Hurst Peirce + Malcolm LLP
CONSULTING CIVIL & STRUCTURAL ENGINEERS

HPM

THE MANOR HOUSE,
HAM ST, RICHMOND

STRUCTURAL IMPACT ASSESSMENT

FOR

PROPOSED BASEMENT DEVELOPMENT ADJACENT TO A GRADE II* LISTED BUILDING AND ASSOCIATED ALTERATIONS & EXTENSIONS

In Conjunction with

PAUL DAVIS ARCHITECTURE WITH TSOLAKIS ARCHITECTS

JOB NO:	23725
REPORT PREPARED BY:	R SALMON *BENG(HONS) CENG MISTRUCTE*
DATE:	DECEMBER 2018
REV:	0

CELTIC HOUSE
33 JOHN'S MEWS
LONDON WC1N 2QL
TEL: 020 7242 3593
FAX: 020 7405 5274

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- **Geotechnical Investigation Report**
- **Design Basis Report**
- **Ground Movement Analysis**
- **Flood Risk Assessment** (within appendices)

HPM

1.0 INTRODUCTION

1.01 Hurst Peirce + Malcolm have been instructed to provide a Structural Impact Assessment in support of the planning application for a new basement structure adjacent to the Grade II* Listed Manor House, along with alterations and extensions to the house itself.

1.1 The Property

1.1.1 The existing building comprises a central five window wide Queen Anne house with smaller buildings attached to the north. In the Edwardian period, the house was extended both to the south and north with additional 3 window wings and the ground floor and part of the first floor of the original house were extensively re-modelled with the removal of internal walls.

1.1.2 The house comprises two/three storeys above ground with attic rooms on the west side and a second floor on the east side of the original house. There is a basement under the original part of the house.

1.1.3 The house is located on generally level ground with a slight fall to the north. The land in this area forms part of the historic flood plain for the river Thames and is relatively flat.

1.1.4 The adjoining two-storey Coach House is separately listed at Grade II and retains much of its existing layout.

1.2 The proposed alterations in summary comprise:

1.2.1 New remote submerged basement spa with pool, connected to main house by narrow underground passage. A previous conservatory will be recreated above this passage.

1.2.2 Internal alterations to provide more suitable space for family usage.

1.2.3 Modest alterations and extensions at north end, including recreation of Victorian terrace/loggia facing into garden.

1.2.4 Modest alterations and extensions to the Coach House.

1.2.5 Formalisation of existing partly converted open roof space at north end and conversion of existing loft space at south end into habitable attic rooms.

1.3 Feasibility

1.3.1 The feasibility of these will be considered in the stages of construction commencing with excavation.

2 EXCAVATION

2.1 Ground conditions

2.1.1 A full geotechnical investigation has been undertaken by GEA and is contained within Appendix C. Borehole logs show reworked topsoil and made ground, overlying Kempton Park Gravel (silty sand and gravels), overlying London Clay encountered at 5m depth. A standpipe was installed and the first readings show the water level to be at 4.5m depth (+3.31mAOD). The water level will vary depending upon rainfall.

2.1.2 There is a pond half a mile to the south with the water level at about 2m below the general flood plain level.

2.2 Depths

2.2.1 The current basement floor is at approximately +6.1mAOD and has a porous quarry tile floor which does not show any signs of dampness.

2.2.2 The main part of the new basement will have a floor level at +2.8mAOD with a swimming pool requiring excavation to +0.8mAOD. Both these levels will be below the water table.

2.3 Restrictions on excavation.

2.3.1 The new basement has been sited to minimize the impact on existing trees and avoids all but two root protection areas, with these particular trees not being classified as important by the Arboricultural Consultant. However, minimizing that impact means that it will not be acceptable to batter back the sides of the excavation.

2.3.2 Where the new basement link runs up to the main house, it will undermine the foundations of the walls both within and beyond the existing basement. These walls will require either underpinning or the insertion of jet grout piles.

2.3.3 Excavation in fine sand is difficult if there is water present because the sand can liquidise and run out. Even when the excavation is above the water table, it is difficult because the sides tend to slump down. For this reason, conventional underpinning would be difficult and we recommend the use of jet grout columns. The principle is that a rotating lance is pushed down into the ground which stirs up the sand and mixes in a cement grout with the sand to form solid interlocking vertical cylinders. This work can be carried out from the outside of the building with the cylinders extending under and right up to the underside of the existing foundations. If the existing foundations project out from the face of the wall, holes will be diamond cored through the projections to allow the jet piles to be located under the foundations. The process is vibrationless and should cause no damage to the existing building.

2.3.4 Elsewhere, insitu bored permanent secant piling or temporary sheet piles installed using a silent piling technique (minimal vibration) can be used to hold up the ground. These would be in two lengths to suit the basement floor level and the deeper pool areas. Economy of design is likely to dictate that horizontal propping will be required to the tops of all piled walls until the basement roof slab can be constructed.

2.3.5 Once all the piles are in place, the basement can be excavated to suit the new basement floor level. Use of either piling system should extend into the London Clay, this effectively cutting off groundwater from the open excavation.

2.4 Construction of the basement

2.4.1 A new basement box would then be constructed within the excavation using watertight concrete for the walls if sheet piling is adopted. The water tightness would be tested by flooding the gap between the sheet pile wall and the concrete box up to a level of +5.5mAOD. Any leaks would be sealed. If secant piling is adopted, this is effectively watertight, but would be enhanced with an inner lining of waterproof concrete. As a further precaution a drained floor and wall cavity system will be provided to drain away any water should the water table rise.

2.4.2 A proposed structural basement design drawing is attached to this report in Appendix B

2.5 Effect of basement on the local hydrology.

2.5.1 If the piles are sealed into the London Clay each box will act as a barrier to any water flows in the sand. However, when considering the whole frontage of this property (135m), the interruption to flow is negligible. We do not consider that this will have any impact on water flows in the sand above the London Clay.

2.5.2 In addition, the proposed basement is somewhat remote from any other basements, with the nearest neighbouring property being at least 30m away.

2.5.3 Please also refer to the GEA report in Appendix C.

3 WORKS WITHIN THE EXISTING HOUSE

3.1 Roof voids

3.1.1 The existing open roof space at the north end of the building has previously been partially remodelled to remove internal strutting and strengthen ceiling structures, etc. This space will now be formalised into habitable attic rooms.

3.1.2 The loft space at the south end is to be converted into attic rooms. This space is generally open, with the exception of a central truss. The truss will be modified into an attic truss, with local strengthening works as required, to open up the space. The existing ceiling joists are quite large, but there is an allowance to double-up the joists if necessary to carry the new floor loading.

3.2 First Floor

3.2.1 Only very minor changes are planned at first floor, involving the relocation of some non-loadbearing partitions.

3.2.2 The only exception to this being the formation of a new walk-through opening in the primary cross wall adjacent to the chimney breast to connect the most northerly room to the rest of first floor.

3.3 Ground floor

3.3.1 In the original central section of the building, it is proposed to remove the chimney breast adjacent to the main stair, which currently forms the downstairs WC. The retained breast and wall above will need to be re-supported on fairly significant steelwork framing, which will also need to provide the lateral robustness that the chimney breast currently provides, albeit all subject to listed buildings consent.

3.3.2 The extreme north end single storey section is to be extended. Due to the presence of a large protected tree in close proximity, the foundations for this extension are to be a “no-dig” mini-piled raft foundation.

3.3.3 Elsewhere, there is some fairly minor remodelling of north end Victorian and Edwardian sections.

3.4 Basement

3.4.1 Within the existing basement, the only planned modifications are relocation of the staircase from ground floor and formation of a new opening into the new basement passageway.

3.5 The Coach House

3.5.1 Fairly minor alterations are required to improve the space, including relocation of an internal staircase, which will have little impact on the structure of the original section of the building

3.5.2 More recent, but dilapidated, lean-to sections at the north end will be removed and reconstructed with attic trusses to provide more habitable loft space.

3.6 Drawings

3.6.1 Proposed structural alterations plans are attached to this report in Appendix B.

4 CONDITION OF THE STRUCTURE OF THE EXISTING HOUSE

4.1 Introduction

4.1.1 A full structural survey has not been carried out. The following comments are observations made during initial inspections of the building, with limited intrusive exploratory works, to consider the proposed alterations.

4.2 Foundation stability

4.2.1 The GEA report in Appendix C indicates that the building will be founded on sand which is not subject to volume change like clay so subsidence due to tree root action is not of concern and no evidence of subsidence was observed.

Slight distortion of spandrel panel on west elevation

Slight dropping of pier between windows

4.2.2 There are two locations on the original building where there is evidence of slight ground movement. One is on the west elevation at the north end and the other is on the east elevation between each pair of windows either side of the doorway. The brickwork spandrel panels between the windows appear to suggest that the piers between the windows have dropped very slightly. This will be historic and probably dates from the time of construction. Its most likely cause is that the brick piers between the windows continue down to basement level and lead to a concentrated load on the foundations which may have settled more elastically as a result. No action is required.

4.2.3 External Cracking

South elevation

Cracking

4.2.4 There is cracking on the south elevation of the single storey part of the Edwardian extension. This is thought to be the result of expansion of metal ties within the wall and not the result of foundation movement.

4.3 Internal cracking

Cracking in partition wall

Cracking in ceiling

4.3.1 The first floor structure under Master bedroom suite 1 lobby and dressing rooms is overloaded by heavy partition walls. This deflection of the floor has resulted in the visible cracking within the dressing room. This should be remedied by floor strengthening works.

4.3.2 There is also cracking at high level in the lobby at the junction with the southern Edwardian extension (main master bedroom). This is due to deflection of the beam under the wall between above noted lobby and dressing room. It is not of structural concern and should be remedied by the floor strengthening works.

4.3.3 At ground floor there is a vertical crack in the north wall of the library, close to the external wall. The reason for this crack is not clear unless the internal wall between library and corridor is the remainder of an earlier building and the Queen Anne frontage was added and attached to the internal wall. The crack is not visible on the corridor side so its reason is not clear. It is not large so we recommend that it is monitored for the time being with Demec points and, if it is found to be getting worse, it can be pinned by drilling in long Cintec anchors from the outside or by cutting into the plaster and stitching with Helifix ties. If, however, the movement is due to the fact that the return wall runs away from the basement, there may be some slight differential vertical movement.

4.3.4 Timbers

4.3.5 A small number of existing timbers have been inspected. Timbers will develop problems where they get damp either from roof leaks or where they are embedded in damp masonry. Some leaks have been noticed so attention should be given to inspecting the timbers in those areas.

4.3.6 In addition, very probably there are timbers built into the external walls. These were called bond timbers. Normally they align with the internal face. Occasionally they are concealed within the thickness of the wall. It also seems possible that the original Queen Anne construction may have included partial or full timber framing, with a possible later brick re-facing. More investigation will be required to determine the full extent of embedded timbers in walls.

4.3.7 Deterioration of these timbers can lead to concentrations of stress within the load bearing masonry walls and that can lead to lamination of the wall such that the outer 4.5” of brickwork loosens and bulges out due to poor bond between the facing bricks and the backing brickwork. There was no visible evidence of any problems but when the building is scaffolded, the brickwork of the original building should be sounded for hollowness. If any areas are found to be hollow, then the brickwork should be pinned back using Helfix pins. This can be done discreetly in the mortar joints.

5 CONCLUSION

5.1 Viability of construction and protection of original building:

5.1.1 We have considered the way in which the proposed works can be undertaken and following our detailed ground movement analysis we are satisfied that they can be carried out in a way which will at worst cause only Category 0 'negligible' or Category 1 'very slight' damage to the existing historic building. BRE Digest 251 "Assessment of damage in low-rise buildings" defines these categories as follows:

"Category 0 - Hairline cracks of less than about 0.1 mm which are classed as negligible. No action required".

"Category 1 - Fine cracks that can be treated easily using normal decoration. Damage generally restricted to internal wall finishes; cracks rarely visible in external brickwork. Typical crack widths up to 1 mm".

It should also be noted that it is primarily the Edwardian section of the building that may be subject to movement rather than the more historic parts.

5.1.2 Further mitigation measures are under consideration and structural movement will be monitored on the most proximate parts of the main house and boundary wall (Sandy Lane side) throughout the basement construction period.

5.1.3 We also conclude that the basement works will have no significant effect on the hydrogeology of the area.

5.1.4 Though much mitigated by the adoption of secant piled walling to the new basement, groundwater control measures during and after excavation will need to be considered.

5.1.5 Internal alterations within the historic building will inevitably destroy some historic fabric. We have proposed methods of construction to minimise that loss and we have also suggested improvements which can be made to remedy the existing overloading of one of the floors.

5.1.6 The site is at low risk of flooding, provided that the new basement is adequately tanked.

5.2 Structural condition:

5.2.1 Whilst not undertaking a full structural survey we have identified a few defects in the fabric but which either need no action or can be remedied easily.

5.2.2 We recommend that the timbers are carefully examined wherever they could become wet.

Appendix A – Existing floor plans (from Oxford Archaeology Report)

Figure 12: First floor of Manor House

Figure 11: Ground floor of Manor House

Appendix B – Proposed Structural Alterations Plans & Proposed Basement Construction

General Notes

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2. Dimensional/level accuracy only applies to the written notation.
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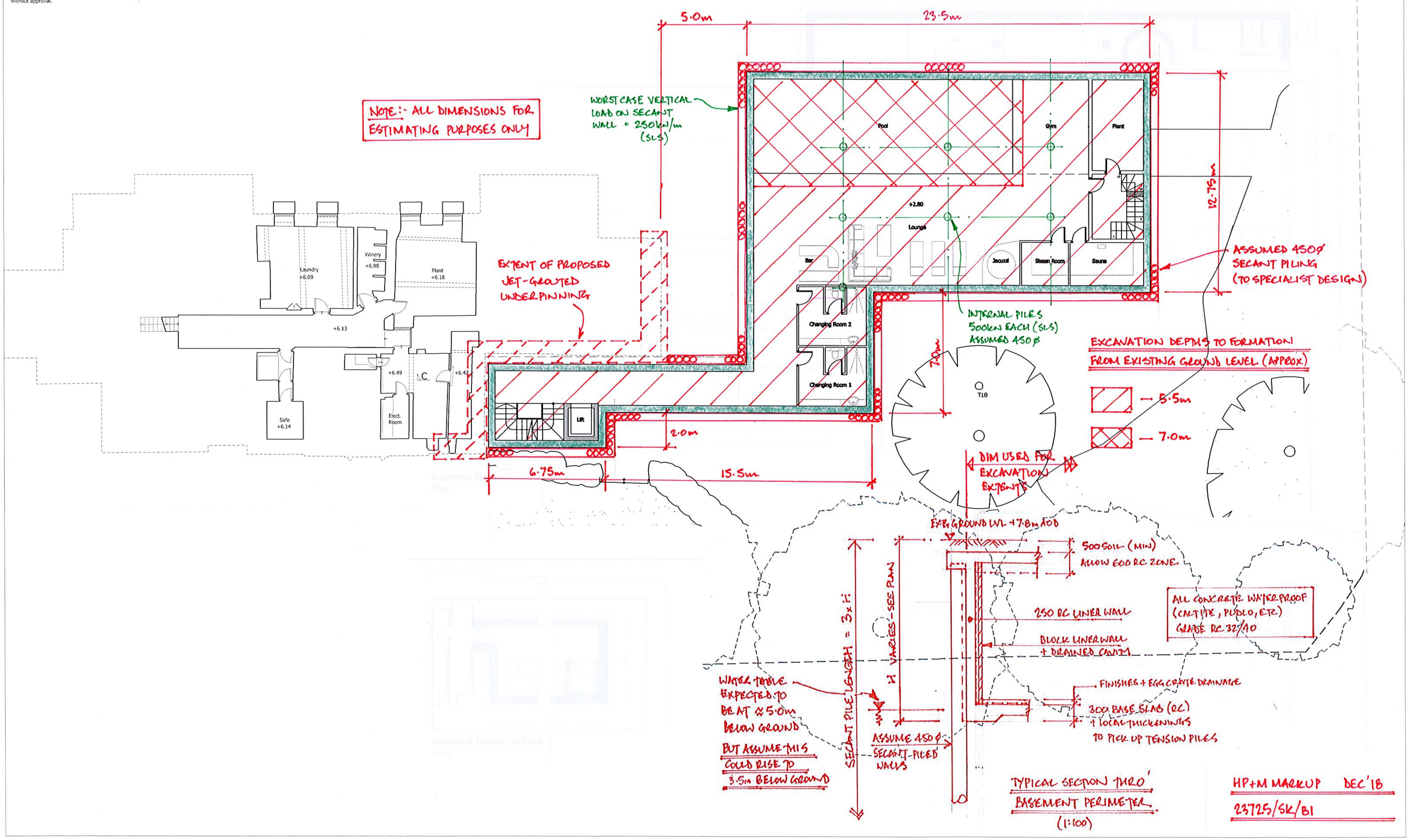

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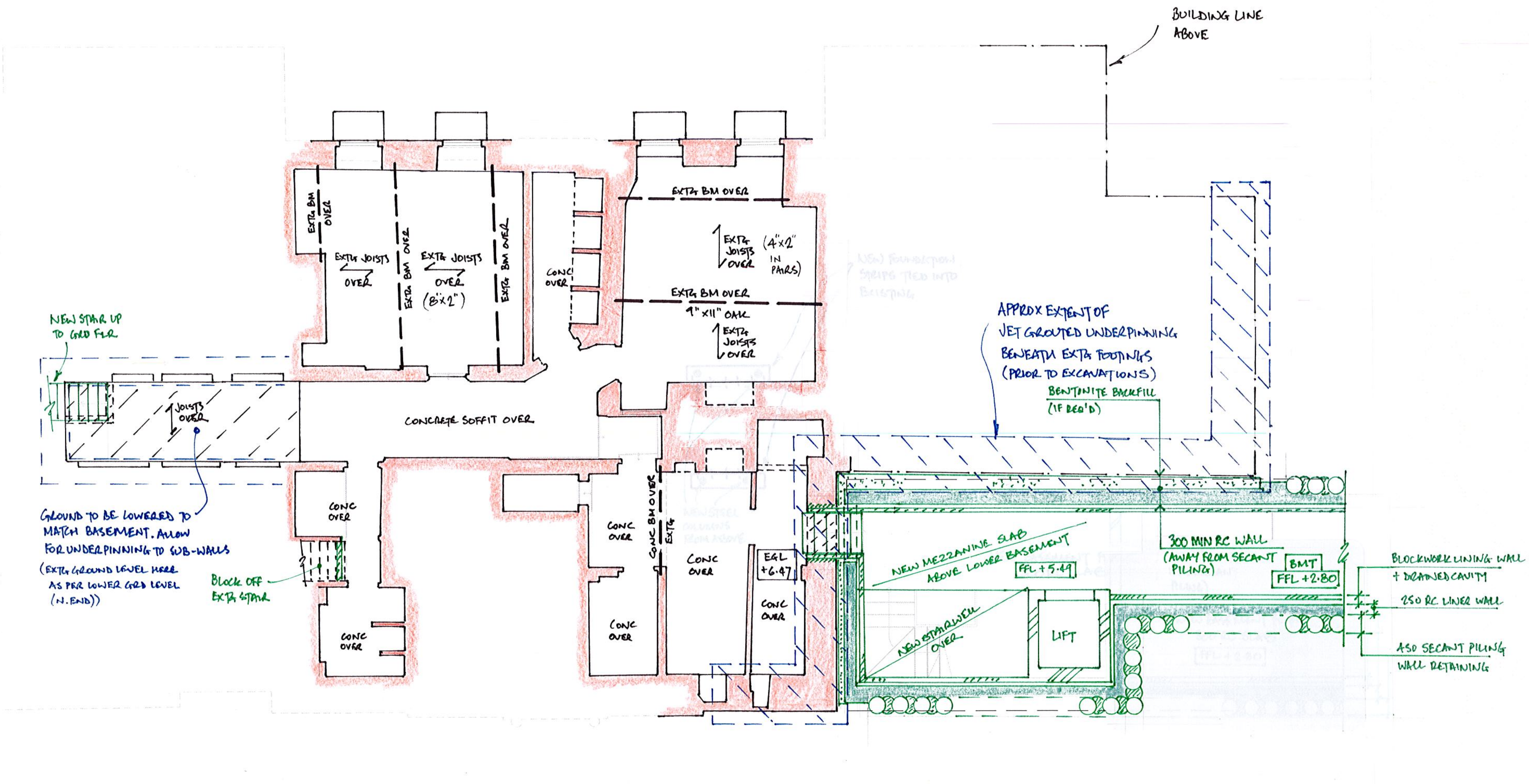

BASEMENT PLAN
(SHOWING STRUCTURE OVER)

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Hurst Peirce + Malcolm LLP HPM
CONSULTING CIVIL & STRUCTURAL ENGINEERS

Celtic House
33 John's Mews
Holborn
London WC1N 2QL

©
Tel: 020 7242 3593
Fax: 020 7405 5274

E-mail: enquiries@hurstpm.co.uk
Web Page: www.hurstpm.co.uk

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Project: THE MANOR HOUSE, HAM STREET, RICHMOND

Status: PLANNING

Scale: 1:100 @ A3

Title: PROPOSED STRUCTURAL ALTERATIONS BASEMENT

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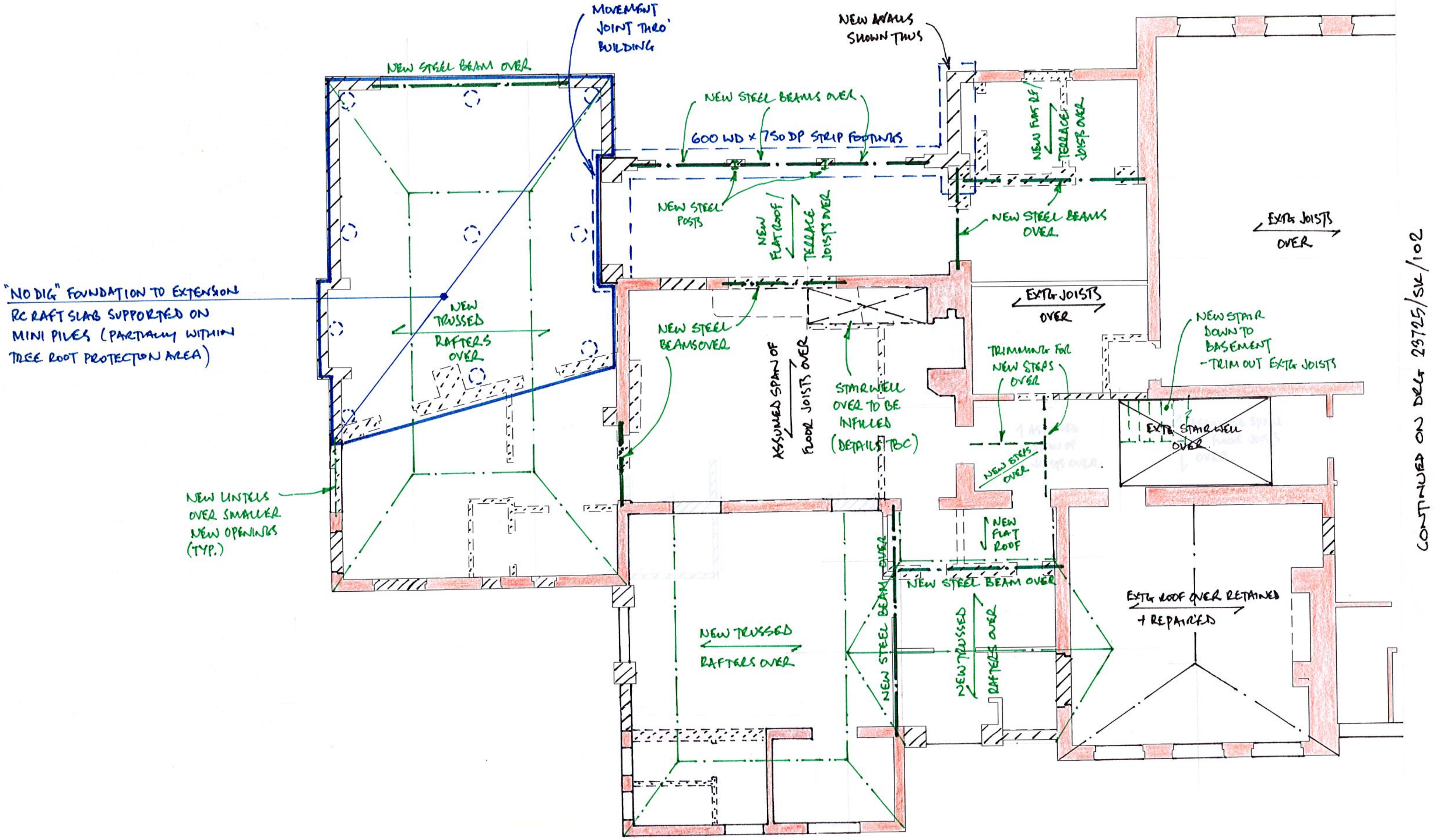

