The Theatre of Comedy Company

Shaftesbury Theatre, London

Basement Impact Assessment

Project no. 371647 – 01 (01)

NOVEMBER 2017

RSK GENERAL NOTES

Report No.: 371647 - 01 (01)

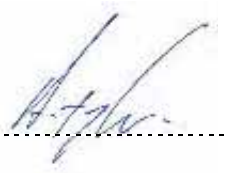
Title: Basement Impact Assessment for Shaftesbury Theatre

Client: The Theatre of Comedy Company, Shaftesbury Theatre, 210 Shaftesbury Avenue, London, WC2H 8DP

Date: 17th November 2017

Office: RSK, 18 Frogmore Rd, Hemel Hempstead, HP3 9RT

Status: Final

Author	Andy Tyler BSc MSc CGeol Principal Geotechnical Engineer	
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NON-TECHNICAL SUMMARY

NON-TECHNICAL SUMMARY	
Site description	The site is located at Shaftesbury Theatre, Shaftesbury Avenue, WC2H 8DP at grid reference 530150E, 181350N, in the London Borough of Camden. The site is surrounded predominantly by a mixture of commercial and residential buildings, of which a number bound the site to the north. The south, west and east of the site are bounded by highways. The topography of the site is generally level with a very minor slope southwards towards High Holborn road. The topography in the immediate site area is also of a similar nature, largely very flat with a shallow sloping descent to the south. The current building on site houses a theatre which is some three storeys in height with a basement excavation which slopes down from a single storey level on the western elevation at 20.80mAOD down to 18.20mAOD on the eastern elevation. This sloping basement houses the theatre seating to the west and the stage and associated back stage areas to the east.
Proposed development	The proposed redevelopment is understood to comprise the widening of the existing basement footprint to facilitate the construction of a larger bar area which would extend underneath Bloomsbury Way, in addition to the widening of the basement southwards beneath the pavement to High Holborn to accommodate additional toilets, changing areas, plant rooms, lifts and back of house storage. The new single level excavation is understood to extend outside the existing basements extent by some 3.00m and is aligned with existing on High Holborn. It extends 6.0m from the existing façade. The proposed basement will have a finished floor level (FFL) of approximately 20.55mAOD and will require the installation of a piled wall around the perimeter of the site in addition to a series of piles to take up the load of the existing theatres external wall.
Ground / Groundwater conditions	Intrusive site investigation works were undertaken at the site by Southern Testing in January 2013, report ref. J11265, and comprised one restricted access cable percussive borehole drilled to a depth of 25.20m below the basement floor or 28.00m below stage level to the east of the site. Due to restrictions regarding access the investigation ground level was taken as the stage level. The floor of the basement from which intrusive drilling commenced is 2.80m below this level. In total the basement level was approximately 6.00m below street level. The works confirmed the ground conditions as a superficial thickness of made ground generally comprising crushed fragments of brick and concrete in a clay matrix overlying the London Clay Formation with the Lambeth Group at depth. The London Clay was encountered at 3.20m and comprised a stiff to very stiff, dark grey brown fissured clay. The Lambeth Group was

	encountered at 24.50m and comprised very stiff, blue grey mottled red brown fissured clay. Plasticity classification testing indicates that the clays are of high to very high plasticity, typical of both the London Clay Formation and Lambeth Group. Additional trial pitting works to inspect the existing foundations on site were ongoing at the time of writing this report. Of the pits completed TP3 was the deepest and was undertaken on the southern elevation at basement level within a Plant Room at a level of 21.24mAOD. The pit revealed masonry corbelled footings overlying a mass concrete pad / strip extending to a depth of 1.50m (19.74mAOD). The pad was observed to be founded on the Lynch Hill Gravel and was dry at the time of inspection. The works undertaken on site to date did not reveal the presence of groundwater within the London Clay Formation, nor perched groundwater within the overlying made ground soils.
Screening and scoping	**Subterranean (ground water): Potential impacts include:** • The site located directly above an aquifer; and • The proposed basement extends beneath the water table surface. **Surface flow and flooding:** No potential impacts identified beyond the scoping stage **Land stability:** Potential impacts identified relate to ground stability associated with: • Retaining wall installation and ground excavation; and • Elastic heave of the London Clay in the basement excavation.
Impact Assessment	The following nearby structures were identified for assessment relating to potential ground movements: • The highways of Shaftesbury Avenue, High Holborn and Grape Street • Sovereign House which bounds the site to the north • 167 High Holborn which lies on the opposite side of Grape Street to the east of the site • Berkshire House which lies on the opposite side of High Holborn to the south of the site **Structural stability of adjacent structures resulting from the proposed development** Numerical modelling has been undertaken to determine the deflections at key stages in the construction process, namely: • Basement excavation and pile wall installation; and • Full loading following construction of the new basement and building. Movement analyses have been undertaken in accordance with CIRIA C760. All building structures fall into 'Category 0' (Negligible). The results fulfil the requirements of CPG4 in that they do not exceed the damage category of

	'very slight' (Category 1). The predicted movements of Shaftesbury Avenue, High Holborn and Grape Street road/pavements of are of limited magnitude as a result of the proposed development.
Cumulative Impacts	No potential cumulative impacts have been identified for the proposed development.

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1 INTRODUCTION

1.1 Instructions

RSK Environment Limited (RSK) was commissioned by The Theatre of Comedy Company to carry out a Basement Impact Assessment for a proposed development at Shaftesbury Theatre located within the London Borough of Camden.

1.2 Regulatory Context

This assessment is designed to be compliant with guidance provided by the London Borough of Camden (Camden) in their guidance document 'Camden Planning Guidance for Basements and Lightwells, CPG4' (amended June 2015) and its supporting study 'Camden Geological, Hydrogeological and Hydrological Study' produced for Camden by ARUP in November 2010. All the technical analysis and recommendations contained within the planning guidance are taken from this latter study, which is treated as the evidence base and technical advice when Camden are assessing Basement Impact Assessments.

This guidance applies to all developments in Camden that propose a new basement development, or an extension to existing basement accommodation where planning permission is required. In accordance with policy A5, Camden will only permit basement and other underground development where it can be demonstrated that it will not cause harm to the built and natural environment, including to the local water environment and ground conditions.

Addressing these issues requires the submission of a Basement Impact Assessment (BIA). A BIA will be specific to a particular site and proposed development, but includes the following stages:

- *Screening*; the identification of any matters of concern with regard to hydrogeology, hydrology or ground stability, which should be investigated.
- *Scoping*; production of a statement that defines further the matters of concern identified at the screening stage.
- *Site Investigation and Study*; undertaken to establish the baseline conditions. This can be done by utilising existing information and/or collecting new information.
- *Impact Assessment*; undertaken to determine the impact of the proposed basement on the baseline conditions, taking into account any mitigation measures proposed.
- *Review and Decision-Making*; this final stage is undertaken by Camden and consists of an audit of the information supplied and a decision on the acceptability of the impacts of the basement proposal.

A Basement Impact Assessment (BIA) should demonstrate that the impacts of the proposed development are acceptable, or that appropriate mitigation measures will be adopted.

1.3 Background

By way of background to the current project, an intrusive site investigation was undertaken by Southern Testing in January 2013, report ref. J11265. The current assessment draws on the results of that report. For full details reference should be made to the original report.

This report provides site specific information whilst considering the data requirements as set out in Appendix G of 'Camden Geological, Hydrogeological and Hydrological Study' produced for Camden by ARUP in November 2010. The conditions at the site have not changed since these reports were commissioned and, therefore, the information within these reports is relevant to the proposed scheme described herein.

1.4 Standards and Limitations

This report is based on information available at the time of writing. This report should be considered in the light of any changes in legislation, statutory requirement or industry practices that may have occurred subsequent to the date of issue.

2 SITE DETAILS

2.1 Site description

The site is located at Shaftesbury Theatre, 210 Shaftesbury Avenue, WC2H 8DP at grid reference 530150E, 181350N, as shown on Figure 1.

The site is surrounded predominantly by commercial buildings, as detailed in Table 1.

Table 1: Site setting

To the north:	Sovereign House, which comprises mixed commercial and retail units at 222 Shaftesbury Avenue, bounds the site to the north west. 6 to 8 Grape Street bounds the site to the north east and comprises mixed commercial, retail and high level residential units.
To the east:	The site is bound to the east by Grape Street, beyond which 167 High Holborn and 13 to 17 Grape Street contain mixed commercial, retail and high level residential units.
To the south:	High Holborn bounds the site to the south, beyond which Berkshire House and The Place are present. Berkshire House which currently houses a mix of commercial and sports leisure facilities sits adjacent to The Place which appears to be a mixed commercial and retail units. It is understood that part of the Crossrail network is present some 8.0m south of the site at a depth of some 14.0m.bgl.
To the west:	Shaftesbury Avenue bounds the site to the west. Beyond which Bloomsbury Street bounds the site beyond which a traffic island containing a water fountain is present.

The site covers approximately 850m^2 at an elevation of approximately 24m above Ordnance Datum (AOD).

The topography of the site is generally level with a very minor slope southwards towards High Holborn road. The topography in the immediate site area is also of a similar nature, largely very flat with a shallow sloping descent to the south.

The current building on site houses a theatre which is some three storeys in height with a basement excavation which slopes down from a single storey level on the western elevation at 20.80mAOD down to 18.20mAOD on the eastern elevation. This sloping basement houses the theatre seating to the west and the stage and associated back stage areas to the east.

The only buildings that directly bound the site are present to the north and comprise Sovereign House (210 to 222 Shaftesbury Avenue) and 6 to 8 Grape Street. All of the properties surrounding the site are known to have at least single storey basement levels.

2.2 Planning records

A search of publicly available planning records on Camden's planning website revealed a number of planning permissions related to the site dating back to 1980. The majority of the applications are concerned with minor alterations to the theatre structure and the construction of an additional two storeys on the south eastern corner at roof level. The remaining applications refer to largely cosmetic changes and there are no other large scale structural changes of note.

In addition a number of applications relating to basement construction and / or change of use in close proximity to the site have been noted. Figure 3 details those sites within the local site area which are known to have basements. This figure is not exhaustive and is based on observations made during the walkover and from information gleamed from Camden's planning portal.

3 DESK STUDY FINDINGS

3.1 Site walkover

The site was visited on 24th October 2017 to undertake a site walkover. Photographs of the site walkover are provided in Appendix A.

During this walkover it was highlighted that there are three groundwater pumps located within the basement area that have been in operation, albeit replaced periodically, since the theatre was constructed in 1911. It is understood that in the past these pumps have failed and as such an accumulation of groundwater has occurred at the lowest basement level. Although the ingress of groundwater has occurred in the past discussions with the estates manager on site highlighted that the volumes were never significant enough to impact the long term operation of the theatre.

Following the completion of the walkover it was concluded that no potentially significant geotechnical issues were identified during the site reconnaissance survey.

3.2 Ground conditions

3.2.1 British Geological Survey Data

Published maps (British Geological Survey, 2006) and borehole records for the area indicate the geology of the site to be characterised by the succession recorded in Table 2 and generally comprising the superficial Lynch Hill Gravel Member underlain by the London Clay Formation. Underlying this is a further succession of the Lambeth Group, the Thanet Sand and the White Chalk Sub Group.

Table 2: Geology at the site

Geological unit	Description	Estimated thickness (m)	Estimated base level (mAOD)
Lynch Hill Gravel Member (superficial)	Sand and gravel, locally with lenses of silt, clay or peat	Approximately 4m	~20mAOD
London Clay Formation	Silty to very silty clay, clayey silt and sometimes silt, with some layers of sandy clay	Approximately 20m	~0mAOD
Lambeth Group	Sands at base (Bottom Bed), overlain by grey clays and sands (Woolwich Beds), and variegated clays and sands (Reading Beds).	Approximately 20m	~-20mAOD
Thanet Sand	Nodular flint at base, overlain by pale yellow-brown, fine-grained sand that can be clayey	Approximately 4m	~-24mAOD
White Chalk Sub Group	Chalk, with or without flint	Variable, 400-560m	~-424mAOD

A number of images such as Illustrations 1 and 2 below have been inserted into this report from the 'Camden Geological, Hydrogeological and Hydrological Study' produced for Camden by ARUP in November 2010. This report has been referenced and any pertinent figures reproduced and included and where relevant these figures have been discussed during the screening and scoping stages.

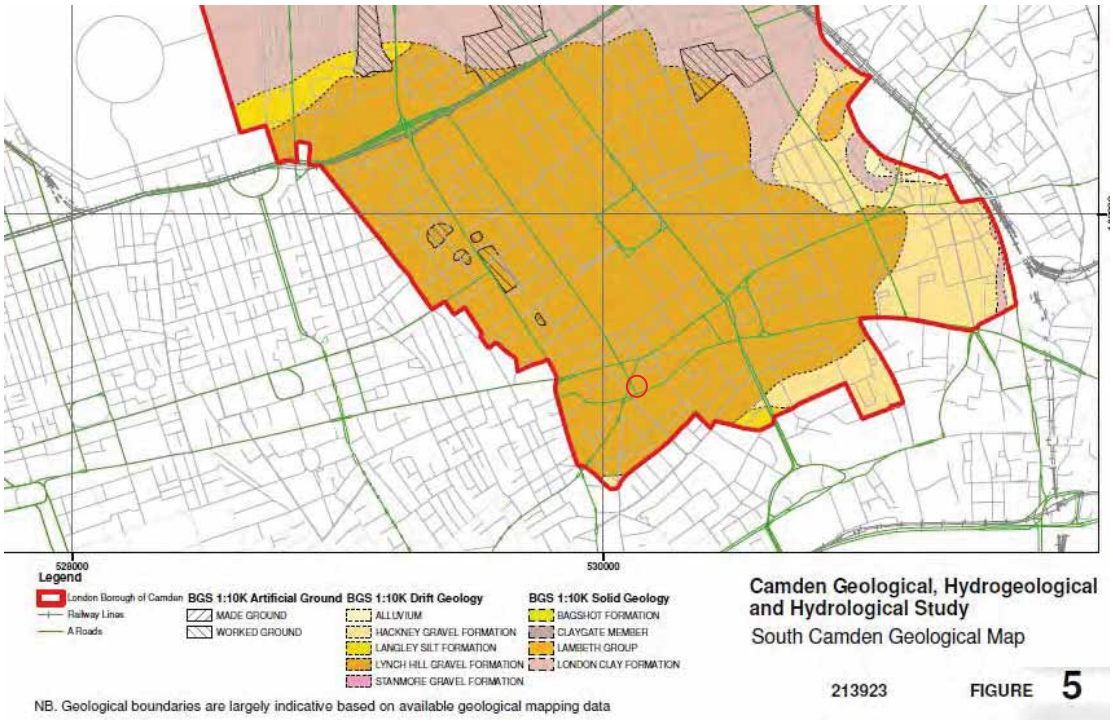


Illustration 1: ARUP Report Figure 5.

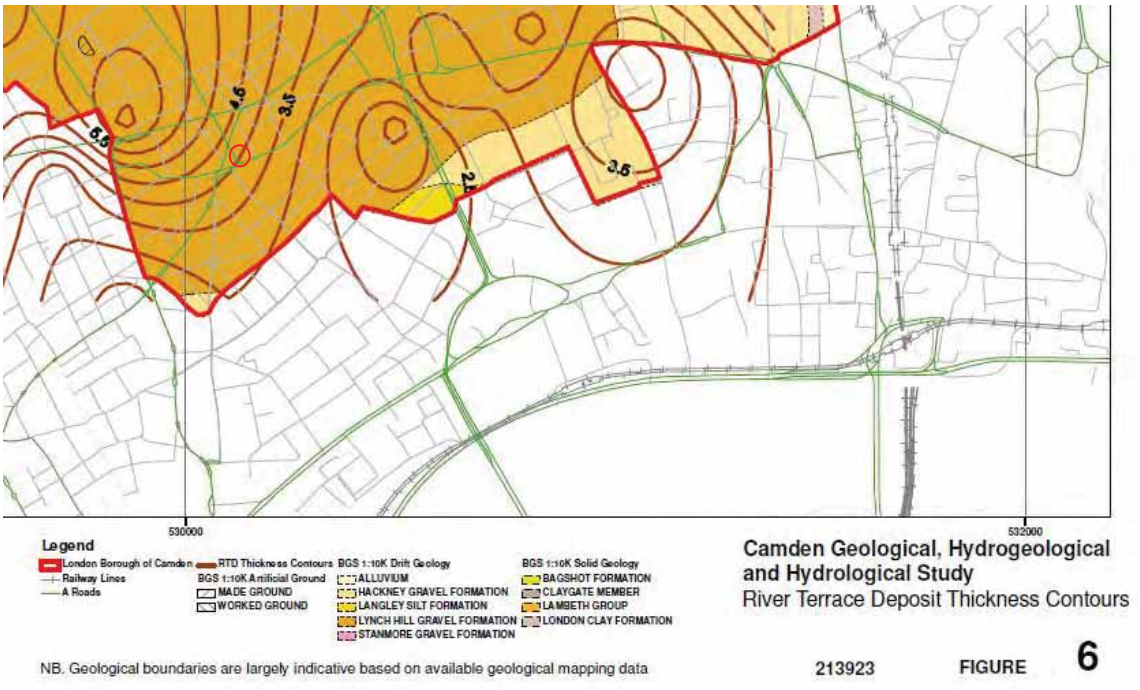


Illustration 2: ARUP Report Figure 6.

3.2.2 Historical borehole records

There are three sets of borehole records in close proximity to the site that can be downloaded from the British Geological Survey website to provide further information regarding ground conditions in the vicinity of the site.

Two of these records are publically available and one remains the property of Crossrail has been provided without prejudice on a strict non-disclosure basis and as such is not presentable.

Approximately 50.00m to the north west Borehole ref TQ38SW189 indicates made ground to 2.70m underlain by loam and ballast to 6.70m, this is underlain by the London Clay Formation to 9.75m where the borehole terminated.

Approximately 35.00m to the east Borehole ref TQ38SW799 indicates four boreholes of varying depths with a variable thickness of made ground ranging from some 1.20m to 3.30m underlain by sand and gravel to some 4.80m, this is underlain by the London Clay Formation to a maximum depth of some 18.00m at which level the borehole was terminated. Groundwater levels appear to be in the order of some 4.00m below ground level based on the water strike information on the logs.

Copies of these two borehole records are included in Appendix A.

Given that the site is already developed suggests that, in addition to natural strata, made ground should be expected beneath the site.

3.2.3 Site Specific Intrusive Investigation Data

3.2.3.1 Southern Testing Investigations

Intrusive site investigation works were undertaken at the eastern end of the site by Southern Testing in January 2013, report ref. J11265, and comprised one restricted access cable percussive borehole drilled to a depth of 25.20m below the basement floor or 28.00m below stage level. Due to restrictions regarding access the investigation level was taken as stage level. The floor of the basement from which intrusive drilling commenced is 2.80m below this level. In total the basement level was approximately 6.00m below street level.

The works confirmed the ground conditions as a superficial thickness of made ground generally comprising crushed fragments of brick and concrete in a clay matrix overlying the London Clay Formation with the Lambeth Group at depth. The London Clay was encountered at 3.20m and comprised a stiff to very stiff, dark grey brown fissured clay. The Lambeth Group was encountered at 24.50m and comprised very stiff, blue grey mottled red brown fissured clay.

Plasticity classification testing indicates that the clays are of high to very high plasticity, typical of both the London Clay Formation and Lambeth Group.

3.2.3.2 Trail Pitting Investigations

Additional trial pitting works to inspect the existing foundations on site were ongoing at the time of writing this report. Of the pits completed TP3 was the deepest and was undertaken on the southern elevation at basement level within a Plant Room at a level of 21.24mAOD. The pit revealed masonry corbelled footings overlying a mass concrete

pad / strip extending to a depth of 1.50m (19.74mAOD). The pad was observed to be founded on the Lynch Hill Gravel and was dry at the time of inspection.

3.2.3.3 Hydrological/Hydrogeological Conditions Determined by the Site Investigations

The works undertaken on site to date did not reveal the presence of groundwater within the London Clay Formation, nor perched groundwater within the overlying made ground soils while both the borehole and trial pitting works were being undertaken.

3.2.4 Radon

The environmental database report indicates that the site is in a lower probability radon area where less than 1% of homes are estimated to be at or above the action level. It is not located within an 'Affected Area' as defined by the Documents of the National Radiological Protection Board (Radon Atlas of England and Wales, NRPB-W26-2002) and therefore the risk of significant ingress of radon into structures on-site is considered low and no radon protective measures are required within new structures.

3.2.5 Mining and quarrying

Evidence has been sought to identify any mining and quarrying operations, past and present, which have taken place within a radius of 250m of the site. The sources of information referenced in this element of the desk study include:

- environmental database report;
- archival Ordnance Survey maps and plans;
- Coal Authority interactive map viewer; and
- published geological records.

With reference to the above data there are no recorded mines, quarries, natural cavities within a 500m radius of the site.

The Groundsure report (included within Appendix A) highlights that Johnson Poole Bloomer holds information on past mining activities within 1000m of the site. However, upon considering the other available information it unlikely that mining occurred on or within the vicinity of the site.

3.2.6 Landfilling and land reclamation

Evidence has been sought to identify areas of made ground, landfilling or land reclamation operations, past and present, which have taken place in the vicinity of the site. The sources of information referenced in this element of the desk study include:

- environmental database report;
- Environment Agency records, accessed via online map tool;

There are no records of landfill sites (former or current) within 250m of the site (i.e. within the planning consultation zone). Furthermore, there are no records of landfills within a 0.5km radius of the site.

3.3 Unexploded Ordnance (UXO)

Based on the regional UXO bomb damage maps of London, a low risk was identified. However, a threat assessment for risks associated with Unexploded Ordnance (UXO) at the site was still prepared and issued under a separate cover (ref.: EP5487-00, dated October 2017). Following the findings of this preliminary report, the report identified a negligible risk of encountering UXO at the site.

3.4 Hydrogeology

3.4.1 Aquifer characteristics

With reference to the environmental database report and the Environment Agency (EA) online resource, the hydrogeology of the site is likely to be classified by the presence of an Secondary A Aquifer relating to the Lynch Hill Gravel deposits and an unproductive Aquifer associated with the underlying London Clay Formation, as noted in Illustration 3.

It is therefore envisaged that groundwater beneath the site will be restricted to perched water associated within any made ground soils (if any) or within the granular Lynch Hill Gravel.

The site has been classified by the EA website to overlie a:

- secondary A aquifer: 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
- 'unproductive' strata: low permeability with negligible significance for water supply or river base flow.

