beep'. The level is then read from the tape.

In-situ Permeability Tests (after BS EN ISO 22282)

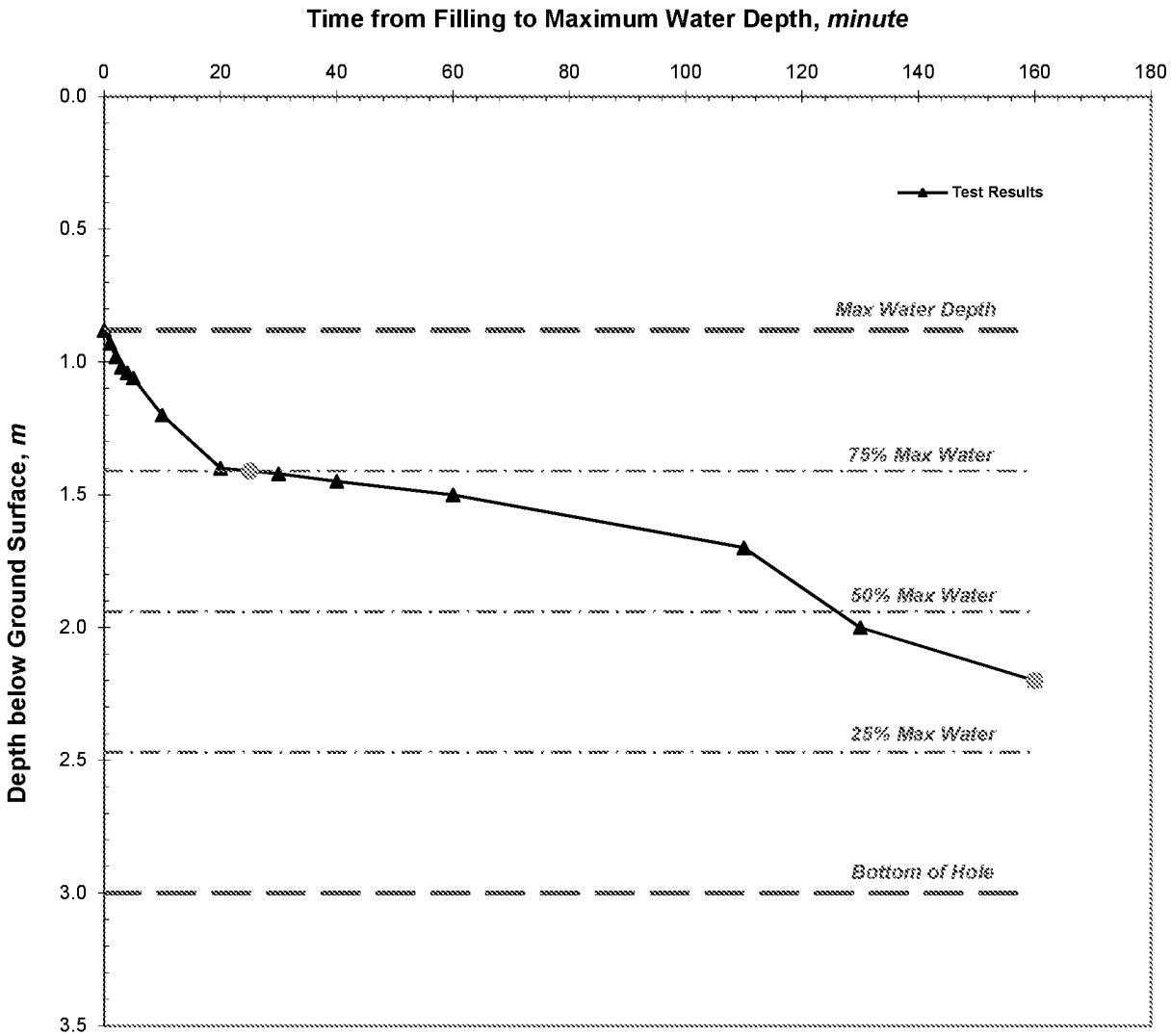
Testing within boreholes can either be a variable head test (falling or rising head) where the hydraulic pressure within the borehole during the test is either increased or lowered or a constant head where the hydraulic pressure is held constant. During boring when the required depth for testing has been reached, the borehole casing is withdrawn by one metre and the borehole cleaned out if necessary. Testing can alternatively be undertaken within a piezometer sealed into the strata of interest.

Detailed guidance for such tests are given within BS EN ISO 22282 Ref [47], and are summarised below.

- **Falling Head Test** - the borehole is filled with water and the head loss is then recorded either until the level falls to the standing water level (or until dry), or a maximum two-hour period.
- **Rising Head Test** - where a standing water level is established, the groundwater is pumped to reduce the head and then the rise in water level is recorded against time.
- **Constant Head Test** - the borehole is filled to a specified level and water is then pumped in, or discharged from a bowser, to maintain that level. The quantities of water used are recorded at regular intervals and a steady rate of flow is determined. In some cases where the borehole acceptance is very high, it may not be possible to achieve a steady state, and the quantity of water delivered to the borehole is averaged out over the test period.

Preliminary Falling-Head Soakage Test

Test Hole No: WLS01
Test No: Test No 1 (Initial)



Diameter of Borehole, m	0.100	Depth to Water at Start of Test, *m*	0.880
Depth to End of Borehole Casing, m		Max Water Dropdown during Test, *m*	1.320
Depth to Borehole Base, m	3.000	Total Soakage Test Time, *min*	160.0
Depth to Top of Permeable Soils, *m*		Mean Internal Discharge Area, m^2	0.383
Depth to Groundwater Surface, *m*		Discharge Rate, *litre/min*	0.046
Depth to Top of Granular Fill, *m*		Soakage Rate, $litre/m^2/min$	**0.120**
Voids Assumed within Borehole, %	100%	BRE Soil Infiltration Rate, *m/sec*	**2.00E-06**

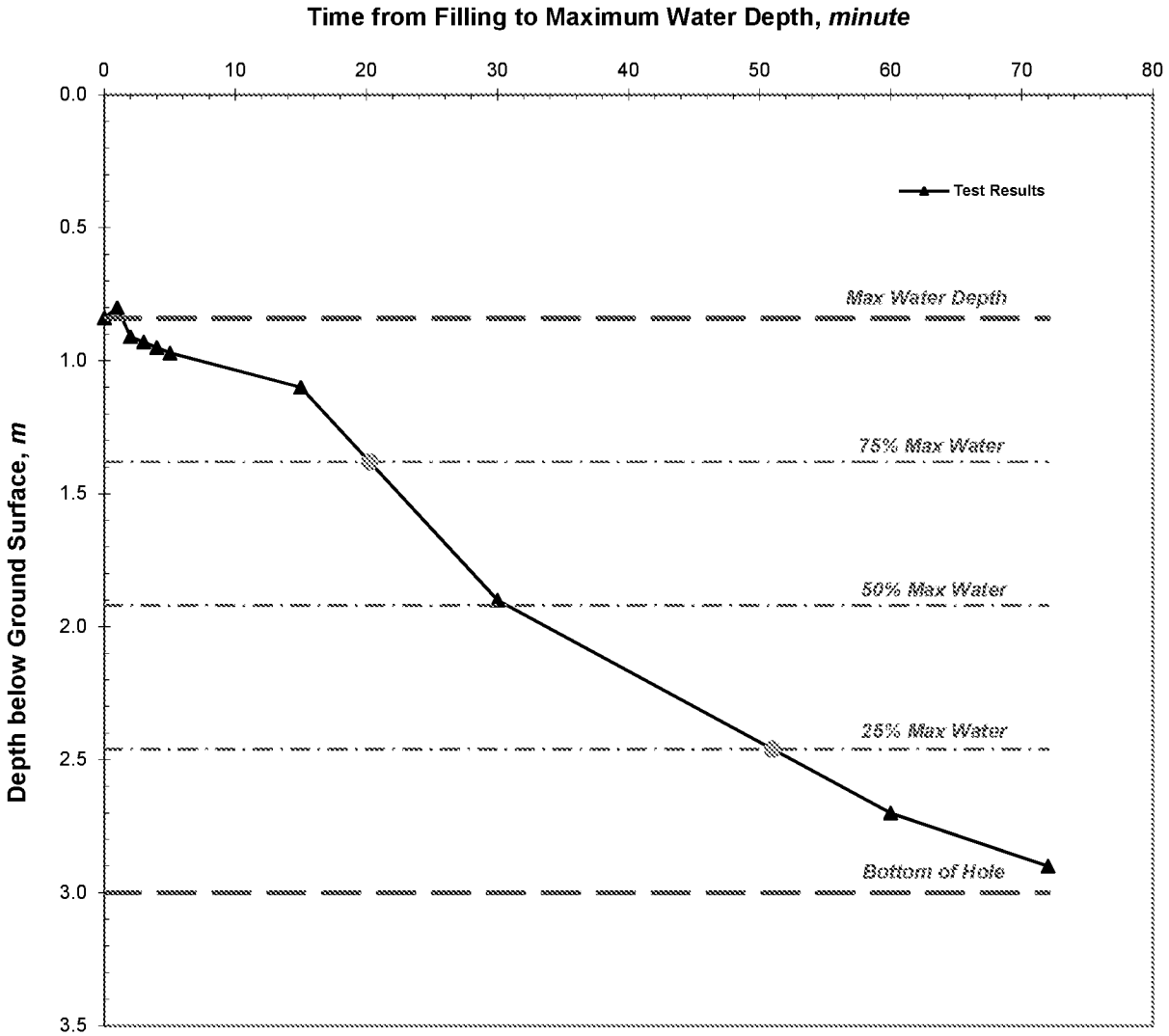
Comments:

Water level fell to 50% -- 25% max water depth, calculations were based on actual fall of water level achieved.
Result not compliant with BRE365 requirement since water did not fall to 25% max water depth.