GROUND FLOOR PLAN - NORTH
(SHOWING STRUCTURE OVER)

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CONSULTING CIVIL & STRUCTURAL ENGINEERS

Celtic House
33 John's Mews
Holborn
London WC1N 2QL

©
Tel: 020 7242 3593
Fax: 020 7405 5274

E-mail: enquiries@hurstpm.co.uk
Web Page: www.hurstpm.co.uk

Architect	PAUL DAVIS ARCHITECTURE WITH TSOLAKIS ARCHITECTS
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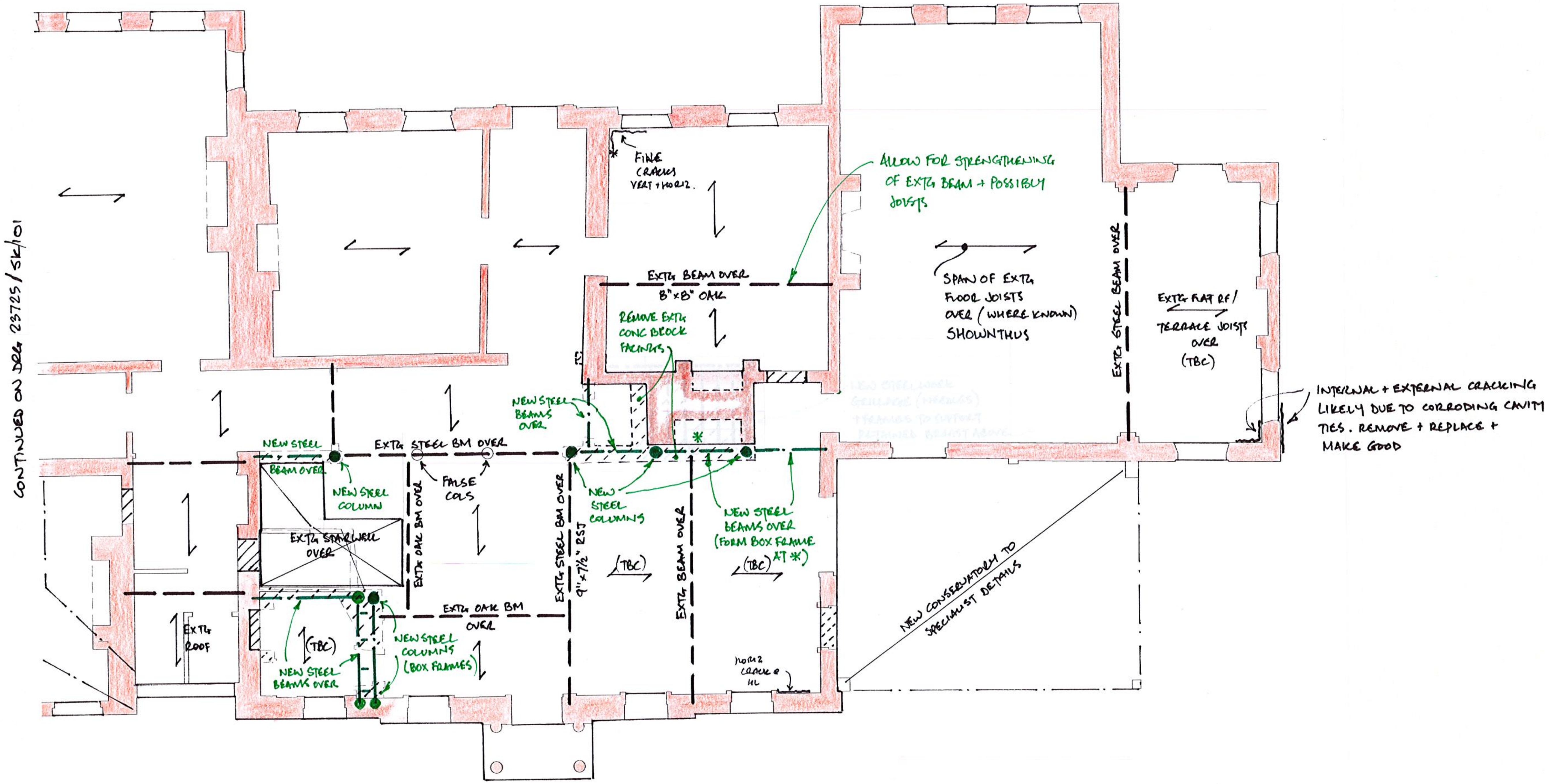

GROUND FLOOR PLAN – SOUTH

(SHOWING STRUCTURE OVER)

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Hurst Peirce + Malcolm LLP HPM
CONSULTING CIVIL & STRUCTURAL ENGINEERS
Celtic House
33 John's Mews
Holborn
London WC1N 2QL
©
Tel: 020 7242 3593
Fax: 020 7405 5274
E-mail: enquiries@hurstpm.co.uk
Web Page: www.hurstpm.co.uk

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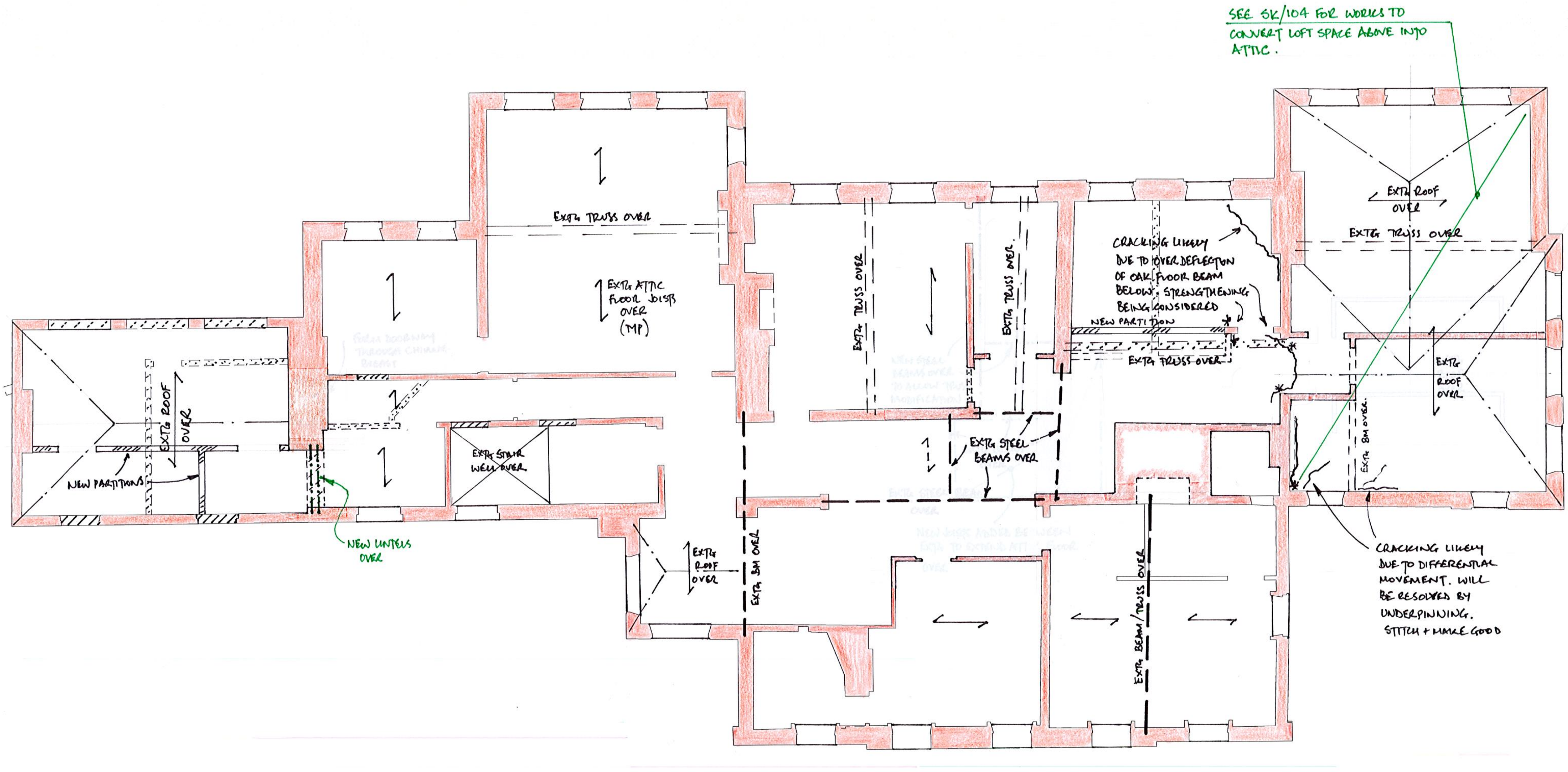

FIRST FLOOR PLAN
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Hurst Peirce + Malcolm LLP HPM
CONSULTING CIVIL & STRUCTURAL ENGINEERS
Celtic House
33 John's Mews
Holborn
London WC1N 2QL
©
Tel: 020 7242 3593
Fax: 020 7405 5274
E-mail: enquiries@hurstpm.co.uk
Web Page: www.hurstpm.co.uk

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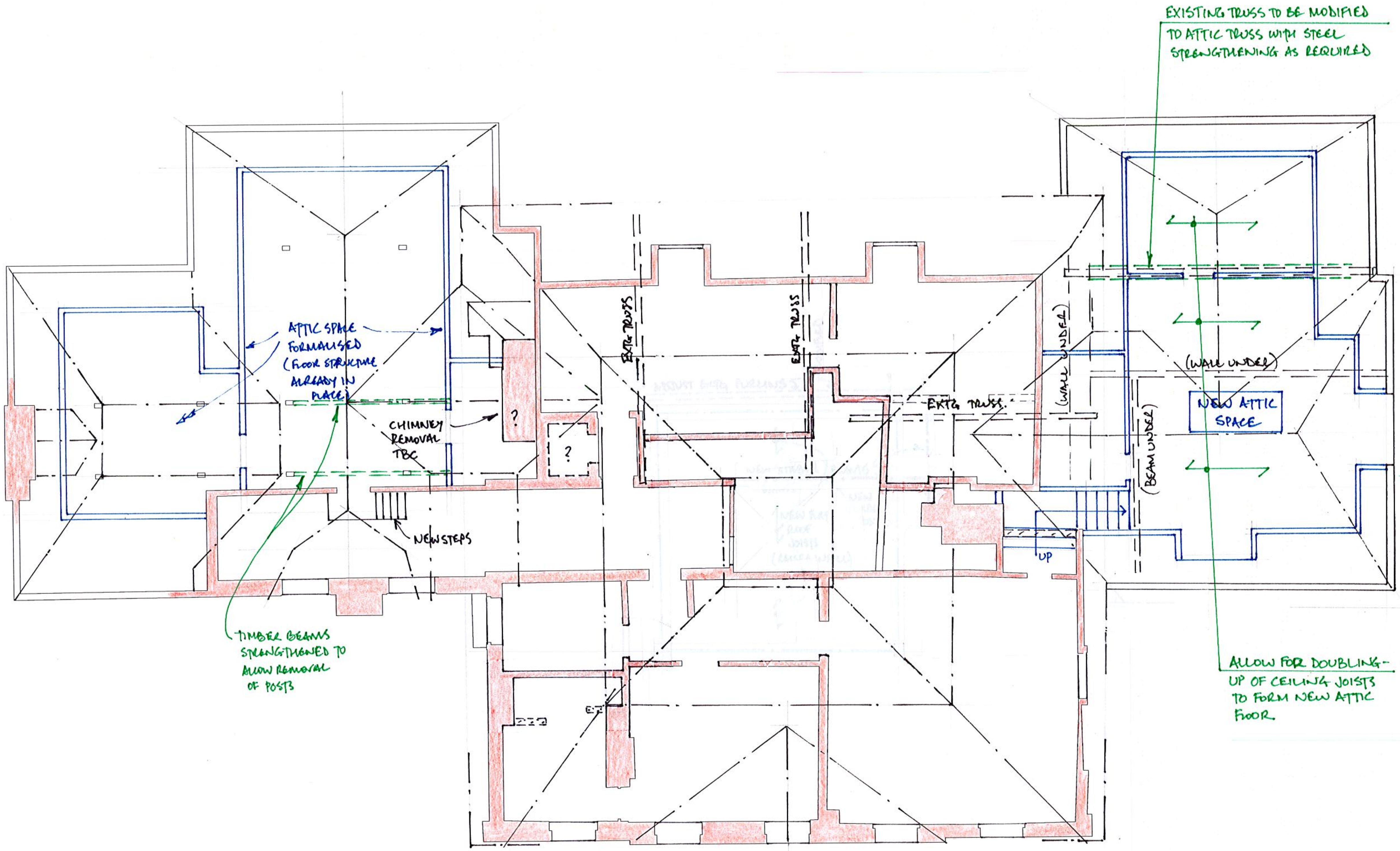

SECOND FLOOR PLAN
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Hurst Peirce + Malcolm LLP HPM
CONSULTING CIVIL & STRUCTURAL ENGINEERS
CELTIC HOUSE
33 JOHN'S MEWS
HOLBORN
LONDON WC1N 2QL
©
TEL: 020 7242 3593
FAX: 020 7405 5274
E-MAIL: enquiries@hurstpm.co.uk
WEB PAGE: www.hurstpm.co.uk

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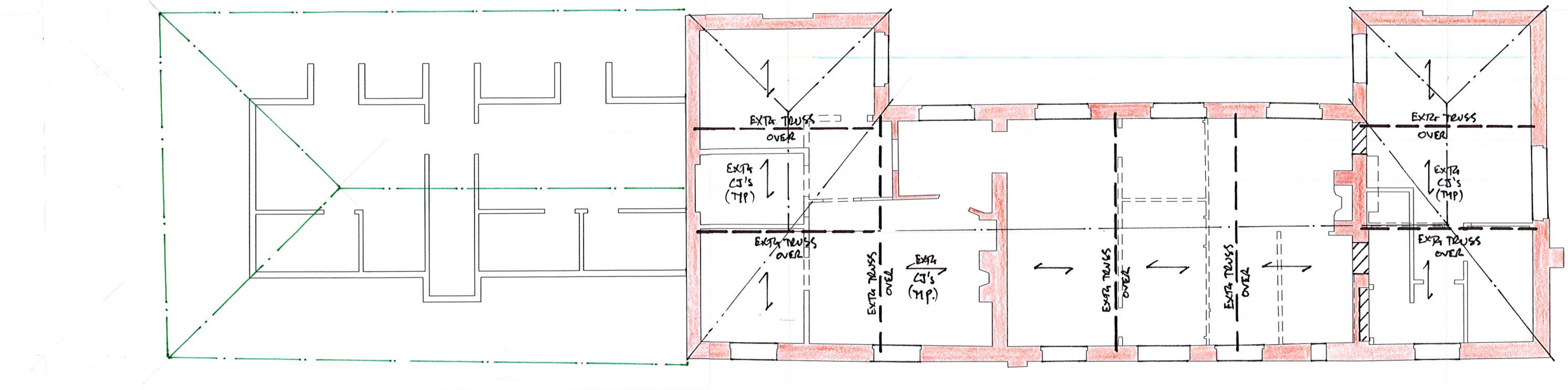
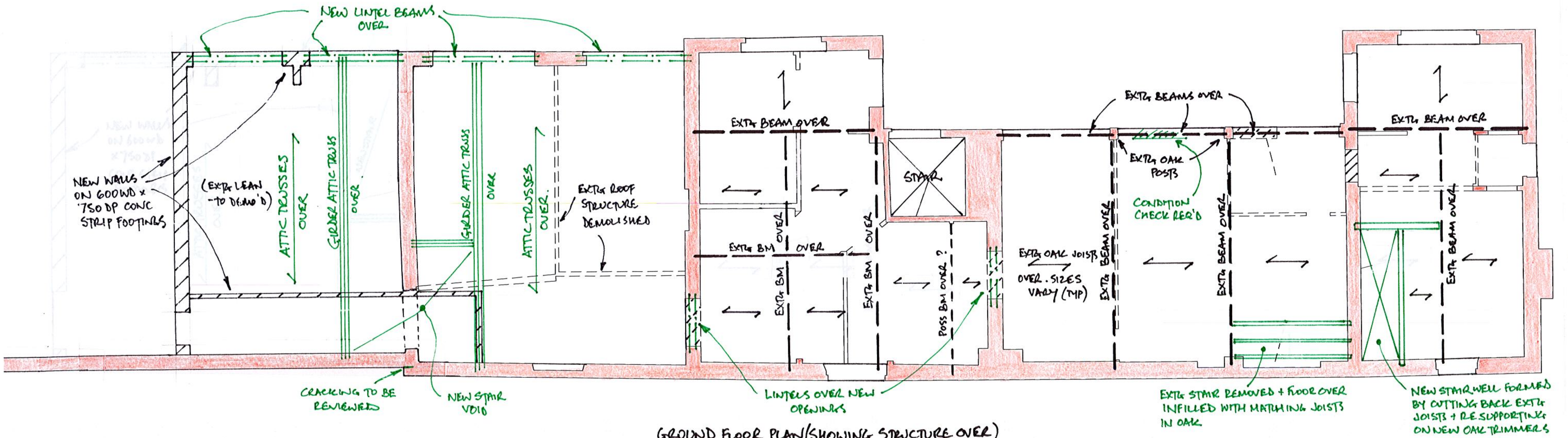


FIRST FLOOR PLAN (SHOWING STRUCTURE OVER)



GROUND FLOOR PLAN (SHOWING STRUCTURE OVER)

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Holborn
London WC1N 2QL

©

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Fax: 020 7405 5274

E-mail: enquiries@hurstpm.co.uk
Web Page: www.hurstpm.co.uk

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Appendix C – Basement Impact Assessment *(by GEA Geotechnical & Environmental Associates)*

- **Geotechnical Investigation Report**
- **Design Basis Report**
- **Ground Movement Analysis**
- **Flood Risk Assessment** (within sub-appendices)

DESK STUDY & GROUND INVESTIGATION REPORT

The Manor House
Ham Street
Richmond
Surrey

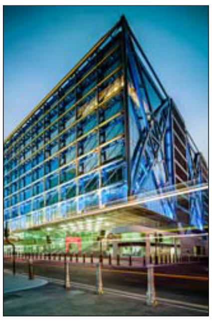
Client: Primus Inter Pares Limited

Engineer: Hurst Peirce + Malcolm LLP

J16002

April 2016



Geotechnical & Environmental Associates

Document Control

Project title	The Manor House, Ham Street, Richmond, TW10 7HA		**Project ref**	J16002
Report prepared by	Matthew Penfold MSci MSc DIC CGeol FGS	Jane Sell BSc MSc FGS		
Report checked and approved for issue by	Steve Branch BSc MSc CGeol FGS FRGS MIEnvSc			
Issue No	**Status**	**Date**	**Approved for Issue**	
1	Final	18 April 2016		

This report has been issued by the GEA office indicated below. Any enquiries regarding the report should be directed to the office indicated or to Steve Branch in our Herts office.

✓	Hertfordshire	tel 01727 824666	mail@gea-ltd.co.uk
	Nottinghamshire	tel 01509 674888	midlands@gea-ltd.co.uk

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EXECUTIVE SUMMARY

This executive summary contains an overview of the key findings and conclusions. No reliance should be placed on any part of the executive summary until the whole of the report has been read. Other sections of the report may contain information that puts into context the findings that are summarised in the executive summary.

BRIEF

This report describes the findings of a desk study and ground investigation carried out by Geotechnical and Environmental Associates Limited (GEA) on the instructions of Hurst Peirce + Malcolm LLP, on behalf of Primus Inter Pares Limited, with respect to the construction of a 5.5 m to 7.0 m deep basement beneath the existing garden to the south of the main house. The purpose of the investigation has been to research the history of the site with respect to possible contaminative uses, to determine the ground conditions and hydrogeology, to assess the extent of any contamination and to provide information to assist with the design of the basement structure and suitable foundations for the proposed development. A ground movement assessment has also been carried out to provide an indication of the likely impact of the proposed development on the existing building and adjoining structures.

DESK STUDY FINDINGS

The Manor House is a Grade II listed building that is understood to date from the early to mid-18th Century and is shown on the earliest map studied, dated 1868. At some time between 1898 and 1913, the house was extended to the south, with a number of small buildings to the front of the house demolished and replaced with the existing semi-circular driveway. Over the same period a rifle range was established approximately 250 m to the northwest, a number of sand and gravel pits had been excavated approximately 800 m to the west-southwest and a sewage works had been established 400 m to the southwest. Sand and ballast works were subsequently established approximately 600 m to the southwest. By 1991, the northwestern corner of the gardens had been sold for residential development, whilst a tennis court in the centre of the site was removed between 2006 and 2015.

GROUND CONDITIONS

The investigation has generally confirmed the expected ground conditions in that, beneath a surface covering of topsoil and made ground, Kempton Park Gravel was encountered overlying the London Clay Formation. The made ground extended to depths of between 0.30 m (7.51 m OD) and 0.60 m (7.21 m OD) and generally comprised orange-brown to dark brown and greyish brown silty sand with gravel, brick fragments, occasional roots and rootlets and rare lime mortar. Below the made ground, locally loose to medium dense orange-brown to brown sand, sandy gravel or sand and gravel, with variable amounts of gravel, occasional rootlets, and clay layers of 0.1 m to 0.3 m thickness was encountered to depths of between 5.80 m (2.01 m OD) and 6.30 m (1.51 m OD). The London Clay comprises an upper 'weathered' layer, which comprised firm brown slightly silty clay, below which stiff becoming very stiff fissured high strength becoming very high strength dark grey clay was proved to the full depth of the investigation, of 20.0 m (12.19 m OD).

Groundwater is likely to be present within the Kempton Park Gravel at depths of between 4.50 m (3.31 m OD) and 4.70 m (3.11 m OD).

RECOMMENDATIONS

Excavations for the proposed basement structure will require temporary support to maintain stability and to prevent any excessive ground movements. The investigation has indicated that groundwater will be encountered within the proposed depth of excavation, such that groundwater control measures are likely to be required, although continued groundwater monitoring should be carried out to confirm this. The excavation of the basement will result in a formation level in the Kempton Park Gravel or underlying London Clay and it should be possible to adopt spread foundations in these soils designed to apply a minimum net allowable bearing pressure of 150 kN/m^2 below the level of the proposed basement floor. Alternatively, piled foundations extending into the London Clay would also provide a suitable solution.

The ground investigation has not provided any evidence to suggest that the proposed development will have a significant influence on the local hydrogeology, whilst the ground movement analysis has indicated that building damage will fall within acceptable limits. No visual or olfactory evidence of contamination was noted during the fieldwork and testing of soils has not identified the presence of elevated concentrations of contaminants, such that a requirement for remediation work is not envisaged.

Part 1: INVESTIGATION REPORT

This section of the report details the objectives of the investigation, the work that has been carried out to meet these objectives and the results of the investigation. Interpretation of the findings is presented in Part 2.

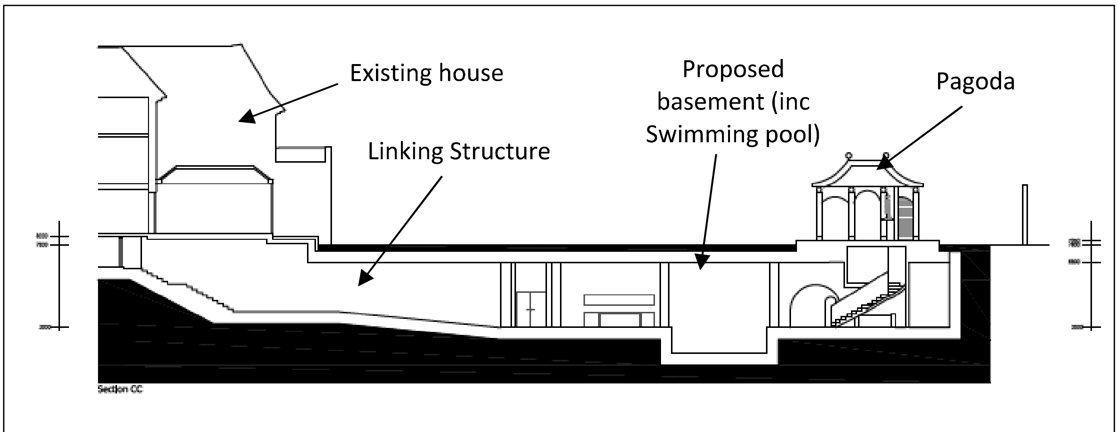
1.0 INTRODUCTION

Geotechnical and Environmental Associates Limited (GEA) has been commissioned by Hurst Peirce + Malcolm LLP, on behalf of Primus Inter Pares Limited, to carry out a desk study and ground investigation at The Manor House, Ham Street, Richmond, TW10 7HA, within the London Borough of Richmond upon Thames.