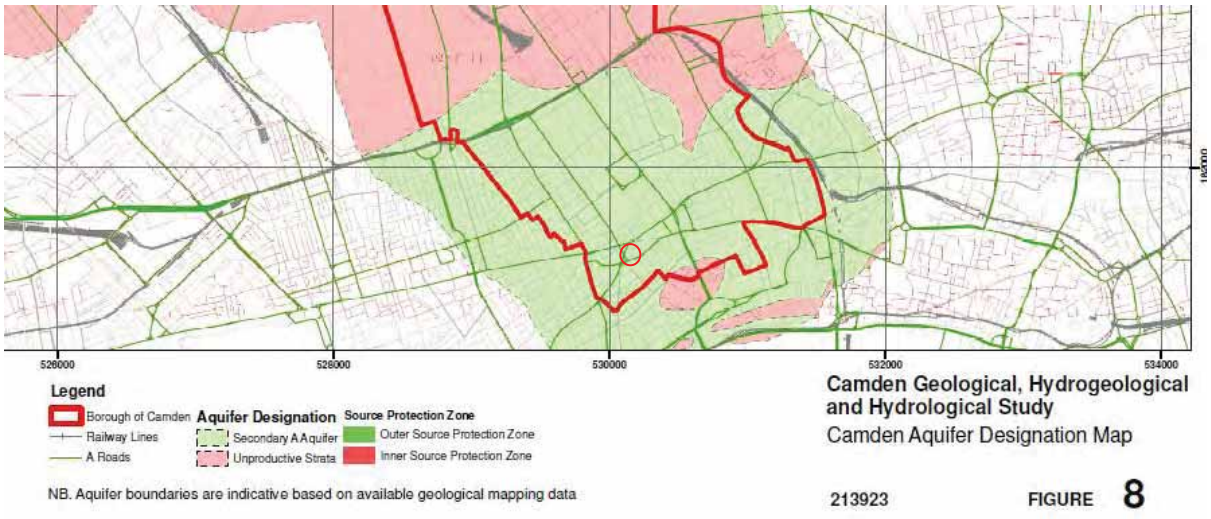


Illustration 3: ARUP Report Figure 7.

Confined by the London Clay Formation is a deep aquifer, comprising a sequence of deposits consisting of the lower part of the Lambeth Group and Thanet Sands (Basal Sands) and the White Chalk. These units are expected to be in hydraulic continuity.

3.4.2 Risk from rising groundwater levels

Rising groundwater levels can affect foundations and structures and may result in flooding if not properly controlled. In certain areas, groundwater levels are rising owing to reduced groundwater abstraction by industry.

As defined within CIRIA Special Publication 69 (Simpson et al., 1989) the site does not lie within the critical areas in the London basin in which shallow foundations and basements are potentially at risk from the rising groundwater levels in the deep aquifer. The rise in groundwater levels started during the mid-1960s as a result of a significant reduction in groundwater abstraction from the Chalk aquifer. Prior to this, the Chalk aquifer had been increasingly exploited as a result of increasing industrialisation throughout the 19th century and early part of the 20th century.

The deep aquifer beneath the site comprises a sequence of Tertiary Deposits (consisting of the lower part of the Lambeth Group and Thanet Sands) and the Chalk, these units are expected to be in hydraulic continuity and therefore have been considered as a single aquifer unit.

Following the issue of CIRIA Special Publication 69 (Simpson et al., 1989), the Rising Groundwater Level Working Group (GARDIT) was formed in March 1998. This group publicly launched a strategy proposal for controlling rising groundwater beneath London. As a result of the implementation of the GARDIT strategy, groundwater levels are now considered to be stabilising across much of the London Basin and the GARDIT Strategy is considered to have been successful. There will be ongoing monitoring and control of groundwater levels in the London Basin using the abstraction licensing process.

The EA status report issued in August 2017 ‘Management of the London Basin Chalk Aquifer’ indicates that the potentiometric surface of the groundwater in the deep aquifer in the site area in January 2017 was at approximately -35.0mAOD, i.e. approximately 59.0m below ground level.

3.5 Hydrology

3.5.1 Surface watercourses

Information obtained via the site walkover inspection and review of Ordnance Survey mapping data and the environmental database report indicates that there are no surface water features located within 250m of the site. The closest surface water course is located 905m south (River Thames).

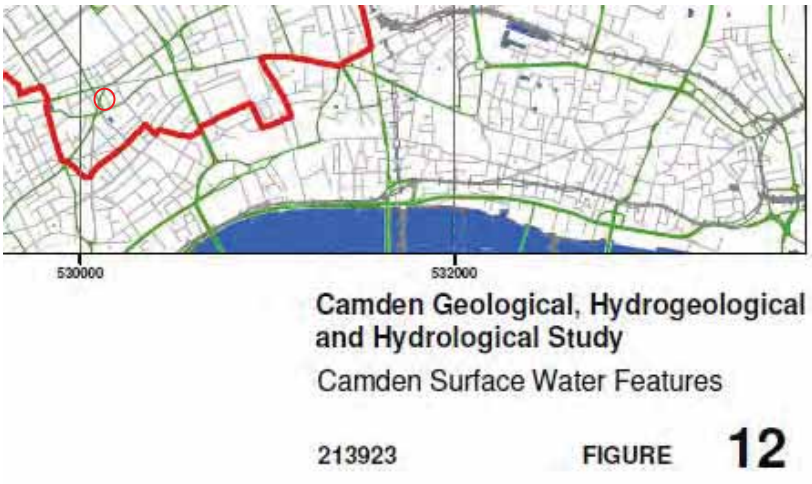


Illustration 4: ARUP Report Figure 12.

In addition there are no historic water courses noted in close proximity to the site as noted in Illustration 5.

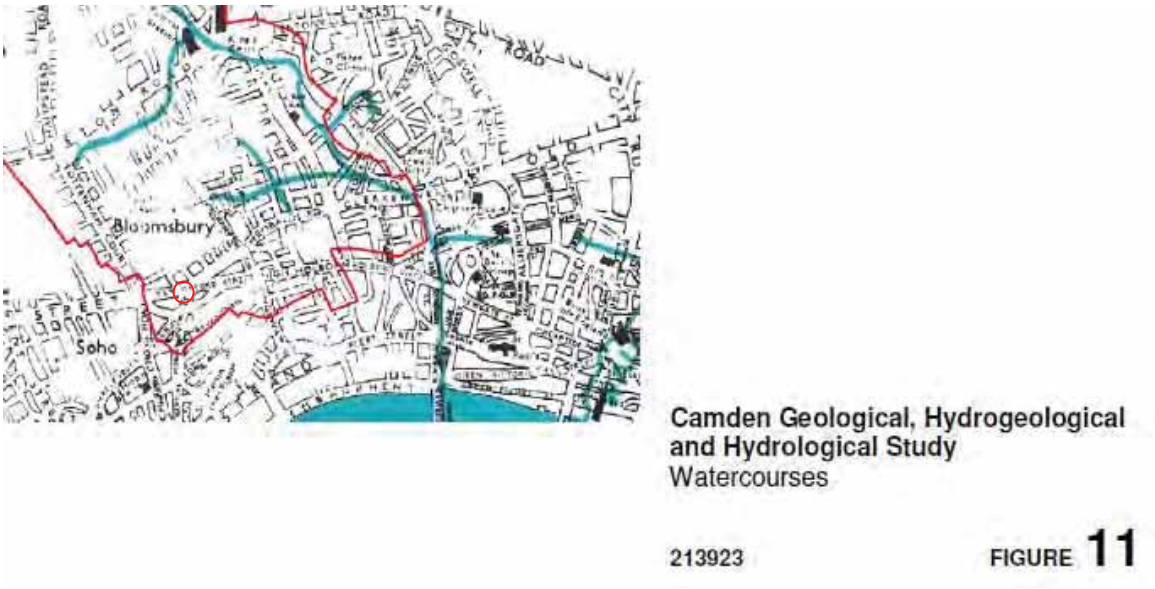


Illustration 5: ARUP Report Figure 11.

3.5.2 Site drainage

Surface and foul water drainage have been confirmed to be connected to Thames Water public sewers. It is therefore assumed that no other soakaway or SUDS systems are present on site.

It is noted that three pumps are present on site which remove the limited accumulation of groundwater at lower basement level into the public sewers.

3.5.3 Preliminary flood risk assessment

The indicative floodplain map for the area, published by the EA, and the Groundsure report shows that the site does not lie within any Flood Zones. Furthermore there are no Zone 2 of Zone 3 Flood Zones within 250m of the site.

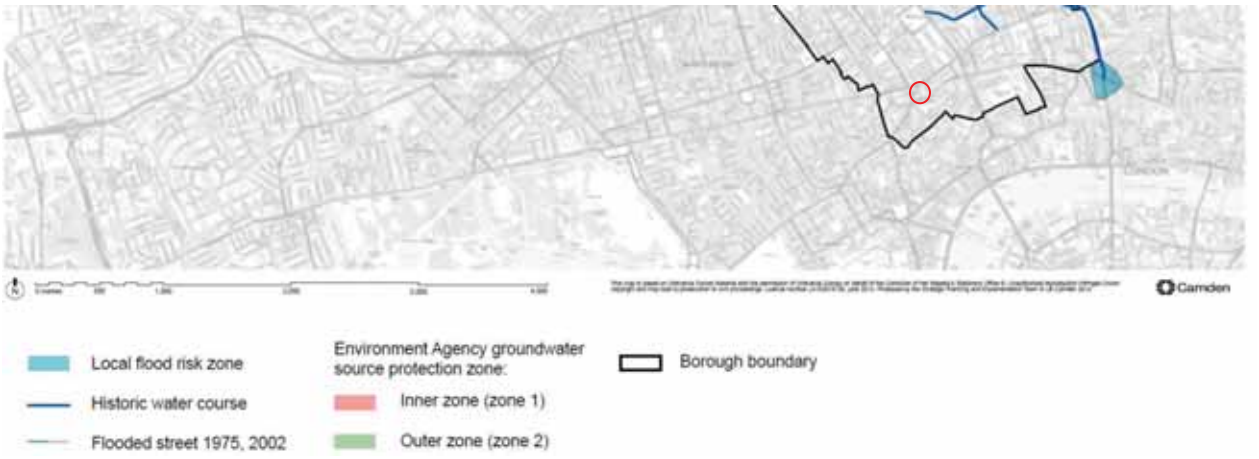


Illustration 6: Camden Local Plan Map 6: Historic Flooding and Local Flood Risk Zones

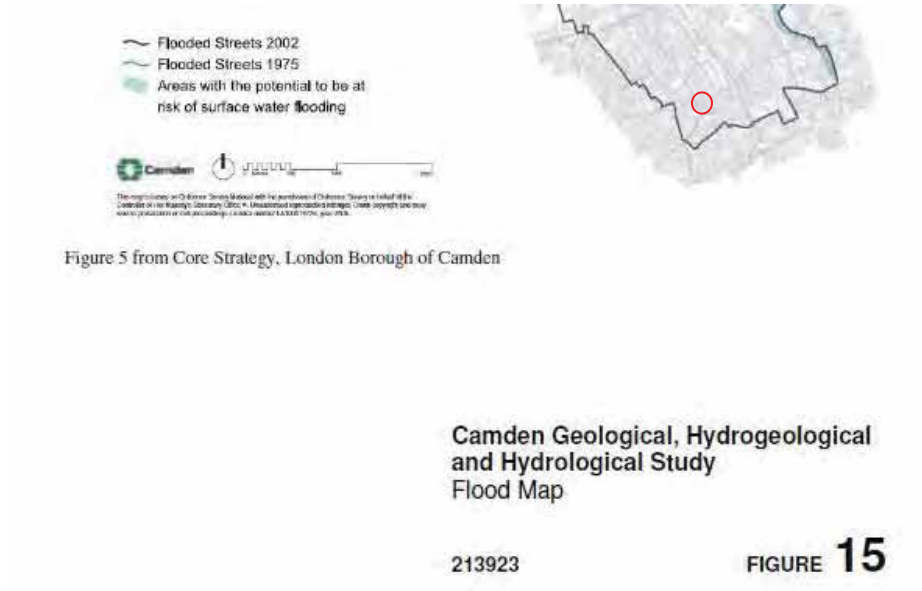


Illustration 7: ARUP Report Figure 15.

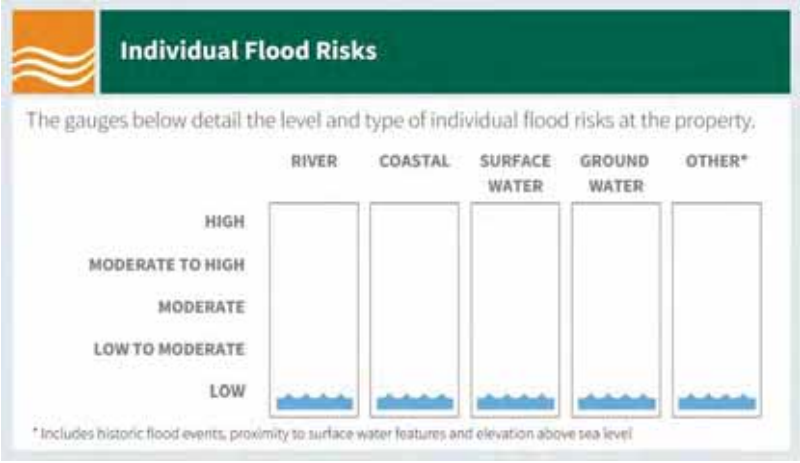


Illustration 8: Flooding potential findings.

The flooding records held by Thames Water and included within Appendix F indicate that there have been no incidents of flooding in the requested area as a result of surcharging public sewers.

3.6 Development History

Copies of OS and County Series maps are included in the environmental database report in Appendix A. Pertinent features are summarised below. Reference to historical maps provides invaluable information regarding the land use history of the site, but historical evidence may be incomplete for the period pre-dating the first edition and between successive maps.

Table 3: Summary of historical development

Date	Land use/features on site	Land use/features in vicinity of site
1875	The site comprises what appear to be predominantly terraced residential properties and a public house.	The surrounding area comprises largely residential / commercial buildings. The site is bounded to the east by Vine Street, the south by Broad Street and the west by Bloomsbury Street. A drinking fountain is noted some 80m south west of the site in the middle of Broad Street.
1896	No significant change.	Shaftesbury Avenue replaces a series of properties to the north of the site and Bloomsbury Street bounds the site to the west. A series of urinals are present some 25m west of the site. A trough is present 60m south west of the site on the southern side of Broad Street.
1916	By 1916 the buildings on site are replaced with the Princes Theatre.	The buildings that bound the site to the north are replaced with a series of terraced residential properties. Vine Street is renamed Grape Street which now bounds the site the east. A drinking fountain is noted some 90m north of the site in the middle of Oxford Street. The trough is no longer visible.
1951	No significant change.	Broad Street is renamed High Holborn.
1974	By 1974 the site is referred to as Shaftesbury Theatre.	No significant change.
1974 - 1995	No significant change.	No significant change.

4 PROPOSED DEVELOPMENT

The proposed redevelopment is understood to comprise the widening of the existing basement footprint to facilitate the construction of a larger bar area which would extend underneath Bloomsbury Street, in addition to the widening of the basement southwards beneath the pavement to High Holborn to accommodate additional toilets, changing areas, plant rooms, lift and back of house storage. The new single level excavation is understood to extend outside the existing basements extent by some 6.00m from the façade and by some 3.00m from the existing basement.

The proposed basement will have a finished floor level (FFL) of approximately 20.55mAOD and will require the installation of a piled wall around the perimeter of the site in addition to a series of piles to take up the load of the existing theatres external wall.

Proposed engineering plans and sections for the development are included in Appendix C.

In the temporary case a propped perimeter contiguous bored piled wall is proposed to support the basement excavation in addition to the installation of a series of beams on piles to support the existing facade. Following the installation of the temporary supports the basement box will be constructed from reinforced concrete, with concrete slabs at basement and ground floor levels, forming rigid propping in the permanent condition. It is proposed to support the structure on piled foundations.

The basement construction will be required to be designed in the permanent condition as a water retaining structure in accordance with BS8007, design of concrete structures for retaining aqueous liquids, with a secondary means of defence such as a tanked system, in accordance with BS8102, as required.

5 STAGE 1 - SCREENING

This section of the report provides information for the purpose of screening in accordance with CPG4 and addresses all questions raised within the relevant sections of that document. Tables summarising the screening flowcharts are shown as Tables 1 to 3. In accordance with procedure, where a 'yes' or 'unknown' response is returned, the potential issue is taken to the scoping stage in **Section 6**.

Table 4: Subterranean (groundwater) screening

Question		Answer	Evidence/Comment
1	Is the site located directly above an aquifer?	Yes	The site is underlain by the Lynch Hill Gravel Member which is classified as a Secondary A Aquifer. It is unclear how much of the Lynch Hill Gravel Member remains on site following the excavation of the existing basement structure.
1a	Will the proposed basement extend beneath the water table surface?	Yes	Works completed to date on site did not encounter any groundwater, as such, it is not clear what the groundwater level is outside the site boundary. Information collated from various BGS sources indicate that groundwater levels in the vicinity of the site are in the order of 3.50m to 4.00m below ground level, or just above the surface of the London Clay Formation, as such it is likely that the proposed development, specifically the installation of the contiguous piled wall, will extend into the local water table, much like the existing basement.
2	Is the site within 100m of a watercourse, well (used/disused) or potential spring line?	No	There are no ponds, streams, drainage ditches or potential spring lines on or adjacent to the site. The nearest identified surface watercourse to the site is the River Thames located approximately 905m to the south of the site.
3	Is the site within the catchment of the pond chains on Hampstead Heath?	No	See location plan.
4	Will the proposed basement development result in a change in the proportion of hard surfaced / paved areas?	No	There is no change from the existing hardstanding covering compared with that of the proposed.
5	As part of the site drainage, will more surface water (e.g. rainfall and run-off) than at present be discharged to the ground (e.g. via soakaways and/or SUDS)?	No	See response to Question 4, above. It is proposed that the existing drainage connection to the public combined sewer will be retained and reused. This will be subject to approvals from Thames Water as well as to its location and condition, which will be confirmed by CCTV survey.
6	Is the lowest point of the proposed excavation (allowing for any drainage and foundation space under the basement floor) close to, or lower than, the mean water	No	See response to Question 2, above.

Question		Answer	Evidence/Comment
	level in any local pond (not just the pond chains on Hampstead Heath) or spring line?		

Table 5: Surface flow and flooding screening

Question		Answer	Evidence/Comment
1	Is the site within the catchment of the pond chains on Hampstead Heath?	No	See location plan.
2	As part of the proposed site drainage, will surface water flows (e.g. volume of rainfall and peak run off) be materially changed from the existing route?	No	See responses to Questions 4, Table 3 (Subterranean (groundwater) screening)
3	Will the proposed basement development result in a change in the proportion of hard surfaced / paved external areas?	No	See responses to Questions 4, Table 3 (Subterranean (groundwater) screening)
4	Will the proposed basement result in changes to the profile of the inflows (instantaneous and long term) of surface water being received by adjacent properties or downstream watercourses?	No	There are no proposed changes to the surface use, as such it is envisaged that surface was flows will not be altered.
5	Will the proposed basement result in changes to the quality of surface water being received by adjacent properties or downstream watercourses?	No	Control measures employed at the site should comply with CIRIA Report 532 'Control of Water Pollution from Construction Sites' and Environment Agency guidance 'Protect Groundwater and Prevent Groundwater Pollution' and should be included at the detailed design stage.
6	Is the site in an area known to be at risk from surface water flooding, or is it at risk from flooding, for example because the proposed basement is below the static water level of a nearby surface water feature?	No	Reference to the EA floodplain maps, North London Strategic Flood Assessment and The London Borough of Camden flood risk management strategy shows that the site does not lie within any known flood zones. The site, nor any streets within the area are on Camden's own list of streets at risk of surface water flooding and does not lie in an area of known flooding from sewer surcharge (Figure 15 of the ARUP report).

Question		Answer	Evidence/Comment
			Thames Water flooding documentation indicates there have been no incidents of flooding in the requested area as a result of surcharging public sewers.

Table 6: Land Stability Screening

Question		Answer	Evidence/Comment
1	Does the existing site include slopes, natural or manmade, greater than 7°?	No	
2	Will the proposed re-profiling of landscaping at the site change slopes at the property boundary to more than 7°?	No	
3	Does the development neighbour land, including railway cuttings and the like, with a slope greater than 7°?	No	
4	Is the site within a wider hillside setting in which the general slope is greater than 7°?	No	
5	Is the London Clay the shallowest stratum at the site?	No	Although the large proportion of the existing basement on site lies directly within the London Clay Formation, the area earmarked for proposed development would appear to be underlain by some 4.00m of the Lynch Hill Gravel Member. BGS logs and Figure 16 of the ARUP report.
6	Will any tree/s be felled as part of the proposed development and/or are any works proposed within any tree protection zones where trees are to be retained?	No	
7	Is there a history of seasonal shrink-swell subsidence in the local area, and/or evidence of such effects at the site?	No	There is no immediate or direct evidence of seasonal shrink-swell effects on site.
8	Is the site within 100m of a watercourse or a potential	No	See responses to Questions 2, Table 3 (Subterranean (groundwater)

Question		Answer	Evidence/Comment
	spring line?		screening)
9	Is the site within an area of previously worked ground?	No	A natural ground stability hazard dataset supplied by the BGS and historical and geological mapping reveal that there are no recorded hazards associated with previously worked ground, landfilling or compressible and collapsible ground at the site that could lead to stability issues. Although the site investigations undertaken have revealed the presence of a superficial covering of made ground beneath the basement level, these deposits are not considered to pose a risk to with regard to land stability.
10	Is the site within an aquifer? If so, will the proposed basement extend beneath the water table such that dewatering may be required during construction?	Yes	The portion of the site that has been considered for development is maybe underlain by some 4.00m of the Lynch Hill Gravel Member which is classified as a Secondary A Aquifer, however the remainder of the site to the east has been observed to extend into the underlying London Clay Formation. The proposed development is envisaged to comprise a reduction in site levels to some 20.30mAOD or up to 3.85m.bgl. At present the groundwater levels beneath the site have been observed on site to be at least below some 19.74mAOD based on the inspection of TP3. However, despite the absence of groundwater within the trial pits and boreholes the presence of water cannot be discounted, as such, allowance might need to be given to a secant piled wall solution over the currently proposed contiguous option.
11	Is the site within 50m of the Hampstead Heath ponds?	No	
12	Is the site within 5m of a highway or pedestrian right of way?	Yes	See Section 6 (Scoping)
13	Will the proposed basement significantly increase the differential depth of foundations relative to neighbouring properties?	No	The site is surrounded on the eastern, southern and western elevations by public highways, beyond which it is noted that each of the properties on the far side of the highway appear to already comprise at least a single level basement. The properties that bound the site to the north are also noted to have existing single level basements, as such there is not envisaged to be

Question		Answer	Evidence/Comment
			an increase in the differential depth of foundations relative to neighbouring properties.
14	Is the site over (or within the exclusion zone of) any tunnels?	No	It is noted that a Crossrail operated tunnel is present some 8.00m south of the site at an approximate depth of 14.00m.bgl. Although the site is outside the tunnel exclusion zone the possible displacements observed at the tunnel location as a result of the proposed development has been considered in this report.