Client: Worthing Homes	**Job No:** J14912	**Test Date:** 30/Jan/2019	
Site: Toddington Lane, Littlehampton	**Tested By:** AA	**Engineer:** JAC	**Fig. S1**

Preliminary Falling-Head Soakage Test

Test Hole No: WLS02
Test No: Test No 1 (Initial)



Diameter of Borehole, m	0.100	Depth to Water at Start of Test, *m*	0.840
Depth to End of Borehole Casing, m		Max Water Dropdown during Test, *m*	2.060
Depth to Borehole Base, m	3.000	Total Soakage Test Time, *min*	72.0
Depth to Top of Permeable Soils, *m*		Mean Internal Discharge Area, m^2	0.347
Depth to Groundwater Surface, *m*		Discharge Rate, *litre/min*	0.276
Depth to Top of Granular Fill, *m*		Soakage Rate, *litre/m^2/min*	**0.795**
Voids Assumed within Borehole, %	100%	BRE Soil Infiltration Rate, *m/sec*	**1.32E-05**

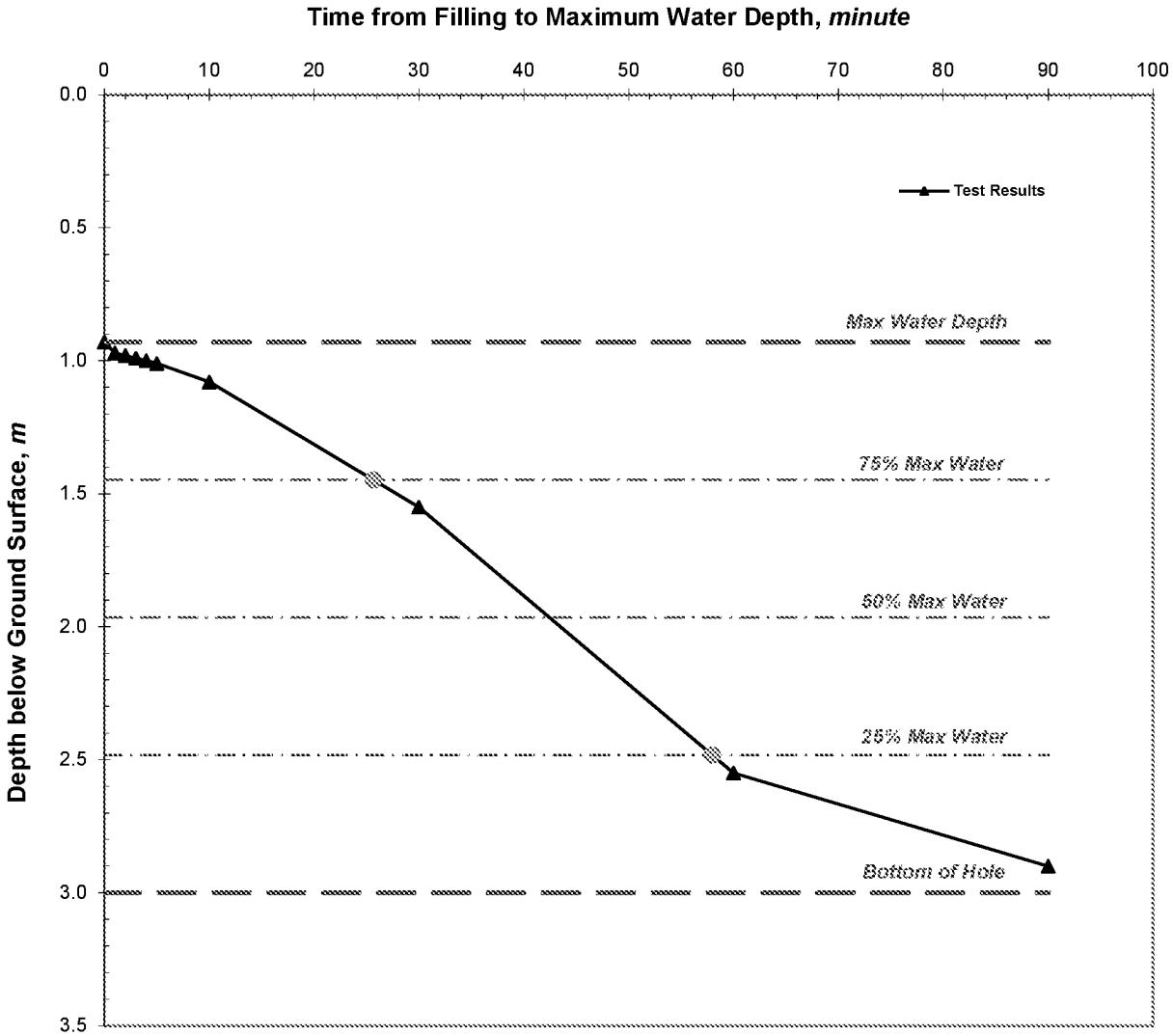
Comments:

Pit was nearly emptied at finish of test.

Client: Worthing Homes	**Job No:** J14912	**Test Date:** 15.9.21	
Site: Toddington Lane, Littlehampton	**Tested By:** AA	**Engineer:** JAC	**Fig. S2**

Preliminary Falling-Head Soakage Test

Test Hole No: WLS02
Test No: Test No 2 (Repeated)



Diameter of Borehole, m	0.100	Depth to Water at Start of Test, *m*	0.930
Depth to End of Borehole Casing, m		Max Water Dropdown during Test, *m*	1.970
Depth to Borehole Base, m	3.000	Total Soakage Test Time, *min*	90.0
Depth to Top of Permeable Soils, *m*		Mean Internal Discharge Area, m^2	0.333
Depth to Groundwater Surface, *m*		Discharge Rate, *litre/min*	0.251
Depth to Top of Granular Fill, *m*		Soakage Rate, *litre/m^2/min*	**0.755**
Voids Assumed within Borehole, %	100%	BRE Soil Infiltration Rate, *m/sec*	**1.26E-05**

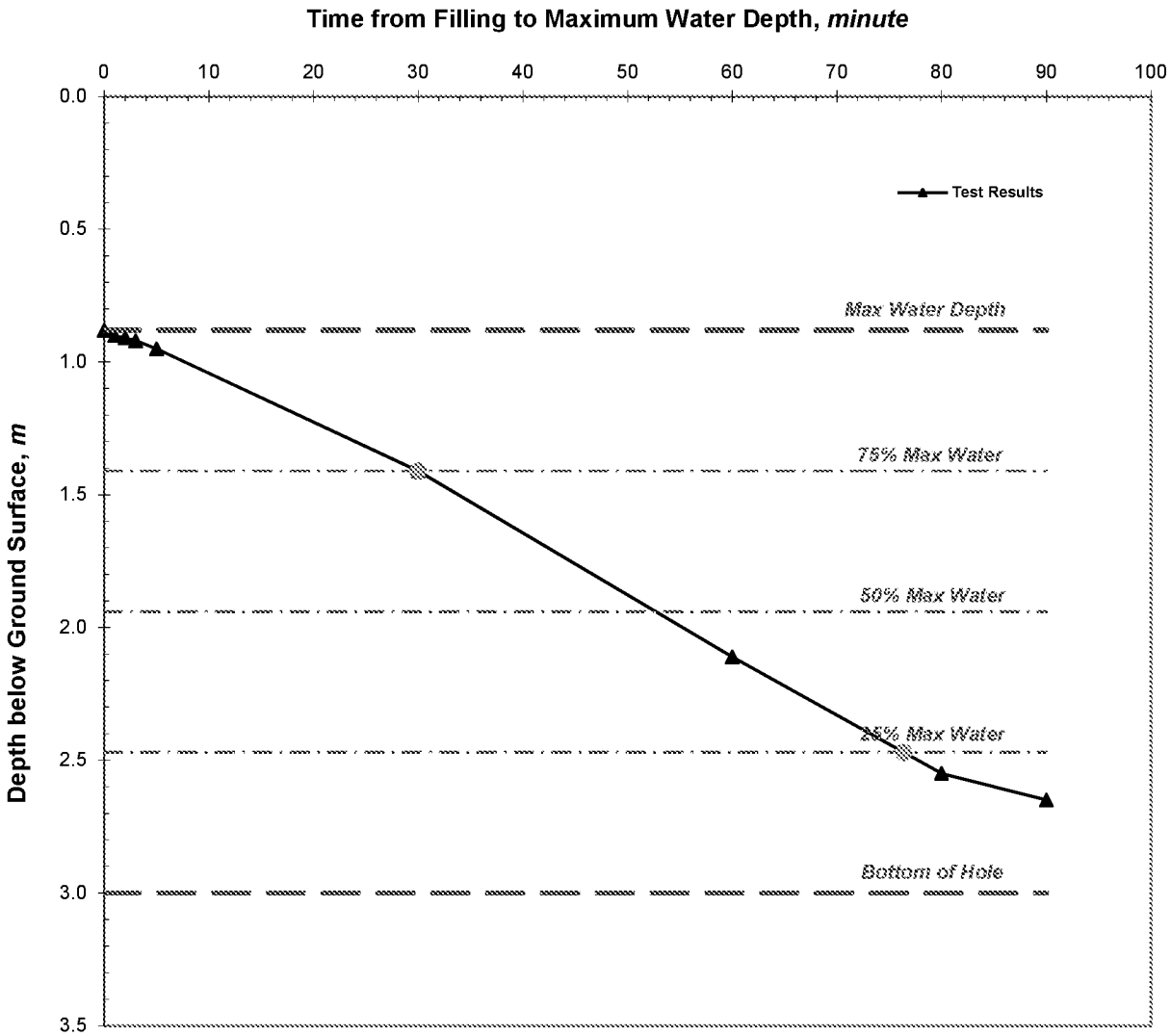
Comments:

Pit was nearly emptied at finish of test.

Client: Worthing Homes	**Job No:** J14912	**Test Date:** 15.9.21	
Site: Toddington Lane, Littlehampton	**Tested By:** AA	**Engineer:** JAC	**Fig. S3**

Preliminary Falling-Head Soakage Test

Test Hole No: WLS02
Test No: Test No 3 (Repeated)



Diameter of Borehole, m	0.100	Depth to Water at Start of Test, *m*	0.880
Depth to End of Borehole Casing, m		Max Water Dropdown during Test, *m*	1.770
Depth to Borehole Base, m	3.000	Total Soakage Test Time, *min*	90.0
Depth to Top of Permeable Soils, *m*		Mean Internal Discharge Area, m^2	0.341
Depth to Groundwater Surface, *m*		Discharge Rate, *litre/min*	0.180
Depth to Top of Granular Fill, *m*		Soakage Rate, $litre/m^2/min$	**0.527**
Voids Assumed within Borehole, %	100%	BRE Soil Infiltration Rate, *m/sec*	**8.78E-06**