1.1 Proposed Development

It is understood that it is proposed to excavate a 5.5 m deep basement beneath the existing garden to the south of the main house, which will be locally deepened to 7.0 m to accommodate a swimming pool and will include an approximately 4.5 m deep link to the southern end of the adjoining house. The design also includes a pagoda at ground level above the southern end of the basement, which will have a stepped entrance leading down into the basement, whilst also allowing in natural light.

A section through the site is included below to aid understanding of the proposed development.



This report is specific to the proposed development and the advice herein should be reviewed once the development proposals are finalised.

1.2 Purpose of Work

The principal technical objectives of the work carried out were as follows:

- to check the history of the site with respect to previous contaminative uses;
- to determine the ground conditions and their engineering properties;
- to assess the possible impact of the proposed development on the local hydrogeology and surrounding structures;

- to provide advice with respect to the design of shallow foundations and retaining walls;
- to provide an indication of the degree of soil contamination present; and
- to assess the risk that any such contamination may pose to the proposed development, its users or the wider environment.

1.3 Scope of Work

In order to meet the above objectives, a desk study was carried out, followed by a ground investigation. The desk study comprised:

- A review of readily available geological and hydrogeological maps;
- a review of historical Ordnance Survey (OS) maps and environmental searches sourced from the Envirocheck database and;
- a flood risk assessment, undertaken by Evans Rivers and Coastal Ltd (report ref 1573/RE/02-16/01, dated February 2016).

In the light of the desk study, an intrusive ground investigation was carried out which comprised, in summary, the following activities:

- three opendrive sampler boreholes advanced to a depth of 6.00 m (1.81 m OD);
- two cable percussion boreholes advanced to depths of 15.00 m (- 7.19 m OD) and 20.00 m (- 12.19 m OD);
- the installation of four groundwater monitoring standpipes to depths of 5.20 m (2.61 m OD), 5.00 m (2.81 m OD), 6.00 m (1.81 m OD) and 6.50 m (1.31 m OD) and two subsequent monitoring visits;
- laboratory testing of selected soil samples for geotechnical purposes and for the presence of contamination; and
- provision of a report presenting and interpreting the above data, together with our advice and recommendations with respect to the proposed development.

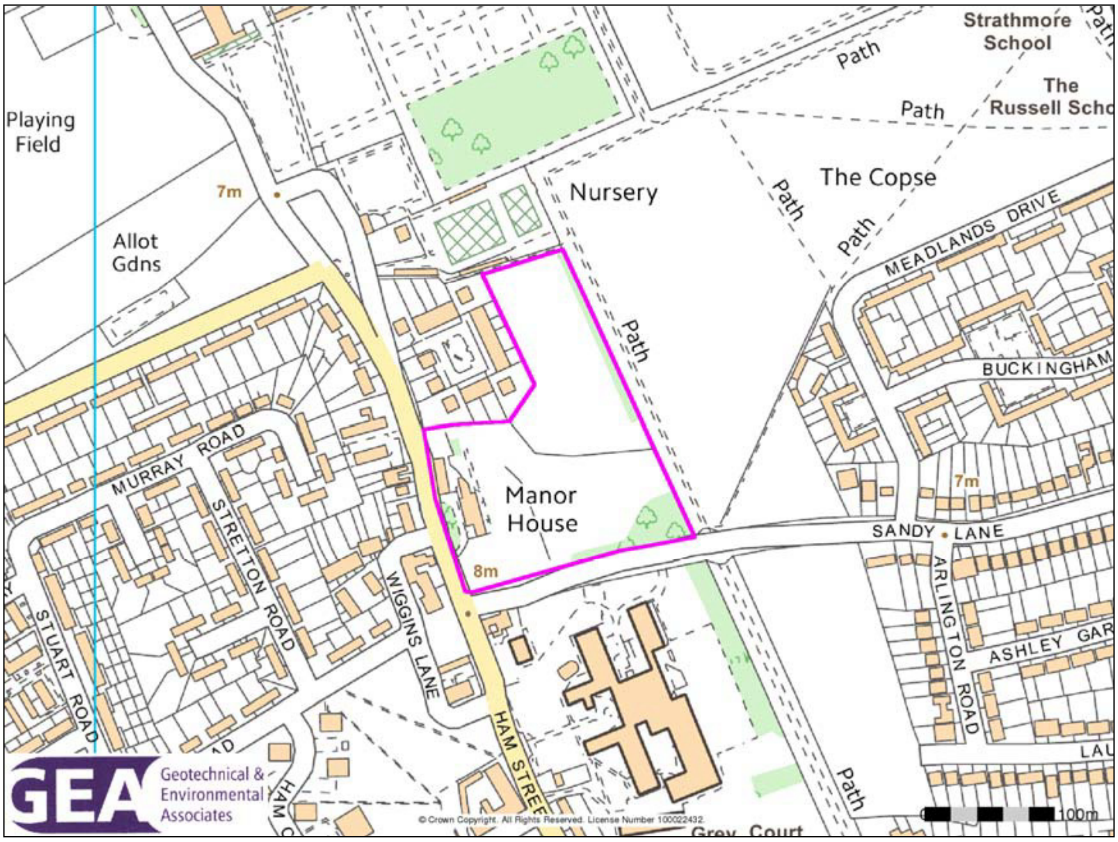
1.4 Limitations

The conclusions and recommendations made in this report are limited to those that can be made on the basis of the investigation. The results of the work should be viewed in the context of the range of data sources consulted and the number of locations where the ground was sampled. No liability can be accepted for information in other data sources or conditions not revealed by the sampling or testing. Any comments made on the basis of information obtained from the client or other third parties are given in good faith on the assumption that the information is accurate; no independent validation of such information has been made by GEA.

2.0 THE SITE

2.1 Site Description

The site is located approximately 2.5 km southwest of Richmond Railway Station and 60 m south of Ham House and Garden, owned by the National Trust. It is bounded by an alleyway to the north, Ham Avenues public footpath and a common to the east, Sandy Lane to the south, Ham Street to the west and 'The Orangery' residential area to the northwest. The site can additionally be located by National Grid Reference 517359, 172655 and is shown on the map extract below.



The site is essentially level and irregular in shape and measures 190 m by 250 m in maximum dimensions. The Manor House occupies the south-western part of the site and comprises a two to three-storey building, with a partial basement beneath the majority of the main house. A row of two-storey buildings, comprising former stables and a workshop, is located immediately adjacent to the north-western part of the house. The garden wraps around the main house to the south and east and is separated from the adjoining parkland by a sunken retaining wall (Ha-Ha), which extends to the east and northeast of the house. An above ground fuel tank is situated to the west of the driveway, against the boundary wall with Ham Street. The tank was observed to be in good condition, with no evidence of any leaks or spillages on the area immediately below and surrounding the tank.

2.2 Site History

The site history has been researched by reference to historical Ordnance Survey (OS) maps obtained from the Landmark Envirocheck database.

The Manor House is a Grade II listed building that is understood to date from the early to mid-18th Century. The house and existing gardens are shown on the earliest map studied, dated 1868, with Ham Lodge to the north, a tree-lined avenue leading to Ham House to the east, Sandy Lane to the south and Ham Street to the west. At some time between 1898 and 1913, the house was extended to the south with a number of small buildings to the front of the house demolished and replaced with the existing semi-circular driveway. Over the same period a rifle range was established approximately 250 m to the northwest, a number of sand and gravel pits had been excavated approximately 800 m to the west-southwest and a sewage works had been established 400 m to the southwest. Sand and ballast works were subsequently established approximately 600 m to the southwest.

The area remained essentially unaltered until some time between 1935 and 1938 when the existing housing to the west of the site was established. A second phase of residential development to the west, south and east then occurred between 1966 and 1975. By 1991, the northwest corner of the gardens had been sold for residential development. The site itself has changed little since 1935, except for the addition of a tennis court in the centre of the garden between 1973 and 1991, which was subsequently removed between 2006 and 2015.

2.3 Geology

The British Geological Survey (BGS) map of the area (sheet 256) indicates that the site is underlain by Kempton Park Gravel over London Clay.

A review of publicly available information from the BGS database has revealed several shallow boreholes, one located on the northern boundary of the site and two located 60 m to the southeast, which show that the Kempton Park Gravel extends to depths of between 5.5 m and 8.0 m. A deeper borehole, located 1.5 km northwest of the site shows that the London Clay extends to a depth of 53.0 m, below which the Lambeth Group and Thanet Sand were found to be present, with the top of the White Chalk encountered at a depth of approximately 80.0 m.

2.4 Hydrology and Hydrogeology

The Kempton Park Gravel is classified by the Environment Agency (EA) as a Secondary 'A' aquifer, which refers to permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers. Under the same system, the London Clay is designated by the EA as Unproductive Strata, which refers to deposits that have low permeability and negligible significance for water supply or river base flow.

The direction of groundwater flow within the nearby river terrace gravels is likely to be in a northerly direction, towards the River Thames, which is located approximately 0.6 km to the north. Water infiltrating the underlying London Clay will generally tend to flow vertically downwards at a very slow rate towards the lower chalk aquifer.

The permeability of the Kempton Park Gravel is expected to range between about 1×10^{-6} m/s and 1×10^{-4} m/s, whereas in contrast, any groundwater flow within the London Clay will be at a very slow rate, due to its negligible permeability. The permeability will be predominantly secondary, through fissures in the clay, and published data indicates the horizontal permeability of the London Clay to generally range between 1×10^{-11} m/s and 1×10^{-9} m/s.

Groundwater is likely to be encountered within the Kempton Park Gravel and is shown on the record of the shallow BGS borehole to the north and to the southeast to be present at depths of approximately 3.8 m and 5.0 m.

The site is mostly covered by the existing garden, with the main house and outbuildings occupying a relatively small area of the site. Rainwater will therefore mostly infiltrate into the ground beneath the site.

The site is not within an area shown by the Environment Agency to be at risk from flooding from rivers and seas and there are no Environment Agency designated Source Protection Zones (SPZs) within the vicinity. The central part of the site, approximately 75 m to the north of the proposed basement, is indicated as having a low risk of surface water flooding.

A separate flood risk assessment, undertaken by Evans Rivers and Coastal Ltd (report ref 1573/RE/02-16/01, dated February 2016), has also confirmed that there is a low risk of groundwater flooding, provided the basement is tanked, and a very low risk of surface water flooding across the site, with a low risk of flooding from sewers. As a precaution, the risk from sewer flooding should be mitigated by introducing a non-return valve to the pumped system. The site is located within Flood Zone 1 and therefore all uses of land are appropriate.

2.5 Other Information

A search of public registers and databases has been made via the Envirocheck database and relevant extracts from the search are appended. Full results of the search can be provided if required.

The search has revealed that there are no waste management facilities within 1 km of the site:
The search has revealed that there are no landfills, waste management, treatment or disposal sites within 1000 m of the site.

Two minor pollution incidents to controlled waters were reported in 1996 and 1999, 500 m to the southeast and 200 m to the northwest respectively, neither of which is likely to have had any adverse impact on the site.

The site is located within a nitrate vulnerable zone.

Reference to the National Radiological Protection Agency (NRPB, now part of the Health Protection Agency) Radon Atlas of England and Wales, indicates that the site falls within an area where less than 1% of homes are affected by radon emissions and therefore radon protective measures will not be necessary.

2.6 Preliminary Risk Assessment

Part IIA of the Environmental Protection Act 1990, which was inserted into that Act by Section 57 of the Environment Act 1995, provides the main regulatory regime for the identification and remediation of contaminated land. The determination of contaminated sites is based on a "suitable for use" approach which involves managing the risks posed by contaminated land by making risk-based decisions. This risk assessment is carried out on the basis of a source-pathway-receptor approach.

2.6.1 Source

The historical usage of the site that has been established by a historical map review and the site walkover indicates that the site does not have a potentially contaminative history by virtue of it having been a private residence for more than 100 years. There are thus no obvious likely sources of contamination on the site or in its immediate vicinity.

An above ground fuel tank is situated to the west of the driveway, against the boundary wall with Ham Street, in excess of 25 m from the area of development. The tank was observed to be in good condition, with no evidence of any leaks or spillages on the area immediately below and surrounding the tank. It is not therefore considered to represent a risk to the proposed development.

No source of landfill gas has been identified within 1000 m of the site.

2.6.2 Receptors

The use of the site for a residential end use may result in exposure to the soil and thus represents a relatively high sensitivity end-use, although it is a continuation of the existing use. Buried services are likely to come into contact with any contaminants present within the soils through which they pass and site workers are likely to come into contact with any contaminants present in the soils during demolition and construction works.

Any perched groundwater in the Kempton Park Gravel could theoretically be at risk from leaching contaminants in any made ground, and is considered to represent a moderate risk receptor. At depth the site is underlain by a non-aquifer, the London Clay, so deep groundwater is not considered to be a potential receptor.

2.6.3 Pathway

The proposed development will result in the removal of any made ground from within the footprint of the proposed basement. However, made ground will still be present in the surrounding garden and existing pathways will remain.

The Kempton Park Gravel will provide a potential pathway for contaminants to migrate onto or off site. The negligible permeability of the underlying London Clay Formation will limit the potential for groundwater percolation into the underlying chalk, and thus a pathway is not considered likely to exist to the Principal Aquifer.

The construction phase is considered to be a pathway by which site workers and new buried services may come in contact with any contamination.

There is thus considered to be limited potential for a significant contaminant pathway to be present between any potential contaminant source and a target for the particular contaminant beneath the new basement.

2.6.4 Preliminary Risk Appraisal

On the basis of the above it is considered that there is a low risk of there being a significant contaminant linkage at this site which would result in a requirement for any remediation work.

Furthermore as there is no evidence of filled ground within the vicinity of the site and there is not considered to be a potential for landfill gas to be present on or migrating towards the site: there should thus be no need to consider soil gas exclusion systems.

3.0 EXPLORATORY WORK

In order to meet the objectives described in Section 1.2, a series of three opendrive window sampler boreholes was advanced to a maximum depth of 6.0 m (1.81 m OD) in addition to which, two cable percussion boreholes were advanced to a maximum depth of 20.0 m (-12.19 m OD).

Standard Penetration Tests (SPTs) were carried out at regular intervals in each of the boreholes to provide quantitative data on the strength of soils encountered, and disturbed and undisturbed samples were recovered for subsequent laboratory examination and testing.

Four groundwater monitoring standpipes were installed to depths of 5.20 m (2.61 m OD), 5.00 m (2.81 m OD), 6.00 m (1.81 m OD) and 6.50 m (1.31 m AD) and these have been monitored on two occasions to date, approximately three weeks and five weeks after installation.

A selection of the samples recovered from the boreholes was submitted to a soil mechanics laboratory for a programme of geotechnical testing and an analytical laboratory for a programme of contamination testing.

The borehole records are appended, together with the results of the laboratory testing and a site plan indicating the exploratory locations. The levels shown on the boreholes have been interpolated from spot heights shown on a drawing provided by the consulting engineers (ref S8286, dated September 2011).

3.1 Sampling Strategy

The boreholes were positioned by GEA to provide general coverage of the area of the site, with due regard to the footprint of the proposed basement, whilst avoiding the areas of known services.

A number of samples recovered from the boreholes were submitted to a geotechnical laboratory for a programme of testing that included moisture content and Atterberg limit tests, and soluble sulphate and pH level analysis.

Four samples recovered from the made ground were subjected to analysis for a range of common industrial contaminants and contamination indicative parameters. For this investigation the analytical suite for the soil included a range of metals, total petroleum hydrocarbons (TPH), polycyclic aromatic hydrocarbons (PAH), total cyanide and monohydric phenols.

The soil samples were selected to provide a general view of the chemical conditions of the soils that are likely to be involved in a human exposure or groundwater pathway and to provide advice in respect of re-use or for waste disposal classification. The contamination analyses were carried out at an MCERTs accredited laboratory with the majority of the testing suite accredited to MCERTS standards. Details of the MCERTs accreditation and test methods are included in the Appendix together with the analytical results.

4.0 GROUND CONDITIONS

The investigation has confirmed the expected ground conditions in that, beneath a variable thickness of made ground, Kempton Park Gravel was encountered overlying the London Clay, which was proved to the full depth of the investigation.

4.1 Made Ground

The made ground generally comprised orange-brown to dark brown and greyish brown silty sand with gravel, brick fragments, occasional roots and rootlets and rare lime mortar, and was found to extend to depths of between 0.3 m (7.51 m OD) to 0.6 m (7.21 m OD), with the greatest thickness in Borehole No 3.

Apart from the presence of fragments of extraneous material noted above, no visual or olfactory evidence of contamination was observed during the fieldwork. However, four samples of the made ground have been subject to contamination testing as a precautionary measure and the results are presented in Section 4.5.

4.2 Kempton Park Gravel

The Kempton Park Gravel comprised locally loose to medium dense becoming dense orange-brown to brown sand, sandy gravel or sand and gravel, with variable amounts of gravel, occasional rootlets, and clay layers of 0.1 m to 0.3 m thickness, and was encountered to depths of between 5.8 m (2.01 m OD) and 6.3 m (1.51 m OD).

A layer of “stiff” dark brown silty sandy clay was observed in Borehole No 3 between 2.50 m (5.31 m OD) and 3.00 m (4.81 m OD).

The results of laboratory classification tests indicate that the clay of the Kempton Park Gravel is of low to medium volume change potential

No visual or olfactory evidence of contamination was observed in this stratum.

4.3 London Clay

In Borehole Nos 3, 4 and 5, the London Clay initially comprised an upper weathered layer of firm brown slightly silty clay, which was encountered to depths of between 6.00 m (1.81 m OD) and 6.60 m (1.21 m OD). Below this weathered zone, stiff becoming very stiff fissured high strength becoming very high strength fissured dark grey clay was proved to the full depth of the investigation, of 20.0 m (-12.19 m OD) .

The results of laboratory classification tests indicate that the London Clay is of high volume change potential, whilst the results from the laboratory undrained triaxial compression tests, which are plotted against depth on a graph in the appendix, indicate the clay to generally increase in strength with depth from moderate strength to very high strength.

No visual or olfactory evidence of contamination was observed in this stratum.

4.4 Groundwater

Groundwater was encountered during drilling in all five boreholes from within the Kempton Park Gravel at depths of between 4.00 m (3.81 m OD) and 5.00 m (2.81 m OD).

Monitoring of the standpipes installed in each of the boreholes has been carried out on two occasions to date, approximately three and five weeks after installation, and the results are shown in the table below.

Date	Borehole No	Depth to water (m) [Level (m AD)]
16/02/2016	1	4.70 [3.11]
	3	4.63 [3.18]
	4	4.64 [3.17]
	5	4.70 [3.11]
04/03/2016	1	4.68 [3.13]
	3	4.57 [3.24]
	4	4.58 [3.23]
	5	4.20 [3.61]*

* Top of standpipe in BH5 was found to be blocked on the second visit, with standing water trapped in the wellhead chamber. Once the blockage was cleared, the subsequent reading was affected by this water entering the installation and is not considered to be representative of the actual groundwater level on this occasion.

The levels recorded in the boreholes indicate a groundwater flow direction to the north, with a hydraulic gradient of approximately 0.005.

4.5 Soil Contamination

The table below sets out the values measured within four samples of made ground analysed; all concentrations are in mg/kg unless otherwise stated.

Determinant	BH 1: 0.25 m	BH 2: 0.30 m	BH 3: 0.30 m	BH3: 0.70 m
pH	6.3	6.3	5.9	7.1
Arsenic	27	5.7	7.8	4.1
Cadmium	0.27	<0.1	<0.1	<0.1
Chromium	23.0	28.0	16.0	12.0
Copper	16.0	9.5	16.0	4.0
Mercury	0.19	0.19	0.23	<0.1
Nickel	18.0	26.0	13.0	8.6
Lead	140.0	48.0	190.0	8.6
Selenium	<0.2	<0.2	<0.2	<0.2
Zinc	73.0	280.0	34.0	13.0
Total Cyanide	<0.5	<0.5	<0.5	<0.5
Total Phenols	<0.3	<0.3	<0.3	<0.3
Sulphide	1.6	1.2	1.1	0.84
Total PAH	2.3	<2.0	<2.0	<2.0

Determinant	BH 1: 0.25 m	BH 2: 0.30 m	BH 3: 0.30 m	BH3: 0.70 m
Benzo(a)pyrene	0.2	<0.1	<0.1	<0.1
Naphthalene	<0.1	<0.1	<0.1	<0.1
TPH	<10.0	<10.0	<10.0	<10.0
Total organic carbon %	0.75	0.58	1.0	<0.2
Notes: Figure in **bold** indicates concentration in excess of risk-based soil guideline values, as discussed in Part 2 of this report				

The results of the contamination analyses generally indicate 'typical' soil concentrations with respect to metallic and organic contaminants.

4.5.1 Generic Quantitative Risk Assessment

The use of a risk-based approach has been adopted to provide an initial screening of the test results to assess the need for subsequent site-specific risk assessments. To this end contaminants of concern are those that have values in excess of a generic human health risk based guideline values which are either that of the CLEA[1] Soil Guideline Value where available, or is a Generic Screening Value calculated using the CLEA UK Version 1.06[2] software assuming a residential end use, or is based on the DEFRA Category 4 Screening values[3]. The key generic assumptions for this end use are as follows:

- that groundwater will not be a critical risk receptor;
- that the critical receptor for human health will be a young female child aged 0 to six years old;
- that young children will not have prolonged exposure to the site;
- that the exposure duration will be six years;
- that the critical exposure pathways will be direct soil and indoor dust ingestion, consumption of homegrown produce, consumption of soil adhering to homegrown produce, skin contact with soils and dust, and inhalation of dust and vapours; and
- that the building type equates to a two-storey small terraced house

It is considered that these assumptions are acceptable for this generic assessment of this site, albeit conservative as no new pathways will be introduced and the basement excavations will result in the majority of the made ground present beneath the site.

The tables of generic screening values derived by GEA and an explanation of how each value has been derived are included in the Appendix.

Where contaminant concentrations are measured at concentrations below the generic screening value it is considered that they pose an acceptable level of risk and thus further consideration of these contaminant concentrations is not required. However, where

1 *Updated Technical Background to the CLEA Model (Science Report SC050021/SR3) Jan 2009* and Soil Guideline Value reports for specific contaminants; all DEFRA and Environment Agency.

2 Contaminated Land Exposure Assessment (CL|EA) Software Version 1.06 Environment Agency 2009

3 CL:AIRE (2013) *Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination* Final Project Report SP1010 and DEFRA (2014) *Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination* Policy Companion Document SP1010

concentrations are measured in excess of these generic screening values there is considered to be a potential that they could pose an unacceptable risk and thus further action will be required which could include;

- additional testing to zone the extent of the contaminated material and thus reduce the uncertainty with regard to its potential risk;
- site specific risk assessment to refine the assessment criteria and allow an assessment to be made as to whether the concentration present would pose an unacceptable risk at this site; or
- soil remediation or risk management to mitigate the risk posed by the contaminant to a degree that it poses an acceptable risk.

When comparing the results from the contamination testing to those in the Soil Guideline Values and Generic Guideline Values, the analysis has not revealed any concentrations in excess of the generic risk-based screening values for these contaminants. This assessment is based upon the potential for risk to human health, which at this site is considered to be the critical risk receptor.

Part 2: DESIGN BASIS REPORT

This section of the report provides an interpretation of the findings detailed in Part 1, in the form of a ground model, and then provides advice and recommendations with respect to the basement excavation, foundations and the potential impact on hydrogeology.

5.0 INTRODUCTION

It is understood that it is proposed to excavate a 5.5 m deep basement beneath the existing garden to the south of the main house, which will be locally deepened to 7.0 m to accommodate a swimming pool and will include an approximately 4.5 m deep link to the southern end of the adjoining house. The design also includes a pagoda at ground level above the southern end of the basement, which will have a stepped entrance leading down into the basement, whilst also allowing in natural light.

It is understood from information provided by the consulting engineers that the exterior loads around the perimeter of the basement structure are anticipated to be approximately 210 kN/m, whilst the individual pile loads supporting the internal columns are expected to be approximately 400 kN. Piled strips will also be included across the floor of the proposed basement with a line load of approximately 90 kN/m.

6.0 GROUND MODEL

The desk study does not indicate that the site is likely to have had a potentially contaminative history and on the basis of the fieldwork, the ground conditions at this site can be characterised as follows:

- below a limited thickness of made ground, Kempton Park Gravel overlies the London Clay Formation, which was proved to the maximum depth of the investigation of 20.00 m (-12.19 m OD);
- the made ground comprises orange-brown to dark brown and greyish brown silty sand with gravel, brick fragments, occasional roots and rootlets and rare lime mortar, and was found to extend to depths of between 0.30 m (7.51 m OD) to 0.60 m (7.21 m OD);
- the Kempton Park Gravel generally comprises locally loose to medium dense becoming dense orange-brown to brown sand, sandy gravel or sand and gravel, with occasional clay layers of between 0.10 m to 0.30 m in thickness, which extends to depths of between 5.80 m (2.01 m OD) and 6.30 m (1.51 m OD);
- the London Clay comprises an upper ‘weathered’ layer, which comprised firm brown slightly silty clay, below which stiff becoming very stiff fissured hiugh strength becoming very high strength dark grey clay was proved to the full depth of the investigation, of 20.00 m (-12.19 m OD);
- groundwater is expected to be present within the Kempton Park Gravel at depths of between 4.50 m (3.31 m OD) and 4.70 m (3.11 m OD); and
- the investigation has not indicated any evidence of contamination.