6 STAGE 2 – SCOPING

As defined in CPG4, the scoping stage is used to identify the potential impacts of the proposed scheme for each of the matters of concern identified in the previous screening stage (i.e. those questions answered with a “yes” or “unknown” response). The sections below present statements that define further the matters of concern identified at the screening stage. The data summarised in **Section 2, Section 3 and Section 4** has been used to develop a conceptual ground model to carry out the scoping stage.

6.1 Subterranean (Groundwater) Scoping

6.1.1 QUESTION 1: Is the site located directly above an aquifer?

POTENTIAL IMPACT: Potentially the basement may extend into the underlying aquifer and thus affect the groundwater flow regime.

At present the site houses a theatre which is some three storeys in height with a basement excavation which slopes down from a single storey level on the western side at 20.80mAOD (FFL) to 18.20mAOD (FFL) on the eastern side. Based on the information obtained from publically available borehole records and the information contained within the ARUP report it is assumed that the interface with the Lynch Hill Gravel Member (classified as a Secondary A Aquifer) and the underlying London Clay Formation is some 4.00m.bgl or at an approximate elevation of 20.00mAOD. If we consider the levels indicated above are at finished floor level (FFL) it is highly likely that only limited if any deposits of the Lynch Hill Gravel Member remain on site. Notwithstanding the above it is understood that the proposed development will comprise the extension of the existing basement horizontally outside the existing perimeter. It is therefore possible that in undertaking these proposed excavation and construction works that granular deposits of the Lynch Hill Gravel Member may well be encountered.

Even if the Lynch Hill Gravel were to be encountered within the new excavation works the statements below, which can be found within the ARUP report, are of particular note:

“In the City of London (the Square Mile), the natural, near-surface geology is very similar to that present under the southern area of the LB Camden south of Euston Road, with River Terrace Deposits overlying London Clay. In and around the City, the pressure on available real estate has meant that the installation of large basements has been the norm since the post war period. Even earlier than this, most bank buildings had basements as this offered greater security for vaults and storage. Across swathes of the City, the basements of adjoining buildings touch their neighbours such that there is little or no soil left in the ground down to the depth of the basements, which typically extend as deep as the upper part of the London Clay. In such areas, the only remaining shallow, permeable soil exists underneath the roadways.

The large-scale removal of the River Terrace Deposits from the City has not caused significant problems associated with localised “damming” in the shallow groundwater table. The groundwater, where it is present and if it is moving, simply finds another

route if it becomes “blocked” by a subterranean structure at a particular location, although there may be local rises in level. In the City, this alternative route for groundwater flow is under the roads. The loss of storage and transmissivity due to the removal of the River Terrace Deposits has been balanced by reduction in infiltration due to hard surfacing. The urbanisation of London has significantly altered ground water levels in the Upper Aquifer and the natural trends and directions of flow within this aquifer. For example, the sealing of the ground surface by pavements and buildings; leakage from water mains and sewers, culverting of the Fleet and Tyburn, the cut-and-cover construction of London Underground tunnels in the north of this area have all acted to alter groundwater levels and flow regimes.”

In summary given the density of existing basement developments that bound the site and within the local area of the site coupled with the absence of any evidence to suggest these basement excavations have resulted in an increase in surface water flooding events it is concluded that the proposed development will have little or no impact on the existing subterranean water flows.

6.1.2 QUESTION 1a: Will the proposed basement extend beneath the water table surface?

POTENTIAL IMPACT: The groundwater flow regime may be altered by the proposed basement. Changes in flow regime could potentially cause the groundwater level within the zone encompassed by the new flow route to increase or decrease locally. For existing nearby structures then the degree of dampness or seepage may potentially increase as a result of changes in groundwater level.

Following on from the comments made above it is concluded that the marginal increase in basement footprint, which may extend locally into the water table beneath the site although not observed, is unlikely to contribute to a significant increase in flow and unduly impact properties in close proximity or down hydraulic gradient of the site.

6.2 Surface Flow and Flooding Scoping

No issues raised.

6.3 Land Stability Scoping

6.3.1 QUESTION: Is the site within an aquifer? If so, will the proposed basement extend beneath the water table such that dewatering may be required during construction?

POTENTIAL IMPACT: Dewatering can cause ground settlement. The zone of settlement will extend for the dewatering zone, and thus could extend beyond a site boundary and affect neighbouring structures. Conversely, an increase in water levels can have a detrimental effect on stability.

It is understood that the proposed development will comprise the installation of a contiguous piled wall around the perimeter of the site which should effectively allow groundwater movement. On consulting various BGS and anecdotal evidence sources it is considered that the local groundwater level is likely to be just above the interface

between the Lynch Hill Gravel Member and the underlying London Clay Formation which is at some 4.00m.bgl or in the order of 20.00mAOD. At present it is proposed that the basement excavation will extend to a depth of some 3.85m.bgl or 20.30mAOD. Based on the observations made within the recently undertaken trial pits, which extended to a depth of 1.50m or 19.74mAOD and remained dry within the Lynch Hill Gravel, it is currently assumed that groundwater will likely be absent. Although not observed the presence of groundwater cannot be discounted and consideration will need to be given to ensuring that if any is encountered during excavation works then a contingency is in place to mitigate against any potential settlement outside the site if and when a requirement to dewater arises.

6.3.2 QUESTION: Is the site within 5m of a highway or pedestrian right of way?

POTENTIAL IMPACT: Excavation for a basement may result in damage to the road, pavement or any underground services buried in trenches beneath the road or pavement.

The southern and western boundaries of the site lie immediately adjacent to the pavement along High Holborn and Bloomsbury Street.

There is the potential for ground movements associated with basement excavation to impact the adjacent pedestrian walkways. An impact assessment addressing this issue is reported in **Section 8**.

7 STAGE 3 – SITE INVESTIGATION AND STUDY

As previously discussed, a desk study detailed within this report and a site investigation undertaken by Southern Testing in January 2013, report ref. J11265 has been undertaken taking into account the requirements as set out in Appendix G of 'Camden Geological, Hydrogeological and Hydrological Study' produced for Camden by ARUP in November 2010.

8 STAGE 4 - IMPACT ASSESSMENT

8.1 Introduction

This stage is concerned with evaluating the direct and indirect implications of the proposed basement development. It involves describing, quantifying and aggregating the effects of the development on those attributes or features which have been identified in the scoping stage as being potentially affected.

The only potential impacts that have been identified by this assessment relate to ground stability hazards associated with:

- Movements associated with contiguous piled wall installation and ground excavation; and
- Elastic heave of the Lynch Hill Gravel Member, London Clay Formation and Lambeth Group in the basement excavation associated with stress release.

The following nearby structures have been identified for assessment in relation to potential ground movements

- Sovereign House which bounds the site to the north.
- 167 High Holborn which lies on the opposite side of Grape Street to the east of the site.
- Berkshire House which lies on the opposite side of High Holborn to the south of the site.

8.2 Scope of Works

The scope of works following the screening and scoping stages has been summarised and is as presented below:

- Model the construction sequence on site from demolition through to the proposed development using OASYS PDISP 19.3.0.16 elastic analysis package.
- Output displacements along the line of the neighbouring building foundations at the various stages of construction.
- Estimate the likely ground movements resulting from installation of the proposed piled wall and basement excavation based on the empirical information contained in CIRIA C760 “Guidance on Embedded Retaining Wall Design” 2017 using the OASYS XDISP 19.4.0.4 software.
- Use the program XDISP to combine the ground displacements determined from the numerical analyses PDISP and the CIRIA C760 assessment.
- From the resulting displacements determine the strains that are likely to be induced in the neighbouring buildings to derive a likely damage classification.

8.3 PDISP - Ground Model Construction

A settlement / heave analysis has been completed adopting the OASYS PDISP 19.3.0.16 software produced by ARUP to assess the likely vertical ground movements to be expected from the proposed development activities.

The PDISP computer package adopts the Boussinesq method of elastic analysis to calculate the stresses and strains generated within the soil, due to an applied loading and determines the associated displacements by integrating the vertical strains. Settlements are defined as positive movements and heave as negative movements.

The loads applied in the PDISP model are split into various elements, those applied from unloading, those applied from loading of the piles within the central portion of the site. The application of loads to represent excavation is completed by applying negative load at the base of excavation, whereas the loads applied from reloading or construction are applied by inducing a positive load, in this case at 2/3 the depth of pile over the zone of actively contributing skin friction assuming a 1 horizontal to 4 vertical load spread.

For the purpose of the analyses a distribution of Young's modulus with depth has been based on the results of the site investigation previously carried out by Southern Testing Limited. This work included an assessment of undrained shear strength with depth through SPT testing and the completion of a number of quick untrained triaxial tests.

The undrained Young's Modulus (E_u) has been obtained using a relationship of $E_u = 500c_u$ for the cohesive London Clay. The drained Young's Modulus (E') has been obtained using the relationship of $E' = 0.6E_u$. The drained Young's Modulus for the coarse grained Lynch Hill Gravel Member has been taken as very conservatively to be 20,000kN/m^2 based on the correlation $E' = 2.0 \times N_{60}$, presented in CIRIA Report 143 (1995).

For the purpose of the model a rigid boundary layer was assumed to be at -10.10mAOD below which no movement is considered to occur.

In the PDISP model negative loads have been applied to the model to represent unloading due to basement excavation works and positive loads to represent the weight of the new development.

8.3.1.1 Ground Model Parameters

The parameters adopted for the ground movement assessment in PDISP are summarised below in Table 7.

Table 7: Ground Model Parameters – Drained and Undrained

Material	Young's Modulus (kN/m^2)	Young's Modulus – Increase with Depth (kN/m^2/m)	Poisson's Ratio
Lynch Hill Gravel Member - Drained	20,000	N/A	0.2
London Clay Formation - Undrained	28,000	6,303	0.5

Material	Young's Modulus (kN/m^2)	Young's Modulus – Increase with Depth ($kN/m^2/m$)	Poisson's Ratio
London Clay Formation - Drained	16,000	3,789	0.2
Lambeth Group - Undrained	140,000	N/A	0.5
Lambeth Group - Drained	85,000	N/A	0.2

8.3.1.2 Adopted Ground Profile

The ground profile adopted for the ground movement assessment in PDISP is summarised below in Table 8.

Table 8: Ground Profile

Material	Top of Stratum (mAOD)	Thickness (m)
Lynch Hill Gravel Member	24.15	4.00
London Clay Formation	20.15	26.65
Lambeth Group	-6.50	3.60

The following PDISP analyses have been undertaken to determine the ground movements at key stages in the constructions process. Both undrained and drained conditions have been considered for the appropriate stages.

- **Basement Excavation – Short Term and Long Term**. This has been calculated by the removal of an overburden pressure for the proposed areas of basement extension. For the proposed development, there is envisaged to be approximately 3.75m of material removed which equates to an unloading of some equal to $75kN/m^2$ where $20kN/m^3$ is unit weight of soil. This stage has been analysed using undrained and drained soil parameters.

- **Loading from the proposed new basement on piled foundations – Short Term and Long Term.** The loads were modelled as individual piles with a load spread area located at a depth of 2/3 the length of the piles assuming a 1 in 4 load spread. In the absence of a preliminary piling scheme and layout information the analysis has considered individual piles of a uniform pile dimension (0.45m diameter, 23m in length) chosen to broadly accommodate the proposed column load at any given location. This loading case has been considered in the short and long term, using undrained and drained parameters.

The analysis has considered both undrained and drained soil conditions to give an indication of the immediate short term and the maximum expected long term ground movements resulting from the proposed development.

In order to model these conditions two analyses have been carried out, the first considering undrained ground stiffness parameters and a Poisson's ratio of 0.50 and the second considering a drained modulus and a Poisson's ratio of 0.20. The first of these analyses allows an assessment of the immediate elastic heave that would result from excavation. This would typically be expected to occur over a period of a few weeks. The second analysis allows for long term net movements following construction of the new development to be determined, which will include the total heave that would develop in the long term and settlement following consolidation of the underlying clay following pile loading. The fully drained (long term) conditions would typically take many years to develop (10 years or more).

The ground movements have been isolated based on the particular phases of development in addition to the anticipated time frames of which any movements are anticipated to be realised, i.e. short term / long term. These movements have then been used in the empirical building damage assessment, using OASYS XDISP 19.4.0.10. Contour plots of ground movements at the adjacent building foundation level for each phase are included in Appendix D.

8.4 Empirical Assessment of Building Damage Preamble

The approach adopted for the purpose of this assessment, combines both CIRIA C760 and the net long term vertical movements from for the various construction stages, obtained from PDISP.

In this case the results of numerical modelling using PDISP for various construction stages have been imported into the XDISP software and an assessment of potential damage for each stage has been completed using the C760 approach of assessing lateral strain and deflection ratio to determine potential damage category.

The deformations and associated potential damage of the various adjacent buildings have been determined at the end of the stages of construction presented in Table 9.

Table 9: Stages of Construction at which Building Damage is Assessed

No.	Construction Stage	Short / Long Term	Cumulative Effect
1	Basement construction	Short	(A) + (B)
2	Basement construction and proposed development	Long	(A) + (B) + {(D) – (C)} + (F)

The various elements of work used to determine the deformations for the buildings at the various stages of construction are given in Table 10. This table also defines how the associated movements have been determined and whether they are long or short term.

Table 10: Construction Sequence

Element	Construction Component	Calculation Method	Short or Long Term
A	Basement wall installation	CIRIA C760 (XDISP)	Short Term
B	Basement excavation	CIRIA C760 (XDISP)	Short Term

Element	Construction Component	Calculation Method	Short or Long Term
C	Basement excavation	PDISP	Short Term
D	Basement excavation	PDISP	Long Term
E	Loading of new structure	PDISP	Short Term
F	Loading of new structure	PDISP	Long Term

The ground deformations and building damage categories following each of these stages of construction have been derived by combining the deformations calculated for the various elements of work carried out as indicated in Table 9.

The assessment has been undertaken using XDISP version 19.4.0.10 computer package supplied by OASYS, which uses the empirical approach outlined in CIRIA C580 to assess vertical and horizontal ground movements resulting from installation of embedded retaining walls and excavation in front of walls. It should be noted that XDISP version 19.4.0.10 was developed at which time CIRIA C580 was still the current guidance, the only observable difference with regards to assessing building damage is a change to the ground movement curves for excavation in front of a low stiffness wall which were reduced in CIRIA C760.

The empirical approach is well described in CIRIA C760 “Guidance on Embedded Retaining Wall Design” 2017. This document provides charts of vertical and horizontal ground movements resulting from installation of embedded retaining walls and excavation in front of the walls. These charts have been normalised with wall length and excavation depth to facilitate their use for new development. As noted above the charts remain applicable for the purpose of this assessment, the only difference being a more conservative approach has been adopted for excavations in front of a low stiffness wall in the updated CIRIA C760.

The analysis undertaken conservatively assesses the ground movements for the buildings identified in Section 8.4.2, (horizontal and vertical) around the site resulting from the installation of the secant piled wall during the basement excavation, followed by propping and excavation of the basement, even though it is understood a contiguous piled wall option has been proposed. A secant pile wall has been adopted for the assessment as the installation movements from this method are greater than those of a contiguous method and as such provide an added level of assurance in respect of the ground movement implications.

8.4.1 Assessment of Damage to Adjacent Properties

CIRIA C760 also provides a methodology to assessing the potential damage to properties within the zone of influence of the basement excavation. Figures 6.17 and 6.27 of CIRIA C760 summarise this approach. This methodology uses the relationship between Damage Category, horizontal strain and deflection ratio developed by Boscardin and Cording (1989) and Burland (2001).

The definition of the categories is presented below. The categories assume brick masonry with cement mortar and as such represent a conservative estimate of likely damage that will occur at these properties.

Table 11: Classification of damage category (from Table 6.4, CIRIA C760)

Category of damage	Description of typical damage	Approximate crack width (mm)	Limiting tensile strain ε_{lim} (%)
0 Negligible	Hairline cracks of less than about 0.1mm are classed as negligible.	<0.1	0.00 - 0.05
1 Very slight	Fine cracks that can easily be treated during normal decoration. Cracks in external brickwork visible on inspection.	<1	0.05 - 0.075
2 Slight	Cracks easily filled. Redecoration probably required. Cracks are visible externally and some repointing may be required externally to ensure watertightness. Doors and windows may stick slightly.	<5	0.075 - 0.15
3 Moderate	The cracks require some opening up and can be patched by a mason. Repointing of external brickwork and possibly a small amount of brickwork to be replaced. Doors and windows sticking. Service pipes may fracture. Weathertightness often impaired.	5 – 15 or a number of cracks >3	0.15 - 0.3
4 Severe	Extensive repair work involving breaking-out and replacing sections of walls, especially over doors and windows. Windows and frames distorted, floor sloping noticeably. Walls leaning or bulging noticeably, some loss of bearing in beams. Service pipes disrupted.	15 – 25 but also depends on number of cracks	>0.3
5 Very severe	This requires a major repair involving partial or complete rebuilding. Beams lose bearings, walls lean badly and require shoring. Windows broken with distortion. Danger of instability.	Usually >25 but depends on number of cracks	

8.4.2 Buildings to be Assessed

There are a number of buildings which surround the site, however, the properties considered to be potentially most at risk are those to the north comprising Sovereign House, the Archway that bounds the northern site boundary, 167 High Holborn which is located on the far side of Grape Street and finally Berkshire House on the southerly side of High Holborn.

The buildings assessed in this report are presented in Figure 2, which provides a system for identifying the various structures.

From the information obtained during the walkover and what is known about the existing development construction we are able to derive a suite of parameters to assist in the completion of this portion of the assessment. Where site specific information is not known then conservative assumptions have been made.

On the basis of the available information, a summary of the specific dimensions and construction details used for these analyses are presented below.

Table 12: Specific dimensions used for analyses

Adjacent Property	Adopted Wall Depth (m)	Adopted Excavation Depth (m.bgl)	Approximate Distance to Face of Property (m)	Approximate Length of Property Perpendicular to Basement (m)
The Archway	10.0	3.75	0.0	2.5
Sovereign House	10.0	3.75	2.5	11.0
167 High Holborn	10.0	3.75	6.0	7.0
Berkshire House	10.0	3.75	20.0	28.0

Table 13: Specific construction details

Adjacent Property	Building Material	Assumed Foundation Type	Assumed Foundation Depth (m.bgl)	Building Height (m)
The Archway	Masonry	Strip / Pad*	3.5	18.0
Sovereign House	Masonry	Strip / Pad*	3.5	19.0
167 High Holborn	Masonry	Strip / Pad*	3.5	14.0
Berkshire House	Concrete Framed	Piles*	1.0	35.0
Notes: *Assumed				

These parameters have then been used to determine the displacements and horizontal tensile strains and Deflection Ratios for the adjacent properties.

8.5 Results of Empirical Assessment of Ground Movements and Building Strains

A summary of estimated ground movements at the front and rear of the adjacent properties and the calculated maximum horizontal strains and deflection ratios for each property during the key stages of construction are presented in Tables 14 to 17. The results of the numerical analysis are included in Appendix D.

8.5.1 Basement Construction

A summary of the estimated ground movements likely to be experienced following completion of the basement construction are presented in Table 14.

Table 14: Ground Movements Resulting from Basement Construction

Adjacent Property	Ground Movement at Front of Adjacent Property		Ground Movement at Rear of Adjacent Property	
	Lateral (mm)	Vertical (mm)	Lateral (mm)	Vertical (mm)
The Archway	4.00	6.00	4.00	6.00
Sovereign House	4.00	6.00	1.00	1.00
167 High Holborn	0.00	0.00	0.00	0.00
Berkshire House	0.00	0.00	0.00	0.00

Notes:
- Lateral displacement recorded as movement along the line.
- Positive lateral displacement values indicate ground movement towards the excavation.
- Negative vertical displacement values indicate ground heave.

The maximum resulting horizontal strains and deflection ratios are presented in Table 15 below.

Table 15: Calculated Horizontal Strains and Deflection Ratios

Adjacent Building	Horizontal Strain (%)	Deflection Ratio (%)	Damage Category
The Archway	-0.096	0.022	0 (Negligible)
Sovereign House	0.000	0.015	0 (Negligible)
167 High Holborn	0.000	0.000	0 (Negligible)
Berkshire House	0.000	0.000	0 (Negligible)

8.5.2 Long Term Proposed Construction

A summary of the estimated ground movements likely to be experienced following completion of the development are presented in Table 16.

Table 16: Ground Movements Resulting from Long Term Loading

Adjacent Property	Ground Movement at Front of Adjacent Property		Ground Movement at Rear of Adjacent Property	
	Lateral (mm)	Vertical (mm)	Lateral (mm)	Vertical (mm)
The Archway	4.00	6.00	4.00	6.00
Sovereign House	4.00	6.00	1.00	1.00
167 High Holborn	0.00	0.00	0.00	0.00
Berkshire House	0.00	0.00	0.00	0.00

Notes:
- Lateral displacement recorded as movement along the line.
- Positive lateral displacement values indicate ground movement towards the excavation.
- Negative vertical displacement values indicate ground heave.

The maximum resulting horizontal strains and deflection ratios are presented in Table 17 overleaf.

Table 17: Calculated Horizontal Strains and Deflection Ratios

Adjacent Building	Horizontal Strain (%)	Deflection Ratio (%)	Damage Category
The Archway	-0.229	0.019	0 (Negligible)
Sovereign House	0.000	0.015	0 (Negligible)
167 High Holborn	0.000	0.000	0 (Negligible)
Berkshire House	0.000	0.000	0 (Negligible)

8.6 Highway Assessment

An assessment of the horizontal and vertical ground movements that could impact highways to Grape Street, High Holborn and Bloomsbury Street has been undertaken and the displacements associated the final long term phase of the construction are presented below in Table 18.

Table 18: Highway Displacements

Asset	Near Side		Far Side	
	Lateral (mm)	Vertical (mm)	Lateral (mm)	Vertical (mm)
Grape Street	1.00	1.00	0.00	0.00
High Holborn	12.00	13.00	0.00	0.00
Bloomsbury Street	13.00	11.00	7.00	4.00

From the above results it is considered that the impact from the development will impart relatively small ground movements on the adjacent highways and as such the impact is likely to be negligible.

8.7 Crossrail Assessment

An assessment of the vertical ground movements that could impact the Crossrail asset that runs some 14.00m.bgl at a distance of approximately 8.00m from the site has been undertaken. A graph displaying displacements along the alignment of the tunnel at this level has been undertaken using PDISP and included in Appendix D. From the assessment it is noted that based on the proposed development information provided to date net displacements are observed to be less than 1mm along the length of the asset. As such it is considered that any impact is likely to be negligible.