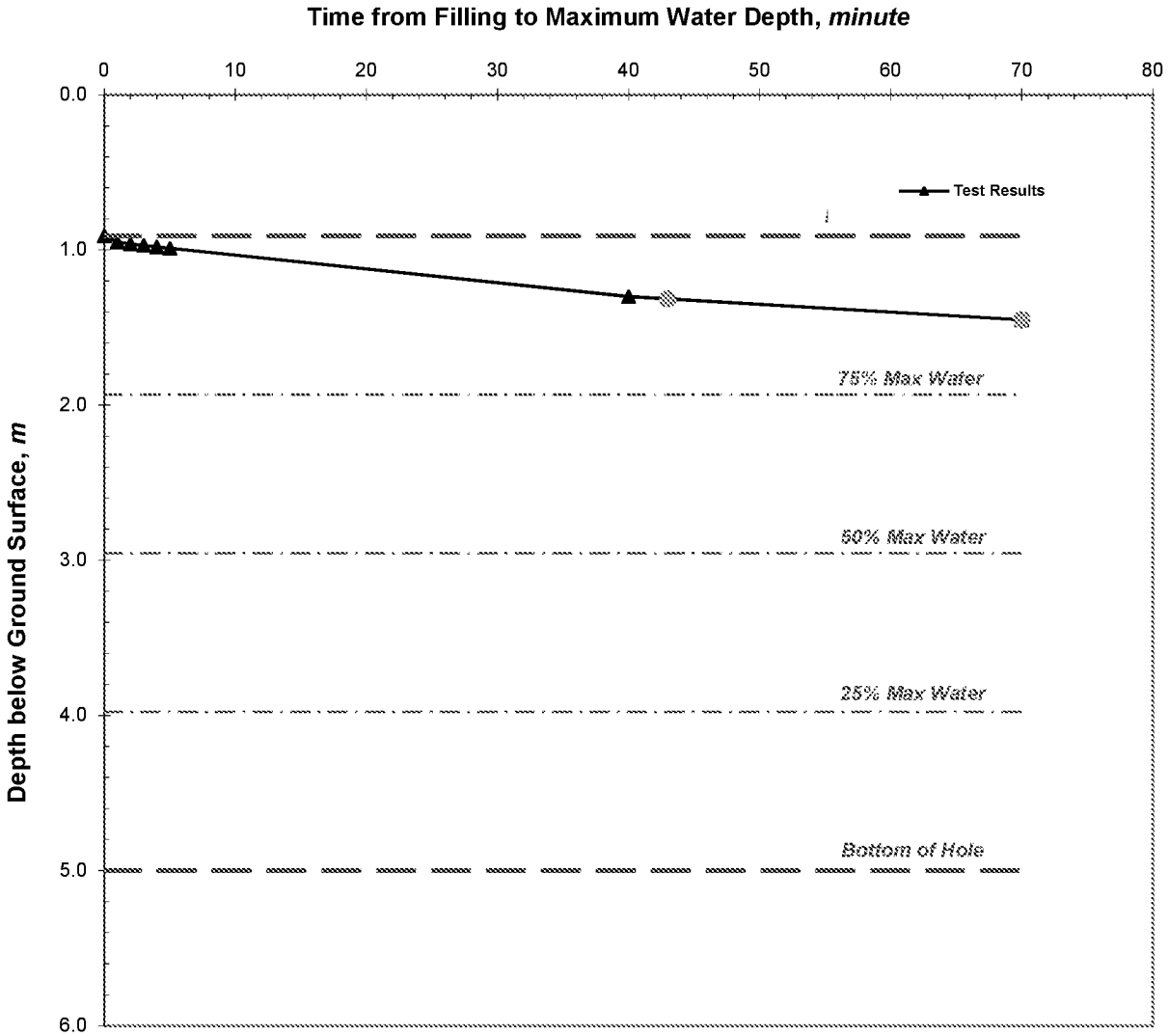
Comments:

Pit was nearly emptied at finish of test.

Client: Worthing Homes	**Job No:** J14912	**Test Date:** 15.9.21	
Site: Toddington Lane, Littlehampton	**Tested By:** AA	**Engineer:** JAC	**Fig. S4**

Preliminary Falling-Head Soakage Test

Test Hole No: WLS03
Test No: Test No 1 (Initial)



Diameter of Borehole, m	0.100	Depth to Water at Start of Test, *m*	0.910
Depth to End of Borehole Casing, m		Max Water Dropdown during Test, *m*	0.540
Depth to Borehole Base, m	5.000	Total Soakage Test Time, *min*	70.0
Depth to Top of Permeable Soils, *m*		Mean Internal Discharge Area, m^2	1.144
Depth to Groundwater Surface, *m*		Discharge Rate, *litre/min*	0.039
Depth to Top of Granular Fill, *m*		Soakage Rate, $litre/m^2/min$	**0.034**
Voids Assumed within Borehole, %	100%	BRE Soil Infiltration Rate, *m/sec*	**5.72E-07**

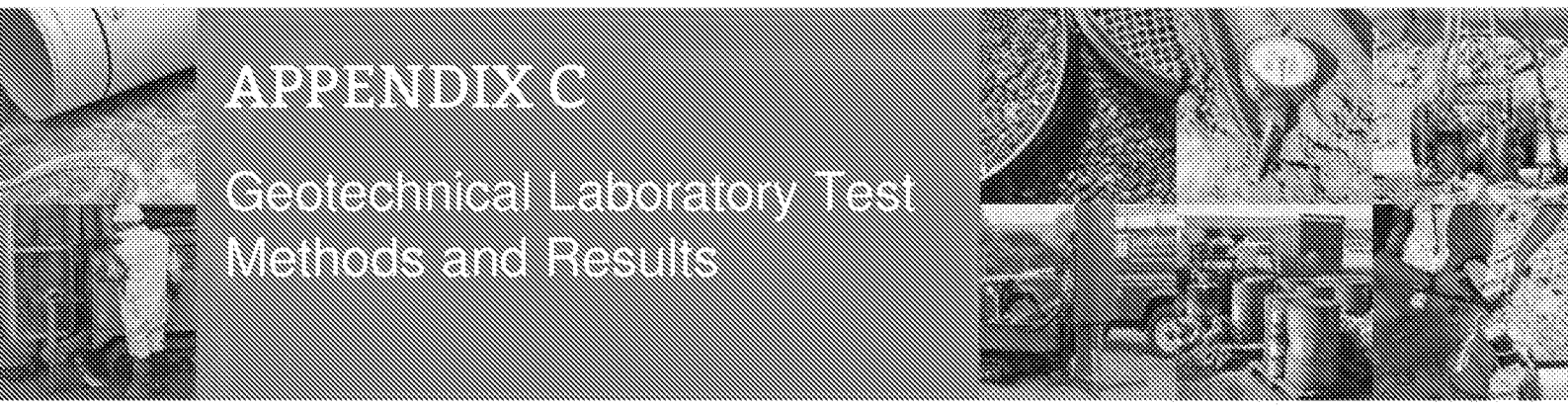
Comments:

Water level did not fall to 75% max water depth, calculations were based on actual fall of water level achieved.
Result not compliant with BRE365 requirement since water did not fall to 25% max water depth.

Client: Worthing Homes	**Job No:** J14912	**Test Date:** 15.9.21	
Site: Toddington Lane, Littlehampton	**Tested By:** AA	**Engineer:** JAC	**Fig. S5**

Southern Testing
Environmental & Geotechnical

ST Consult
Environmental & Geotechnical



APPENDIX C

Geotechnical Laboratory Test Methods and Results

C

Southern Testing | ST Consult

Atterberg and Moisture Content Summary

BS1377-2 cl.3.2, 3.3, 4.2, 4.3 & BS EN ISO 17892-1

AGS

Project Name	*Toddington Lane, Littlehampton*					Project Number		*J14912*	
Client	*Worthing Homes*			PE	*JAC*	Date Issued		*05-Oct-21*	
Location	Depth m	Sample Type	Visual Description	Comments	Natural MC %	Liquid Limit %	Plastic Limit %	Plasticity Index	Classi-fication	Passing 425 micron %
WLS01	2.50	D	*Stiff yellow brown sandy slightly gravelly CLAY. Gravel consists of fine and medium subangular sandstone and flint.*		*15*	*30*	*14*	*16*	*CL*	*90*
WLS02	1.60	D	*Stiff yellow brown sandy slightly gravelly CLAY. Gravel consists of fine subangular flint.*		*15*	*36*	*14*	*22*	*CI*	*95*
WLS03	1.50	D	*Firm orange brown speckled dark grey very sandy CLAY.*		*16*	*30*	*11*	*19*	*CL*	*100*
WLS03	2.00	D	*Very stiff light orange brown speckled orange and dark grey slightly sandy CLAY.*		*18*	*35*	*14*	*21*	*CL/CI*	*100*
WLS04	1.00	D	*Very stiff dark brown speckled black very sandy slightly gravelly CLAY. Gravel consists of fine subangular flint.*		*17*	*38*	*21*	*17*	*CI*	*98*
WLS05	1.00	D	*Very stiff yellow low speckled brown sandy CLAY.*		*17*	*34*	*18*	*16*	*CL*	*100*

