A14.2 – Geotechnical Desk Study (Mott MacDonald)

Geotechnical Desk Study

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London Underground

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Executive Summary

The proposed Bank Station Capacity Upgrade project is a significant infrastructure enhancement to the existing Bank-Monument Stations complex in the City of London. It comprises the construction of a new southbound platform tunnel and associated length of running tunnel to the Northern Line, and connecting passageways to the existing station tunnels as well as the provision of step-free access.

The purpose of this Geotechnical Desk Study report is to describe the salient aspects of the historic development of the site, summarise the ground investigations undertaken, review the ground and groundwater conditions and identify the ground related risks. Proposals for supplementary ground investigations to reduce project risks associated with uncertainties in the ground and groundwater conditions, for the design of the temporary and permanent works and the development of construction techniques, are also included.

The general ground and groundwater conditions across the site have been established from ground investigations undertaken for adjacent infrastructure and commercial developments as well as data obtained from the British Geological Survey. In broad terms, the ground conditions comprise Made Ground underlain by superficial deposits comprising Alluvium and River Terrace Deposits. These are underlain by the London Clay, which overlies at depth, the upper units of the Lambeth Group.

The historic development of the site, the ground and groundwater conditions present a number of challenges to the proposed works. Particular hazards are summarised as follows:

- Man-made buried structures – the presence of existing foundations, buildings founded on shallow footings and piled foundations within the zone of influence of the excavations, and tunnelling works;
- The potential for unexploded ordnance;
- River Terrace Deposits – local variations in the nature of these materials has a significant bearing on the type of ground improvement techniques that can be implemented and on the choice of construction techniques for underground works within these materials;
- London Clay – the potential for erosion features in the surface of the London Clay as well as ‘greasy backs’ at depth. The sub-divisions of the London Clay have different material properties, which, if well understood, can be particularly beneficial in rationalising the design of both the permanent and temporary works and for the assessment of building response to underground works.
- Groundwater control – dewatering can result in consolidation settlement of the Alluvium and to a lesser extent the River Terrace Deposits where cohesive materials are present.

Consequently, proposals for ground investigations are provided in order to reduce the project risks and facilitate detailed design of the temporary and permanent works. These proposals include:

- the formation of boreholes to verify strata thicknesses and elevations;
- detailed logging, high quality sampling, insitu and laboratory testing to facilitate informed decisions regarding more-cost effective design and more realistic ground movement predictions as well as appropriate ground improvement methods.

Recommendations for further work also include:

- The preparation of Geotechnical Design Guidance Notes which include preliminary geotechnical parameters, to facilitate the design of the proposed works;

- The anticipated ground movements due to tunnelling and shaft excavation should be evaluated and potential damage assessment of existing surface and sub-surface assets undertaken to determine which structures might be affected. The design should consider appropriate remedial works to mitigate foreseeable effects;

- As part of the potential damage assessment process and Transport and Works Act Order application Inspections for Assessment should be carried out as necessary.

1. Introduction

1.1 Scope

Mott MacDonald was commissioned by London Underground Limited in March 2011 to develop the design for the Bank Station Capacity Upgrade project. As part of this commission a comprehensive geotechnical desk study is to be completed to progress the works through RIBA Stage D Scheme Design. The proposed capacity upgrade involves the construction of a new southbound platform tunnel and associated length of running tunnel to the Northern Line, and connecting passageways to the existing station tunnels as well as the provision of step-free access.

This desk study report summarises the anticipated geological and hydrogeological conditions at the site through a review of the history of previous site use, published geological and hydrogeological records as well as archive site investigation data, and existing infrastructure within the vicinity including London Underground and the Docklands Light Railway tunnels, and Thames Water Utilities sewers and water mains. The report commences by summarising the historical development of the site before reviewing the existing infrastructure that may be a constraint on the site development. The desk study report then provides a general overview of the geology and hydrogeology of the site, including a discussion of the findings of the various ground investigations undertaken in the vicinity to date.

Geo-environmental issues associated with the potential for contamination of the materials to be encountered on site during the proposed works are being addressed separately and will be reported as part of the Environmental Impact Assessment (EIA) as will the waste strategy. The archaeological aspects of the site shall also be addressed in the EIA.

This report has been prepared as part of the Bank Station Capacity Upgrade project by MM for London Underground Limited. It is not intended for and should not be relied upon by any Third Party; no responsibility is undertaken to any Third Party. In preparing this report it has been assumed that the information obtained from previous investigations and studies is accurate and can be relied upon. Whilst MM has carefully reviewed the various information consulted in the preparation of this report, they cannot accept responsibility for any shortcomings that result from data deficiency (except in so far as such deficiencies should have been apparent to an experienced Engineer).

Unless indicated otherwise all levels quoted in this report are to LU Tunnel Datum (TD). Tunnel Datum is located 100m below Ordnance Datum.

1.2 Site Description

Bank Underground Station is located within a congested urban environment. As shown in Figure 1 the geographical focal point of the proposed Bank Station Capacity Upgrade scheme centres on King William Street which runs south towards the River Thames from the Scissors Crossing road junction of Poultry, Queen Victoria Street, Threadneedle Street and Cornhill, in the City of London (approximate grid reference TQ38SW). Buildings of note in the area include The Mansion House, the official residence of the Lord Mayor of London, and the Bank of England. Much of the remainder of the building stock in the area house financial institutions.

The Bank of England is visible at the northern end of King William Street and the Monument at its southern end. Buildings in the area are mainly in office use with shops, cafes, pubs and restaurants at ground level.

There is little open space in the area although there is a small paved square in front of the entrance to St Mary Abchurch in Abchurch Lane. There are very few trees in the immediate area of the site; the residential population in the City of London is small. Roads in the vicinity are very busy during the working week although much less so at weekends. This is also the case for pedestrian traffic.

An underground station has been present beneath King William Street since 1900; the Northern Line station at Bank opened in February 1900 with the completion of the City & South London Railway extension from Borough to Moorgate.

The adjacent underground station at Monument on the District and Circle Line was opened in 1884; the platforms were subsequently extended with access being provided to the Northern Line in 1933. Thus the Bank-Monument Station complex was formed. The station complex has been developed in a piecemeal manner as additional lines have been built and integrated into the system. The station complex reached its present form on completion of the Docklands Light Railway in the early 1990s when additional escalator access was provided to Bank Station.

The existing station complex occupies a large area under the City of London, stretching from Threadneedle Street in the north, Queen Victoria Street in the west, King William Street in the east and Eastcheap in the south. The station complex, which serves the City of London, is one of the busiest on the underground network with almost 41 million entries/exits in 2009. Six underground lines serve the station complex: the Central Line; the District & Circle Line; the Northern Line; the Waterloo and City Line, as well as the Docklands Light Railway, with a total of 10 platforms. As a result the station complex is a major interchange station as well as a destination.

The works to construct the Northern Line station represented the first incarnation of Bank Station in 1900. Ninety years later in 1991, the last addition to the interchange saw the arrival of the Docklands Light Railway. The DLR City Extension brought the DLR westwards from its previous terminus at Tower Gateway to the City of London at Bank.

The topography in this area of the City of London is relatively flat with a gentle downward slope north and south from the centre of King William Street; street level generally ranges from about 13m to about 16mAOD (113 to 116mTD). To the south of the Bank-Monument Station complex, the ground slopes down towards the River Thames, to approximately 5mAOD (105mTD). The approximate ground levels recorded on the main streets are as follows:

- Princes Street (Northern Limit): 12.8mAOD (112.8mTD);
- Queen Victoria Street/ Mansion House Street, Princes Street, Threadneedle Street, Cornhill and Lombard Street: 13.5mAOD (113.5mTD);
- King William Street: 15.7mAOD (115.7mTD);
- Cannon Street: 14.5mAOD (114.5mTD);
- Lower Thames Street (Southern Limit): 6.5mAOD (106.5mTD).

Main arterial streets of the City of London (Princess Street, Queen Victoria Street/ Mansion House Street, Princes Street, Threadneedle Street, Cornhill and Lombard Street, King William Street, Cannon Street, Arthur Street and Lower Thames Street) traverse the study area.

There are two bodies responsible for managing the public highways in the City of London. Transport for London (TfL) manages what are termed 'Red Routes' (i.e. the main roads, or Transport for London Road Network [TLRN]). The 'Red Routes' comprise around 15% of the streets in the City. Red Routes are marked by red lines on the carriageway. The following Red Route designated streets are in close proximity to the Study Area:

- Bishopsgate
- Gracechurch Street
- Queen Victoria Street (Blackfriars Bridge approach)
- Upper and Lower Thames Street
- Victoria Embankment

The second body is the City of London Corporation, which is the Highway Authority for the remainder of the streets in the 'Square Mile'. Both bodies have responsibility for planning street works on their respective streets.

1.3 Project Description

London Underground's Bank Station is located in the heart of the City of London financial district. As the main gateway to the City for employees and visitors alike, the station is of strategic importance to the UK's economy. As shown in Figure 1 Bank Station is also a strategic network interchange served by six underground lines (the Northern, Central, Waterloo & City, and the District and Circle at Monument, part of the same station complex), and the Docklands Light Railway, for which Bank is the major Central London terminus. The station has been developed in a piecemeal manner from 1900 onwards as additional lines have been built, reaching its present form in 1991 when the DLR opened. Most of the platforms are at deep level (i.e. a depth of 25m to 30m), and, therefore, are dependent upon escalators or lifts for passenger access and egress. The station has three ticket halls, ten platforms, 15 escalators, six lifts and two 300ft long moving walkways.

Bank Station was designed and built for passenger levels far less than those currently being catered for at the station. It is the fourth busiest station on the Underground network. To mitigate the need to implement severe station control measures to manage the forecasted increase in congestion there is a need to upgrade capacity at the station. The requirements of the Bank Station Capacity Upgrade project (LUSTN-0008798-SCH-000935) are:

- To increase the capacity at Bank Station, principally to the Northern Line and DLR areas as well as the associated interchange routes;
- To provide step-free route(s) to the Northern Line platforms from street and DLR levels, and an accepted means of escape for Persons with Reduced Mobility;

- To provide compliant emergency fire and evacuation protection measures for Northern Line /DLR passengers.

To deliver these objectives the core outputs of the project will include:

- A new Northern Line South Bound platform tunnel with associated sections of running tunnel. This will enable the existing South Bound platform tunnel to be used as a concourse tunnel for access to the North Bound platform thus improving passenger space and movement within the station complex;
- Cross passages between the existing Northern Line North Bound and new South Bound platform tunnels;
- Additional escalator and/or stair link(s) between the Northern Line and DLR;
- A new shaft with lifts providing access from street level to Northern Line platform level, and DLR step free access from Northern Line platform level;
- A new access route from Northern Line platform level to the Triplication;
- An additional interchange link between the Northern and Central Lines (feasibility TBC).

The proposed works will principally affect the Northern Line, with a significant interface with the Docklands Light Railway. Construction work is to take place from 10 King William Street, a site currently occupied by an existing structure; the site will require purchase and the structure demolished before the shaft can be constructed.

2. Sources of Information

The following sources of information were consulted during the preparation of this desk study:

External sources:

- British Geological Survey, 1998. 1:50 000 Series England and Wales Sheet 256 North London Solid and Drift Geology.
- British Geological Survey, 2004. Geology of London: Special Memoir for 1:50 000 Geological Sheets 256 (North London), 257 (Romford), 270 (South London) and 271 (Dartford) (England and Wales).
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- CIRIA R129, 1993. A Study of the Impact of Urbanisation on the Thames Gravels Aquifer.
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- Principal Inspection of King William Street Bridge, London. FaberMaunsell, October 2005.
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- Lee, C.E. (1970). Seventy years of the central. London Transport, 1970.
- Lee, C.E. (1968). 100 years of the district. London Transport, 1968.
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- Pearce, A., Hardy, B., and Stannard, C. (TBC). The Docklands Light Railway Official Handbook.

Internal sources/project documents:

- Bank Station Capacity Upgrade Project Requirements – LUSTN-0008798-SCH-000935.
- Bank Station Northern Line Upgrade RIBA Stage B Geotechnical Desk Study. Jacobs Engineering, October 2008.
- Bank Station Northern Line – Congestion Relief and Step Free Access Stage B Report. Jacobs Engineering, October 2008.
- Borehole records held within the Mott MacDonald 'DIGS' database, various dates.
- Bank Station Northern Line – Congestion Relief and Step Free Access, Stage B Report – Volume 2.
- Baseline Report - Archaeology - N133-BCR-MMD-00-Z-DC-N-0013-S0-0.1.
- Baseline Report – Built Heritage - N133-BCR-MMD-00-Z-DC-N-0010-S0-0.1.
- Baseline Report – Water Resources - N133-BCR-MMD-00-Z-DC-N-0007-S0-0.1.
- Ground Investigation Specification – N133-BCR-MMD-00-Z-DC-Y-0002-S2-0.1.
- Ground Investigation – Scope of works – LUSTN-0008798-DOC-000514 v1.0.
- Bank Station – Potential Damage Assessment Strategy Document – N133-BCR-MMD-00-Z-DC-Z-0041-S0-0.1.
- Bank Station - Phase 1 Potential Damage Assessment – LUSTN-0008798-DOC-000515.
- Bank Station - Preliminary Geotechnical Design Guidance Notes - N133-BCR-MMD-00-Z-DC-Z-0048-S0-0.1.
- X4503/194 – LUL Bank Station Services Surveys, Impact Study Report FINAL DRAFT, Thames Water Assets located within the immediate vicinity of LU's Proposed Works to Bank/Monument Station in Central London. Thames Water Utilities Limited, July 2010.
- Unexploded Ordnance Desk Study, Bank Station Capacity Upgrade. MACC International Limited, July 2011.

3. Site History

A chronological discussion of the most significant features of the historic development at the Bank site is outlined in the following paragraphs. The details are based on a review of the available historic maps and relevant information obtained from various other sources. Historic maps illustrating the urban development of the site are presented in the Envirocheck Report commissioned for the area as part of this project; salient extracts from this report are included in Appendix A. The following section is also based on information contained in the project document, Baseline Report – Archaeology (document no. N133-BCR-MMD-00-Z-DC-N-0013-S0-0.1).

The site is situated in the historic core of London, within the Roman city walls of *Londinium*, to the east of the Saxon burh of *Lundenburh* and located centrally within medieval London. As such the natural topography of the area has been obscured by centuries of development. Geological data surrounding the site indicates that it was originally situated on the side of the valley leading down to the Walbrook to the west and to the Thames to the south.

There is little evidence of prehistoric activity within a 150m radius of the site, although Palaeolithic activity is well-attested within the Thames Estuary river terrace gravels, particularly to the east of London, along the Essex and Kent shorelines. Evidence of later prehistoric activity, during the Mesolithic and Neolithic, periods has also been identified along the banks of the Thames.

Roman London (*Londinium*) was located at the tidal head of the River Thames and as such was ideally situated for the import and export of goods. By AD 60 *Londinium* covered around 30 acres of land, (Sheppard 1998). A layer of dark red burnt material dating to AD 60 found at many archaeological sites within the City of London is the result of the Boudiccan revolt. A large quay was constructed soon after the sacking of *Londinium* which was a driving force for the subsequent large-scale redevelopment of the rest of the city during the last two decades of the first century.

The area surrounding the site was located in the heart of the Roman town and the Governor's Palace, a Scheduled Monument, was located to south. A large excavation at No 1 Poultry, to the north-west of the site, revealed a Roman road, amongst other significant Roman artefacts, thought to have been the *Via Decumana*, which runs on a roughly west to east alignment and probably passes just to the north of No 10 King William Street.

A parallel road, running along Cannon Street and Watling Street was located to the south. The excavation of sewer trenches in various locations around the site during the 19th century revealed numerous Roman walls and *tesserae* pavements. Immediately adjacent to the site at 12-14 Nicholas Lane revealed Roman wall footings and fire destruction horizons. Towards the southern end of Nicholas Lane the quoin end of a rag, chalk and flint wall, around 2.13m thick, was revealed; the tops of the wall here were around 2.74m below the surface. Early 20th century repairs to the sewerage system along St Nicholas Lane revealed a Roman dwelling and a red tessellated pavement. Excavations to the east of the site at Clement's Lane revealed Roman occupation dating from the Neronian period and Roman quarry pits were identified at Nos. 3-7 King William Street.

The church of St Nicholas Acons, formerly located to the north of the site, was founded during the 9th Century indicating that the area surrounding the site was settled during the Saxon period. Several Late Saxon finds have been recorded within 150m of the site area, in particular sunken-floored buildings were

identified to the south of the site and a Ringerike style engraved bone pin was found in Abchurch Lane. Excavation evidence indicates that Lombard Street also had a Saxon predecessor.

Immediately after the Norman Conquest of 1066 William the Conqueror ordered the fortification of London which included reinforcing the old Roman walls and erecting replacement fortified towers, including the White Tower in the south-east corner of the city (in the location of the future Tower of London). The church of St Nicholas Acons was also rebuilt in 1084 for Malmesbury Abbey. Abchurch Lane was first noted in 1291 and was named for St Mary Abchurch, which is situated on the western side of the lane.

By the 16th century London had expanded outside of its town walls. The Great Fire of London (1666) destroyed much of the town situated within the walls. Indeed the church of St Nicholas Acons was razed to the ground and never rebuilt. Any structures standing on the proposed site at this time would have been affected by the Great Fire of London. Changes to the street pattern of the City subsequently took place in the 17th century following the Great Fire of London.

The area surrounding the site had been rebuilt by the start of the 18th century and remained relatively unaltered until the early 19th century when King William Street (named after the reigning monarch of the time, King William IV) was constructed as part of the Metropolitan Improvements scheme. The laying of sewers at this time identified, and disturbed, a large amount of archaeological evidence in the area immediately surrounding the proposed site area. The groundworks for the construction of King William Street also revealed various Roman features overlain by a deposit of dark earth and subsequently cut by medieval features.

The site altered little once this streetscape had been established. It should be noted that a number of alterations to the properties along King William Street make the early street numbering unreliable as an indicator for the use of the site, for example No. 10 King William Street is recorded at London Bridge in 1834 (National Record Archive), indicating that this property was located further to the south. Two wells dating to 1916 are recorded at the site by the British Geological Survey (NGR TQ 3279 8093). These are not shown on any of the early 20th century mapping but they date to the period during which the site underwent the slight alteration as described above.

The London Blitz started on the 7th September 1940. London was bombed every day or night from 7th September 1940 until 2nd November 1940. There are records of a bomb hitting St Mary Abchurch in September 1940. On the night of 10th January 1941 the Bank Underground station sustained a direct hit by a High Explosive bomb. The bomb detonated within the escalator machinery room with the blast travelling through the ticket hall. Such was the level of destruction that the figures given for the total number of fatalities in the incident vary from 50 to 117 (The most credible number is considered to be 56 deceased and 69 seriously injured.). The crater, measuring 37m x 30 m, was covered with a bailey bridge to enable traffic to pass over. Bank Station itself was closed for two months. By May of 1941 the worst of the blitz was over.

The records produced by London County Council (LCC) indicate that the bomb density for the area was over 600 bombs per 1,000 acres. Some of the bombs dropped failed to explode therefore there is a credible risk of encounter with unexploded ordnance (UXO) from intrusive activities such as ground investigation. During the post WWII period extensive works were carried out to remove UXO but not all were discovered. Hence a UXO desk study and detailed risk assessment, in accordance with CIRIA C681 “Unexploded Ordnance (UXO): A guide for the construction industry”, was commissioned as part of this geotechnical desk study. The findings of the desk study and threat assessment identified the UXO risk

level to be “Medium to High” with regards to the proposed ground investigations within the identified bomb penetration depth (8.0mbgl). A copy of the UXO desk study and detailed risk assessment will be included within the PCIP.

Other key dates in the development of the area include:

- The time of Henry VIII - No.10 King William Street was built-upon with at least seven separate two- and three-storey structures with a courtyard in the centre. It is probable that these buildings represent a mixture of residential and commercial properties, fronting onto both Abchurch and St Nicholas Lanes.

- 1682 - The layout of the site has altered slightly. Several small possible structures are depicted within the interior of the plot bounded by Abchurch Lane and St Nicholas Lane; there is a lack of structures shown along the street frontages. Otherwise no significant changes evident.

- 1755 - Several courtyards are evident located within the plot of land bounded by Abchurch Lane and St Nicholas Lane. St Nicholas Church is shown to the north of “St Nicholas Ally”. Otherwise no significant changes evident.

- 1829-1835 - The site changes little until the creation of King William Street.

- 1855 - The London Bridge Sewer (Trunk Sewer) has been built and is located beneath Princes and King William Streets. Otherwise no significant changes evident.

- 1878-1880 - Several parallel, terraced and back-to-back structures, one of which is a bank at the north-western corner, evident at 10 King William Street. Otherwise no significant changes evident.

- 1884 - Monument Station of the District & Circle Line opened. Otherwise no significant changes evident.

- 1890 – The City and South London Railway (C&SLR) opened on 18 December 1890. King William Street was the original but short-lived northern terminus of the C&SLR, the first deep tube underground railway in London and one of the component parts of the Northern Line. It was located on King William Street/ Arthur Street, just south of the present Monument Station. Otherwise no significant changes evident.

- 1898 - The ‘City’ Station of the Waterloo & City Railway (W&C) opened on 8 August 1898. It was built by the London and South Western Railway Company (L&SWR) to link its terminus at Waterloo to the City. The station platforms are located under Queen Victoria Street, close to The Mansion House. Otherwise no significant changes evident.

- 1900 – (The) Bank (of England) Station opened; it is served by the Northern, Central and Waterloo & City Lines. The Central London Railway (now the Central Line) opened in July 1900. The King William Street terminus of the C&SLR closed. Otherwise no significant changes evident.

- 1907 - The two low level (Main Line) sewers have been built and are located in Goswell Street and Cannon Street. Otherwise no significant changes evident.

- 1916-1920 - The layout has changed little; a large bank has subsumed the majority of the original properties, with the exception of two separate properties at the north-west of the site, at the corner with Abchurch Lane. Otherwise no significant changes evident.

- 1932 - The London Bridge Sewer (Trunk Sewer) has been diverted. Otherwise no significant changes evident.

- 1933 – Monument and Bank Stations linked thus forming the Bank-Monument Station complex. Otherwise no significant changes evident.

- 1991 - The Docklands Light Railway extension opened on 29 July 1991. Otherwise no significant changes evident.

The area is highly permeable, especially for pedestrians; there is a network of alleys and lanes (often closed to through traffic), which provide short cuts to different areas of the City. Legibility is also good, with the landmarks of the Monument and the Bank of England at either end of King William Street, the spire of St Mary Abchurch and the distinctive architecture of the north-west front of St Mary Woolnoth. King William Street is heavily used by vehicles, particularly buses, taxis and goods vehicles. It links the City with South London via London Bridge and the north via the A10 which starts in Gracechurch Street.

The side streets in the area are much quieter and many are one-way. There is a high population in the area during working hours and the streets are generally busy in the rush hour and at lunchtime. At the weekend the area is quieter, though pubs and clubs are often busy in the evenings. City workers mainly arrive in the area by public transport or bike (there are cycle lanes on both sides of King William Street); private car use is relatively low. Tourists and school groups also visit the area to see the Monument, the Bank of England, the 17th century churches and the Mansion House. There is frequent construction work in progress in the area with demolition, rebuilding and refurbishment of buildings and consequently the area is not tranquil.

4. Existing Infrastructure

A brief summary of the existing infrastructure within the vicinity of the Bank Station Capacity Upgrade project site is presented in the following sections. Both the surface and sub-surface infrastructure that may interface with the proposed works are discussed. Details of the locations of the structures in relation to the proposed works are shown in Figures 1 and 2.

The construction of the tunnels, cross passages, escalator barrels and access shaft at Bank will inevitably result in excavation-induced ground movements. The magnitude of these movements will be dependent upon a number of factors including the ground and groundwater conditions, the construction methods and the quality of workmanship employed as well as the level of supervision provided. Existing surface buildings, sub-surface structures and services/utilities in the vicinity are all likely to be affected to a greater or lesser extent by the construction of these works.

Phase 1 of the PDA process has been carried out for the proposed works in the area; the settlement contours thus produced identify, in the first instance, the number of structures within the anticipated zone of influence attributable to excavation-induced ground movement. This zone of influence is usually defined as the 1mm greenfield ground surface settlement contour. A greenfield assessment ignores any positive contribution made by existing structures, both surface and sub-surface, in mitigating the effect of excavation-induced ground movement. Structures outwith the 1mm settlement contour are usually not considered further. Generalised criteria, for example a minimum settlement of 10mm or a slope of 1:500 (Rankin 1988), are then applied to eliminate structures from further consideration in Phase 2 of the PDA process.

Phases 2 and 3 of the Potential Damage Assessment process are to be completed during RIBA Stage D. As part of this process potential damage categories (Burland et al, 1977) are assigned. For Non-listed buildings, if the damage classification indicates that there is the potential for the structure to sustain Category 2 (Slight) damage, or below, no further action is necessary and the assessment process concluded. Where there is the potential for Category 3 (Moderate) damage or worse to be sustained as a result of the excavation-induced ground movements, a Phase 3 assessment, possibly involving sophisticated numerical analysis techniques, will be required. Listed buildings if not eliminated at Phase 1, are automatically referred for Phase 3 level assessment. Building inspections and surveys shall be required to inform these various assessments.

A document outlining the strategy to be adopted in the assessment of the impact of the proposed works on the affected existing assets has been issued (document no. N133-BCR-MMD-00-Z-DC-N-0041-S0-0.1).

4.1 Buildings

The proposed Bank Station Capacity Upgrade works are located beneath and adjacent to a number of buildings, including the Grade I Listed Buildings ‘The Mansion House’ and ‘The Bank of England’. Tables, and the related location plan, summarising the buildings that may be affected by the proposed works are presented in Appendix B. Individual gazetteers have been prepared for those Listed Buildings that are likely to be affected by the proposed works; these gazetteers are included in Appendix B, extracted from the Bank Station Capacity Upgrade project document, ‘Baseline Report – Built Heritage’ (document no. N133-BCR-MMD-00-Z-DC-N-0010-S0-0.1).

Inspections/surveys of those buildings anticipated to be within the zone of influence of the proposed underground works are currently in progress as is a desktop review to ascertain likely foundation type.

Listed buildings in the UK are given one of three grades as described below:

- Grade I buildings are of exceptional interest, sometimes considered to be internationally important. Just 2.5% of listed buildings are classified as Grade I.
- Grade II* buildings are particularly important buildings of more than special interest. 5.5% of listed buildings are classified as Grade II*.
- Grade II buildings are nationally important and of special interest. The vast majority (92%) of all listed buildings are in this class.

There is one Scheduled Ancient Monument (SAM) within the anticipated zone of influence of the proposed underground works, the site of the Roman Governors Palace. The Monument (also a SAM) although not located within the anticipated zone of influence of the proposed underground works it is in close proximity to the site and the impact on this structure will require consideration.

There are 18 conservation areas (designated for their architectural and historic interest and special character and appearance) in the City of London. The proposed works are located within the Bank Conservation area, which covers the area north of Canon Street.

4.2 Transport Infrastructure

The scheme is located adjacent to a number of underground railway lines of both the London Underground (Central, District & Circle, Northern and Waterloo & City lines) and the Docklands Light Railway networks. In addition the disused City and South London Line is present beneath Arthur Street in the southern part of the project site. The general locations of the existing sub-surface railways are shown in Figure 1 in relation to the proposed works. Details of the sub-surface railways in the vicinity including available plans and sections are included within the Health, Safety and Environment Pre-Construction Information Pack (PCIP); the following sub-sections should be read in conjunction with the civil and structural drawings included in the PCIP for these existing assets.

The London Underground Streets with 'Special Engineering Difficulties' (SED) drawings for the Bank area are included in Appendix C. These plans show the extent of the existing underground railway network in the area. Under Section 63 of the New Roads and Street Works Act (NRSWA) the term SED relates to streets or parts of streets associated with structures, or streets of extraordinary construction, where works must be carefully planned and executed to avoid damage to, or failure of, the street itself or the associated structure, with attendant danger to person or property. In accordance with Schedule 4 to the NRSWA, proposed street works must be approved by the each authority with an interest in the structure concerned, i.e. the street authority, and/or the sewer, transport or bridge authority. The designation of streets with SED should be used only where strictly necessary; circumstances where designation may be appropriate include:

Subways and tunnels at shallow depth: areas immediately above subways and tunnels and adjacent areas may be designated.

Reference should be made to the supplementary references given on these drawings during the subsequent phases of the design process. Additionally, reference will be required to the corresponding set of drawings for the highway infrastructure produced by TfL Streets and the City of London.

4.2.1 Northern Line

The Northern Line station at Bank opened in February 1900 with the completion of the City & South London Railway Extension from Borough to Moorgate. Access to the station was by lift via a subsurface ticket hall in the crypt of St Mary Woolnoth church on the corner of Lombard Street. These lifts are still in use today. Construction of the station required extensive underpinning of St Mary Woolnoth, a Grade I listed building which dates from 1716. Interchange with the Central Line was via an 11' 6" (3.5 m) cast iron lined passage (now referred to as the Low Level Interchange Passage, LLIP).

The platform area consists of two (North and Southbound) segmentally-lined cast iron tunnels approximately 106m long at a depth of about 30 metres below existing ground level. The two platform tunnels are linked at various positions along their length by cross passages (8No.) of varying size. Entry to and egress from the platforms are facilitated by stairways leading to the Northern Line Lower Concourse at the northern ends of the platform tunnels and a bank of two escalators to the District and Circle Line platform tunnels at the southern ends of these platform tunnels.

Historic drawings indicate that the original 21'2½" (approximately 6.46 m) cast iron platforms were shorter than the present 106m length with six 4'6" (approximately 1.37m) openings between the two tunnels and two 25' (approximately 7.62m) shield chambers at the northern end of the platform tunnels. It is understood that the running tunnels were enlarged with the platforms extended to their current length. In 1933 the escalator link to Monument Station was opened with two additional 7'6" (approximately 2.29m) cross passages created at the southern end of the platform tunnels. Subsequently the access passages to the lift shaft and Central Line interchange passage were modified, enlarging a portion of the concrete square works with cast iron rings.

Later, floodgates and cable tunnels were added to the running tunnels south of Bank Station, although drawings provide no date information. A watertight door was also installed in the Central Line interchange passage; this appears to have been undertaken circa 1953.

During construction of the DLR in the late 1980s an 1800mm wide cross passage was installed at the northern end of the platform tunnels, between the 25' (7.62m) shield chamber of the northbound platform tunnel and the 21'2½" (6.46 m) southbound platform tunnel. Modification was also carried out to the Central Line interchange passage with a section of the original lining encircled and replaced by 37 No. 7.5m I.D. SGI rings, with three tunnels providing interchange with the DLR. This section is now known as the Triplication.

In addition, at the southern ends of the platform tunnels there are two sets of stairs situated between the platform tunnels that lead down to the Docklands Light Railway (DLR). They have been constructed using steel beams and columns encased in concrete (Square work). At platform level the DLR stair structure encroaches on to the platform area. During the construction of these staircases part of the platform tunnel lining was demolished and steel 'C' frames installed. These frames are designed to support the tunnel lining and provide space for the staircase. In the areas where the 'C' fames have been installed the Northern Line platform width has been reduced to approximately 2.7m.

The escalator link to the District and Circle Line consists of a 5.7m ID segmentally-lined cast iron tunnel with a 6.7m wide oval shaped segmentally-lined cast Iron Lower Machine Chamber at the junction with the platform tunnel and a 7.5m ID segmentally-lined cast iron Upper Machine Chamber.

The stair link to the Northern Line Lower Concourse consists of a set of two staircases, one from each platform tunnel. These staircases provide access to the Central Line and to the Northern Line Ticket Hall via the lifts situated adjacent to the Northern Line Lower Concourse. Each staircase is 2.5m wide and is divided by a central handrail. The stairway is constructed of a central concrete wall and concrete arches above and below. Side walls are made up of steel columns encased in concrete.

The Northern Line Lower Concourse Tunnel consists of a 6.46m I.D. segmentally-lined cast iron tunnel which links the stairways from the Northern Line platform tunnels with the passageway link to the Central Line platform tunnel. Running parallel to the Lower Concourse is a segmentally-lined cast iron tunnel which links the escalator from the DLR to the escalator that connects to the cruciform. The two tunnels are linked by three 3.0m wide passageways. This area is known as the triplication. The lift shaft from the DLR links into passageway.

Passageways off the Lower Concourse Tunnel lead to a lift shaft. The lift shaft contains 4 No. 72 person through lifts i.e. entry and exit through type opposing side lifts. These lifts service the Northern Line Ticket Hall.

In 1994 the direct stair link to the DLR was opened. The stairs are 1760mm wide and accessed via two cross passages, construction took place mostly in engineering hours and required extensive rebuilding of the southern end of the platform tunnels. One of the cross passages built in 1933 was modified to provide access with another 2325mm wide cross passage serving as the other northern access.

4.2.2 Station Operations

Bank Station suffers from significant congestion which is caused by heavy morning egress and interchange flows, and heavy evening access and interchange flows, along with conflicting interchange, access and egress routes. In addition, and with the exception of the DLR, there is no step free access for mobility impaired passengers to the platforms from street level; access to the DLR platforms is via 3 separate lifts.

Entrance and egress from the northern ends of the Northern Line platform tunnels is provided by two sets of stairs, one serving the Northbound platform and the other the Southbound. These stairways have a limited width and are significantly smaller than required to handle the volume of passengers that pass through. During peak times queuing occurs resulting in passengers not clearing the platform by the time the next train has arrived at the station which in turn can result in the temporary closure of the platform.

Vertical interchange capacity between the DLR and the Northern Line is insufficient for the volume of passengers. The stairs leading from the centre of the Northern Line platform tunnels down to the DLR can be heavily congested, causing queuing on the central areas of the Northern Line platforms.

The escalators leading up from the DLR to the Triplication area are also at capacity, and large numbers of passengers are forced to queue for 20m or more to access this escalator. With the future introduction of DLR three car trains, this situation will worsen and an alternative vertical interchange and exit route is needed in order to cater for the increased demand. It is anticipated that these congestion problems will

worsen as demand increases in line with the London Plan 1 and as commercial developments are realised within the area.

The current means of escape from the Northern Line platforms is through the Bank or Monument area of the station via the triplication area or escalators respectively. At present there are no protected zones and the agreed target between LU and the emergency services for complete station evacuation is 15 minutes.

4.2.3 City and South London Railway

Figure 3 shows extracts relating to the construction of the first phase of the City and South London Railway to its City terminus, located below King William Street near the Monument at a depth of about 70 feet (about 21.3m) below the surface. The two cast-ironed lined tunnels run one above the other along Arthur Street and Swan Lane to the River Thames, the tunnels have internal diameters of 10 feet and 2 inches (i.e. approximately 3.1m). These tunnels are disused bar for electrical services.

For further details of the construction of the City and South London Railway at London Bridge reference should be made to the paper by Greathead (1895).

4.2.4 Waterloo & City Line

The 'City' Station of the Waterloo & City Railway (W&C) opened on 8 August 1898; the two platform tunnels are about 59 feet (i.e. approximately 18m) below the existing ground level. The station platforms (platforms 7 and 8) are located under Queen Victoria Street, close to The Mansion House. The station was built by the London and South Western Railway Company (L&SWR) to link its terminus at Waterloo to the City; it is connected directly to the Central Line Ticket Hall by an escalator passageway.

It is connected directly to the Central Line Ticket Hall by an escalator passageway. Another passageway connects the W&C Line to the Northern Line Lower Concourse. This underground asset has been subject to modification throughout the life of the underground railway and additional access is currently proposed as part of the Walbrook Square development.

For further details of the construction of the Waterloo & City Line reference should be made to the paper by Dalrymple-Hay (1899).

4.2.5 District & Circle Line

The station at Monument opened in 1884. The platforms were subsequently extended with access to the Northern Line being provided in 1933. On completion of the DLR City Extension in the early 1990s additional escalator access was provided to Bank Station.

The District & Circle Line Ticket Hall has three different entrances around "The Monument"; it has links to the Northern Line and DLR as well as the District & Circle Line platforms. The District & Circle Line platforms (Nos. 1 & 2) are approximately 8.2m below existing ground level.

4.2.6 Central Line

The Central London Railway (now the Central Line) opened in July 1900. As shown in Figure 4 the Central Line platform area consists of two approximately 120m long, 21'2½" (approximately 6.5m) I.D. segmentally

lined cast iron platform tunnels (3/265 and 3/266) running East to West on a tight radius bend. At the eastern end of the platform area the eastbound and westbound platform tunnels have been enlarged to 25' (approximately 7.6m) I.D. and 23' 2¼" (approximately 7.1m) I.D. respectively. A 25' (approximately 7.6m) I.D. shield chamber is located at the eastern end of each platform tunnel.

Originally served by 5 lifts each in a 20' (approximately 6.1m) I.D. shaft and an 18' (approximately 5.5m) I.D. spiral stair shaft, the station was soon modified by the addition of a triple escalator barrel. This barrel severed the link passage with the Northern Line and resulted in the complete demolition of one of the shafts, partial demolition of two more and capping off at ticket hall level of the other two and the stair shaft. The Northern Line interchange was provided by fitting one of the abandoned lift shafts with a spiral stair case.

Other major structural work carried out included the extension of the platforms westwards in 1934, the fitting out of another shaft with a spiral stair and link to the Northern Line interchange passage in 1972 and the provision of direct access to the DLR in 1991.

Access to the Central Line platform area is gained via a number of routes. At the eastern end an escalator shaft containing a set of three escalators (escalators 1, 2, 3) connects the platform area to the Central Line Ticket Hall. Five 20' ID (approximately 6.1m) disused lift shafts and an 18' ID (approximately 5.5m) disused spiral staircase are located between the two platform areas. Currently two of the lift shafts (3/206 and 3/207) are open to passengers and contain spiral staircases which link to the Northern Line Lower Concourse. At the western end of the platforms, a stairway (3/607) has been constructed from the Central Line cross passage 3/209 to link in with the cruciform area. This stairway passes through an old lift shaft (3/782) above a transformer room.

4.2.7 Docklands Light Railway

The Docklands Light Railway tunnelled extension to Bank opened in 1991. The platforms are 95m long, with 7.0m internal diameter bolted segmental concrete linings; there is also a central 5.0m internal diameter concourse tunnel. There is approximately three metres between the crown of the DLR and invert of the Northern Line tunnels (extrados to extrados). The two platform tunnels are linked to the Central Concourse tunnel at various positions along their length by 3 cross passages which are each approximately 3m wide. Other short adits have been constructed linking the platform tunnels with the Central Concourse tunnel. These adits contain toilets and locker rooms for staff, traffic rooms and switch rooms. Escalator barrels connect the concourse tunnel to the Bank and Monument stations.

4.2.8 Highway and Pedestrian Infrastructure

4.2.8.1 King William Street Bridge

King William Street Bridge, which spans over Upper and Lower Thames Street, is a continuation to the north of London Bridge; it carries the A3 over Lower Thames Street and is owned by Bridgehouse Estates. The structure, completed in 1973, comprises a 27.620m single span simply-supported deck made up of 33 pre-stressed, pre-cast beams at one metre centres; these are finished with a reinforced concrete in-situ topping. The beams sit on elastomeric bearings. The bridge's parapet is formed of decorative pre-cast concrete units. The reinforced concrete abutments to the bridge are approximately 4.6m high and about 33m wide with a concrete cladding, both of the abutments are supported on reinforced concrete piled foundations.

The Northern Approach to King William Street Bridge spans between the main bridge and King William Street. This structure, also completed in 1973, consists of two spans: the first span consists of a simply-supported reinforced concrete deck supported to the south on the northern reinforced concrete abutment to King William Street Bridge and to the north supported by a reinforced concrete retaining wall; the second span consists of a reinforced concrete slab supported on two brick arches. The abutment to the King William Street Bridge has a piled foundation while the retaining wall and brick arch vaults are supported by a raft foundation. The structure's bearings comprise rubber pads.

Within the Northern Approach structure there are three rooms used as storage areas by the Corporation of the City of London.

A Principal Inspection of King William Street Bridge was carried out in 2005 (Faber Maunsell, 2005) as was a Principal Inspection of the Northern Approach to King William Street Bridge; a General Inspection of the bridge was undertaken in 2009 (Faber Maunsell, 2009). The Principal Inspection of King William Street Bridge concluded that the bridge was generally in a good condition structurally; some defects were recorded in isolated areas. The inspection noted on the basis of the defects to the bridge parapets that the structure had been subject to movement in the past; some parapet panels were now out of alignment. The parapets were considered to be in poor condition with areas of spalled concrete, cracking and other signs of movement. It was recommended that the parapets should be refurbished at the earliest opportunity. Water leakage was also noted at the bridge abutments.

The subsequent General Inspection of King William Street Bridge concluded that the waterproofing was the cause of most of the defects in the structure and should be repaired. It was also concluded that the parapets required complete refurbishment to ensure that they are safe and durable.

The Principal Inspection of the Northern Approach structure concluded that the structure was generally in reasonable condition; defects were noted in a number of isolated areas. Leakage was noted throughout the structure. The subsequent inspection report recommended that measures be taken to tackle the problems evident with drainage and leakage.

Maintenance responsibility for these structures is understood to rest with the Corporation of the City of London. This asset is due another Principal Inspection in the near future; the Bank Station Capacity Upgrade project team should liaise with the City of London as this Principal Inspection could also serve as the Inspection for Assessment for this existing asset as part of the potential damage assessment process and Transport and Works Act Order application.

4.2.8.2 King William Street Underpass

King William Street Underpass was completed in 1935 and is still in use today providing safe pedestrian access to both sides of King William Street. It is a reinforced concrete box type structure at shallow depth. No historic inspections have been made available for this structure to date. An Inspection for Assessment will be required as part of the potential damage assessment process and Transport and Works Act Order application.