9 CUMMULATIVE IMPACTS

A requirement of CPG4 is to consider the aggregate (cumulative) potential for impacts associated with basement construction.

A search of publicly available planning records (dating back to 1924) on Camden's planning website revealed records of granted permissions for basement development or changes of use at a number properties in the site area. In addition to the information available on the planning website it was also noted during the walkover that the majority of the properties within the local area contain basements which most likely predated the earliest planning records held by Camden. All of the properties within the local areas that are known to contain basements are presented on Figure 3, however, this is not a definitive list.

9.1 Hydrogeology

Based on the information collated to date it is noted that the existing basement on site slopes down from a single storey level on the western side at 20.80mAOD (FFL) to 18.20mAOD (FFL) on the eastern side at which level it is directly overlying the London Clay Formation. Although not encountered it is assumed that based on the proposals comprising an extension of the existing basement horizontally outside the existing perimeter it is possible that the proposed excavation and construction works may encounter granular deposits of the Lynch Hill Gravel Member.

Even if the Lynch Hill Gravel were to be encountered within the new excavation works the statement included within Section 6.1.1 makes a valid case for how much impact an extension to an existing basement in an area already teeming with basements would realistically make.

In summary given the density of existing basement developments that bound the site and within the local area of the site coupled with the absence of any evidence to suggest these basement excavations have resulted in an increase in surface water flooding events it is concluded that the proposed development will have little or no impact on the existing subterranean water flows.

9.2 Hydrology

In the absence of any recovered flooding events, the distance from any flood zones and surface watercourses and given that the site is located within an area known to contain an abundance of basements without causing any undue changes to the local hydrology, it is considered that there will be negligible potential for impact and no cumulative impact on shallow water flows in the vicinity of the proposed development.

9.3 Land Stability

From the results of the elastic displacement analyses it is indicated that in both the short-term and long-term (once building loads are applied) net movements beyond the site boundary will be negligible.

For cumulative ground movements associated with piled wall installation and basement excavation, resultant horizontal strains and deflection ratios are very small and are unlikely to be damaging to the identified features.

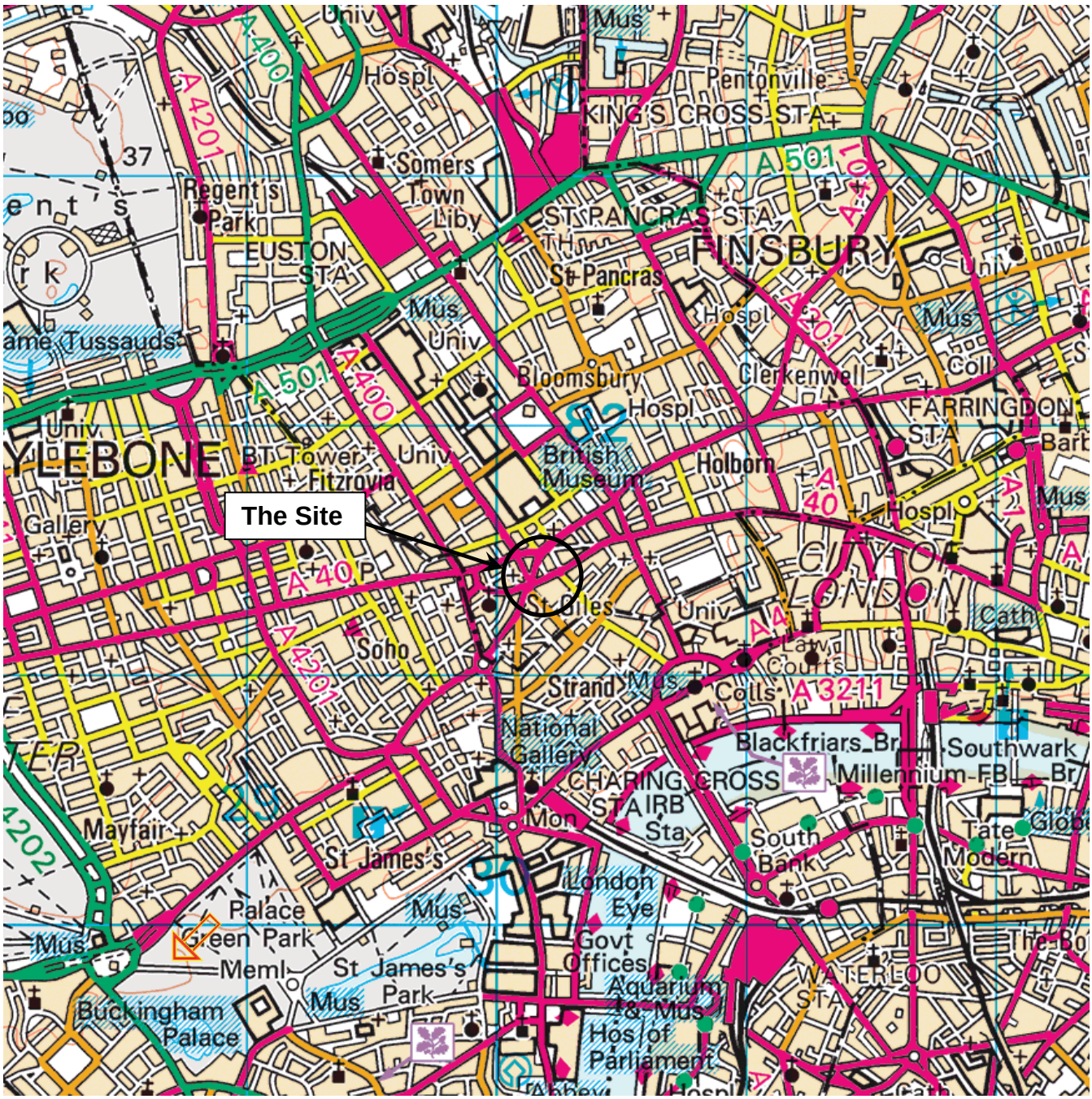
It should be noted that the calculations undertaken as part of this assessment are necessarily preliminary and these calculations should be re-checked at the detailed design stage to ensure that more detailed predicted movements are within tolerable limits.

9.3.1 Control of ground movements

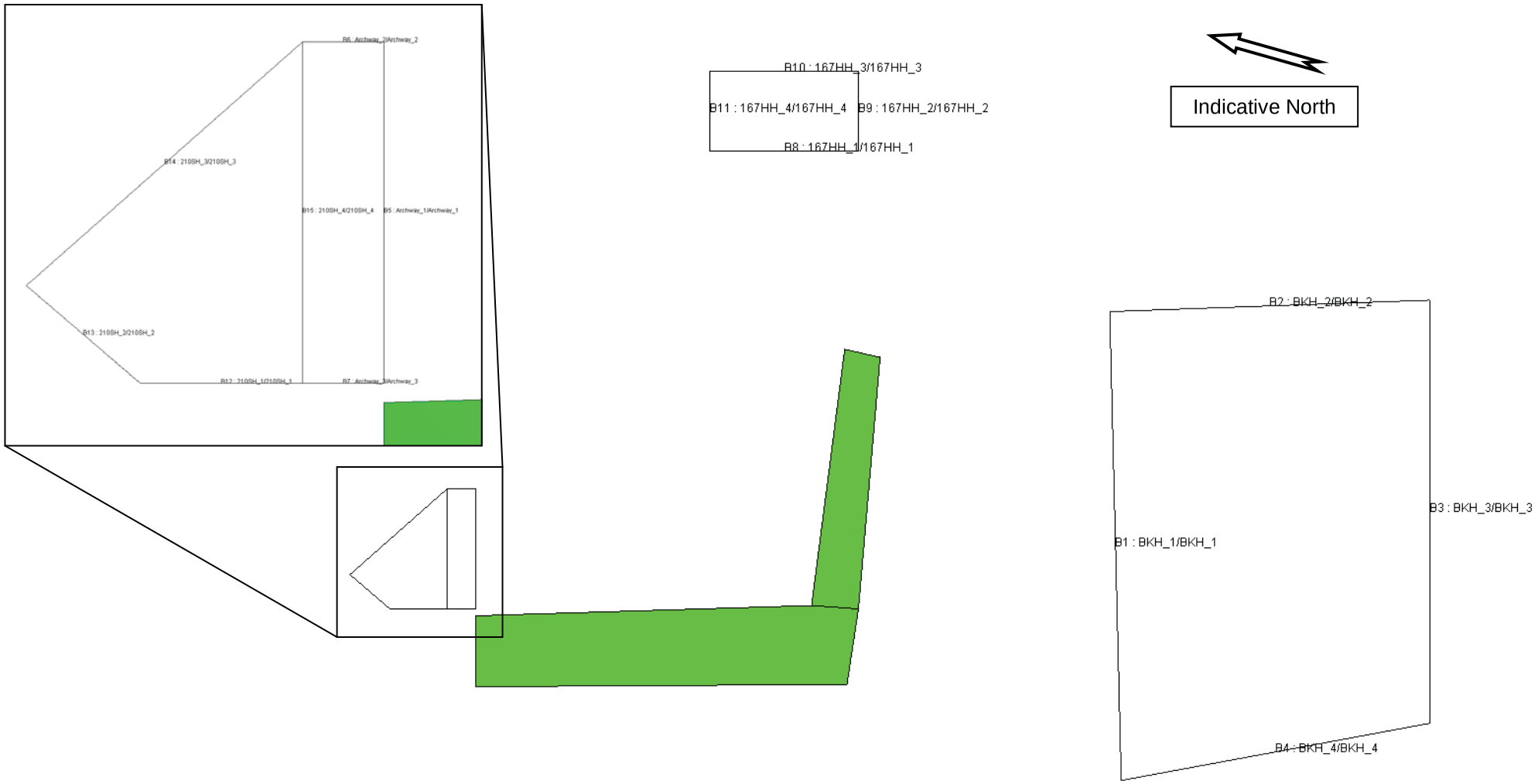
In order to reduce the potential for any movement over and above that expected, the following methods of safe practice should be considered prior to and during construction:

- Good workmanship will be required to ensure that pile installation induced settlements are kept to a minimum. It will be essential to ensure that the made ground is not allowed to collapse prior to casting of the contiguous piled wall;
- The contiguous piled wall should be installed to a suitable depth and have adequate embedment in stiff strata for satisfactory vertical and lateral stability;
- It should be ensured that basement slab is cast as early as possible and tight to the piled retaining wall. Sufficient time should be given for the slab to cure and gain strength prior to the removal of any temporary propping;
- Where temporary props are required they should be designed to provide adequate restraint to limit lateral ground movements. Walings should be tied in so they do not rely on friction or adhesion between the prop end and waling to be held in place;
- The first stage of excavation should be minimised and the first (stiff) support should be installed as early as possible in the construction sequence;
- The construction of the wall and its support systems should not be delayed;
- Over-excavation should be avoided;
- Monitoring both above and below ground should be carried out to ensure that the expected displacements are not exceeded. Limits of lateral and vertical displacement should be set beyond which the method of construction should be re-assessed.

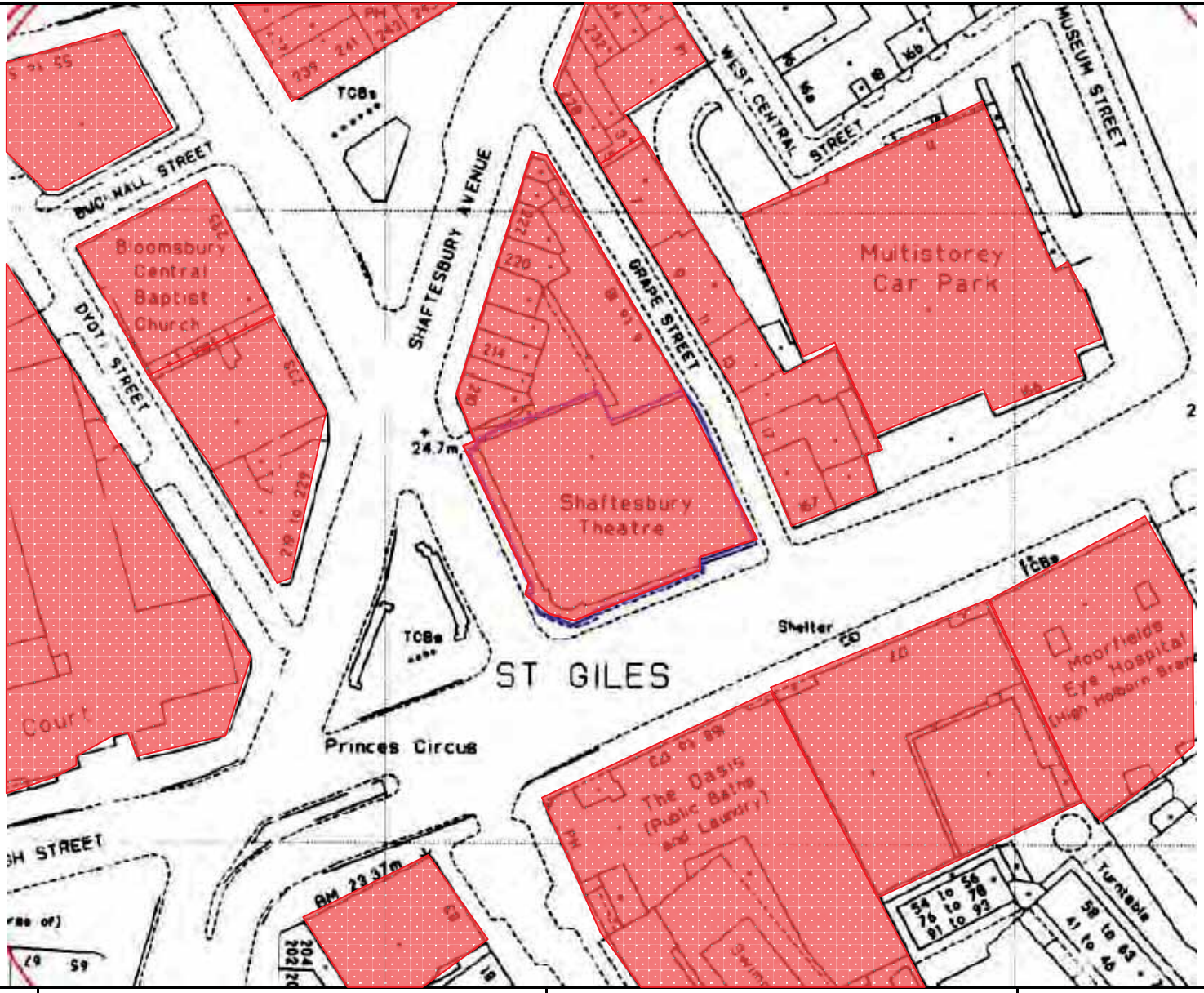
FIGURES



RSK	**SITE LOCATION PLAN**	**Client:** The Theatre of Comedy Company	**Figure No:** 1
		Site: Shaftsbury Theatre	**Job No:** 371647
		Scale: NTS	**Source:** OS



RSK	**LAYOUT PLAN**	**Client:**	The Theatre of Comedy Company	**Figure No:**	2
		Site:	Shaftsbury Theatre	**Job No:**	371647
		Scale:	NTS	**Source:**	XDISP



RSK	**EXISITING BASEMENTS**	**Client:**	The Theatre of Comedy Company	**Figure No:**	3
		Site:	Shaftsbury Theatre	**Job No:**	371647
		Scale:	NTS	**Source:**	Grouudsure

APPENDIX A
DESK STUDY INFORMATION

BGS ID: 1063496 : BGS Reference: TQ38SW189
British National Grid (27700) : 530060,181380
Report an issue with this borehole

T 106.

WELL BORING at Dyott St, Bloomsbury County

Geol. map 1 in. map New Series 256 6 in. map 7 SW.

Made by TQ 38 SW 189 Date

Sunk feet. Bored feet.

Communicated by H C C.

Height above Ordnance Datum — Ca +82' Rest level of water

Yield

Quality (with copy of analysis on separate sheet) 3006 8138

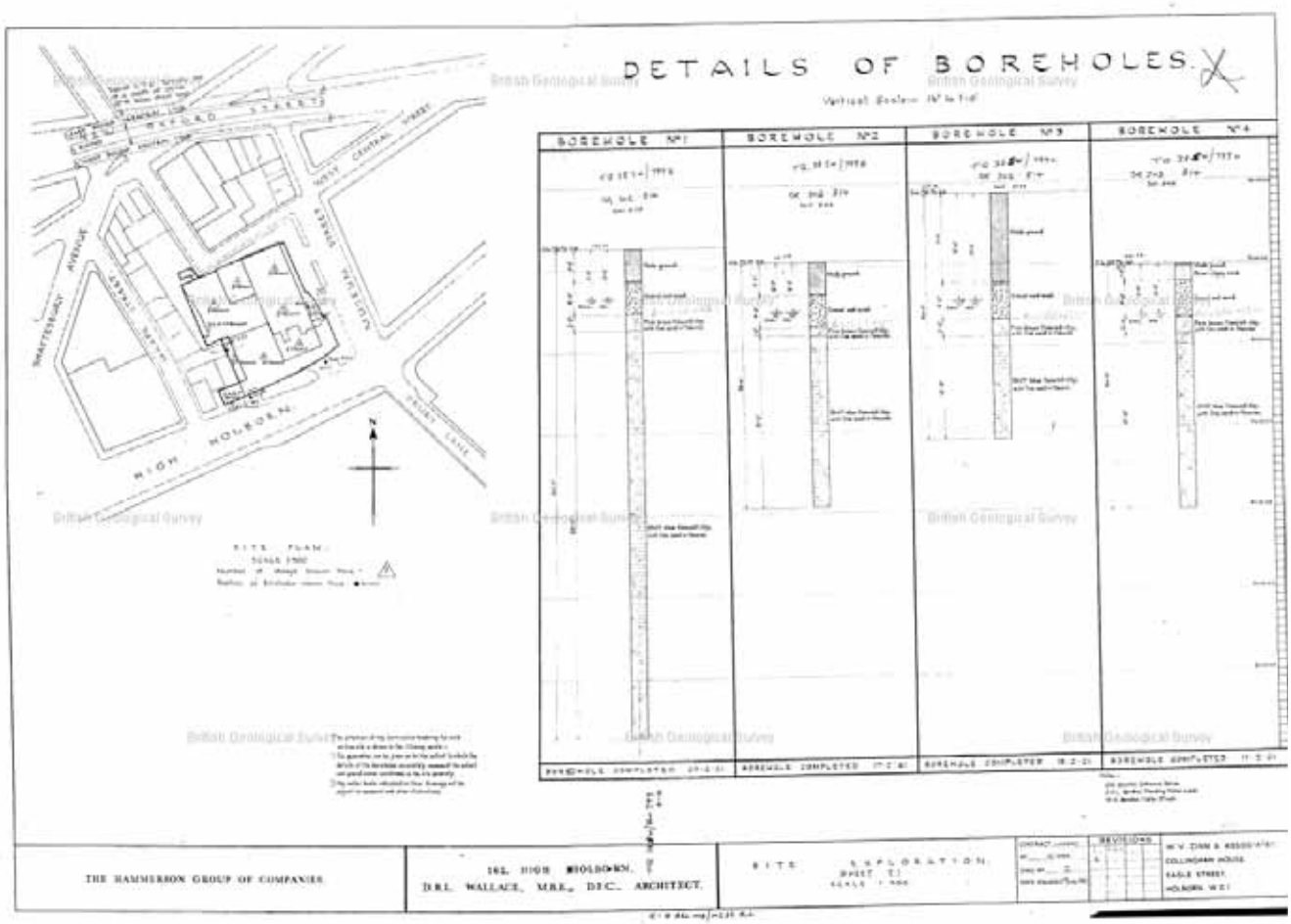
GEOLOGICAL FORMATION	NATURE OF STRATA	THICKNESS Feet	THICKNESS Inches	DEPTH Feet	DEPTH Inches
	Made ground.	? 9	-0"	9'	-0"
	Loam	? 4	-0"	13'	-0"
	Ballast.	? 9	-0"	22'	-0"
	Yellow Clay	? 1'	-0"	23'	-0"
	Blue Clay	? 9'	-0"	32'	-0"
	NOT MAPPED				
	Bottom Level Ca +160'00				

GEOLOGICAL SURVEY AND MUSEUM,
JERMYN STREET, LONDON, S.W. 1.

(50478X) Wt. W39733/0131 2,500 4/31 H. J. R. & L., Ltd. Gp. 616

British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

BGS ID: 1064449 : BGS Reference: TQ38SW799/B
British National Grid (27700) : 530190,181370
Report an issue with this borehole



emapsite

Masdar House, 1 Reading Road,
Eversley, RG27 0RP

Report Reference: EMS-444986_596607

Your Reference: EMS_444986_596607

Report Date 17 Oct 2017

Report Delivery Method: Email - pdf

Geo Insight

Address: Shaftsbury Theatre, WC2H 8DP,

Dear Sir/ Madam,

Thank you for placing your order with Groundsure. Please find enclosed the **Groundsure Geo Insight** as requested.

If you would like further assistance regarding this report then please contact the emapsite customer services team on 0118 9736883 quoting the above report reference number.