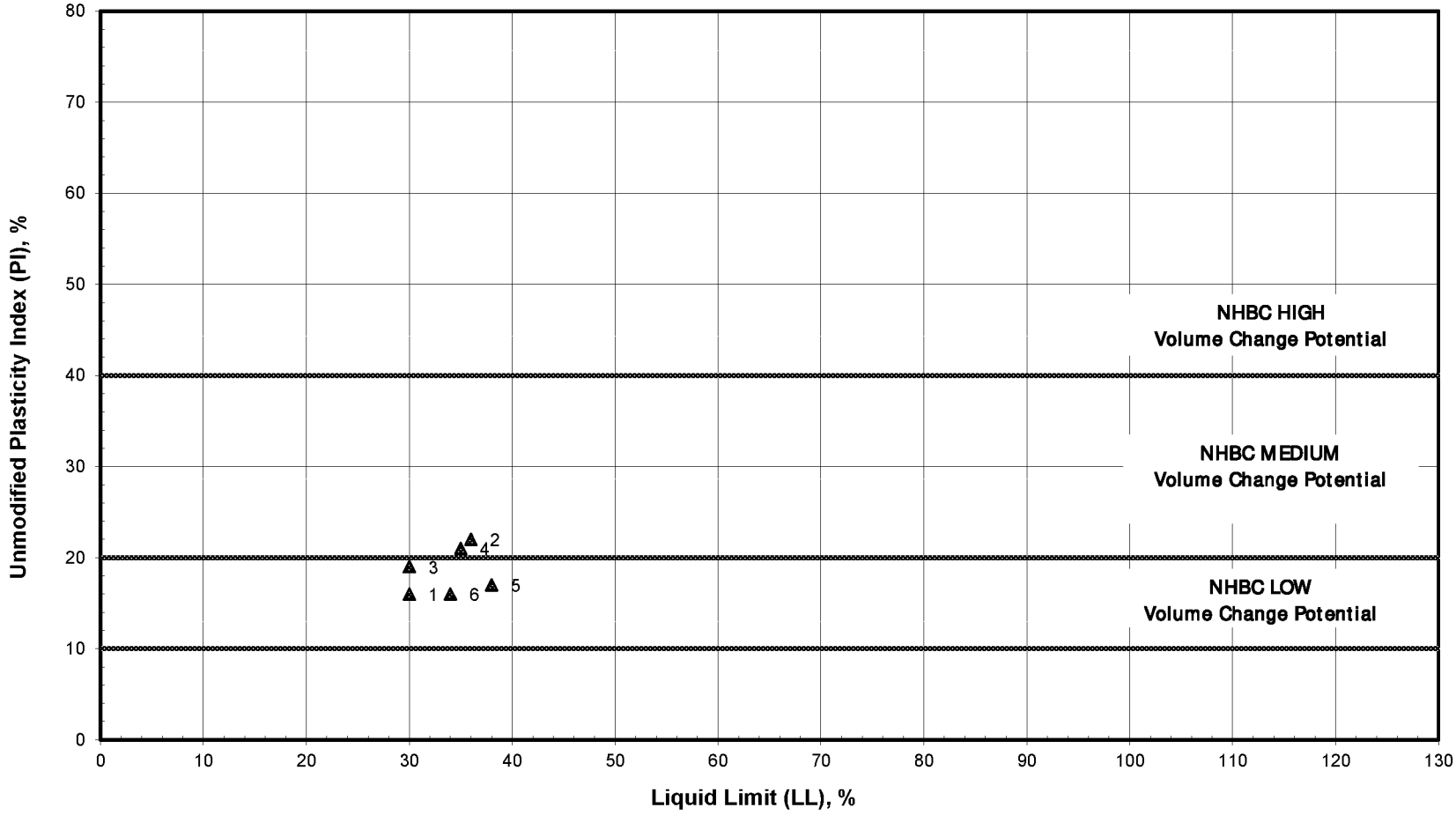
Jun 13

NHBC Classification for Volume Change Potential

Project Name	*Toddington Lane, Littlehampton*			**Project Number**	*J14912*
Client Name	*Worthing Homes*	**PE**	*JAC*	**Date Issued**	*05-Oct-21*

Key

No.	TH No.	Depth
1	WLS01	2.50
2	WLS02	1.60
3	WLS03	1.50
4	WLS03	2.00
5	WLS04	1.00
6	WLS05	1.00



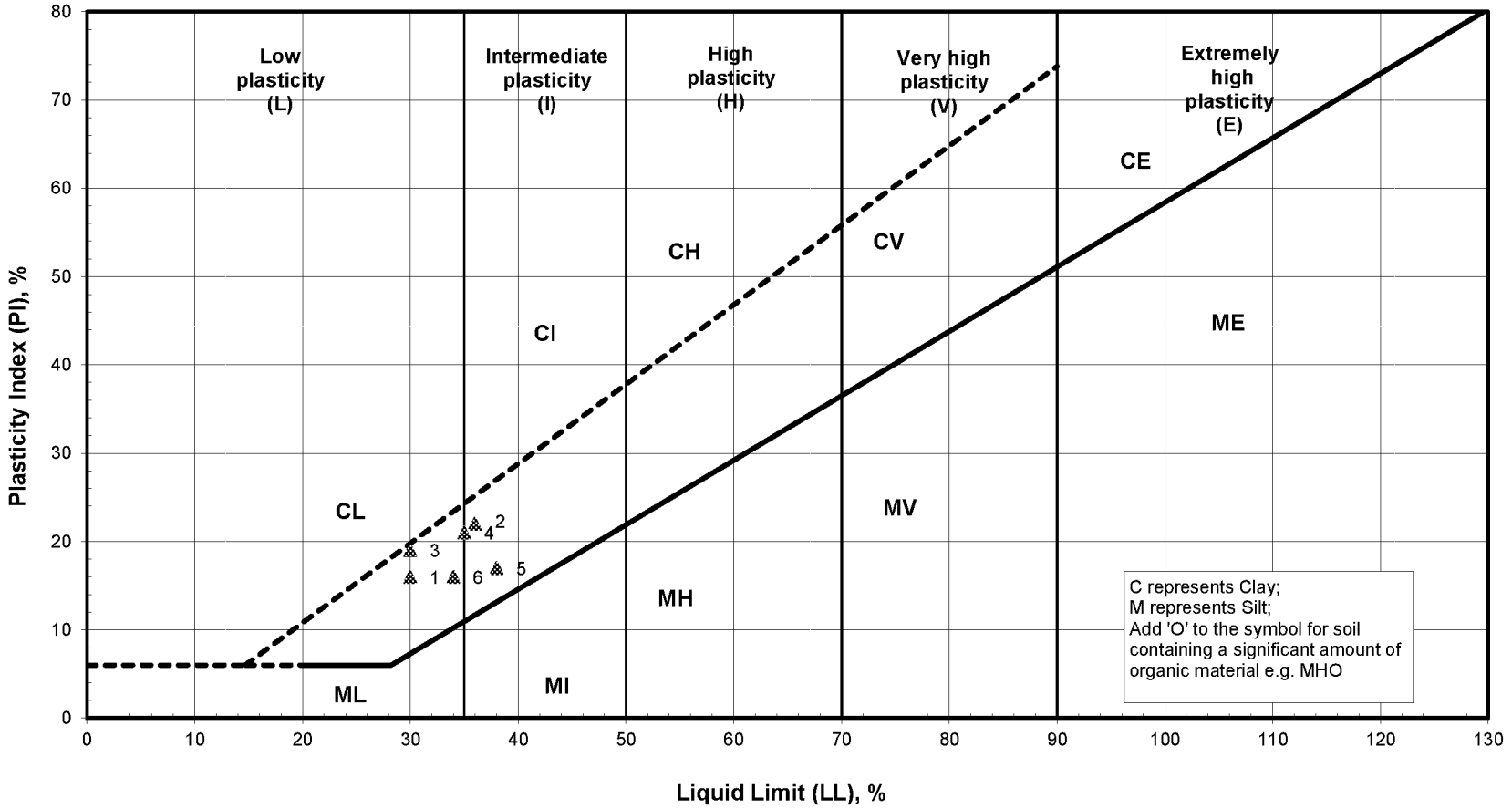
Liquid Limit		**Plastic Limit**		**Unmodified Plasticity Index**	
Maximum Value	38	Maximum Value	21	Maximum Value	22
Minimum Value	30	Minimum Value	11	Minimum Value	16
Average Value	34	Average Value	15	Average Value	19

Plasticity Chart for Atterberg Limit Tests

Project Name	*Toddington Lane, Littlehampton*			**Project Number**	*J14912*
Client Name	*Worthing Homes*	**PE**	*JAC*	**Date Issued**	*05-Oct-21*

Key

No.	TH No.	Depth
1	WLS01	2.50
2	WLS02	1.60
3	WLS03	1.50
4	WLS03	2.00
5	WLS04	1.00
6	WLS05	1.00



Liquid Limit		**Plastic Limit**		**Plasticity Index**	
Maximum Value	38	Maximum Value	21	Maximum Value	22
Minimum Value	30	Minimum Value	11	Minimum Value	16
Average Value	34	Average Value	15	Average Value	19

Southern Testing | ST Consult

Classification Summary

BS1377-2 cl. 3.2, 3.3, 8.3 & BS1377-9 cl. 2.4 & BS EN ISO 17892-1, 2 & 3

AGS

Project Name	*Toddington Lane, Littlehampton*			Project Number	*J14912*
Client	*Worthing Homes*	PE	*JAC*	Date Issued	*05-Oct-21*

Location	Depth m	Sample Type	Visual Description	Comments	Natural MC %	Particle Density Mg/m³	Bulk Density Mg/m³	Dry Density Mg/m³	Saturation MC %
WLS02	3.00	D	*Off white patched brown clayey/silty fine to coarse subangular chalk GRAVEL.*		*19*		*2.16*	*1.82*	*18*
WLS04	4.00	D	*Stiff yellow brown sandy slightly gravelly CLAY. Gravel consists of fine and medium chalk. Occasional flint.*		*21*		*2.11*	*1.74*	*20*

Notes: Saturation Moisture Content of chalk test is carried out on intact fragments selected from the supplied sample. Particle density of chalk is assumed to be 2.7Mg/m³ unless otherwise stated above.

Southern Testing Laboratories Limited, East Grinstead is registered under BS EN ISO 9001 BSI ref: FS29280

Oct 14

Southern Testing | ST Consult

PARTICLE SIZE DISTRIBUTION REPORT

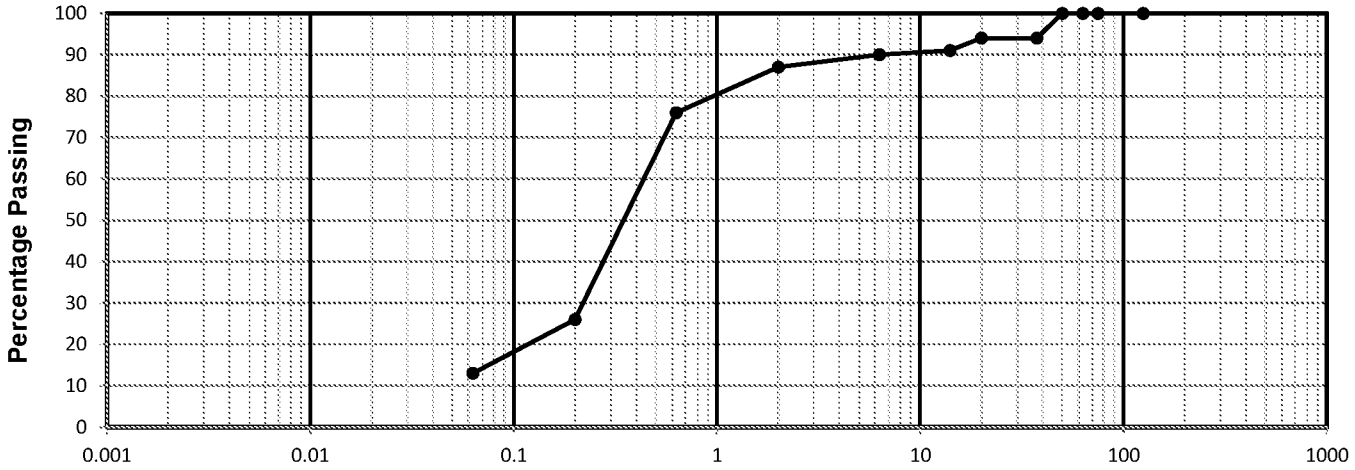
To BS1377-2 cl. 9.2-9.5

AGS

Project Name	*Toddington Lane, Littlehampton*			**Project Number**	***J14912***
Client Name	*Worthing Homes*	**PE**	*JAC*	**Date Issued**	*05-Oct-21*

Particle Size	% Passing
125mm	100
75mm	100
63mm	100
50mm	100
37.5mm	94
20mm	94
14mm	91
6.3mm	90
2mm	87
630µm	76
200µm	26
63µm	13

Particle Size Distribution Chart



CLAY	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse	COBBLES
	SILT			SAND			GRAVEL			
	13			74			13			0

Visual Description of Sample:

Orange brown clayey/silty gravelly fine to coarse SAND. Gravel consists of fine to coarse subrounded to subangular flint.