7.0 ADVICE AND RECOMMENDATIONS

Excavations for the proposed basement structure will require temporary support to maintain stability of the existing and surrounding structures and to prevent any excessive ground movements. Based on the groundwater observations to date, groundwater will be encountered towards the base of the excavation, such that some form of groundwater protection and control will be required.

Formation level for the proposed development will be within the Kempton Park Gravel or the underlying London Clay, both of which should provide an eminently suitable bearing stratum for spread foundations excavated from basement level, provided that groundwater can be adequately controlled. Alternatively, piled foundations extending into the London Clay would also provide a suitable solution.

There should not be a requirement for remediation with respect to ground contamination.

7.1 Basement Construction

It is proposed to excavate a basement beneath the garden area adjacent to the southern end of the exisitng house, which will generally extend to depths of between 4.50 m (3.31 m OD) and 5.50 m (2.31 m OD), with additional excavation across the central part of the proposed basement, to a depth of 7.00 m (0.81 m OD), for the formation of an indoor swimming pool. Formation level will be within the Kempton Park Gravel for the majority of the proposed basement structure, which extends to depths of between 5.8 m (2.01 m OD) and 6.3 m (1.51 m OD), whilst formation level for the proposed swimming pool is likely to be witin the underlying London Clay.

The investigation has indicated that groundwater is likely to be encountered within the basement excavation, although it is recommended that further monitoring is carried out to determine the extent of any seasonal fluctuations and that consideration is given to the completion of trial excavations to check the rate of groundwater inflows and to provide an indication of the stability of excavations.

The design of basement support in the temporary and permanent conditions needs to take account of the need to maintain the stability of the excavation and nearby structures, namely the existing house, and to protect against groundwater inflows.

Give the available space on the site, consideration could be given to the construction of the proposed basement within an open cut excavtion, although given the sensitivity of the existing house and the depth of the proposed basement and resulting degree of disturbance, it is understood that the preferred solution is to adopt a secant piled wall to support the majority of the basement excavations, which would have the advantage of being incorporated into the permanent works and may be able to provide support for structural loads.

Where the proposed basement joins to the existing house, it is understood that it is proposed to underpin the existing foundations to the same depth as the proposed linking structure. It is presently understood that consideration is being given to the uses of jet grouting to form the proposed underpins and careful consideration will need to be given to the most appropriate technique. In this respect permeation grouting could be considered as the grout is not injected under high pressure, with the intention being to bind with the existing soil rather than displace it, and is not therefore subject to some of the same issues as jet grouting, which relies on the grout being injected under high pressure.

Alternatively, the simplest method would be to form the retaining walls by means of concrete underpinning of the existing foundations using a traditional hit and miss approach, although this technique would require the soils being underpinned to stand unsupported, and in the Kempton Park Gravel at this site, difficulties can be encountered with unsupported excavations, particularly if groundwater is encountered. Careful workmanship would therefre be required to ensure that movement of the surrounding structures does not arise, and the contractor should have a contingency in place to deal with groundwater inflows and / or instability of the gravel soils.

The ground movements associated with the basement excavation will depend on the method of excavation and support and the overall stiffness of the basement structure in the temporary condition. Thus, a suitable amount of propping will be required to provide the necessary rigidity and the timing of the provision of support to the wall will have an important effect on movements. The stability of the existing house and nearby structures will need to be ensured at all times. Further consideration is given to these movements in Part 3.0 of this report.

7.1.1 Basement Retaining Walls

The following parameters are suggested for the design of the permanent basement retaining walls.

Stratum	Bulk Density (kg/m^3)	Effective Cohesion (c' – kN/m^2)	Effective Friction Angle Φ' – degrees)
Made ground	1700	Zero	20
Kempton Park Gravel	1800	Zero	32
London Clay	1950	Zero	23

Groundwater is likely to be encountered within the proposed excavations during construction, particularly where additional excavations are proposed for the proposed swimming pool, although monitoring of the standpipes should be continued to confirm this view, along with trial excavations.

Monitoring of the standpipe should be continued to determine the design water level at this site and advice in BS8102:2009[4] should be followed in this respect.

7.1.2 Basement Heave

The proposed development will generally comprise an excavation depth of approximately 4.5 m to 5.5 m, which will result in a net unloading of between 80 kN/m^2 and 100 kN/m^2.

Where additional excavation to a depth of 7.0 m is required to form the proposed swimming pool, the net unloading will increase to approximately 130 kN/m^2.

The unloading will result in heave of the underlying clay soils and further consideration is given to these movements in Part 3.0 of this report.

7.2 Basement Raft Foundation

Depending on the loads and whether they can be relatively uniformly distributed, it may be feasible to adopt a basement raft foundation for the proposed development.

4 BS8102 (2009) *Code of practice for protection of below ground structures against water from the ground*

It is likely, in view of the weight of the soil excavated to form the proposed basement that a raft would be subject to a net unloading. However, further consideration will need to be given to possible movements once the loads have been finalised if this foundation solution is to be considered.

7.3 Spread Foundations

The excavation of the basement will result in a formation level within the Kempton Park Gravel or underlying London Clay and, providing groundwater inflows can be controlled, it should be possible to adopt moderate width pad or strip foundations within these strata, designed to apply a minimum net allowable bearing pressure of 150 kN/m^2 below the level of the proposed basement floor.

This value has been restricted in order to prevent overstressing of the underlying London Clay and therefore provides an adequate factor of safety against bearing capacity failure, as well as ensuring that settlement remains within normal tolerable limits.

The design value should, however, be checked once the final loads and levels are known, as it is dependent on tolerable settlement and on the thickness of gravel remaining below the foundations.

7.4 Shallow Excavations

On the basis of the borehole findings it is considered that shallow excavations for foundations and services that extend through the made ground should and into the Kempton Park Gravel remain generally stable in the short term, although some instability may occur. Where personnel are required to enter excavations, a risk assessment should be carried out and temporary lateral support or battering of the excavation sides considered in order to comply with normal safety requirements.

Inflows of groundwater into shallow excavations are not generally anticipated, although seepages may be encountered from perched water tables, particularly within the vicinity of existing foundations, although such inflows should be suitably controlled by sump pumping.

7.5 Piled Foundations

For the ground conditions at this site, driven or bored piles could be adopted. Driven piles would have the advantage of minimising the spoil that is generated, but consideration would need to be given to the effects of noise and vibrations on neighbouring sites. Some form of bored pile may therefore be more appropriate.

A conventional rotary augered pile could be considered, although to avoid any requirement for casing through the gravel, which would probably need to be vibrated to reach the London Clay, bored piles installed using continuous flight auger (cfa) techniques are likely to be more appropriate.

The following table of ultimate coefficients may be used for the preliminary design of bored piles from proposed basement level, based on the measured SPT and cohesion / depth and level graph in the appendix.

Stratum	Depths m	kN / m²
Ultimate Skin Friction		
Basement Excavation	GL to 5.5	Ignore
Kempton Park Gravel (Ks = 0.7, Φ' = 32°)	5.5 to 6.0	Ignore
London Clay (α = 0.5)	6.0 to 20.0	Increasing linearly from 35 to 85
Ultimate End Bearing		
London Clay	10.0 to 20.0	Increasing linearly from 900 to 1530

In the absence of pile tests, guidance from the London District Surveyors Association (LDSA)[5] suggests that a factor of safety of 2.6 should be applied to the above coefficients in the computation of safe theoretical working loads.

On this basis the following safe working loads have been estimated for 300 mm, 450 mm and 600 mm diameter piles bearing at depths of 14 m, 16 m and 18 m below, or equivalent to 8.5 m, 10.5 m and 12.5 m below the depth of proposed basement respectively.

Pile Diameter mm	Formation level m [m OD]	Pile length m	Safe Working Load kN
300	14.00 (-6.19]	8.5	190
	16.00 [-8.19]	10.5	230
	18.00 [-10.19]	12.5	285
450	14.00 (-6.19]	8.5	310
	16.00 [-8.19]	10.5	375
	18.00 [-10.19]	12.5	455
600	14.00 (-6.19]	8.5	445
	16.00 [-8.19]	10.5	535
	18.00 [-10.19]	12.5	645

The above examples are not intended to constitute any form of recommendation with regard to pile size or type, but merely serve to illustrate the use of the above coefficients. Specialist piling contractors should be consulted with regard to the design of an appropriate piling scheme and their attention should be drawn to potential groundwater inflows within the made ground and Kempton Park Gravel, as well as silt and sand partings and claystones within the London Clay.

7.6 Basement Floor Slab

Unless a raft is adopted, it is possible that the floor slab for the proposed basement may need to be suspended over a void or a layer of compressible material to accommodate the anticipated heave of the underlying London Clay, unless the slab can be suitably reinforced to cope with these movements. This should be reviewed once the levels and loads are known.

5 LDSA (2009) *Foundations No 1 – Guidance notes for the design of straight shafted bored piles in London Clay*. LDSA Publications

7.7 Effect of Sulphates

Chemical analyses of a sample of the London Clay has revealed low concentrations of soluble sulphate, corresponding to Class DS-1 and ACEC AC-1s of Table C1 of BRE Special Digest 1 Part C (2005).

The guidelines contained in the above digest should be followed in the design of foundation concrete.

7.8 Site Specific Risk Assessment

The site is not considered to have had a historical contaminative use and no elevated concentrations of contaminants were measured by the chemical analyses.

Remedial measures to protect sensitive receptors, including end users, are not therefore deemed necessary. However, in accordance with standard construction practice, a safe programme of working should be identified to protect workers handling any soil.

7.8.1 Site Workers

Site workers should be made aware of the potential for the presence of contaminated material within the made ground and in accordance with standard construction practice, a safe programme of working should be identified to protect workers handling any soil.

The method of site working should be in accordance with guidelines set out by HSE[6] and CIRIA[7] and the requirements of the Local Authority Environmental Health Officer.

In addition, it is also recommended that a watching brief be maintained during ground works and any suspected contamination, especially in areas not covered by the investigation, should be brought to the attention of a geoenvironmental engineer.

7.9 Waste Disposal

Under the European Waste Directive, waste is classified as being either Hazardous or Non-Hazardous and landfills receiving waste are classified as accepting hazardous or non-hazardous wastes or the non-hazardous sub-category of inert waste in accordance with the Waste Directive. Waste classification is a staged process and this investigation represents the preliminary sampling exercise of that process. Once the extent and location of the waste that is to be removed has been defined, further sampling and testing may be necessary. The results from this ground investigation should be used to help define the sampling plan for such further testing, which could include WAC leaching tests where the totals analysis indicates the soil to be a hazardous waste or inert waste from a contaminated site. It should however be noted that the Environment Agency guidance WM3[8] states that landfill WAC analysis, specifically leaching test results, must not be used for waste classification purposes.

Any spoil arising from excavations or landscaping works, which is not to be re-used in accordance with the CL:AIRE[9] guidance, will need to be disposed of to a licensed tip. Waste going to landfill is subject to landfill tax at either the standard rate of £82.60 per tonne (about £150 per m^3) or at the lower rate of £2.60 per tonne (roughly £5 per m^3). However, the

6 HSE (1992) HS(G)66 *Protection of workers and the general public during the development of contaminated land* HMSO
7 CIRIA (1996) *A guide for safe working on contaminated sites* Report 132, Construction Industry Research and Information Association
8 Environment Agency 2015. *Guidance on the classification and assessment of waste.* Technical Guidance WM3 First Edition
9 CL:AIRE March 2011. *The Definition of Waste: Development Industry Code of Practice* Version 2

classifications for tax purposes and disposal purposes differ and currently all made ground and topsoil is taxable at the 'standard' rate and only naturally occurring soil and stones, which are accurately described as such in terms of the 2011 Order, would qualify for the 'lower rate' of landfill tax.

Based upon on the technical guidance provided by the Environment Agency it is considered likely that the soils encountered during this ground investigation, as represented by the four chemical analyses, would be generally classified as follows;

Soil Type	Waste Classification (Waste Code)	WAC Testing Required Prior to Landfill Disposal?	Comments
Made ground	Non-hazardous (17 05 04)	No	-
Kempton Park Gravel	Inert (17 05 04)	Should not be required but confirm with receiving landfill	-
London Clay			

Under the requirements of the European Waste Directive all waste needs to be pre-treated prior to disposal. The pre-treatment process must be physical, thermal, chemical or biological, including sorting. It must change the characteristics of the waste in order to reduce its volume, hazardous nature, facilitate handling or enhance recovery. The waste producer can carry out the treatment but they will need to provide documentation to prove that this has been carried out. Alternatively, the treatment can be carried out by an approved contractor. The Environment Agency has issued a position paper[10] which states that in certain circumstances, segregation at source may be considered as pre-treatment and thus excavated material may not have to be treated prior to landfilling if the soils can be segregated onsite prior to excavation by sufficiently characterising the soils insitu prior to excavation.

The above opinion with regard to the classification of the excavated soils is provided for guidance only and should be confirmed by the receiving landfill once the soils to be discarded have been identified.

The local waste regulation department of the Environment Agency (EA) should be contacted to obtain details of tips that are licensed to accept the soil represented by the test results. The tips will be able to provide costs for disposing of this material but may require further testing.

8.0 HYDROGEOLOGICAL ASSESSMENT

The current development proposal includes the excavation of a basement to depths of between 4.5 m (3.31 m OD) and 7.0 m (0.81 m OD) below the existing ground level.

Monitoring of the standpipe has indicated that groundwater is likely to be present within the Kempton Park Gravel at depths of between 4.50 m (3.31 m OD) and 4.70 m (3.11 m OD) and that groundwater flow is in a northerly direction across the site.

The proposed basement will extend below the water table and is likely to key into the London Clay, but it will not act as a barrier to flow by filling space laterally, as there is amplespace for groundwater to flow around the proposed basement structure.

10 Environment Agency 23 Oct 2007 *Regulatory Position Statement Treating non-hazardous waste for landfill - Enforcing the new requirement*

On this basis, it is considered that the groundwater will follow a pathway around the proposed basement and will not build up significantly behind it. The basement should not, therefore, have any discernible effect on groundwater flow.

Part 3: GROUND MOVEMENT ANALYSIS

This section of the report comprises an analysis of the ground movements arising from the proposed basement and foundation scheme discussed in Part 2 and the information obtained from the investigation, presented in Part 1 of the report.

9.0 INTRODUCTION

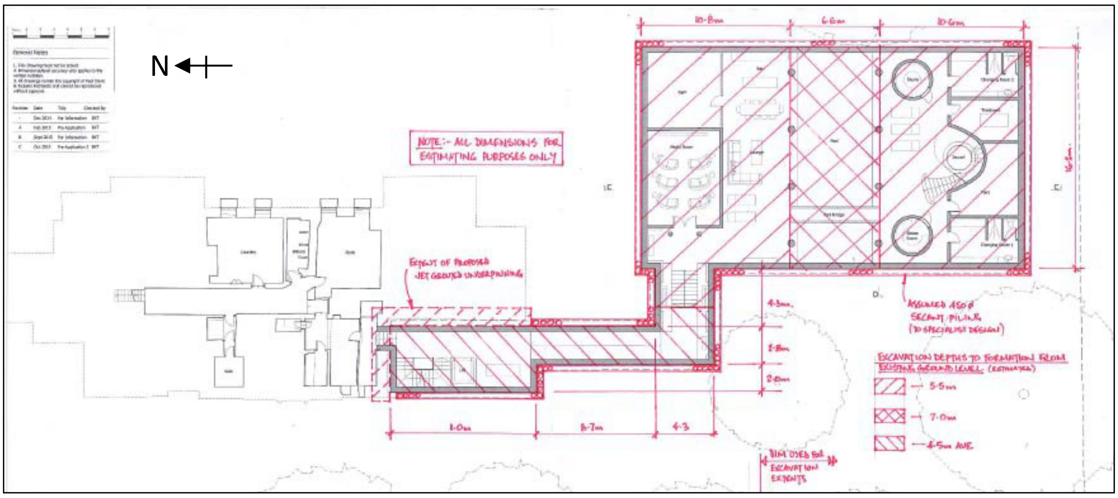
The sides of a basement excavation will move to some extent regardless of how they are supported. The movement will typically be both horizontal and vertical and will be influenced by the engineering properties of the ground, groundwater level and flow, the efficiency of the various support systems employed during underpinning and the efficiency or stiffness of any support structures used.

An analysis has been carried out of the likely movements arising from the proposed basement excavation and the results of this analysis have been used to predict the effect of these movements on surrounding structures. The damage assessment is considered to represent a reasonable estimate of movements at this stage and offer a simple 'global' view of the movement contours around the site.

10.0 CONSTRUCTION SEQUENCE

The following sequence of operations has been derived to enable analysis of the ground movements around the basement both during and after construction and is based upon the preferred construction method of adopting a secant piled wall to form the majority of the new basement structure, as shown on the drawing below.

Underpining of the adjoining house is proposed, where the new basement will be joined to the existing house.



Essentially the sequence may be considered as two groups of activities, the first comprising the short term temporary works, whilst the second represents the construction of the permanent works.

The detail of the support provided to adjacent walls is beyond the scope of this report at this stage and the structural engineer will be best placed to agree a methodology with the piling contractor once appointed. However, it is assumed that propping of all walls will take place through the temporary and permanent works.

10.1 Temporary Support to Underpinned Sections

The exact proposals are not known at this stage. However, it is understood that underpinning to deepen the foundations of the existing house, where the proposed linking structure will join to the existing basement structure, will be undertaken through jet grouting.

10.2 Temporary Support to Piled Walls

Following installation of the bored pile wall and capping beams at ground floor level, temporary props will be installed and the basement excavation will proceed. The details of section sizes and spacings will be finalised by the contractor but it is anticipated that the general philosophy adopted will be for diagonal braces to be used across the corners or returns of the basement walls whilst props will be positioned at regular intervals along the long walls of the basement. Where horizontal restraint cannot be provided by other parts of the piled wall the prop forces will be provided by so-called ‘flying shores’ where the reaction to horizontal forces is provided by pile caps, gravity blocks or basement thickenings in the centre of the excavation.

It is anticipated that steel temporary props will be used with strut forces spread along the wall by steel waling beams fixed to the piles. Although the detail of the propping is to be finalised there is the option to use hydraulic ‘active’ props where the propping force is applied prior to excavation in order to minimise movement at critical locations.

Excavation will proceed in stages and in broad terms the order of operations will be install capping beam props, excavate to a suitable depth below the next propping level, install props and then repeat the operation until the final excavation level has been reached.

10.3 Permanent Works

When the final excavation depths have been reached the permanent works will be formed, which are likely to comprise reinforced concrete walls with a drained cavity lining the inside of the bored pile wall. Reinforced concrete will be used for floor slabs and it is anticipated that heave protection will be installed beneath the lowest slabs.

It is anticipated that the floor slabs will be constructed lowest level first and when each floor has achieved adequate strength, the temporary props will be removed and the subsequent walls and floors cast until the structure is complete.

11.0 GROUND MOVEMENTS

An assessment of ground movements within and surrounding the excavation has been undertaken using the X-Disp and P-Disp computer programs licensed from the OASYS suite of geotechnical modelling software from Arup. These programs are commonly used within the ground engineering industry and are considered to be appropriate tools for this analysis.

The X-Disp (Version 19.3.1.35) program has been used to predict ground movements likely to arise from the construction of the proposed basement. This includes the settlement of the ground (vertical movement) and the lateral movement of soil behind the proposed retaining walls (horizontal movement).

The analysis of potential ground movements within the excavation, as a result of unloading of the underlying soils, has been carried out using the Oasys P-Disp (Version 19.3.0.4) software package and is based on the assumption that the soils behave elastically, which provides a reasonable approximation to soil behaviour at small strains.

For the purpose of these analyses, the corners have been defined by x and y coordinates, with the x-direction parallel with the orientation of Ham Street (approx. north-south), whilst the y-direction is parallel with the orientation of the Sandy Lane (approx. east-west). Vertical movement is in the z-direction.

Due to shape the of the proposed basement, which includes a linking structure between the main excavation and the adjoining house, it has been necessary to divide the proposed footprint up into a number of individual rectangles for the purpose of the analysis. Whilst this does mean that the model more closely reflects the actual basement construction, an artefact of the way that the software works means that, where individual areas meet, there is an interaction between the predicted movements calculated for each area, which leads to an overestimate of the likely movements where this overlap occurs, such that the model can be considered to be extremely conservative in these areas.

It is assumed that suitable propping will be provided during the construction of the basement and in the permanent condition, such that the walls can be considered to be stiff for the purpose of the ground movement modelling. Contour plots and the full outputs of the analyses are included in the appendix.

11.1 Ground Movements – Surrounding the Basement

11.1.1 Model Used

For the X-Disp analysis, the soil movement relationships used for the embedded retaining walls are the default values within CIRIA report C580[11], which were derived from a number of historic case studies of the short term movements that result from wall installation and basement excavation.

For the new basement construction, which will be formed through secant piling, the ground movement curves for 'installation of secant bored pile wall in stiff clay' have been adopted as being most appropriate for modelling the likely ground movements during the installation phase, as it is assumed that the piles will be embedded into the underlying London Clay.

11 Gaba, A, Simpson, B, Powrie, W and Beadman, D (2003) *Embedded retaining walls – guidance for economic design* .CIRIA Report C580.

On this site it is assumed that underpinning to deepen the foundations of the existing basement beneath the house, that abut the proposed linking structure, will be supported or propped in the temporary condition to maintain its stability during the excavation and that reinforced concrete retaining walls will be cast at a later stage in the appropriate areas. On this basis it is considered reasonable to adopt the ground movement curves for 'no horizontal and vertical movement' for this analysis of the underpinning in these areas.

As it is assumed that the piles will be embedded into the underlying London Clay, the ground movement curves for 'excavations in front of a high stiffness wall in stiff clay' have then been adopted to provide an estimate of the likely movements from the subsequent excavations.

11.1.2 Results

The movements predicted by X-Disp are summarised in the table below; the results are presented below and in subsequent tables to the degree of accuracy required to allow predicted variations in ground movements around the structure to be illustrated, but may not reflect the anticipated accuracy of the predictions.

Phase of Works	Wall Movement (mm)	
	Vertical Settlement	Horizontal Movement
Pile Installation	4.0 to 10.0	6.0 to 10.0
Basement Excavation	2.0 to 10.0	7.5 to 12.5
Combined Movements	5.0 to 20.0	10.0 to 20.0

The analysis has indicated that the maximum vertical and horizontal settlements that will result from underpinning are less than 10.0 mm, whilst the maximum vertical and horizontal settlements that will take place behind the walls as a result of the basement excavations are unlikely to exceed 12.5 mm.

The vertical and horizontal movements arising from the combined underpinning and excavation phases are therefore unlikely to exceed a maximum vaule of 20.0 mm.

The estimated movements are considered to represent a worst case scenario, particularly as the movements resulting from basement excavation will be minimised due to control of the propping in the temporary works and a regime of monitoring.

11.2 Movements within the Excavation (Heave)

11.2.1 Model Used

At this site unloading of the London Clay will take place as a result of the sub-basement excavation and the reduction in vertical stress will cause heave to take place. Undrained soil parameters have been used to estimate the potential short term movements, which include the "immediate" or elastic movements as a result of the basement excavation. Drained parameters have been used to provide an estimate of the total movement, from which the post-construction or long term movements can be calculated.

The elastic analysis requires values of soil stiffness at various levels to calculate displacements. Values of stiffness for the soils at this site are readily available from published data and we have used a well-established method to provide our estimates. This relates values of E_u and E', the drained and undrained stiffness respectively, to values of undrained cohesion, as described by Padfield and Sharrock[12] and Butler[13] and more recently by O'Brien and Sharp[14]. Relationships of E_u = 500 C_u and E' = 300 C_u for the cohesive soils and 2000 x SPT 'N' for granular soils have been used to obtain values of Young's modulus. More recent published data[15] indicates stiffness values of 750 x Cu for the London Clay and a ratio of E' to Cu of 0.75, but it is considered that the use of the more conservative values provides a sensible approach for this stage in the design.

The proposed development will generally comprise a maximum excavation depth of approximately 4.5 m to 5.5 m, which will result in a net unloading of between 80 kN/m^2 and 100 kN/m^2. Where additional excavation to a depth of 7.0 m is required to form the proposed swimming pool, the net unloading will increase to approximately 130 kN/m^2.