4.3 Utilities

Buried services are anticipated within the near surface zones of the scheme, particularly below the public highways. Under the New Roads and Street Works Act 1991, initial C2 Enquiries were carried out by

Jacobs Engineering in 2008/2009 as part of the RIBA Stage B commission. More recent C2 enquiries have been made by Mott MacDonald Limited as part of the RIBA Stage C+/D commissions.

Indicative combined utilities plans have been prepared and are included as Appendix D to this desk study; the plans are also included in the project Health, Safety and Environment Pre-Construction Information Pack (PCIP). The information in these plans is a combination of the most recent utilities information available at the time this document was prepared in addition to the older information (2008/2009) compiled previously. The combined utilities plans indicate that there are water, sewer, electrical, gas and considerable communications services/utilities in the study area. In particular the following significant services/utilities have been identified:

- Thames Water Utilities Limited infrastructure:
  - London Bridge Sewer (Trunk Sewer) - located beneath Princes and King William Streets;
  - Low Level (Main Line) Sewer No.1 - located in Cannon Street;
  - Low Level (Main Line) Sewer No.2 - located in Goswell Street;
  - Various water mains - located beneath the main roads and streets in the study area;
- National Grid Gas – a significant network of gas mains is present throughout the study area;
- BT Openreach – a large network of ducts and cables is present throughout the study area;
- Transport for London (signals and telecoms cables throughout the scheme area);
- EDF Energy (power supply cables throughout the scheme area);
- THUS Limited, 51 Degrees and Interoute, Global Crossing, FiberNet Network Solutions, euNetworks Group Limited, Easynet Global Services, Verizon, Level (3) Communications, Colt Technology Services Group Limited, Virgin Media, Cable and Wireless Worldwide plc, Abovenet (significant network of communications ducts and cables throughout the scheme area).

Details of buried services including available utility plans will be included within the Health, Safety and Environment PCIP. A comprehensive utilities survey in addition to consultation with utilities stakeholders will be necessary prior to any works being carried out.

An assessment of the impact of the excavation-induced ground movements on these utilities shall be carried out as part of the asset protection process associated with the Bank Station Capacity Upgrade project.

4.3.1 TWUL Sewers

As shown in Figure 1 there are two deep level sewers and one trunk sewer in the study area, which could have a significant effect on the design of the proposed works. London Bridge Sewer (the trunk sewer) is located beneath Princes and King William Streets and is believed to have been built circa 1855, in brickwork/vitrified clayware, and is of egg-shaped construction, except for one, 100m section which was diverted in 1932, and built as a circular cast iron pipe, to enable the construction of the nearby railway

subways. The Trunk Sewer serves as a combined sewer, draining both foul and surface water flows. The sewer ranges in size from 2286mm x 2210mm, to 3048mm x 2438mm, and is classed as a 'man-entry' sewer. There is insufficient information available to establish the exact depth of the sewer, but there are indications to suggest the sewer may be up to 8.5m below existing ground level. There are also suggestions that Fibre Optic cables have been installed in some sections of the sewer.

The two low level (Main Line) sewers located in Goswell Street and Cannon Street are believed to have been built in 1907, in brick, cast iron and vitrified clayware, with sizes ranging from 305mm to 2667mm in diameter, and 1219mm x 787mm (egg-shaped). There is insufficient data currently available to report accurate sewer invert levels.

4.3.2 TWUL Water Mains

The water distribution mains in the study area generally range from 100mm to 250mm in diameter, and serve the Crouch Hill Water Pressure Zone; four water mains run down King William Street. The two trunk water mains identified in the study area are 600mm diameter, ductile iron and 304mm diameter cast iron. The specific depths of the mains are unknown at this stage, but, in general, are likely to be shallow, i.e. less than 2m below existing ground level. The locations of the various water mains are shown in the various drawings included in Appendix D.

The material types of the water mains are not currently known; steel or PE water mains will be less susceptible the effects of excavation-induced ground movements than cast iron water mains.

4.3.3 National Grid Gas

National Grid Gas has a significant network of gas mains throughout the study area. The record drawings provided indicate that all the mains in the immediate vicinity of Bank Station are in PE. There is a single 355mm diameter gas main running down King William Street with smaller mains linking into it from the adjacent side roads.

4.3.4 BT Openreach

BT have a large network of cables and ducts throughout the study area as does EdF. There are 4 duct routes, totalling 75 cables/ducts running down King William Street, which carry a mixture of copper and fibre optic cables. Some of the multi-way ducts are in box section tunnel and will be embedded in concrete. There are also many duct routes in the adjacent side roads which link to those in the main road.

5. Previous Investigations

5.1 British Geological Survey Records

Borehole records for the area around Bank Underground Station have been obtained from the British Geological Survey. While many of the logs have poor material descriptions and were produced before current logging techniques were developed, they do provide a general indication of the ground conditions and the strata boundaries.

The existing available exploratory hole record sheets are summarised in Appendix E; an assessment of the quality of the borehole logs is included in this summary.

5.2 Mott MacDonald Borehole Records

Mott MacDonald maintains an in-house database of borehole records, the 'DIGS' database, from previous historic ground investigations. This database has been interrogated to provide amongst other things additional information on the surface of the London Clay in the vicinity of Bank Station.

5.3 Site-specific Ground Investigations

Several ground investigations and surveys have been undertaken within the vicinity of the Bank Station site. These are summarised in Table 5.1 and briefly discussed below.

Table 5.1: Summary of Ground Investigations in the Study Area

Scheme	Location	Contractor	Max depth of investigation	Date
One Lothbury Development	One Lothbury	Concept Site Investigations	46m below existing ground level	2006
Redevelopment of 81 King William Street	King William Street/ Nicholas Lane	Wembley Laboratories Limited	43m below existing basement level	1982
Redevelopment of 10 King William Street	10 King William Street	Wimpey Laboratories Limited	50m below existing ground level	1974
The Walbrook Development	Walbrook/Canon Street/St Swithin's Lane	Fugro Engineering Services Limited	82.3m below existing ground level	2006
N M Rothschild Bank	New Court and Nos 1-10 St Swithin's Lane	Norwest Holst Soil Engineering Limited	52.3m below existing ground level	2007
The Walbrook Square Development	Walbrook Square	Soiltechnics	50m below existing ground level	2007

5.3.1 One Lothbury Development

It is understood that a ground investigation was carried out by Concept Site Investigations in 2006 for the property developer Welbeck Land. The scope of the investigation included the sinking of three cable percussion boreholes to a maximum depth of 46m below existing ground level and the completion of static cone penetration testing to a maximum depth of 20 below existing ground level. Instrumentation,

standpipes/piezometers/gas monitoring wells, was installed in a number of the exploratory holes to obtain data on the prevailing groundwater conditions at the site. The associated laboratory testing comprised a standard suite of soils and chemical tests.

The Factual Ground Investigation report for this work has not yet been obtained by the project; efforts are continuing in this regard.

5.3.2 Redevelopment of 81 King William Street (1982)

A site investigation was undertaken by Wembley Laboratories in 1982 for Messrs Swires to provide information for the redevelopment of the site at 81 King William Street. The scope of the investigation included the sinking of four cable tool boreholes within the basement of the existing building and laboratory testing comprising a suite of general classification tests as well as strength and consolidation testing. Chemical testing was also undertaken as part of the site investigation.

5.3.3 10 King William Street (1974)

A ground investigation was undertaken by Wimpey Laboratories in 1974 to provide information for the redevelopment of 10 King William Street, the site of the proposed shaft of the Bank Station Capacity Upgrade project. The scope of the investigation included the sinking of three cable tool boreholes to depths of between approximately 20m and 50m below existing ground level within the footprint of the site; standard insitu penetration resistance testing was undertaken in these boreholes. At present it is not known what laboratory testing was undertaken as part of the ground investigation.

5.3.4 The Walbrook Development (TBC)

Fugro Engineering Services Limited undertook two ground investigations within the footprint of this development: a main ground investigation and an additional ground investigation. The fieldworks included the sinking of three cable percussion boreholes with rotary follow-on to a maximum depth of approximately 82.3m below existing ground level. Instrumentation including gas monitoring standpipes and vibrating wire piezometers, was installed in the boreholes. Routine insitu testing and sampling was undertaken during the formation of the boreholes. The subsequent laboratory testing comprised conventional classification and strength testing as well as chemical testing of the samples recovered.

5.3.5 NM Rothschild Bank (2007)

A site investigation was undertaken by Norwest Holst Soil Engineering in 2007 for Messrs Stanhope Plc to provide information for the redevelopment of the site at New Court/Nos 1-10 St Swithin's Lane in the City of London. The scope of the investigation included the sinking of one cable percussion borehole to a depth in excess of 52m below existing ground level and laboratory testing comprising a suite of general classification tests as well as routine strength testing. Chemical testing was also undertaken as part of the site investigation.

5.3.6 Walbrook Square (2007)

A ground investigation was undertaken by Soiltechnics in 2007 to provide information for the redevelopment of this site at Walbrook Square. The scope of the investigation included the sinking of four cable tool boreholes to depths of between 12m and 50m below existing ground level within the footprint of

the site; standard insitu penetration resistance testing was undertaken in these boreholes. The corresponding laboratory testing comprised a suite of general classification tests as well as routine strength testing..

Shallower investigations (not reproduced here) have also been undertaken at The Mansion House to determine details of the foundations to this prestigious building.

5.3.7 Wells

The presence of wells within the study area has been identified from the available historic information. Two wells have been identified in the footprint of 10 King William Street; Well 'A' dates from 1916 whilst Well 'B' dates from 1925. Both wells penetrate the chalk. The wells are likely to have been associated with water abstraction.

6. Geology and Ground Conditions

6.1 General

The geological sequence at the site as shown on the 1 : 50 000 geological map Sheet 256 North London indicates that the ground conditions comprise Superficial Deposits (Alluvium and River Terrace Deposits) underlain by the London Clay Formation which in turn overlies the Lambeth Group. Made Ground is present overlying the Superficial Deposits. An extract from Sheet 256 which includes the study area is presented in Figure 5.

A summary of the ground conditions based on the investigations undertaken in the area generally are presented in Table 6.1. These investigations confirmed the sequence of materials shown on the geological map as well as identifying a layer of Made Ground covering the Superficial Deposits. The table also summarises the elevations of the various interfaces between the different materials and the anticipated strata thicknesses.

Geotechnical parameters for preliminary design are included in the document titled 'Bank Station - Geotechnical Design Guidance Notes' (document no. N133-BCR-MMD-00-Z-DC-Z-0048-S0-0.1) together with outline geotechnical design guidance for the main underground structures of the scheme.

Table 6.1: Summary of Ground Conditions in the Study Area

Material	Surface elevation (mTD)			Base elevation (mTD)			Thickness (m)		
	Min	Max	Ave	Min	Max	Ave	Min	Max	Ave
Made Ground	96.77	116.35	106.56	96.73	111.08	103.90	0	5	2.5
Alluvium	96.73	111.08	103.90	91.84	115.85	103.84	0	2.5	1.2
River Terrace Deposits	91.84	115.85	103.84	88.87	108.99	98.93	2	10	6
London Clay Formation	88.87	108.99	98.93	49.55	78.72	64.135	35	45	40

6.1.1 Made Ground

6.1.1.1 Background Information

A thin band of Made Ground is present alongside the River Thames as a result of infilling and reclamation of old wharves, the desirability of raising the shoreline on embankments free of inundation, the provision of walkways and continuity of riverside access. Elsewhere, Made Ground resulting from backfilling to basement and utilities, raising of roadways in the vicinity of bridge crossings (to provide acceptable gradients to traffic and pedestrians) and WWII bomb craters (e.g. Bank Station, 1941) is likely to be present.

The study area has been subject to urban development since the eighteenth century with much well-established surface and subsurface infrastructure. As such the majority of the site is underlain by Made Ground, the nature of which will reflect the historic development and redevelopment of the site and surrounding area. Currently, the entire study area is covered with hard surfacing, paving slabs, asphalt

and/or concrete (often reinforced). The thickness of this hard surfacing varies between 0.15 and 1.0 metres. This material is underlain by Alluvium which in turn overlies the River Terrace Deposits.

6.1.1.2 Site Investigations

Made Ground was encountered in the majority of the boreholes obtained for the study area with thicknesses varying as detailed in Table 6.1. The Made Ground was very heterogeneous as illustrated in the strata descriptions and available particle size distributions. It is typically more granular towards the surface with predominantly cohesive material occasionally occurring towards the base of the unit. As such it can difficult to identify the interface between the Made Ground and the underlying Alluvium.

6.1.1.3 Background Information

Alluvial deposits were formed on the floodplains and channels of both the River Thames and River Walbrook. The BGS Special Memoir on the Geology of London (2004) suggests a thickness of between two and five metres of alluvium can be expected in tributary river valleys. In the Central London area, the alluvium typically consists of silty clays and clayey silts, with locally developed beds of fine to coarse grained sand generally less than one metre thick, but locally up to four metres thick.

6.1.1.4 Site Investigations

Alluvium is present to the west and in the north of the study area as a ribbon of material overlying the River Terrace Deposits and London Clay. Emanating from the River Thames immediately west of Cannon Street Station, the eastern boundary of the Alluvium with the underlying Clay extends northwards by approximately 1km (to Finsbury Circus), crossing the study area beneath Princes Street to the north of the 'scissors' road junction. The alluvium is likely to be associated with the River Walbrook.

6.1.2 River Terrace Deposit

6.1.2.1 Background Information

During the period between the Anglian glaciation and the Devensian stage, the River Thames was diverted into its present valley. It deposited a series of sheets of granular material at progressively lower elevations as the valley cut downwards in response to neotectonic uplift and lower sea levels. This gave rise to a series of terraces. The materials deposited on these terraces comprised variable proportions of sand and gravel, depending on the source material and the energy of the environment during deposition. Individually the River Terrace Deposits in the London area are almost indistinguishable with only minor variations in the clast lithologies and proportion. The River Terrace Deposits directly overly the London Clay.

On the 1:50 000 geological map the River Terrace Deposits within the study area are identified as the Taplow Gravels. The thickness of these gravels is highly variable as evidenced by the data presented in Table 6.1.

6.1.2.2 Site Investigations

The Taplow Gravel is recorded generally between 5m and 10m below the existing ground level within the study area. It is typically described as a very dense brown, grey and black sandy fine to coarse gravel. The gravel is described as angular to rounded whilst the sand is described as fine to coarse.

6.1.3 London Clay

6.1.3.1 Background Information

The London Clay Formation of the Thames Group forms the top of the solid geology in the area under consideration. The BGS British Regional Geology publication for London suggests that the London Clay below Central London is up to 150 metres thick. The formation consists of dark bluish to brownish grey fissured clay, containing variable amounts of fine grained sand and silt; the clays weather to a chocolate brown colour, the more sandy beds to an orange colour. London Clay is typically stiff to very stiff, over-consolidated and of high plasticity.

The BGS memoir for London and the Thames Valley describes minor constituents of the London Clay including calcareous and phosphatic nodules, barite, siderite, glauconite and pyrite. Beds of calcareous 'cementstone' concretions, up to 0.4 metres in diameter occur sporadically throughout the London Clay. Glauconite is commonly present in the form of small pellets and microcrystalline grains typically within the more sandy beds. Pyrite occurs throughout the formation as replacement fossil shell debris and as nodules within the weathered zone. The pyrite is oxidised to selenite.

The London Clay Formation is the most extensive of the Palaeogene Deposits in the London Basin and was deposited in a marine environment during the Eocene epoch 50 to 55 million years BP, in a drowned platform of the North Sea basin. Although the London Clay Formation is relatively homogeneous in lithological terms there are distinct vertical lithological subdivisions that are regionally persistent in the London area. These features can have a significant effect on both the near surface geology and hydrogeology of an area.

Five major transgressive-regressive cycles are recognised within the London Clay Formation (King 1981) and are used to broadly define five divisions in the clay, based on a combination of lithological and bio-stratigraphical data. Each cycle ideally marks the base of a coarsening upwards facies sequence. In Central London, the London Clay comprises a deepwater marine mud deposited in water depths in excess of 100 metres.

The macrofabric of the London Clay is characterised by the presence of discontinuities including fissures, joints, bedding surfaces, shear surfaces and minor faults. Of particular relevance to tunnelling are pre-existing shear surfaces referred to as 'backs' and 'greasy backs' (Ward et al. 1959), which are larger than fissures and typically form a series of intersecting curved surfaces. These features can give rise to slips and overbreak during excavation.

The units of the London Clay can be divided into the following successive divisions: A1, A2, A3, B, C, D and E. These divisions are characterised by changes in the proportions of clay, sand and silt. Such changes can be identified by, amongst other techniques, the careful visual logging of the material or from the analysis of natural moisture content profiles. In Central London, only the lower part of the sequence, units A1, A2, A3 and occasionally B are generally preserved.

Standing and Burland (1999, 2006) proposed further sub-division of division A3, namely A3(i) and A3(ii), following investigations into the higher than anticipated volume losses observed during excavation of the Jubilee Line Extension running tunnels at St James Park. These sub-divisions were postulated to delineate the upper region of this division, which was seen to contain distinct water-bearing silt and sand partings that are of important engineering significance.

The London Clay is typically a blue grey, stiff to very stiff, fissured over-consolidated silty clay of high plasticity often containing thin silt and fine sand partings. The weathered zone is of high moisture content, extending to depths of up to 6m below the surface of the London Clay; it is brown rather than dark grey in colour due to the oxidation of pyrite and contains selenite (calcium sulphate) and secondary calcium carbonate nodules.

Fissures are a persistent feature within the London Clay and their existence has a significant influence on the engineering behaviour of the clay. At the macro scale, their presence can induce block failures in unsupported tunnel face. Claystones within the London Clay also offer considerable obstruction to underground works. They occur at specific horizons within the sedimentary cycle but are difficult to trace laterally as they tend not to be continuous.

6.1.3.2 Site investigations

Within the study area the London Clay was encountered underlying the River Terrace Deposits in all of the boreholes formed. It is typically described as a firm becoming stiff to very stiff/hard fissured brown/grey silty/sandy clay. The sand is generally fine grained and often present as partings or laminations. The depth of the London Clay was proved with a number of the boreholes within the study area extending into the chalk.

The fissures are described as sub-vertical to sub-horizontal as well as being orientated at 45 degrees to the horizontal locally. Striations are noted at depth in one or two of the boreholes, particularly those sunk within the footprint of 10 King William Street. Some of the fissures are described as smooth and infilled with sand; black staining is also noted in some of the fissures. The formation contains occasional beds of grey claystone. Selenite crystals were also noted in some of the boreholes.

The strength of the London Clay determined from the boreholes sunk within the study area is similar.

The Harwich Formation was not encountered in any of the boreholes sunk to date within the study area and reviewed as part of this desk study.

6.1.4 Lambeth Group

6.1.4.1 Background Information

The Woolwich and Reading beds of the Lambeth Group occur in the London and Hampshire Basins, where it directly overlies the Thanet Sand Formation or Chalk and is overlain by either the Harwich Formation or the London Clay.

The sediments of the Lambeth Group were laid down in one or more embayments on the western margin of a deep-water marine basin centred on the present North Sea. The period was characterised by small but significant variations in sea level producing periodic migration of depositional environments resulting in complex lithological variation. The environments include near-shore marine, lagoonal and estuarine settings as well as wide floodplains. The relationship between the different depositional environments is seen in central and south-east London. Here, deposits of fine-grained sand, flint gravel beds, mottled clay, shell beds and altered beds form a complex interdigitating sequence that is divided into three formations and several informal lithological units.

6.2 Route Alignment

A broad summary of the profile of the ground conditions identified from the historic ground investigations applicable for the works is presented in Table 6.1. This information is based upon the findings of the investigations obtained from both the British Geological Survey and Mott MacDonald's database of historic information. A geological long section along the proposed Southbound Running/Platform tunnel based on previous ground investigations carried out in the vicinity is presented in Figure 6. In general the sequence of materials comprises:

- Made Ground
- Alluvium
- River Terrace Deposits
- London Clay
- Lambeth Group
- Thanet Sand
- Chalk

The proposed tunnels and associated shafts/adits (as described in Section 1.3) are to be excavated through the London Clay; the Shaft is to be excavated from within an existing basement through the River Terrace Deposits and the London Clay. In its current position, and based on the rule of thumb thicknesses for the A2 and A3 sub-units of the London Clay, the Running/Platform tunnels are likely to be formed within Sub-unit A3 of the London Clay, and more specifically Sub-unit A3(ii) which has the potential to contain water-bearing silt and sand partings (Standing & Burland, 2006).

6.3 Structural Geology

Neither the 1:50 000 scale geological map nor the BGS Special Memoir on the Geology of London show any significant faults in the vicinity of the study area. CIRIA Report 129 'Structure of the Lower Thames Basin' suggests the site is close to the axis of a syncline which trends approximately southwest to northeast.

6.4 Relic Periglacial Features

6.4.1 Possible Depression in the London Clay Formation in the Study Area

Within the Bank Station Capacity Upgrade study area the following potential depression in the top of the London Clay Formation has been identified:

- The contour plot presented in Figure 7 shows a drop in the elevation of the surface of the London Clay by up to 6 m at the scissors junction between King William Street and Lombard Street; this localised depression could be associated with a wider area of erosion formed by glacial action.

It should be noted that the elevation of the London Clay surface has been contoured based upon the available, relatively sparse ground investigation information. The contours have been generated using the

Surfer software (Kriging Method); the information provided in the borehole logs obtained from the BGS and held within the Mott MacDonald DIGS database were used in generating the contours.

6.4.2 Irregularities in the top of the London Clay

Local, deep drift-filled hollows, 'Scour Hollows', exist in the surface of the London Clay (Berry, 1979). A number of these features have been identified beneath the Kempton Park Gravel in Central London, particularly in the area between Battersea and Greenwich, and are illustrated in Figure 8.

It is widely acknowledged that these hollows were formed in the late Quaternary under the prevailing periglacial climatic conditions. There are several mechanisms that can result in the formation of such local depressions, namely:

- local scale channel formation from the River Walbrook;
- local scale channel formation from periglacial rivers and streams;
- regional scale channel formation from the proto-Thames; or
- scour hollows of periglacial pingo origin.

The first three mechanisms result in an undulating surface at the top of the formation, with an amplitude of generally less than 5 metres, while the final mechanism may result in deeper hollows.

The characteristics of these features include:

- depths varying typically between 5 and 15 m; the deepest depression recorded is 60 metres at Blackwall;
- in plan the depressions are irregular, roughly circular or 'boat shaped' and can vary between 90m and 475 m in width;
- locally steep sides;
- infill deposits consisting mainly of sand and gravel with some clayey beds. The deposits are usually stratified but can be disturbed by soft sediment deformation;
- upwards injections and gentle folding of London Clay and Lambeth Group material have also been recorded at the base of some of these depressions; and
- only a very small number of depressions have been identified that penetrate through the London Clay and Lambeth Group deposits into the underlying Thanet Sand and Chalk aquifer.

7. Hydrology and Hydrogeology

The following section is largely based on the text included in the internal project document 'Baseline Report – Water Resources' (document no. N133-BCR-MMD-00-Z-DC-N-0007-S0-0.1).

7.1 Hydrology

The study area is located approximately 300 m north of the River Thames, in the Thames River Basin District. As the name of the basin district suggests, the drainage network is dominated by the River Thames and its tributaries. The river meanders through London and discharges into the North Sea 58 km east of the study area via the Thames Estuary.

The River Thames is a tidally influenced river, with tidal influence reaching as far upstream as Teddington.

The study area is located immediately to the east of the buried River Walbrook, one of the so called Lost Rivers of London. The Lost Rivers of London is a term used to describe historic rivers, which have now been turned into subsurface sewers and form part of Thames Water's combined sewer system. The River Walbrook runs along the road 'Walbrook' towards the River Thames.

No other surface water features have been identified within the study area.

7.2 Hydrogeology

7.2.1 Aquifers

An overview of the stratigraphy and the presence of aquifers in the vicinity of the study area, with indicative thicknesses, are given in Table 7.1. For further details of the geology reference should be made to Section 6.

Table 7.1: Site Geology and Hydrogeology

Time	Group	Formation	Aquifer type	Average Thickness (m)
Quaternary		Made Ground	Non-aquifer	2.5
		Alluvium	Secondary aquifer	1.2
		River Terrace Deposits (also known as Taplow Gravel Formation)	Secondary aquifer	6.0
Eocene		London Clay Formation	Non-aquifer	40.0
Palaeocene	Lambeth Group	Reading Formation	Non-aquifer	17.0
		Woolwich Formation	Non-aquifer	
		Upnor Formation	Secondary aquifer	
		Thanet Sand	Principal aquifer	9.0
Cretaceous	Chalk Group	Chalk	Principal aquifer	>

The Chalk is the principal aquifer in the London and Thames Valley region. The Chalk is usually hydraulically connected to the overlying Thanet Sand and sandier facies of the Upnor Formation and other lower Lambeth Group strata; together these strata constitute the deep aquifer. The Chalk is confined by the London Clay and the clay beds of the Upper Lambeth Group.

The Chalk forms a synclinal basin underneath London. Groundwater collects in the higher ground to the north and south and flows through the Chalk towards the centre of the basin below London.

The River Terrace Deposits are defined as a secondary aquifer in the region. This shallow aquifer is unconfined; it is saturated at depth, and generally unsaturated near the surface, above the water table. It contains a perched water table, which is separated from the deep aquifer by the London Clay and upper Lambeth Group. These formations generally have low permeability and are therefore classed as non-aquifer or 'aquitard'. Although there may be small amounts of groundwater present in occasional sandier layers or sand lenses, this groundwater can be considered isolated from the aquifers above and below the clay formation.

The groundwater vulnerability map of the site shows the shallow aquifer to be of high vulnerability. Due to the less reliable soil information in urban areas, a worst case scenario is assumed and the soils are classed as having high leaching potential until proven otherwise.

7.2.1.1 Upper (secondary) aquifer

Groundwater has been encountered at approximately 10 metres below existing ground level (mbegl) at a borehole located in Swan Lane. This suggests a water table at around 102 to 105 mTD.

Water levels within the shallow aquifer are generally controlled by the balance between urban recharge from rainfall, soakaways, and pipeline leakage and outflows to natural and artificial drains. It is also likely that the water levels and local groundwater flow within the upper aquifer is locally related to the tidal fluctuations in the Thames. However the magnitude of tidal fluctuation is attenuated with distance from the river bank and the type of flood defences in place. A study of the shallow aquifer in the nearby Tyburn catchment, including a review of water table fluctuations, was undertaken by CIRIA and the general principles apply to the Walbrook catchment.

There may also be some lowering of groundwater levels along preferential flow paths in the backfill along the culverted River Walbrook, or sediments along the original course of the river.

7.2.1.2 Deep (principal) aquifer

The Environment Agency publishes an annual report with groundwater levels in the London Basin. Monitoring boreholes near the study area show groundwater levels at between 60 to 65 mTD in January 2010. The two closest boreholes are at Leith House in Gresham Street and St Agnes Well.

At present, the groundwater levels in the Chalk are controlled by the GARDIT (General Aquifer Research, Development and Investigation Team) strategy. GARDIT was developed to address the issue of rising groundwater levels. The objective of the strategy is “to control groundwater level in the Chalk aquifer under central London in order to maintain the integrity of underground structures and foundations in the London Clay”.

Historically, the Chalk groundwater levels in London were lowered by over abstraction; the water level had been depleted by many years of abstract6ion following the Industrial Revolution, with industry sinking numerous private wells to recover water or to use water in processes and machinery. Following a reduction in abstractions from the mid 1960’s onwards, groundwater levels recovered at a rate of up to a few metres per year. However, the 2010 Environment Agency report suggests levels fell by up to 5 m between January 2000 and January 2010.

7.2.2 Groundwater quality

No groundwater quality data for the shallow aquifer has been acquired for this project to date. However, it has been reported in the Environmental Statement for Crossrail that ‘The water is very rarely of a quality suitable for potable supply and is therefore seldom abstracted. CIRIA (1993) reports on seven sample sites with high lead concentrations being common, electrical conductivities over 2000 µS/cm at two sites but less than 1000 µS/cm at only two sites’. The status of the shallow aquifer at Bank is expected to be similarly affected and non-potable as a result of urbanisation.

The Environment Agency has reported on the qualitative status of groundwater in London, where the principal (Chalk) aquifer is confined. Their site reference PGWU1416 is close to Bank Station and is reported as being of type Na-SO_4-HCO_3. This suggests a degree of sodium and sulphate enrichment compared to most potable water wells in the Chalk aquifer. The accompanying maps suggest the fluoride

concentration is between 1.4 and 2 mg/l which is possibly too high for a potable water supply (MAC 1.5 mg/l).

7.2.3 Pathways between the shallow and deep aquifers

Although the water quality and water level data suggest there is insignificant hydraulic connection between the shallow and deep aquifers, there is potential for pathways to develop and thus allow indirect impacts on water quality in the deep aquifer. The potential for a natural pathway arises because the London Clay formation is associated with local, deep drift filled hollows. These are thought to be glacial features which are evident as depressions in the surface of the London Clay.

Hutchinson (1991) agreed with Berry (1979) that scour hollows would have been created in channels formed by river erosion at times when rivers exhibited higher energies due to glacial melt-water. However, Hutchinson argues that this does not account for the depth of some of the depressions. Hutchinson suggests that the deep depressions encountered in Central London are actually groundwater discharge features formed in areas where the covering of London Clay is thinner (less than 35 metres thick) and unable to withstand artesian pressures emanating from groundwater present in the underlying strata. The forces required for the hydraulic uplift to have occurred may have resulted from a build-up of artesian water pressures generated by melt-water run-off into the aquifer during interstadial/interglacial warm periods. Springs formed, forcing themselves up from the aquifer through the frozen ground above in areas where resistance was lower and where the ground above had been removed by scouring. Hutchinson suggests that under the appropriate climatic and hydrogeological conditions, some of the depressions may have formed open-system pingos, generated from the water-bearing strata below the London Clay.

On the basis of the data reviewed during this desk study there is the suggestion of the presence of a depression in the study area, at the scissors junction in the north of the site, which may be a drift filled hollow. As a result the presence of a fully penetrating pingo, even if unlikely, remains a possibility to be resolved by further site investigation or construction monitoring.

There are also breaks in the continuity of the London Clay and Lambeth Group strata where Chalk water supply boreholes have been constructed. There is an attendant generic risk that a pathway between the two aquifers could develop if the works result in collapse of such water wells. Boreholes constructed in the last 50 years or those now in use as licensed abstractions (see below) tend to have grouted steel casing as a liner and reasonable information as to their location. The location, construction and status of older boreholes, especially those associated with the 17th and 18th century in the study area, are less well documented.

The groundwater baseline study has identified 68 recorded water supply boreholes within 250 m of the study area using the “water well” filter within the BGS GeoIndex. There is a remaining risk of unrecorded water supply boreholes or dug wells.

7.2.4 Abstractions

Seven water abstraction points have been identified within 250 m of the study area. These are summarised in Table 7.2.

Table 7.2: Water abstractions within 250 m of the development site

Reference	1	2	3	4	5	6	7
Operator	The London Assurance	J.P.I.T. (Pte) Limited	City Of London Real Property	Asgard Estates Ltd	Lloyds TSB Bank Plc	National Westminster Bank Plc	Bank Of China
Licence number	28/39/39/0127	28/39/39/0056	28/39/39/0050	28/39/39/0094	28/39/39/0166	28/39/39/0072	28/39/39/0170
Location	1 King William Street, LONDON, EC4	Three Boreholes At 9 Gracechurch Street, London EC3	52 Gracechurch Street, LONDON, EC3	Borehole At 98/106 Cannon Street, London EC4	71 Lombard Street, London – Borehole	1 Princes Street, LONDON, EC2	90-96 Cannon Street, LONDON
Abstraction	Office	Commercial/ Industrial/ Public Services: Drinking; Cooking; Sanitary; Washing; (Small Garden)	Commercial Use (pubs etc)	Commercial/ Industrial/ Public Services: Drinking; Cooking; Sanitary; Washing; (Small Garden)	Commercial/ Industrial/ Public Services: Drinking; Cooking; Sanitary; Washing; (Small Garden)	Commercial Use (pubs etc)	Drinking, Cooking, Sanitary, Washing or Swimming Pools
Abstraction type	Not Supplied	Water may be abstracted from a single point	Not Supplied	Water may be abstracted from a single point	Water may be abstracted from a single point	Not Supplied	Not Supplied
Source	Groundwater	Groundwater	Groundwater	Groundwater	Groundwater	Groundwater	Groundwater
Authorised start	Not Supplied	01-Jan-10	Not Supplied	31-Dec-10	01-Jan-10	Not Supplied	Not Supplied
Authorised end	Not Supplied	31-Dec-10	Not Supplied	20-Feb-90	31-Dec-10	Not Supplied	Not Supplied
Permit start date	Not Supplied	01-Jan-97	Not Supplied	Not Supplied	06-Apr-00	Not Supplied	Not Supplied

Although drinking is stated to be included within the permitted use, it is likely that none of the users are in fact treating the water to potable standards and supplying this as drinking water. The current regulatory requirements and attendant costs of treatment tend to result in drinking water being supplied by Thames Water.

The licensed abstractions from the Chalk aquifer are included within the water resources baseline since it is possible that the owners would prefer to see their assets included within the EIA process rather than being excluded.

The Environment Agency has defined Source Protection Zones (SPZs) for groundwater sources that are used for public drinking water supply. These zones indicate the risk of contamination of the drinking water supply from any pollution sources and activities in the area. There are no source protection zones within 1km of the study area.

7.3 Flood Risk

7.3.1 Fluvial and tidal flood risk

The proposed development is located outside flood zones 2 and 3 and is therefore considered at low risk from fluvial or tidal flooding (i.e. the probability of flooding in any year is less than 1 in 1000). The nearest surface water feature is the tidal River Thames. The river benefits from flood defences along its length and from the Thames Barrier. The river is located at approximately 5 mAOD, whilst the study area is located at approximately 14 mAOD. A flood risk map of the area is included in Appendix A. The study area is marked in pink on the figure. The flood risk area is marked in blue, whilst the area benefiting from flood defences is the hatched area.

7.3.2 Surface water runoff

Intense rainfall, often of short duration, unable to soak into the ground or enter the drainage system can cause local flooding. In heavily developed areas such as the study area in the vicinity of Bank Station there is no open ground allowing easy infiltration into the ground. Furthermore the drainage system can be overwhelmed with heavy rainfall, blockage or inadequate capacity being contributing factors. The direction and depth of the resulting surface flows along the road network depends on the local topography.

Due to its location on a slope, surface flood water is likely to enter the study area from the north and flow southwards towards the River Thames.

A number of drainage points exist along King William Street. It is assumed that these drainage points connect to the underlying combined sewer.

7.3.3 Groundwater flood risk

The study area is underlain by a superficial minor aquifer. Groundwater levels are indicated as being approximately 10 mbegl. The area has been identified to be of moderate to moderately high susceptibility to groundwater flooding although it is not known how this conclusion was arrived at.

The groundwater levels within the Chalk are both deep and controlled as a result of the abstraction regime in place. The Chalk aquifer is therefore unlikely to result in flooding at the site. The City of London Strategic Flood Risk Assessment considers the City of London to be at low risk of groundwater flooding due to the tight control of water levels within the Chalk.

7.3.4 Sewers and Water Mains

7.3.4.1 Sewers

The sewer records from Thames Water indicate one trunk sewer (the London Bridge Sewer) and two low level sewers (Low Level Sewers Nos. 1 and 2) in the study area. The trunk sewer serves as a combined sewer, draining foul water and surface water flows and is located beneath Princes and King William Streets. It is understood that the sewer is up to 8.5 mbegl with its invert at the interface between the River Terrace Deposits and the London Clay.

The two low level sewers run approximately west to east, under Canon Street and about half way up King William Street. The depths of these assets are unknown although it is likely that they have been constructed within the London Clay Formation.

As previously mentioned, the former River Walbrook was located on the western flank of the study area. The river is now culverted and forms part of London's combined sewer system. The river does not discharge freely into the River Thames, except during high rainfall events when overflows occur. Normal flows in the combined sewer are intercepted and ultimately piped to the Beckton sewage treatment plant.

The study area is not located within the so called critical drainage area. This is an area which is at risk of sewer flooding in extreme circumstances. The outline of the critical drainage areas is defined in the City of London Strategic Flood Risk Assessment.

It is currently unclear where the inlet gullies and manholes are located specifically within the study area. Any individual overflows from gullies or manholes are likely to flow towards the south, and the River Thames along the roads over the impermeable surfaces.

7.3.4.2 Water Mains

Bursts in water mains cause local flooding of the highway. The risk or history of bursts has not been investigated since the resultant flooding is expected to discharge to the combined sewer system via the gullies in the road.

TWUL water mains are located within the roads around the development site, including King William Street, Nicholas Lane, Cannon Street and Abchurch Lane. Two 600mm diameter trunk water mains and water distribution mains have been identified within the study area. The water distribution mains range in diameter from 100 mm to 250 mm, and serve the Crouch Hill Water Pressure Zone. The specific depths of these various mains are unknown at this stage, but, in general, are likely to be less than 2 m below existing ground level.

7.3.5 Flood Defences

The River Thames flood defences are located within 350 m of the study area and a lesser distance to the proposed underground construction works. Ground movement modelling undertaken to date has not identified impacts to the flood defences as a result of the proposed tunnelling works.

Recent records and predictions of tidal variations are available free of charge from the website of the Port of London Authority. The nearest monitoring station to the study area is located at Tower Pier.

8. Potential Geotechnical Hazards

8.1 Preliminary Geotechnical Risk Register

The intention of the preliminary geotechnical risk register is to provide a summary of the potential interfaces between the existing ground and groundwater conditions and the proposed works thereby identifying ground related issues that could have an adverse effect on the construction including health and safety, environment, programme and cost. For each of the issues identified potential mitigation measures are identified along with details of further investigations that can be undertaken to reduce the project risk.

It should be noted that the risk register is a project management tool and that it should be reviewed regularly by the design team and progressively updated during project development, as more information becomes available and elements of the design work are undertaken.

8.2 Man-Made Buried Structures

Man-made buried structures are present across the site and have evolved from the development and redevelopment of buildings and infrastructure extending back as far as the seventeenth century. In addition temporary works structures are also likely to be present associated with the development of the underground transport infrastructure.

The preliminary geotechnical risk register has identified the principal interface issues associated with the known existing buried structures and the proposed works. For each of the existing structures, where there is a potential interface issue the risk register includes a description of the risk and details the potential mitigation measures that could be implemented to enhance the level of understanding about the interface issue or to reduce the level of risk.

The principal risks presented by man-made buried structures are conflicts between the existing and proposed structures as well as the effect of excavation-induced ground movements on the existing structures as a result of underground construction. The presence of old/current foundations could have an adverse effect on the excavations for the proposed underground works.

8.3 Unexploded Ordnance

The presence of unexploded ordnance within the study area cannot be discounted; it was subject to bombing during WWII. To reduce the risk to the project a UXO desk study and detailed risk assessment, in accordance with CIRIA C681 “Unexploded Ordnance (UXO): A guide for the construction industry”, was commissioned as part of this geotechnical desk study. The findings of the desk study and threat assessment identified the UXO risk level to be “Medium to High” with regards to the proposed ground investigations within the identified bomb penetration depth (8.0mbgl) and thus a robust UXO mitigation strategy is required to be implemented to permit the work to proceed in the safest “acceptable” manner“ (i.e. As Low as Reasonably Practical” (ALARP)). The UXO desk study and detailed risk assessment is included within the PCIP.

The UXO threat assessment concludes that specialists in the identification of unexploded ordnance should be present on site during any ground investigations, particularly whilst boring or excavation for the proposed works is undertaken through the Made Ground and underlying materials considered susceptible to the presence of unexploded ordnance (i.e. up to a depth of 8m). Pre testing and clearance certification

of the intended boring/drilling locations could be achieved by progressively introducing a specialist magnetometer into the borehole to ensure it is safe to continue drilling. Where possible, stainless steel casing should be used in the leading three metres of the casing to reduce delays to the drilling process. Alternatively it may be possible to pre-test and provide clearance certification of the intended positions using a "Magcone" or other specialist "safe look ahead" capable magnetometer system testing from the existing ground level. It should be noted that whilst execution of the above risk mitigation strategy will significantly reduce the risk, zero risk is not achievable given the possible variables.

8.4 Made Ground

A layer of Made Ground is likely to be present across most of the site. The principal uncertainties are the thickness and spatial variation of these materials. However, as most of the proposed works are at depth, interface issues with the Made Ground may not be particularly extensive.

Perched groundwater is also likely to be encountered within the Made Ground. However, its presence is not likely to be a significant obstacle to the construction works.

Material disposal issues are beyond the scope of this report, but will need to be considered in relation to the disposal of Made Ground and the control of perched groundwater within these materials.

8.5 Alluvium

Alluvium is present across the site and its presence gives rise to a number of ground engineering hazards. A summary of the main issues associated with the Alluvium is presented below:

- The Alluvium could be highly compressible and hence the design of any shallow foundations within the Alluvium will need to consider the potential for (differential) settlements;
- The interface between the Made Ground and Alluvium will in some instances be indistinct as the base of the Made Ground may comprise re-worked Alluvium. Hence, if certainty of the interface is required for design then further investigation will be required;
- Groundwater control – groundwater seepage through the Alluvium from perched water tables should be anticipated and some groundwater control may be required. However, excessive dewatering of these materials and corresponding changes in pore water pressure should be avoided as it could lead to large consolidation settlement and building damage; such works would probably require either groundwater recharge or impermeable barriers.