Particle Density (Assumed) Mg/m³	**N/A**
Coefficient of Uniformity	

Test Methods:

Wet & Dry Grading BS1377-2
cl.9.2 & 9.3 & BS EN ISO 17892-4

Location	WLS01
Depth (m)	1.75
Sample Type	B

Comments:

Tested By	STL Lab
Checked By	Timon

Contam Results
Southern Testing Laboratories Ltd
Keeble House
Stuart Way
East Grinstead
West Sussex
RH19 4QA

[redacted]

i2 Analytical Ltd.
7 Woodshots Meadow,
Croxley Green
Business Park,
Watford,
Herts,
WD18 8YS

[redacted]

Analytical Report Number : 21-11334

Project / Site name:	Toddington Lane, Littlehampton	Samples received on:	22/09/2021
Your job number:	J14912	Samples instructed on/ Analysis started on:	22/09/2021
Your order number:	J14912_2	Analysis completed by:	28/09/2021
Report Issue Number:	1	Report issued on:	29/09/2021
Samples Analysed:	6 soil samples		

Signed: [redacted]

Agnieszka Czerwińska
Technical Reviewer (Reporting Team)
For & on behalf of i2 Analytical Ltd.

Standard Geotechnical, Asbestos and Chemical Testing Laboratory located at: ul. Pionierów 39, 41 -711 Ruda Śląska, Poland.

Accredited tests are defined within the report, opinions and interpretations expressed herein are outside the scope of accreditation.

Standard sample disposal times, unless otherwise agreed with the laboratory, are :

soils - 4 weeks from reporting
leachates - 2 weeks from reporting
waters - 2 weeks from reporting
asbestos - 6 months from reporting

Excel copies of reports are only valid when accompanied by this PDF certificate.

Any assessments of compliance with specifications are based on actual analytical results with no contribution from uncertainty of measurement.
Application of uncertainty of measurement would provide a range within which the true result lies.
An estimate of measurement uncertainty can be provided on request.

Analytical Report Number: 21-11334
Project / Site name: Toddington Lane, Littlehampton
Your Order No: J14912_2

Lab Sample Number				2018543	2018544	2018545	2018546	2018547
Sample Reference				WLS01	WLS01	WLS03	WLS04	WLS04
Sample Number				None Supplied	None Supplied	None Supplied	None Supplied	None Supplied
Depth (m)				0.50	1.00	1.00	0.75	2.00
Date Sampled				15/09/2021	15/09/2021	15/09/2021	15/09/2021	15/09/2021
Time Taken				1200	1200	1200	1200	1200
Analytical Parameter (Soil Analysis)	Units	Limit of detection	Accreditation Status					
Stone Content	%	0.1	NONE	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Moisture Content	%	0.01	NONE	13	14	12	11	9.1
Total mass of sample received	kg	0.001	NONE	1.6	1.5	1.5	1.5	1.5
General Inorganics								
pH - Automated	pH Units	N/A	MCERTS	6.4	6.9	8.0	5.4	8.0
Water Soluble SO4 16hr extraction (2:1 Leachate Equivalent)	g/l	0.00125	MCERTS	0.065	0.066	0.018	0.035	0.038
Water Soluble SO4 16hr extraction (2:1 Leachate Equivalent)	mg/l	1.25	MCERTS	65.3	65.5	17.9	34.9	38.2
Water Soluble Chloride (2:1) (leachate equivalent)	mg/l	0.5	MCERTS	1.6	1.8	1.1	9.7	2.0
Water Soluble Nitrate (2:1) as N (leachate equivalent)	mg/l	2	NONE	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Heavy Metals / Metalloids								
Magnesium (water soluble)	mg/kg	5	NONE	< 5.0	< 5.0	13	< 5.0	7.7
Magnesium (leachate equivalent)	mg/l	2.5	NONE	< 2.5	< 2.5	6.2	< 2.5	3.9

U/S = Unsuitable Sample I/S = Insufficient Sample

Analytical Report Number: 21-11334
Project / Site name: Toddington Lane, Littlehampton
Your Order No: J14912_2

Lab Sample Number				2018548
Sample Reference				WLS05
Sample Number				None Supplied
Depth (m)				2.00
Date Sampled				15/09/2021
Time Taken				1200
Analytical Parameter (Soil Analysis)	Units	Limit of detection	Accreditation Status	
Stone Content	%	0.1	NONE	< 0.1
Moisture Content	%	0.01	NONE	9.7
Total mass of sample received	kg	0.001	NONE	1.4
General Inorganics				
pH - Automated	pH Units	N/A	MCERTS	7.2
Water Soluble SO4 16hr extraction (2:1 Leachate Equivalent)	g/l	0.00125	MCERTS	0.062
Water Soluble SO4 16hr extraction (2:1 Leachate Equivalent)	mg/l	1.25	MCERTS	61.7
Water Soluble Chloride (2:1) (leachate equivalent)	mg/l	0.5	MCERTS	1.8
Water Soluble Nitrate (2:1) as N (leachate equivalent)	mg/l	2	NONE	< 2.0
Heavy Metals / Metalloids				
Magnesium (water soluble)	mg/kg	5	NONE	9.7
Magnesium (leachate equivalent)	mg/l	2.5	NONE	4.8

U/S = Unsuitable Sample I/S = Insufficient Sample

Analytical Report Number : 21-11334
Project / Site name: Toddington Lane, Littlehampton

* These descriptions are only intended to act as a cross check if sample identities are questioned. The major constituent of the sample is intended to act with respect to MCERTS validation. The laboratory is accredited for sand, clay and loam (MCERTS) soil types. Data for unaccredited types of solid should be interpreted with care.

Stone content of a sample is calculated as the % weight of the stones not passing a 10 mm sieve. Results are not corrected for stone content.

Lab Sample Number	Sample Reference	Sample Number	Depth (m)	Sample Description *
2018543	WLS01	None Supplied	0.5	Brown clay and loam.
2018544	WLS01	None Supplied	1	Brown clay and loam.
2018545	WLS03	None Supplied	1	Brown clay and loam.
2018546	WLS04	None Supplied	0.75	Brown clay and loam.
2018547	WLS04	None Supplied	2	Brown clay and loam.
2018548	WLS05	None Supplied	2	Brown sandy clay.

Analytical Report Number : 21-11334
Project / Site name: Toddington Lane, Littlehampton

Water matrix abbreviations: Surface Water (SW) Potable Water (PW) Ground Water (GW)

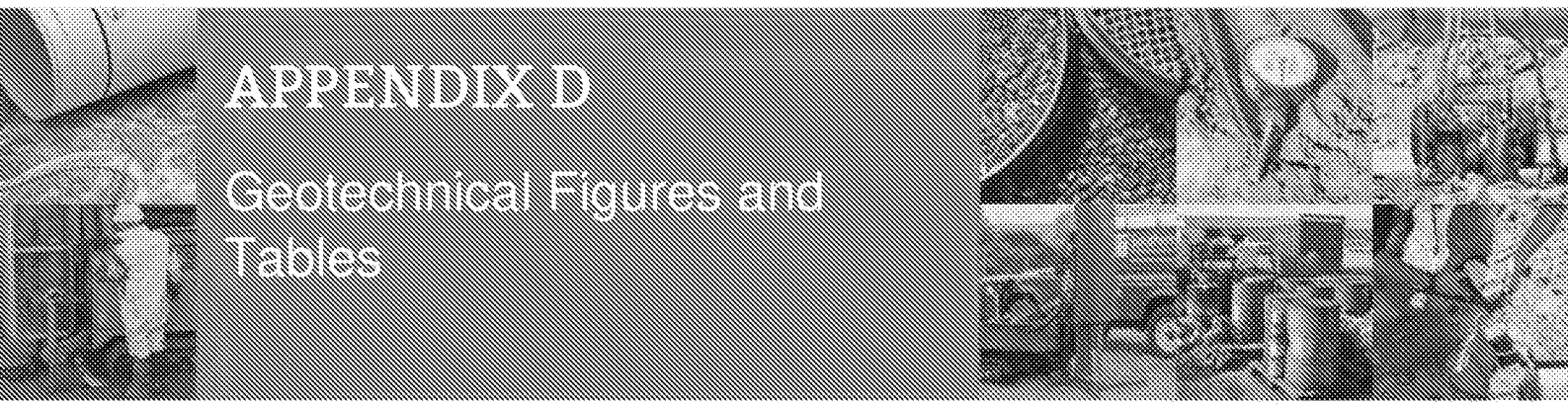
Analytical Test Name	Analytical Method Description	Analytical Method Reference	Method number	Wet / Dry Analysis	Accreditation Status
Magnesium, water soluble, in soil	Determination of water soluble magnesium by extraction with water followed by ICP-OES.	In-house method based on TRL 447	L038-PL	D	NONE
Moisture Content	Moisture content, determined gravimetrically. (30 oC)	In house method.	L019-UK/PL	W	NONE
pH in soil (automated)	Determination of pH in soil by addition of water followed by automated electrometric measurement.	In house method.	L099-PL	D	MCERTS
Stones content of soil	Standard preparation for all samples unless otherwise detailed. Gravimetric determination of stone > 10 mm as % dry weight.	In-house method based on British Standard Methods and MCERTS requirements.	L019-UK/PL	D	NONE
Sulphate, water soluble, in soil (16hr extraction)	Determination of water soluble sulphate by ICP-OES. Results reported directly (leachate equivalent) and corrected for extraction ratio (soil equivalent).	In house method.	L038-PL	D	MCERTS
Water Soluble Nitrate (2:1) as N in soil	Determination of nitrate by reaction with sodium salicylate and colorimetry.	In-house method based on Examination of Water and Wastewatern & Polish Standard Method PN-82/C-04579.08, 2:1 extraction.	L078-PL	W	NONE
Chloride, water soluble, in soil	Determination of Chloride colorimetrically by discrete analyser.	In house method.	L082-PL	D	MCERTS
Sulphate, water soluble, in soil	Determination of water soluble sulphate by ICP-OES. Results reported directly (leachate equivalent) and corrected for extraction ratio (soil equivalent).	In house method.	L038-PL	D	MCERTS

For method numbers ending in 'UK' analysis have been carried out in our laboratory in the United Kingdom.
For method numbers ending in 'PL' analysis have been carried out in our laboratory in Poland.
Soil analytical results are expressed on a dry weight basis. Where analysis is carried out on as-received the results obtained are multiplied by a moisture correction factor that is determined gravimetrically using the moisture content which is carried out at a maximum of 30oC.

Unless otherwise indicated, site information, order number, project number, sampling date, time, sample reference and depth are provided by the client. The instructed on date indicates the date on which this information was provided to the laboratory.