A rigid boundary for the analysis has been set within the London Clay at a depth of about 53 m (approx. -45 m AD) below existing ground level, below which relatively incompressible soils of the Lambeth Group and underlaying Thanet Sand are present.

11.2.2 Results

An assessment of ground movements within the basement excavation has been undertaken by GEA using the P-Disp computer program licensed from the OASYS suite of programmes from Arup. The predicted movements are summarised in the table below.

Location	Movement (mm)		
	Short-term Heave (Excavation Phase)	Long-term Heave (post construction)	Total Heave
Centre of excavations	12 to 24	8 to 21	20 to 45
Edge of excavations	8 to 12	2 to 8	10 to 20

The P-Disp analysis indicates that, by the time the basement construction is complete, up to 12 mm to 24 mm of heave is likely to have taken place at the centre of the proposed excavations, reducing to between 8 mm and 12 mm at the edges.

In the long term, following completion of the basement construction, a further 8 mm to 21 mm of heave is estimated as a result of long term swelling of the underlying clay soils.

The results of the P-Disp analysis also indicate the likely impact of the proposed basement construction beyond the site boundaries. It is, however, important to bear in mind that the figures in the above table are based on an unrestrained excavation as the model is unable to take account of the mitigating effect of the existing (or proposed) structures, the stiffness of the proposed floor slab and the retaining structures, which in reality will combine to restrict these movements within the basement excavation. The movements predicted at or just beyond the site boundaries are unlikely to be fully realised and should not therefore have a detrimental impact upon any nearby structures.

In order to mitigate the effects of heave on the new building, the basement could be designed to transmit heave forces into the wall piles or onto tension piles within the basement.

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12 Padfield CJ and Sharrock MJ (1983) *Settlement of structures on clay soils*. CIRIA Special Publication 27

13 Butler FG (1974) *Heavily overconsolidated clays: a state of the art review*. Proc Conf Settlement of Structures, Cambridge, 531-578, Pentech Press, London.

14 O'Brien AS and Sharp P (2001) *Settlement and heave of overconsolidated clays - a simplified non-linear method.* Part Two, Ground Engineering, Nov 2001, 48-53

15 Burland JB, Standing, JR, and Jardine, FM (2001) Building response to tunnelling, case studies from construction of the Jubilee Line Extension. CIRIA Special Publication 200

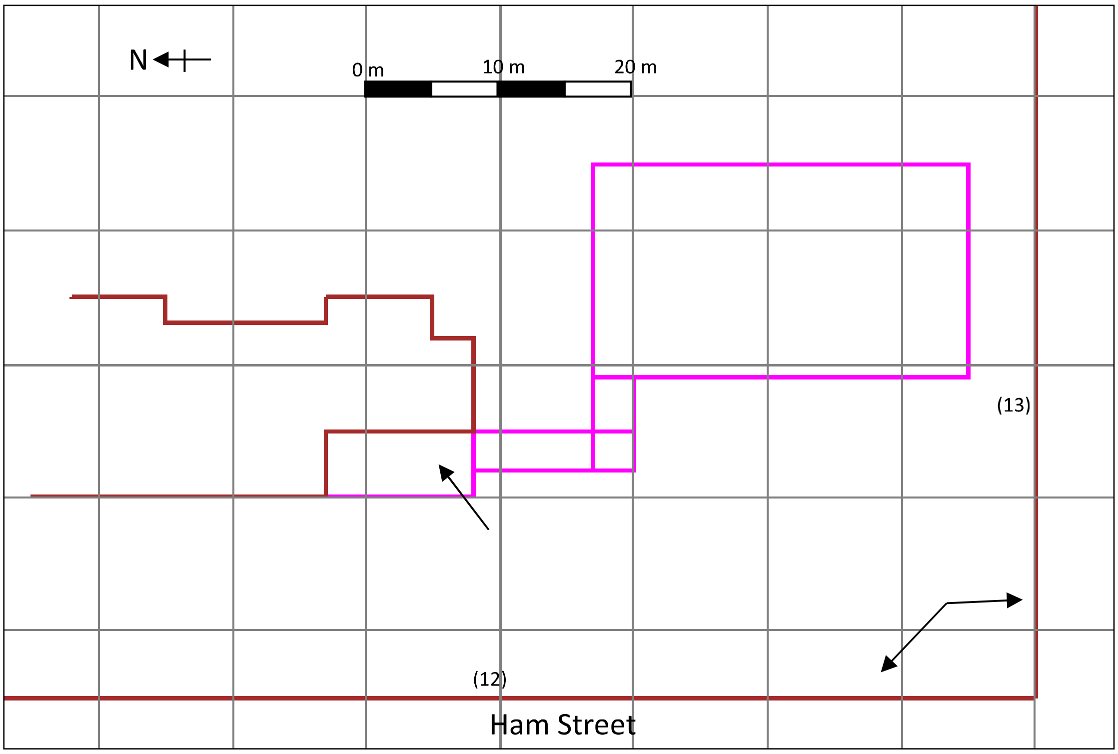
If a compressible material is used beneath the slab, it will need to be designed to be able to resist the potential uplift forces generated by the ground movements. In this respect potential heave pressures are typically taken to equate to around 50% of the total unloading pressure.

12.0 DAMAGE ASSESSMENT

In addition to the assessment of the likely movements that will result from the proposed development, some of the neighbouring structures have been set as sensitive structures, requiring Building Damage Assessments, on the basis of the classification given in Table 2.5 of C580, as follows:

- The Grade II listed Manor House, located to the north of the main excavation;
- the boundary wall with Ham Street to the west; and
- the boundary wall with Sandy Lane to the south.

The sensitive structures outlined above have been modelled as lines in the analysis and are the lines along which the damage assessment has been undertaken. The location of each of the buildings or sensitive structure is detailed on the plan below.



The critical lines are expected to be sensitive at their foundation level, which for the purpose of this analysis have been set at a depth of approxiamtley 1.0 m below ground level (approx. 7.0 m OD).

12.1 Damage to Neighbouring Structures

The combined movements resulting from pile installation and basement excavation calculated using the X-Disp modelling software have been used to carry out an assessment of the likely damage to adjacent properties and the results are summarised in the table below.

Building Damage Assessment		
Sensitive Structure	**Elevation**	**Category of Damage***
The Manor House	Frontage (1)	Category 0 (Negligible)
	South Elevation (2)	Category 0 (Negligible)
	South Elevation (3)	Category 1 (Very Slight)
	South Elevation (4)	Category 0 (Negligible)
	South Elevation (5)	Category 1 (Very Slight)
	South Elevation (6)	Category 0 (Negligible)
	East Elevation (7)	Category 1 (Very Slight)
	East Elevation (8)	Category 0 (Negligible)
	East Elevation (9)	Category 0 (Negligible)
	East Elevation (10)	Less than the limit of sensitivity
	East Elevation (11)	Less than the limit of sensitivity
Boundary wall with Ham Street	Brick Wall (12)	Category 0 (Negligible)
Boundary wall with Sandy Lane	Brick Wall (13)	Category 0 (Negligible)

**From Table 2.5 of C580: Classification of visible damage to walls.*

The building damage reports for sensitive structures highlighted in the above table predict that the damage to the adjoining and nearby structures will generally be Category 0 (Negligible), with limited sections of Category 1 (Very Slight) damage to parts of the existing Manor House (Elevation Nos 3, 5 and 7).

It should be noted that the results discussed above are based on individual building lines, or walls, which have been further divided up into a series of segments that can move independently of each other. In reality this is unlikely to be the case as the walls will behave as single stiff elements that are also joined continuously with the rest of the structure. The results therefore provide a conservative estimate of the behaviour of each of the sensitive structures, although they provide a useful indication of the most critical sections / elevations within the adjoining structures.

12.2 Monitoring of Ground Movements

The predictions of ground movement based on the ground movement analysis should be checked by monitoring of adjacent properties and structures. The structures to be monitored during the construction stages should include:

- The existing Grade II Listed Manor House; and
- the boundary wall with Sandy Lane.

Condition surveys of the above existing structures should be carried out before and after the proposed works.

The precise monitoring strategy will be developed at a later stage and it will be subject to discussions and agreements with the owners of the adjacent properties and structures. Contingency measures will be implemented if movements of the adjacent structures exceed predefined trigger levels. Both contingency measures and trigger levels will need to be developed within a future monitoring specification for the works.

13.0 CONCLUSIONS

The analysis has concluded that the predicted damage to the neighbouring properties would generally be 'negligible', with the exception of some limited sections of Category 1 (Very Slight) damage the the existing Manor House (Elevation No 3, 5 and 7).

It is important to bear in mind that the results provide a conservative estimate of the behaviour of each of the sensitive structures and that in reality the predicted movements are unlikely to be fully realised. However, they do provide a useful indication of the most critical within the adjoining properties and identify where mitigation measures should be implemented to ensure they are not adversely affected by the proposed development.

On this basis, the damage that would inevitably occur as a result of such an excavation would fall within acceptable limits, although monitoring and mitigation measures will be required to ensure that no excessive movements occur that would lead to damage in excess of these limits.

In practice, demolition of the existing extension building, underpinning of the existing foundations and the subsequent excavation of the proposed basement, will be staged processes and will take place over a number of weeks. This will provide an opportunity for the ground movements during and immediately after the installation of the retaining walls to be measured and the data acquired can be fed back into the design and compared with the predicted values. Such a comparison will allow the ground model to be reviewed and the predicted wall movements to be reassessed prior to the main excavation taking place, so that propping arrangements can be adjusted if required.

14.0 OUTSTANDING RISKS AND ISSUES

This section of the report aims to highlight areas where further work is required as a result of limitations on the scope of this investigation, or where issues have been identified by this investigation that warrant further consideration. The scope of risks and issues discussed in this section is by no means exhaustive, but covers the main areas where additional work may be required.

The ground is a heterogeneous natural material and variations will inevitably arise between the locations at which it is investigated. This report provides an assessment of the ground conditions based on the discrete points at which the ground was sampled, but the ground conditions should be subject to review as the work proceeds to ensure that any variations from the Ground Model are properly assessed by a suitably qualified person.

Monitoring of the standpipes should be carried out to determine equilibrium groundwater levels and to establish any seasonal fluctuations. Ideally, trial excavations extending to as close to the full depth of the proposed basement as possible should be carried out to determine likely groundwater inflows into the basement excavation.

The investigation has not identified the presence of any contamination and as such remedial measures should not be required. However, as with any site there is a potential for areas of contamination to be present within the made ground beneath parts of the site not covered by the investigation it is recommended that a watching brief is maintained during any groundworks for the proposed new foundations and that if any suspicious soils are encountered that they are inspected by a geoenvironmental engineer and further assessment may be required.

Monitoring of the standpipes should be carried out to determine equilibrium groundwater levels and to establish any seasonal fluctuations. Ideally, trial excavations extending to as close to the full depth of the proposed basement as possible should be carried out to determine likely groundwater inflows into the basement excavation.

The findings of the ground movement analysis and damage assessment should be reviewed once the design proposals have been finalised, particularly if any changes are made to the proposed basement construction.

These areas of doubt should be drawn to the attention of prospective contractors and further investigation will be required or sufficient contingency should be provided to cover the outstanding risk.

APPENDIX

Borehole Records

Laboratory Geotechnical Test Results

SPT & Cohesion / Depth & Level Graph

Chemical Analyses (Soil)

Generic Risk-Based Soil Guideline Values

SOIL DISPLACEMENT MODEL RESULTS

X-DISP ANALYSIS

Pile Installation

Contour Plots of Vertical Movements and Horizontal Movements

Basement Excavation

Contour Plots of Vertical Movements

Pile Installation and Basement Excavation

Contour Plots of Combined Vertical Movements and Horizontal Movements

P-DISP ANALYSIS

Short Term Movement

Total Movement

BUILDING DAMAGE ASSESSMENT (X-DISP)

Tabular Output of Results

Envirocheck Extracts

Historical Maps

Flood Risk Assessment

Site Plan

GEA Geotechnical & Environmental Associates	Widbury Barn, Widbury Hill, Ware, Herts, SG12 7QE	Site: The Manor House, Ham Street, Richmond, TW10 7HA	Number: **BH1**

Excavation Method	Dimensions	Ground Level (mOD)	Client	Job Number
Opendrive lined percussive sampler	110mm to 1.00m	7.81	Primus Inter Pares Limited	J16002
	Location	**Dates**	**Engineer**	**Sheet**
		26/01/2016	MP	1/1

Depth (m)	Sample / Tests	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
				7.71	(0.10) 0.10	Topsoil		
0.25	D1			7.51	(0.20) 0.30	Made Ground (orange-brown slightly silty sand with flint gravel and frequent brick fragments)		
0.75	D2					Locally loose to medium dense orange-brown fine to coarse SAND with gravel, roots and rootlets; clayey bands at 1.9 m to 2.0 m and 3.9 m to 4.0 m; gravel content increasing with depth		
1.00-1.45	SPT N=4		0,1/0,1,1,2					
1.50	D3							
1.90	D4							
2.00-2.45	CPT N=18		2,4/4,5,4,5					
2.50	D5							
3.00-3.45	SPT N=6		1,2/1,2,2,1		(5.50)			
3.50	D6							
4.00-4.45	CPT N=8		2,1/2,2,2,2					
4.50	D7							
			Slow Inflow(1) at 5.00m, not sealed.					∇1
5.00-5.45	CPT N=23		2,3/5,6,5,7					
5.50	D8							
				2.01	5.80 (0.20)	Medium dense brown sandy GRAVEL		
6.00-6.45	CPT N=15		3,2/3,3,4,5	1.81	6.00			
						Complete at 6.45m		

Remarks
Groundwater monitoring standpipe installed to 5.2 m
Borehole collapsed to 5.0 m on completion of SPT at 6.0 m

Scale (approx)	Logged By
1:50	JS / MP

Figure No. J16002.BH1

Geotechnical & Environmental Associates

Widbury Barn
Widbury Hill
Ware,Herts
SG12 7QE

Site	Borehole Number
The Manor House, Ham Street, Richmond, TW10 7HA	BH1

Installation Type	Dimensions	Client	Job Number
Standpipe	Internal Diameter of Tube [A] = 30 mm Internal Diameter of Tube [B] = 60 mm	Primus Inter Pares Limited	J16002

Location	Ground Level (mOD)	Engineer	Sheet
	7.81	MP	1/1

Legend	Water	Instr (A)	Level (mOD)	Depth (m)	Description
					Bentonite Seal
			6.81	1.00	
	∇1				Slotted Standpipe
			2.61	5.20	
					General Backfill
			1.36	6.45	

Groundwater Strikes During Drilling

Date	Time	Depth Struck (m)	Casing Depth (m)	Inflow Rate	Readings 5 min	Readings 10 min	Readings 15 min	Readings 20 min	Depth Sealed (m)
26/01/16		5.00	1.00	Slow Inflow					NOT

Groundwater Observations During Drilling

Date	Start of Shift					End of Shift				
	Time	Depth Hole (m)	Casing Depth (m)	Water Depth (m)	Water Level (mOD)	Time	Depth Hole (m)	Casing Depth (m)	Water Depth (m)	Water Level (mOD)

Instrument Groundwater Observations

Inst. [A] Type : Slotted Standpipe

Date	Instrument [A]			Remarks
	Time	Depth (m)	Level (mOD)	
16/02/16		4.70	3.11	
04/03/16		4.68	3.13	

Remarks

GEA Geotechnical & Environmental Associates	Widbury Barn Widbury Hill Ware,Herts SG12 7QE	**Site** The Manor House, Ham Street, Richmond, TW10 7HA	**Number** **BH2**

Excavation Method	**Dimensions**	**Ground Level (mOD)**	**Client**	**Job Number**
Opendrive lined percussive sampler	110mm to 1.00m	7.81	Primus Inter Pares Limited	J16002
	Location	**Dates** 26/01/2016	**Engineer** MP	**Sheet** 1/1

Depth (m)	Sample / Tests	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
				7.66	(0.15) 0.15	Topsoil		
0.30	D1			7.31	(0.35) 0.50	Made Ground (brown sand with gravel, brick fragments, roots and rootlets)		
0.70	D2					Locally loose to medium dense brown fine to medium SAND with occasional gravel, roots and rootlets; clay content increasing from 2.7 m to 2.9 m; gravel content increasing with depth		
1.00-1.45	SPT N=5		1,0/1,1,1,2					
1.50	D3							
2.00-2.45	CPT N=7		1,1/1,2,2,2					
2.50	D4							
3.00-3.45	CPT N=22		3,4/6,6,5,5		(5.50)			
3.50	D5							
4.00-4.45	CPT N=4		1,1/1,1,1,1					
4.50	D6		Slow Inflow(1) at 4.50m, not sealed.					∇1
5.00-5.45	CPT N=12		2,3/3,3,3,3					
6.00-6.45	CPT N=17		4,2/4,3,5,5	1.81	6.00			
						Complete at 6.45m		

Remarks	**Scale (approx)**	**Logged By**
Borehole collapsed to 4.1 m upon completion of SPT at 6.0 m	1:50	JS / MP
	Figure No. J16002.BH2	

Geotechnical & Environmental Associates

Widbury Barn
Widbury Hill
Ware,Herts
SG12 7QE

Site The Manor House, Ham Street, Richmond, TW10 7HA				**Number** BH3
Excavation Method Opendrive lined percussive sampler	**Dimensions** 110mm to 1.00m	**Ground Level (mOD)** 7.81	**Client** Primus Inter Pares Limited	**Job Number** J16002
	Location	**Dates** 26/01/2016	**Engineer** MP	**Sheet** 1/1

Depth (m)	Sample / Tests	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
				7.71	(0.10) 0.10	Topsoil		
0.30	D1			7.21	(0.50) 0.60	Made Ground (dark brown to grey-brown slightly silty sand with frequent gravel, roots and rootlets; occasional brick fragments and lime mortar)		
0.70	D2					Loose becoming mdium dense orange-brown fine to medium SAND with occasional roots and rootlets; clay content increasing from 1.5 m to 1.8 m; gravel layer from 2.0 m to 2.4 m		
1.00-1.45	SPT N=2		1,0/1,0,0,1					
1.50	D3				(1.90)			
2.00-2.45	CPT N=10		2,2/3,3,2,2					
				5.31	2.50			
					(0.50)	"Stiff" dark brown silty sandy CLAY; desiccated soil		
2.75	D4			4.81	3.00			
3.00-3.45	CPT N=45		8,13/14,13,9,9			Initially dense becoming medium dense orange-brown fine to coarse SAND with gravel		
3.50	D5							
4.00-4.45	CPT N=17		3,4/5,4,4,4					
4.50	D6				(2.80)			
			Slow Inflow(1) at 5.00m, not sealed.					∇1
5.00-5.45	CPT N=21		3,5/5,5,6,5					
5.50	D7			2.01	5.80			
5.90	D8			1.81	(0.20) 6.00	Firm brown slightly silty CLAY		
						Complete at 6.00m		

Remarks
Groundwater monitoring standpipe installed to 5.0 m
After reaching 6.0 m, borehole collapsed to 5.0 m preventing compeltion of SPT from 6.0 m

Scale (approx) 1:50	**Logged By** JS / MP
Figure No. J16002.BH3	

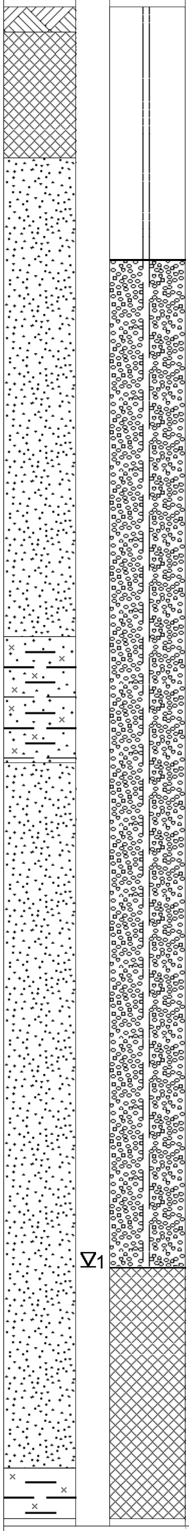
Geotechnical & Environmental Associates

Widbury Barn
Widbury Hill
Ware,Herts
SG12 7QE

Site	Borehole Number
The Manor House, Ham Street, Richmond, TW10 7HA	BH3

Installation Type	Dimensions	Client	Job Number
Standpipe	Internal Diameter of Tube [A] = 30 mm Internal Diameter of Tube [B] = 60 mm	Primus Inter Pares Limited	J16002

Location	Ground Level (mOD)	Engineer	Sheet
	7.81	MP	1/1



Legend	Water	Instr (A)	Level (mOD)	Depth (m)	Description
					Bentonite Seal
			6.81	1.00	
					Slotted Standpipe
	∇1		2.81	5.00	
					General Backfill
			1.81	6.00	

Groundwater Strikes During Drilling

Date	Time	Depth Struck (m)	Casing Depth (m)	Inflow Rate	Readings 5 min	10 min	15 min	20 min	Depth Sealed (m)
26/01/16		5.00	1.00	Slow Inflow					NOT

Groundwater Observations During Drilling

Date	Start of Shift					End of Shift				
	Time	Depth Hole (m)	Casing Depth (m)	Water Depth (m)	Water Level (mOD)	Time	Depth Hole (m)	Casing Depth (m)	Water Depth (m)	Water Level (mOD)

Instrument Groundwater Observations

Inst. [A] Type : Slotted Standpipe

Date	Instrument [A]			Remarks
	Time	Depth (m)	Level (mOD)	
16/02/16		4.63	3.18	
04/03/16		4.57	3.24	

Remarks

Geotechnical & Environmental Associates (GEA) — Widbury Barn, Widbury Hill, Ware, Herts, SG12 7QE	Site: The Manor House, Ham Street, Richmond, TW10 7HA	Borehole Number: BH4

Boring Method	Casing Diameter	Ground Level (mOD)	Client	Job Number
Cable Percussion	150mm cased to 6.00m	7.81	Primus Inter Pares Limited	J16002
	Location	**Dates**	**Engineer**	**Sheet**
		27/01/2016	MP	1/2

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
						(0.30)	Topsoil		
					7.51	0.30	Loose becoming medium dense brown clayey fine to medium SAND		
0.40	D1								
0.80	D2								
1.20-1.65 1.20	SPT N=3 S1	1.20	DRY	1,1/0,1,1,1					
						(2.80)			
1.80	D3								
2.00-2.45 2.00	SPT N=10 S2	2.00	DRY	1,1/2,2,3,3					
2.80	D4								
3.00-3.45 3.00	SPT N=32 S3	3.00	DRY	3,7/8,8,8,8	4.71	3.10	Medium dense to dense brown SAND and GRAVEL		
									▼1
4.00	B1			Slow Inflow(1) at 4.00m, no rise after 20 mins, sealed at 5.70m.					
4.00-4.45	CPT N=27	4.00	3.80	3,5/6,6,7,8		(2.60)			
5.00-5.45 5.00	CPT N=41 B2	5.00	3.70	4,5/5,9,12,15					
					2.11	5.70 (0.40)	Firm brown silty CLAY		
6.00-6.45 6.00	SPT N=18 S4	6.00	5.90	2,3/3,4,5,6	1.71	6.10	Stiff fissured high strength dark grey CLAY		
7.50	U1								
8.00	D5								
9.00-9.45 9.00	SPT N=18 S5	6.00	DRY	3,3/4,4,5,5					

Remarks
Groundwater monitoring standpipe installed to 6.0 m
Water added to aid drilling from 3.0 m to 7.0 m

Scale (approx)	Logged By
1:50	JS / MP

Figure No. J16002.BH4

GEA Geotechnical & Environmental Associates	Widbury Barn Widbury Hill Ware,Herts SG12 7QE	**Site** The Manor House, Ham Street, Richmond, TW10 7HA	**Borehole Number** **BH4**

Boring Method	**Casing Diameter**	**Ground Level (mOD)**	**Client**	**Job Number**
Cable Percussion	150mm cased to 6.00m	7.81	Primus Inter Pares Limited	J16002
	Location	**Dates** 27/01/2016	**Engineer** MP	**Sheet** 2/2

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
10.50	U2								
11.00	D6								
12.00-12.45 12.00	SPT N=22 S6	6.00	DRY	3,4/5,5,6,6					
						(8.90)			
13.50	U3								
14.00	D7								
14.50-14.95 14.50	SPT N=25 S7	6.00	DRY	4,5/5,6,7,7					
					-7.19	15.00			
							Complete at 15.00m		