However, as most of the proposed works are at depth, interface issues with the Alluvial deposits may not be particularly extensive.

8.6 River Terrace Deposit

The River Terrace Deposits are the source of a number of risks to both the temporary and permanent works. The following provides a brief summary of the key issues associated with the River Terrace Deposits:

- Excavation face stability – River Terrace Deposits, particularly in the presence of groundwater, will be unstable and measures to prevent face instability of underground excavations will be required. The development of robust construction procedures/ground treatment methodologies to consider all likely eventualities will be a prerequisite for successful construction;

- Groundwater control – the presence of groundwater within the River Terrace Deposits should be expected. However, suitable groundwater control measures will be a function of the material particle size distribution and hence it is important to understand the spatial distribution and composition of the River Terrace Deposits.

- The presence of lenses of silt and organic material within the River Terrace Deposits. When exposed during tunnelling operations such lenses can become compressed and extruded into the open excavation;

- Grouting – the spatial variation in the composition of the River Terrace Deposits will affect the suitability of different grouting and tunnelling techniques. It is therefore important to understand as far as possible the spatial distribution of the different material gradings prior to designing ground treatment works and to undertake grouting trials to demonstrate the effectiveness of the proposed techniques prior to commencement of construction; and

- Ground freezing – the use of ground freezing requires an understanding of groundwater flow rates, chemistry and temperature. Currently there is negligible information on these parameters. If ground freezing is to be adopted as a mitigation measure these parameters will need to be established.

However, as most of the proposed works are at depth, interface issues with the River Terrace Deposits may not be particularly extensive.

8.7 London Clay

The London Clay underlies the superficial deposits across the whole of the site. Although in general the properties of the London Clay are well documented, a number of risks have been identified. The following provides a brief summary of the main risks associated with the London Clay and also the interface with the River Terrace Deposits.

- Definition of the sub-divisions of the London Clay and their material properties – the sub-divisions of the London Clay have different material properties, which, if well understood, can be particularly beneficial in rationalising the design of both the permanent and temporary works and for the assessment of building response to underground works. In its current position, and based on the rule of thumb thicknesses for the A2 and A3 sub-units of the London Clay, the Running/Platform tunnels are likely to be formed within Sub-unit A3 of the London Clay, and more specifically Sub-unit A3(ii) which has the potential to contain water-bearing silt and sand partings (Standing & Burland, 2006).;

- 'Greasy backs' – these are pre-existing shear surfaces within the London Clay and can present some difficulties during tunnelling. Typically they are formed from a series of intersecting curved surfaces and can give rise to slips and overbreak during excavation;

- Scour holes in the surface of the London Clay – the presence of scour holes or local depressions in the top of the London Clay, infilled with River Terrace Deposits, is a potential source of problems during construction. Excavations into the London Clay unexpectedly encountering River Terrace Deposits could lead to local face instability particularly if groundwater has collected in the hollows. Such features would therefore require some stabilisation prior to excavation. A secondary consequence of face instability would be settlement at the ground surface, which potentially could have an adverse effect on existing surface structures and utilities; and

- 'Pingos' – the presence of periglacial pingos in the top of the London Clay would locally modify the ground conditions with the presence of weaker London Clay and possibly infilled water-bearing deposits.

8.8 Groundwater

Groundwater can be expected throughout the materials encountered within the study area in the form of:

- Made Ground – perched groundwater tables;

- Alluvium – perched groundwater tables;

- River Terrace Deposits – perched groundwater tables, with potential for large groundwater inflows, and

- London Clay – local seepages through permeable silty and sandy horizons.

The provision of groundwater control measures will be required throughout the underground works to facilitate their construction. However, it should be noted that extensive dewatering within the superficial deposits would lead to consolidation settlement of the Alluvium, which could potentially damage buildings with shallow foundations. Ground freezing could in the short term lead to heave and subsequently some consolidation settlement following thawing of the frozen ground.

The design should also consider the regional groundwater table; trends should be considered in relation to the permanent works design.

8.9 Aggressive Soil

The design of the sub-surface reinforced concrete structures will need to consider the aggressivity of the soil against which the concrete is to be placed. In general the main concerns would be the chemical composition of the Made Ground, Alluvium and River Terrace Deposits and to a lesser extent the London Clay. BRE Special Digest 1 provides advice on aggressive soil and groundwater chemistry and should be used as the basis for the design of buried concrete.

9. Ground Investigation Proposals

In order for London Underground (LU) to take the scheme design forward to construction, it is proposed to undertake a ground investigation to obtain a comprehensive understanding of the ground and groundwater conditions at the site.

Reducing the ground related risks associated with the scheme will have a considerable beneficial impact on the scheme construction costs. To achieve this a ground investigation is to be undertaken with its focus being to obtain specific information for the design and construction of particular elements of the proposed works such as the escalator barrels, deep running/platform tunnels and shaft, and to reduce uncertainties associated with the existing information.

Additional specialist and advanced field testing, together with sampling and laboratory testing over and above that currently available from previous investigations is to be undertaken. This is to enable the characterisation of the soil behaviour thus enabling more economic design and construction as well as more realistic estimates of ground movements. This level of information is not currently available within the existing geotechnical data.

The ground investigation shall be undertaken in two separate phases. Phase 1 being the "Main Investigation" and Phase 2 the "Supplementary Investigation". The need, extent and/or scope of the works proposed under Phase 2 will be dependent on the results obtained from the Phase 1 works.

From the studies undertaken to date a number of geotechnical issues have been identified associated with the proposed scheme, namely:

- The construction of an approximately 28m deep (from the base of the existing sub-basement) 17m i.d. shaft through the Made Ground, Superficial Deposits (Alluvium and River Terrace Deposits) and underlying London Clay Formation;
- the construction of a number of tunnels, shafts and escalator barrels through the London Clay Formation;
- the feasibility of treating the River Terrace Deposits (RTD);
- the interaction between the existing LU and DLR networks of tunnels and shafts and the proposed works and in particular the ground movements induced, and
- the impact of the works on the existing surface
  - the various Listed Buildings within the vicinity of the footprint of the proposed works,
  - The sub-surface structures, i.e. services/utilities which traverse the site, particularly those of Thames Water Utilities Limited such as Low Level Sewers Nos. 1 and 2, and the London Bridge Sewer.

The ground investigation has been designed to provide site-specific geotechnical data to better assess the effect of the works on adjacent buildings, utilities and other existing infrastructure. The project risk register identifies settlement effects as a 'high' risk. Ground investigation will help further assess this risk and thus assess how this risk can be eliminated and/ or managed.

Phase 1 is to comprise 6 No. boreholes and 6 No. Cone Penetration Tests (CPTs) while Phase 2 is to consist of 4 No. boreholes and 4 No. CPTs. A CPT is to be carried out at the site of each borehole. The CPTs have been scheduled as a complementary investigative technique to the boreholes and will allow corroboration of geotechnical parameters. The justification for these exploratory holes is presented below and in the accompanying tables. The need for the exploratory holes currently scheduled as part of the Phase 2 fieldworks will be reviewed on completion of the Phase 1 investigation; it may be that the scope of the Phase 2 ground investigation can be reduced.

The schedule of ground investigation exploratory holes is included in Appendix F together with the corresponding exploratory hole location plans; the Preliminary Geotechnical Risk Register is included as Appendix G.

10. Conclusions and Recommendations for Further Study

The proposed Bank Station Capacity Upgrade project is a significant infrastructure enhancement to the existing Bank-Monument Stations complex in the City of London. It comprises the construction of a new southbound platform tunnel and associated length of running tunnel to the Northern Line, and connecting passageways to the existing station tunnels as well as the provision of step-free access.

This Geotechnical Desk Study report has described the historic development of the site, summarised the ground investigations undertaken, reviewed the ground and groundwater conditions and identified the ground related risks. Proposals for supplementary ground investigations to reduce project risks associated with uncertainties in the ground and groundwater conditions, for the design of the temporary and permanent works and the development of construction techniques, have also been included.

The general ground and groundwater conditions across the site have been established from ground investigations undertaken for adjacent infrastructure and commercial developments as well as the data obtained from the BGS. In broad terms, the ground conditions comprise Made Ground underlain by superficial deposits comprising Alluvium and River Terrace Deposits. These are underlain by the London Clay with, at depth, the upper units of the Lambeth Group.

10.1 Obtain further ground investigation data

10.1.1 Historic Data – One Lothbury

It is understood that a ground investigation was undertaken for this development during the last decade. This information has been requested by the Bank Station Capacity Upgrade project team. The scope of the Bank Station Capacity Upgrade project-specific ground investigation (See Section 9 for further details) should be reviewed and revised as necessary on receipt of this information.

10.1.2 Bank Station Capacity Upgrade Ground Investigation

Based on the existing ground investigation made available to the project to date there is a requirement to undertake geotechnical investigations at all locations to support the design of the shaft and running/platform tunnels. The scope of the investigations should encompass both cable tool and rotary drilling and CPT techniques. In situ testing to establish material stiffness and in situ stresses is also required (e.g. pressuremeter testing).

As part of the investigations disturbed and undisturbed samples should be collected for laboratory testing. The testing should encompass routine classification and strength testing and more advanced testing for verification of the stiffness of the materials. The installation of instrumentation to facilitate subsequent groundwater monitoring should also form part of the ground investigation.

10.2 Investigation for Ground and Groundwater Contamination

Throughout the investigations, samples should be obtained for the assessment of the chemical composition of the materials, such that informed decisions on the extent of ground and groundwater contamination can be made. In addition, the testing will provide a basis for future construction teams to identify appropriate disposal sites for materials and define appropriate levels of personal protective equipment for site operatives.

10.3 Preliminary Geotechnical Parameters for Design

Geotechnical Design Guidance Notes, which include preliminary geotechnical parameters, to facilitate the design of the proposed works should be prepared (Document No. N133-BCR-MMD-00-Z-DC-Z-0048-S0-1.0; LUSTN-0008798-DOC-001229 refers).

10.4 Transport Infrastructure

10.4.1 Surface Buildings

Phases 2 and 3 of the Potential Damage Assessment process are to be completed during RIBA Stage D; both Listed and Non-Listed buildings shall be assessed as part of this process. Building inspections and surveys shall be required to inform these various assessments.

10.4.2 Underground Railways

The scheme is located adjacent to a number of underground railway lines of both the London Underground (Central, District & Circle, Northern and Waterloo & City lines) and the Docklands Light Railway networks. In addition the disused City and South London Line is present beneath Arthur Street in the southern part of the project site.

The London Underground Streets with 'Special Engineering Difficulties' (SED) drawings for the Bank area have been reviewed. These plans show the extent of the existing underground railway network in the area. Reference should be made to the supplementary references given on these drawings during the subsequent phases of the design process. Additionally, reference will be required to the corresponding set of drawings for the highway infrastructure produced by TfL Streets and the City of London.

10.4.3 Highway Structures

10.4.3.1 King William Street Bridge

This asset is due another Principal Inspection in the near future; the Bank Station Capacity Upgrade project team should liaise with the City of London as this Principal Inspection could also serve as the Inspection for Assessment for this existing asset which will be required as part of the potential damage assessment process and Transport and Works Act Order application.

10.4.3.2 King William Street Underpass

No historic inspections have been made available for this structure to date. An Inspection for Assessment will be required as part of the potential damage assessment process and Transport and Works Act Order application.

10.4.4 Services/Utilities

Details of buried services including available utility plans will be included within the Health, Safety and Environment PCIP. A comprehensive utilities survey in addition to consultation with utilities stakeholders will be necessary prior to any works being carried out; line and level surveys are to be undertaken for the key strategic TWUL assets during RIBA Stage D to determine the actual clearance to these assets.

An assessment of the impact of the excavation-induced ground movements on these utilities shall be carried out as part of the asset protection process associated with the Bank Station Capacity Upgrade project.

10.5 Settlement Assessment

The anticipated ground movements due to tunnelling and shaft excavation should be evaluated and potential damage assessment of overlying and underlying structures undertaken to determine which structures might be affected. The design will consider appropriate remedial works to mitigate foreseeable effects.

11. References

- Berry, F.G. (1979). Late Quaternary scour-hollows and related features in central London. Quarterly Journal of Engineering Geology, 1979 Vol. 12 pp. 9-29, 20 Figs;
- Ward, W.H., Samuels, S.G. and Butler, M.E. (1959). Further studies of the properties of London Clay. Geotechnique, Volume IX, Nr.2, June 1959, pp 33-58.
- Standing, J.R. and Burland, J.B. (1999). Report on Ground Characterisation to explain JLEP Tunnelling Volume Losses in the Westminster Area. Unpublished report prepared for London Underground Limited, December 1999.
- Standing, J.R. and Burland, J.B. (2006). Unexpected tunnelling volume losses in the Westminster area, London. Geotechnique 56, Nr.1, February 2006.
- Hutchinson, J.N. (1991). Theme lecture: Periglacial and slope processes. From Forster, A. , Culshaw, M.G., Cripps, J.C., Little, J.A. & Moon, C.F. (eds), 1991. Quaternary Engineering Geology, Geological Society Engineering Group Special Publication Nr. 7, pp 283-331;
- Ellison R.A. Geology of London. British Geological Survey, Keyworth, Nottingham, 2004.
- Greathead J.H. The City and South London Railway; with some remarks on subaqueous Tunnelling by Shield and Compressed Air. Proceedings of the Institution of Civil Engineers, November 1895.
- Dalrymple-Hay, H.H. The Waterloo and City Railway. Proceedings of the Institution of Civil Engineers, November 1899.

Figure 1: The Proposed Works and Existing Sub-surface Infrastructure

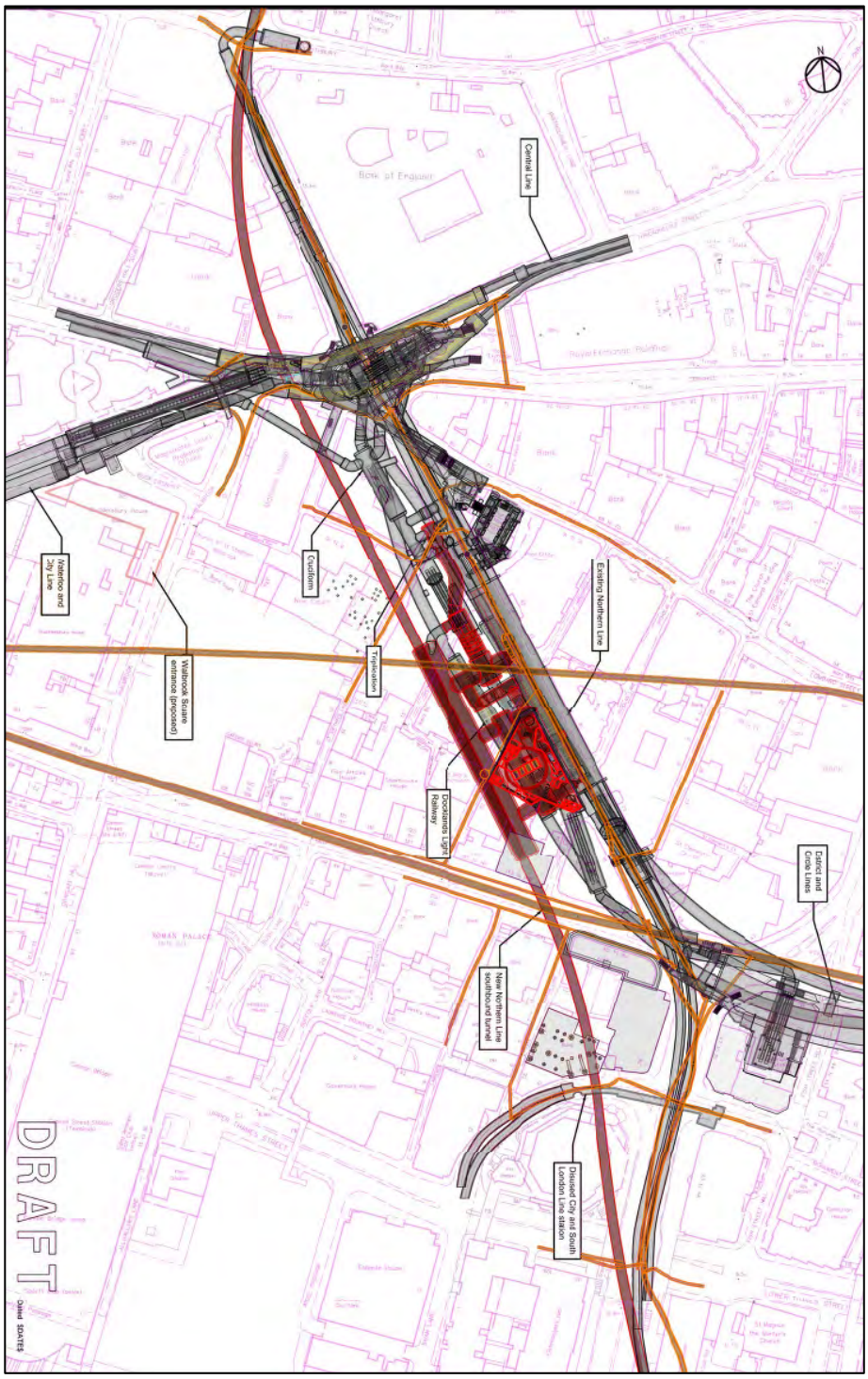


Figure 2: Buildings affected by the Proposed Works

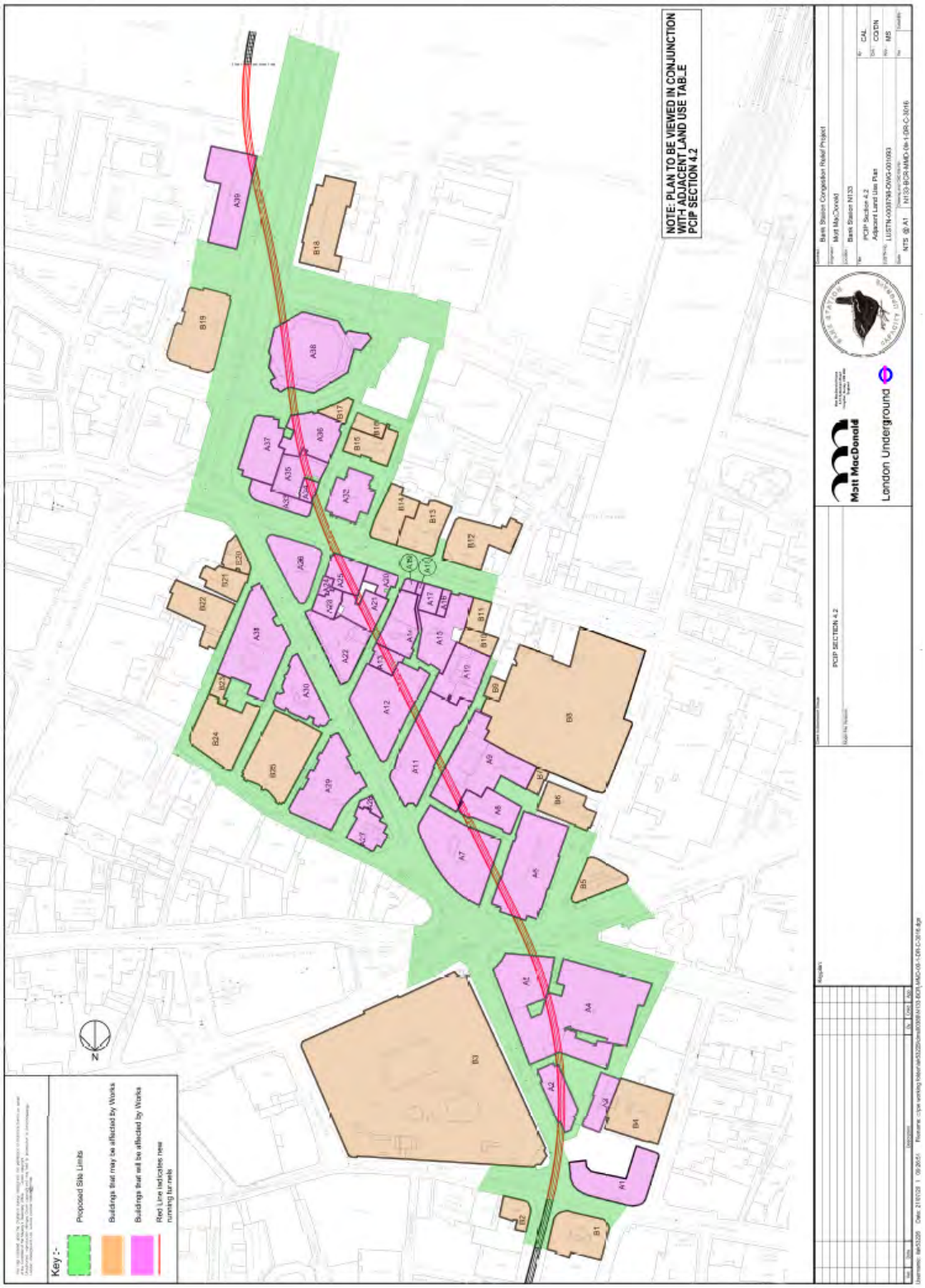


Figure 3: Plans and Sections of the City and South London Railway

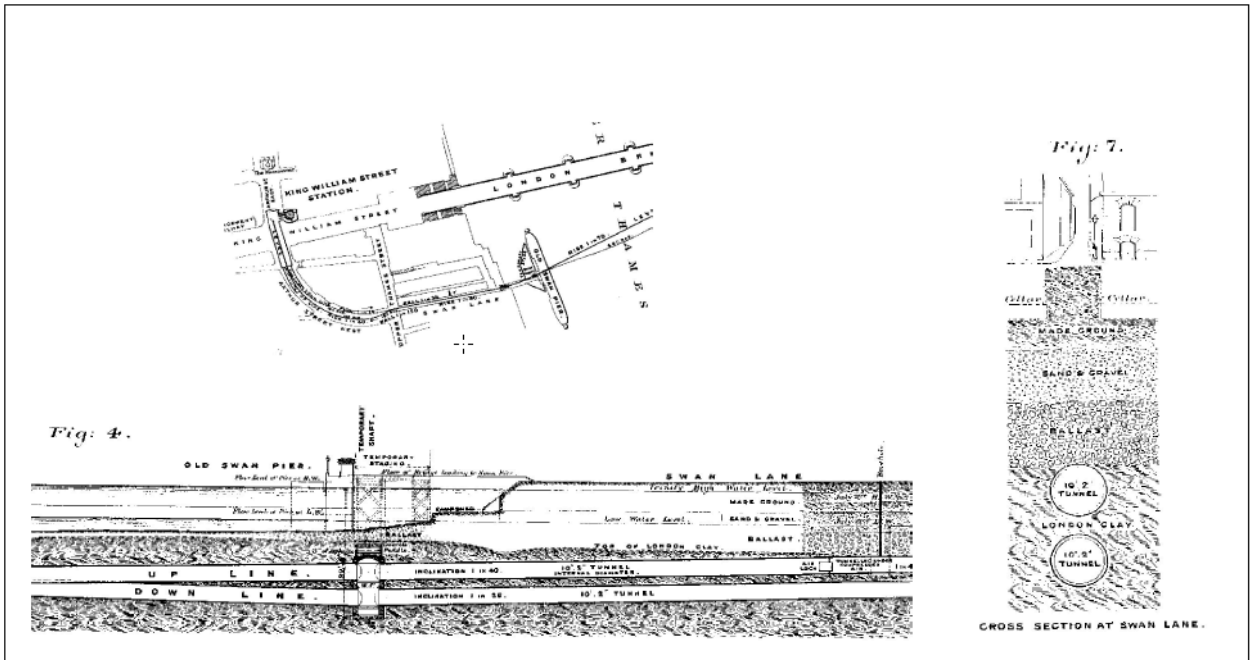


Figure 4: Existing Central Line Platform Area

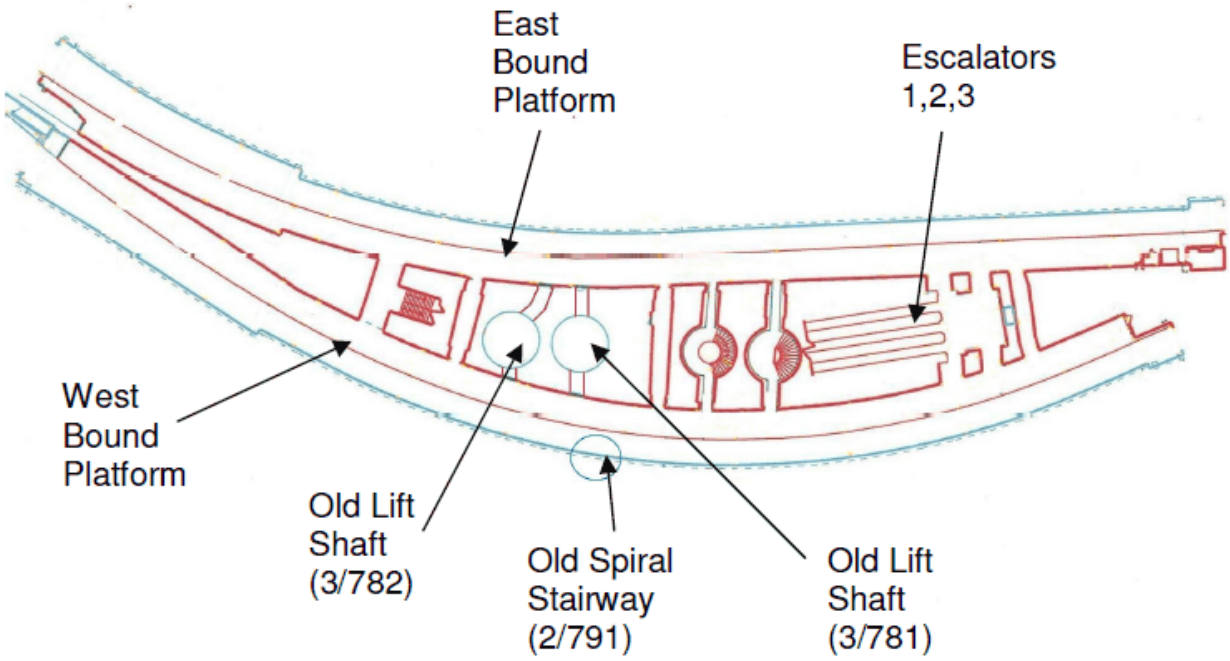
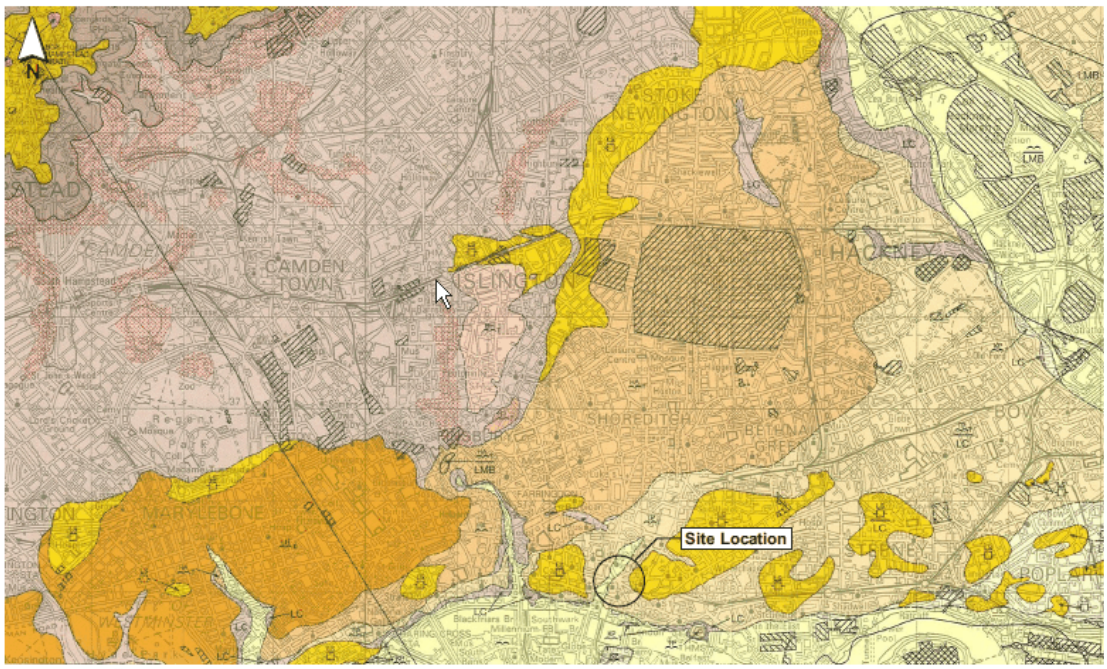


Figure 5: Extract from 1:50 000 BGS Geological Map



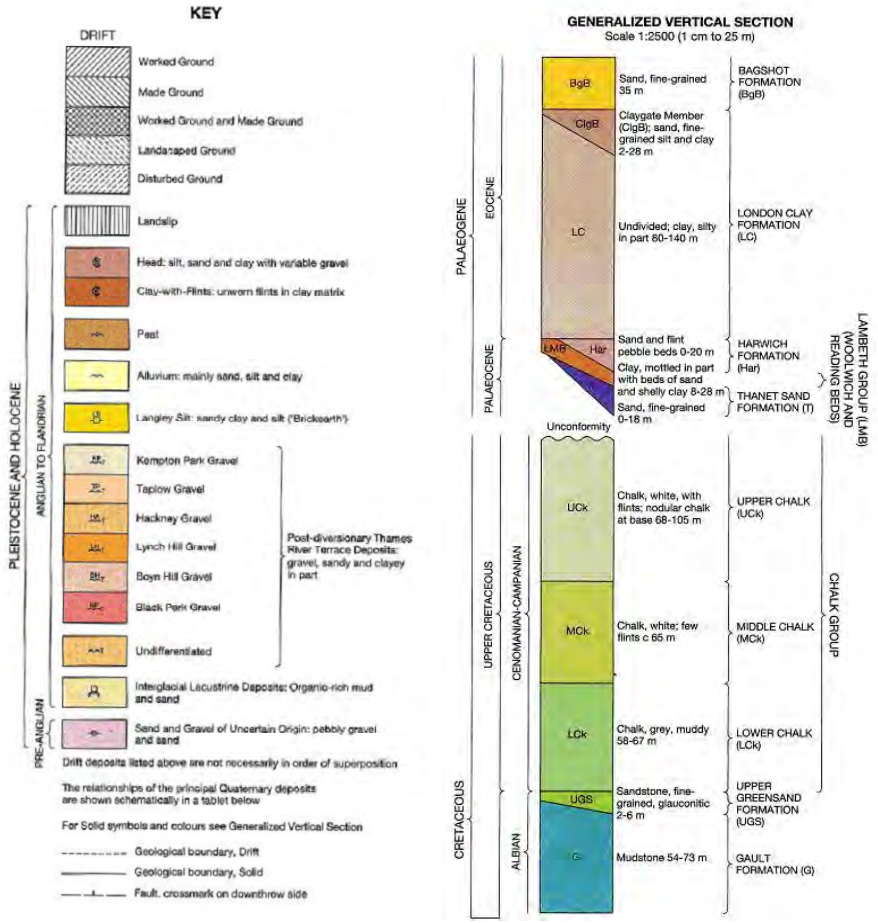


Figure 6:. Geological Section along Proposed Running/Platform Tunnel Alignment

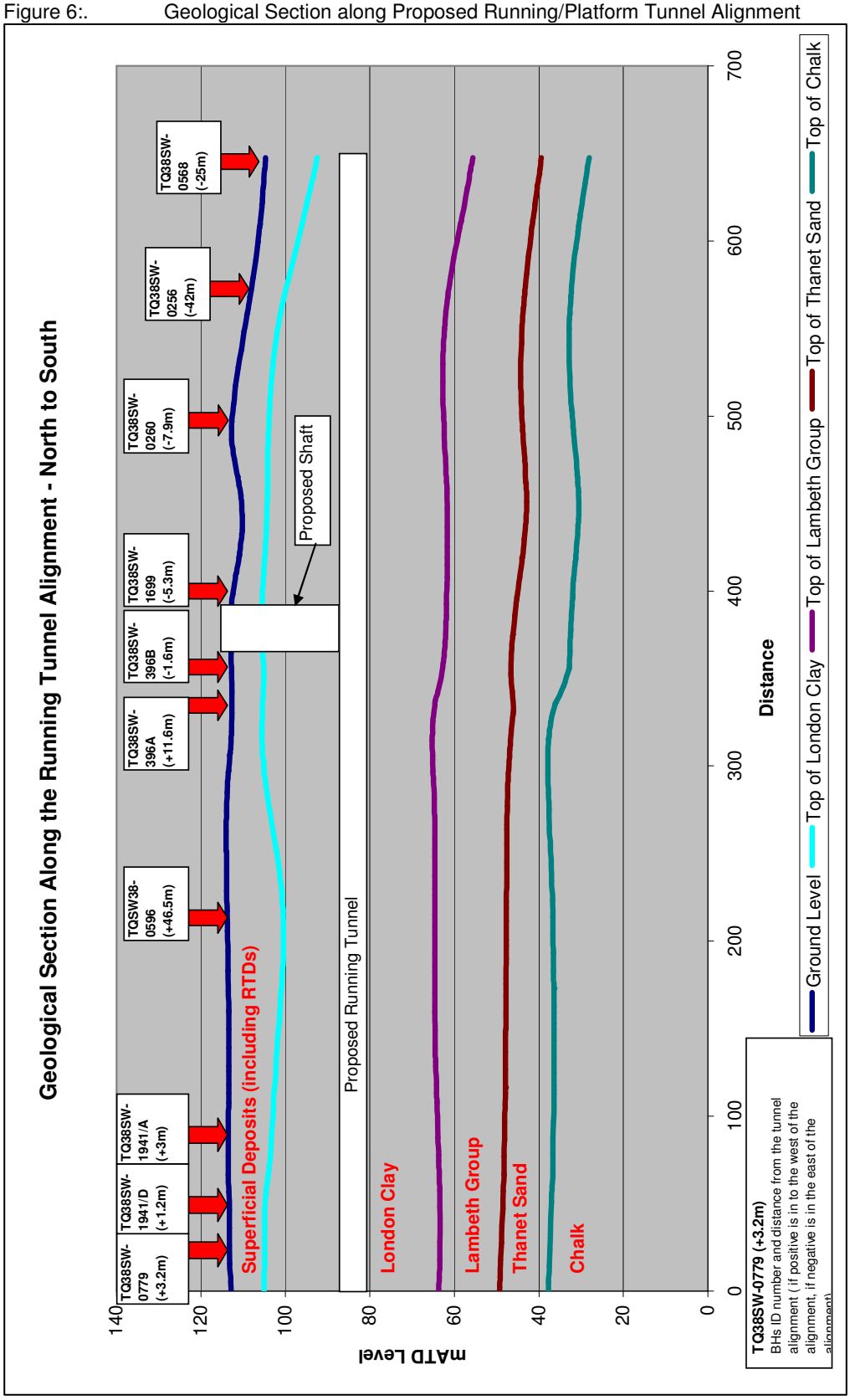


Figure 7: Contour Plot of the surface of the London Clay

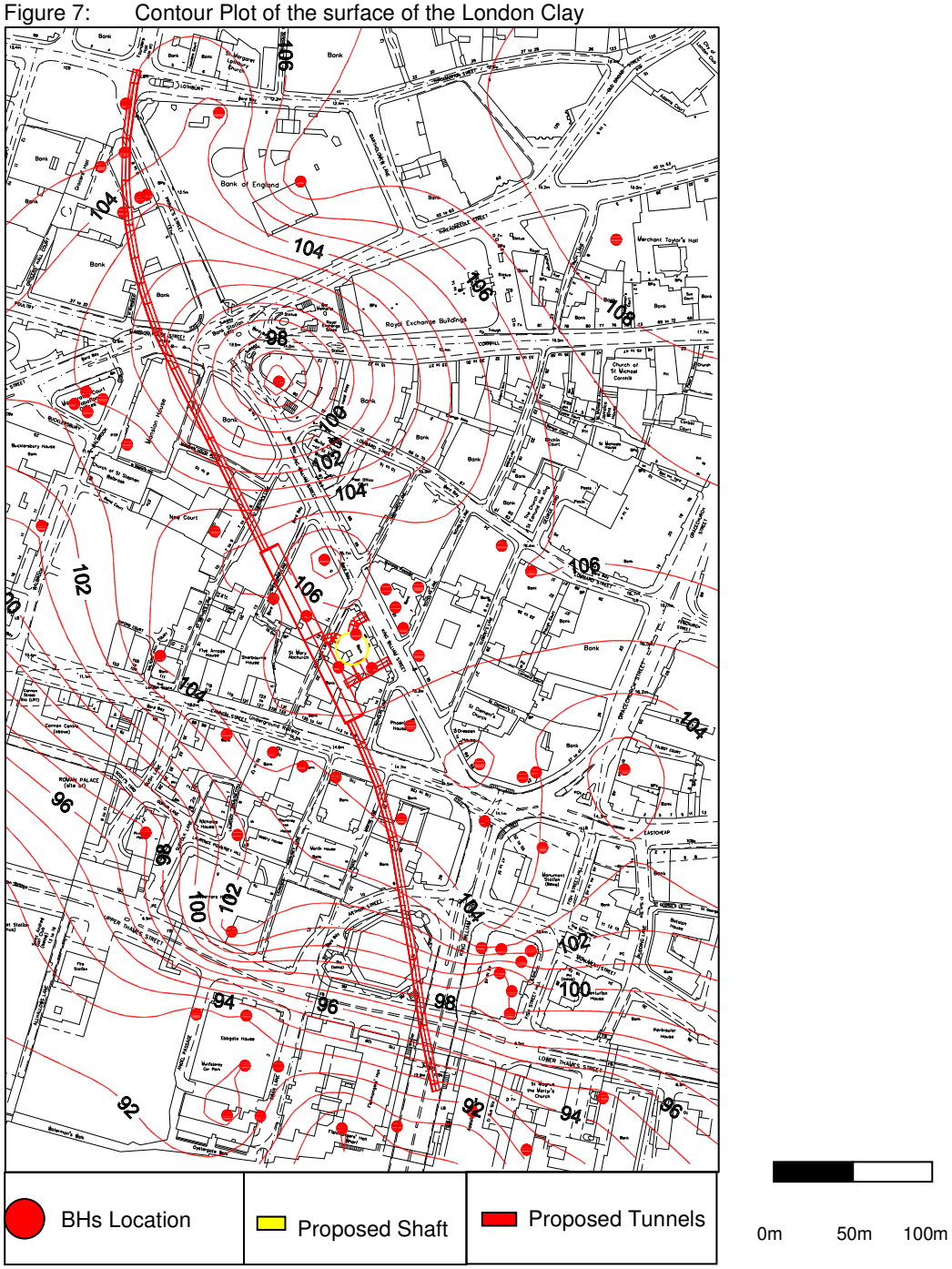
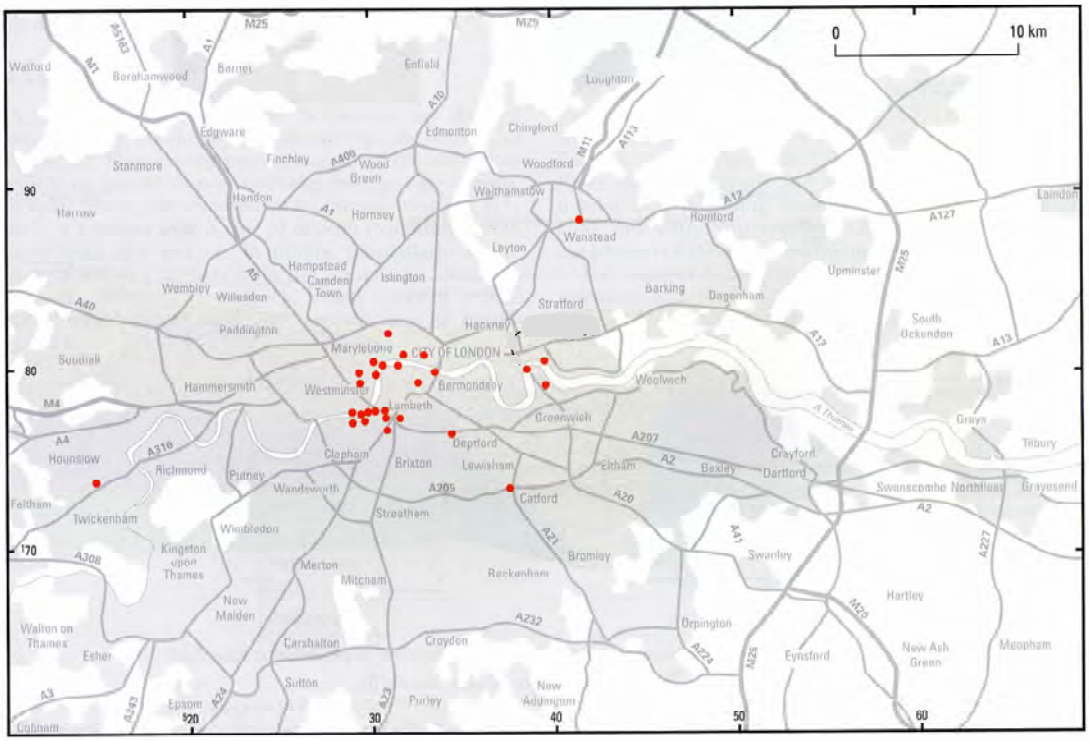