Southern Testing
Environmental & Geotechnical

ST Consult
Environmental & Geotechnical



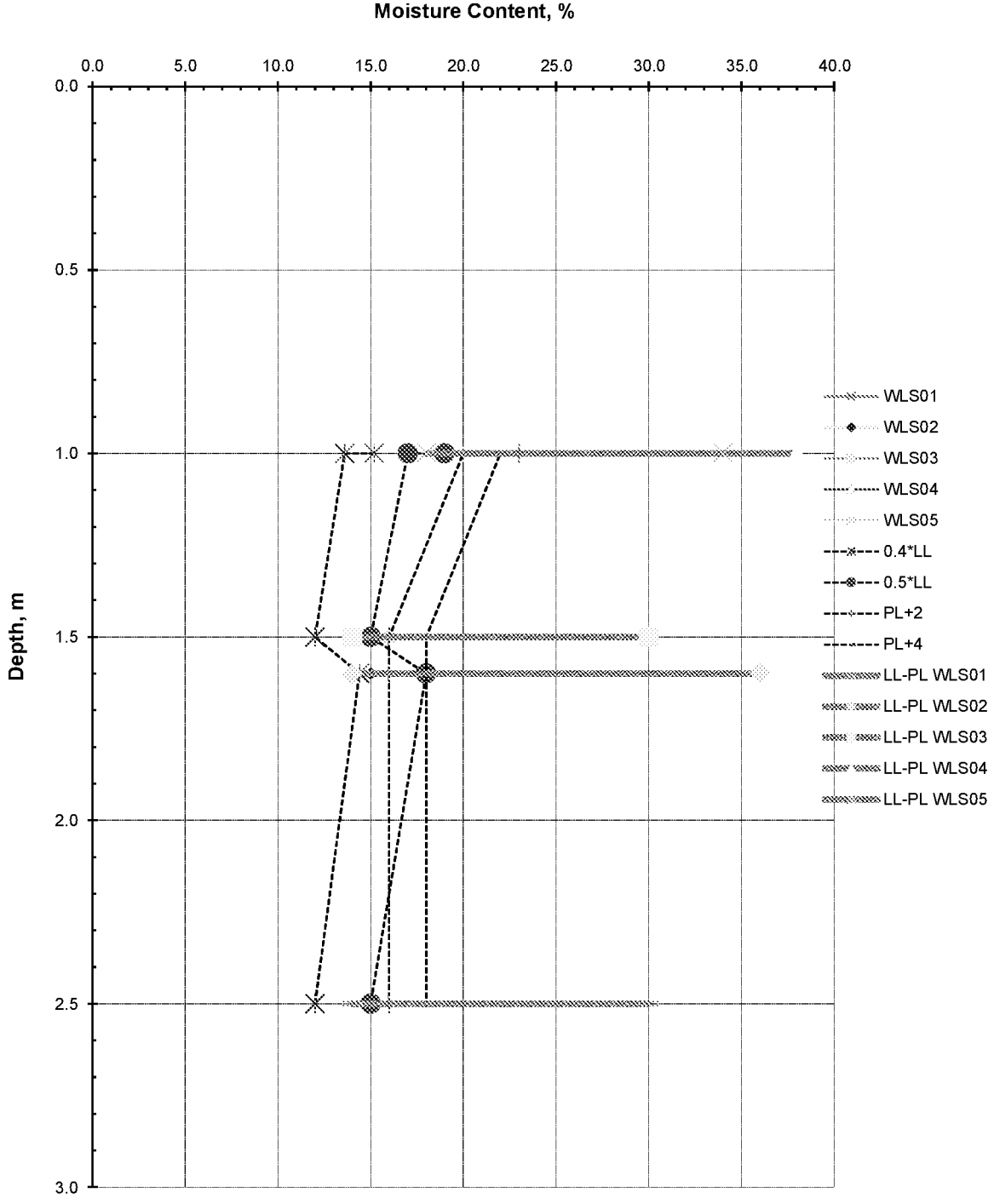
APPENDIX D

Geotechnical Figures and Tables

D

Moisture Content and Atterberg Limit Tests *vs* Depth

In Accordance with BS 1377 : Part 2 : 1990 : Clause 3

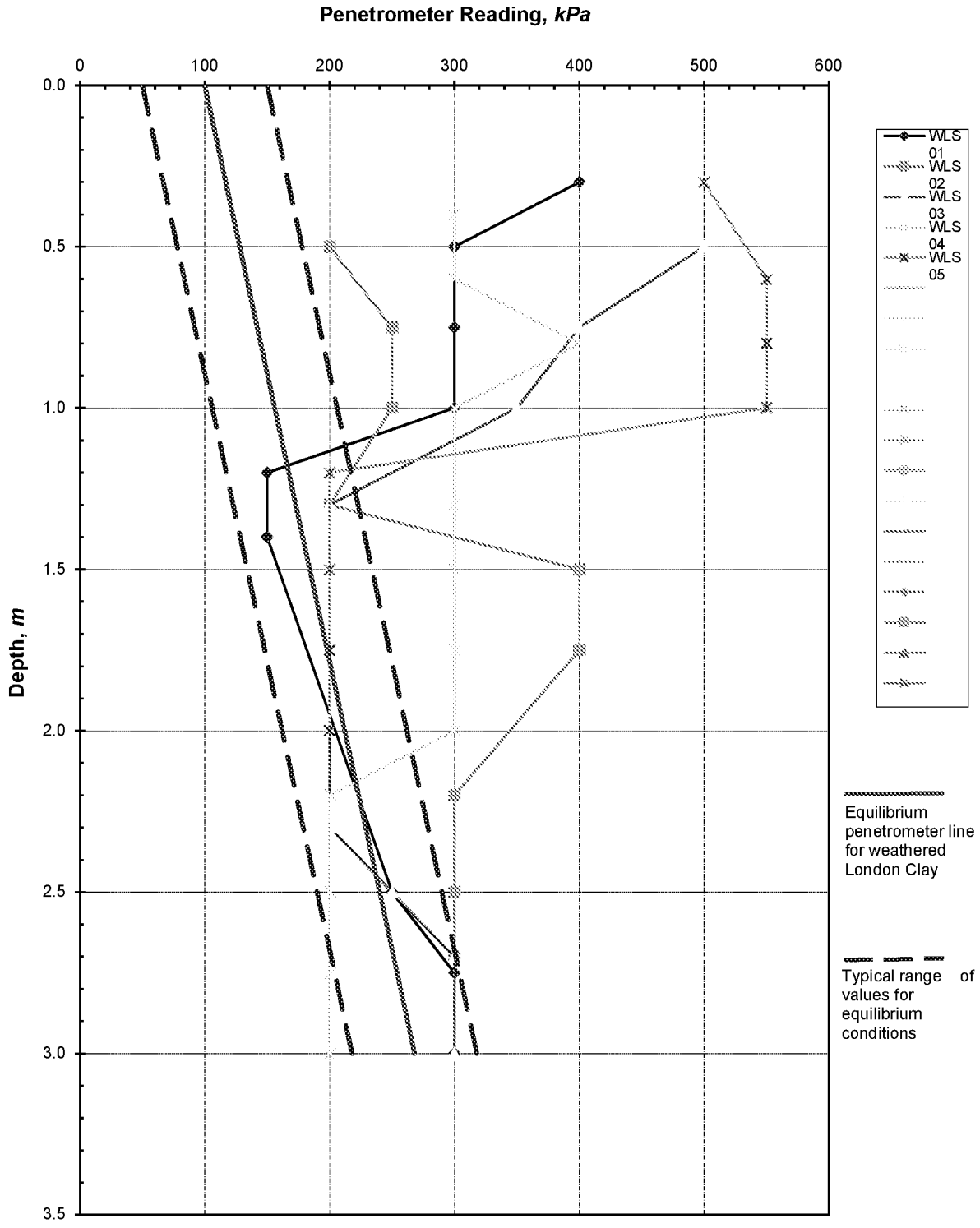


Note:

Client: Toddington Lane	**Site:** Worthing Homes	
Job No: J14912	**Date:** 02/11/2021	**Figure:** 3

Pocket Penetrometer Reading *vs* Depth

Test Hole Nos:



* *Reference made to "A rapid and reliable on-site method of assessing desiccation in clay soils", by R S Pugh, P G Parnell, and R D Parkes, Proc. Instn Civ. Engrs. Geotech. Engng. 1995, 113 pp. 25-30*

Client:	**Worthing Homes**	**Job No:**	J14912		
Site:	**Toddington Lane**	**Date:**	02/11/2021	**Fig.**	**4**

Southern Testing
Environmental & Geotechnical

ST Consult
Environmental & Geotechnical

APPENDIX E

Preliminary UXO Risk Assessment

E

PRELIMINARY UNEXPLODED ORDNANCE RISK ASSESSMENT

P&O Scaffolding Services Ltd, Scaffold House, Toddington Lane, Littlehampton, BN17 7PN

Prepared for: Southern Testing Ltd

Project Number: 7369

Version: 1.0

Dated: 03/09/2021

MACC International Limited
Camilla Court
Nacton Ipswich
IP10 0EU

Telephone Number: [redacted]
Email:

Registered in England Company Registration Number 3014471

CONTENTS

REFERENCES

Publications

Sources of information used in the compilation of this assessment included:

German Air Raids on Britain 1914-18. Morris 1925

Unexploded Ordnance (UXO) – A guide for the Construction Industry. CIRIA C681

Dangerous Energy. Cocroft 2000

The Blitz Then and Now Volumes 1 to 3. Ramsey 1987

Advanced German Weapons WW2. Ford 2000

Dealing with Munitions in Marine Aggregates. UMA 2008

United Nations International Mine Action Standards (IMAS). UN 2010

Military Engineering Volume XII. War Office 1956

German Bomb Fuzes. USN 1945

Fields of Deception & Anti Aircraft Command. Dobinson 1988

Target Reconnaissance Photography. Luftwaffe 1939-44

Internet Information

Additional information was provided through the following credible internet sites, their assistance is credited where appropriate:

Army EOD Incidents

RAF EOD Incidents & Air Situation Reports 1939-45

Luftwaffe Strategy & Tactics

Luftwaffe Bomber Specifications

WO Defence Arrangements 1939-45

News Reports Witness Accounts 1939-45

Latest News Reports

Project Information

Site and project information was provided by Southern Testing Ltd.

TERMS AND DEFINITIONS

Anti Aircraft Ammunition (AAA)
High Explosive shells ranging from 30mm to 155mm used by air defence batteries to attack or deter enemy air attack.

Air Dropped Munition
A bomb or container dropped from an aircraft which is designed to detonate at a pre determined altitude, on impact or using a delay mechanism; after impact.