Remarks	**Scale (approx)**	**Logged By**
	1:50	JS / MP
	Figure No. J16002.BH4	

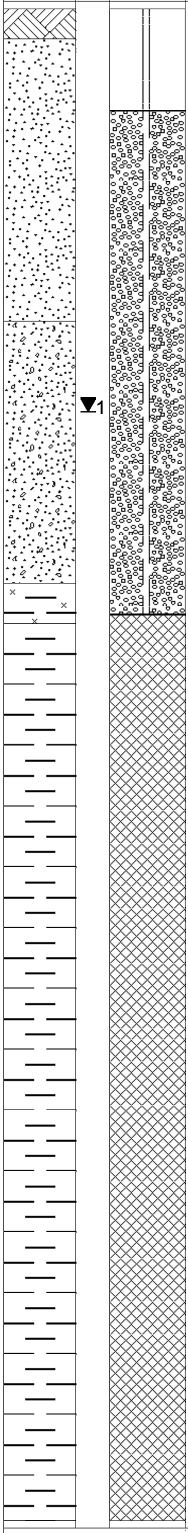
GEA Geotechnical & Environmental Associates

Widbury Barn
Widbury Hill
Ware,Herts
SG12 7QE

Site	Borehole Number
The Manor House, Ham Street, Richmond, TW10 7HA	BH4

Installation Type	Dimensions	Client	Job Number
Standpipe	Internal Diameter of Tube [A] = 30 mm Internal Diameter of Tube [B] = 60 mm	Primus Inter Pares Limited	J16002

Location	Ground Level (mOD)	Engineer	Sheet
	7.81	MP	1/1



Level (mOD)	Depth (m)	Description
		Bentonite Seal
6.81	1.00	
		Slotted Standpipe
1.81	6.00	
		General Backfill
-7.19	15.00	

Groundwater Strikes During Drilling

Date	Time	Depth Struck (m)	Casing Depth (m)	Inflow Rate	Readings 5 min	10 min	15 min	20 min	Depth Sealed (m)
27/01/16		4.00	4.00	Slow Inflow				4.00	5.70

Groundwater Observations During Drilling

Date	Start of Shift					End of Shift				
	Time	Depth Hole (m)	Casing Depth (m)	Water Depth (m)	Water Level (mOD)	Time	Depth Hole (m)	Casing Depth (m)	Water Depth (m)	Water Level (mOD)

Instrument Groundwater Observations

Inst. [A] Type : Slotted Standpipe

Date	Instrument [A]			Remarks
	Time	Depth (m)	Level (mOD)	
16/02/16		4.64	3.17	
04/03/16		4.58	3.23	

Remarks

Geotechnical & Environmental Associates — Widbury Barn, Widbury Hill, Ware, Herts, SG12 7QE	Site: The Manor House, Ham Street, Richmond, TW10 7HA	Borehole Number: BH5

Boring Method	Casing Diameter	Ground Level (mOD)	Client	Job Number
Cable Percussion	150mm cased to 7.00m	7.81	Primus Inter Pares Limited	J16002
	Location	**Dates** 28/01/2016	**Engineer** MP	**Sheet** 1/2

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
					7.61	(0.20) 0.20	Topsoil		
0.40	D1						Medium dense brown clayey SAND with occasional gravel		
0.90	D2								
1.20-1.65 1.20	SPT N=12 S1	1.20	DRY	1,2/2,3,3,4					
						(3.10)			
2.00-2.45 2.00	CPT N=11 B1	2.00	DRY	2,2/2,3,3,3					
3.00-3.45 3.00	CPT N=10 B2	3.00	2.70	2,3/2,3,2,3					
					4.51	3.30	Medium dense becoming very dense brown very gravelly SAND		
4.00-4.45 4.00	CPT N=28 B3	4.00	3.00	3,4/6,6,7,9 Slow Inflow(1) at 4.30m, no rise after 20 mins, sealed at 6.50m.					▼1
						(3.00)			
5.00-5.45 5.00	CPT N=67 B4	5.00	3.80	7,9/12,15,17,23					
6.00-6.45 6.00	CPT N=12 B5	6.00	4.20	4,5/3,2,3,4					
					1.51	6.30 (0.30)	Firm brown CLAY		
					1.21	6.60	Stiff becoming very stiff fissured high strength becoming very high strength dark grey CLAY		
6.70	D3								
7.50	U1								
8.00	D4								
9.00	U2								
9.50	D5								

Remarks
Groundwater monitoring standpipe installed to 6.5 m
Water added to aid drilling from 1.5 m to 6.3 m

Scale (approx)	Logged By
1:50	JS / MP

Figure No. J16002.BH5

Geotechnical & Environmental Associates Widbury Barn Widbury Hill Ware,Herts SG12 7QE		**Site** The Manor House, Ham Street, Richmond, TW10 7HA	**Borehole Number** **BH5**
Boring Method Cable Percussion	**Casing Diameter** 150mm cased to 7.00m	**Ground Level (mOD)** 7.81	**Client** Primus Inter Pares Limited	**Job Number** J16002
	Location	**Dates** 28/01/2016	**Engineer** MP	**Sheet** 2/2

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
10.50-10.95 10.50	SPT N=23 S2	7.00	DRY	4,4/5,5,6,7					
12.00	U3								
12.50	D6								
13.50-13.95 13.50	SPT N=24 S3	7.00	DRY	4,5/5,6,6,7					
						(13.40)			
15.00	U4								
15.50	D7								
16.50-16.95 16.50	SPT N=27 S4	7.00	DRY	5,5/6,7,7,7					
18.00	U5								
18.50	D8								
19.50-19.95 19.50	SPT N=31 S5	7.00	DRY	5,6/7,7,8,9					
					-12.19	20.00			

Remarks	**Scale (approx)** 1:50	**Logged By** JS / MP
	Figure No. J16002.BH5	

Geotechnical & Environmental Associates

Widbury Barn
Widbury Hill
Ware,Herts
SG12 7QE

Site
The Manor House, Ham Street, Richmond, TW10 7HA

Borehole Number
BH5

Installation Type
Standpipe

Dimensions
Internal Diameter of Tube [A] = 30 mm
Internal Diameter of Tube [B] = 60 mm

Client
Primus Inter Pares Limited

Job Number
J16002

Location

Ground Level (mOD)
7.81

Engineer
MP

Sheet
1/1

Legend	Water	Instr (A)	Level (mOD)	Depth (m)	Description
			6.81	1.00	Bentonite Seal
	▼1		1.31	6.50	Gravel Filter
			-12.19	20.00	General Backfill

Groundwater Strikes During Drilling

Date	Time	Depth Struck (m)	Casing Depth (m)	Inflow Rate	Readings 5 min	Readings 10 min	Readings 15 min	Readings 20 min	Depth Sealed (m)
28/01/16		4.30	4.00	Slow Inflow				4.30	6.50

Groundwater Observations During Drilling

Date	Start of Shift					End of Shift				
	Time	Depth Hole (m)	Casing Depth (m)	Water Depth (m)	Water Level (mOD)	Time	Depth Hole (m)	Casing Depth (m)	Water Depth (m)	Water Level (mOD)

Instrument Groundwater Observations

Inst. [A] Type : Slotted Standpipe

Date	Instrument [A]			Remarks
	Time	Depth (m)	Level (mOD)	
16/02/16		4.70	3.11	
04/03/16		4.20	3.61	

Remarks

SUMMARY OF GEOTECHNICAL TESTING

Sample details					Classification Tests					Density Tests		Undrained Triaxial Compression			Chemical Tests			Other tests and comments
Borehole / Trial Pit	Sample Ref	Depth (m)	Type	Description	MC (%)	LL (%)	PL (%)	PI (%)	<425 µm (%)	Bulk Mg/m³	Dry Mg/m³	Cell Pressure kPa	Deviator Stress kPa	Shear Stress kPa	pH	2:1 W/S SO4 (g/L)	W/S Mg (mg/L)	
BH1	4	1.90	D	Orangish brown slightly sandy slightly gravelly CLAY.	16.5	30	16	14	96									
BH2	6	4.50	D	Yellowish brown gravelly SAND. Gravel is fine to medium flint.														Particle Size Distribution
BH3	4	2.75	D	Brown slightly gravelly silty CLAY with rare rootlets.	17.2	43	18	25	96						7.6	0.01		
BH3	5	3.50	D	Yellowish brown gravelly SAND. Gravel is flint.														Particle Size Distribution
BH4	5	1.20	S	Brown clayey fine to medium SAND.														Particle Size Distribution
BH4	1	4.00	B	Yellowish brown SAND and flint GRAVEL.														Particle Size Distribution
BH4	5	6.00	D	Mottled dark brown and brown silty CLAY with rare fine gravel.	20.3	72	28	44	98						8.0	0.05		
BH4	1	7.50	U	Stiff fissured brownish grey CLAY	29.0					2.01	1.56	150	187	94				
BH4	2	10.50	U	Stiff fissured brownish grey CLAY	29.2					1.99	1.54	210	213	106				
BH4	3	13.50	U	Stiff fissured brownish grey CLAY	27.5					2.01	1.58	270	252	126				

Sample type: B (Bulk disturb.) BLK (Block) C (Core) D (Disturbed) LB (Large Bulk dist.) U (Undisturbed)

Checked and Approved by

S Burke

S Burke - Senior Technician
16/02/2016

Project Number:

GEO / 23679

Project Name:

THE MANOR HOUSE, TW10 7HA
J16002

GEOLABS®

SUMMARY OF GEOTECHNICAL TESTING

Sample details					Classification Tests					Density Tests		Undrained Triaxial Compression			Chemical Tests			Other tests and comments
Borehole / Trial Pit	Sample Ref	Depth (m)	Type	Description	MC (%)	LL (%)	PL (%)	PI (%)	<425 µm (%)	Bulk Mg/m³	Dry Mg/m³	Cell Pressure kPa	Deviator Stress kPa	Shear Stress kPa	pH	2:1 W/S SO4 (g/L)	W/S Mg (mg/L)	
BH5	1	2.00	B	Wet yellowish brown clayey slightly gravelly SAND.														Particle Size Distribution
BH5	4	5.00	B	Wet yellowish brown very gravelly SAND.														Particle Size Distribution
BH5	1	7.50	U	Stiff fissured brownish grey CLAY	29.0					1.98	1.53	150	168	84				
BH5	4	8.00	D	Dark brown silty CLAY.	28.5	70	25	45	100						8.2	0.40		
BH5	2	9.00	U	Very stiff fissured brownish grey CLAY	27.1					2.02	1.59	180	174	87				
BH5	3	12.00	U	Stiff fissured brownish grey CLAY	28.3					1.97	1.54	240	194	97				
BH5	4	15.00	U	Very stiff fissured brownish grey CLAY	27.9					1.98	1.55	300	330	165				
BH5	5	18.00	U	Very stiff fissured brownish grey CLAY	29.1					2.00	1.55	360	361	181				

Sample type: B (Bulk disturb.) BLK (Block) C (Core) D (Disturbed) LB (Large Bulk dist.) U (Undisturbed)

Checked and Approved by

S Burke

S Burke - Senior Technician
16/02/2016

Project Number: **GEO / 23679**

Project Name: **THE MANOR HOUSE, TW10 7HA**
J16002

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BS1377 : Part 2 : Clause 9 : 1990

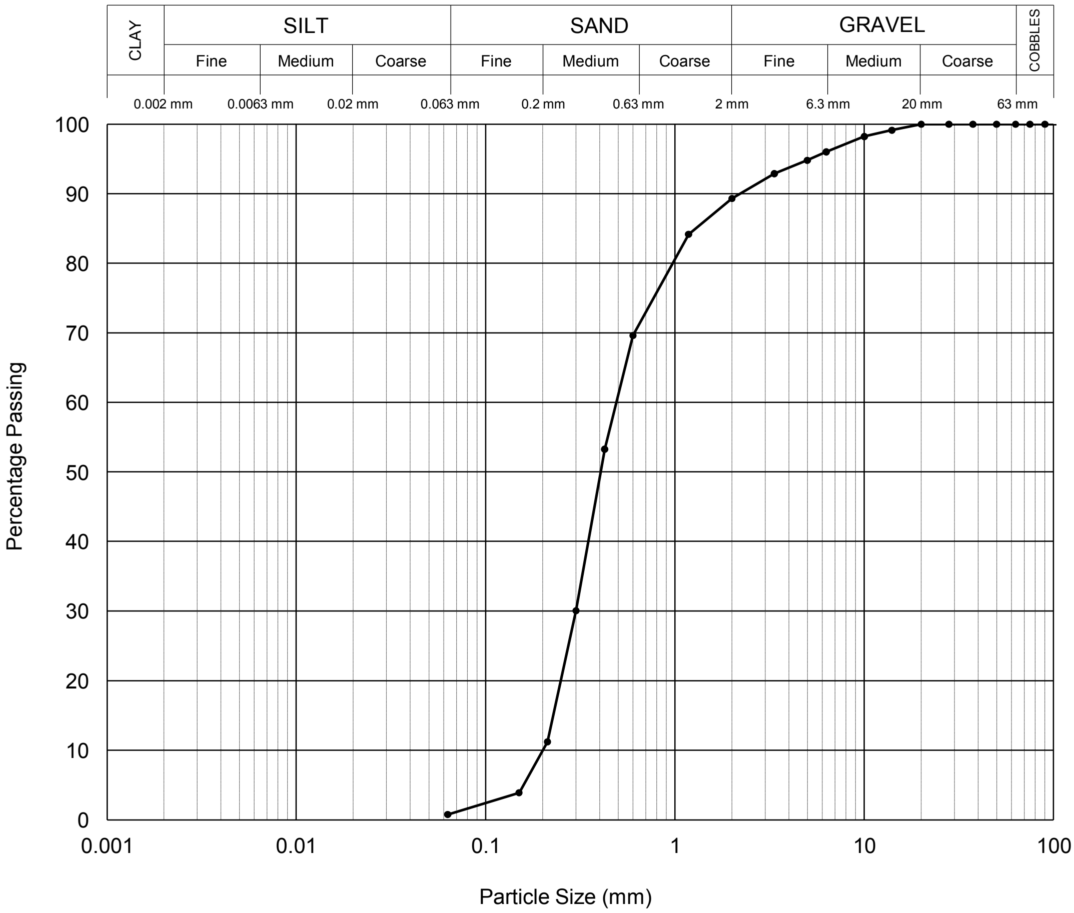
PARTICLE SIZE DISTRIBUTION

BH/TP No:	BH2
Sample Ref.	6
Depth (m):	4.50
Sample Type	D

Description:
Yellowish brown gravelly SAND. Gravel is fine to medium flint.

BS1377 : Part 2 : Clause 9.3 : 1990 Dry Sieving Method

Sieve	
Sieve (mm)	% pass
200	100
125	100
90	100
75	100
63	100
50	100
37.5	100
28	100
20	100
14	99
10	98
6.3	96
5	95
3.35	93
2	89
1.18	84
0.6	70
0.425	53
0.3	30
0.212	11
0.15	4
0.063	1



Particle Proportions	
Cobbles	0.0 %
Gravel	10.7 %
Sand	88.6 %
Silt & Clay	0.8 %

Checked and Approved by

S Burke

S Burke - Senior Technician
16/02/2016

Project Number:

GEO / 23679

Project Name:

THE MANOR HOUSE, TW10 7HA
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BS1377 : Part 2 : Clause 9 : 1990

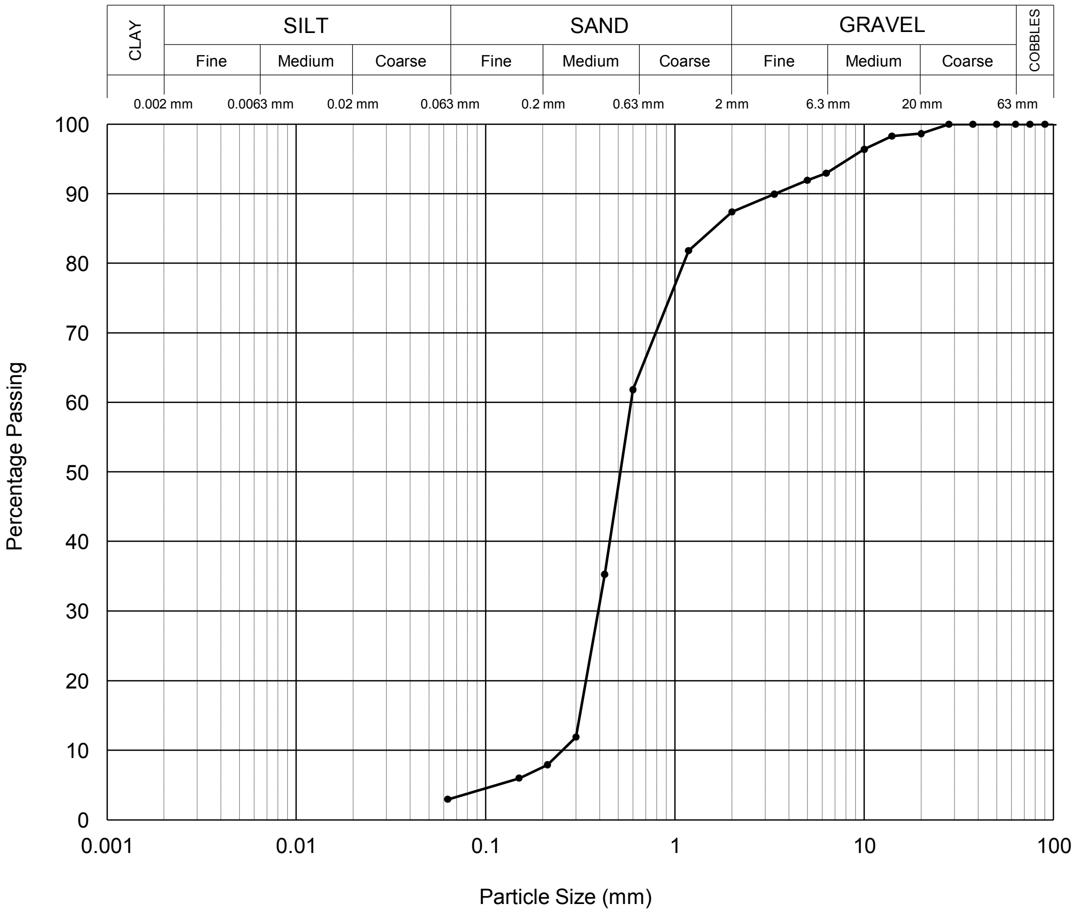
PARTICLE SIZE DISTRIBUTION

BH/TP No:	BH3
Sample Ref.	5
Depth (m):	3.50
Sample Type	D

Description:
Yellowish brown gravelly SAND. Gravel is flint.

BS1377 : Part 2 : Clause 9.3 : 1990 Dry Sieving Method

Sieve	
Sieve (mm)	% pass
200	100
125	100
90	100
75	100
63	100
50	100
37.5	100
28	100
20	99
14	98
10	96
6.3	93
5	92
3.35	90
2	87
1.18	82
0.6	62
0.425	35
0.3	12
0.212	8
0.15	6
0.063	3



Particle Proportions	
Cobbles	0.0 %
Gravel	12.6 %
Sand	84.5 %
Silt & Clay	2.9 %

Checked and Approved by

S Burke

S Burke - Senior Technician
16/02/2016

Project Number:

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Project Name:

THE MANOR HOUSE, TW10 7HA
J16002

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BS1377 : Part 2 : Clause 9 : 1990

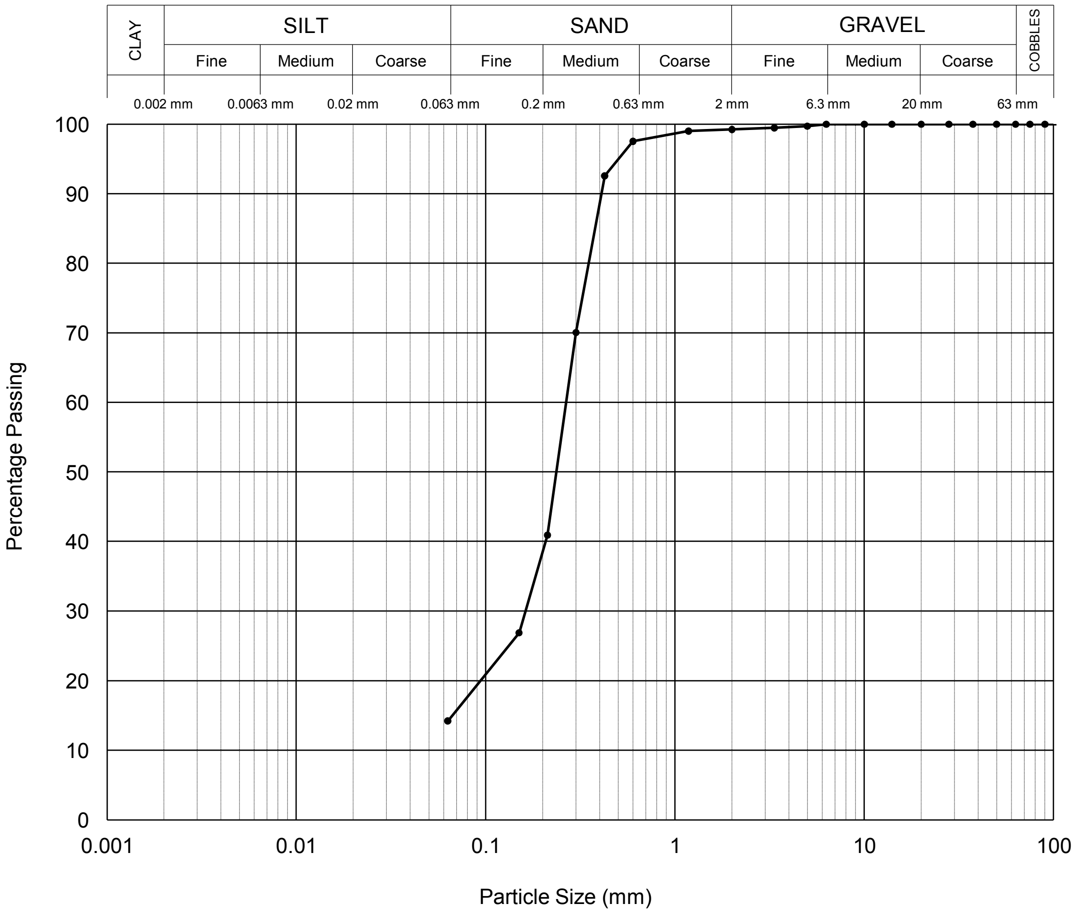
PARTICLE SIZE DISTRIBUTION

BH/TP No:	BH4
Sample Ref.	5
Depth (m):	1.20
Sample Type	S

Description:
Brown clayey fine to medium SAND.

BS1377 : Part 2 : Clause 9.2 : 1990 Wet Sieving Method

Sieve (mm)	% pass
200	100
125	100
90	100
75	100
63	100
50	100
37.5	100
28	100
20	100
14	100
10	100
6.3	100
5	100
3.35	99
2	99
1.18	99
0.6	98
0.425	93
0.3	70
0.212	41
0.15	27
0.063	14



Particle Proportions	
Cobbles	0.0 %
Gravel	0.8 %
Sand	85.0 %
Silt & Clay	14.2 %

Checked and Approved by

S Burke

S Burke - Senior Technician
16/02/2016

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Project Name:

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J16002

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BS1377 : Part 2 : Clause 9 : 1990

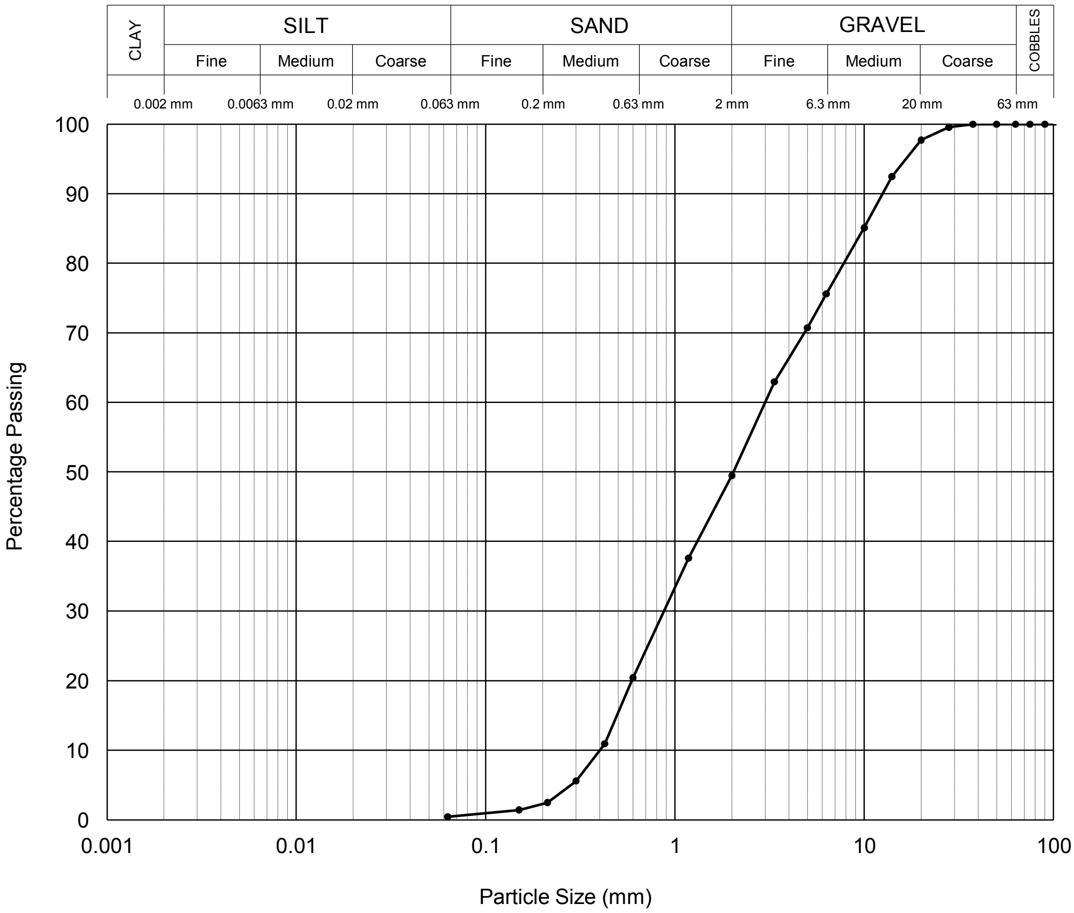
PARTICLE SIZE DISTRIBUTION

BH/TP No:	BH4
Sample Ref.	1
Depth (m):	4.00
Sample Type	B

Description:
Yellowish brown SAND and flint GRAVEL.