Yours faithfully,

emapsite customer services team

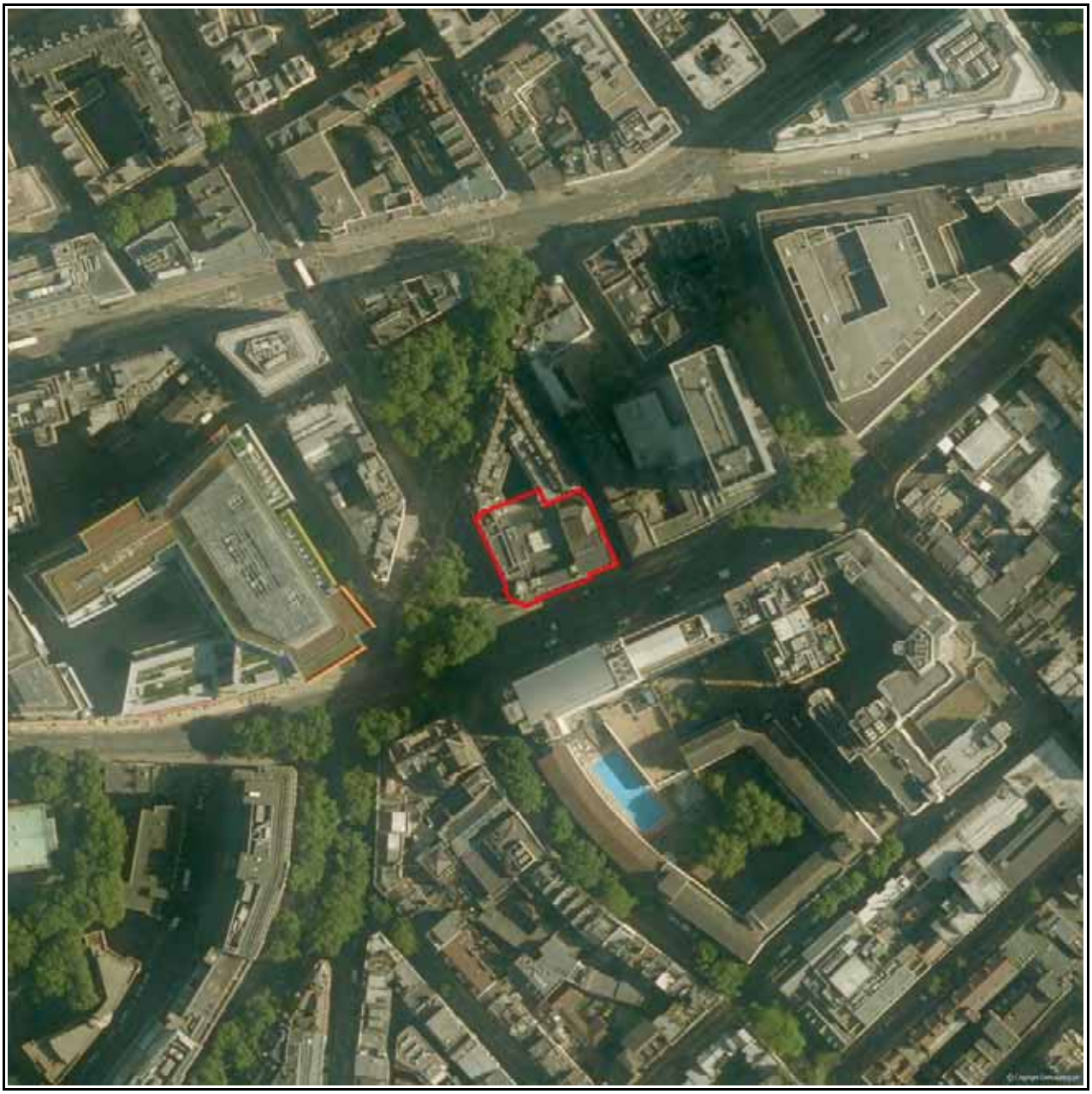
Enc.
Groundsure Geo Insight

Geo Insight

Address:	**Shaftsbury Theatre, WC2H 8DP,**
Date:	**17 Oct 2017**
Reference:	**EMS-444986_596607**
Client:	**emapsite**

NW N NE

W E



SW S SE

Aerial Photograph Capture date:	07-Jun-2015
Grid Reference:	530136,181354
Site Size:	0.11ha

Contents Page

Overview of Findings

The Groundsure Geo Insight provides high quality geo-environmental information that allows geo-environmental professionals and their clients to make informed decisions and be forewarned of potential ground instability problems that may affect the ground investigation, foundation design and possibly remediation options that could lead to possible additional costs.

The report is based on the BGS 1:50,000 and 1:10,000 Digital Geological Map of Great Britain, BGS Geosure data; BRITPITS database; Non-coal mining data and Borehole Records, Coal Authority data including brine extraction areas, PBA non-coal mining and natural cavities database, Johnson Poole and Bloomer mining data and Groundsure's unique database including historical surface ground and underground workings.

For further details on each dataset, please refer to each individual section in the report as listed. Where the database has been searched a numerical result will be recorded. Where the database has not been searched '-' will be recorded.

Section 1: Geology 1:10,000 Scale		
1.1 Artificial Ground	1.1 Is there any Artificial Ground/ Made Ground present beneath the study site at 1:10,000 scale?	No
1.2 Superficial Geology and Landslips	1.2.1 Is there any Superficial Ground/Drift Geology present beneath the study site at 1:10,000 scale?*	Yes
	1.2.2 Are there any records of landslip within 500m of the study site boundary at 1:10,000 scale?	No
1.3 Bedrock, Solid Geology and Faults	1.3.1 For records of Bedrock and Solid Geology beneath the study site* see the detailed findings section.	
	1.3.2 Are there any records of faults within 500m of the study site boundary at 1:10,000 scale?	No

Section 2: Geology 1:50,000 Scale		
2.1 Artificial Ground	2.1.1 Is there any Artificial Ground/ Made Ground present beneath the study site?	No
	2.1.2 Are there any records relating to permeability of artificial ground within the study site*boundary?	No
2.2 Superficial Geology and Landslips	2.2.1 Is there any Superficial Ground/Drift Geology present beneath the study site?*	Yes
	2.2.2 Are there any records of permeability of superficial ground within 500m of the study site?	Yes
	2.2.3 Are there any records of landslip within 500m of the study site boundary?	No
	2.2.4 Are there any records relating to permeability of landslips within the study site* boundary?	No

Section 2: Geology 1:50,000 Scale

2.3 Bedrock, Solid Geology and Faults	2.3.1 For records of Bedrock and Solid Geology beneath the study site* see the detailed findings section.	
	2.3.2 Are there any records relating to permeability of bedrock ground within the study site boundary?	Yes
	2.3.3 Are there any records of faults within 500m of the study site boundary?	No

Section 3: Radon

3. Radon	3.1Is the property in a Radon Affected Area as defined by the Health Protection Agency (HPA) and if so what percentage of homes are above the Action Level?	The property is not in a Radon Affected Area, as less than 1% of properties are above the Action Level.
	3.2Radon Protection	No radon protective measures are necessary.

Section 4: Ground Workings	On-site	0-50m	51-250	251-500	501-1000
4.1 Historical Surface Ground Working Features from Small Scale Mapping	0	0	0	Not Searched	Not Searched
4.2 Historical Underground Workings from Small Scale Mapping	0	0	0	0	3
4.3 Current Ground Workings	0	0	0	0	0

Section 5: Mining, Extraction & Natural Cavities	On-site	0-50m	51-250	251-500	501-1000
5.1 Historical Mining	0	0	0	0	0
5.2 Coal Mining	0	0	0	0	0
5.3 Johnson Poole and Bloomer Mining Area	1	0	0	1	3
5.4 Non-Coal Mining*	0	0	0	0	0
5.5 Non–Coal Mining Cavities	0	0	0	0	0
5.5 Natural Cavities	0	0	0	0	0

Section 5: Mining, Extraction & Natural Cavities	On-site	0-50m	51-250	251-500	501-1000
5.6 Brine Extraction	0	0	0	0	0
5.7 Gypsum Extraction	0	0	0	0	0
5.8 Tin Mining	0	0	0	0	0
5.9 Clay Mining	0	0	0	0	0

Section 6: Natural Ground Subsidence	On-site
6.1 Shrink-Swell Clay	Moderate
6.2 Landslides	Very Low
6.3 Ground Dissolution of Soluble Rocks	Negligible
6.4 Compressible Deposits	Negligible
6.5 Collapsible Deposits	Very Low
6.5 Running Sand	Very Low

Section 7: Borehole Records	On-site	0-50m	51-250
7 BGS Recorded Boreholes	0	3	40

Section 8: Estimated Background Soil Chemistry	On-site	0-50m	51-250
8 Records of Background Soil Chemistry	1	0	0

Section 9: Railways and Tunnels	On-site	0-50m	51-250	250-500
9.1 Tunnels	0	0	1	Not Searched
9.2 Historical Railway and Tunnel Features	0	0	0	Not Searched
9.3 Historical Railways	0	0	1	Not Searched
9.4 Active Railways	0	0	0	Not Searched
9.5 Railway Projects	0	1	1	0

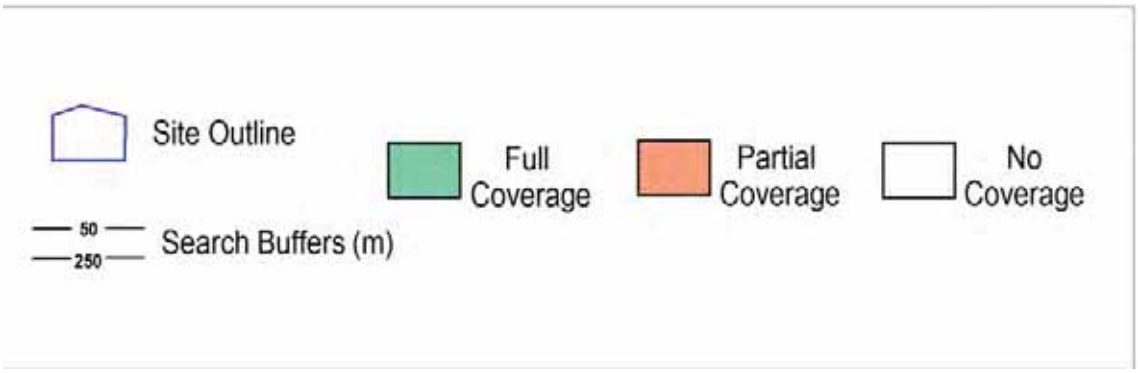
1:10,000 Scale Availability

NW N NE

W E

SW S SE

1_10,000 Availability Legend



Availability of 1:10,000 Scale Geology Mapping

The following information represents the availability of the key components of the 1:10,000 scale geological data.

ID	Distance	Artificial Coverage	Superficial Coverage	Bedrock Coverage	Mass Movement Coverage
1	0.0	Some deposits are mapped	Full	Full	No coverage
2	113.0	Some deposits are mapped	Full	Full	No coverage
N3	1334.0	Some deposits are mapped	Full	Full	No coverage
N4	1340.0	Some deposits are mapped	Full	Full	No coverage

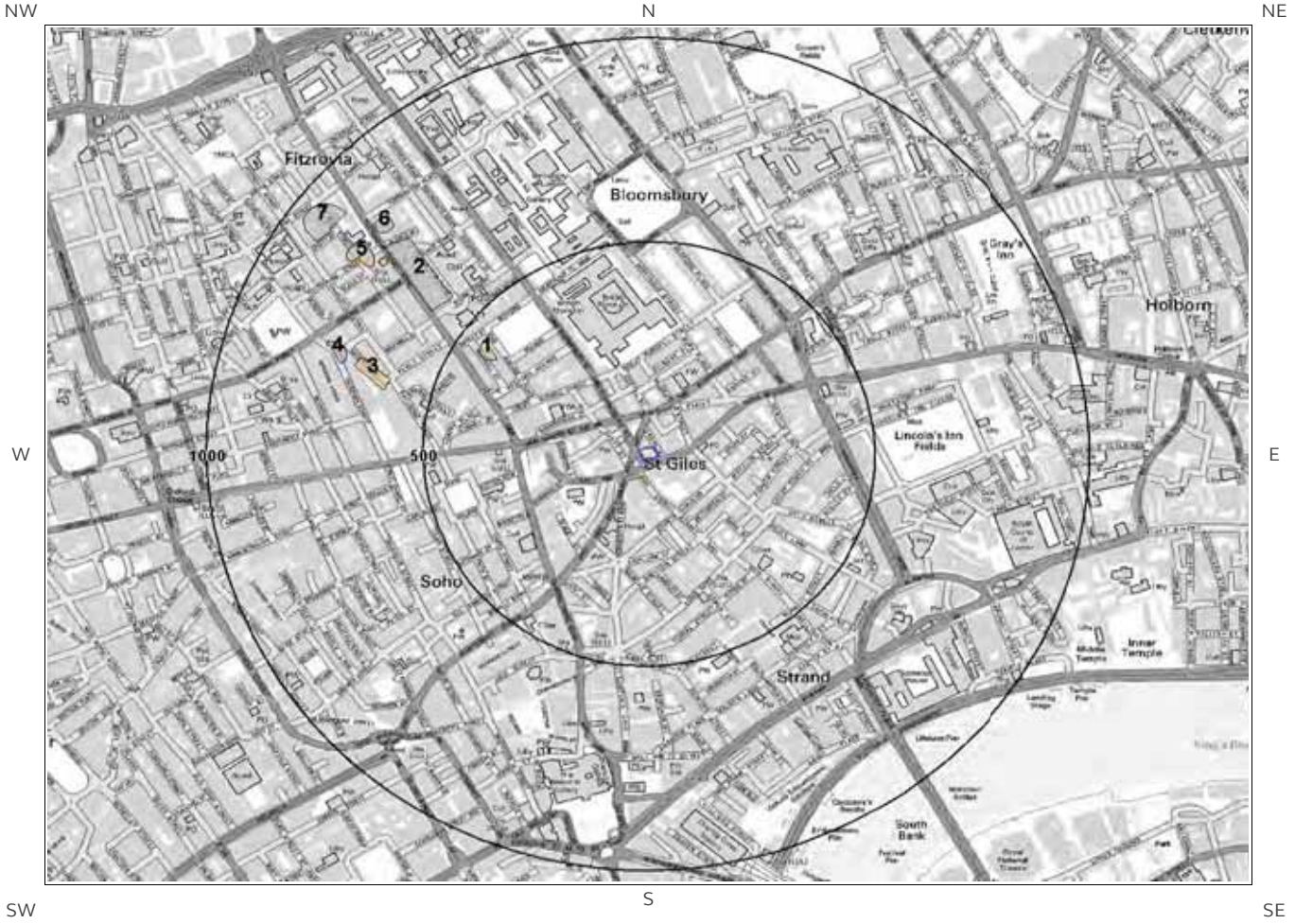
Guidance: The 1:10,000 scale geological interpretation is the most detailed generally available from BGS and is the scale at which most geological surveying is carried out in the field. The database is presented as four types of geology (artificial, mass movement, superficial and bedrock), although not all themes are mapped or available on every map sheet. Therefore a coverage layer showing the availability of the four themes is presented above.

The definitions of coverage are as follows:

Geology	Full Coverage	Partial Coverage	No Coverage
Bedrock	The whole tile has been mapped	Some but not all the tile has been mapped	No coverage
Superficial	The whole tile has been mapped	Some but not all of the tile has been mapped	No coverage
Artificial	Some deposits are mapped on this tile	-	No deposits are mapped
Mass Movement	Some deposits are mapped on this tile	-	No coverage

1 Geology (1:10,000 scale).

1.1 Artificial Ground Map (1:10,000 scale)



Artificial Ground Legend

1. Geology 1:10,000 scale

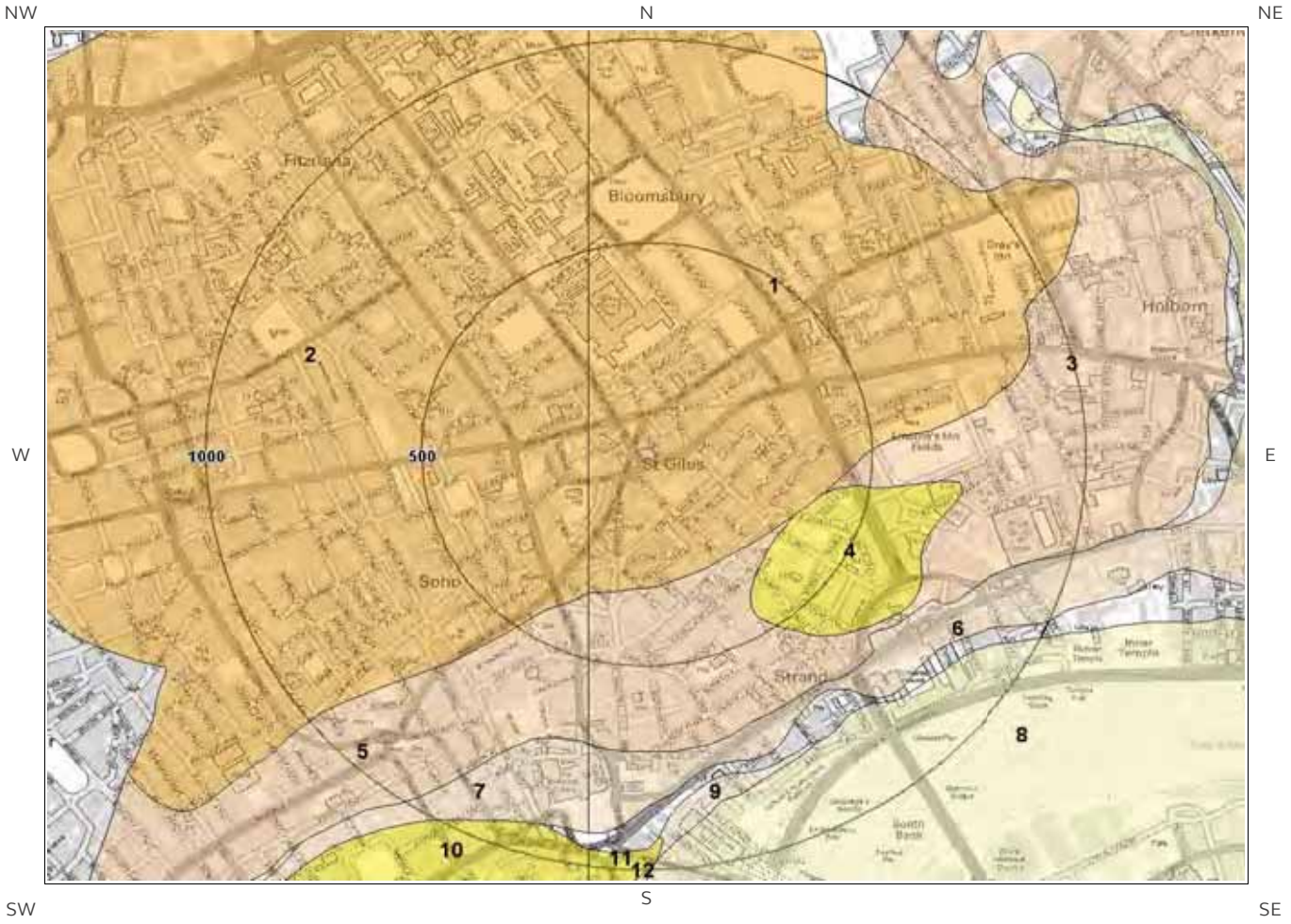
1.1 Artificial Ground

The following geological information represented on the mapping is derived from 1:10,000 scale BGS Geological mapping.

Are there any records of Artificial/ Made Ground within 500m of the study site boundary at 1:10,000 scale? Yes

ID	Distance	Direction	LEX Code	Description	Rock Description
1	399.0	NW	MGR-UKNOWN	Made Ground (Undivided)	Unknown/unclassified Entry

1.2 Superficial Deposits and Landslips Map (1:10,000 scale)



Artificial Ground Legend

Site Outline

500
1000
Search Buffers (m)

1.2 Superficial Deposits and Landslips

The following geological information represented on the mapping is derived from 1:10,000 scale BGS Geological mapping

1.2.1 Superficial Deposits/ Drift Geology

Are there any records of Superficial Deposits/ Drift Geology within 500m of the study site boundary at 1:10,000 scale? Yes

ID	Distance (m)	Direction	LEX Code	Description	Rock Description
1	0.0	On Site	LHGR-XSV	Lynch Hill Gravel Member - Sand And Gravel	Sand And Gravel
2	113.0	W	LHGR-XSV	Lynch Hill Gravel Member - Sand And Gravel	Sand And Gravel
3	292.0	SE	HAGR-XSV	Hackney Gravel Member - Sand And Gravel	Sand And Gravel
4	340.0	SE	LASI-Z	Langley Silt Member - Silt (unlithified Deposits Coding Scheme)	Silt
5	346.0	S	HAGR-XSV	Hackney Gravel Member - Sand And Gravel	Sand And Gravel

1.2.2 Landslip

Are there any records of Landslip within 500m of the study site boundary at 1:10,000 scale?

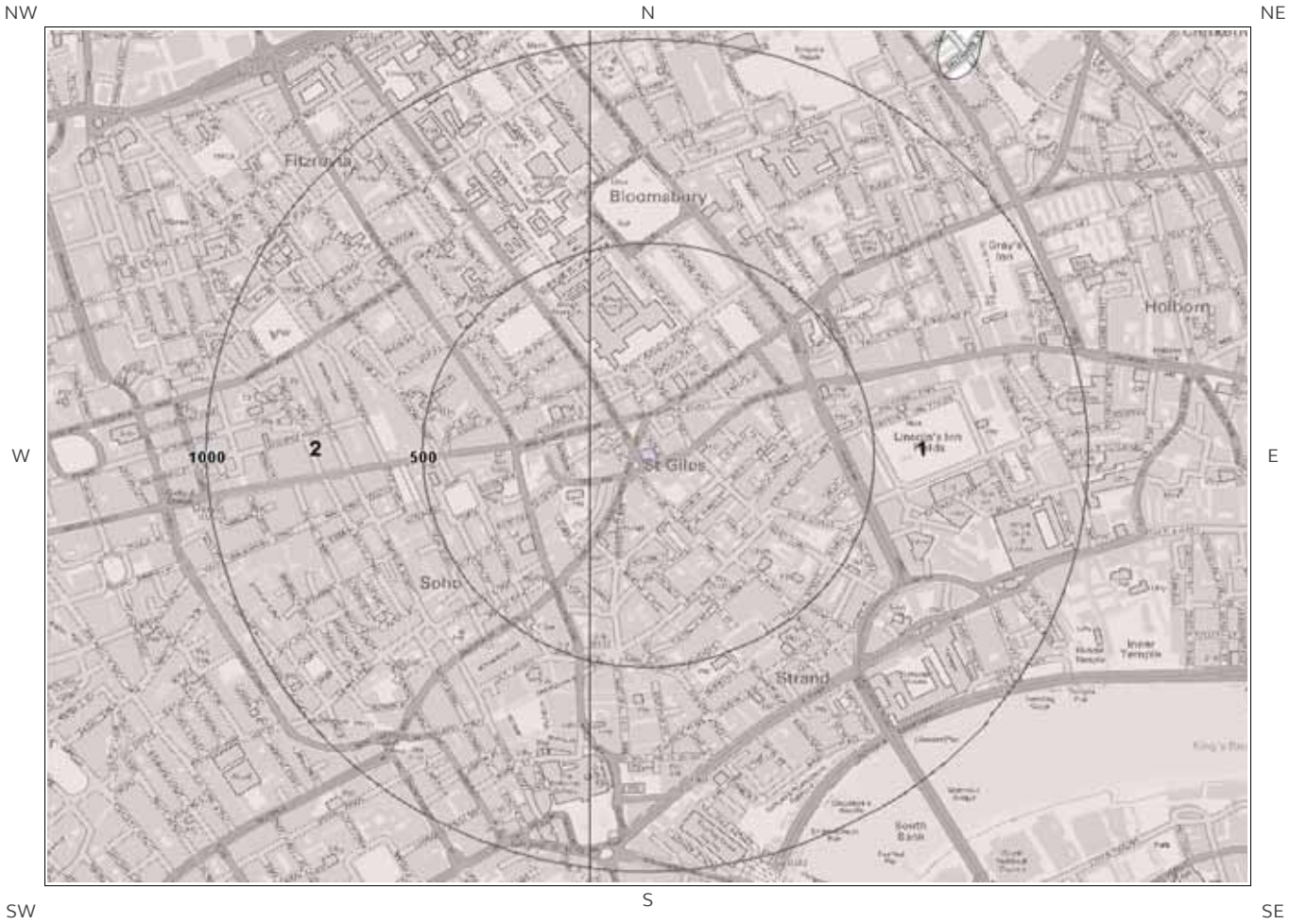
No

Database searched and no data found.