Figure 8: Scour Hollow Locations

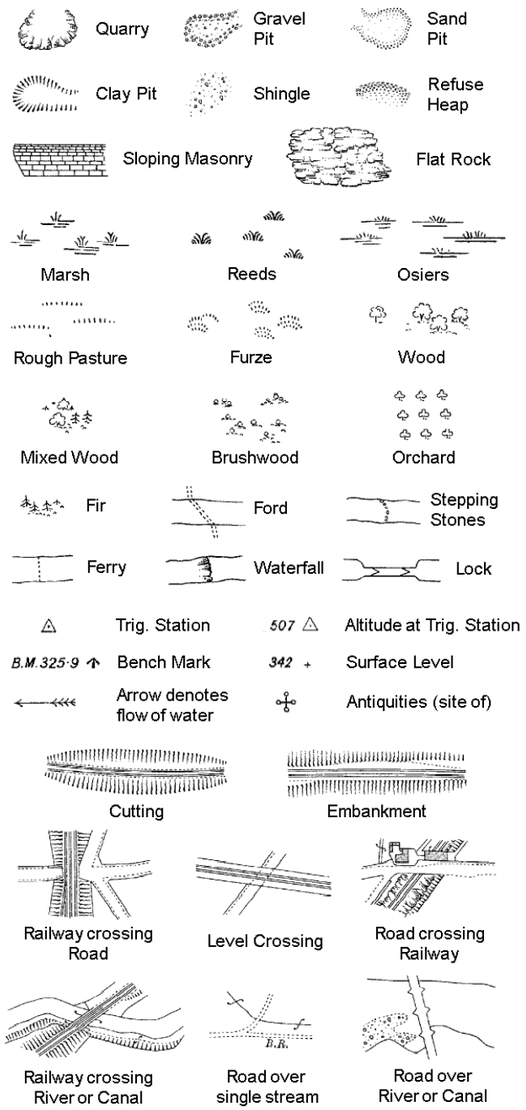


Appendices

Appendix A. Envirocheck Report Extracts

Historical Mapping Legends

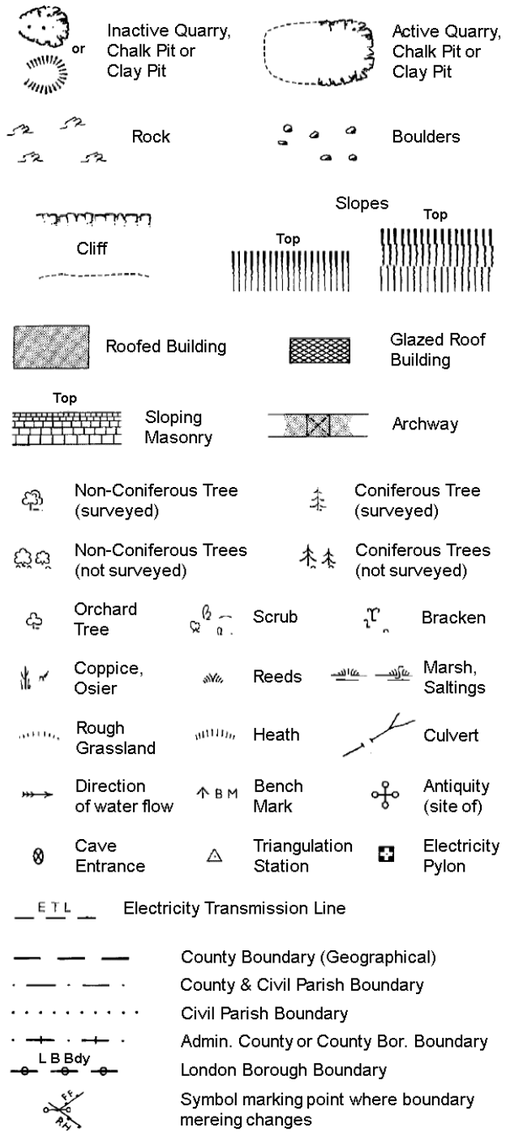
Ordnance Survey County Series and Ordnance Survey Plan 1:2,500



County Boundary (Geographical)
County & Civil Parish Boundary
Administrative County & Civil Parish Boundary
Co. Boro. Bdy.
County Borough Boundary (England)
Co. Burgh Bdy.
County Burgh Boundary (Scotland)

B P B S	Boundary Post or Stone	P.C.B	Police Call Box
B.R.	Bridle Road	P	Pump
E.P	Electricity Pylon	S.P	Signal Post
F.B.	Foot Bridge	St.	Sluice
F.P.	Foot Path	Sp.	Spring
G.P	Guide Post or Board	T.C.B	Telephone Call Box
M.S	Mile Stone	Tr.	Trough
M.P M.R	Mooring Post or Ring	W	Well

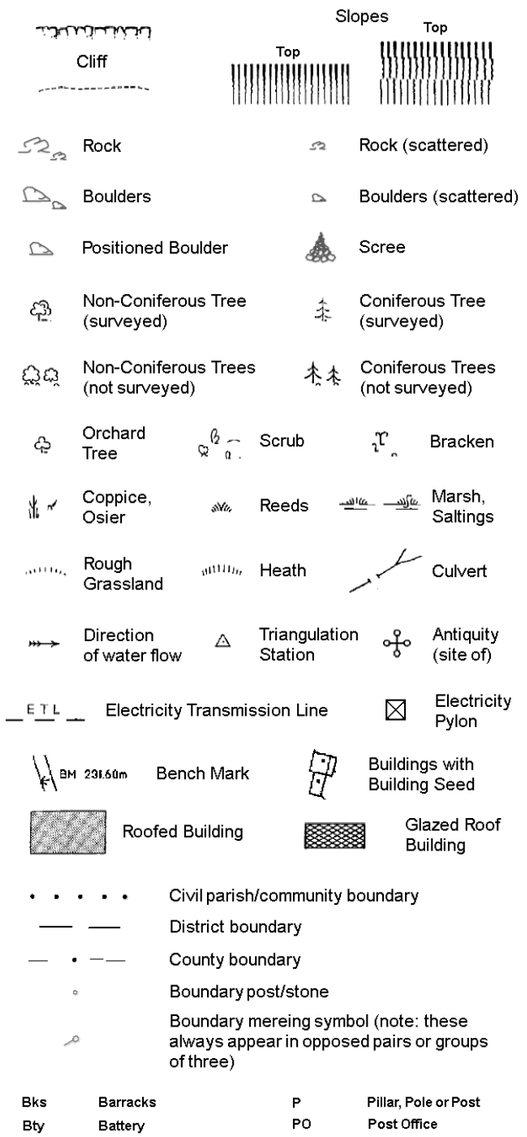
Ordnance Survey Plan, Additional SIMs and Supply of Unpublished Survey Information 1:2,500 and 1:1,250



County Boundary (Geographical)
County & Civil Parish Boundary
Civil Parish Boundary
Admin. County or County Bor. Boundary
L B Bdy
London Borough Boundary
Symbol marking point where boundary mereing changes

BH	Beer House	P	Pillar, Pole or Post
BP, BS	Boundary Post or Stone	PO	Post Office
Cn, C	Capstan, Crane	PC	Public Convenience
Chy	Chimney	PH	Public House
D Fn	Drinking Fountain	Pp	Pump
El P	Electricity Pillar or Post	SB, S Br	Signal Box or Bridge
FAP	Fire Alarm Pillar	SP, SL	Signal Post or Light
FB	Foot Bridge	Spr	Spring
GP	Guide Post	Tk	Tank or Track
H	Hydrant or Hydraulic	TCB	Telephone Call Box
LC	Level Crossing	TCP	Telephone Call Post
MH	Manhole	Tr	Trough
MP	Mile Post or Mooring Post	Wr Pt, Wr T	Water Point, Water Tap
MS	Mile Stone	W	Well
NTL	Normal Tidal Limit	Wd Pp	Wind Pump

Large-Scale National Grid Data 1:2,500 and 1:1,250



Civil parish/community boundary
District boundary
County boundary
Boundary post/stone
Boundary mereing symbol (note: these always appear in opposed pairs or groups of three)

Bks	Barracks	P	Pillar, Pole or Post
Bty	Battery	PO	Post Office
Cemy	Cemetery	PC	Public Convenience
Chy	Chimney	Pp	Pump
Cis	Cistern	Ppg Sta	Pumping Station
Dismtd Rly	Dismantled Railway	PW	Place of Worship
El Gen Sta	Electricity Generating Station	Sewage Ppg Sta	Sewage Pumping Station
El P	Electricity Pole, Pillar	SB, S Br	Signal Box or Bridge
El Sub Sta	Electricity Sub Station	SP, SL	Signal Post or Light
FB	Filter Bed	Spr	Spring
Fn / D Fn	Fountain / Drinking Ftn.	Tk	Tank or Track
Gas Gov	Gas Valve Compound	Tr	Trough
GVC	Gas Governer	Wd Pp	Wind Pump
GP	Guide Post	Wr Pt, Wr T	Water Point, Water Tap
MH	Manhole	Wks	Works (building or area)
MP, MS	Mile Post or Mile Stone	W	Well

Envirocheck®

Historical Mapping & Photography included:

Mapping Type	Scale	Date	Pg
London	1:2,500	1878 - 1880	2
London	1:2,500	1896	3
London	1:2,500	1916	4
Historical Aerial Photography	1:1,250	1947	5
Ordnance Survey Plan	1:1,250	1952 - 1953	6
Ordnance Survey Plan	1:2,500	1953 - 1954	7
Additional SIMs	1:2,500	1953	8
Ordnance Survey Plan	1:1,250	1957 - 1963	9
Additional SIMs	1:1,250	1957 - 1982	10
Ordnance Survey Plan	1:2,500	1958 - 1966	11
Ordnance Survey Plan	1:2,500	1966	12
Ordnance Survey Plan	1:1,250	1968 - 1975	13
Additional SIMs	1:1,250	1968 - 1989	14
Supply of Unpublished Survey Information	1:1,250	1974 - 1976	15
Supply of Unpublished Survey Information	1:1,250	1976	16
Additional SIMs	1:1,250	1982 - 1987	17
Ordnance Survey Plan	1:1,250	1989	18
Additional SIMs	1:1,250	1990	19
Large-Scale National Grid Data	1:1,250	1991	20
Large-Scale National Grid Data	1:1,250	1991 - 1992	21
Large-Scale National Grid Data	1:1,250	1992 - 1996	22
Large-Scale National Grid Data	1:1,250	1993 - 1997	23
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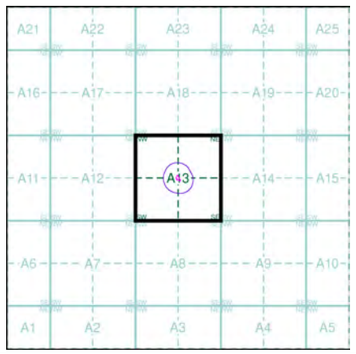
Historical Map - Segment A13



Order Details

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Slice:	A
Site Area (Ha):	0.08
Search Buffer (m):	100

Site Details

5 King William Street, LONDON, EC4N 7DA

Landmark Information Group

Tel: 0844 844 9952
Fax: 0844 844 9951
Web: www.envirocheck.co.uk

Historical Mapping Legends

Ordnance Survey County Series 1:10,560

Gravel Pit
Sand Pit
Other Pits
Quarry
Shingle
Orchard
Osiers
Reeds
Marsh
Mixed Wood
Deciduous
Brushwood
Fir
Furze
Rough Pasture
Arrow denotes flow of water
Trigonometrical Station
Site of Antiquities
Bench Mark
Pump, Guide Post, Signal Post
Well, Spring, Boundary Post
·285 Surface Level
Sketched Contour
Instrumental Contour
Main Roads
Fenced
Un-Fenced
Minor Roads
Fenced
Un-Fenced
Sunken Road
Raised Road
Road over Railway
Railway over River
Railway over Road
Level Crossing
Road over River or Canal
Road over Stream
Road over Stream
County Boundary (Geographical)
County & Civil Parish Boundary
Administrative County & Civil Parish Boundary
Co. Boro. Bdy. County Borough Boundary (England)
Co. Burgh Bdy. County Burgh Boundary (Scotland)
R.D. Bdy. Rural District Boundary
Civil Parish Boundary

Ordnance Survey Plan 1:10,000

Chalk Pit, Clay Pit or Quarry
Gravel Pit
Sand Pit
Disused Pit or Quarry
Refuse or Slag Heap
Lake, Loch or Pond
Dunes
Boulders
Coniferous Trees
Non-Coniferous Trees
Orchard
Scrub
Coppice
Bracken
Heath
Rough Grassland
Marsh
Reeds
Saltings
Building
Direction of Flow of Water
Shingle
Sand
Glasshouse
Pylon
Pylon
Electricity Transmission Line
Sloping Masonry
Cutting
Embankment
Standard Gauge Multiple Track
Road Under
Road Over
Level Crossing
Foot Bridge
Standard Gauge Single Track
Siding, Tramway or Mineral Line
Narrow Gauge
Geographical County
Administrative County, County Borough or County of City
Municipal Borough, Urban or Rural District, Burgh or District Council
Borough, Burgh or County Constituency
Shown only when not coincident with other boundaries
Civil Parish
Shown alternately when coincidence of boundaries occurs

BP, BS	Boundary Post or Stone	Pol Sta	Police Station
Ch	Church	PO	Post Office
CH	Club House	PC	Public Convenience
F E Sta	Fire Engine Station	PH	Public House
FB	Foot Bridge	SB	Signal Box
Fn	Fountain	Spr	Spring
GP	Guide Post	TCB	Telephone Call Box
MP	Mile Post	TCP	Telephone Call Post
MS	Mile Stone	W	Well

1:10,000 Raster Mapping

Gravel Pit
Refuse tip or slag heap
Rock
Rock (scattered)
Boulders
Boulders (scattered)
Shingle
Mud
Mud
Sand
Sand
Sand Pit
Slopes
Top of cliff
General detail
Underground detail
Overhead detail
Narrow gauge railway
Multi-track railway
Single track railway
County boundary (England only)
Civil, parish or community boundary
District, Unitary, Metropolitan, London Borough boundary
Constituency boundary
Area of wooded vegetation
Non-coniferous trees
Non-coniferous trees (scattered)
Coniferous trees
Coniferous trees (scattered)
Positioned tree
Orchard
Coppice or Osiers
Rough Grassland
Heath
Scrub
Marsh, Salt Marsh or Reeds
Water feature
Flow arrows
MHW(S) Mean high water (springs)
MLW(S) Mean low water (springs)
Telephone line (where shown)
Electricity transmission line (with poles)
BM 123.45 m Bench mark (where shown)
Triangulation station
Point feature (e.g. Guide Post or Mile Stone)
Pylon, flare stack or lighting tower
Site of (antiquity)
Glasshouse
General Building
Important Building

Envirocheck®

Historical Mapping & Photography included:

Mapping Type	Scale	Date	Pg
Surrey	1:10,560	1880	3
Middlesex	1:10,560	1882	4
London	1:10,560	1896	5
Surrey	1:10,560	1898	6
London	1:10,560	1920	7
London	1:10,560	1938	8
Ordnance Survey Plan	1:10,000	1940	9
Historical Aerial Photography	1:10,560	1948 - 1949	10
Ordnance Survey Plan	1:10,000	1954 - 1957	11
Ordnance Survey Plan	1:10,000	1962 - 1966	12
Ordnance Survey Plan	1:10,000	1968	13
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Ordnance Survey Plan	1:10,000	1979	15
Ordnance Survey Plan	1:10,000	1981	16
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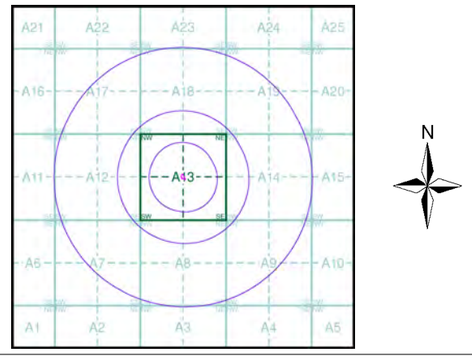
10K Raster Mapping	1:10,000	2009	22

Historical Map - Slice A



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Russian Military Mapping Legends

1:5,000 and 1:10,000 mapping

a. Not drawn to scale b. Drawn to scale

- Government and Administrative Buildings
- Military and Industrial Buildings
- Military and Communication Areas
- Subway Entrance
- Fireproof Building
- Prominent Fireproof Building
- Non-fireproof Building
- Non-fireproof Building (non-dwelling)
- Factory, mill, and flour mill, with chimneys
- Factory, mill, and flour mill, without chimneys
- Power Station, drawn to scale
- Hydroelectric Power Station
- Radio Station, drawn to scale
- Telephone Station, drawn to scale
- Abandoned Open-pit Mine or Quarry
- Open-pit Salt Mine
- Pit
- Oil Deposit or Well
- Oil Seepage
- Tailings Pile
- Fuel Storage Tanks
- Natural Gas Tank
- Bench Mark
- Drill Hole
- Burial Mound
- Triangulation Point on Burial Mound
- Single-track Railroad
- Double-track Railroad and Station Building
- Coniferous Forest
- Deciduous Forest
- Mixed Forest
- Lawns
- Citrus Orchard
- Wet Ground
- Scattered Vegetation

243,8 — Values for prominent elevations

186.0 — Numbers for spot elevations, depth soundings, contour lines, etc.

0,2 — Velocity of the current, width of river bed, depth of river

Fractional terms: length and capacity of bridges; depth of fords and condition of the river bottom; height of forest and the diameter of trees

Russian Alphabet (For reference and phonetic interpretation of map text)

А а (A)	З з (Z)	П п (P)	Ч ч (CH)
Б б (B)	И и (I)	Р р (R)	Ш ш (SH)
В в (V)	Й й (Y)	С с (S)	Щ щ (SHCH)
Г г (G)	К к (K)	Т т (T)	ъ (–)
Д д (D)	Л л (L)	У у (U)	ы (Y)
Е е (E)	М м (M)	Ф ф (F)	ь (')
Ё ё (YO)	Н н (N)	Х х (KH)	Э э (E)
Ж ж (ZH)	О о (O)	Ц ц (TS)	Ю ю (YU or IU)
			Я я (YA or IA)

1:25,000 mapping

a. Not drawn to scale b. Drawn to scale

- Government and Administrative Buildings
- Military and Industrial Buildings
- Military and Communication Areas
- Subway Entrance
- Partly Demolished Buildings
- Demolished Buildings
- Built-Up Area with Fireproof Buildings Predominant
- Built-Up Area with Non-Fireproof Buildings Predominant
- Individual Fireproof Building
- Prominent Industrial Building
- Individual Dwelling, Fireproof
- Ruins of an Individual Dwelling
- Factory or Mill Chimney
- Factory or Mill with Chimney
- Factory or Mill without Chimney
- Mine or Open Pit Mine
- Operating Shaft or Mine
- Non-Operating Shaft or Mine
- Salt Mine
- Tailings Pile
- Pit
- Stone Quarry
- Gas Pump or Service Station
- Fuel Storage or Natural Gas Tank
- Oil or Natural Gas Derrick
- Small Hydroelectric Power Station
- Power Station
- Transformer Station
- Cemetery
- Burial Mound (height in metres)
- Triangulation Point on Burial Mound
- Triangulation Point
- Bench Mark
- Bench Mark (monumented)
- Telegraph Office
- Telephone Station
- Radio Station
- Radio Tower
- Airfield or Seaplane Base
- Landing Strip
- Main Highway
- Highway under Construction
- Improved Dirt Road (former truck road)
- Double-track Railroad with First Class Station
- Dismantled Railroad
- Railroad Under Construction
- Shore Embankment
- River or Ditch with Embankment
- Direction and velocity of current
- Well
- Water Reservoir or Rain Water Pit
- Spring
- Isobath with value
- Heavy (Index) Contour Line
- Contour Line and Value
- Half Contour Line
- Spot Elevation Value
- Coniferous
- Deciduous
- Mixed
- Scrub

Key to Numbers on Mapping

TQ38_London

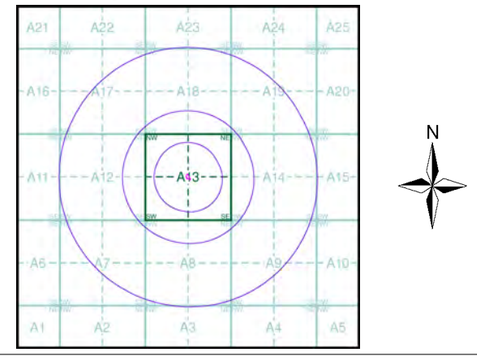
No.	Description
16	Exchange
17	Royal Exchange
20	Railway Station
23	Railway Station
24	Railway Station
25	Railway Station
34	Tower Of London
237	Military Barracks
253	Post Office
259	Council/Government Buildings/Courts
264	Council/Government Buildings/Courts
326	Custom House
366	Power Station (Thermo-Electric)

Envirocheck®

Historical Mapping & Photography included:

Mapping Type	Scale	Date	Pg
Surrey	1:10,560	1880	3
Middlesex	1:10,560	1882	4
London	1:10,560	1896	5
Surrey	1:10,560	1898	6
London	1:10,560	1920	7
London	1:10,560	1938	8
Ordnance Survey Plan	1:10,000	1940	9
Historical Aerial Photography	1:10,560	1948 - 1949	10
Ordnance Survey Plan	1:10,000	1954 - 1957	11
Ordnance Survey Plan	1:10,000	1962 - 1966	12
Ordnance Survey Plan	1:10,000	1968	13
Ordnance Survey Plan	1:10,000	1972 - 1975	14
Ordnance Survey Plan	1:10,000	1979	15
Ordnance Survey Plan	1:10,000	1981	16
London	1:25,000	1985	17
Ordnance Survey Plan	1:10,000	1988	18
Ordnance Survey Plan	1:10,000	1995	19
10K Raster Mapping	1:10,000	1999	20
10K Raster Mapping	1:10,000	2006	21
10K Raster Mapping	1:10,000	2009	22

Russian Map - Slice A



Order Details

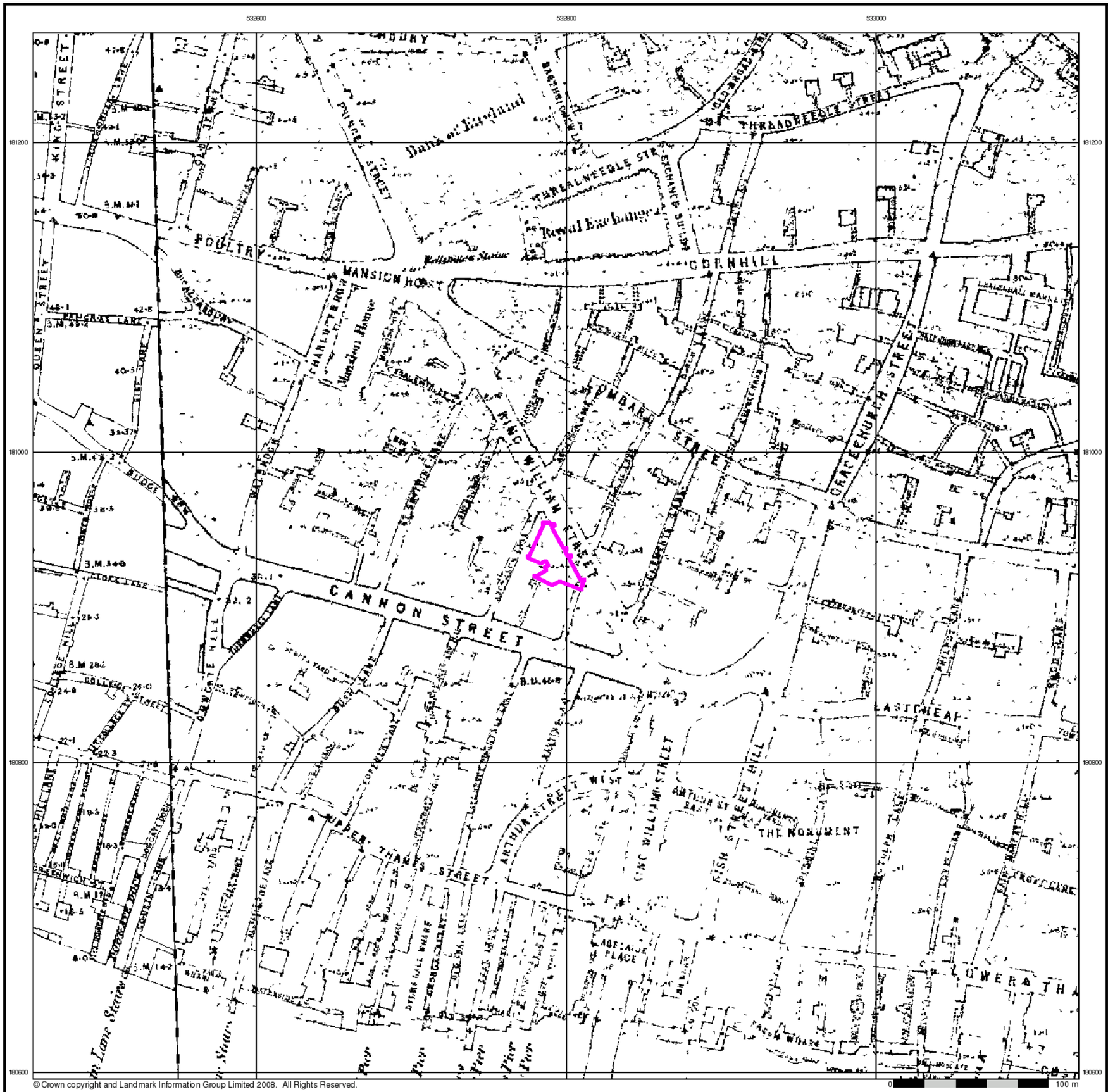
Order Number:	29551950_1_1
Customer Ref:	261008
National Grid Reference:	532790, 180930
Slice:	A
Site Area (Ha):	0.08
Search Buffer (m):	1000

Site Details

5 King William Street, LONDON, EC4N 7DA

Landmark Information Group

Tel: 0844 844 9952
Fax: 0844 844 9951
Web: www.envirocheck.co.uk



Envirocheck® Historical

London

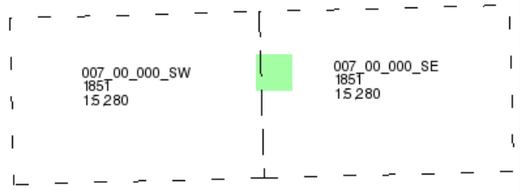
Published 1851

Source map scale - 1:5,280

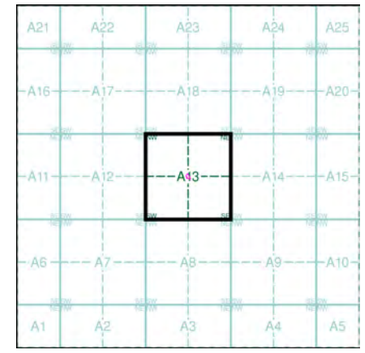
The historical town plans shown derive from Ordnance Survey mapping from the early to mid 1850s. The 1:2640 scale was introduced in the early 1850s, to survey districts covered by the Local Boards of Health and for a map of the Osborne Estate of Queen Victoria. The general style is similar to that of the early 1:2500s published shortly afterwards.
1:5280 scale was surveyed shortly afterwards in the mid 1850s as general purpose mapping with a standard of content similar to the more contemporary 1:10.560 mapping. The scale was also used for a reduction of the 1:1056 'skeleton survey' of London that was undertaken between 1848 and 1850.

Please note: Due to the partial coverage of Historical Town Plans, it is possible that not all segments within an order will contain mapping. Only the segments that have Town Plan coverage will be generated.

Map Name(s) and Date(s)



Historical Town Plan - Segment A13



Order Details

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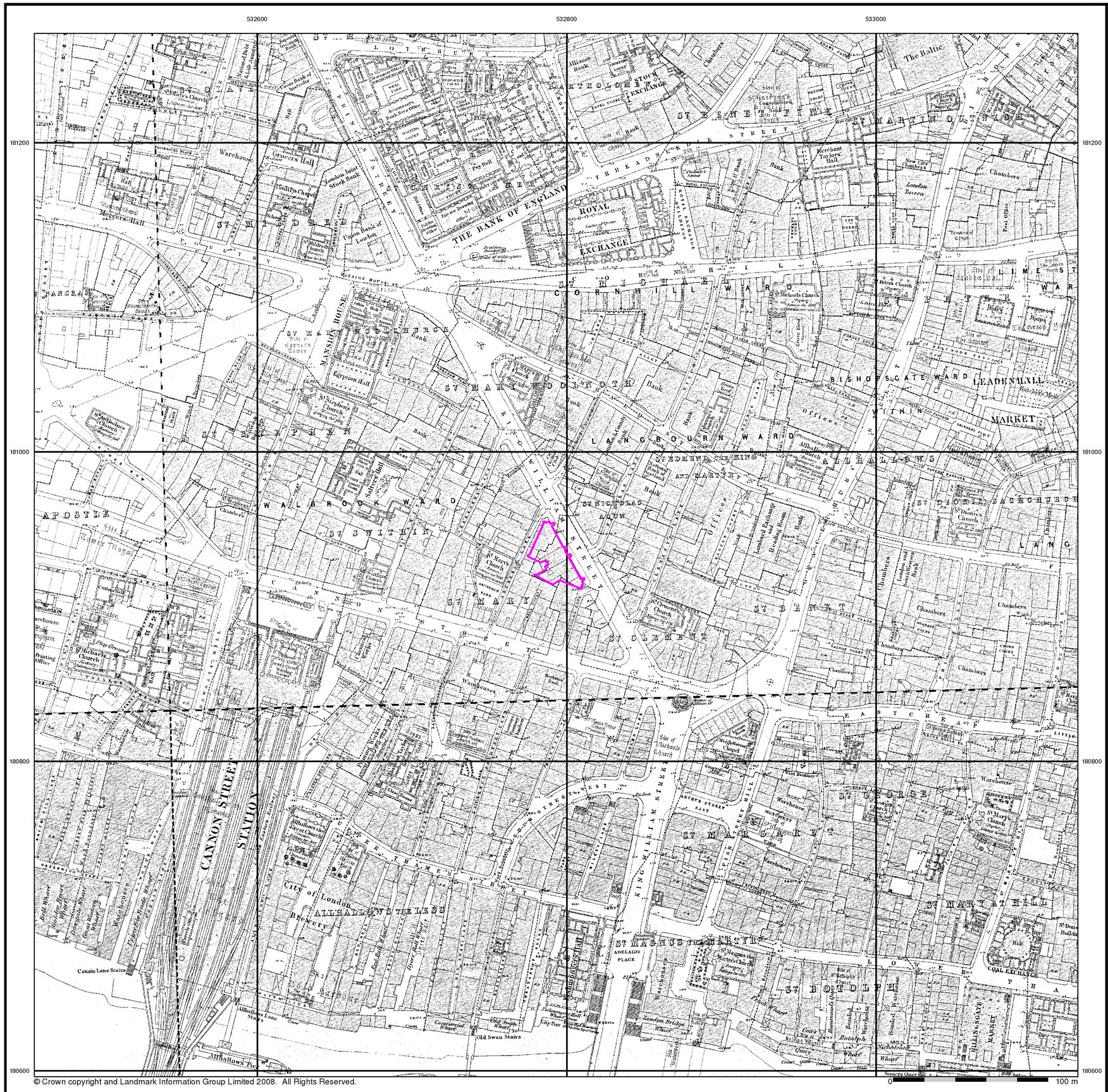


Envirocheck® Historical

London

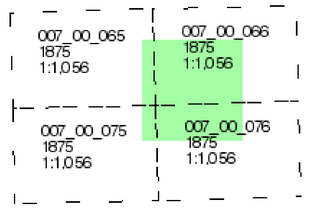
Published 1875

Source map scale - 1:1,056

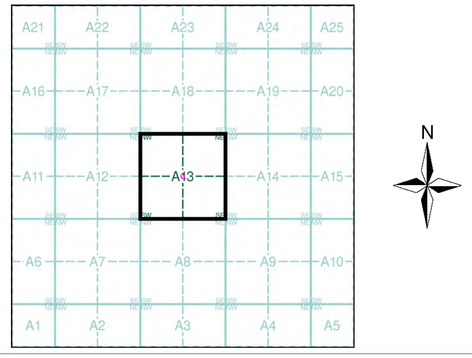
The 1:1056 scale of Ordnance Survey mapping was adopted from Ireland in 1848 and was used to survey towns with a population of over 4000, plus county towns of lesser population, in those counties mapped at the six-inch scale in 1841-55. The scale was the largest scale at which London was mapped by the Ordnance Survey and a 'skeleton' survey of the capital, showing little more than streets, street names, frontages and altitudes, was undertaken between 1848 and 1850. The majority of the 1:1056 surveys were later replaced by 1:500 surveys; although almost all the remainder were revised at this scale, sometimes more than once before 1895. The type of detail shown on the 1:1056 scale is broadly similar to that on 1:500; the apparent omission of minor details such as sewer access points and street lights may be as much a reflection of the generally earlier date of these plans, as of the specification of the map.

Please note: Due to the partial coverage of Historical Town Plans, it is possible that not all segments within an order will contain mapping. Only the segments that have Town Plan coverage will be generated.

Map Name(s) and Date(s)



Historical Town Plan - Segment A13



Order Details

Order Number:	29551950_1_1
Customer Ref:	261008
National Grid Reference:	532790, 180930
Slice:	A
Site Area (Ha):	0.08
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London

Published 1878 - 1880

Source map scale - 1:2,500

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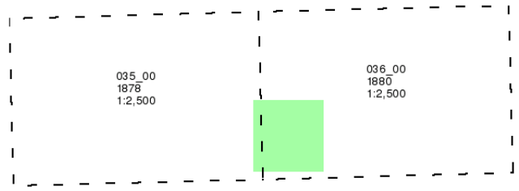
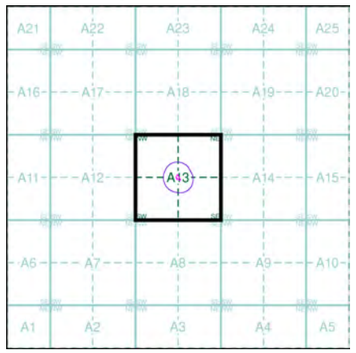
Map Name(s) and Date(s)



Historical Map - Segment A13



Order Details

Order Number:	29551950_1_1
Customer Ref:	261008
National Grid Reference:	532790, 180930
Slice:	A
Site Area (Ha):	0.08
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Site Details

5 King William Street, LONDON, EC4N 7DA

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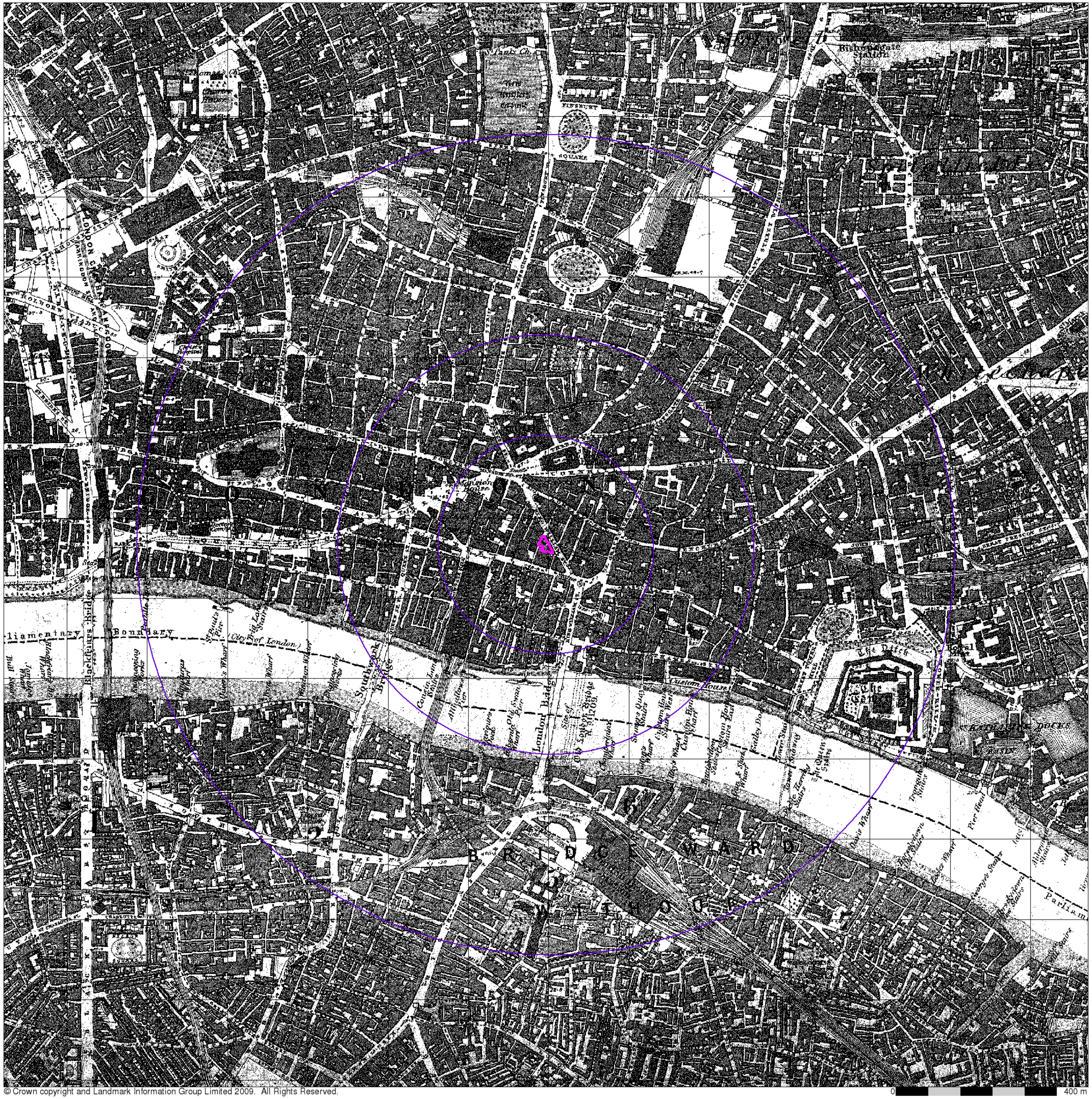


0 400 m

Envirocheck®

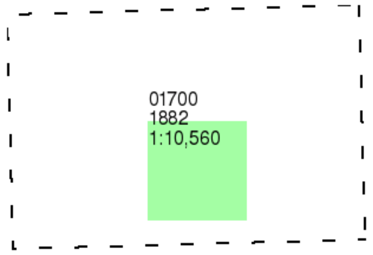
Middlesex

Published 1882

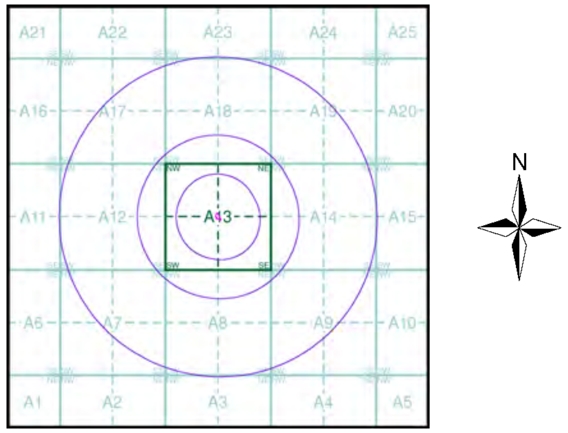
Source map scale - 1:10,560

The historical maps shown were reproduced from maps predominantly held at the scale adopted for England, Wales and Scotland in the 1840`s. In 1854 the 1:2,500 scale was adopted for mapping urban areas; these maps were used to update the 1:10,560 maps. The published date given therefore is often some years later than the surveyed date. Before 1938, all OS maps were based on the Cassini Projection, with independent surveys of a single county or group of counties, giving rise to significant inaccuracies in outlying areas. In the late 1940`s, a Provisional Edition was produced, which updated the 1:10,560 mapping from a number of sources. The maps appear unfinished - with all military camps and other strategic sites removed. These maps were initially overprinted with the National Grid. In 1970, the first 1:10,000 maps were produced using the Transverse Mercator Projection. The revision process continued until recently, with new editions appearing every 10 years or so for urban areas.