BS1377 : Part 2 : Clause 9.3 : 1990 Dry Sieving Method

Sieve	
Sieve (mm)	% pass
200	100
125	100
90	100
75	100
63	100
50	100
37.5	100
28	100
20	98
14	92
10	85
6.3	76
5	71
3.35	63
2	49
1.18	38
0.6	20
0.425	11
0.3	6
0.212	2
0.15	1
0.063	0



Particle Proportions	
Cobbles	0.0 %
Gravel	50.5 %
Sand	49.1 %
Silt & Clay	0.4 %

Checked and Approved by

S Burke

S Burke - Senior Technician
16/02/2016

Project Number:

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Project Name:

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J16002

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BS1377 : Part 2 : Clause 9 : 1990

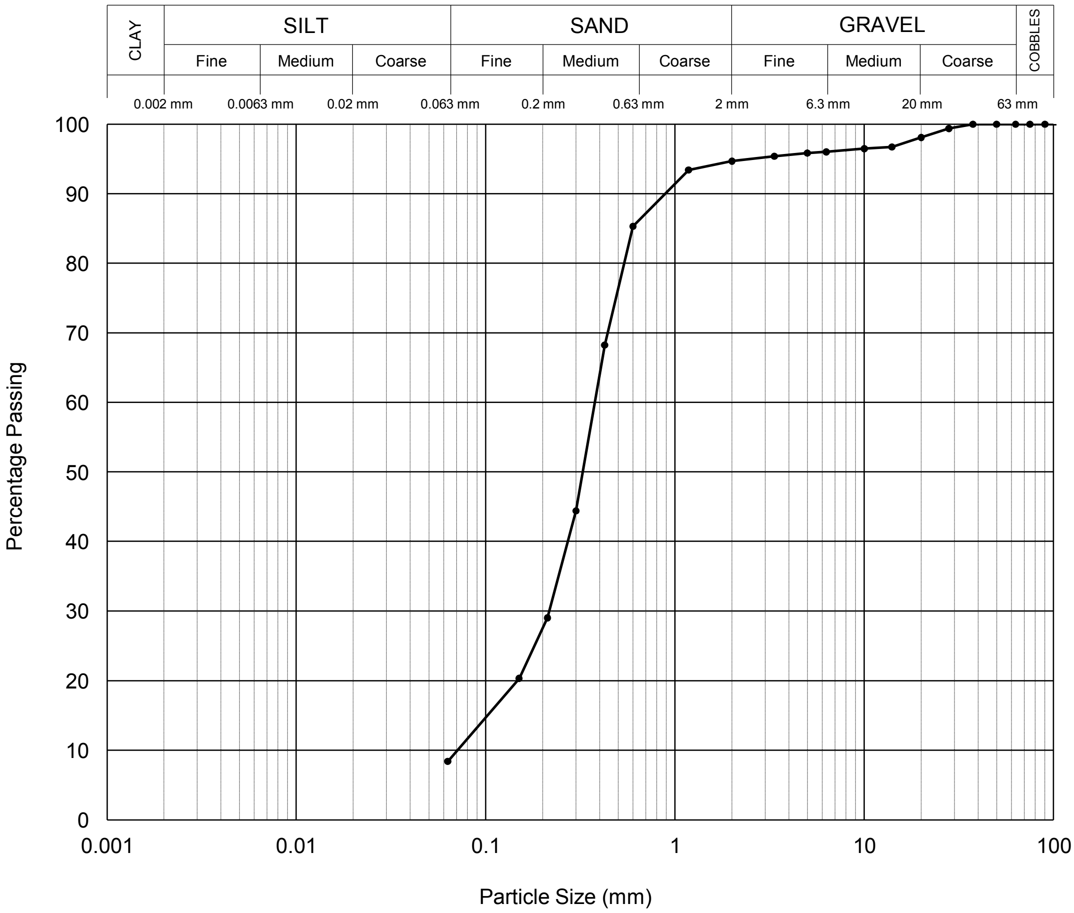
PARTICLE SIZE DISTRIBUTION

BH/TP No:	BH5
Sample Ref.	1
Depth (m):	2.00
Sample Type	B

Description:
Wet yellowish brown clayey slightly gravelly SAND.

BS1377 : Part 2 : Clause 9.2 : 1990 Wet Sieving Method

Sieve	
Sieve (mm)	% pass
200	100
125	100
90	100
75	100
63	100
50	100
37.5	100
28	99
20	98
14	97
10	96
6.3	96
5	96
3.35	95
2	95
1.18	93
0.6	85
0.425	68
0.3	44
0.212	29
0.15	20
0.063	8



Particle Proportions	
Cobbles	0.0 %
Gravel	5.3 %
Sand	86.3 %
Silt & Clay	8.4 %

Checked and Approved by

S Burke

S Burke - Senior Technician
16/02/2016

Project Number:

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Project Name:

THE MANOR HOUSE, TW10 7HA
J16002

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BS1377 : Part 2 : Clause 9 : 1990

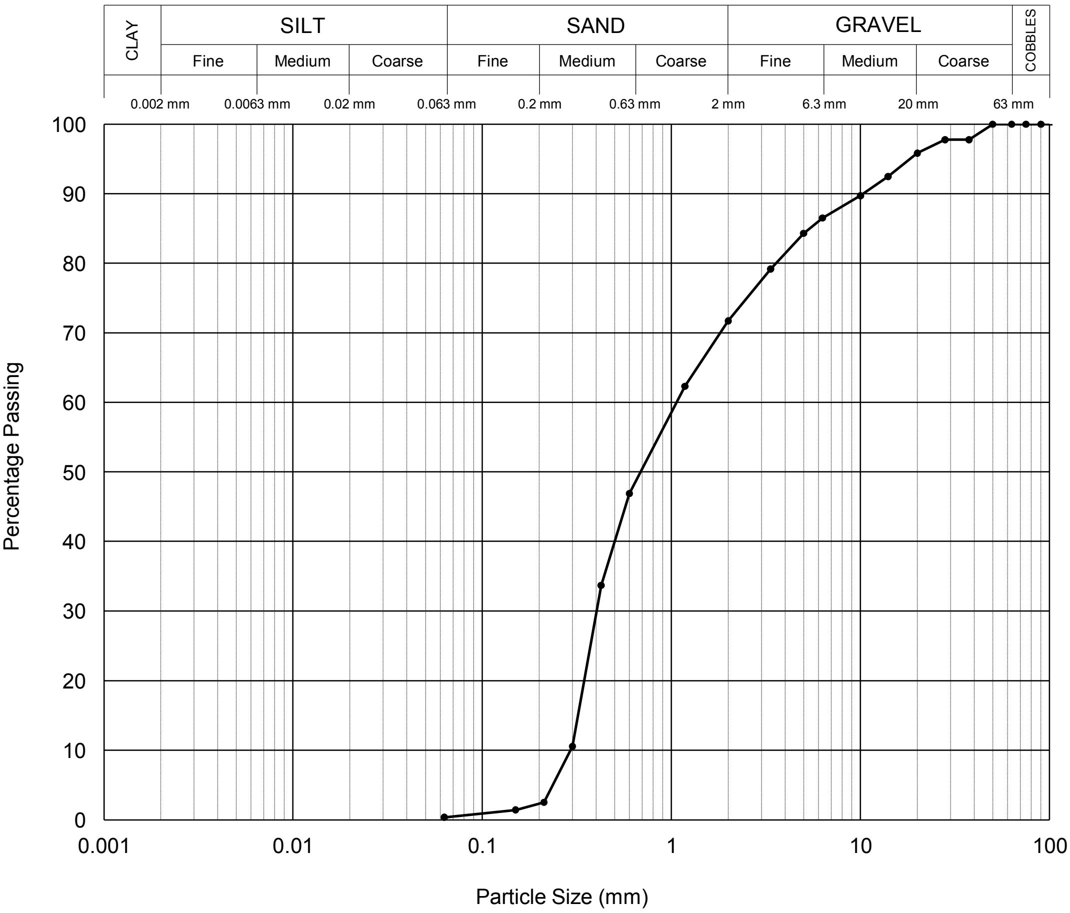
PARTICLE SIZE DISTRIBUTION

BH/TP No:	BH5
Sample Ref.	4
Depth (m):	5.00
Sample Type	B

Description:
Wet yellowish brown very gravelly SAND.

BS1377 : Part 2 : Clause 9.3 : 1990 Dry Sieving Method

Sieve	
Sieve (mm)	% pass
200	100
125	100
90	100
75	100
63	100
50	100
37.5	98
28	98
20	96
14	92
10	90
6.3	87
5	84
3.35	79
2	72
1.18	62
0.6	47
0.425	34
0.3	11
0.212	2
0.15	1
0.063	0



Particle Proportions	
Cobbles	0.0 %
Gravel	28.3 %
Sand	71.4 %
Silt & Clay	0.3 %

Checked and Approved by

S Burke - Senior Technician
16/02/2016

Project Number:

GEO / 23679

Project Name:

THE MANOR HOUSE, TW10 7HA
J16002

1731 - UUTXL BH4 07.50 1 U - 23679-138865.XLSM

BS 1377 : Part 7 : 1990 Clause 8

Quick Undrained Triaxial Compression Test

BH/TP No	BH4
Sample Ref	1
Depth (m)	7.50
Sample Type	U

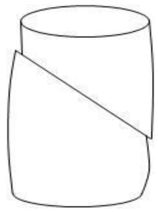
Description:

Stiff fissured brownish grey CLAY

Specimen Details

Specimen conditions		Undisturbed
Length	(mm)	202.3
Diameter	(mm)	102.4
Moisture Content	(%)	29.0
Bulk Density	(Mg/m³)	2.01
Dry Density	(Mg/m³)	1.56
Test Details		
Latex membrane thickness	(mm)	0.3
Membrane correction	(kPa)	0.3
Axial displacement rate	(%/min)	2.0
Cell pressure	(kPa)	150
Strain at failure	(%)	4.2
Maximum Deviator Stress	(kPa)	187
Shear Stress Cu	(kPa)	94

Mode of failure



Orientation of the sample	Vertical
Distance from top of tube mm	70

GL:Version 1.53 - 23/12/2015

Checked and Approved by:

S Burke

S Burke - Senior Technician
16/02/2016

Project Number:

GEO / 23679

Project Name:

THE MANOR HOUSE, TW10 7HA
J16002

GEOLABS® UKAS TESTING 1982

1731 - UUTXL BH4 10.50 2 U - 23679-138861.XLSM

BS 1377 : Part 7 : 1990 Clause 8

Quick Undrained Triaxial Compression Test

BH/TP No	BH4
Sample Ref	2
Depth (m)	10.50
Sample Type	U

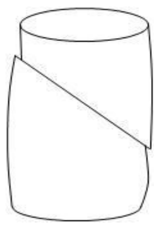
Description:

Stiff fissured brownish grey CLAY

Specimen Details

Specimen conditions		Undisturbed
Length	(mm)	202.4
Diameter	(mm)	102.8
Moisture Content	(%)	29.2
Bulk Density	(Mg/m^3)	1.99
Dry Density	(Mg/m^3)	1.54
Test Details		
Latex membrane thickness	(mm)	0.3
Membrane correction	(kPa)	0.5
Axial displacement rate	(%/min)	2.0
Cell pressure	(kPa)	210
Strain at failure	(%)	6.9
Maximum Deviator Stress	(kPa)	213
Shear Stress Cu	(kPa)	106

Mode of failure



Orientation of the sample	Vertical
Distance from top of tube mm	75

GL:Version 1.53 - 23/12/2015

Checked and Approved by:

S Burke - Senior Technician
16/02/2016

Project Number:

GEO / 23679

Project Name:

THE MANOR HOUSE, TW10 7HA
J16002

GEOLABS® UKAS TESTING 1982

1731 - UUTXL BH4 13.50 3 U - 23679-138863.XLSM

BS 1377 : Part 7 : 1990 Clause 8

Quick Undrained Triaxial Compression Test

BH/TP No	BH4
Sample Ref	3
Depth (m)	13.50
Sample Type	U

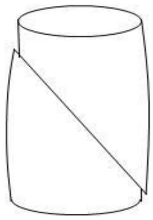
Description:

Stiff fissured brownish grey CLAY

Specimen Details

Specimen conditions		Undisturbed
Length	(mm)	202.4
Diameter	(mm)	102.9
Moisture Content	(%)	27.5
Bulk Density	(Mg/m^3)	2.01
Dry Density	(Mg/m^3)	1.57
Test Details		
Latex membrane thickness	(mm)	0.3
Membrane correction	(kPa)	0.1
Axial displacement rate	(%/min)	2.0
Cell pressure	(kPa)	270
Strain at failure	(%)	1.7
Maximum Deviator Stress	(kPa)	252
Shear Stress Cu	(kPa)	126

Mode of failure



Orientation of the sample	Vertical
Distance from top of tube mm	95

GL:Version 1.53 - 23/12/2015

Checked and Approved by:

S Burke

S Burke - Senior Technician
16/02/2016

Project Number:

GEO / 23679

Project Name:

THE MANOR HOUSE, TW10 7HA
J16002

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UKAS TESTING 1982

BS 1377 : Part 7 : 1990 Clause 8

Quick Undrained Triaxial Compression Test

BH/TP No	BH5
Sample Ref	1
Depth (m)	7.50
Sample Type	U

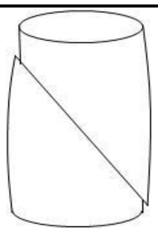
Description:

Stiff fissured brownish grey CLAY

Specimen Details

Specimen conditions		Undisturbed
Length	(mm)	202.2
Diameter	(mm)	102.7
Moisture Content	(%)	29.0
Bulk Density	(Mg/m³)	1.98
Dry Density	(Mg/m³)	1.53
Test Details		
Latex membrane thickness	(mm)	0.3
Membrane correction	(kPa)	1.1
Axial displacement rate	(%/min)	2.0
Cell pressure	(kPa)	150
Strain at failure	(%)	19.8
Maximum Deviator Stress	(kPa)	168
Shear Stress Cu	(kPa)	84

Mode of failure



Orientation of the sample	Vertical
Distance from top of tube mm	115

Checked and Approved by:

S Burke - Senior Technician
16/02/2016

Project Number:

GEO / 23679

Project Name:

THE MANOR HOUSE, TW10 7HA
J16002

BS 1377 : Part 7 : 1990 Clause 8

Quick Undrained Triaxial Compression Test

BH/TP No	BH5
Sample Ref	2
Depth (m)	9.00
Sample Type	U

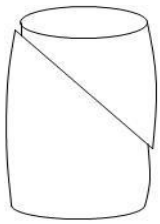
Description:

Very stiff fissured brownish grey CLAY

Specimen Details

Specimen conditions		Undisturbed
Length	(mm)	203.3
Diameter	(mm)	102.3
Moisture Content	(%)	27.1
Bulk Density	(Mg/m³)	2.02
Dry Density	(Mg/m³)	1.59
Test Details		
Latex membrane thickness	(mm)	0.3
Membrane correction	(kPa)	0.6
Axial displacement rate	(%/min)	2.0
Cell pressure	(kPa)	180
Strain at failure	(%)	7.9
Maximum Deviator Stress	(kPa)	174
Shear Stress Cu	(kPa)	87

Mode of failure



Orientation of the sample	Vertical
Distance from top of tube mm	60

Checked and Approved by:

S Burke

S Burke - Senior Technician
16/02/2016

Project Number:

GEO / 23679

Project Name:

THE MANOR HOUSE, TW10 7HA
J16002

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BS 1377 : Part 7 : 1990 Clause 8

Quick Undrained Triaxial Compression Test

BH/TP No	BH5
Sample Ref	3
Depth (m)	12.00
Sample Type	U

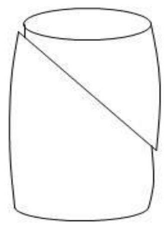
Description:

Stiff fissured brownish grey CLAY

Specimen Details

Specimen conditions		Undisturbed
Length	(mm)	202.5
Diameter	(mm)	103.3
Moisture Content	(%)	28.3
Bulk Density	(Mg/m³)	1.97
Dry Density	(Mg/m³)	1.54
Test Details		
Latex membrane thickness	(mm)	0.3
Membrane correction	(kPa)	0.5
Axial displacement rate	(%/min)	2.0
Cell pressure	(kPa)	240
Strain at failure	(%)	7.9
Maximum Deviator Stress	(kPa)	194
Shear Stress Cu	(kPa)	97

Mode of failure



Orientation of the sample	Vertical
Distance from top of tube mm	85

GL:Version 1.53 - 23/12/2015

Checked and Approved by:

S Burke

S Burke - Senior Technician
16/02/2016

Project Number:

GEO / 23679

Project Name:

THE MANOR HOUSE, TW10 7HA
J16002

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BS 1377 : Part 7 : 1990 Clause 8

Quick Undrained Triaxial Compression Test

BH/TP No	BH5
Sample Ref	4
Depth (m)	15.00
Sample Type	U

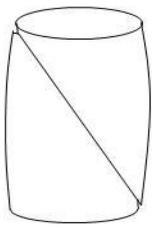
Description:

Very stiff fissured brownish grey CLAY

Specimen Details

Specimen conditions		Undisturbed
Length	(mm)	202.8
Diameter	(mm)	102.9
Moisture Content	(%)	27.9
Bulk Density	(Mg/m³)	1.98
Dry Density	(Mg/m³)	1.55
Test Details		
Latex membrane thickness	(mm)	0.3
Membrane correction	(kPa)	0.3
Axial displacement rate	(%/min)	2.0
Cell pressure	(kPa)	300
Strain at failure	(%)	3.9
Maximum Deviator Stress	(kPa)	330
Shear Stress Cu	(kPa)	165

Mode of failure



Orientation of the sample	Vertical
Distance from top of tube mm	140

Checked and Approved by:

S Burke

S Burke - Senior Technician
16/02/2016

Project Number:

GEO / 23679

Project Name:

THE MANOR HOUSE, TW10 7HA
J16002

GEOLABS® UKAS TESTING 1982

1731 - UUTXL BH5 18.00 5 U - 23679-138860.XLSM

BS 1377 : Part 7 : 1990 Clause 8

Quick Undrained Triaxial Compression Test

BH/TP No	BH5
Sample Ref	5
Depth (m)	18.00
Sample Type	U

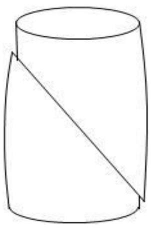
Description:

Very stiff fissured brownish grey CLAY

Specimen Details

Specimen conditions		Undisturbed
Length	(mm)	202.5
Diameter	(mm)	102.7
Moisture Content	(%)	29.1
Bulk Density	(Mg/m³)	2.00
Dry Density	(Mg/m³)	1.55
Test Details		
Latex membrane thickness	(mm)	0.3
Membrane correction	(kPa)	0.3
Axial displacement rate	(%/min)	2.0
Cell pressure	(kPa)	360
Strain at failure	(%)	3.7
Maximum Deviator Stress	(kPa)	361
Shear Stress Cu	(kPa)	181

Mode of failure



Orientation of the sample	Vertical
Distance from top of tube mm	105

GL:Version 1.53 - 23/12/2015

Checked and Approved by:

S Burke

S Burke - Senior Technician
16/02/2016

Project Number:

GEO / 23679

Project Name:

THE MANOR HOUSE, TW10 7HA
J16002

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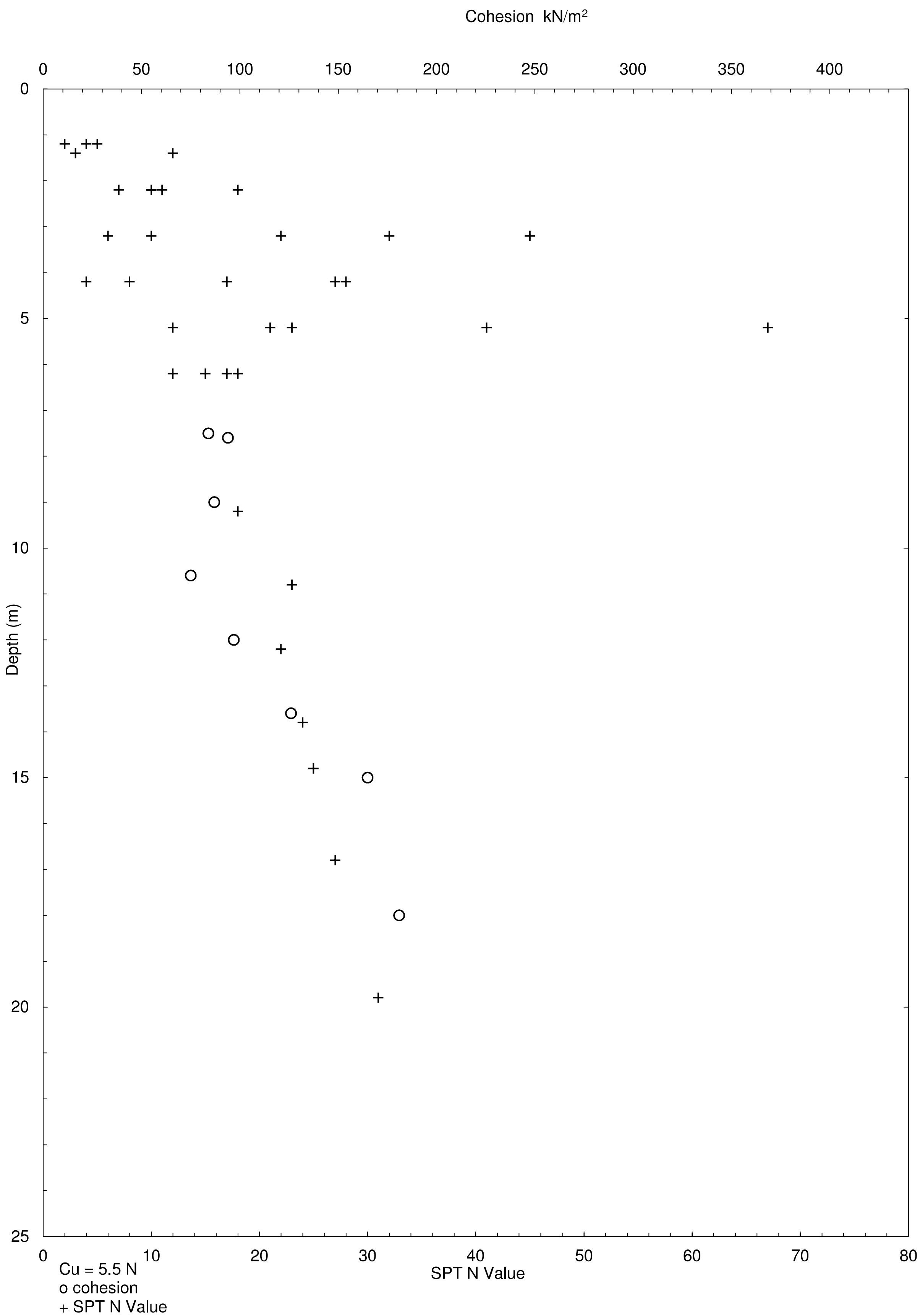
UKAS TESTING 1982

Geotechnical & Environmental Associates	Widbury Barn Widbury Hill Ware Herts SG12 7QE	**SPT & Cohesion / Depth & Level Graph**