Air Dropped Sub-Munitions (Bomblet)
Small sub-munitions dispensed from a larger carrier which may be fixed to the aircraft or dropped as a single container munition which was designed to open above the target spreading its contents over a large area. Some designs are extremely dangerous and fitted with anti-handling devices.

Area Clearance
This is the term used for the systematic clearance of explosive ordnance from land, including military property, firing and bombing ranges, airfields and training areas. When the land is a former wartime battle ground, the term used is Battle Area Clearance (BAC)

Blast Zone
This term refers to the area around an explosive detonation where the explosive overpressure (Blast) can cause damage, injury or death.

Explosive Ordnance (EO)
All manufactured or improvised items designed to contain explosive, propellant, pyrotechnic and fissionable material or biological or chemical agents or pre-cursers which when coupled with an initiation or dispersal system are designed to cause damage, injury or death.

Explosive Ordnance Disposal (EOD)
A series of recognised procedures and protocols which are used by specialists in the detection, identification, evaluation, risk assessment, render safe, recovery and disposal of any item of explosive ordnance or improvised explosive device.

Fragmentation Zone
This is the term which refers to the danger area in which a piece of an item of explosive ordnance will travel on detonation. This zone is normally greater than the blast zone.

Geophysical Survey
The use of magnetometers, ground penetrating radar or other geophysical data gathering systems, which is then used for evaluation, risk assessment and to quantify further mitigation requirements.

High Explosive (HE)
High explosives react/detonate at a rate of around 9,000 metres per second, to all intents and purposes, instantaneously.

Incendiary Bomb (IB)
Incendiary bombs ranged from 1kg in size to 500kg the larger sizes were designated as Oil Bombs. Fills range from Thermite mixtures, Phosphorus, Kerosene or other pyrotechnic mixtures.

Intrusive Search

This term refers to the process of introducing a specialist magnetometer by pushing or drilling the sensor in to the ground to a pre determined depth, thus allowing construction activities such as: piling, soil testing and deep intrusive ground works to be conducted safety.

Land Service Ammunition (LSA)

LSA is a term that refers to all items containing explosives, pyrotechnic or noxious compounds which are placed, thrown or projected during land battles.

Oil Bomb (OB)

Large airdropped bomb or modified ordnance container containing flammable material and accelerant, these weapons normally range in weight from 250 – 500kg.

Parachute Mine (PM)

Air-dropped mine designed to detonate at a pre set altitude above the ground. Essentially a large blast bomb with an explosive content of 1600 kg commonly fitted with anti-handling or anti-removal fuzes.

Unexploded Bomb (UXB)

Any air dropped bomb that has failed to function as designed.

Unexploded Ordnance (UXO)

Explosive ordnance that has been primed, fused, armed or otherwise prepared for use or used. It may have been fired, dropped, launched or projected yet remains unexploded either through malfunction or design or for any other cause.

War Office (WO)

This was the United Kingdom Government department responsible for defence of the realm, forerunner of the Ministry of Defence (MoD).

White Phosphorus (WP)

Munitions filled with WP are designed for signalling, screening and incendiary purposes. They achieve their effect by dispersing WP, which burns on contact with the air.

1 INTRODUCTION

1.1 Instruction & Scope

MACC International Ltd was commissioned by Southern Testing Ltd to conduct a Preliminary Unexploded Ordnance (UXO) Risk Assessment for P&O Scaffolding Services Ltd, Scaffold House, Toddington Lane, Littlehampton, BN17 7PN (See Annex 'A'). The scope of the assessment is to determine the likelihood of an uncontrolled encounter with UXO within the context of ground investigations.

1.2 Methodology & Purpose

The methodology used in the assessment complies with the United Nations (IMAS) standards, the CIRIA C681 "Unexploded Ordnance (UXO) – A guide for the Construction Industry" and the recognised best practice advocated by the Health and Safety Executive (HSE). The quality and environmental aspects of the assessment comply with UKAS Accredited ISO 9001:2015 and ISO 14001:2015 standards. The purpose of the assessment is that of evaluation and to provide an aid in decision making by our client.

2 DETERMINING THE LIKELIHOOD OF ENCOUNTER

2.1 Aim, Research Restrictions & Indemnity

This assessment has drawn upon archive records which are within the public domain; however, these are acknowledged to be incomplete. Consequently, some incidents may have occurred where the records no longer exist or could not be located. The Secretary of State of the United Kingdom and MACC International Ltd does not accept responsibility for the accuracy or completeness of the information contained within the records. Some records regarding the UXO situation on some sites may not yet be within the public domain. Consequently, such information was not available for evaluation by MACC International Ltd.

.

2.2 Relevant Publications & Credible Internet Information

Published sources of information used in the compilation of this assessment are listed within the reference section of this assessment including those provided by the client. Additional information was provided through credible internet sites, their assistance is credited where appropriate and details are listed within the reference section of this assessment.

3 FUTURE DEVELOPMENT

Future intentions for the site are understood to include a new residential development. It has been assumed that geo-environmental investigations will be undertaken prior to the commencement of subsequent development works.

4 HISTORICAL INFORMATION

4.1 British Archives

Prior to 1942 the United Kingdom did not operate a national recording system for EO/UXO incidents or military use of land. The records compiled during 1939-1942 were conducted under local arrangements and were only as detailed and accurate as the availability of time, personnel and the ease of access to information would allow. In April 1942 the Ministry of Home Security instigated a training programme for all personnel maintaining bomb census records, these standardised national records and greatly improved the accuracy of the information.

4.2 Manned Air Raids & Unmanned Rocket Attack Reports

WWI: No records were found to confirm a bomb strike within the site footprint or immediate surrounding area during this period. Consequently, this source of UXO contamination is considered to be highly unlikely.

WWII: Records indicate that Littlehampton suffered multiple enemy bombing raids during WWII with the coastal area to the south of the site suffering most heavily. Records indicate that the Toddington area suffered far less heavily with the closest known bomb strike approximately 950m south-west at Grand Avenue. No records were found to confirm a bomb strike within the site footprint or immediately adjacent land. Consequently, this source of UXO contamination is considered to be unlikely.

4.3 Other Sources of UXO Contamination

Anti-Aircraft Defences: Anti-Aircraft batteries were located in the general area to defend against air attack, the nearest of which was a Heavy Anti-Aircraft battery located approximately 0.10km to the north of the site. It is considered reasonable to assume that test firing and combat engagements with enemy aircraft did take place during WWII. Consequently, this source of UXO contamination is considered to be credible. However, the site was developed during this period, decreasing the likelihood of an Anti-Aircraft shell falling unnoticed within the site.

Military Use: There was a significant military presence in the surrounding area. Large areas of woodland and open land surrounding Arundel to the north of the site were requisitioned by the War Office during WWII. There was also military presence within Littlehampton and RAF Ford was located approximately 3.3km south-west. However, no records were found to confirm any significant military use of the site footprint. Consequently, this source of UXO contamination is on balance considered to be unlikely.

5 DETERMINING THE NATURE OF RISK

5.1 General

While HE bombs are very unlikely to detonate if left undisturbed it remains inherently dangerous and may function if subjected to suitable stimuli. The most common of these stimuli is shock, friction or heat which may cause the fuze to function or unstable explosive materials (Picrate Acid) to explode. However, in the case of incendiary bombs containing White Phosphorus (WP) exposure of the WP to the air will result in its violent ignition and combustion.

5.2 Bomb Trajectory & Ground Penetration

During WWII the Ministry of Home Security undertook a major assessment on bomb penetration depths using 1,328 actual bomb impact events to provide statistical analysis of penetration potential. As a result they determined the expected behaviour of a range of bomb weights through different geological strata around the Capital. Their findings remain the only empirical gained figures to have been gathered to date for England. A number of factors will influence the behaviour of a bomb on impact with the target and its trajectory through the ground. Relevant factors include: Height and speed of release of the bomb, aerodynamic qualities of the bomb, the angle of flight and impact and the nature of impact surface and sub soil. In determining the potential bomb penetration depths into the ground, historic geotechnical information and typical bomb characteristics were used. The maximum bomb penetration depth is estimated at 8.5 metres from the 1941 ground levels.

5.3 Bombs have been known to strike outside a building footprint and travel below the surface coming to rest within the building footprint. As did the recent 250kg HE bomb found within a cellar in Bethnal Green. The expected offset from impact point is estimated to be 3.0-5.0 metres.

6 ENVIRONMENTAL IMPACT FROM UXO

6.1 Ground Contamination & Health Risk vectors

While it is acknowledged that there is a potential risk of ground contamination arising from explosive fillings which may leach from a damaged bomb casing into the surrounding soil. The amount of explosive material within the most common bombs is not considered sufficient to pose a significant environmental risk. Nevertheless, it should be noted that the following components are commonly used in the manufacture of a high explosive bomb and may pose a localised contamination risk to health: metals including; Lead, Zinc, Brass, Copper, Steel, Mercury, Silver Fulminate and Aluminium. Other chemical Compounds including; Trinitrophenol, Trinitrotolulene, Trimethylene Trinitramine, Ammonium, Sodium Nitrate, Nitro-glycerine and White Phosphorus. It is recommended that specialist medical advice be sought to identify specific risks to health posed by these chemical compounds.

7 RISK ASSESSMENT

7.1 Risk Source

Although the surrounding area did suffer enemy bombing during WWII no records were found to indicate a bomb strike within the site footprint. Records are acknowledged to be incomplete and may include omissions and errors; the possibility that items of UXO may have found their way onto the site and remain there to the present day is considered credible.

7.2 Risk Pathway

The risk pathway is considered to be any ground intrusive earth works carried out while undertaking geo-environmental investigations or building work.

7.3 Consequence

The consequences of a UXB detonation on site during construction works are considered to be a factor of the size of the blast and the proximity of assets and individuals to the point of detonation. These will include potential to kill or seriously injure personnel destroy or damage high value site assets, nearby public and private property and infrastructure.

7.4 Risk Rating

Table 1 Risk Level

PRELIMINARY UXO RISK RATING			
Hand dug excavations	2 x 1 = 2	1 x 5 = 5	2 x 5 = 10
Limited mechanical excavations or trenching	2 x 2 = 4	2 x 5 = 10	4 x 10 = 40
Drilling or Sampling	2 x 3 = 6	3 x 5 = 15	6 x 15 = 90

1= Minimal 5=significant	LOW 0-100	MEDIUM 100-200	HIGH 200+

8 ASSESSMENT FINDINGS

8.1 Risk Levels

The assessment has determined the preliminary UXO risk within the site footprint. When viewed from likelihood versus consequence standpoint; it is considered prudent to recommend a suitable degree of UXO mitigation to permit the work to proceed in the safest "acceptable" manner in compliance with current legislation and best practices.