Map Name(s) and Date(s)



Historical Map - Slice A



Order Details

Order Number:	29551950_1_1
Customer Ref:	261008
National Grid Reference:	532790, 180930
Slice:	A
Site Area (Ha):	0.08
Search Buffer (m):	1000

Site Details

5 King William Street, LONDON, EC4N 7DA

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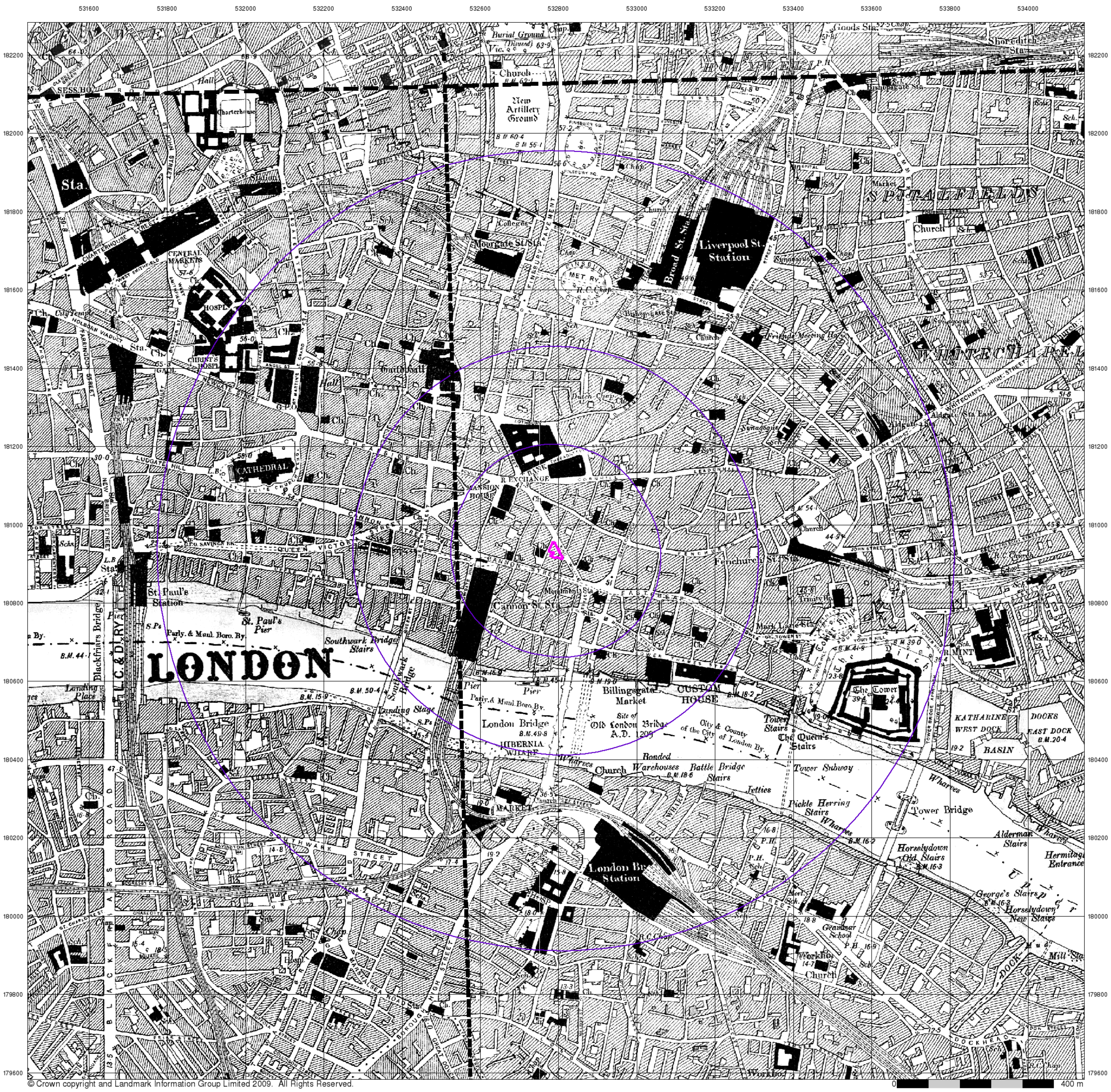


Envirocheck®

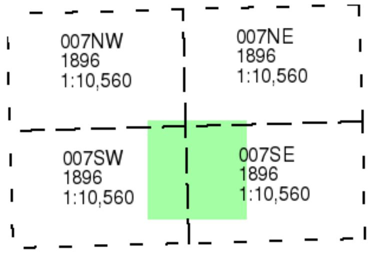
London

Published 1896

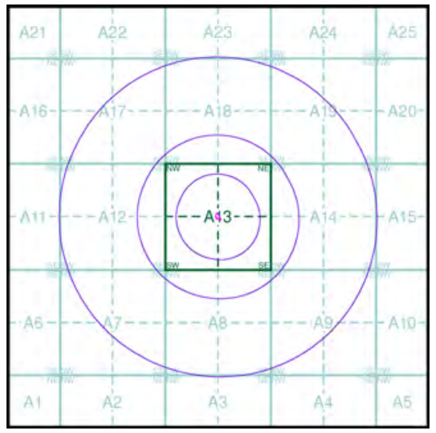
Source map scale - 1:10,560

The historical maps shown were reproduced from maps predominantly held at the scale adopted for England, Wales and Scotland in the 1840`s. In 1854 the 1:2,500 scale was adopted for mapping urban areas; these maps were used to update the 1:10,560 maps. The published date given therefore is often some years later than the surveyed date. Before 1938, all OS maps were based on the Cassini Projection, with independent surveys of a single county or group of counties, giving rise to significant inaccuracies in outlying areas. In the late 1940`s, a Provisional Edition was produced, which updated the 1:10,560 mapping from a number of sources. The maps appear unfinished - with all military camps and other strategic sites removed. These maps were initially overprinted with the National Grid. In 1970, the first 1:10,000 maps were produced using the Transverse Mercator Projection. The revision process continued until recently, with new editions appearing every 10 years or so for urban areas.

Map Name(s) and Date(s)



Historical Map - Slice A



N

Order Details

Order Number:	29551950_1_1
Customer Ref:	261008
National Grid Reference:	532790, 180930
Slice:	A
Site Area (Ha):	0.08
Search Buffer (m):	1000

Site Details

5 King William Street, LONDON, EC4N 7DA

Landmark Information Group
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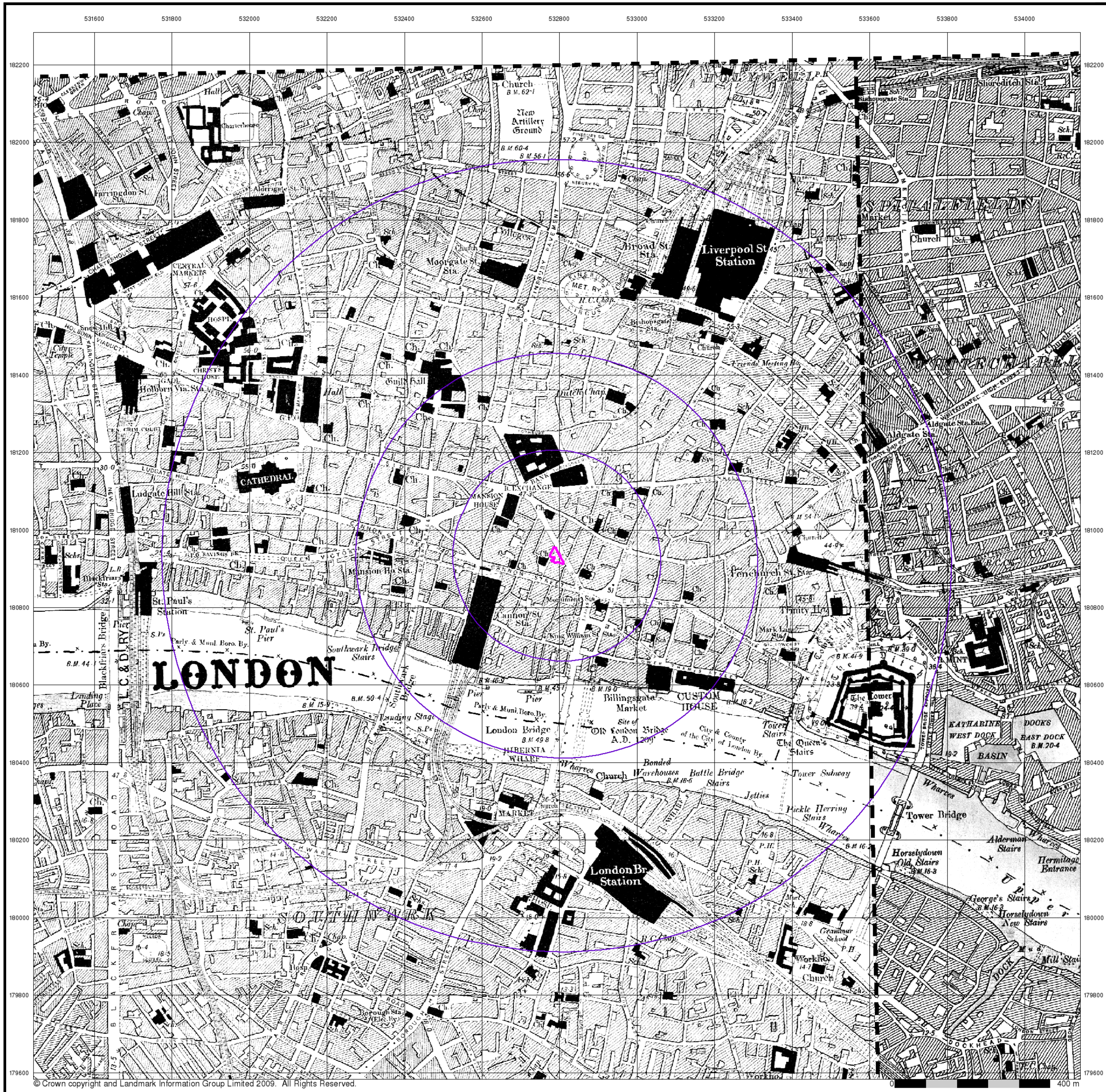


Envirocheck®

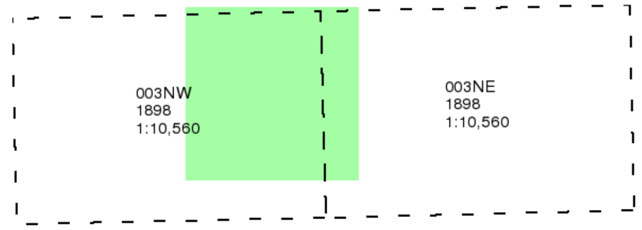
Surrey

Published 1898

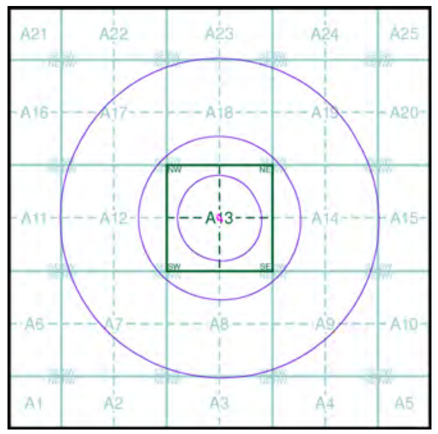
Source map scale - 1:10,560

The historical maps shown were reproduced from maps predominantly held at the scale adopted for England, Wales and Scotland in the 1840`s. In 1854 the 1:2,500 scale was adopted for mapping urban areas; these maps were used to update the 1:10,560 maps. The published date given therefore is often some years later than the surveyed date. Before 1938, all OS maps were based on the Cassini Projection, with independent surveys of a single county or group of counties, giving rise to significant inaccuracies in outlying areas. In the late 1940`s, a Provisional Edition was produced, which updated the 1:10,560 mapping from a number of sources. The maps appear unfinished - with all military camps and other strategic sites removed. These maps were initially overprinted with the National Grid. In 1970, the first 1:10,000 maps were produced using the Transverse Mercator Projection. The revision process continued until recently, with new editions appearing every 10 years or so for urban areas.

Map Name(s) and Date(s)



Historical Map - Slice A



N

Order Details

Order Number: 29551950_1_1
Customer Ref: 261008
National Grid Reference: 532790, 180930
Slice: A
Site Area (Ha): 0.08
Search Buffer (m): 1000

Site Details

5 King William Street, LONDON, EC4N 7DA

Landmark Information Group
Tel: 0844 844 9952
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Web: www.envirocheck.co.uk

Envirocheck®

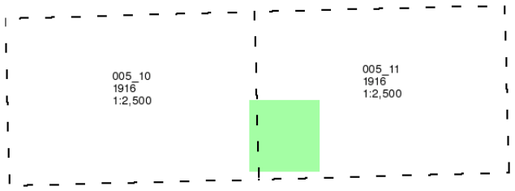
London

Published 1916

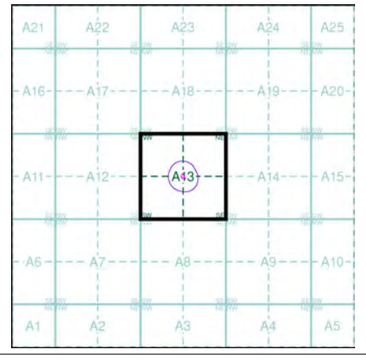
Source map scale - 1:2,500

The historical maps shown were reproduced from maps predominantly held at the scale adopted for England, Wales and Scotland in the 1840`s. In 1854 the 1:2,500 scale was adopted for mapping urban areas and by 1896 it covered the whole of what were considered to be the cultivated parts of Great Britain. The published date given below is often some years later than the surveyed date. Before 1938, all OS maps were based on the Cassini Projection, with independent surveys of a single county or group of counties, giving rise to significant inaccuracies in outlying areas.

Map Name(s) and Date(s)



Historical Map - Segment A13



Order Details

Order Number:	29551950_1_1
Customer Ref:	261008
National Grid Reference:	532790, 180930
Slice:	A
Site Area (Ha):	0.08
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Site Details

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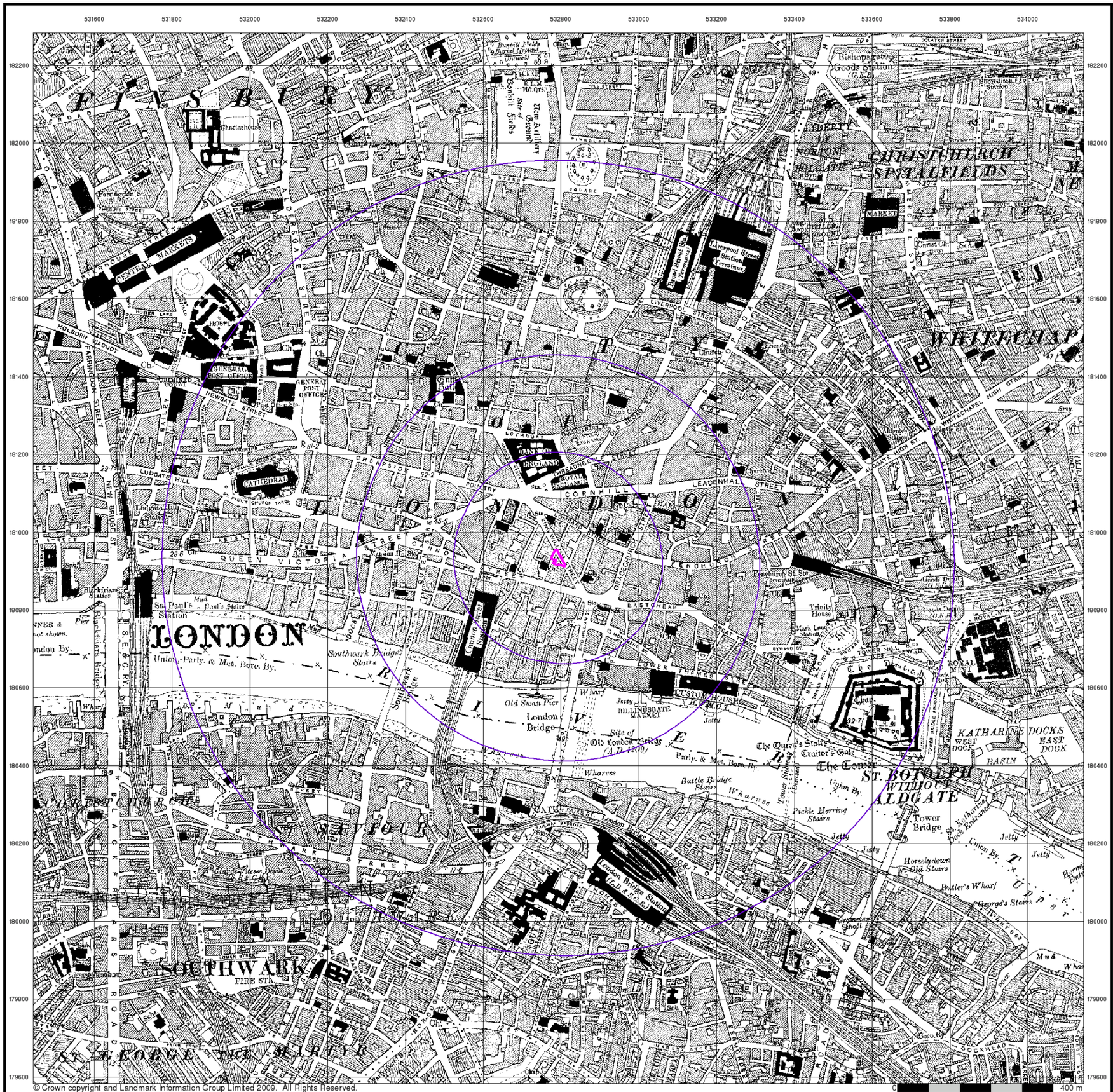


Envirocheck®

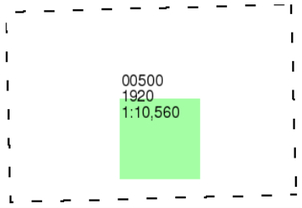
London

Published 1920

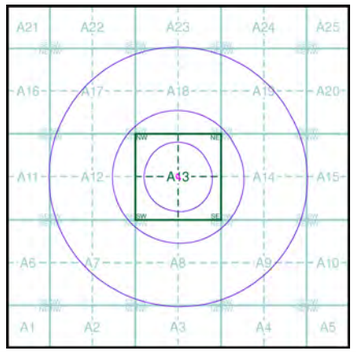
Source map scale - 1:10,560

The historical maps shown were reproduced from maps predominantly held at the scale adopted for England, Wales and Scotland in the 1840`s. In 1854 the 1:2,500 scale was adopted for mapping urban areas; these maps were used to update the 1:10,560 maps. The published date given therefore is often some years later than the surveyed date. Before 1938, all OS maps were based on the Cassini Projection, with independent surveys of a single county or group of counties, giving rise to significant inaccuracies in outlying areas. In the late 1940`s, a Provisional Edition was produced, which updated the 1:10,560 mapping from a number of sources. The maps appear unfinished - with all military camps and other strategic sites removed. These maps were initially overprinted with the National Grid. In 1970, the first 1:10,000 maps were produced using the Transverse Mercator Projection. The revision process continued until recently, with new editions appearing every 10 years or so for urban areas.

Map Name(s) and Date(s)



Historical Map - Slice A



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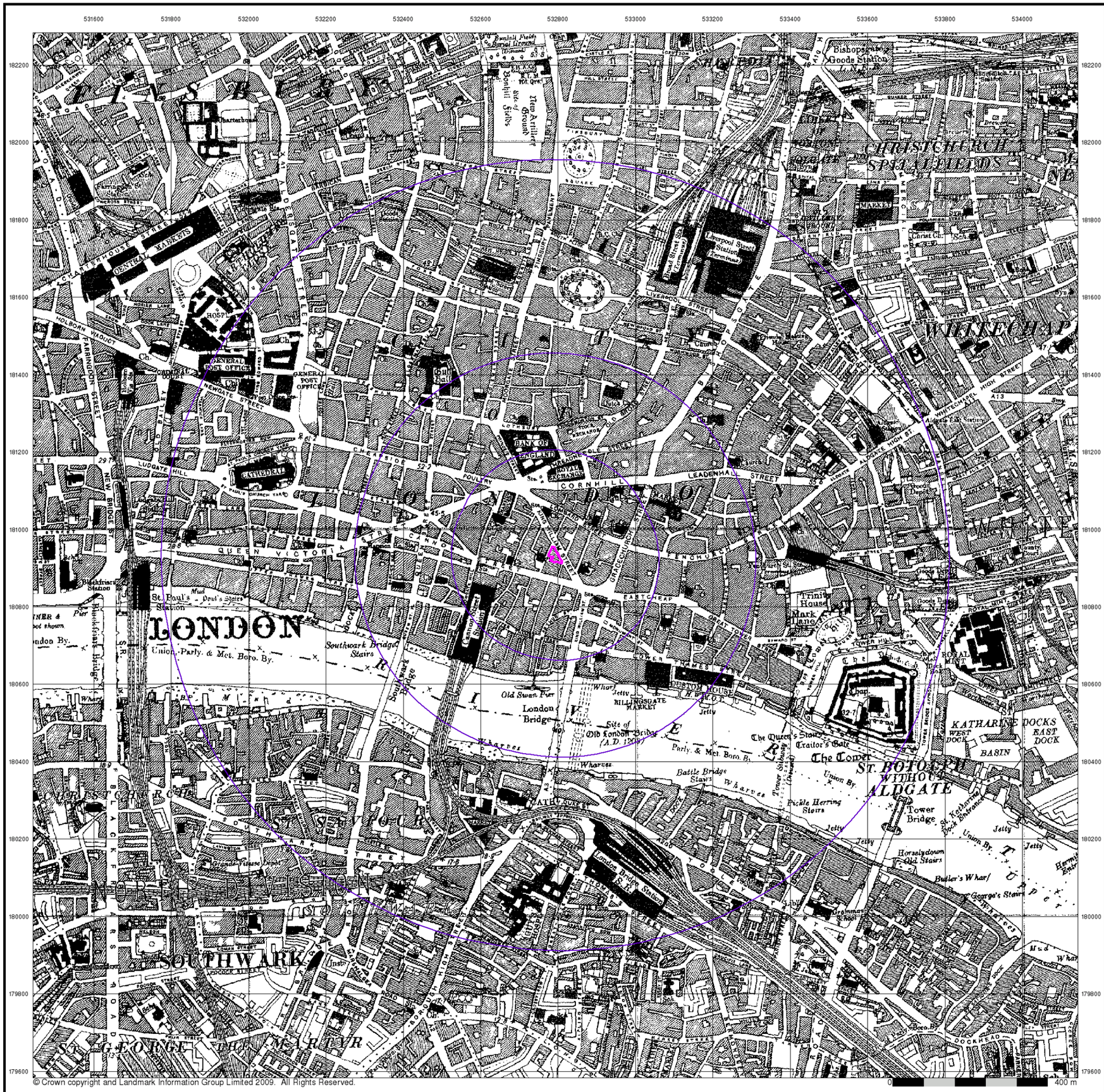

Envirocheck®

London

Published 1938

Source map scale - 1:10,560

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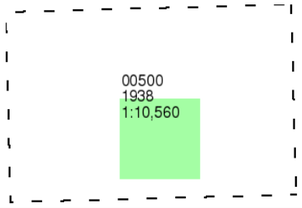
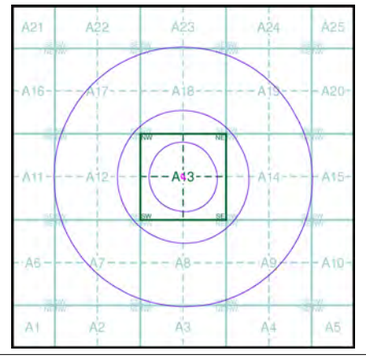
Map Name(s) and Date(s)



Historical Map - Slice A



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Fax: 0844 844 9951
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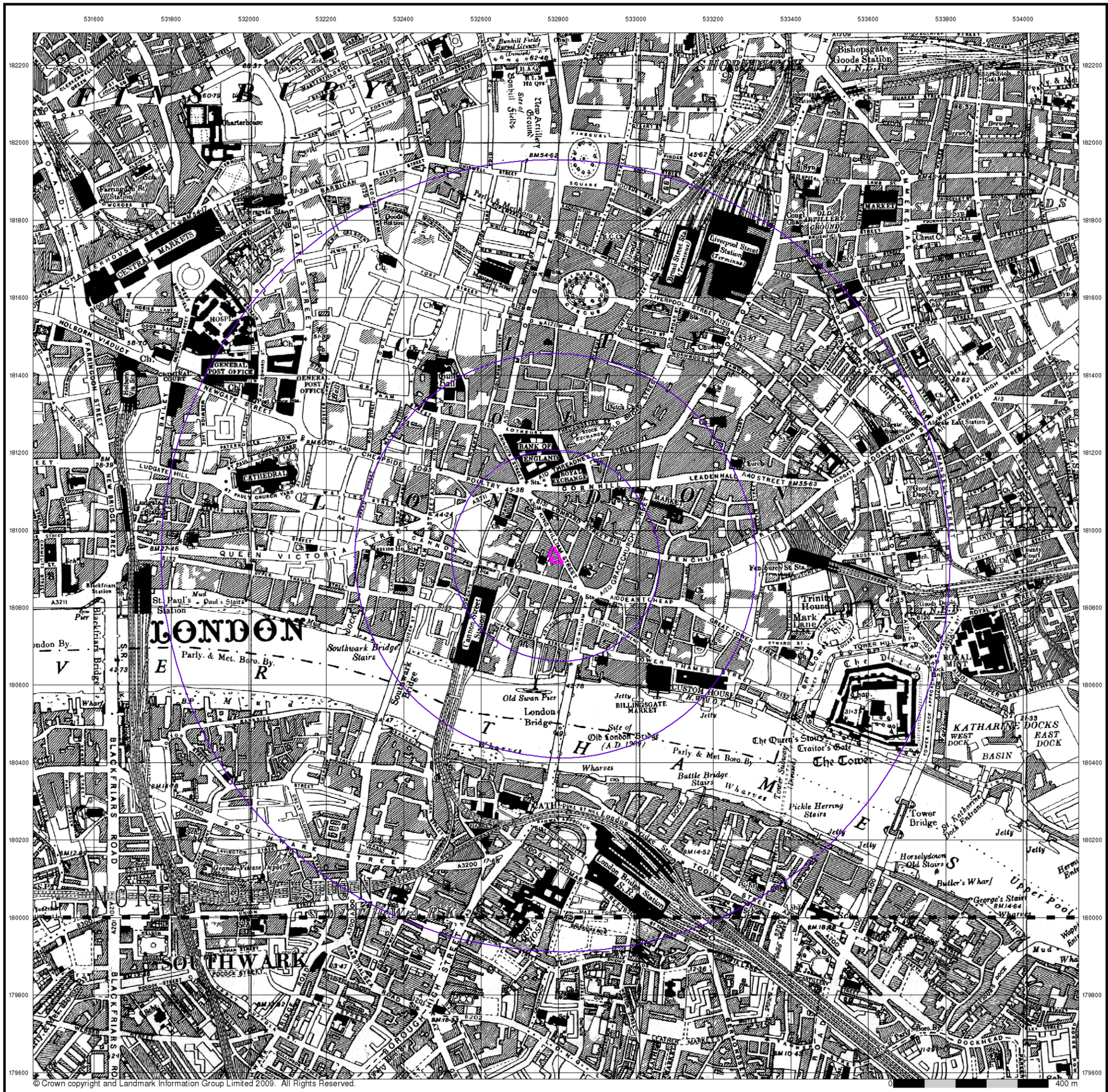

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Ordnance Survey Plan

Published 1940

Source map scale - 1:10,000

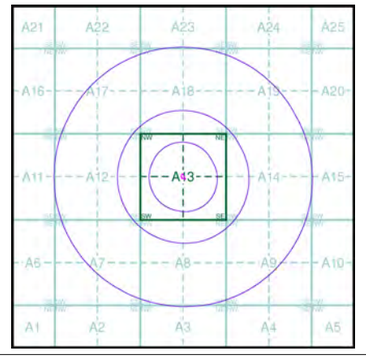
The historical maps shown were reproduced from maps predominantly held at the scale adopted for England, Wales and Scotland in the 1840`s. In 1854 the 1:2,500 scale was adopted for mapping urban areas; these maps were used to update the 1:10,560 maps. The published date given therefore is often some years later than the surveyed date. Before 1938, all OS maps were based on the Cassini Projection, with independent surveys of a single county or group of counties, giving rise to significant inaccuracies in outlying areas. In the late 1940`s, a Provisional Edition was produced, which updated the 1:10,560 mapping from a number of sources. The maps appear unfinished - with all military camps and other strategic sites removed. These maps were initially overprinted with the National Grid. In 1970, the first 1:10,000 maps were produced using the Transverse Mercator Projection. The revision process continued until recently, with new editions appearing every 10 years or so for urban areas.

Map Name(s) and Date(s)

TQ38SW
1940
1:10,560

TQ37NW
1940
1:10,560

Historical Map - Slice A



Order Details

Order Number:	29551950_1_1
Customer Ref:	261008
National Grid Reference:	532790, 180930
Slice:	A
Site Area (Ha):	0.08
Search Buffer (m):	1000

Site Details

5 King William Street, LONDON, EC4N 7DA

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Ordnance Survey Plan

Published 1952 - 1953

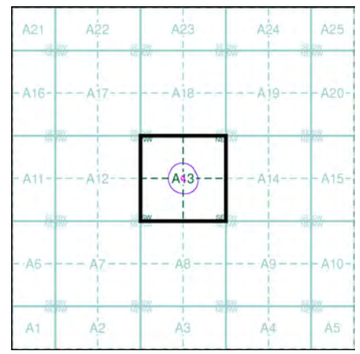
Source map scale - 1:1,250

The historical maps shown were reproduced from maps predominantly held at the scale adopted for England, Wales and Scotland in the 1840`s. In 1854 the 1:2,500 scale was adopted for mapping urban areas and by 1896 it covered the whole of what were considered to be the cultivated parts of Great Britain. The published date given below is often some years later than the surveyed date. Before 1938, all OS maps were based on the Cassini Projection, with independent surveys of a single county or group of counties, giving rise to significant inaccuracies in outlying areas.

Map Name(s) and Date(s)

TQ3281SW 1953 1:1,250	TQ3281SE 1953 1:1,250	TQ3381SW 1952 1:1,250
TQ3280NW 1952 1:1,250	TQ3280NE 1952 1:1,250	TQ3380NW 1952 1:1,250

Historical Map - Segment A13



Order Details

Order Number:	29551950_1_1
Customer Ref:	261008
National Grid Reference:	532790, 180930
Slice:	A
Site Area (Ha):	0.08
Search Buffer (m):	100

Site Details

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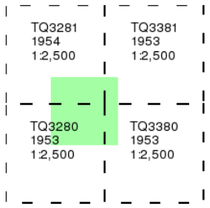
Ordnance Survey Plan

Published 1953 - 1954

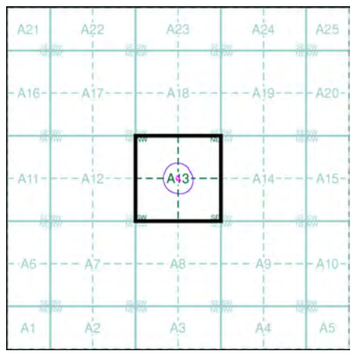
Source map scale - 1:2,500

The historical maps shown were reproduced from maps predominantly held at the scale adopted for England, Wales and Scotland in the 1840`s. In 1854 the 1:2,500 scale was adopted for mapping urban areas and by 1896 it covered the whole of what were considered to be the cultivated parts of Great Britain. The published date given below is often some years later than the surveyed date. Before 1938, all OS maps were based on the Cassini Projection, with independent surveys of a single county or group of counties, giving rise to significant inaccuracies in outlying areas.

Map Name(s) and Date(s)



Historical Map - Segment A13



Order Details

Order Number:	29551950_1_1
Customer Ref:	261008
National Grid Reference:	532790, 180930
Slice:	A
Site Area (Ha):	0.08
Search Buffer (m):	100

Site Details

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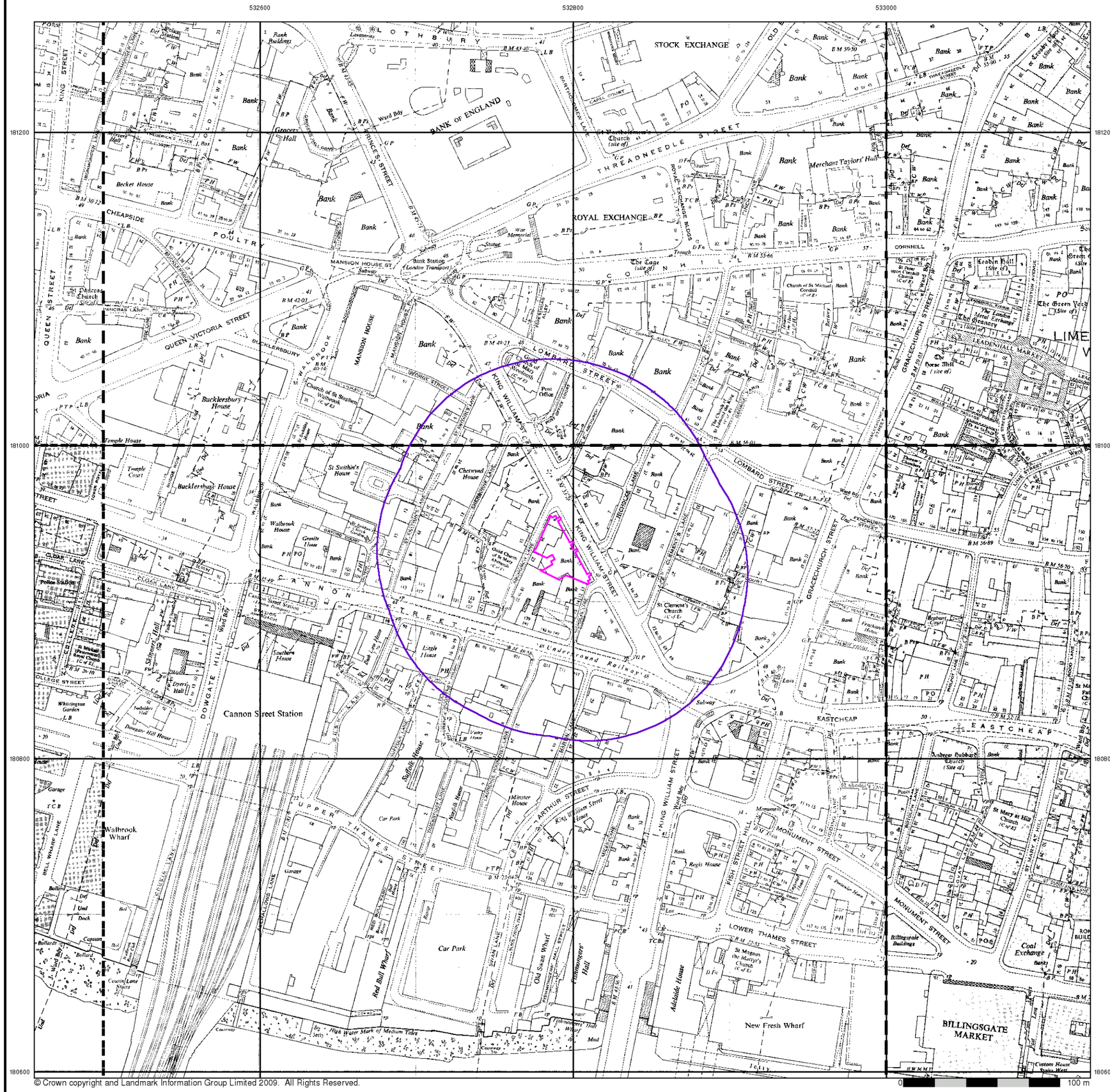

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Ordnance Survey Plan

Published 1957 - 1963

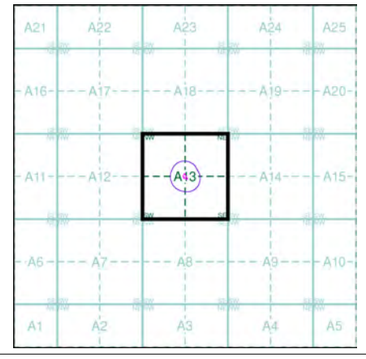
Source map scale - 1:1,250

The historical maps shown were reproduced from maps predominantly held at the scale adopted for England, Wales and Scotland in the 1840`s. In 1854 the 1:2,500 scale was adopted for mapping urban areas and by 1896 it covered the whole of what were considered to be the cultivated parts of Great Britain. The published date given below is often some years later than the surveyed date. Before 1938, all OS maps were based on the Cassini Projection, with independent surveys of a single county or group of counties, giving rise to significant inaccuracies in outlying areas.

Map Name(s) and Date(s)

TQ3281SW 1958 1:1,250	TQ3281SE 1962 1:1,250	TQ3381SW 1959 1:1,250
TQ3280NW 1963 1:1,250	TQ3280NE 1963 1:1,250	TQ3380NW 1957 1:1,250

Historical Map - Segment A13

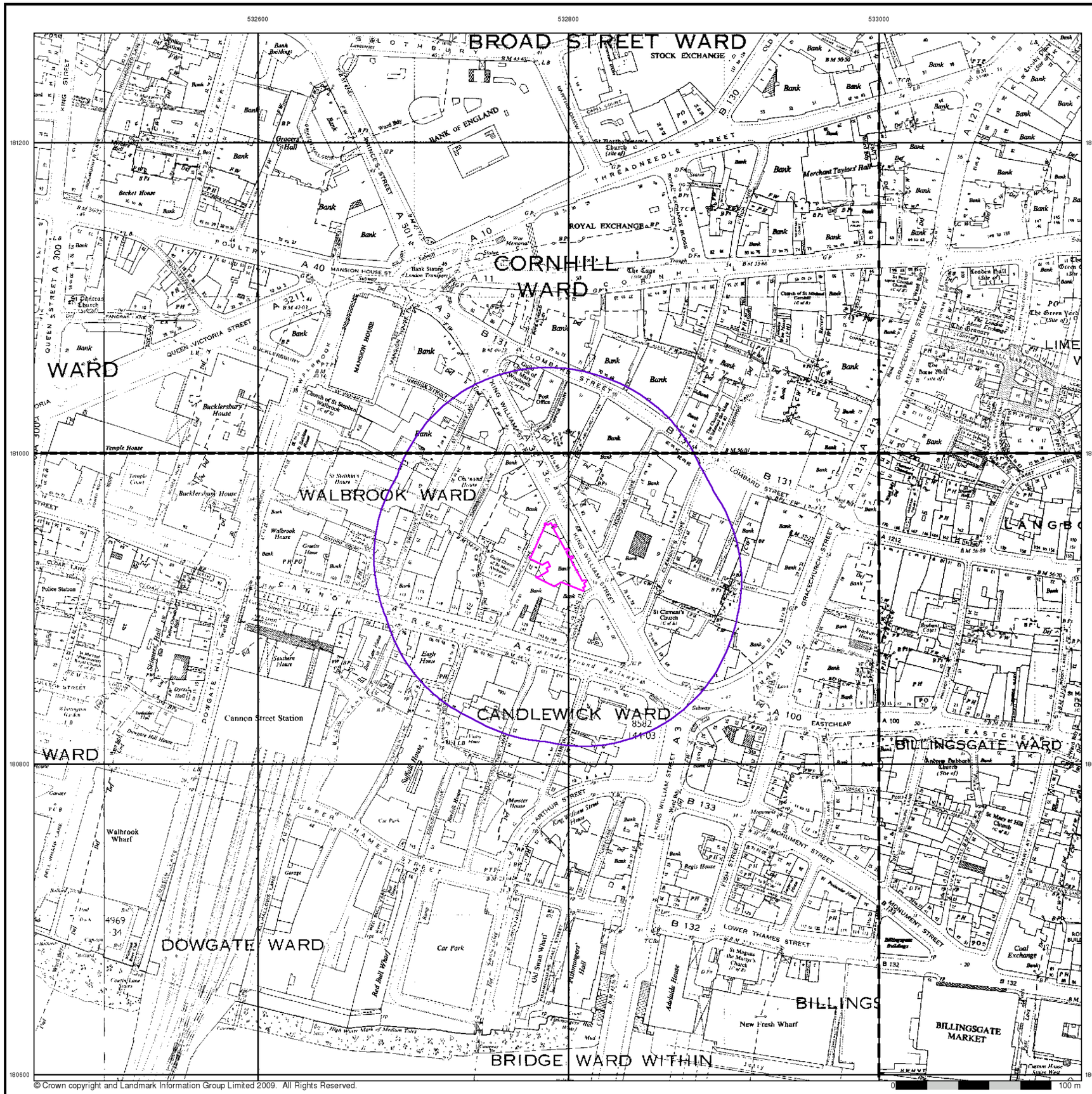


Order Details

Order Number:	29551950_1_1
Customer Ref:	261008
National Grid Reference:	532790, 180930
Slice:	A
Site Area (Ha):	0.08
Search Buffer (m):	100

Site Details

5 King William Street, LONDON, EC4N 7DA



Envirocheck®

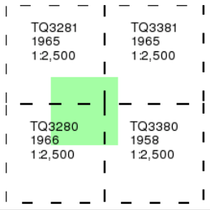
Ordnance Survey Plan

Published 1958 - 1966

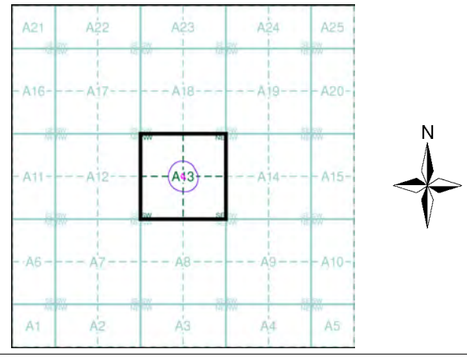
Source map scale - 1:2,500

The historical maps shown were reproduced from maps predominantly held at the scale adopted for England, Wales and Scotland in the 1840`s. In 1854 the 1:2,500 scale was adopted for mapping urban areas and by 1896 it covered the whole of what were considered to be the cultivated parts of Great Britain. The published date given below is often some years later than the surveyed date. Before 1938, all OS maps were based on the Cassini Projection, with independent surveys of a single county or group of counties, giving rise to significant inaccuracies in outlying areas.

Map Name(s) and Date(s)



Historical Map - Segment A13



Order Details

Order Number:	29551950_1_1
Customer Ref:	261008
National Grid Reference:	532790, 180930
Slice:	A
Site Area (Ha):	0.08
Search Buffer (m):	100

Site Details

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Ordnance Survey Plan

Published 1968 - 1975

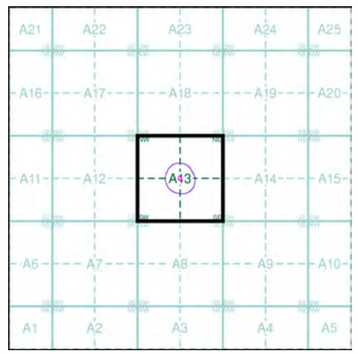
Source map scale - 1:1,250

The historical maps shown were reproduced from maps predominantly held at the scale adopted for England, Wales and Scotland in the 1840`s. In 1854 the 1:2,500 scale was adopted for mapping urban areas and by 1896 it covered the whole of what were considered to be the cultivated parts of Great Britain. The published date given below is often some years later than the surveyed date. Before 1938, all OS maps were based on the Cassini Projection, with independent surveys of a single county or group of counties, giving rise to significant inaccuracies in outlying areas.