The geology map for the site and surrounding area are extracted from the BGS Digital Geological Map of Great Britain at 1:10,000 scale

This Geology shows the main components as discrete layers, these are: Artificial / Made Ground, Superficial / Drift Geology and Landslips. These are all displayed with the BGS Lexicon code for the rock unit and BGS sheet number. Not all of the main geological components have nationwide coverage.

1.3 Bedrock and Faults Map (1:10,000 scale)



Bedrock and Faults Legend

Site Outline

500
1000
Search Buffers (m)

1.3 Bedrock and Faults

The following geological information represented on the mapping is derived from 1:10,000 scale BGS Geological mapping.

1.3.1 Bedrock/ Solid Geology

Records of Bedrock/Solid Geology within 500m of the study site boundary at 1:10,000 scale.

ID	Distance (m)	Direction	LEX Code	Description	Rock Age
1	0.0	On Site	LC-CLAY	London Clay Formation - Clay	Eocene Epoch
2	113.0	W	LC-CLAY	London Clay Formation - Clay	Eocene Epoch

1.3.2 Faults

Are there any records of Faults within 500m of the study site boundary at 1:10,000 scale? No

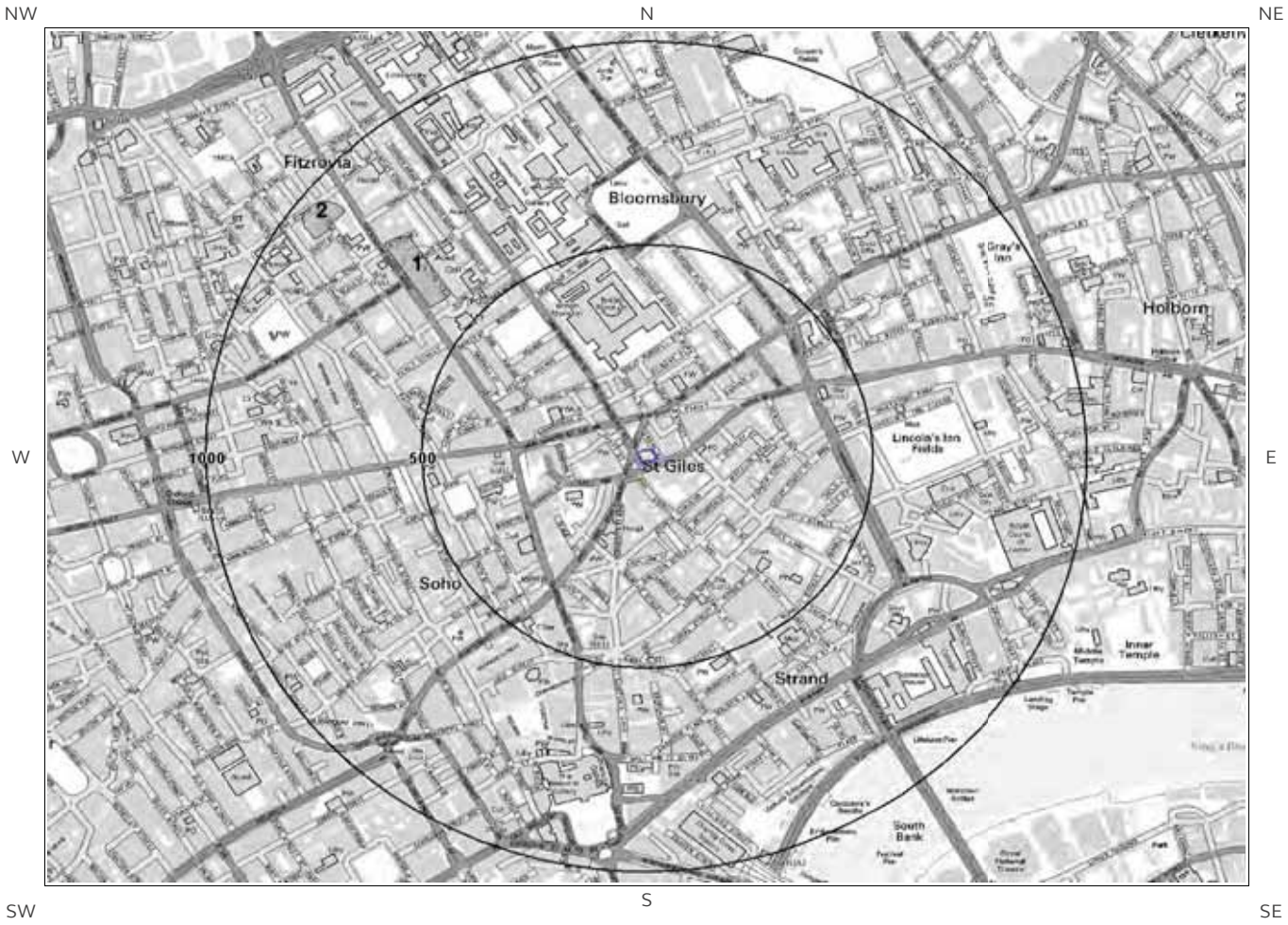
Database searched and no data found at this scale.

The geology map for the site and surrounding area are extracted from the BGS Digital Geological Map of great Britain at 1:10,000 scale.

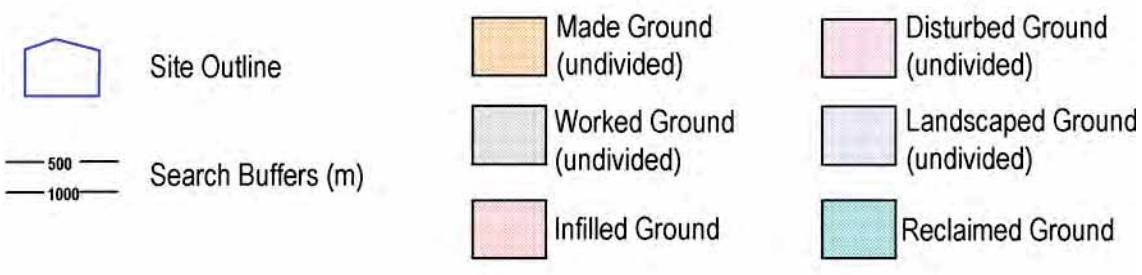
This Geology shows the main components as discrete layers, these are: Bedrock/ Solid Geology and linear features such as Faults. These are all displayed with the BGS Lexicon code for the rock unit and BGS sheet number. Not all of the main geological components have nationwide coverage.

2 Geology 1:50,000 Scale

2.1 Artificial Ground Map



Ground Workings Legend



2. Geology 1:50,000 scale

2.1 Artificial Ground

The following geological information represented on the mapping is derived from 1:50,000 scale BGS Geological mapping, Sheet No: 256

2.1.1 Artificial/ Made Ground

Are there any records of Artificial/ Made Ground within 500m of the study site boundary? No

Database searched and no data found.

2.1.2 Permeability of Artificial Ground

Are there any records relating to permeability of artificial ground within the study site boundary? No

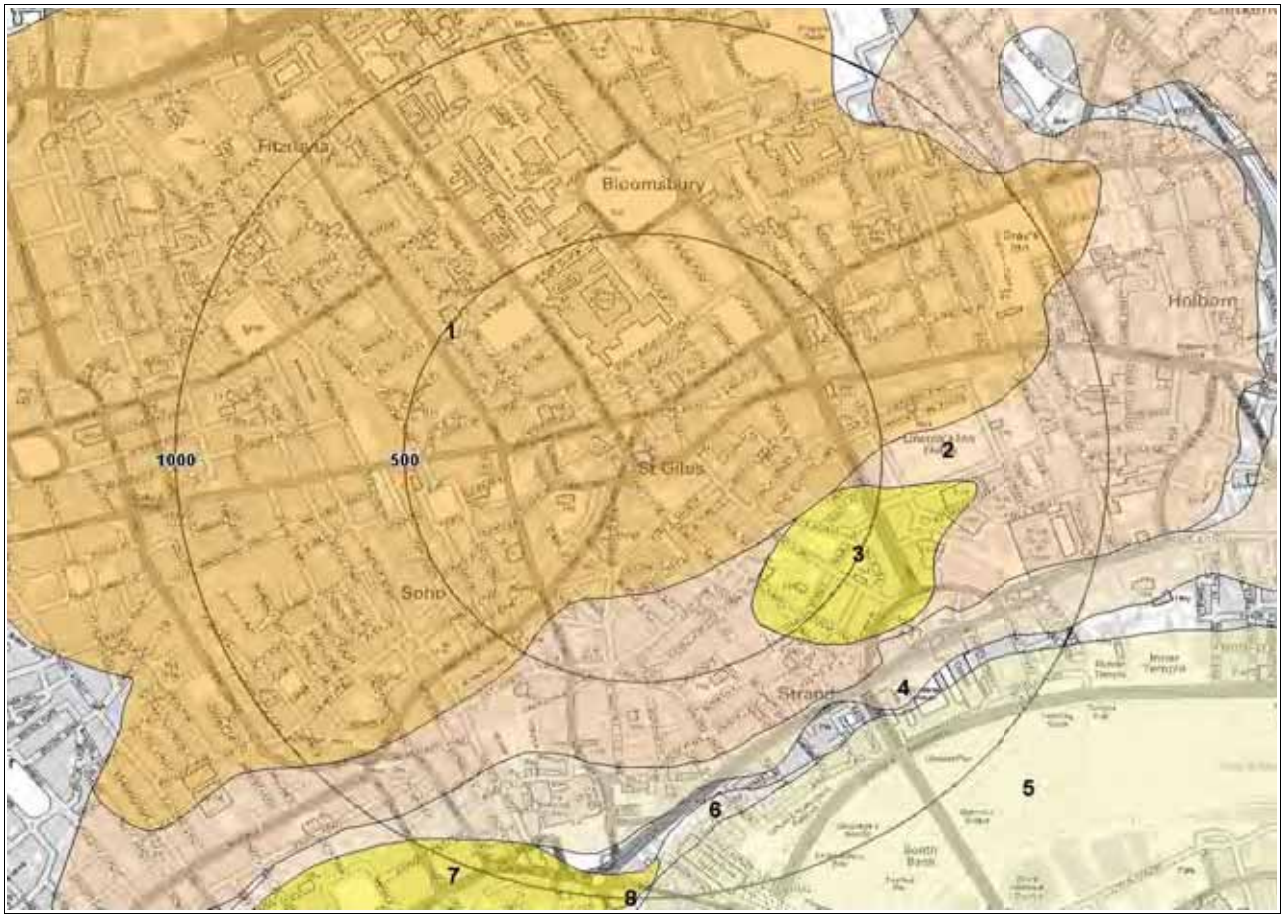
Database searched and no data found.

2.2 Superficial Deposits and Landslips Map (1:50,000 scale)

NW N NE

W E

SW S SE



Ground Workings Legend

Site Outline

500
1000
Search Buffers (m)

2.2 Superficial Deposits and Landslips

2.2.1 Superficial Deposits/ Drift Geology

Are there any records of Superficial Deposits/ Drift Geology within 500m of the study site boundary? Yes

ID	Distance	Direction	LEX Code	Description	Rock Description
1	0.0	On Site	LHGR-XSV	LYNCH HILL GRAVEL MEMBER	SAND AND GRAVEL
2	279.0	SE	HAGR-XSV	HACKNEY GRAVEL MEMBER	SAND AND GRAVEL
3	332.0	SE	LASI-XCZ	LANGLEY SILT MEMBER	CLAY AND SILT

2.2.2 Permeability of Superficial Ground

Are there any records relating to permeability of superficial ground within the study site boundary? Yes

Distance (m)	Direction	Flow Type	Maximum Permeability	Minimum Permeability
0.0	On Site	Intergranular	Very High	High

2.2.3 Landslip

Are there any records of Landslip within 500m of the study site boundary? No

Database searched and no data found.

The geology map for the site and surrounding area are extracted from the BGS Digital Geological Map of Great Britain at 1:50,000 scale.

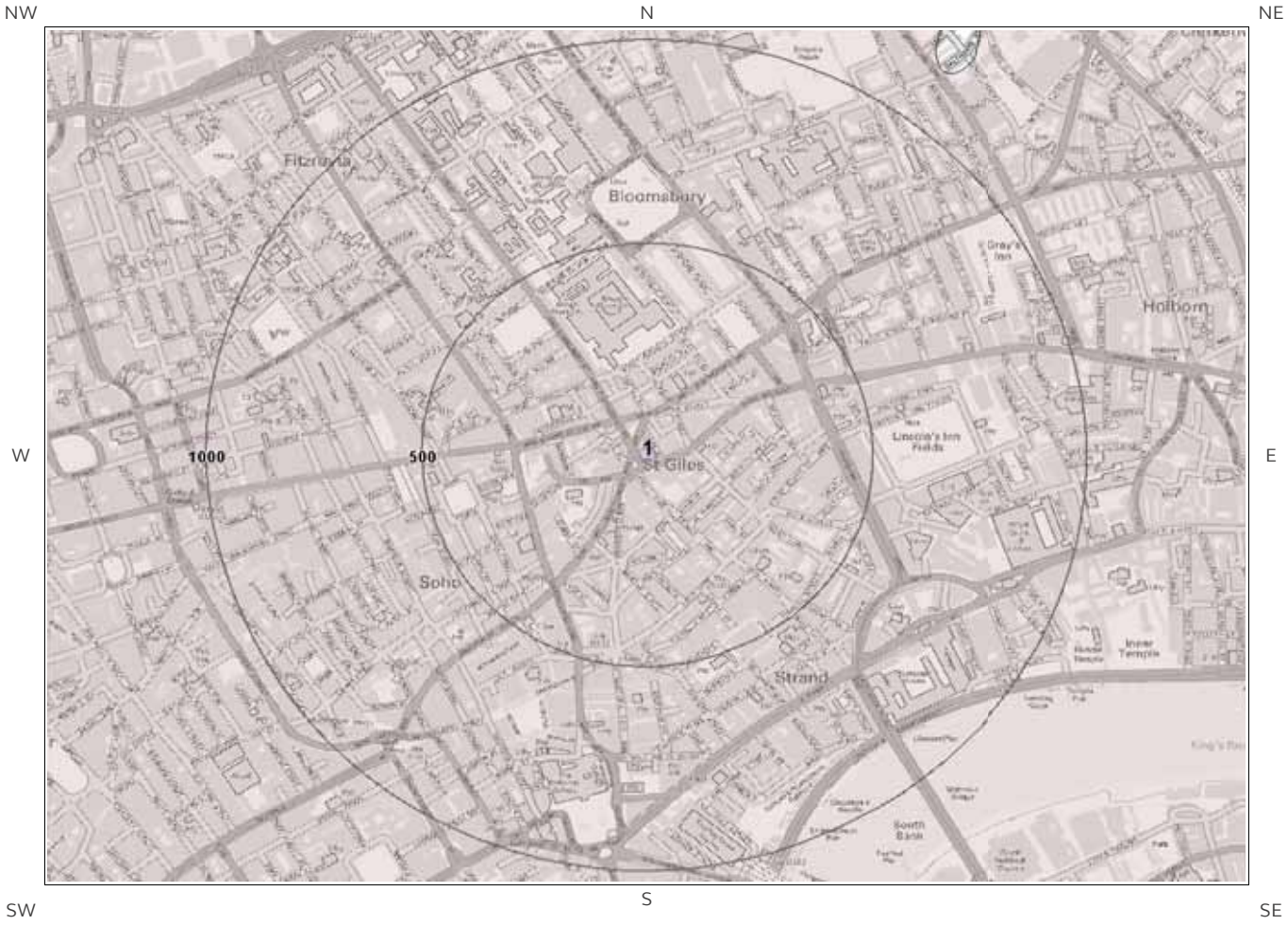
This Geology shows the main components as discrete layers, there are: Artificial/ Made Ground, Superficial/ Drift Geology and Landslips. These are all displayed with the BGS Lexicon code for the rock unit and BGS sheet number. Not all of the main geological components have nationwide coverage.

2.2.4 Landslip Permeability

Are there any records relating to permeability of landslips within the study site boundary? No

Database searched and no data found.

2.3 Bedrock and Faults Map (1:50,000 scale)



Ground Workings Legend

Site Outline

500
1000
Search Buffers (m)

2.3 Bedrock, Solid Geology & Faults

The following geological information represented on the mapping is derived from 1:50,000 scale BGS Geological mapping, Sheet No: 256

2.3.1 Bedrock/Solid Geology

Records of Bedrock/Solid Geology within 500m of the study site boundary:

ID	Distance	Direction	LEX Code	Rock Description	Rock Age
1	0.0	On Site	LC-XCZS	LONDON CLAY FORMATION - CLAY, SILT AND SAND	YPRESIAN

2.3.2 Permeability of Bedrock Ground

Are there any records relating to permeability of bedrock ground within the study site boundary? Yes

Distance	Direction	Flow Type	Maximum Permeability	Minimum Permeability
0.0	On Site	Mixed	Moderate	Very Low

2.3.3 Faults

Are there any records of Faults within 500m of the study site boundary? No

Database searched and no data found.

The geology map for the site and surrounding area are extracted from the BGS Digital Geological Map of Great Britain at 1:50,000 scale.

This Geology shows the main components as discrete layers, these are: Bedrock/Solid Geology and linear features such as Faults. These are all displayed with the BGS Lexicon code for the rock unit and BGS sheet number. Not all of the main geological components have nation wide coverage.

3 Radon Data

3.1 Radon Affected Areas

Is the property in a Radon Affected Area as defined by the Health Protection Agency (HPA) and if so what percentage of homes are above the Action Level? The property is not in a Radon Affected Area, as less than 1% of properties are above the Action Level.

3.2 Radon Protection

Is the property in an area where Radon Protection are required for new properties or extensions to existing ones as described in publication BR211 by the Building Research Establishment? No radon protective measures are necessary.

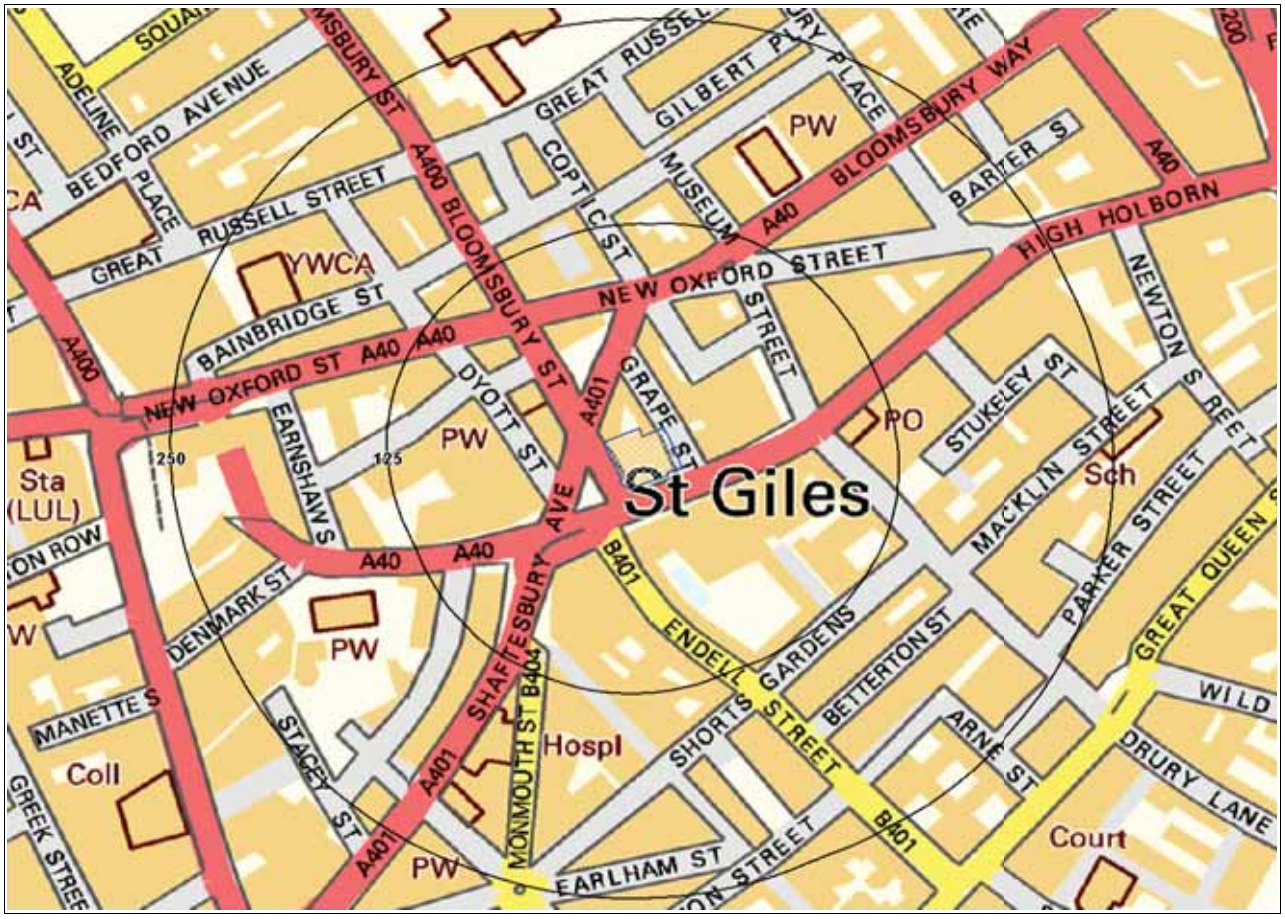
---

4 Ground Workings Map

NW N NE

W E

SW S SE



Ground Workings Legend

Site Outline

125
250
Search Buffers (m)

Historic Surface Ground Workings

Historic Underground Workings

Current Ground Workings

4 Ground Workings

4.1 Historical Surface Ground Working Features derived from Historical Mapping

This dataset is based on Groundsure's unique Historical Land Use Database derived from 1:10,560 and 1:10,000 scale historical mapping

Are there any Historical Surface Ground Working Features within 250m of the study site boundary? No

Database searched and no data found.

4.2 Historical Underground Working Features derived from Historical Mapping

This data is derived from the Groundsure unique Historical Land Use Database. It contains data derived from 1:10,000 and 1:10,560 historical Ordnance Survey Mapping and includes some natural topographical features (Shake Holes for example) as well as manmade features that may have implications for ground stability. Underground and mining features have been identified from surface features such as shafts. The distance that these extend underground is not shown.