Site	The Manor House, Ham Street, Richmond, TW10 7HA	**Job Number** J16002
Client	Primus Inter Pares Limited	
Engineer	Hurst Peirce + Malcolm LLP	**Sheet** 1 / 1



UKAS TESTING
2183

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Chemtest Ltd.
Depot Road
Newmarket
CB8 0AL
Tel: 01638 606070
Email: info@chemtest.co.uk

Final Report

Report No.:	16-02011-1
Initial Date of Issue:	02-Feb-2016
Client	GEA
Client Address:	Widbury Barn Widbury Hill Ware Hertfordshire SG12 7QE
Contact(s):	Matt Penfold
Project	J16002 The Manor House, Ham Street, Richmond

Quotation No.:		**Date Received:**	28-Jan-2016
Order No.:	J16002	**Date Instructed:**	29-Jan-2016
No. of Samples:	4	**Target Date:**	02-Feb-2016
Turnaround (Wkdays):	5	**Results Due:**	04-Feb-2016
Date Approved:	02-Feb-2016		

Approved By:

K T Jones

Details: Keith Jones, Technical Manager

Results - Soil

Project: J16002 The Manor House, Ham Street, Richmond

Client: GEA				**Chemtest Job No.:**	16-02011	16-02011	16-02011	16-02011
Quotation No.:				**Chemtest Sample ID.:**	246427	246429	246430	246431
				Client Sample ID.:	BH1	BH2	BH3	BH3
				Sample Type:	SOIL	SOIL	SOIL	SOIL
				Top Depth (m):	0.25	0.30	0.30	0.70
				Date Sampled:	26-Jan-2016	26-Jan-2016	26-Jan-2016	26-Jan-2016
Determinand	**Accred.**	**SOP**	**Units**	**LOD**				
Moisture	N	2030	%	0.020	9.7	10	12	10
Stones	N	2030	%	0.020	< 0.020	< 0.020	< 0.020	< 0.020
Soil Colour	N	2040		N/A	Brown	Brown	Brown	Brown
Other Material	N	2040		N/A	Stones	Stones	Stones	Stones
Soil Texture	N	2040		N/A	Sand	Sand	Sand	Sand
pH	M	2010		N/A	6.3	6.3	5.9	7.1
Sulphate (2:1 Water Soluble) as SO4	M	2120	g/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010
Chloride (Extractable)	M	2220	g/l	0.010	0.012	< 0.010	< 0.010	< 0.010
Cyanide (Total)	M	2300	mg/kg	0.50	< 0.50	< 0.50	< 0.50	< 0.50
Sulphide (Easily Liberatable)	M	2325	mg/kg	0.50	1.6	1.2	1.1	0.84
Sulphate (Total)	M	2430	mg/kg	100	950	150	340	150
Arsenic	M	2450	mg/kg	1.0	27	5.7	7.8	4.1
Cadmium	M	2450	mg/kg	0.10	0.27	< 0.10	< 0.10	< 0.10
Chromium	M	2450	mg/kg	1.0	23	28	16	12
Copper	M	2450	mg/kg	0.50	16	9.5	16	4.0
Mercury	M	2450	mg/kg	0.10	0.19	0.19	0.23	< 0.10
Nickel	M	2450	mg/kg	0.50	18	26	13	8.6
Lead	M	2450	mg/kg	0.50	140	48	190	8.6
Selenium	M	2450	mg/kg	0.20	< 0.20	< 0.20	< 0.20	< 0.20
Zinc	M	2450	mg/kg	0.50	73	280	34	13
Total Organic Carbon	M	2625	%	0.20	0.75	0.58	1.0	< 0.20
TPH >C5-C6	N	2670	mg/kg	1.0	< 1.0	< 1.0	< 1.0	< 1.0
TPH >C6-C7	N	2670	mg/kg	1.0	< 1.0	< 1.0	< 1.0	< 1.0
TPH >C7-C8	N	2670	mg/kg	1.0	< 1.0	< 1.0	< 1.0	< 1.0
TPH >C8-C10	N	2670	mg/kg	1.0	< 1.0	< 1.0	< 1.0	< 1.0
TPH >C10-C12	N	2670	mg/kg	1.0	< 1.0	< 1.0	< 1.0	< 1.0
TPH >C12-C16	N	2670	mg/kg	1.0	< 1.0	< 1.0	< 1.0	< 1.0
TPH >C16-C21	N	2670	mg/kg	1.0	< 1.0	< 1.0	< 1.0	< 1.0
TPH >C21-C35	N	2670	mg/kg	1.0	< 1.0	< 1.0	< 1.0	< 1.0
Total TPH >C5-C35	N	2670	mg/kg	10	< 10	< 10	< 10	< 10
Naphthalene	M	2700	mg/kg	0.10	< 0.10	< 0.10	< 0.10	< 0.10
Acenaphthylene	M	2700	mg/kg	0.10	< 0.10	< 0.10	< 0.10	< 0.10
Acenaphthene	M	2700	mg/kg	0.10	< 0.10	< 0.10	< 0.10	< 0.10
Fluorene	M	2700	mg/kg	0.10	< 0.10	< 0.10	< 0.10	< 0.10
Phenanthrene	M	2700	mg/kg	0.10	< 0.10	< 0.10	< 0.10	< 0.10
Anthracene	M	2700	mg/kg	0.10	< 0.10	< 0.10	< 0.10	< 0.10
Fluoranthene	M	2700	mg/kg	0.10	0.36	< 0.10	< 0.10	< 0.10
Pyrene	M	2700	mg/kg	0.10	0.39	< 0.10	< 0.10	< 0.10
Benzo[a]anthracene	M	2700	mg/kg	0.10	0.13	< 0.10	< 0.10	< 0.10

Chemtest
The right chemistry to deliver results

Results - Soil

Project: J16002 The Manor House, Ham Street, Richmond

Client: GEA				**Chemtest Job No.:**	16-02011	16-02011	16-02011	16-02011
Quotation No.:				**Chemtest Sample ID.:**	246427	246429	246430	246431
				Client Sample ID.:	BH1	BH2	BH3	BH3
				Sample Type:	SOIL	SOIL	SOIL	SOIL
				Top Depth (m):	0.25	0.30	0.30	0.70
				Date Sampled:	26-Jan-2016	26-Jan-2016	26-Jan-2016	26-Jan-2016
Determinand	**Accred.**	**SOP**	**Units**	**LOD**				
Chrysene	M	2700	mg/kg	0.10	0.21	< 0.10	< 0.10	< 0.10
Benzo[b]fluoranthene	M	2700	mg/kg	0.10	0.29	< 0.10	< 0.10	< 0.10
Benzo[k]fluoranthene	M	2700	mg/kg	0.10	0.22	< 0.10	< 0.10	< 0.10
Benzo[a]pyrene	M	2700	mg/kg	0.10	0.20	< 0.10	< 0.10	< 0.10
Indeno(1,2,3-c,d)Pyrene	M	2700	mg/kg	0.10	0.21	< 0.10	< 0.10	< 0.10
Dibenz(a,h)Anthracene	M	2700	mg/kg	0.10	< 0.10	< 0.10	< 0.10	< 0.10
Benzo[g,h,i]perylene	M	2700	mg/kg	0.10	0.27	< 0.10	< 0.10	< 0.10
Total Of 16 PAH's	M	2700	mg/kg	2.0	2.3	< 2.0	< 2.0	< 2.0
Total Phenols	M	2920	mg/kg	0.30	< 0.30	< 0.30	< 0.30	< 0.30

Chemtest
The right chemistry to deliver results

Report Information

Key

U	UKAS accredited
M	MCERTS and UKAS accredited
N	Unaccredited
S	This analysis has been subcontracted to a UKAS accredited laboratory that is accredited for this analysis
SN	This analysis has been subcontracted to a UKAS accredited laboratory that is not accredited for this analysis
T	This analysis has been subcontracted to an unaccredited laboratory
I/S	Insufficient Sample
U/S	Unsuitable Sample
N/E	not evaluated
<	"less than"
>	"greater than"

Comments or interpretations are beyond the scope of UKAS accreditation
The results relate only to the items tested
Uncertainty of measurement for the determinands tested are available upon request
None of the results in this report have been recovery corrected
All results are expressed on a dry weight basis
The following tests were analysed on samples as received and the results subsequently corrected to a dry weight basis TPH, BTEX, VOCs, SVOCs, PCBs, Phenols
For all other tests the samples were dried at < 37°C prior to analysis
All Asbestos testing is performed at our Coventry laboratory
Issue numbers are sequential starting with 1 all subsequent reports are incremented by 1

Sample Deviation Codes

A - Date of sampling not supplied
B - Sample age exceeds stability time (sampling to extraction)
C - Sample not received in appropriate containers
D - Broken Container

Sample Retention and Disposal

All soil samples will be retained for a period of 60 days from the date of receipt
All water samples will be retained for 14 days from the date of receipt
Charges may apply to extended sample storage

If you require extended retention of samples, please email your requirements to:
customerservices@chemtest.co.uk

Geotechnical & Environmental Associates

Widbury Barn
Widbury Hill
Ware
Herts SG12 7QE

Generic Risk-Based Soil Screening Values

Site	The Manor House, Ham Street, Richmond, TW10 7HA	**Job Number**	J16002
Client	Primus Inter Pares Limited	**Sheet**	1 / 2
Engineer	Hurst Peirce + Malcolm LLP		

Proposed End Use Residential with plant uptake

Soil pH 6

Soil Organic Matter content % 1.0

Contaminant	Screening Value mg/kg	Data Source
Metals		
Arsenic	37	C4SL
Cadmium	26	C4SL
Chromium (III)	3000	LQM/CIEH
Chromium (VI)	21	C4SL
Copper	2,330	LQM/CIEH
Lead	200	C4SL
Elemental Mercury	1	SGV
Inorganic Mercury	170	SGV
Nickel	97	LQM/CIEH
Selenium	350	SGV
Zinc	3,750	LQM/CIEH
Hydrocarbons		
Benzene	0.2	C4SL
Toluene	120	SGV
Ethyl Benzene	65	SGV
Xylene	42	SGV
Aliphatic C5-C6	30	LQM/CIEH
Aliphatic C6-C8	73	LQM/CIEH
Aliphatic C8-C10	19	LQM/CIEH
Aliphatic C10-C12	93	LQM/CIEH
Aliphatic C12-C16	740	LQM/CIEH
Aliphatic C16-C35	45,000	LQM/CIEH
Aromatic C6-C7	See Benzene	LQM/CIEH
Aromatic C7-C8	See Toluene	LQM/CIEH
Aromatic C8-C10	27	LQM/CIEH
Aromatic C10-C12	69	LQM/CIEH
Aromatic C12-C16	140	LQM/CIEH
Aromatic C16-C21	250	LQM/CIEH
Aromatic C21-C35	890	LQM/CIEH
PRO (C_5 – C_{10})	269	Calc
DRO (C_{12} – C_{28})	46,130	Calc
Lube Oil (C_{28} – C_{44})	45,890	Calc
TPH	**1000**	Trigger for speciated testing

Contaminant	Screening Value mg/kg	Data Source
Anions		
Soluble Sulphate	500 mg/l	Structures
Sulphide	50	Structures
Chloride	400	Structures
Others		
Organic Carbon (%)	6	Methanogenic potential
Total Cyanide	140	WRAS
Total Mono Phenols	184	SGV
PAH		
Naphthalene	2.20	C4SL exp & LQM/CIEH
Acenaphthylene	170	LQM/CIEH
Acenaphthene	210	LQM/CIEH
Fluorene	160	LQM/CIEH
Phenanthrene	92	LQM/CIEH
Anthracene	2,300	LQM/CIEH
Fluoranthene	260	LQM/CIEH
Pyrene	560	LQM/CIEH
Benzo(a) Anthracene	4.3	C4SL exp & LQM/CIEH
Chrysene	8	C4SL exp & LQM/CIEH
Benzo(b) Fluoranthene	7.7	C4SL exp & LQM/CIEH
Benzo(k) Fluoranthene	12.1	C4SL exp & LQM/CIEH
Benzo(a) pyrene	4.35	C4SL
Indeno(1 2 3 cd) Pyrene	4.4	C4SL exp & LQM/CIEH
Dibenzo(a h) Anthracene	1.10	C4SL exp & LQM/CIEH
Benzo (g h i) Perylene	65	C4SL exp & LQM/CIEH
Screening value for PAH	**62.1**	B(a)P / 0.15
Chlorinated Solvents		
1,1,1 trichloroethane (TCA)	11.7	LQM/CIEH
tetrachloroethane (PCA)	0.56	LQM/CIEH
tetrachloroethene (PCE)	1.01	LQM/CIEH
trichloroethene (TCE)	0.134	LQM/CIEH
1,2-dichloroethane (DCA)	0.0054	LQM/CIEH
vinyl chloride (Chloroethene)	0.000953	LQM/CIEH
tetrachloromethane (Carbon tetra	0.018	LQM/CIEH
trichloromethane (Chloroform)	0.888	LQM/CIEH

Notes

Concentrations measured below the above values may be considered to represent 'uncontaminated conditions' which pose 'LOW' risk to human health. Concentrations measured in excess of these valuesindicate a potential risk which require further, site specific risk assessment.

SGV - Soil Guideline Value, derived from the CLEA model and published by Environment Agency 2009

LQM/CIEH - Generic Assessment Criteria for Human Health Risk Assessment 2nd edition (2009)derived using CLEA 1.04 model 2009

C4SL - Defra Category 4 Screening value based on Low Level of Toxicological Risk

C4SL exp & LQM/CIEH calculated using C4SL revisions to exposure assessment but LQM/CIEH health croiteria values

Calc - sum of nearest available carbon range specified including BTEX for PRO fraction

B(a)P / 0.15 - GEA experince indicates that Benzo(a) pyrene (one of the most common and most carcenogenic of the PAHs) rarely exceeds 15% of the total PAH concentration, hence this Total PAH threshold is regarded as being conservative

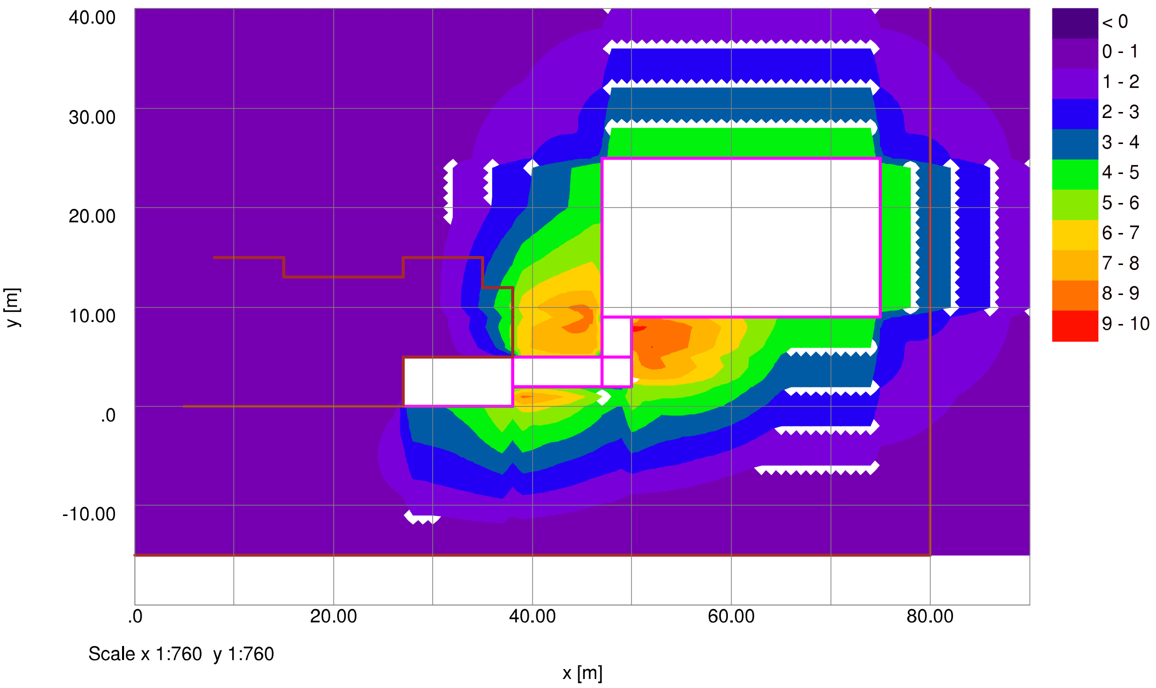
Oasys

The Manor House, Ham Street, Richmond, TW10

Pile Installation

Job No.	Sheet No.	Rev.
J16002		
Drg. Ref.		
Made by MP	Date 13-Mar-2016	Checked

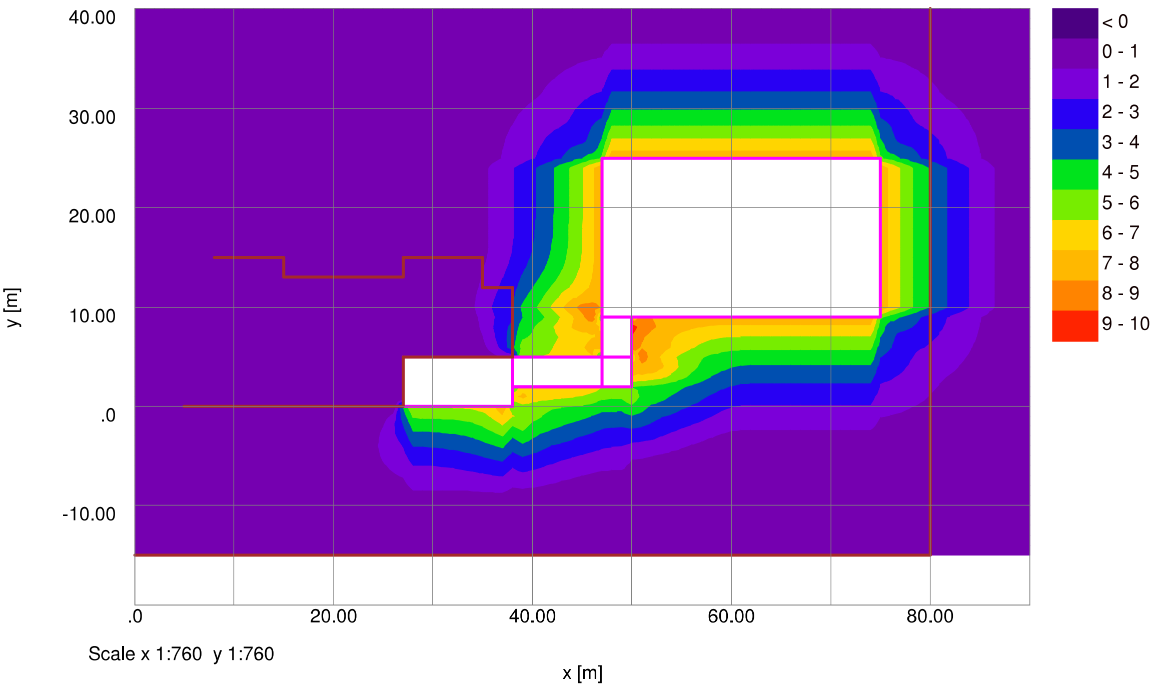
Vertical Settlement Contours: Grid 1 (level 7.000m) (Interval 1mm)



Scale x 1:760 y 1:760

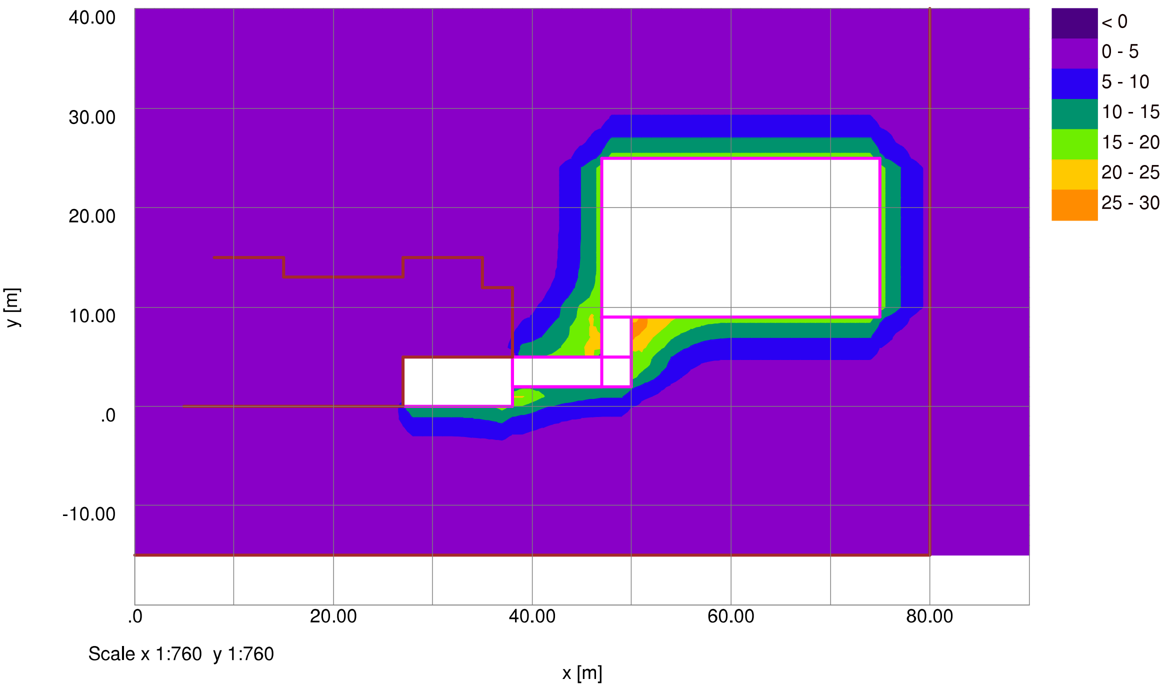
Oasys	Job No.	Sheet No.	Rev.
The Manor House, Ham Street, Richmond, TW10	J16002		
	Drg. Ref.		
Pile Installation	Made by MP	Date 13-Mar-2016	Checked

Horizontal Displacement Contours: Grid 1 (level 7.000m) Interval 1mm



Scale x 1:760 y 1:760

Vertical Settlement Contours: Grid 1 (level 7.000m) (Interval 5mm)



Scale x 1:760 y 1:760

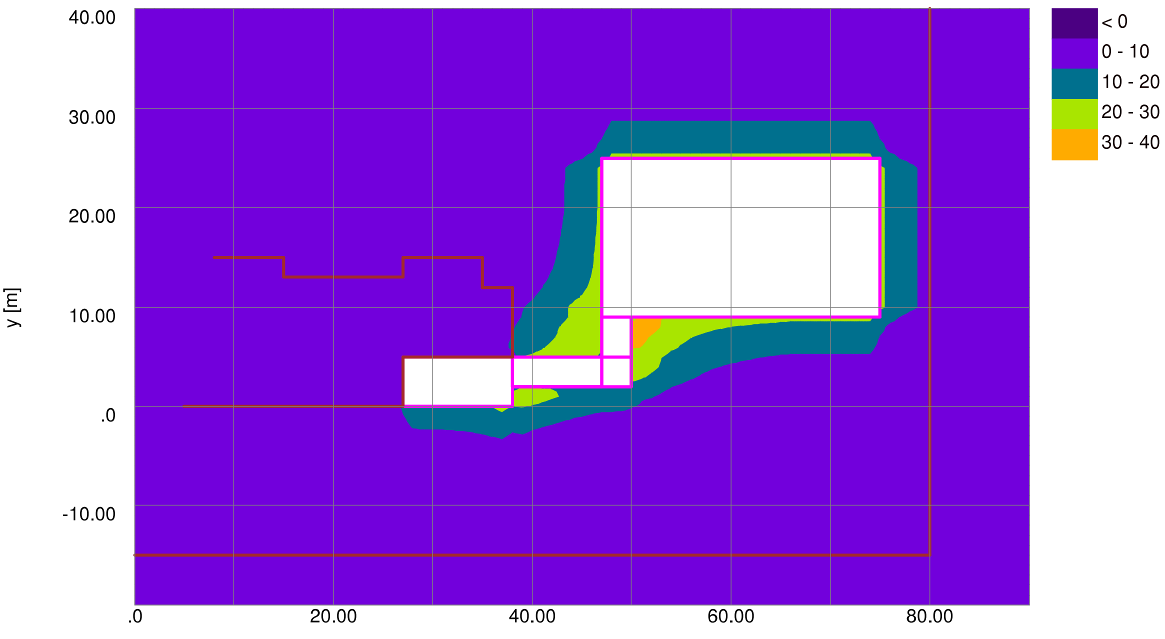
Oasys

The Manor House, Ham Street, Richmond, TW10

Combined Movements

Job No.	Sheet No.	Rev.
J16002		
Drg. Ref.		
Made by MP	Date 13-Mar-2016	Checked

Vertical Settlement Contours: Grid 1 (level 7.000m) (Interval 10mm)



Scale x 1:760 y 1:760

x [m]