Map Name(s) and Date(s)

TQ3281SW 1968 1:1,250	TQ3281SE 1971 1:1,250	TQ3381SW 1970 1:1,250
TQ3280NW 1975 1:1,250	TQ3280NE 1972 1:1,250	TQ3380NW 1971 1:1,250

Historical Map - Segment A13



Order Details

Order Number:	29551950_1_1
Customer Ref:	261008
National Grid Reference:	532790, 180930
Slice:	A
Site Area (Ha):	0.08
Search Buffer (m):	100

Site Details

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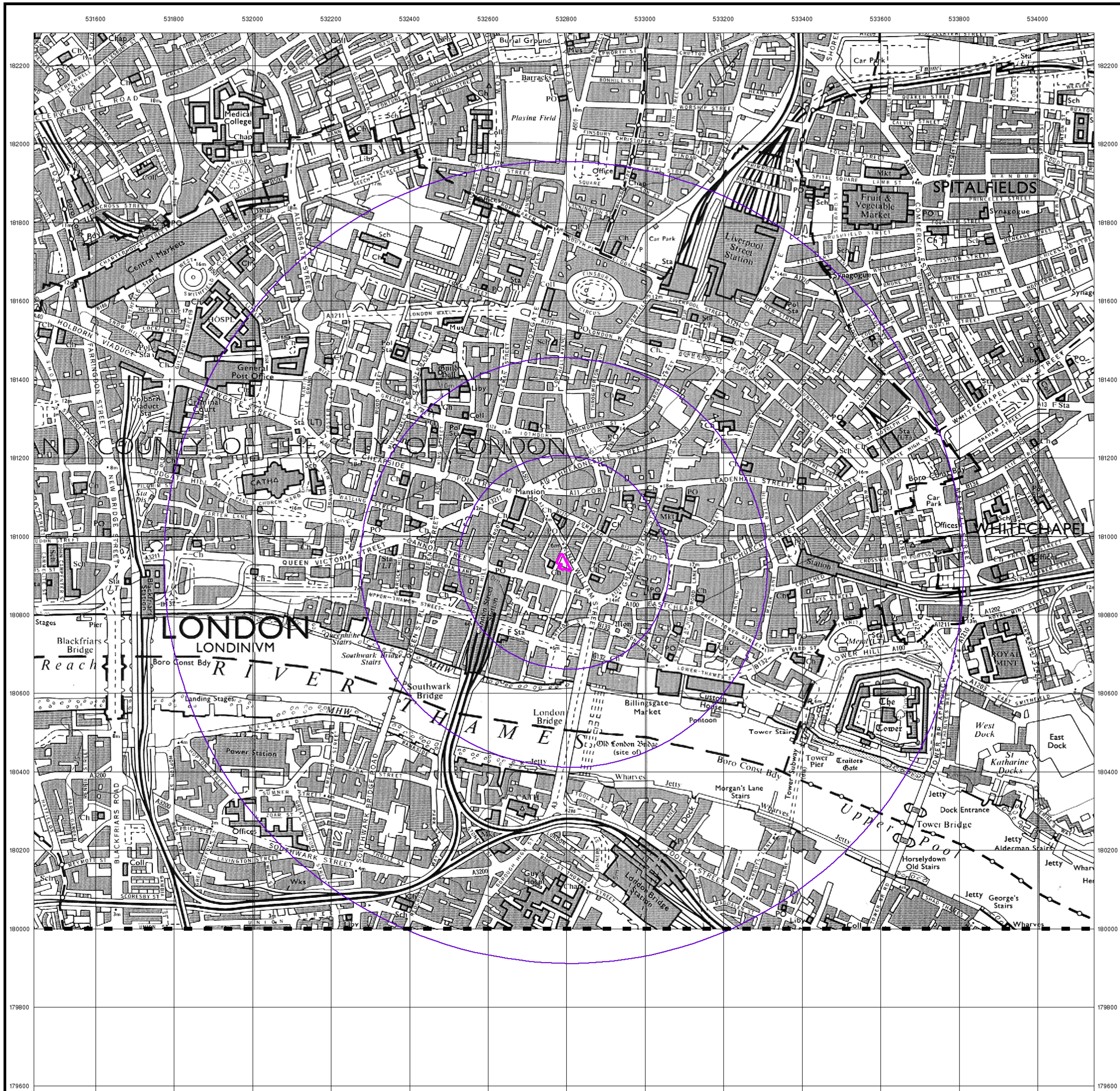


0 400 m

Envirocheck®

Ordnance Survey Plan

Published 1979

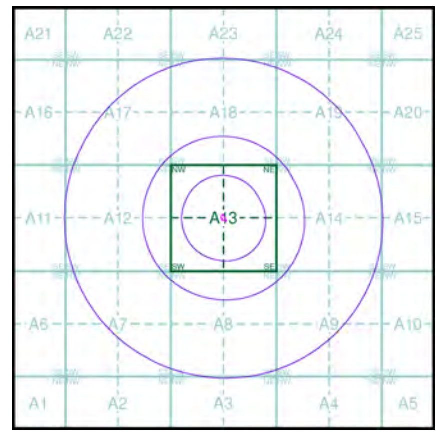
Source map scale - 1:10,000

The historical maps shown were reproduced from maps predominantly held at the scale adopted for England, Wales and Scotland in the 1840`s. In 1854 the 1:2,500 scale was adopted for mapping urban areas; these maps were used to update the 1:10,560 maps. The published date given therefore is often some years later than the surveyed date. Before 1938, all OS maps were based on the Cassini Projection, with independent surveys of a single county or group of counties, giving rise to significant inaccuracies in outlying areas. In the late 1940`s, a Provisional Edition was produced, which updated the 1:10,560 mapping from a number of sources. The maps appear unfinished - with all military camps and other strategic sites removed. These maps were initially overprinted with the National Grid. In 1970, the first 1:10,000 maps were produced using the Transverse Mercator Projection. The revision process continued until recently, with new editions appearing every 10 years or so for urban areas.

Map Name(s) and Date(s)

TQ38SW
1979
1:10,000

Historical Map - Slice A



N

Order Details

Order Number: 29551950_1_1
Customer Ref: 261008
National Grid Reference: 532790, 180930
Slice: A
Site Area (Ha): 0.08
Search Buffer (m): 1000

Site Details

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Landmark Information Group

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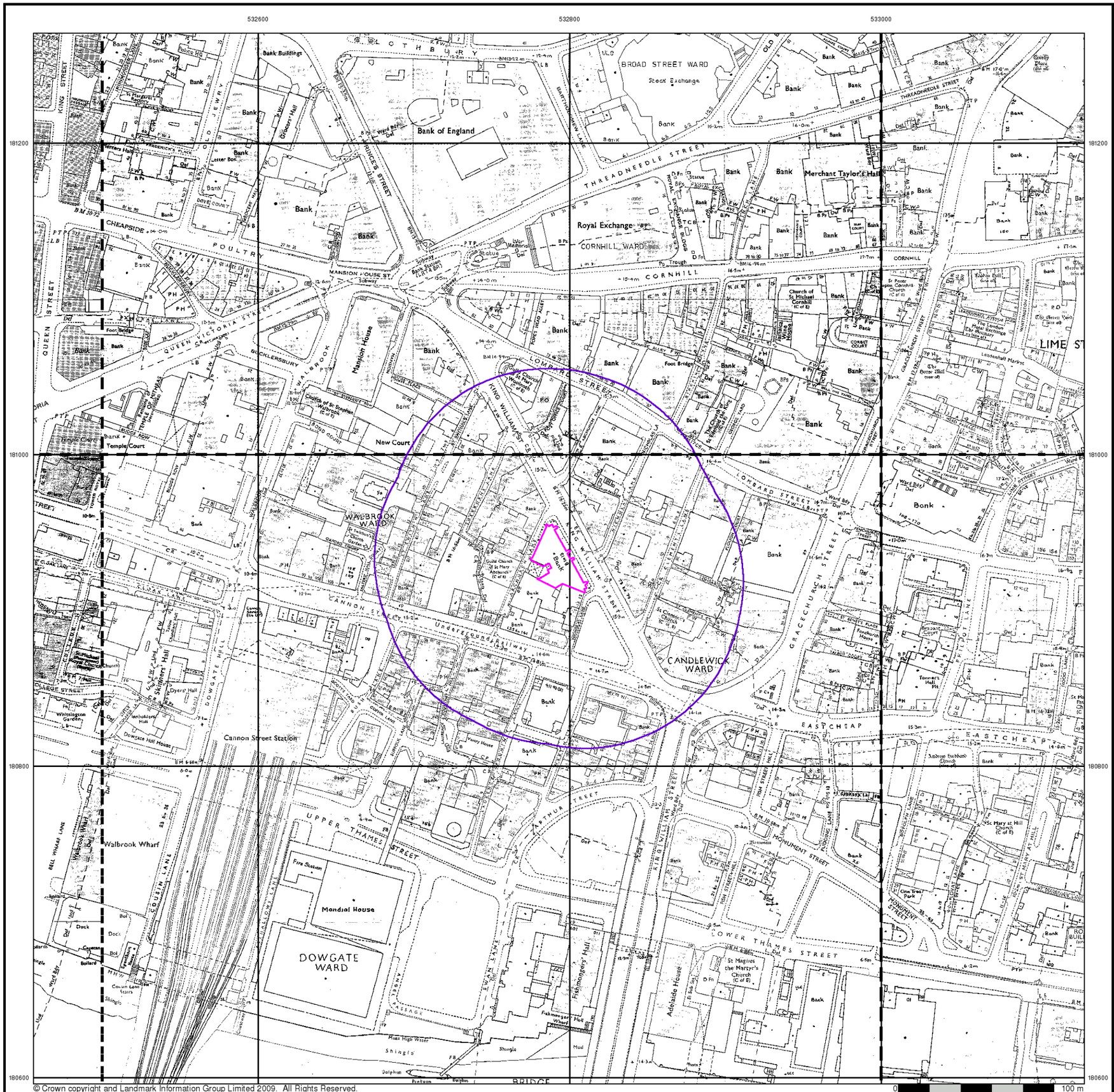
Fax: 0844 844 9951
Web: www.envirocheck.co.uk



Envirocheck®

Additional SIMs

Published 1968 - 1989

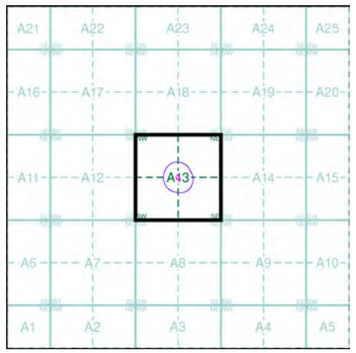
Source map scale - 1:1,250

The SIM cards (Ordnance Survey's `Survey of Information on Microfilm') are further, minor editions of mapping which were produced and published in between the main editions as an area was updated. They date from 1947 to 1994, and contain detailed information on buildings, roads and land-use. These maps were produced at both 1:2,500 and 1:1,250 scales.

Map Name(s) and Date(s)

TQ3281SW 1968 1:1,250	TQ3281SE 1987 1:1,250	TQ3381SW 1982 1:1,250
TQ3280NW 1989 1:1,250	TQ3280NE 1982 1:1,250	TQ3380NW 1989 1:1,250

Historical Map - Segment A13



Order Details

Order Number:	29551950_1_1
Customer Ref:	261008
National Grid Reference:	532790, 180930
Slice:	A
Site Area (Ha):	0.08
Search Buffer (m):	100

Site Details

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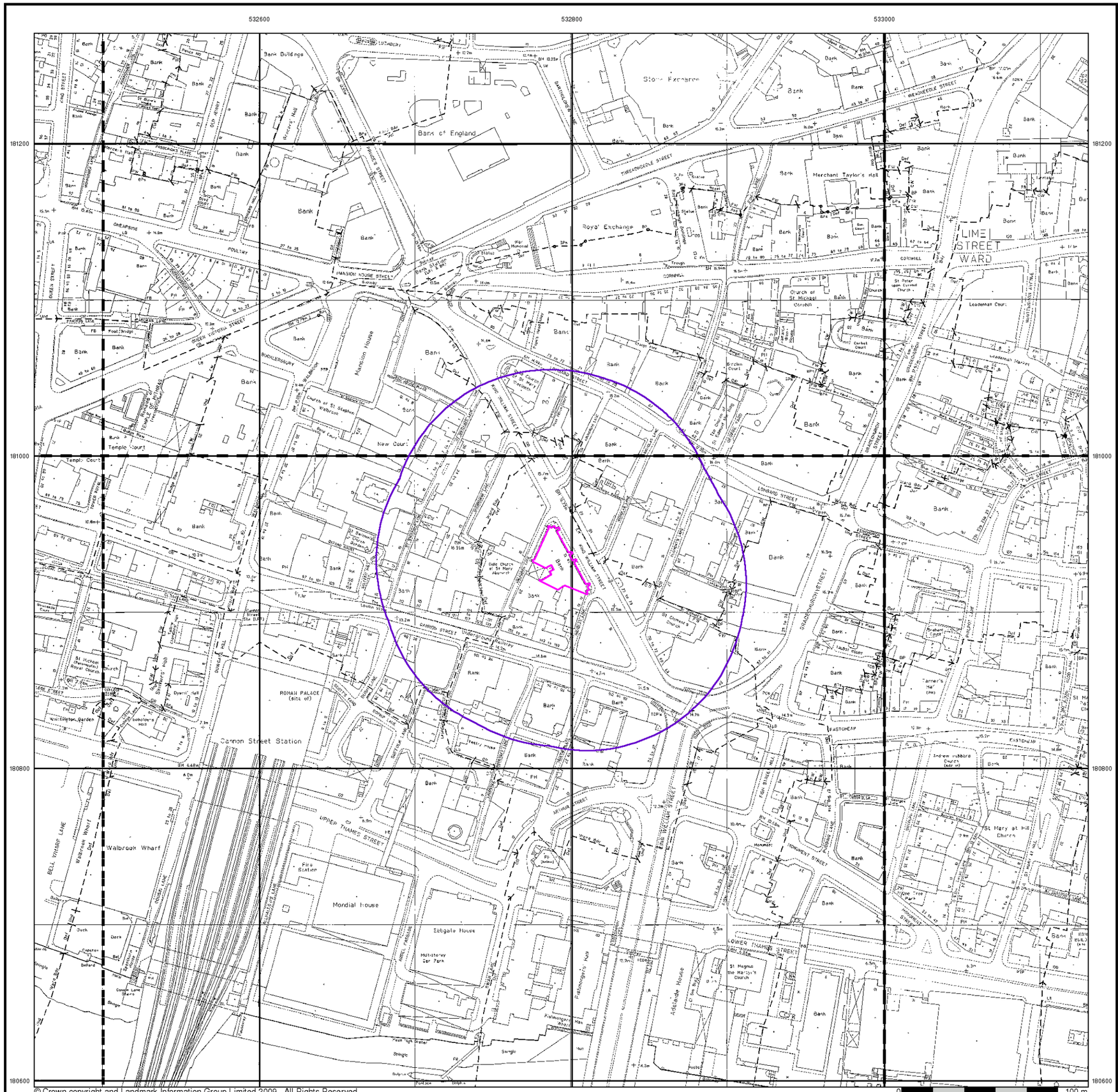


Envirocheck®

Large-Scale National Grid Data

Published 1991

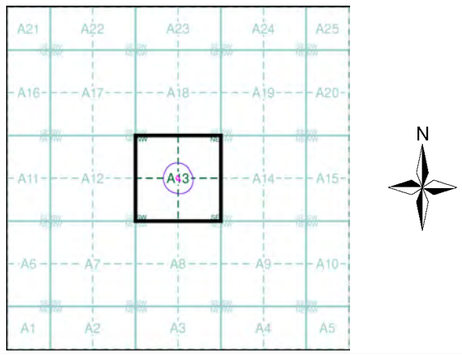
Source map scale - 1:1,250

'Large Scale National Grid Data' superseded SIM cards (Ordnance Survey's 'Survey of Information on Microfilm') in 1992, and continued to be produced until 1999. These maps were the fore-runners of digital mapping and so provide detailed information on houses and roads, but tend to show less topographic features such as vegetation. These maps were produced at both 1:2,500 and 1:1,250 scales.

Map Name(s) and Date(s)

TQ3281SW 1991 1:1,250	TQ3281SE 1991 1:1,250	TQ3381SW 1991 1:1,250
TQ3280NW 1991 1:1,250	TQ3280NE 1991 1:1,250	TQ3380NW 1991 1:1,250

Historical Map - Segment A13



Order Details

Order Number:	29551950_1_1
Customer Ref:	261008
National Grid Reference:	532790, 180930
Slice:	A
Site Area (Ha):	0.08
Search Buffer (m):	100

Site Details

5 King William Street, LONDON, EC4N 7DA

Landmark Information Group

Tel: 0844 844 9952
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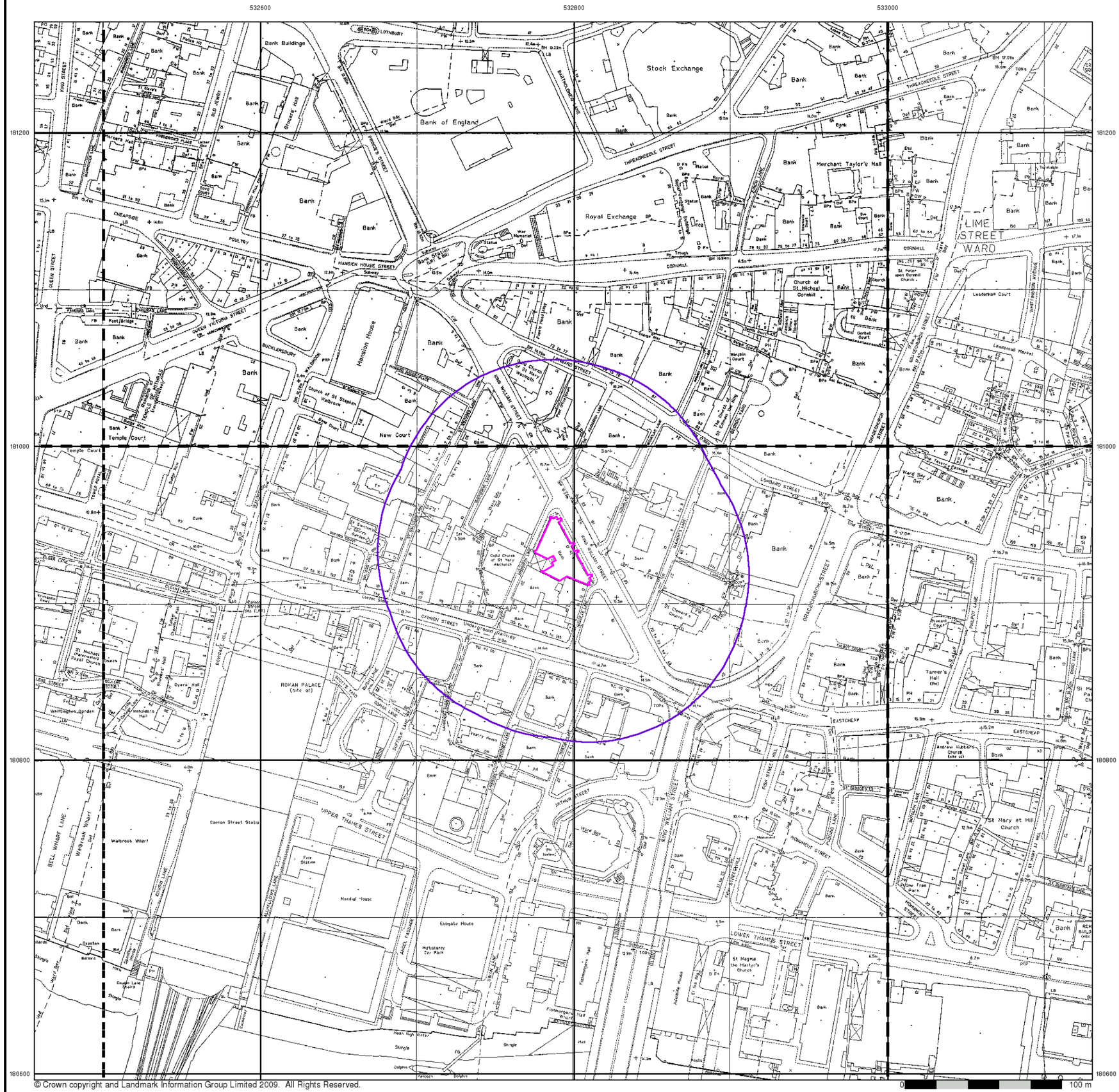


Envirocheck®

Large-Scale National Grid Data

Published 1991 - 1992

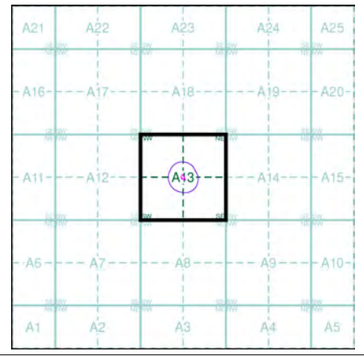
Source map scale - 1:1,250

'Large Scale National Grid Data' superseded SIM cards (Ordnance Survey's 'Survey of Information on Microfilm') in 1992, and continued to be produced until 1999. These maps were the fore-runners of digital mapping and so provide detailed information on houses and roads, but tend to show less topographic features such as vegetation. These maps were produced at both 1:2,500 and 1:1,250 scales.

Map Name(s) and Date(s)

TQ3281SW 1992 1:1,250	TQ3281SE 1992 1:1,250	TQ3381SW 1991 1:1,250
TQ3280NW 1991 1:1,250	TQ3280NE 1991 1:1,250	TQ3380NW 1991 1:1,250

Historical Map - Segment A13



Order Details

Order Number:	29551950_1_1
Customer Ref:	261008
National Grid Reference:	532790, 180930
Slice:	A
Site Area (Ha):	0.08
Search Buffer (m):	100

Site Details

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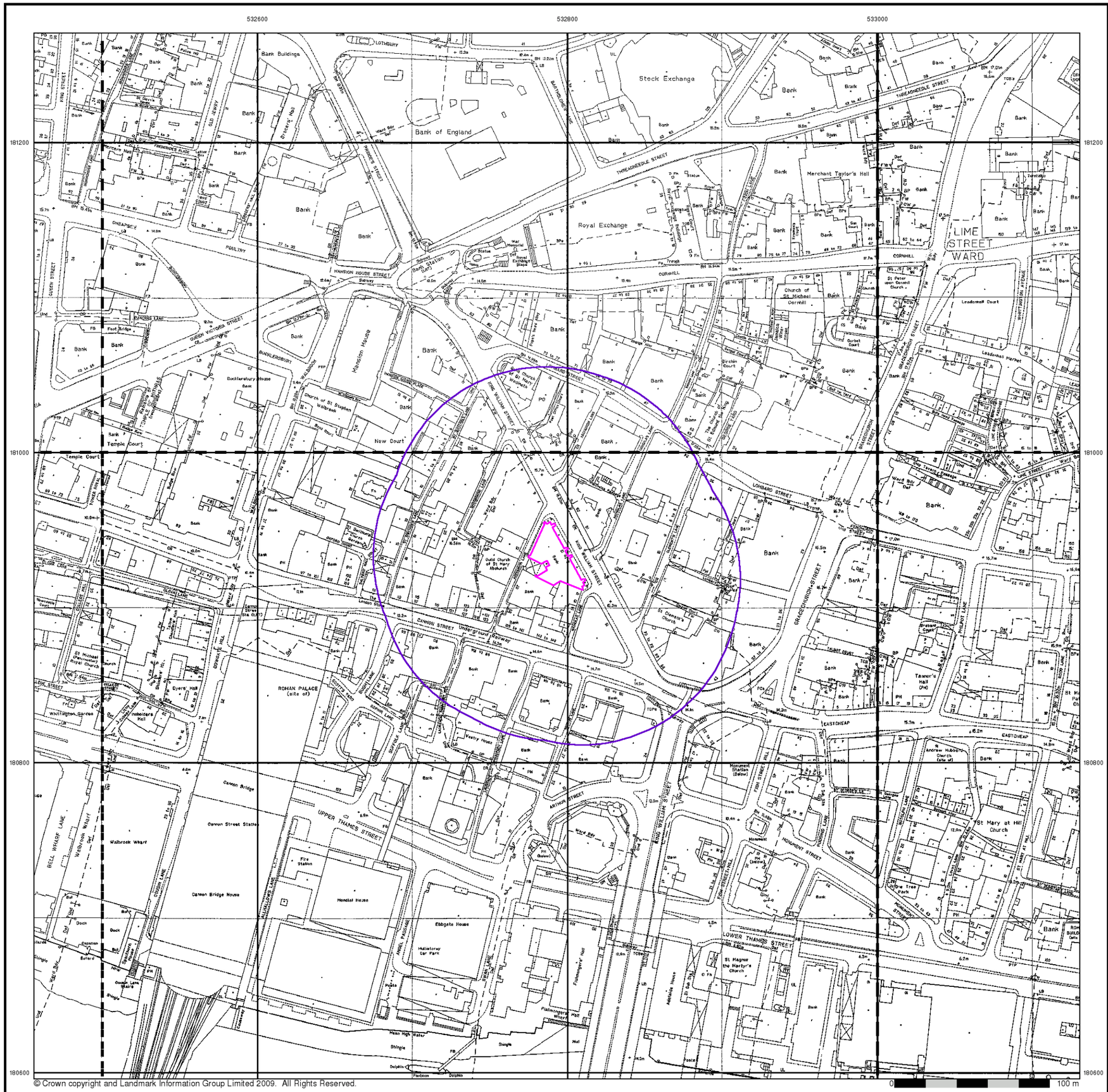


Envirocheck®

Large-Scale National Grid Data

Published 1992 - 1996

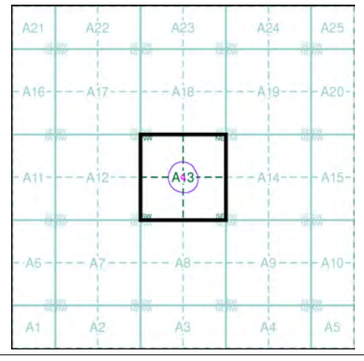
Source map scale - 1:1,250

'Large Scale National Grid Data' superseded SIM cards (Ordnance Survey's 'Survey of Information on Microfilm') in 1992, and continued to be produced until 1999. These maps were the fore-runners of digital mapping and so provide detailed information on houses and roads, but tend to show less topographic features such as vegetation. These maps were produced at both 1:2,500 and 1:1,250 scales.

Map Name(s) and Date(s)

TQ3281SW 1996 1:1,250	TQ3281SE 1994 1:1,250	TQ3381SW 1992 1:1,250
TQ3280NW 1992 1:1,250	TQ3280NE 1993 1:1,250	TQ3380NW 1992 1:1,250

Historical Map - Segment A13



Order Details

Order Number:	29551950_1_1
Customer Ref:	261008
National Grid Reference:	532790, 180930
Slice:	A
Site Area (Ha):	0.08
Search Buffer (m):	100

Site Details

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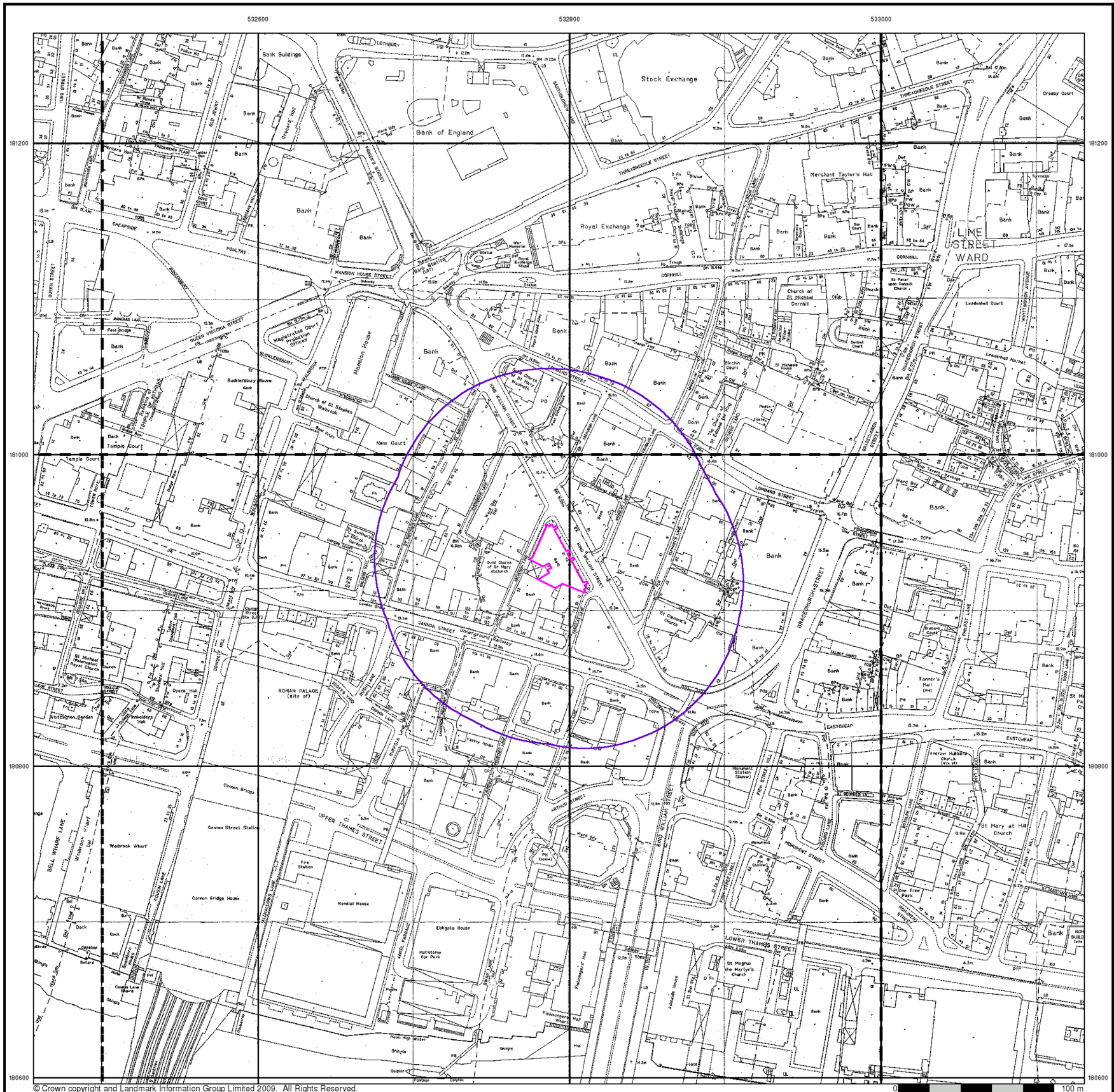


Envirocheck®

Large-Scale National Grid Data

Published 1993 - 1997

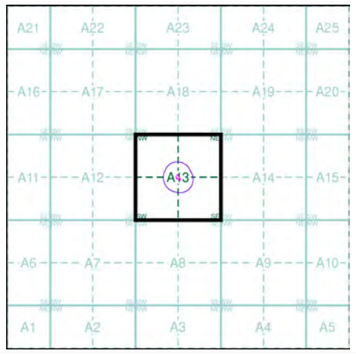
Source map scale - 1:1,250

'Large Scale National Grid Data' superseded SIM cards (Ordnance Survey's 'Survey of Information on Microfilm') in 1992, and continued to be produced until 1999. These maps were the fore-runners of digital mapping and so provide detailed information on houses and roads, but tend to show less topographic features such as vegetation. These maps were produced at both 1:2,500 and 1:1,250 scales.

Map Name(s) and Date(s)

TQ3281SW 1997 1:1,250	TQ3281SE 1997 1:1,250	TQ3381SW 1994 1:1,250
TQ3280NW 1993 1:1,250	TQ3280NE 1993 1:1,250	TQ3380NW 1993 1:1,250

Historical Map - Segment A13



Order Details

Order Number:	29551950_1_1
Customer Ref:	261008
National Grid Reference:	532790, 180930
Slice:	A
Site Area (Ha):	0.08
Search Buffer (m):	100

Site Details

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10k Raster Mapping

Published 2009

Source map scale - 1:10,000

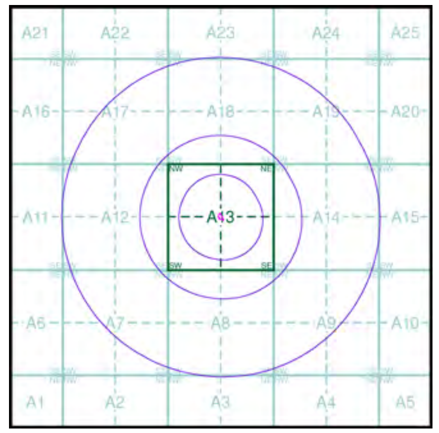
The historical maps shown were produced from the Ordnance Survey`s 1:10,000 colour raster mapping. These maps are derived from Landplan which replaced the old 1:10,000 maps originally published in 1970. The data is highly detailed showing buildings, fences and field boundaries as well as all roads, tracks and paths. Road names are also included together with the relevant road number and classification. Boundary information depiction includes county, unitary authority, district, civil parish and constituency.

Map Name(s) and Date(s)

TQ38SW
2009
1:10,000

TQ37NW
2009
1:10,000

Historical Map - Slice A



N

Order Details

Order Number:	29551950_1_1
Customer Ref:	261008
National Grid Reference:	532790, 180930
Slice:	A
Site Area (Ha):	0.08
Search Buffer (m):	1000

Site Details

5 King William Street, LONDON, EC4N 7DA

Landmark Information Group

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Groundwater Vulnerability

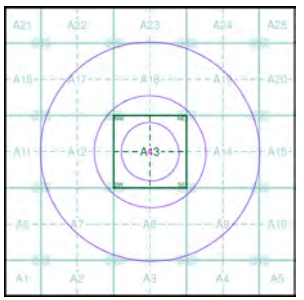
General

Specified Site | Specified Buffer(s) | Bearing Reference Point
Slice | Map ID

Agency and Hydrological

Geological Classes	Soil Classes
Major Aquifer (Highly Permeable)	High (H) 1, 2, 3, U
	Intermediate (I) 1, 2
	Low
Minor Aquifer (Variably Permeable)	High (H) 1, 2, 3, U
	Intermediate (I) 1, 2
	Low
Non Aquifer (Negligibly Permeable)	
Water or Sea	
Drift Deposit	

Site Sensitivity Context Map - Slice A



Order Details

Order Number:	29551950_1_1
Customer Ref:	261008
National Grid Reference:	532790, 180930
Slice:	A
Site Area (Ha):	0.08
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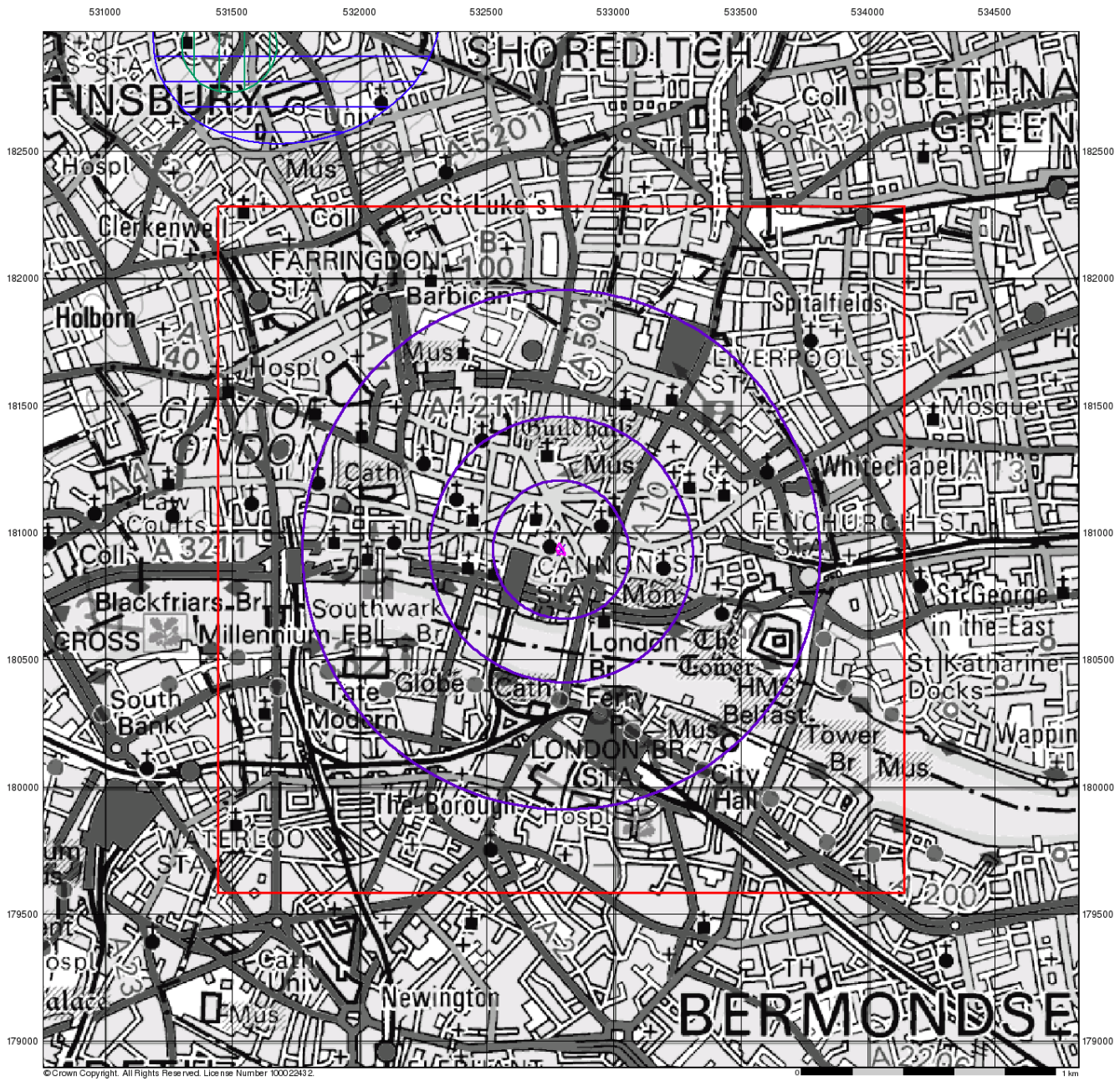

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Source Protection Zones

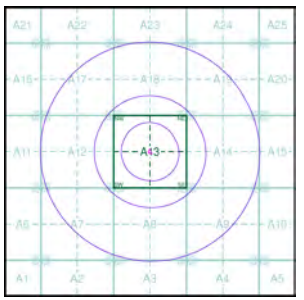
General

Specified Site | Specified Buffer(s) | Bearing Reference Point
Slice | Map ID

Agency and Hydrological

- Source Protection Zone I
- Source Protection Zone II
- Source Protection Zone III
- Zone of Special Interest
- Source Protection Zone Borehole

Site Sensitivity Context Map - Slice A



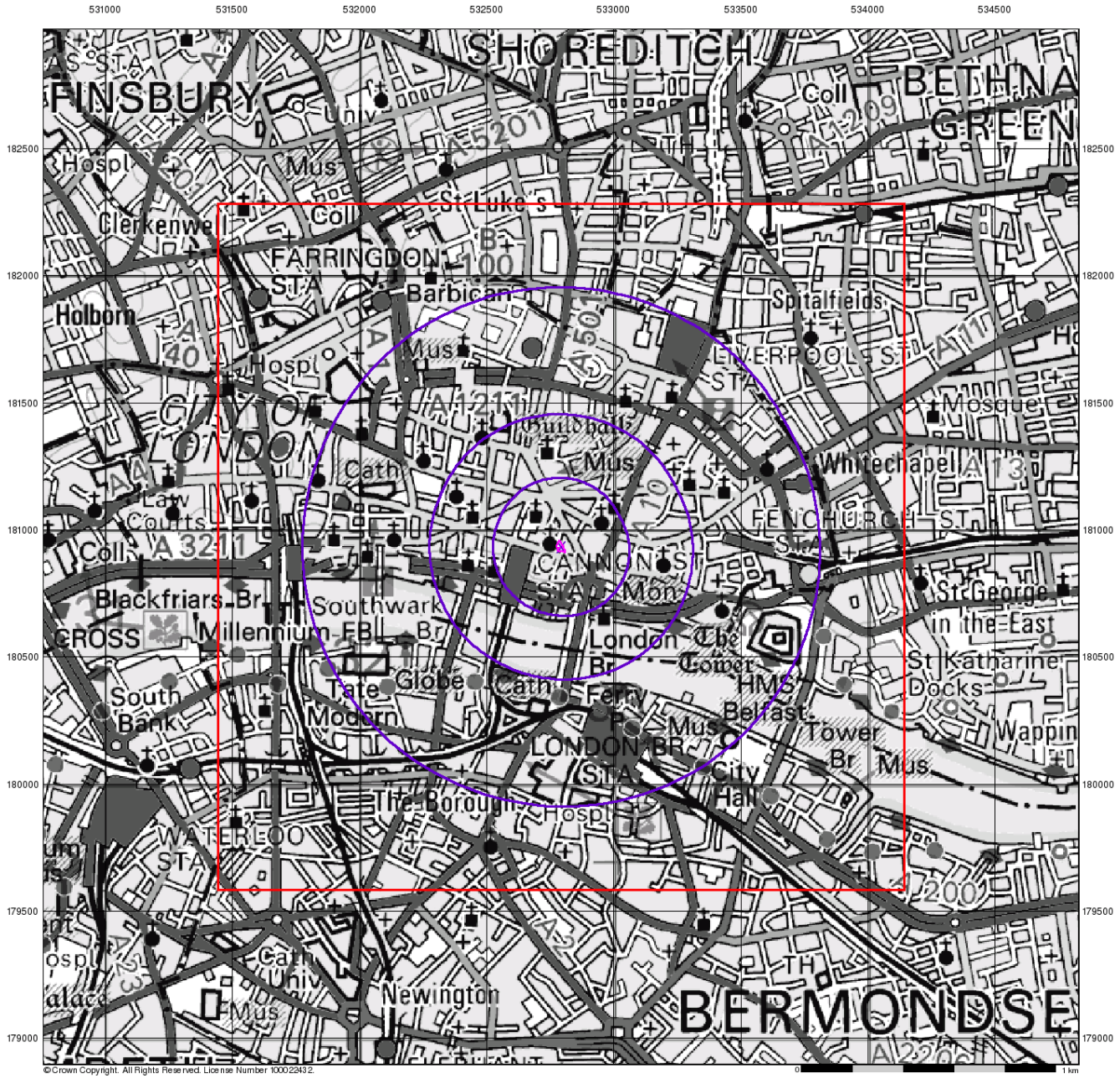
Order Details

Order Number:	29551950_1_1
Customer Ref:	261008
National Grid Reference:	532790, 180930
Slice:	A
Site Area (Ha):	0.08
Search Buffer (m):	1000