Are there any Historical Underground Working Features within 1000m of the study site boundary? Yes

The following Historical Underground Working Features are provided by Groundsure:

ID	Distance (m)	Direction	NGR	Use	Date
Not shown	843.0	SE	530559 180596	Tunnel	1895
Not shown	843.0	SE	530573 180606	Tunnel	1895
Not shown	988.0	SE	531608 180849	Tunnel	1895

4.3 Current Ground Workings

This dataset is derived from the BGS BRITPITS database covering active; inactive mines; quarries; oil wells; gas wells and mineral wharves; and rail deposits throughout the British Isles.

Are there any BGS Current Ground Workings within 1000m of the study site boundary? No

Database searched and no data found.

5 Mining, Extraction & Natural Cavities Map

NW N NE

W E

SW S SE

Mining, Extraction and Natural Cavities Legend

5 Mining, Extraction & Natural Cavities

5.1 Historical Mining

This dataset is derived from Groundsure unique Historical Land-use Database that are indicative of mining or extraction activities.

Are there any Historical Mining areas within 1000m of the study site boundary? No

Database searched and no data found.

5.2 Coal Mining

This dataset provides information as to whether the study site lies within a known coal mining affected area as defined by the coal authority.

Are there any Coal Mining areas within 1000m of the study site boundary? No

Database searched and no data found.

5.3 Johnson Poole and Bloomer

This dataset provides information as to whether the study site lies within an area where JPB hold information relating to mining.

Are there any JPB Mining areas within 1000m of the study site boundary? Yes

The following information provided by JPB is not represented on mapping: Whilst outside of an area where The Coal Authority have information on coal mining activities, Johnson Poole & Bloomer (JPB) have information such as mining plans and maps held within their archive of mining activities that have occurred within 1km of this property. Further details and a quote for services can be obtained by emailing this report to enquiries.gs@jpb.co.uk.

5.4 Non-Coal Mining

This dataset provides information as to whether the study site lies within an area which may have been subject to non-coal historic mining.

Are there any Non-Coal Mining areas within 1000m of the study site boundary? No

Database searched and no data found.

5.5 Non-Coal Mining Cavities

This dataset provides information from the Peter Brett Associates (PBA) mining cavities database (compiled for the national study entitled "Review of mining instability in Great Britain, 1990" PBA has also continued adding to this database) on mineral extraction by mining.

Are there any Non-Coal Mining cavities within 1000m of the study site boundary? No

Database searched and no data found.

5.6 Natural Cavities

This dataset provides information based on Peter Brett Associates natural cavities database.

Are there any Natural Cavities within 1000m of the study site boundary? No

Database searched and no data found.

5.7 Brine Extraction

This data provides information from the Coal Authority issued on behalf of the Cheshire Brine Subsidence Compensation Board.

Are there any Brine Extraction areas within 1000m of the study site boundary? No

Database searched and no data found.

5.8 Gypsum Extraction

This dataset provides information on Gypsum extraction from British Gypsum records.

Are there any Gypsum Extraction areas within 1000m of the study site boundary? No

Database searched and no data found.

5.9 Tin Mining

This dataset provides information on tin mining areas and is derived from tin mining records. This search is based upon postcode information to a sector level..

Are there any Tin Mining areas within 1000m of the study site boundary? No

Database searched and no data found.

5.10 Clay Mining

This dataset provides information on Kaolin and Ball Clay mining from relevant mining records.

Are there any Clay Mining areas within 1000m of the study site boundary? No

Database searched and no data found.

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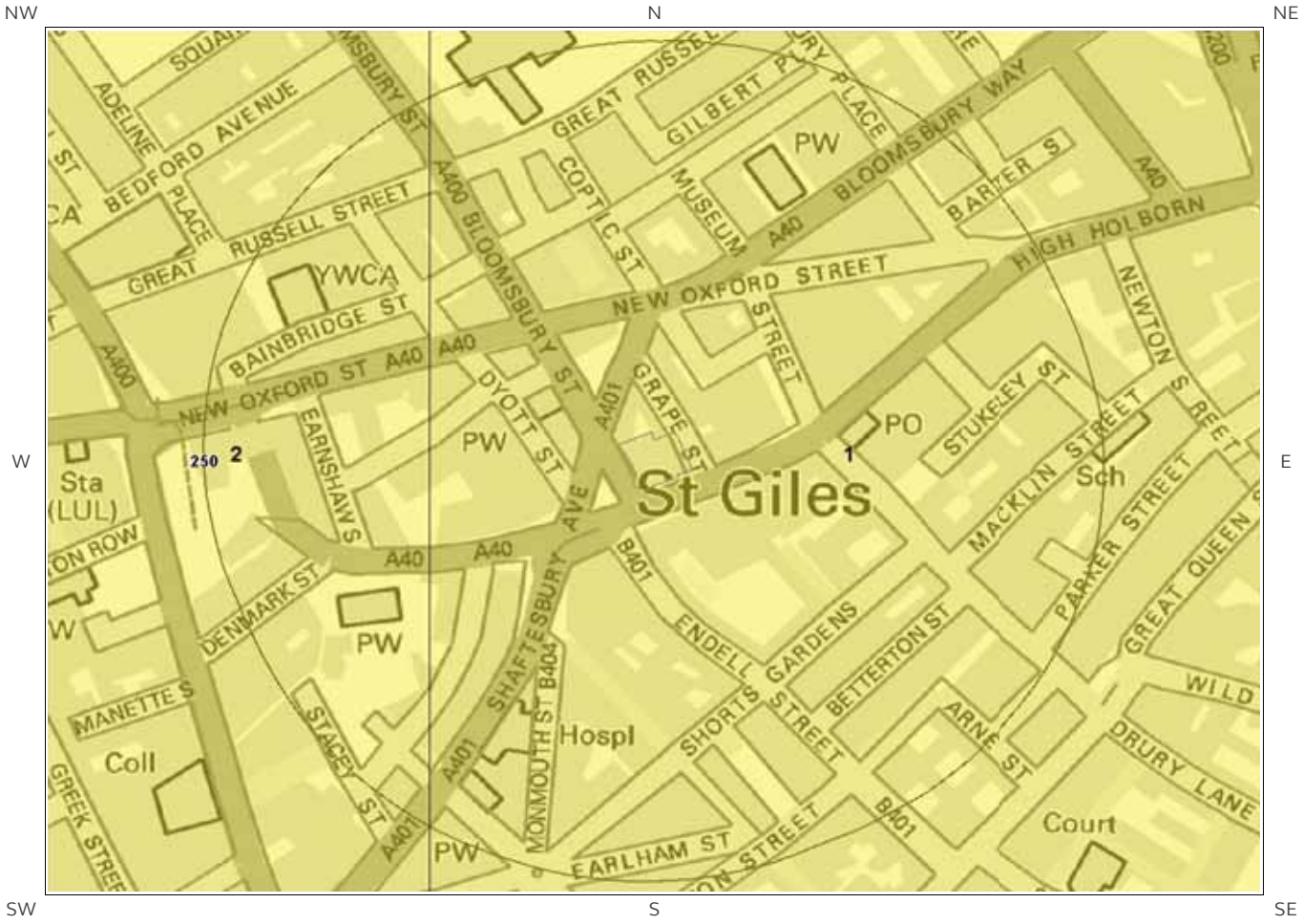
6 Natural Ground Subsidence

6.1 Shrink-Swell Clay Map

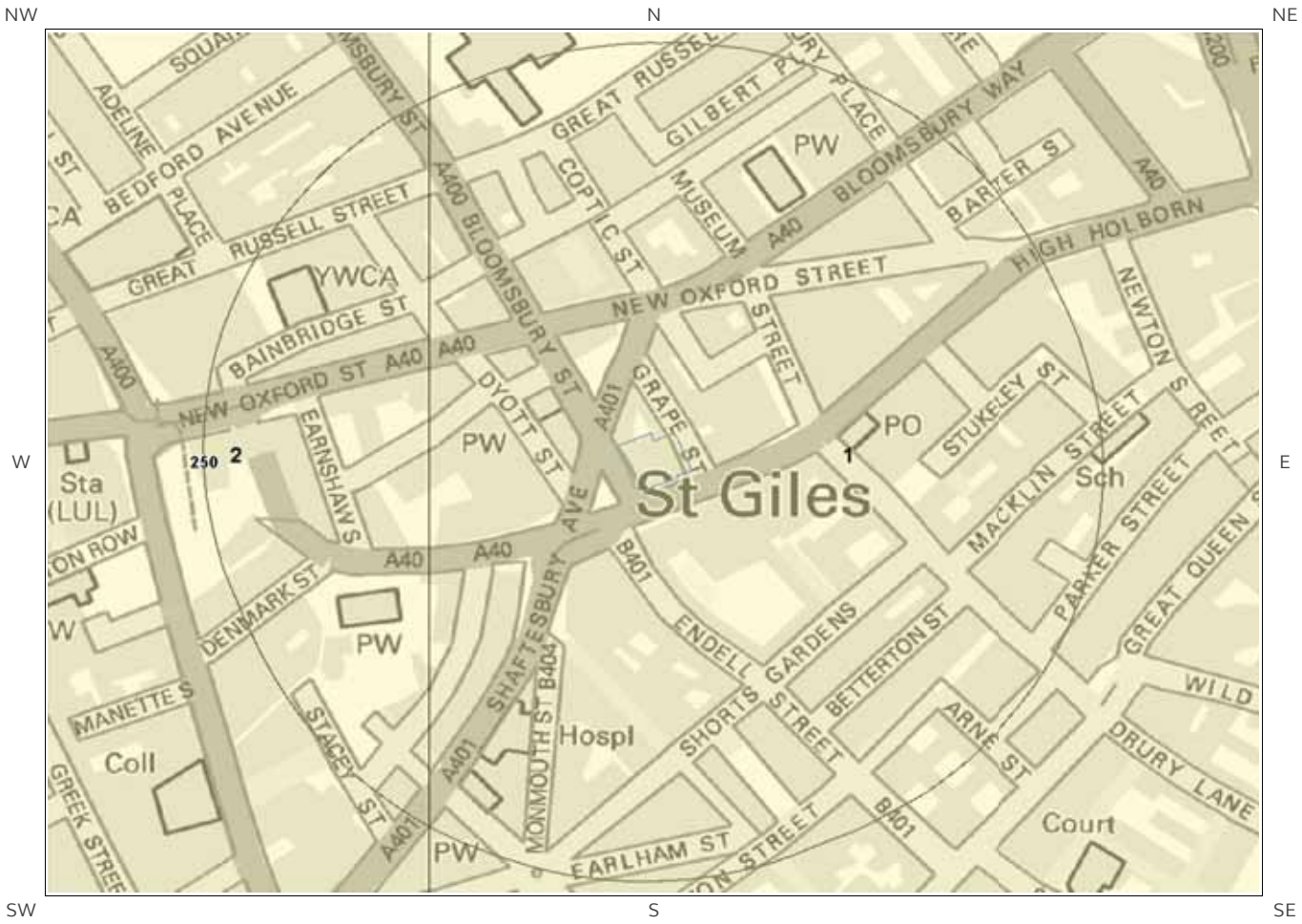
Shrink Swell Clay Legend

6.2 Landslides Map



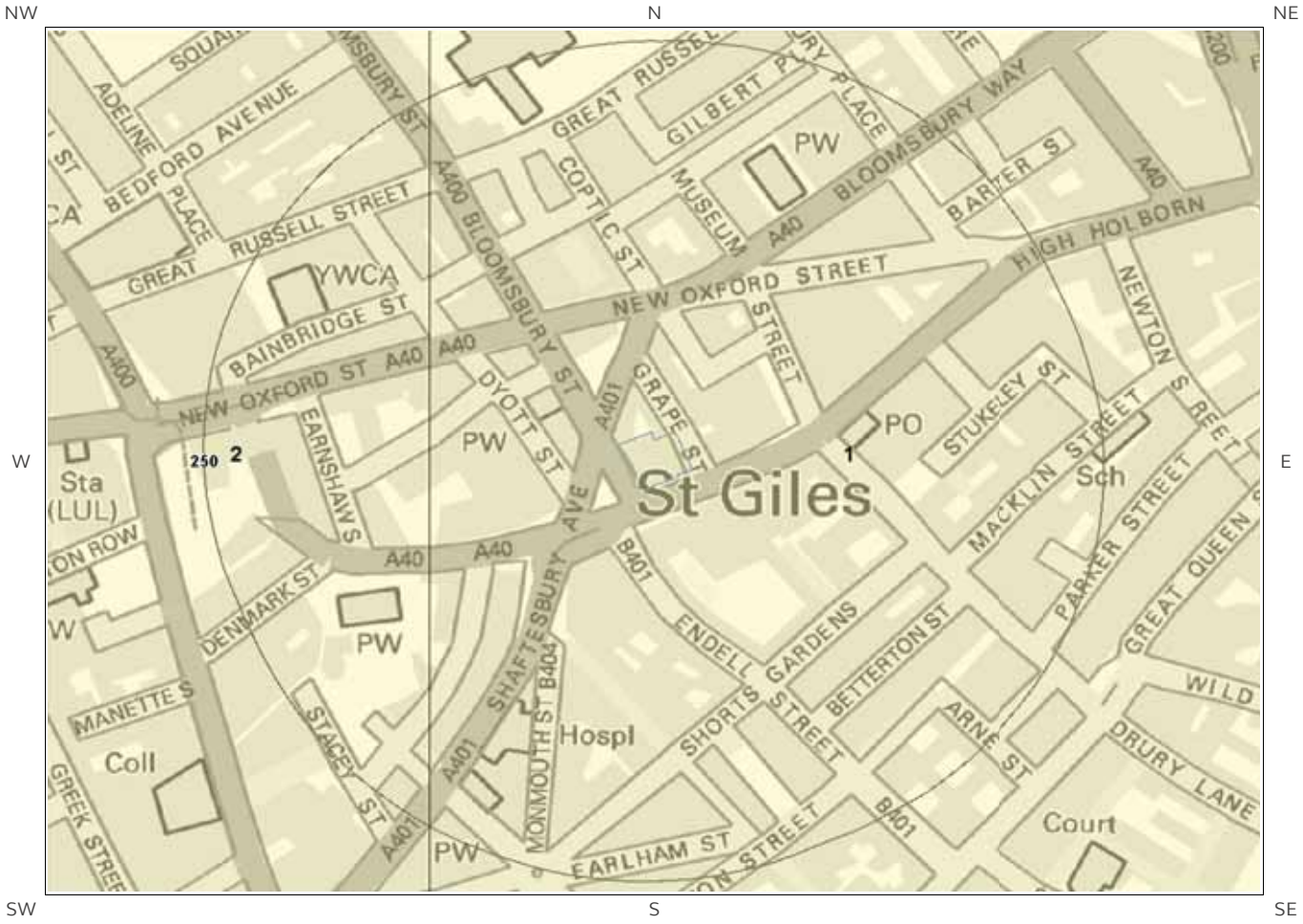
Landslides Legend

6.3 Ground Dissolution of Soluble Rocks Map



Ground Dissolution Soluble Rocks Legend

6.4 Compressible Deposits Map



Compressible Deposits Legend

6.5 Collapsible Deposits Map

Collapsible Deposits Legend

6.6 Running Sand Map

Running Sand Legend

6 Natural Ground Subsidence

The National Ground Subsidence rating is obtained through the 6 natural ground stability hazard datasets, which are supplied by the British Geological Survey (BGS).

The following GeoSure data represented on the mapping is derived from the BGS Digital Geological map of Great Britain at 1:50,000 scale.

What is the maximum hazard rating of natural subsidence within the study site*[*] boundary? Moderate

6.1 Shrink-Swell Clays

The following Shrink Swell information provided by the British Geological Survey:

ID	Distance (m)	Direction	Hazard Rating	Details
1	0.0	On Site	Moderate	Ground conditions predominantly high plasticity. Do not plant or remove trees or shrubs near to buildings without expert advice about their effect and management. For new build, consideration should be given to advice published by the National House Building Council (NHBC) and the Building Research Establishment (BRE). There is a probable increase in construction cost to reduce potential shrink-swell problems. For existing property, there is a probable increase in insurance risk during droughts or where vegetation with high moisture demands is present.
2	0.0	On Site	Negligible	Ground conditions predominantly non-plastic. No special actions required to avoid problems due to shrink-swell clays. No special ground investigation required, and increased construction costs or increased financial risks are unlikely likely due to potential problems with shrink-swell clays.

6.2 Landslides

The following Landslides information provided by the British Geological Survey:

ID	Distance (m)	Direction	Hazard Rating	Details
1	0.0	On Site	Very Low	Slope instability problems are unlikely to be present. No special actions required to avoid problems due to landslides. No special ground investigation required, and increased construction costs or increased financial risks are unlikely due to potential problems with landslides.

* This includes an automatically generated 50m buffer zone around the site

6.3 Ground Dissolution of Soluble Rocks

The following Ground Dissolution information provided by the British Geological Survey:

ID	Distance (m)	Direction	Hazard Rating	Details
1	0.0	On Site	Negligible	Soluble rocks are present, but unlikely to cause problems except under exceptional conditions. No special actions required to avoid problems due to soluble rocks. No special ground investigation required, and increased construction costs or increased financial risks are unlikely due to potential problems with soluble rocks.

6.4 Compressible Deposits

The following Compressible Deposits information provided by the British Geological Survey:

ID	Distance (m)	Direction	Hazard Rating	Details
1	0.0	On Site	Negligible	No indicators for compressible deposits identified. No special actions required to avoid problems due to compressible deposits. No special ground investigation required, and increased construction costs or increased financial risks are unlikely due to potential problems with compressible deposits.

6.5 Collapsible Deposits

The following Collapsible Rocks information provided by the British Geological Survey:

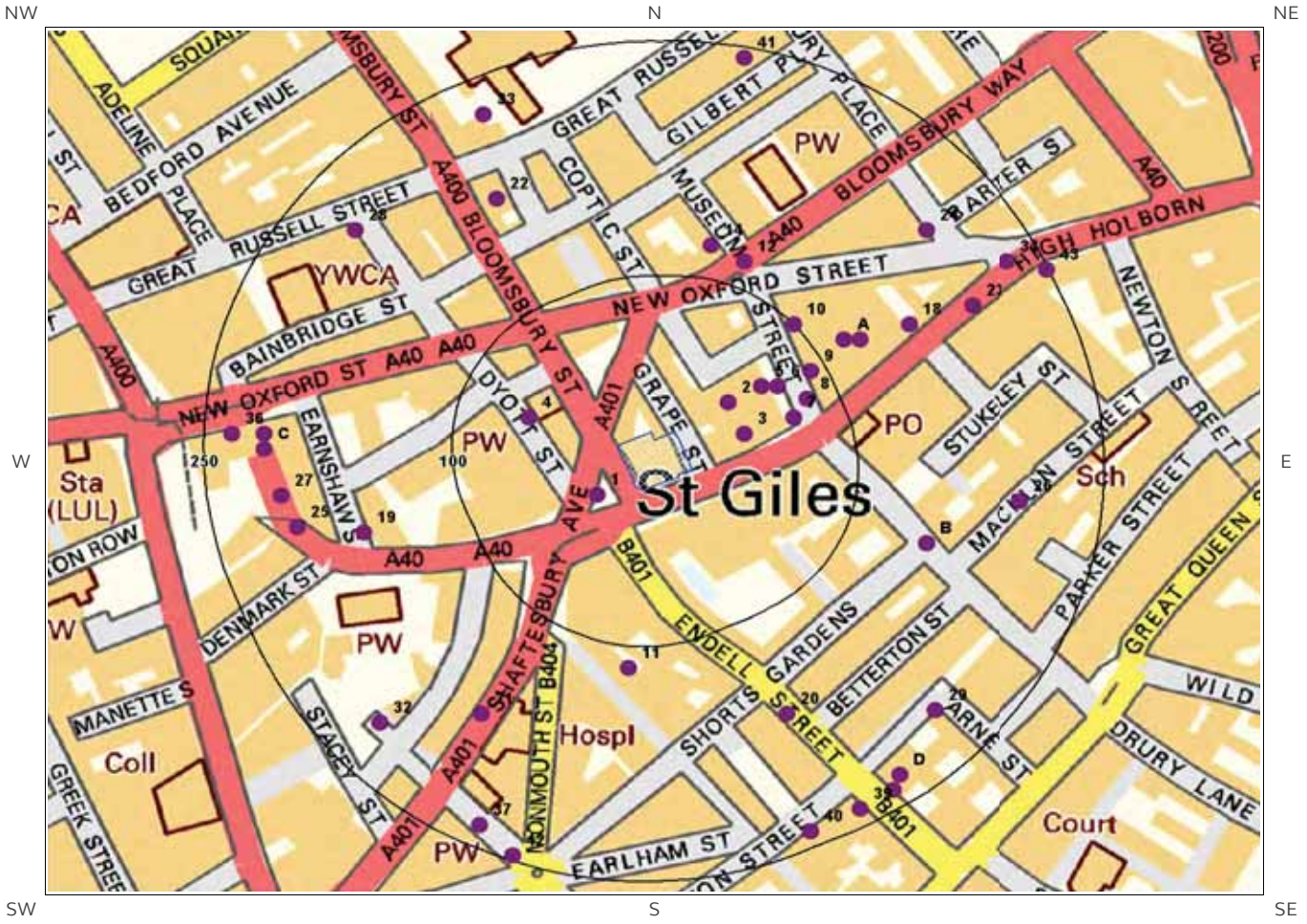
ID	Distance (m)	Direction	Hazard Rating	Details
1	0.0	On Site	Very Low	Deposits with potential to collapse when loaded and saturated are unlikely to be present. No special ground investigation required or increased construction costs or increased financial risk due to potential problems with collapsible deposits.

6.6 Running Sands

The following Running Sands information provided by the British Geological Survey:

ID	Distance (m)	Direction	Hazard Rating	Details
1	0.0	On Site	Very Low	Very low potential for running sand problems if water table rises or if sandy strata are exposed to water. No special actions required, to avoid problems due to running sand. No special ground investigation required, and increased construction costs or increased financial risks are unlikely due to potential problems with running sand.

7 Borehole Records Map



Borehole Records Legend

7 Borehole Records

The systematic analysis of data extracted from the BGS Borehole Records database provides the following information.