9 RECOMMENDATIONS FOR RISK MITIGATION

9.1 It is recommended that the following mitigation measures are carried out:

All Risk Levels:

- Risk Communication & Safety Planning: Stakeholders should be made aware of the UXO risk levels within the project boundary and the possible impact an encounter may have on the project and third parties. Consequently, a UXO Safety Plan should be drawn up and included with the overall project safety planning.
- Safety Training: In keeping with CDM Regulations concerning all sub-surface hazards, UXO Safety Induction Training should be provided to everyone working or visiting the site. The training should be commensurate with the individual's responsibilities and duties on site. The training should be provided by a competent individual (preferably a trained EOD Engineer) and delivered as a separate module of the Site Safety Induction Course or as a Toolbox Talk.

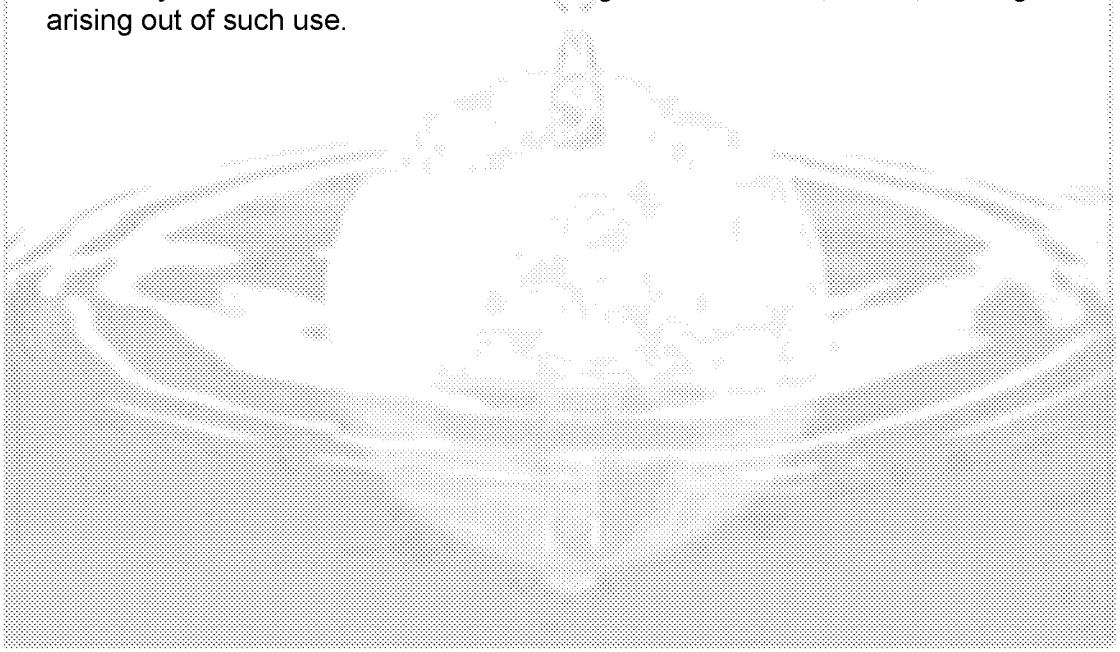
10 POST MITIGATION RISK

10.1 Overview

Prudent execution of the recommended risk mitigation strategy will reduce the risk, however it is emphasised that zero risk is not achievable given the possible variables. The study has confirmed the UXO risk level based on the nature of the work to be undertaken and has recommended suitable mitigation. An effective risk mitigation strategy will require detailed scoping to achieve its desired results in providing an acceptable level of risk. For further information concerning any part of this study please contact MACC International Ltd.

10.2 Intent & Use

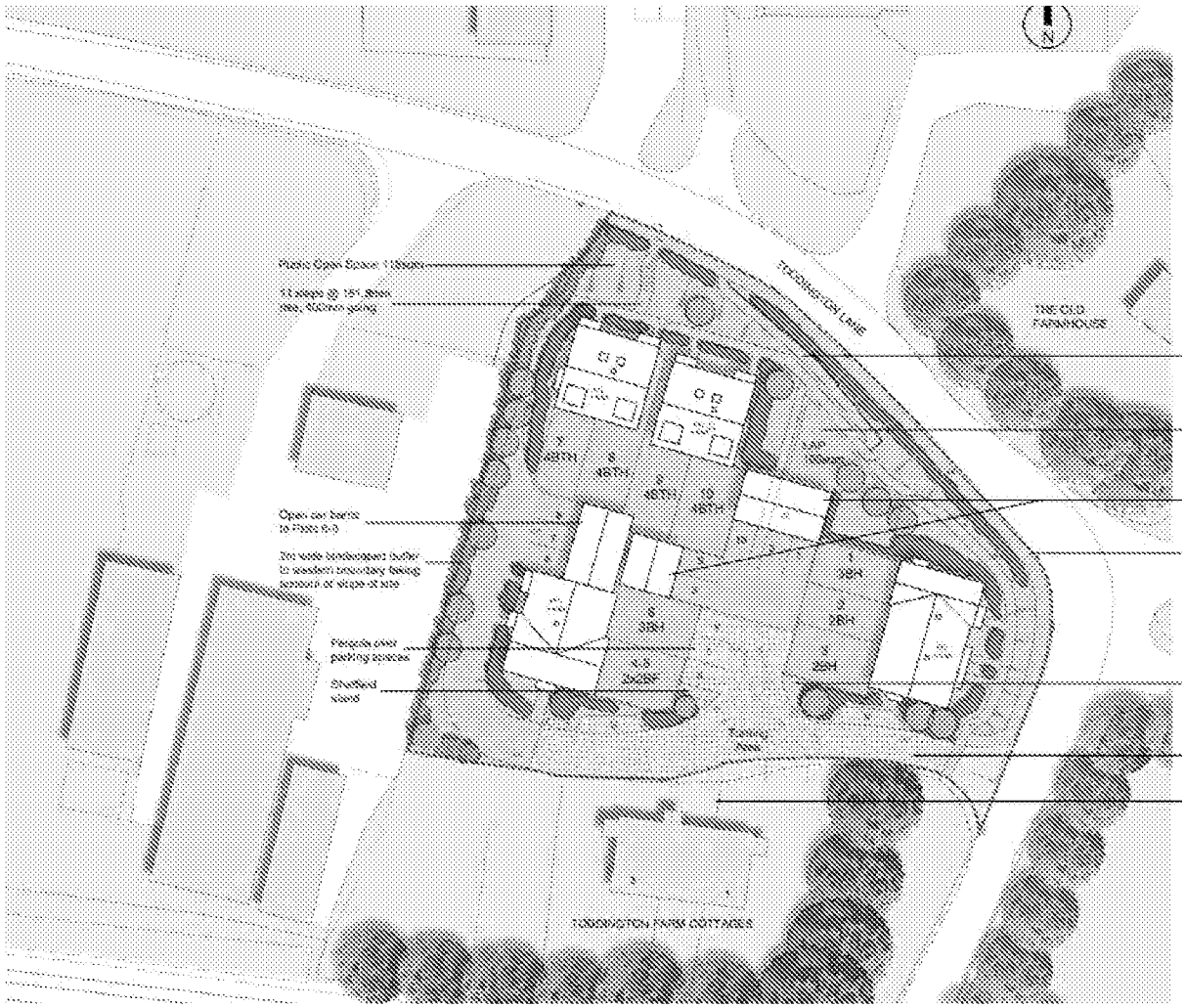
This document has been produced in the United Kingdom by MACC International Limited and meets the requirements of CIRIA C681 "Unexploded Ordnance (UXO) – A guide for the Construction Industry" It has been provided solely for the purpose of assessment and evaluation. It is not intended to be used by any person for any purpose other than that specified. Any liability arising out of use by a third party of this document for purposes not wholly connected with the above shall be the responsibility of that party, who shall indemnify MACC International Limited against all claims, costs, damages and losses arising out of such use.



Annex A

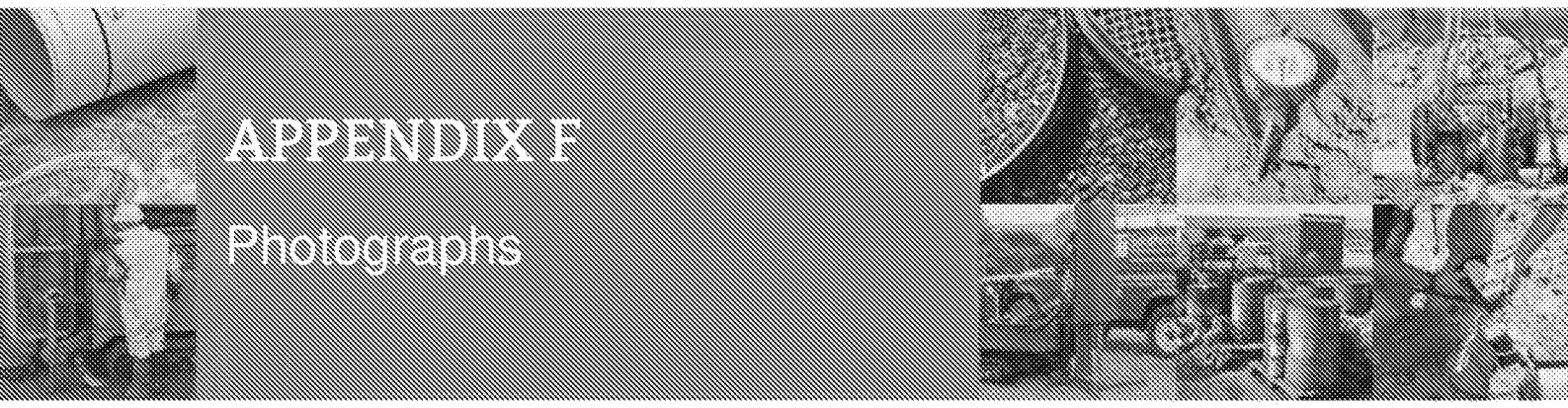
SITE MAPPING

Site Boundary



Southern Testing
Environmental & Geotechnical

ST Consult
Environmental & Geotechnical



APPENDIX F

Photographs

F

Photo 1 - Looking east at the barn taken from the southern end of the site

Photo 2 - Looking north at bonfire remains taken from the centre of the site

Photo 3 - Looking south west viewed from WLS01

Photo 4 - Looking north east at overgrown vegetation along north east corner of site

Photo 5 - Inside the barn looking south

Photo 6 - Looking south taken from north east corner of barn.

Photo 7 - Looking east taken from mid-west of the site

Photo 8 - Samples recovered from WLS04

Southern Testing
Environmental & Geotechnical

ST Consult
Environmental & Geotechnical

Head Office
East Grinstead

ST Consult Midlands
Northampton

ST Consult Thames Valley
Hannington

ST Consult North West
Warrington