Site Details

5 King William Street, LONDON, EC4N 7DA

Landmark Information Group



Envirocheck®

Sensitive Land Uses

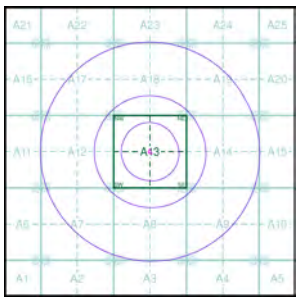
General

Specified Site | Specified Buffer(s) | Bearing Reference Point | Slice | Map ID

Sensitive Land Uses

- Area of Adopted Green Belt
- Area of Unadopted Green Belt
- Area of Outstanding Natural Beauty
- Environmentally Sensitive Area
- Forest Park
- Local Nature Reserve
- Marine Nature Reserve
- National Nature Reserve
- National Park
- Nitrate Sensitive Area
- Nitrate Vulnerable Zone
- Ramsar Site
- Site of Special Scientific Interest
- Special Area of Conservation
- Special Protection Area

Site Sensitivity Context Map - Slice A



Order Details

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Tel: 0844 844 9952
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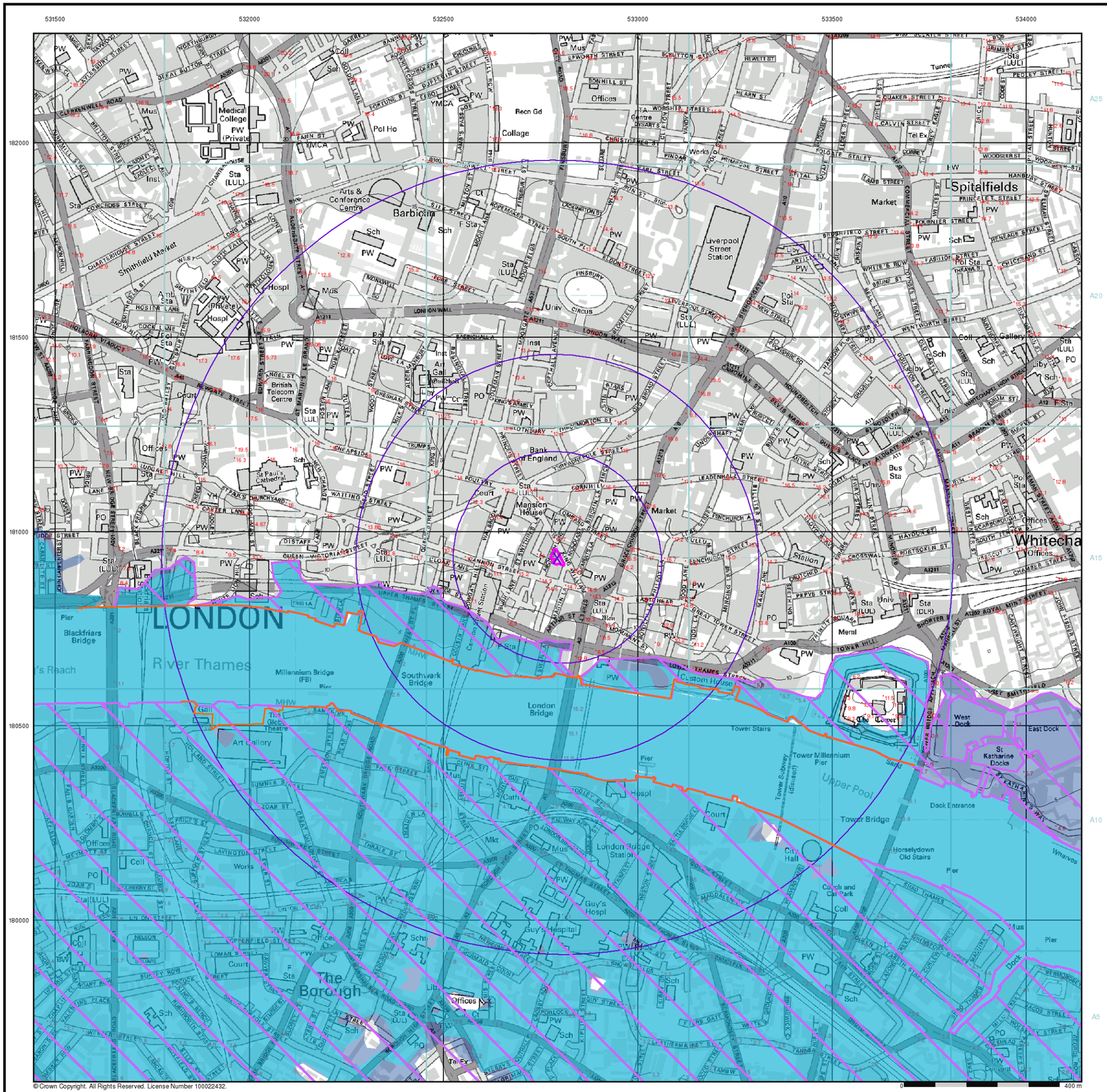
Web: www.envirocheck.co.uk



Envirocheck® Flood

EA Flood Data Map (1:10,000)

General

- Specified Site
- Specified Buffer(s)
- X Bearing Reference Point

Environment Agency Flood Data

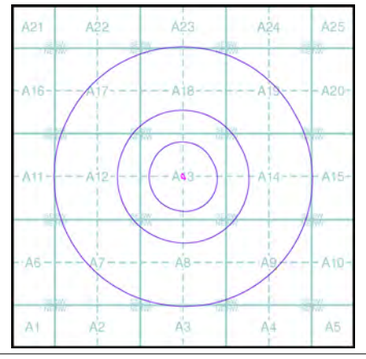
- Extreme Flooding from Rivers or Sea without Defences (Zone 2)
- Flooding from Rivers or Sea without Defences (Zone 3)
- Area Benefiting from Flood Defence
- Flood Water Storage Areas
- Flood Defence

Contours (height in metres)

Standard Contour 105 100 95 — 167.3 Spot Height

Index Contour — 45.8 Air Height

EA Flood Data Map - Slice A



Order Details

Order Number:	29551950_1_1
Customer Ref:	261008
National Grid Reference:	532790, 180930
Slice:	A
Site Area (Ha):	0.08
Search Buffer (m):	1000

Site Details

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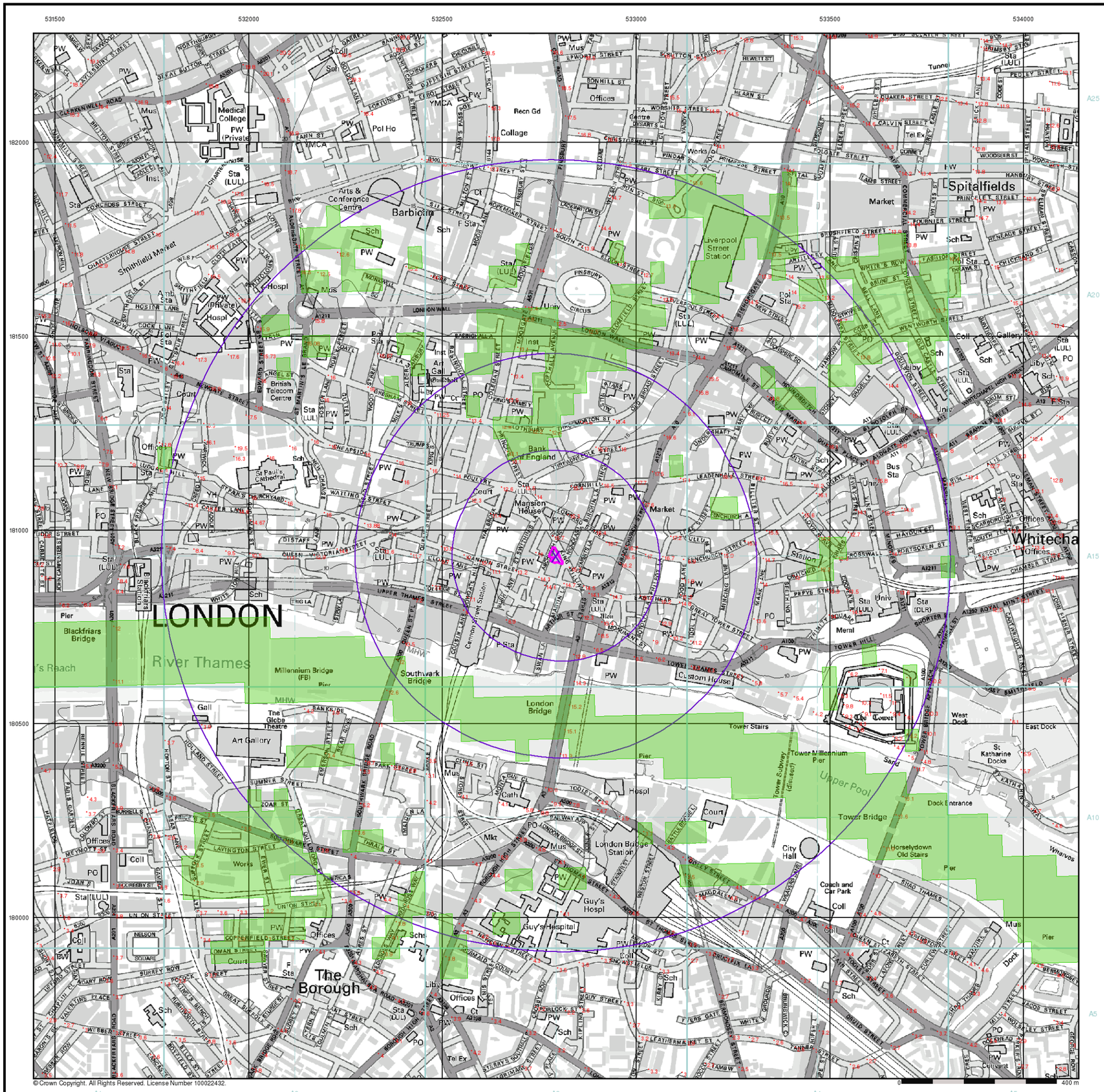


Envirocheck® Flood

RMS 75 year Return Flood Map (1:10,000)

General

- Specified Site
- Specified Buffer(s)
- X Bearing Reference Point

RMS 75 year Return Flood Data

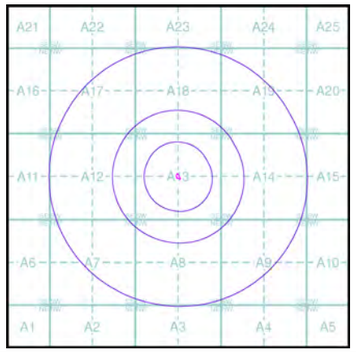
Flood Depth (mm)	Flood Type: Defended Flood	Flood Type: Undefended Flood	Flood Type: Pluvial Flood (flood depth n/a)
0 - 200			
201 - 500			
501 - 2000			
2001 +			

Contours (height in metres)

Standard Contour 105 100 95 — 167.3 Spot Height

Index Contour — 45.8 Air Height

RMS 75 year Return Flood Map - Slice A



Order Details

Order Number:	29551950_1_1
Customer Ref:	261008
National Grid Reference:	532790, 180930
Slice:	A
Site Area (Ha):	0.08
Search Buffer (m):	1000

Site Details

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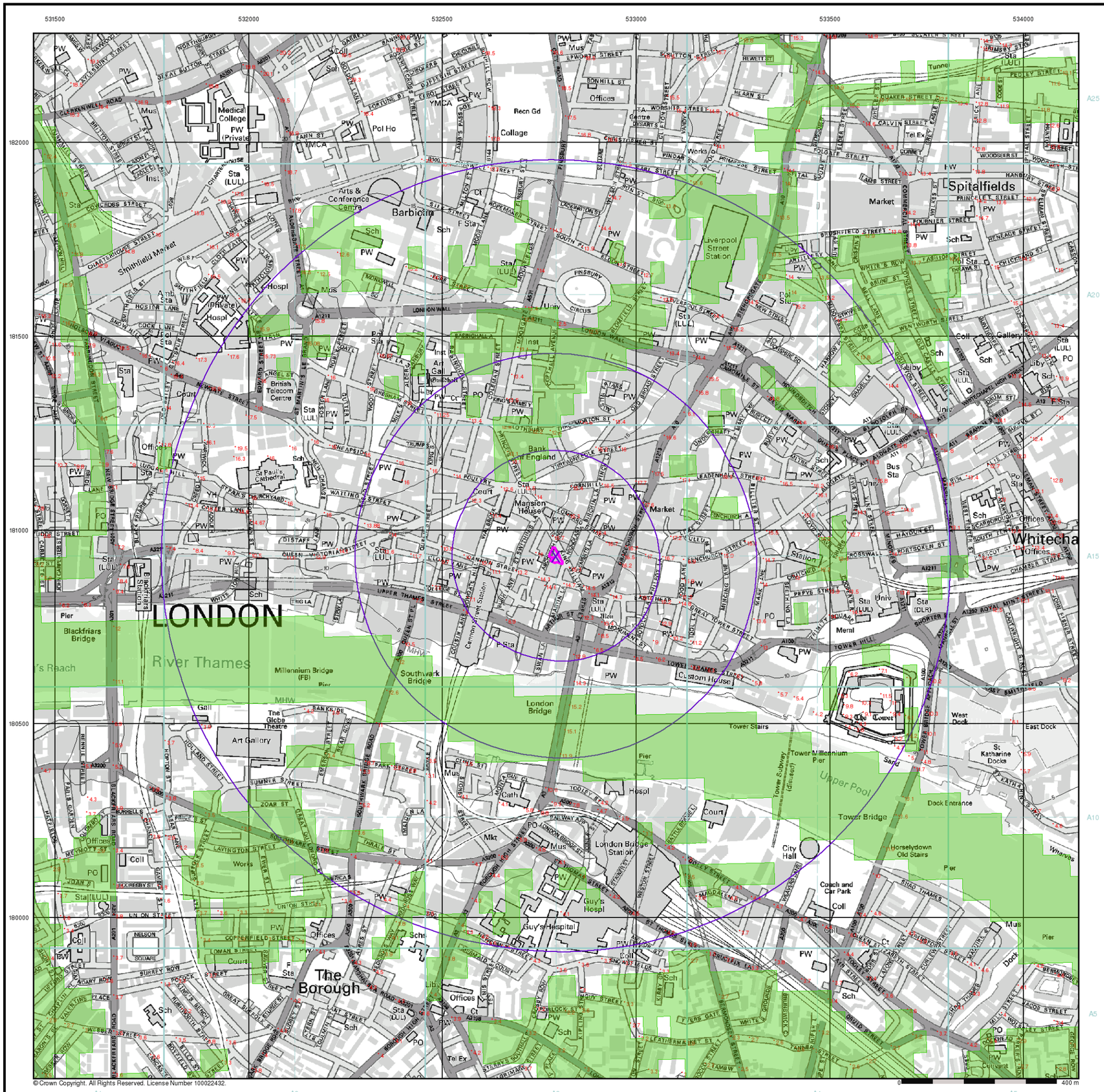


Envirocheck® Flood

RMS 100 year Return Flood Map (1:10,000)

General

- Specified Site
- Specified Buffer(s)
- X Bearing Reference Point

RMS 100 year Return Flood Data

Flood Depth (mm)	Flood Type: Defended Flood	Flood Type: Undefended Flood	Flood Type: Pluvial Flood (flood depth n/a)
0 - 200			
201 - 500			
501 - 2000			
2001 +			

Contours (height in metres)

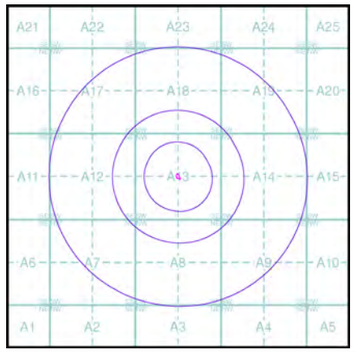
Standard Contour — 105 — 100 — 95

Index Contour

167.3 Spot Height

45.8 Air Height

RMS 100 year Return Flood Map - Slice A



Order Details

Order Number:	29551950_1_1
Customer Ref:	261008
National Grid Reference:	532790, 180930
Slice:	A
Site Area (Ha):	0.08
Search Buffer (m):	1000

Site Details

5 King William Street, LONDON, EC4N 7DA

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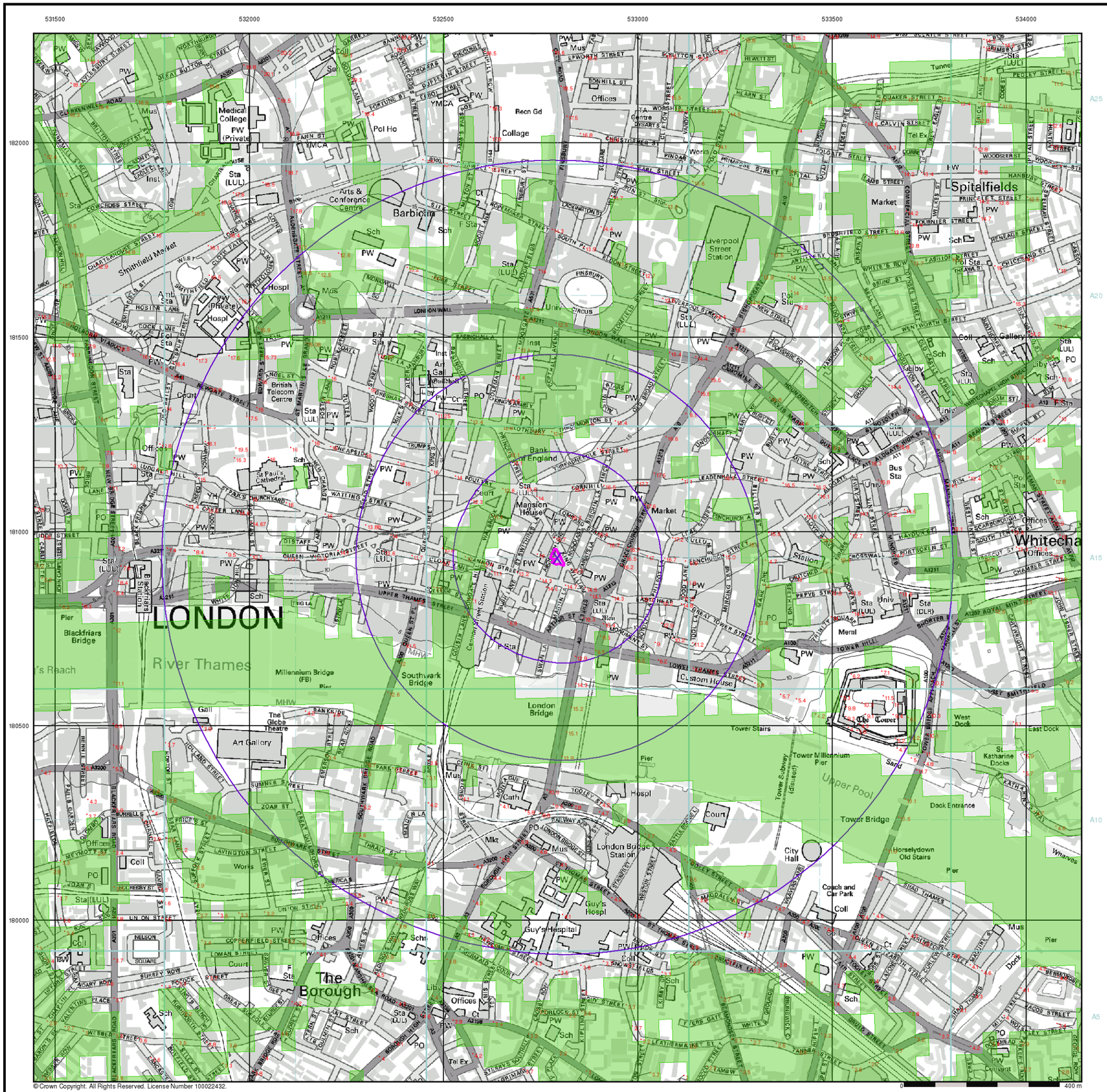


Envirocheck® Flood

RMS 1000 year Return Flood Map (1:10,000)

General

- Specified Site
- Specified Buffer(s)
- X Bearing Reference Point

RMS 1000 year Return Flood Data

Flood Depth (mm)	Flood Type: Defended Flood	Flood Type: Undefended Flood	Flood Type: Pluvial Flood (flood depth n/a)
0 - 200			
201 - 500			
501 - 2000			
2001 +			

Contours (height in metres)

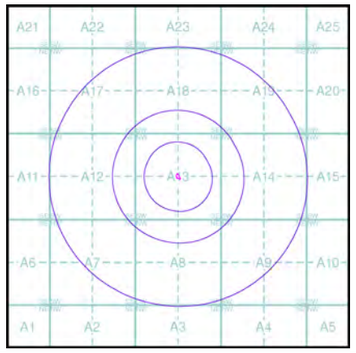
Standard Contour — 105 — 100 — 95

Index Contour

167.3 Spot Height

45.8 Air Height

RMS 1000 year Return Flood Map - Slice A



Order Details

Order Number:	29551950_1_1
Customer Ref:	261008
National Grid Reference:	532790, 180930
Slice:	A
Site Area (Ha):	0.08
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Site Details

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Landmark Information Group

Tel: 0844 844 9952
Fax: 0844 844 9951
Web: www.envirocheck.co.uk

Envirocheck® Flood

EA Detailed River Network Map (1:10,000)

General

- Specified Site
- Specified Buffer(s)
- X Bearing Reference Point
- Map ID

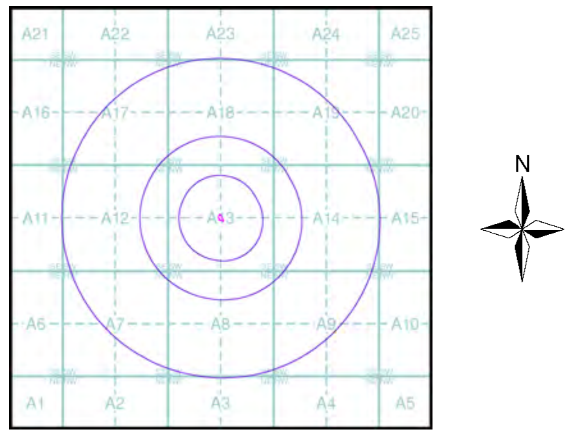
EA Detailed River Network Data

- Primary River
- Secondary River
- Tertiary River
- Canal
- Canal Tunnel
- Undefined River
- Lake/Reservoir
- Extended Culvert (greater than 50m)
- Underground River (inferred)
- Underground River (local knowledge)
- Downstream of High Water Mark
- Downstream of Seaward Extension
- Not assigned River feature
- Source
- Junction
- Sink
- Non-interactive Node
- Not assigned River feature
- Pseudo Node (general)
- Pseudo Node (High Water Mark)
- Pseudo Node (OS MasterMap polygon boundary)
- Offline Drainage Feature

Contours (height in metres)

- Standard Contour
- Index Contour
- 167.3 Spot Height
- 45.8 Air Height

EA Detailed River Network Map - Slice A



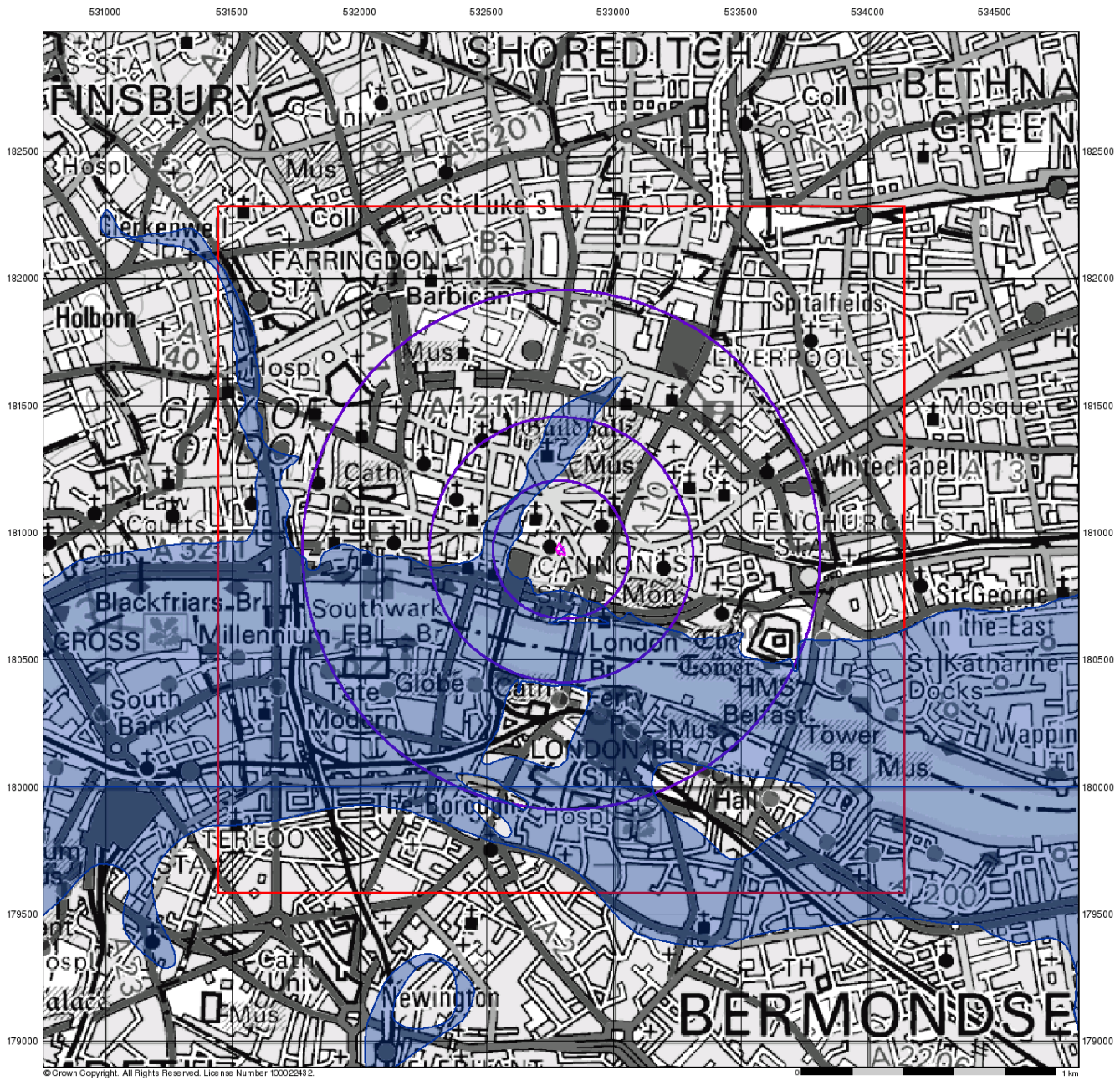
Order Details

Order Number: 29551950_1_1
Customer Ref: 261008
National Grid Reference: 532790, 180930
Slice: A
Site Area (Ha): 0.08
Search Buffer (m): 1000

Site Details

5 King William Street, LONDON, EC4N 7DA

Landmark Information Group
Tel: 0844 844 9952
Fax: 0844 844 9951
Web: www.envirocheck.co.uk



Envirocheck® Flood

BGS Flood Data (1:50,000)

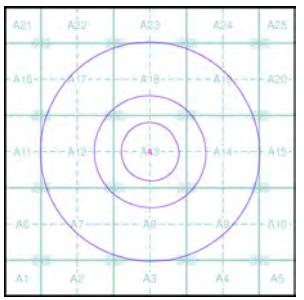
General

Specified Site | Specified Buffer(s) | Bearing Reference Point | Slice | Map ID

BGS Geological Indicators of Flooding

- Coastal
- Inland
- Bodies of Water

BGS Flood Data Map - Slice A



Order Details

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Customer Ref:	261008
National Grid Reference:	532790, 180930
Slice:	A
Site Area (Ha):	0.08
Search Buffer (m):	1000

Site Details

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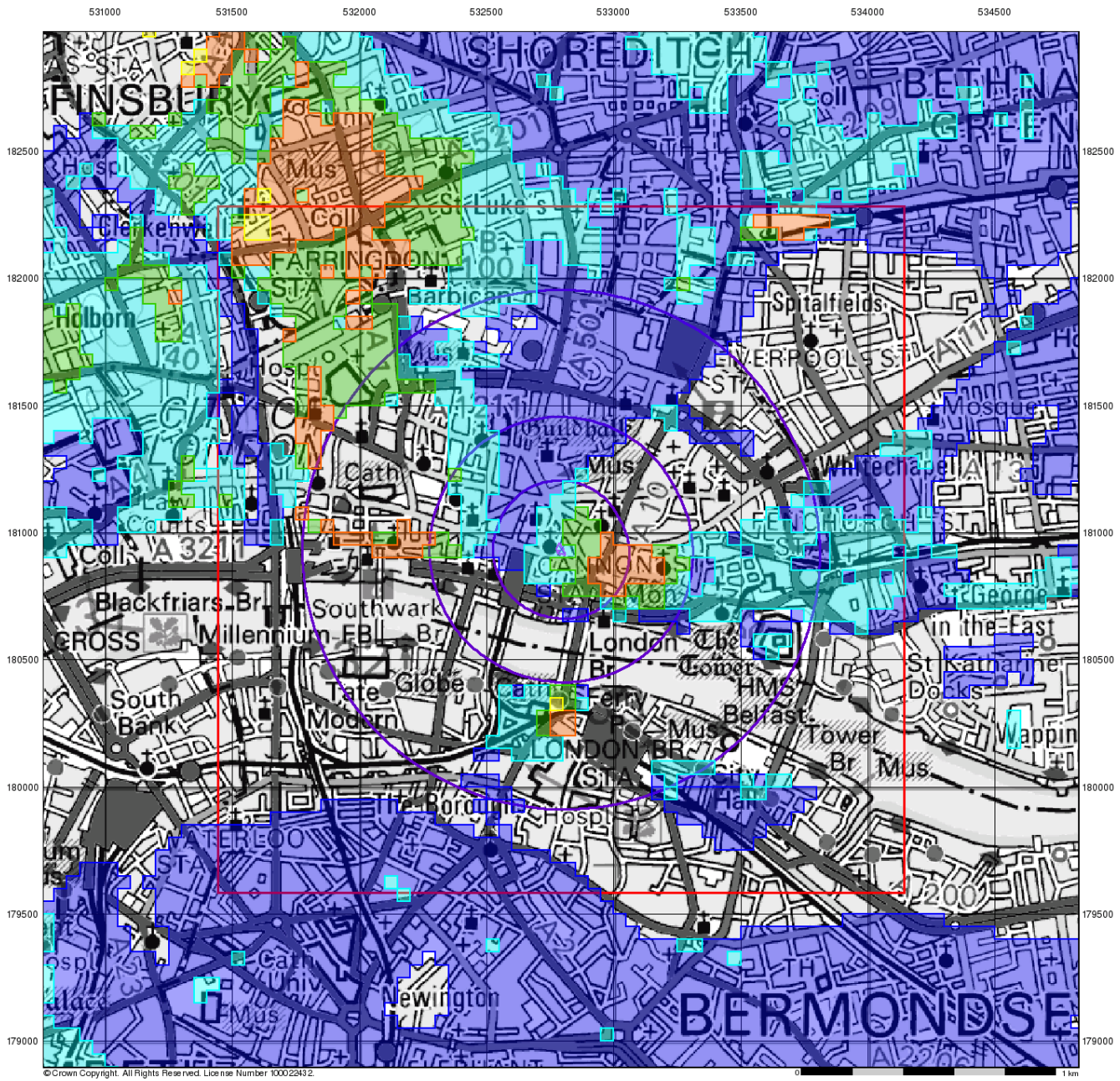
Web: www.envirocheck.co.uk



Envirocheck® Flood

BGS Flood Data (1:50,000)

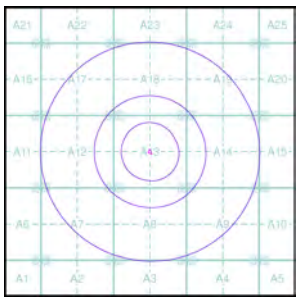
General

Specified Site | Specified Buffer(s) | Bearing Reference Point | Slice | Map ID

BGS Groundwater Flooding Susceptibility

- High Susceptibility
- Moderately High Susceptibility
- Moderate Susceptibility
- Low Susceptibility
- Negligible Susceptibility

BGS Flood Data Map - Slice A



Order Details

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Customer Ref:	261008
National Grid Reference:	532790, 180930
Slice:	A
Site Area (Ha):	0.08
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Site Details

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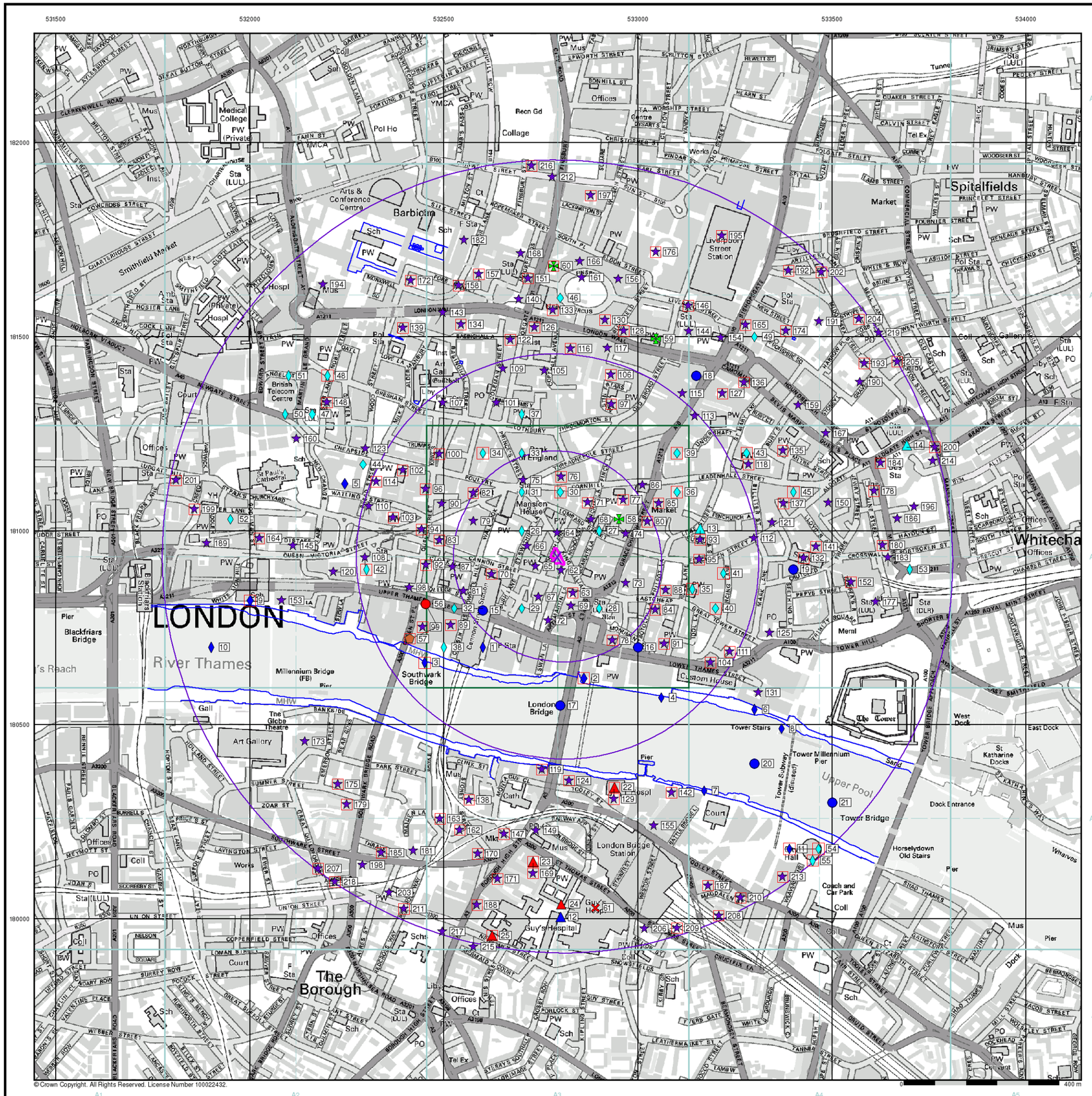


Envirocheck®

General

- Specified Site
- Specified Buffer(s)
- Bearing Reference Point
- Map ID
- Several of Type at Location

Agency and Hydrological

- Contaminated Land Register Entry or Notice (Location)
- Contaminated Land Register Entry or Notice
- Discharge Consent
- Enforcement or Prohibition Notice
- Integrated Pollution Control
- Integrated Pollution Prevention Control
- Local Authority Integrated Pollution Prevention and Control
- Local Authority Pollution Prevention and Control
- Local Authority Pollution Prevention and Control Enforcement
- Pollution Incident to Controlled Waters
- Prosecution Relating to Authorised Processes
- Prosecution Relating to Controlled Waters
- Registered Radioactive Substance
- River Network or Water Feature
- River Quality Sampling Point
- Substantiated Pollution Incident Register
- Water Abstraction
- Water Industry Act Referral

Geological

- BGS Recorded Mineral Site

Industrial Land Use

- Contemporary Trade Directory Entry
- Fuel Station Entry

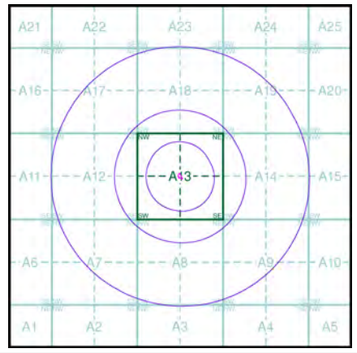
Waste

- BGS Recorded Landfill Site (Location)
- BGS Recorded Landfill Site
- EA Historic Landfill (Buffered Point)
- EA Historic Landfill (Polygon)
- Integrated Pollution Control Registered Waste Site
- Licensed Waste Management Facility (Landfill Boundary)
- Licensed Waste Management Facility (Location)
- Local Authority Recorded Landfill Site (Location)
- Local Authority Recorded Landfill Site
- Registered Landfill Site
- Registered Landfill Site (Location)
- Registered Landfill Site (Point Buffered to 100m)
- Registered Landfill Site (Point Buffered to 250m)
- Registered Waste Transfer Site (Location)
- Registered Waste Transfer Site
- Registered Waste Treatment or Disposal Site (Location)
- Registered Waste Treatment or Disposal Site

Hazardous Substances

- COMAH Site
- Explosive Site
- NIHHS Site
- Planning Hazardous Substance Consent
- Planning Hazardous Substance Enforcement