Records of boreholes within 250m of the study site boundary: 43

ID	Distance (m)	Direction	NGR	BGS Reference	Drilled Length	Borehole Name
1	23.0	W	530101 181331	TQ38SW3592	-1.0	CROSSRAIL PACKAGE C RT28
2	37.0	NE	530180 181390	TQ38SW799/C	9.14	HIGH HOLBORN - MUSEUM ST. 3
3	38.0	NE	530190 181370	TQ38SW799/B	9.14	HIGH HOLBORN - MUSEUM ST. 2
4	56.0	W	530060 181380	TQ38SW189	9.0	DYOTT STREET BLOOMSBURY
5	60.0	NE	530200 181400	TQ38SW799/A-D	-1.0	HAMMERSON HIGH HOLBORN BH1-4
6	68.0	NE	530210 181400	TQ38SW799/D	9.14	HIGH HOLBORN - MUSEUM ST. 4
7	69.0	NE	530220 181380	TQ38SW799/A	18.29	HIGH HOLBORN - MUSEUM ST. 1
8	81.0	NE	530228 181392	TQ38SW3603	-1.0	CROSSRAIL PACKAGE C RT29A
9	90.0	NE	530230 181410	TQ38SW660/A	15.54	HIGH HOLBORN - MUSEUM ST, 1
10	100.0	NE	530220 181440	TQ38SW660/B	7.77	HIGH HOLBORN - MUSEUM ST, 2
11	114.0	S	530120 181220	TQ38SW1280	4.0	70-74 NEAL ST COVENT GARDEN TPS,A-B
12	117.0	N	530190 181480	TQ38SW159	17.57	BLOOMSBURY WAY/NEW OXFORD STREET
13A	118.0	NE	530250 181430	TQ38SW660	3.04	M.O.W. WEST CENTRAL HOLBORN
14	121.0	N	530170 181490	TQ38SW956	-1.0	PROPOSED BRITISH LIBRARY BH2
15A	126.0	NE	530260 181430	TQ38SW660/D	30.48	HIGH HOLBORN - MUSEUM ST, 4
16B	149.0	E	530300 181300	TQ38SW1279	-1.0	DRURY LANE/MACKLIN ST SITE 3A
17B	149.0	E	530300 181300	TQ38SW1278	-1.0	DRURY LANE/MACKLIN ST SITE 1
18	158.0	NE	530290 181440	TQ38SW660/E	21.03	HIGH HOLBORN - MUSEUM ST, 5
19	163.0	W	529960 181307	TQ28SE1747	-1.0	CROSSRAIL PACKAGE C RT26
20	165.0	SE	530216 181191	TQ38SW3598	-1.0	CROSSRAIL PACKAGE C RT28A
21	173.0	SW	530031 181191	TQ38SW3600	-1.0	CROSSRAIL PACKAGE C RT27
22	173.0	NW	530040 181520	TQ38SW955	-1.0	PROPOSED BRITISH LIBRARY BH1

ID	Distance (m)	Direction	NGR	BGS Reference	Drilled Length	Borehole Name
23	197.0	NE	530328 181452	TQ38SW3595	-1.0	CROSSRAIL PACKAGE C RT31A
24	200.0	NE	530300 181500	TQ38SW2898	182.88	HART STREET BLOOMSBURY
25	200.0	W	529920 181310	TQ28SE1621	10.66	ST GILES CIRCUS 9
26	200.0	E	530358 181327	TQ38SW3596	-1.0	CROSSRAIL PACKAGE C RT30
27	206.0	W	529910 181330	TQ28SE1620	10.97	ST GILES CIRCUS 8
28	210.0	NW	529955 181500	TQ28SE180	15.29	T.U.C.MEMORIAL BLDG HOLBORN
29	213.0	SE	530305 181193	TQ38SW1671	10.0	LONG ACRE, LONDON 5
30C	213.0	W	529900 181360	TQ28SE1626	14.47	ST GILES CIRCUS 1
31C	213.0	W	529900 181370	TQ28SE1627	26.21	ST GILES CIRCUS 2
32	216.0	SW	529970 181185	TQ28SE1748	-1.0	CROSSRAIL PACKAGE C RT25
33	226.0	N	530032 181574	TQ38SW2140	3.0	89 GT RUSSELL ST LONDON TP 1
34	229.0	NE	530350 181480	TQ38SW18	6.8	BROAD ST & NEW OXFORD ST.W
35D	232.0	SE	530284 181152	TQ38SW1669	39.5	LONG ACRE LONDON BH3 & BH3A
36	233.0	W	529880 181370	TQ28SE1628	14.17	ST GILES CIRCUS 3
37	236.0	SW	530030 181120	TQ38SW2331	25.0	SHAFTESBURY AVE 2
38D	239.0	SE	530280 181142	TQ38SW1670	0.0	LONG ACRE LONDON BH4
39	239.0	SE	530260 181130	TQ38SW949	15.5	ODHAMS PRESS SITE BH1
40	240.0	SE	530230 181116	TQ38SW1674	10.0	MERCER STREET PHASE 7 BH3
41	243.0	N	530190 181610	TQ38SW957	-1.0	PROPOSED BRITISH LIBRARY BH3
42	247.0	S	530050 181100	TQ38SW2332	25.0	SHAFTESBURY AVE 3
43	248.0	NE	530374 181475	TQ38SW1676	13.0	HIGH HOLBORN-NEWTON STREET BH1

The borehole records are available using the hyperlinks below: Please note that if the donor of the borehole record has requested the information be held as commercial-in-confidence, the additional data will be held separately by the BGS and a formal request must be made for its release.

#2: scans.bgs.ac.uk/sobi_scans/boreholes/1064450
#3: scans.bgs.ac.uk/sobi_scans/boreholes/1064449
#4: scans.bgs.ac.uk/sobi_scans/boreholes/1063496
#5: scans.bgs.ac.uk/sobi_scans/boreholes/1064452
#6: scans.bgs.ac.uk/sobi_scans/boreholes/1064451
#7: scans.bgs.ac.uk/sobi_scans/boreholes/1064448
#9: scans.bgs.ac.uk/sobi_scans/boreholes/1064153
#10: scans.bgs.ac.uk/sobi_scans/boreholes/1064154
#11: scans.bgs.ac.uk/sobi_scans/boreholes/1065155
#12: scans.bgs.ac.uk/sobi_scans/boreholes/1063466
#13A: scans.bgs.ac.uk/sobi_scans/boreholes/1064157
#14: scans.bgs.ac.uk/sobi_scans/boreholes/1064648
#15A: scans.bgs.ac.uk/sobi_scans/boreholes/1064155
#16B: scans.bgs.ac.uk/sobi_scans/boreholes/1065154
#17B: scans.bgs.ac.uk/sobi_scans/boreholes/1065153
#18: scans.bgs.ac.uk/sobi_scans/boreholes/1064156
#22: scans.bgs.ac.uk/sobi_scans/boreholes/1064647
#24: scans.bgs.ac.uk/sobi_scans/boreholes/1067072
#25: scans.bgs.ac.uk/sobi_scans/boreholes/593202
#27: scans.bgs.ac.uk/sobi_scans/boreholes/593201
#28: scans.bgs.ac.uk/sobi_scans/boreholes/591664
#29: scans.bgs.ac.uk/sobi_scans/boreholes/1065598
#30C: scans.bgs.ac.uk/sobi_scans/boreholes/593207
#31C: scans.bgs.ac.uk/sobi_scans/boreholes/593208
#33: scans.bgs.ac.uk/sobi_scans/boreholes/1066313
#34: scans.bgs.ac.uk/sobi_scans/boreholes/1063258
#35D: scans.bgs.ac.uk/sobi_scans/boreholes/1065596
#36: scans.bgs.ac.uk/sobi_scans/boreholes/593209
#37: scans.bgs.ac.uk/sobi_scans/boreholes/1066504
#38D: scans.bgs.ac.uk/sobi_scans/boreholes/1065597
#39: scans.bgs.ac.uk/sobi_scans/boreholes/1064641
#40: scans.bgs.ac.uk/sobi_scans/boreholes/1065601
#41: scans.bgs.ac.uk/sobi_scans/boreholes/1064649
#42: scans.bgs.ac.uk/sobi_scans/boreholes/1066505
#43: scans.bgs.ac.uk/sobi_scans/boreholes/1065603

8 Estimated Background Soil Chemistry

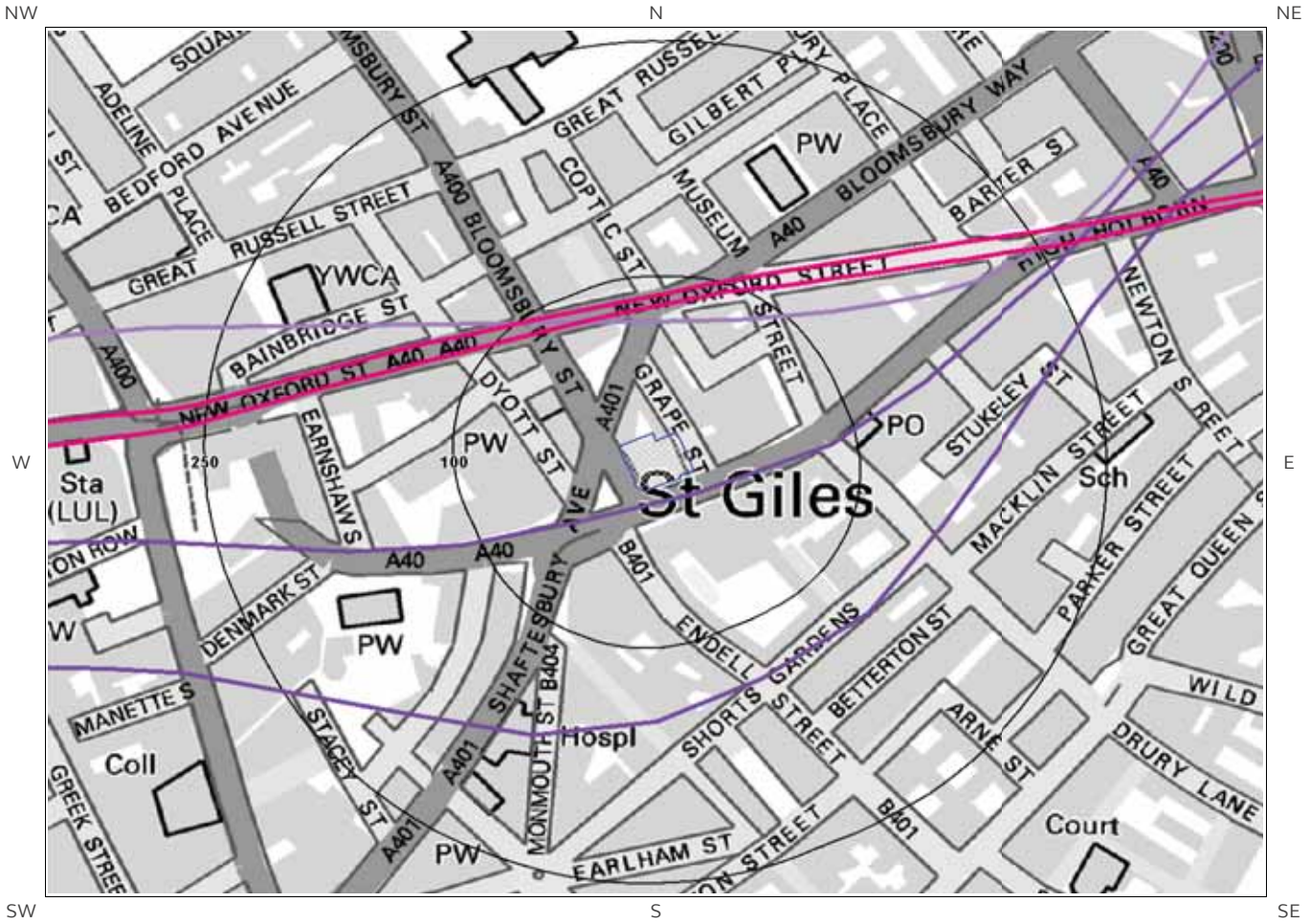
Records of background estimated soil chemistry within 250m of the study site boundary: 1

For further information on how this data is calculated and limitations upon its use, please see the Groundsure Geo Insight User Guide, available on request.

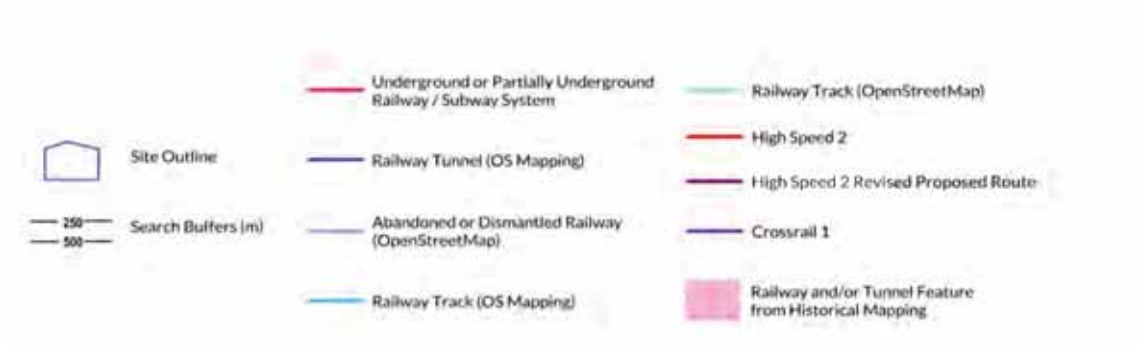
Distance (m)	Direction	Sample Type	Arsenic (As)	Cadmium (Cd)	Chromium (Cr)	Nickel (Ni)	Lead (Pb)
0.0	On Site	London	No data	No data	No data	No data	No data

*As this data is based upon underlying 1:50,000 scale geological information, a 50m buffer has been added to the search radius.

9 Railways and Tunnels Map



Railways and Tunnels Legend



9 Railways and Tunnels

9.1 Tunnels

This data is derived from OpenStreetMap and provides information on the possible locations of underground railway systems in the UK - the London Underground, the Tyne & Wear Metro and the Glasgow Subway.

Have any underground railway lines been identified within the study site boundary?	No
Have any underground railway lines been identified within 250m of the study site boundary?	Yes

Distance (m)	Direction	Detail
79	N	London Underground - Central Line

The approximate depth value for the nearest London Underground line given in this dataset has been extrapolated from published depths of tube lines at station platforms, and assume a constant gradient between stations. Using this method, topographical variation has resulted in some parts of the line having associated depth values either shallower or deeper than the real-world situation. Depth values are for indication only and should not be relied upon for any calculation or technical purpose and are in no way a substitute for a professional survey.

Line
London Underground Line: Central Line Depth: 30mbgl Track Type: Tunnel

Any records that have been identified are represented on the Railways and Tunnels Map.

This data is derived from Ordnance Survey mapping and provides information on the possible locations of railway tunnels forming part of the UK overground railway network.

Have any other railway tunnels been identified within the site boundary?	No
Have any other railway tunnels been identified within 250m of the site boundary?	No

Database searched and no data found.

Any records that have been identified are represented on the Railways and Tunnels Map.

9.2 Historical Railway and Tunnel Features

This data is derived from Groundsure's unique Historical Land-use Database and contains features relating to tunnels, railway tracks or associated works that have been identified from historical Ordnance Survey mapping.

Have any historical railway or tunnel features been identified within the study site boundary? No

Have any historical railway or tunnel features been identified within 250m of the study site boundary? No

Database searched and no data found.

Any records that have been identified are represented on the Railways and Tunnels Map.

9.3 Historical Railways

This data is derived from OpenStreetMap and provides information on the possible alignments of abandoned or dismantled railway lines in proximity to the study site.

Have any historical railway lines been identified within the study site boundary? No

Have any historical railway lines been identified within 250m of the study site boundary? Yes

Distance (m)	Direction	Status
71	N	Disused

Multiple sections of the same track may be listed in the detail above
Any records that have been identified are represented on the Railways and Tunnels Map.

9.4 Active Railways

These datasets are derived from Ordnance Survey mapping and OpenStreetMap and provide information on the possible locations of active railway lines in proximity to the study site.

Have any active railway lines been identified within the study site boundary? No

Have any active railway lines been identified within 250m of the study site boundary? No

Database searched and no data found.

Multiple sections of the same track may be listed in the detail above
Any records that have been identified are represented on the Railways and Tunnels Map.

9.5 Railway Projects

These datasets provide information on the location of large scale railway projects High Speed 2 and Crossrail 1 .

Is the study site within 5km of the route of the High Speed 2 rail project? Yes

Is the study site within 500m of the route of the Crossrail 1 rail project? Yes

Further information on proximity to these routes, the project construction status and associated works can be obtained through the purchase of a Groundsure HS2 and Crossrail 1 Report.

The route data has been digitised from publicly available maps by Groundsure. The route as provided relates to the Crossrail 1 project only, and does not include any details of the Crossrail 2 project, as final details of the route for Crossrail 2 are still under consultation.

Please note that this assessment takes account of both the original Phase 2b proposed route and the amended route proposed in 2016. As the Phase 2b route is still under consultation, Groundsure are providing information on both options until the final route is formally confirmed. Practitioners should take account of this uncertainty when advising clients.

Contact Details

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sales@emapsite.com

British Geological Survey Enquiries

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Tel: 0115 936 3143.
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Email:**enquiries@bgs.ac.uk**
Web:**www.bgs.ac.uk**
BGS Geological Hazards Reports and general geological enquiries

British Gypsum

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LE12 6HX

The Coal Authority

200 Lichfield Lane
Mansfield
Notts NG18 4RG
Tel: 0345 7626 848
DX 716176 Mansfield 5
www.coal.gov.uk

Public Health England

Public information access office
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https://www.gov.uk/government/organisations/public-health-england
Email: **enquiries@phe.gov.uk**
Main switchboard: 020 7654 8000

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Website: http://www.ordnancesurvey.co.uk/

Getmapping PLC

Virginia Villas, High Street, Hartley Witney,
Hampshire RG27 8NW
Tel: 01252 845444
Website:**http://www1.getmapping.com/**

Peter Brett Associates
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Waterman Place
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Tel: +44 (0)118 950 0761 E-mail:**reading@pba.co.uk**
Website:**http://www.peterbrett.com/home**

Standard Terms and Conditions

Groundsure's Terms and Conditions can be viewed online at this link:
https://www.groundsure.com/terms-and-conditions-sept-2016/

emapsite

Masdar House, 1 Reading Road,
Eversley, RG27 0RP

Groundsure Reference:	EMS-444986_596608
Your Reference:	EMS_444986_596608
Report Date	17 Oct 2017
Report Delivery Method:	Email - pdf

Enviro Insight

Address: Shaftsbury Theatre, WC2H 8DP,

Dear Sir/ Madam,

Thank you for placing your order with Groundsure. Please find enclosed the **Groundsure Enviro Insight** as requested.

If you would like further assistance regarding this report then please contact the emapsite customer services team on 0118 9736883 quoting the above report reference number.

Yours faithfully,

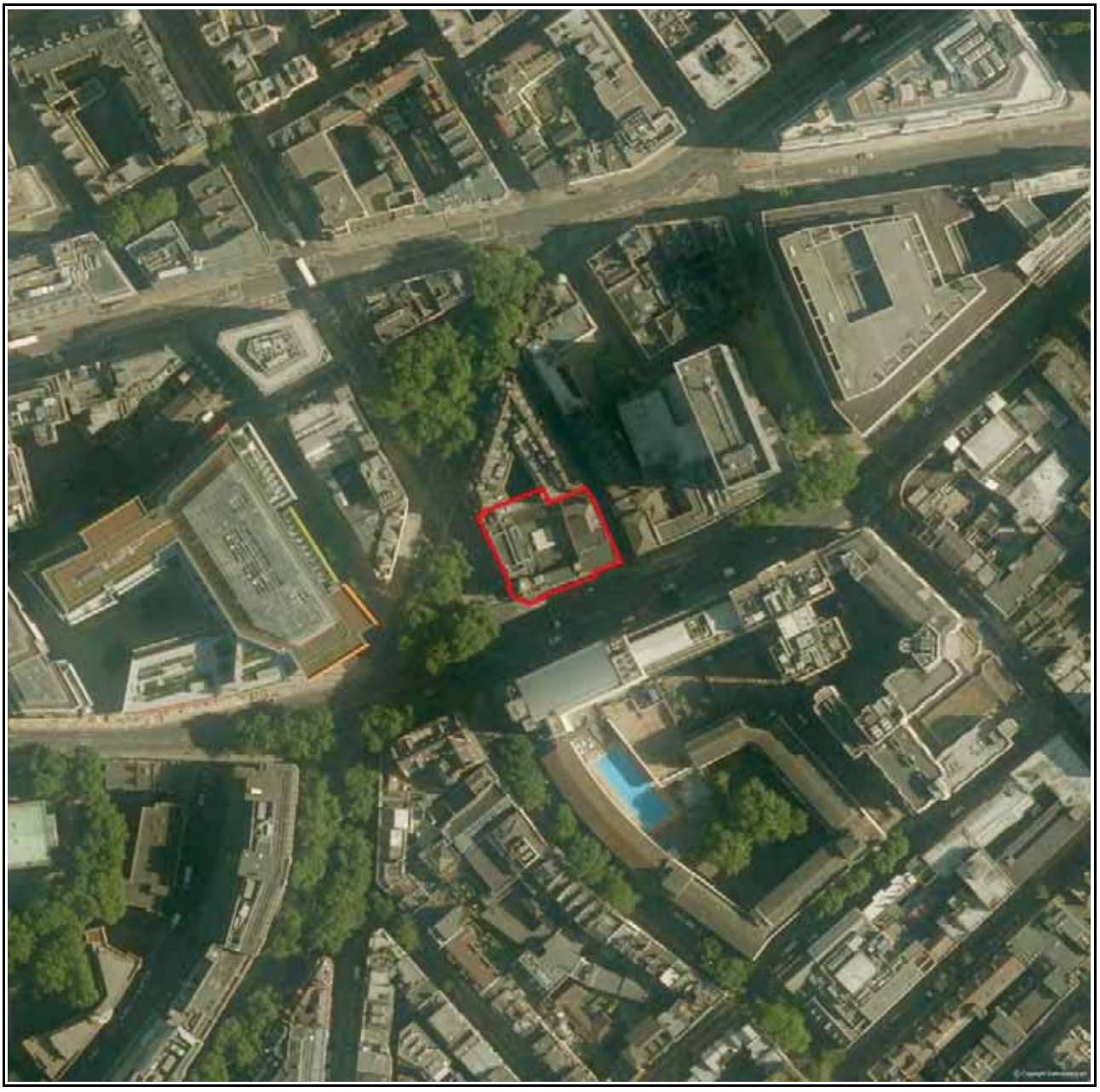
emapsite customer services team

Enc.
Groundsure Enviroinsight

Enviro Insight

Address:	**Shaftsbury Theatre, WC2H 8DP,**
Date:	**17 Oct 2017**
Reference:	**EMS-444986_596608**
Client:	**emapsite**

NW N NE



W E

SW S SE

Aerial Photograph Capture date:	07-Jun-2015
Grid Reference:	530136,181354
Site Size:	0.11ha

Report Reference: EMS-444986_596608
Client Reference: EMS_444986_596608