Site Sensitivity Map - Slice A



Order Details

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National Grid Reference:	532790, 180930
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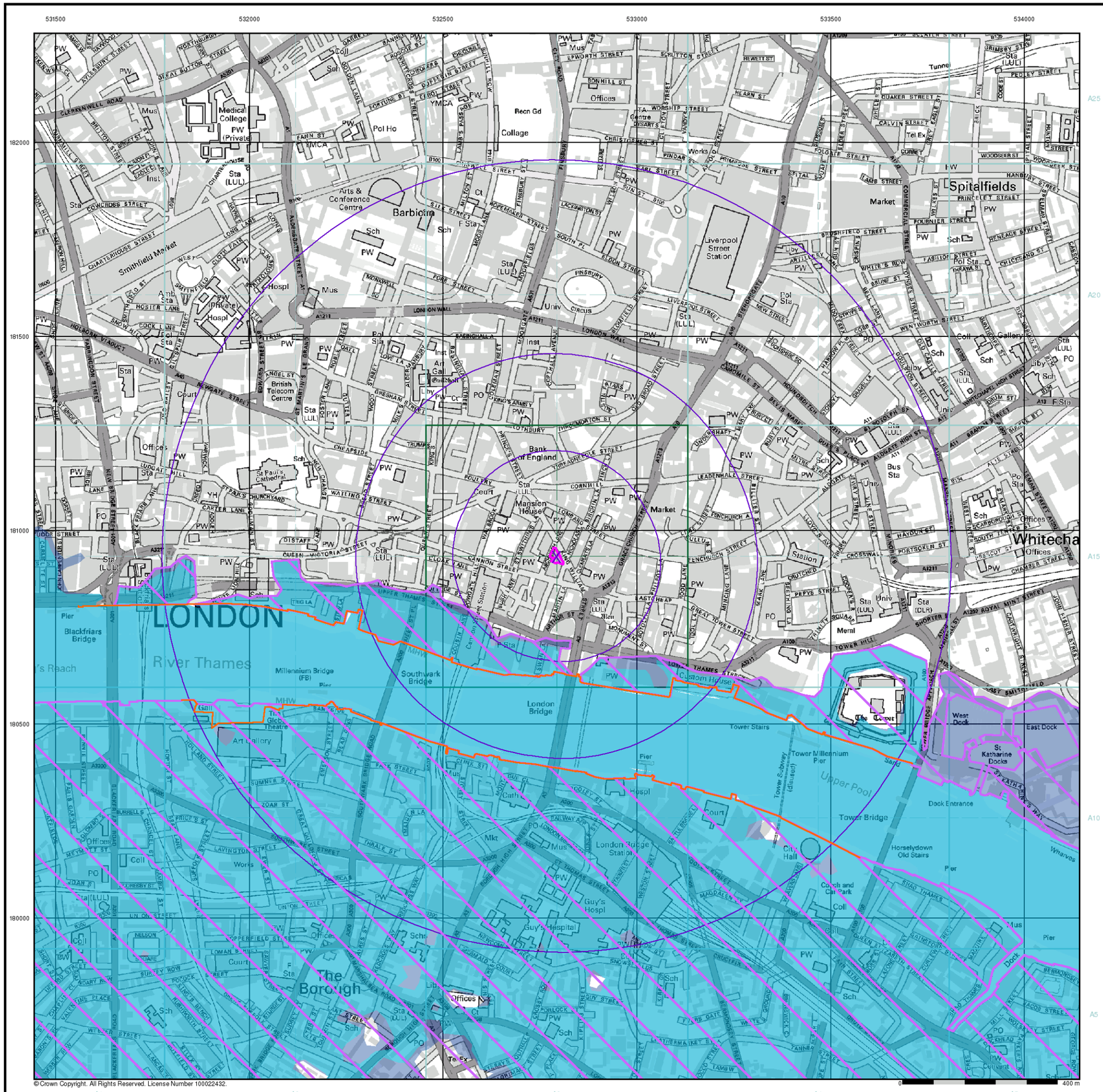


Envirocheck®

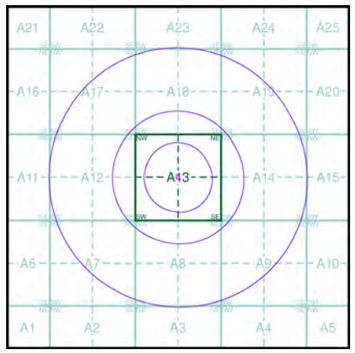
General

- ⬡ Specified Site
- ⬡ Specified Buffer(s)
- X Bearing Reference Point

Agency and Hydrological (Flood)

- ■ Extreme Flooding from Rivers or Sea without Defences (Zone 2)
- ■ Flooding from Rivers or Sea without Defences (Zone 3)
- ▨ Area Benefiting from Flood Defence
- ▨ Flood Water Storage Areas
- — Flood Defence

Flood Map - Slice A



Order Details

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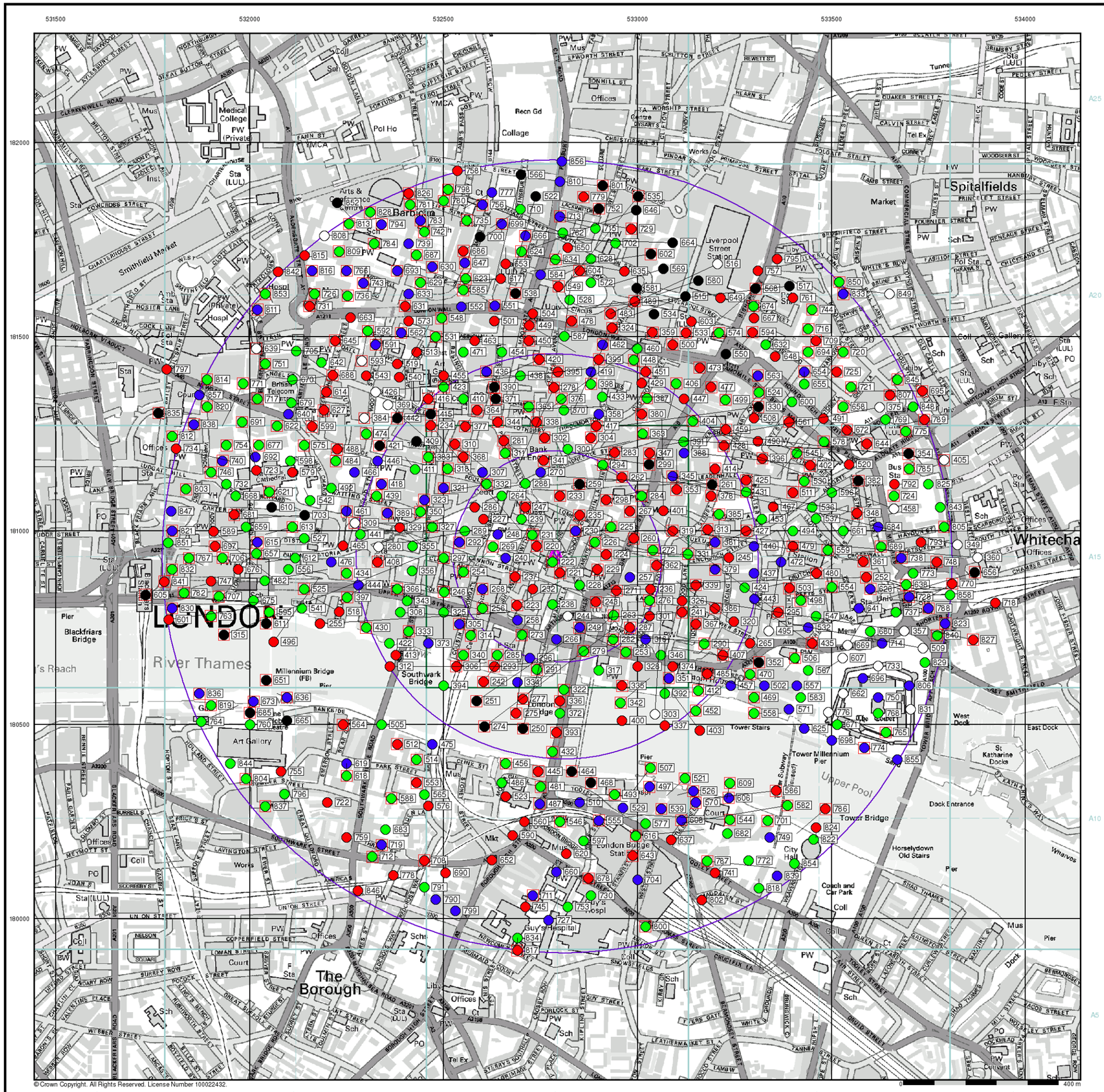


Envirocheck®

General

- Specified Site
- Specified Buffer(s)
- Bearing Reference Point
- Map ID
- Several of Type at Location

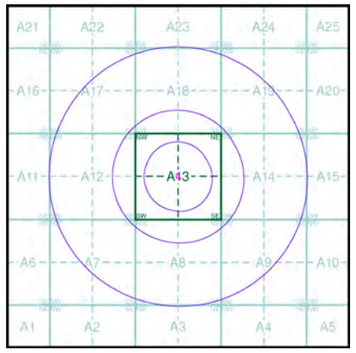
Agency and Hydrological (Boreholes)

- BGS Borehole Depth 0 - 10m
- BGS Borehole Depth 10 - 30m
- BGS Borehole Depth 30m +
- Confidential
- Other

For Borehole information please refer to the Borehole .csv file which accompanied this slice.

A copy of the BGS Borehole Ordering Form is available to download from the Support section of www.envirocheck.co.uk.

Borehole Map - Slice A



Order Details

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Customer Ref:	261008
National Grid Reference:	532790, 180930
Slice:	A
Site Area (Ha):	0.08
Search Buffer (m):	1000

Site Details

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Web: www.envirocheck.co.uk

Appendix B. Buildings affected by the Proposed Works

Key :-

- Proposed Site Limits
- Buildings that may be affected by Works
- Buildings that will be affected by Works
- Red Line indicates new running tunnels

N

B1 B2 B3 B4 B5 B6 B7 B8 B9 B10 B11 B12 B13 B14 B15 B16 B17 B18 B19 B20 B21 B22 B23 B24 B25

A1 A2 A3 A4 A5 A6 A7 A8 A9 A10 A11 A12 A13 A14 A15 A16 A17 A18 A19 A20 A21 A22 A23 A24 A25 A26 A27 A28 A29 A30 A31 A32 A33 A34 A35 A36 A37 A38 A39

NOTE: PLAN TO BE VIEWED IN CONJUNCTION WITH ADJACENT LAND USE TABLE PCIP SECTION 4.2

Ver.	Date	Description	By	Chkd	App

Keyplan:

Client Authorisation Status:

PCIP SECTION 4.2

Model File Versions:

Mott MacDonald

Mott MacDonald House, 8-10 Sydenham Road Croydon, Surrey, CR0 2EE England

London Underground

BANK STATION CAPACITY UPGRADE

Contract :	Bank Station Congestion Relief Project
Originator :	Mott MacDonald
Location :	Bank Station N133
Title :	PCIP Section 4.2 Adjacent Land Use Plan
By :	CAL
Chk :	CQ/DN
App :	MS
LUSTN No:	LUSTN-0008798-DWG-001093
Scale :	NTS @ A1
Drawing and CAD file No :	N133-BCR-MMD-00-1-DR-C-3016
Ver :	
Suitability :	

Username: lak53226 Date: 21/07/2011 09:26:51 Filename: c:\pw working folder\lak53226\dms00380\N133-BCR-MMD-00-1-DR-C-3016.dgn

Table B.1: Summary of the buildings that will be affected by works

Building Area Ref.	Occupier Address	Tenant Description	Listed Building
A1	1 Bank Buildings	Financial Institution	
	2 Bank Buildings	Financial Institution	
	19 Old Jewry	Financial Institution	
A2	8 Princes Street	Financial Institution	
	Princes Court, 7 Princes Street	Mixed Use Building: Financial & Legal Institutions	
A3	Grocers Hall, Princes Street	City of London Guild	
A4	5 Princes Street 27-32 Poultry	Currently being refurbished into a hotel	Grade I
A5	1 Princes Street	Financial Institution	Grade II
A6	The Mansion House	Residence, Lord Mayor of City of London	Grade I
A7	1 Lombard Street	Restaurant	Grade II
	3 Lombard Street	Mixed Use Building: Financial & Asset Management Institutions	Grade II
	6 Lombard Street	Mixed Use Building: Financial Institutions & Car Sales	Grade II
A8	8-10 Mansion House Place	Financial Institution	
A9	1 St. Swithins Lane	Financial Institution	
A10	The Courtyard, 20 St Swithins Lane	Restaurant Also incs ground floor of 19 St Swithins and 20 Cleary Court	Grade II*
	Sandeman House, Cleary Court	Residential	
	19 St Swithins Lane	Hotel (to be opened Aug 11)	
	21-23 St Swithins Lane	Restaurant / Bar	Listed inclined undergro und shaft from building to river. Believed to be partly filled in.
A11	1 King William Street	Financial Institution	Grade II
A12	5 King William Street	Financial Institution	Grade II
A13	15 Abchurch Lane	Private Members Club	Grade II
A14	St Mary Abchurch	Church	Grade I
A15	Sherbourne Lane	Restaurant / Bar	
	119 Cannon Street	Commercial Business - Boot maker	
	Sherbourne House (entrance on Canon Street)		

Address	1-6 Lombard Street
List Grade	Grade II
Date	1905-8 and 1915; refurbished in 1985-7
Building type	Offices
Architect	Dunn & Watson assisted by W. Curtis Green; refurbished by JLW Building Surveying Services
Height (no. storeys)	5 storeys plus 2 attics and 2 basements

Description

The former Scottish Provident Institution, designed by Dunn & Watson, 1905-8 and 1915, assisted by W. Curtis Green. The building comprises a long symmetrical curving elevation to Lombard Street; seventeen bays (3:11:3), with slightly projecting end pavilions, the latter emphasised by a tripartite treatment, each with a central ground floor opening flanked by Byzantine columns carrying an enriched lintel and cornice; channelled quoin piers to the upper storeys. Between the end pavilions, a tall, channelled arcuated base extending over the ground and first floors, each arch containing iron railings to basement/ground floor windows and stone balustrades to first floor windows. Above, a giant Corinthian order uniting the second, third and fourth floors with engaged unfluted columns and richly carved entablature with dentilled and modillioned cornice. Above this, a balustraded parapet behind which rise two dormered roof storeys. Return elevation to St. Swithin's Lane of four storeys and four bays, with set back storeys above. Return elevation to Mansion House Lane of five storeys and five bays, after which the building continues as a plain ashlar single storey surmounted by a balustraded parapet with set back upper storeys in glazed brick. Full height glazed brick rear elevation.

The structure appears to have load-bearing stone/brick façades with steel-framed internal structure with steel beams supporting clay pot floors.

The building was comprehensively refurbished by JLW Building Surveying Services in 1985-7. The £7m project included the removal of the internal lightwell walls and the insertion of new steel framing to create around 100m2 of new lettable floor space or plant rooms on every storey. Bradley & Pevsner (2002:537) relate that, of the original spaces, only the modest entrance hall and one other interior were retained.

William Newton Dunn (1859-1934) and Robert Watson (1865-1916) met in the office of James MacLaren and continued the practice upon the latter's death in 1890. In 1912, they took into partnership William Curtis Green (1875-1960). Green effectively carried on the practice when Dunn retired in 1919.

Significant/Potentially Vulnerable Features

- Stone balustrading at first and attic levels
- Cornice at fifth floor level
- Fine jointed stonework

Foundations

Likely construction

- Probably two levels of basement, with mass concrete external walls.
- Steel columns supported on grillage beams and concrete pad foundations or a raft foundation with thickenings under the columns.

Sources

- List description
- Bradley, Simon & Pevsner, Nikolaus (2002): *London 1: The City of London* (The Buildings of England), Yale University Press, New Haven & London, p. 537
- Gray, A. Stuart (1985): *Edwardian Architecture: A Biographical Dictionary*, Duckworth, London, pp. 170-171, 199-200, 372
- Ridout, Graham (1986): 'Normal services will be maintained', *Building*, 5 September, pp. 36-40
- Service, Alastair (1977): *Edwardian Architecture: a handbook to building design in Britain, 1890-1914*, Thames & Hudson, London, pp. 201-202

Address	1 King William Street
List Grade	Grade II
Date	1921-2; redeveloped behind retained façades in 1996
Building type	Offices
Architect	Campbell-Jones, Son & Smithers; redeveloped behind retained façades by the GMW Partnership
Height (no. storeys)	5 storeys plus attic and 2 basements

Description

The former London Assurance building, designed by Campbell-Jones, Son & Smithers, 1921-2. William Campbell-Jones (1862-1951), who in 1914-15 had designed the Gresham Club at 15 Abchurch Lane [q.v.], was by this time in partnership with his son Owen Campbell-Jones (b.1894) and Alec Smithers (1878-1949). Redeveloped behind retained façades by the GMW Partnership in 1996.

Portland stone, facing a steel frame with staircases and vaults in reinforced concrete. Five storeys, plus probably two basement levels and an attic in a slated mansard roof. As built, the mansard carried two levels of dormers, although just one row is now present. Rusticated ground floor, its openings architraved with festooned console keystones. Plain band at first floor level supporting giant pilasters, with cartouche capitals, which carry the main entablature with projecting bracketed cornice at fourth floor level. Principal elevation to King William Street with domed turret to left (on corner of Sherborne Lane) and canted corner to right (on corner of St. Swithin's Lane). Between these, five bays in a stripped classical style; tall window surrounds linking first and second floor, each with alternating cornice or pediment on console brackets. Return elevation to St. Swithin's Lane originally of three storeys, but now extended up to five plus an attic in a mansard roof – the continuation of that to King William Street. The triangular plan appears to enclose an atrium and central core for what is essentially a new building which extends southwards beyond the building's original footprint with new, long elevations to both Sherborne Lane and St. Swithin's Lane. The original elevation on Sherborne Lane appears to have been raised from third floor level.

The structure appears to have load-bearing stone/brick façades at the front with a steel-framed internal structure. The 1990s structure to the rear is also likely to be steel-framed.

Significant/Potentially Vulnerable Features

- Fine jointed stonework
- Cornice at fourth floor level

Foundations

Likely construction

- Probably two levels of basement with mass concrete perimeter retaining walls.
- Steel columns to original structure likely to be supported on grillage beams and concrete pad foundations or a raft foundation with thickenings under the columns. Recent structure may be on raft or piled foundations.

Sources

- List description
- Bradley, Simon & Pevsner, Nikolaus (2002): *London 1: The City of London* (The Buildings of England), Yale University Press, New Haven & London, p. 526
- *The Builder*, 5 January 1923, p. 41
- Gray, A. Stuart (1985): *Edwardian Architecture: A Biographical Dictionary*, Duckworth, London, pp. 134

Address	5 King William Street
List Grade	Grade II
Date	1915; extended in 1931-32; refurbished and extended in 1983-7
Building type	Offices
Architect	J. Macvicar Anderson & H. L. Anderson; extended by Campbell-Jones & Sons; refurbished and extended by the Fitzroy Robinson Partnership
Height (no. storeys)	5 storeys and 2 basements

Description

The former Phoenix Fire Assurance building, designed by J. Macvicar Anderson & H. L. Anderson, begun 1915. Extended by Campbell-Jones & Sons, 1931-32. Refurbished and extended by the Fitzroy Robinson Partnership, 1983-7.

The original building comprised four main storeys with its principal elevation to King William Street of eleven bays in a symmetrical 3:5:3 composition; the central five bays recessed above the first floor. Arcaded ground floor channelled with alternating plain and vermiculated bands; the first floor treated as a mezzanine with panelled piers between the windows forming pedestals to the giant Corinthian order which unites the second and third floors; columns to the recessed centre, pilasters left and right; bracketed and modillioned cornice with attic storeys to left and right and balustraded parapet to centre. Central entrance with Doric blocked columns and entablature with open-topped segmental pediment and bronze phoenix by C. H. Mabey. Three-bay return to Abchurch Lane in the same style. Curved end at junction with Sherborne Lane, with seven bay return, the ground floor apparently original, the upper storeys a product of the 1980s works. The spacious entrance hall retains the Andersons' octagon of tall green marble columns supporting an arcaded gallery.

In 1931-32, the building was extended to the south along Abchurch Lane by Campbell-Jones & Sons. The structure appears to be a stone-clad steel frame, with a joint at the junction with the original building. The extension comprised four bays, broadly following the motifs established by the main front, but with tall openings linking the ground and first floors. According to Bradley & Pevsner (2002:526), the 1980s works included the reconstruction of the 1930s façade. This may account for the numbering of the stones of this elevation; certainly the arched vehicle entrance appears to be a late 20th century intervention rather than part of the 1930s composition. The 1980s works also appear to have included a new dormer storey to the whole building, and a major extension to the south.

John Macvicar Anderson (1835-1915) was President of the Royal Institute of British Architects between 1891 and 1894. From 1905, he was in partnership with his son Henry Lennox Anderson (1875-1950), who must have effectively completed the Phoenix Fire Assurance building after his father's death. William Campbell-Jones (1862-1951) was, by the 1930s, in partnership with his sons, including Owen Campbell-Jones (b.1894).

Significant/Potentially Vulnerable Features

- Fine jointed stonework
- Cornice at fourth floor level
- Stone balustrades at fourth and fifth floor level

Foundations

Likely construction

- Probably two levels of basement with mass concrete perimeter retaining walls.

- Steel columns to original structure likely to be supported on grillage beams and concrete pad foundations or a raft foundation with thickenings under the columns. Recent structure may be on raft or piled foundations.

- **Sources**
- List description
- Bradley, Simon & Pevsner, Nikolaus (2002): *London 1: The City of London* (The Buildings of England), Yale University Press, New Haven & London, p. 526
- Gray, A. Stuart (1985): *Edwardian Architecture: A Biographical Dictionary*, Duckworth, London, p. 89

Address	St. Mary Abchurch, Abchurch Yard
List Grade	Grade I
Date	1681-6
Building type	Church
Architect	Sir Christopher Wren
Height (no. storeys)	4 storey tower plus spire; main body of church rises to three storeys of the tower; crypt under

Description

St. Mary Abchurch is first mentioned in the late 12th century, but the medieval church was destroyed by the Great Fire in 1666. The present church is by Sir Christopher Wren, and dates from 1681-6. It is a brick building with stone quoins and dressings, and has a brick tower at its north-west corner with a timber-framed cupola, lantern and lead-covered spire. This was originally topped with a gilded pelican weathervane, but this was removed in 1764 and is now kept in the church. The church presents three bays each to the south and east, with round-headed windows with circular lights over, flanking a large segment-headed window (the eastern one blocked). Hipped, slated roof over painted ceiling dome.

Wren's rebuilding reportedly retained the 14th century crypt; the nave floor lies over brick vaulting, with entry from inside the church, although the extent of the vaulting is unknown. From the crypt, there is reportedly access through the south wall of the church to a medieval vault under the former churchyard (now Abchurch Yard). Bradley & Pevsner (1998:104) state that this 14th century vaulted chamber was uncovered by WW2 bombing. The churchyard was paved over in 1877, to a pattern by Edward l'Anson (1811-1888) – following the cessation of burials in London churchyards brought about by the 1853 Burial Act. The roof structure is a daring design probably originally formed of timber 'scissor' trusses supported on the external walls, and has required remedial work at various times due to inadequacies in construction and blast damage. The domed ceiling structure is supported on corbels from the walls and a column on the west side. The ceiling most likely also takes support from the roof structure.

The church was 'restored' in the late 19th century by l'Anson, who was later to become President of the Royal Institute of British Architects (1886-8). The church was badly damaged by bombing in 1940 and subsequently restored, some of l'Anson's Victorianisation being swept away in the process. Jeffery (1996:270) and Bradley & Pevsner (1998:105) state that the work was undertaken by W. Godfrey Allen (1891-1986) in 1954-7. Nairn (1959:99) says it was Lord Mottistone (John Seely, 1899-1963).

The fittings of the church are particularly fine. The carving of the reredos is documented as the work of Grinling Gibbons. The pulpit was by William Grey, with the carving for it possibly by William Newman or William Emmet.

There is cracking in the external elevations on the west side below the main window and on the south elevation alongside and between the windows. The stones forming the arch over the west door have also dropped. Internally there is cracking in the brickwork to the north wall.

To the north is a church room of 1914-15, added by William Campbell-Jones (1862-1951) in connection with the building of the Gresham Club at 15 Abchurch Lane [q.v.].

The LCC's bomb damage map noted that the church was 'seriously damaged, doubtful if repairable'. Further research into the extent of war damage and the nature and extent of subsequent repair is needed.

Significant/Potentially Vulnerable Features

- Painted domed ceiling
- Marble monuments set in walls internally.
- Carved wood reredos.
- Stone quoins/dressings
- Timber roof structure
- Vaults
- Tower moving differentially to the rest of the church

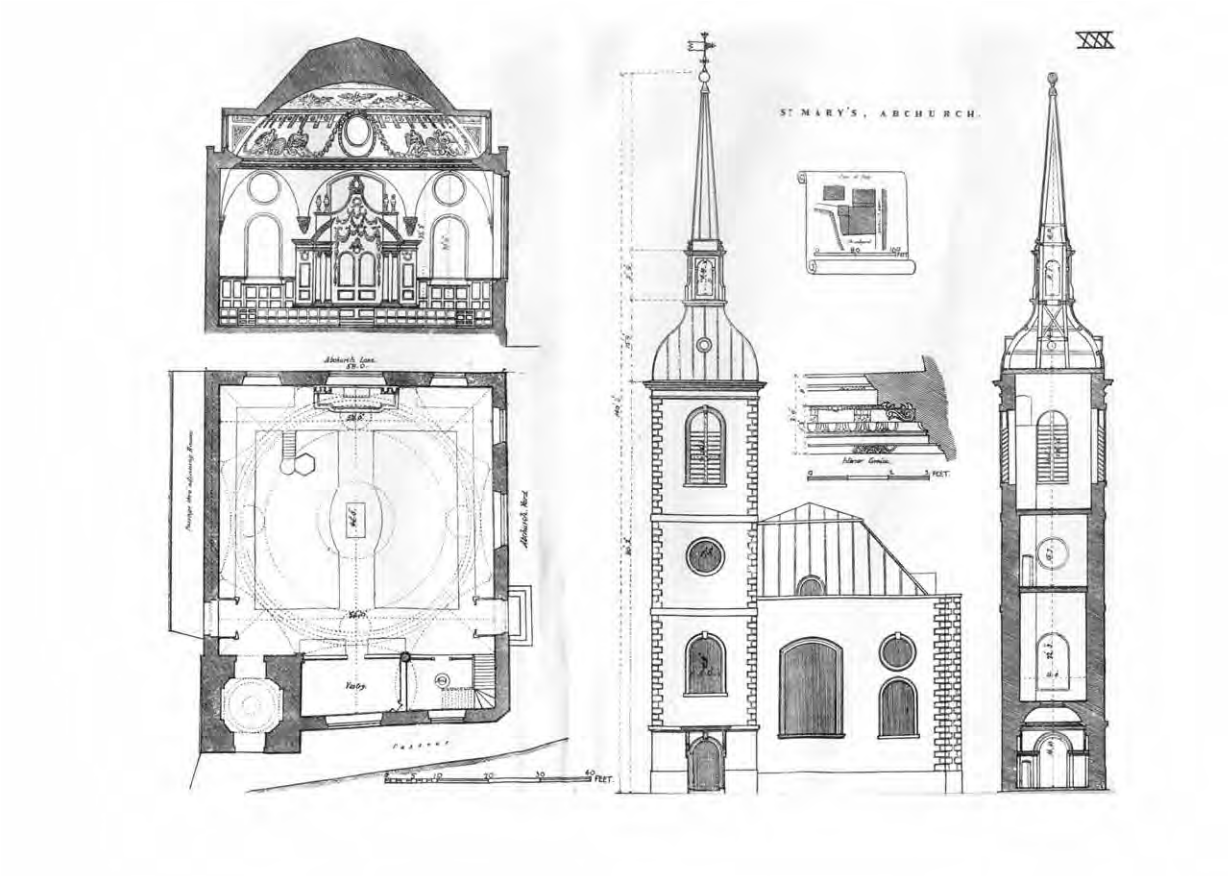
Foundations

Likely construction

- Corbelled masonry strip footings to the brick vault walls/piers.

Sources

- List description
- Bradley, Simon & Pevsner, Nikolaus (1998): *London: The City Churches* (The Buildings of England), Penguin, London, pp. 104-106
- Bradley, Simon & Pevsner, Nikolaus (2002): *London 1: The City of London* (The Buildings of England), Yale University Press, New Haven & London, pp. 238-240
- Colvin, Hugh (1995): *A Biographical Dictionary of British Architects, 1600-1840* (third edition), Yale University Press, New Haven & London, pp. 1083-1097
- Jeffery, Paul (1996): *The City Churches of Sir Christopher Wren*, The Hambledon Press, London & Rio Grande, pp. 268-270
- Nairn, Ian (1959): 'Church restoration', *The Architects' Journal*, 15 January, pp. 99-104
- *The Wren Society, Volume IX: The Parochial Churches of Sir Christopher Wren, 1666-1718, Part One*, 1932, Oxford University Press, p. 40
- *The Wren Society, Volume X: The Parochial Churches of Sir Christopher Wren, 1666-1718, Part Two*, 1933, Oxford University Press, pp. 30-31



1848 drawings of St. Mary Abchurch, which predate the building of the Greshham Club at 15 Abchurch Lane.

Address	20 St. Swithin's Lane
List Grade	Grade II*
Date	c.1800
Building type	Offices over restaurant
Architect	Not known
Height (no. storeys)	2 storeys plus attic and two levels of vaults

Description

A house of c.1800, possibly incorporating earlier fabric. Yellow stock brick, slate roof. Two storeys, seven bays with a further recessed entrance bay to the left; brick band course at first floor level; sash windows in square-headed openings with gauged brick heads. Front elevation sets back to left with recessed radiused corner and re-entrants; entrance bay to left with double doors and moulded architrave. Later mansard roof with pedimented dormers. A shed-like wooden crane house of the same period survives to the right. According to Bradley & Pevsner (2002:600), this structure's 'Capital Patent Crane' was already present in 1805, when the wine merchant George Sandeman took over no. 20.

Vaulted cellars beneath house, crane house and yard; reportedly 18th century brick vaulted cellars, together with, at lower level, a small probably 14th century vault constructed of neatly laid courses of chalk block with a larger springer course. Yard paved with granite sets. Wrought iron gates to the entrance arch.

Significant/Potentially Vulnerable Features

- Vaulted cellars
- Flat brick arches over windows

Foundations

Likely construction

- Corbelled brick footings to the walls/piers forming the vaulted cellars.

Sources

- List description
- Bradley, Simon & Pevsner, Nikolaus (2002): *London 1: The City of London* (The Buildings of England), Yale University Press, New Haven & London, pp. 599-600

Address	15 Abchurch Lane
List Grade	Grade II
Date	1914-15
Building type	Private club
Architect	William Campbell-Jones
Height (no. storeys)	3 storeys plus 2 attics and 2 basements

Description
The former Gresham Club, designed by William Campbell-Jones, 1914-15, also incorporating a parish room for the adjacent Church of St. Mary Abchurch [q.v.].

The Gresham Club was founded in 1843 for bankers, merchants and 'professional gentlemen of known respectability'. Its original premises were at the corner of St. Swithin's Lane and Lombard Street, a site which it was reportedly paid to vacate in 1913. For its new building, the club commissioned William Campbell-Jones (1862-1951), the Surveyor to the Skinners' Company. Campbell-Jones was best known for branch banks, of which he designed many.

The principal elevation to Abchurch Lane comprises three stone-faced storeys, plus two basement levels faced in glazed brick together with a later glazed brick attic. The structure is thought likely to be steel-framed. Three bays, with a projecting two-bay entrance wing to the left, the latter with a segment-headed front door with consoled hood over. Segment-headed windows with console keystones throughout, those to the rusticated ground floor with blocked surrounds. First and second floor windows separated by aprons decorated with swags and urns. There is some cracking to the stonework at the front entrance. To the rear, facing Abchurch Yard, a single bay load-bearing masonry structure with red brick ground floor and glazed brick upper storeys; two attic storeys in roof. Stone doorcase with cherubic keystone plus round-headed window openings with stone archivolt surrounds and keystones, mimicking the windows of the adjacent St. Mary Abchurch.

The building was refurbished as the London Capital Club by CCA (Crapnell Chamberlain Associates) in 1994, at which time further storeys (possibly two) were added. According to Bradley & Pevsner (2002:413), the interiors evoke the late 17th century, but with much use of mahogany.

Significant/Potentially Vulnerable Features

- Chimneys
- Stone joints

Foundations

Likely construction

- Two levels of basement with mass concrete external walls.
- Steel frame likely to be supported on grillage beams and pad foundations or a raft foundation with thickenings under the columns.

Sources

- List description

- Bradley, Simon & Pevsner, Nikolaus (2002): *London 1: The City of London* (The Buildings of England), Yale University Press, New Haven & London, p. 413
- Gray, A. Stuart (1985): *Edwardian Architecture: A Biographical Dictionary*, Duckworth, London, p. 134
- Weinreb, Ben & Hibbert, Christopher [eds.] (1993): *The London Encyclopaedia*, Pan Macmillan, London, pp. 2, 347

Address	29 Martin Lane
List Grade	Grade II
Date	1851-3; adapted for office use in 1978-80
Building type	Offices
Architect	John Davies; adapted for office use by Rolfe Judd
Height (no. storeys)	3 storeys plus 2 attics and basement; 4 storey tower

Description

Italianate former rectory, with integrated tower, designed by John Davies, 1851-3, for St. Clement Eastcheap. Three bays and three storeys, plus single basement and two attic storeys in slated mansard roof rising behind plain parapet. Flemish bond red brick with painted stucco dressings. Ground floor: projecting arched porch in stucco and round-headed windows with stucco architraves. Upper floor sash windows with stucco surrounds. To the right, a slender campanile, also in red brick, with painted stucco quoins. Large wooden bracketed clock with segmental pediment facing Martin Lane, dated 1853. Shallow canted bow window to the south.

The present building stands on the site of the Church of St. Martin Orgar, which was first mentioned in the 12th century, when it was granted by Orgar, the Deacon, to the Canons of St. Paul's Cathedral. Apart from its tower and a small part of the nave, the church was destroyed in 1666 in the Great Fire of London. According to Weinreb & Hibbert (1993:755), French Protestants restored the tower and worshipped in it for more than 150 years. Bradley & Pevsner (2002:555) state that the tower survived until 1847, although some other sources suggest that it disappeared a little earlier. Certainly it appears to have survived until at least 1831, when it was depicted by Thomas Hosmer Shepherd.

When the church had been destroyed, the parish of St. Martin Orgar had merged with that of St. Clement Eastcheap, and it was as a rectory for this parish that the present building was erected in 1851-3. The architect for the building was John Davies (1796-1865), who had been a pupil of George Maddox. Davies exhibited his design at the Royal Academy in 1853. Colvin (1995:295) states that the tower and the rectory were built as a single structure, and Bradley & Pevsner (2002:555) relate that the tower's crude square top stage replaced an ornate cupola some time before 1935. The building is of load-bearing masonry construction, and was adapted for office use by Rolfe Judd in 1978-80, at which point the dormer storeys were most likely introduced.

Excavations in 1987 revealed foundations of a Saxo-Norman eastern apse in the former churchyard to the south, made square-ended in the 13th century; a south chapel with a vaulted crypt was a later addition.

Significant/Potentially Vulnerable Features

- Cornice to tower
- Stucco dressings etc.
- Tower moving differentially to rest of building
- Bay windows

Foundations

Likely construction

- Corbelled brick strip footings; may be shallow to the bay windows.

Sources

- List description
- Bradley, Simon & Pevsner, Nikolaus (2002): *London 1: The City of London* (The Buildings of England), Yale University Press, New Haven & London, p. 555
- Colvin, Hugh (1995): *A Biographical Dictionary of British Architects, 1600-1840* (third edition), Yale University Press, New Haven & London, pp. 294-295
- Weinreb, Ben & Hibbert, Christopher [eds.] (1993): *The London Encyclopaedia*, Pan Macmillan, London, pp. 515, 755

Address	123-127 Cannon Street
List Grade	Grade II
Date	1894-5
Building type	Offices over café use
Architect	Herbert Huntly-Gordon
Height (no. storeys)	6 storeys and basement

Description
Red brick and terracotta building, with Flemish Renaissance and Art Nouveau details, designed by Herbert Huntly-Gordon (1864-1926), 1894-5 – at one time known as Abchurch House. According to Pearson (2005), Huntly-Gordon was an architect and speculative builder who used terracotta for several of his London buildings, and worked in association with Doulton's to produce a rough-faced brown terracotta specifically suited to Renaissance architectural ornament.

Hemmed-in on 2½ sides, the building has façades to Cannon Street and Abchurch Yard. The principal façade to Cannon Street is over six storeys; three asymmetric bays divided by half octagonal pilaster strips; foliage frieze between second and third storeys; frieze with putti engaged in various trades occupies the two left-hand bays at eaves level. Gable to left-hand bay. At ground floor level, a semi-circular arched opening to the left bay and an extended round arch to the right-hand two, both with elaborate piers and foliated spandrels. The extended round arched opening now with an off-centre inserted column behind which the load-bearing masonry 'cross wall' structure sits. Either timber or filler joist floors, timber roof. The terracotta details all painted over in a terracotta colour. Pavement lights indicate the presence of a basement extending under the pavement beyond the building's Cannon Street frontage. Rear elevation to Abchurch Yard in a similar but simplified treatment; the terracotta details all painted over, but in a different terracotta hue to the Cannon Street façade.

Significant/Potentially Vulnerable Features

- Terracotta decorations on front
- Large arch to right hand side
- Chimneys

Foundations

Likely construction

- Corbelled brick strip footings to the basement walls and party walls running north to south.

Sources

- List description
- Bradley, Simon & Pevsner, Nikolaus (2002): *London 1: The City of London* (The Buildings of England), Yale University Press, New Haven & London, p. 444
- Pearson, Lynn (2005): *Tile Gazetteer: A Guide to British Tile and Architectural Ceramics Locations*, Richard Dennis, Shepton Beauchamp

Address	Mansion House, Mansion House Street
List Grade	Grade I
Date	1739-52; much altered in the 1790s, 1840s, 1860s and 1990s
Building type	Civic residence
Architect	George Dance the Elder;
Height (no. storeys)	5 storeys plus attic and basement

Description

Designed as a residence for the Lord Mayor by George Dance the Elder, begun in 1739, occupied in 1752. Much altered, including by George Dance the Younger in 1794-5, and by J. B. Bunning in the 1840s and 1860s. Further major alterations and strengthening works were carried out in the 1990s.

Monumental, classical building of load-bearing masonry construction faced in Portland stone, with rusticated ground storey and giant order of Corinthian columns and pilasters through two main storeys, plus attic above entablature. Narrow north front has hexastyle Corinthian portico with richly carved tympanum to triangular pediment. Balustraded steps at either side. Long returns to east and west relatively plain except for pilastered end pavilions with large, round-arched windows above Venetian openings. Plain south elevation of yellow brick above ground storey. To achieve height in his two main rooms – the Ballroom and the Banqueting Room (also known as the Egyptian Hall) – Dance the Elder (1695-1768) topped the building with two transverse attics that were dubbed the 'Mayor's Nest' and 'Noah's Ark'. Between these was an internal courtyard at first floor level.

In 1794-5, the courtyard was roofed over by Dance the Younger (1741-1825) to create a new saloon. He also removed the transverse attic at the rear ('Noah's Ark'), thus reducing the height of the Egyptian Hall's ceiling, and removed the grand staircase to make way for another two rooms. He also added a small portico to the west door (removed in 1845).

In the 1840s, J. B. Bunning (1802-1863) removed the transverse attic over the ballroom, added the off-centre Doric west porch on Walbrook (now the principal entrance), and enriched the inserted plain coffered ceiling of the Egyptian Hall. In 1861-2, he replaced the roof over the courtyard (which was itself replaced in the 1990s).

There was a general restoration of the whole structure in 1931, although further restoration was required following damage sustained during the Second World War. The building was refurbished and steel ties added in the 1990s prior to construction of the DLR.

Significant/Potentially Vulnerable Features

- Ceilings to the Ballroom/Banqueting room
- Projecting stone balcony to Ballroom
- Main entrance portico
- Cornice at third floor level
- Fine jointed stonework
- Stone balustrades at roof level

Foundations

Likely construction

- The building generally has two levels of brick arched vaults at basement and ground level which support the principal reception areas at first floor level.

- The lower vault is supported on brick strip footings.

Sources

- List description
- Bradley, Simon & Pevsner, Nikolaus (2002): *London 1: The City of London* (The Buildings of England), Yale University Press, New Haven & London, pp. 317-321
- Colvin, Hugh (1995): *A Biographical Dictionary of British Architects, 1600-1840* (third edition), Yale University Press, New Haven & London, pp. 287-288, 290
- Weinreb, Ben & Hibbert, Christopher [eds.] (1993): *The London Encyclopaedia*, Pan Macmillan, London, pp. 508-510

Building Area Ref.	Occupier Address	Tenant Description	Listed Building
A16	121 Cannon Street	Commercial Business - Dry Cleaner	Grade II
A17	5 Abchurch Yard	Restaurant / Bar	Grade II
	123-127 Cannon Street	Restaurant - Fast Food	Grade II
	St Mary Abchurch House, 123 Cannon Street		Grade II
A18	129 Cannon Street	Restaurant - Fast Food	Grade II
	1 Abchurch Yard	Residential	Grade II
A19	131-133 Cannon Street	Recruitment Agency	
A20	141 Cannon Street	Commercial Business - Telecoms Provider	
	135 Cannon Street	Restaurant - Fast Food	
A21	20 Abchurch Lane	Mixed Use Building: Recruitment Agencies, Legal and Notarial Services, Asset Management, Energy Consultancy,	
A22	10 King William Street	City of London Guild	
A23	12 Nicholas Lane	Mixed use Building: Recruitment Agencies, IT / Software Consultants, Financial Institution, National Tourist Organisation (Japan)	
A24	14 Nicholas Lane	Mixed Used Building: Recruitment Agencies, & Financial Services	
A25	143 Cannon Street	Restaurant - Fast Food	
	145 Cannon Street	Mixed use Building: IT / Software Consultants & Management Consultants	
A26	19 King William Street, Pheonix House	Mixed Use Building: Financial Institutions, IT / Software Consultants, IT / Telecommunications provider, Online Company.	
A27	Guild Church of St Mary Woolnoth	Church	Grade I
A28	87 King William Street	Restaurant - Fast Food	
A29	85 King William Street, Capital House	Mixed Use Building: Financial Services, Legal Services, Financial Institution, Real Estate Consultant.	
	85 King William Street	Retail outlets at street level; Restaurants - Fast Food	
	10-16 Lombard Street	Supermarket	
	Post Office Court	Restaurant - Fast Food	
A30	81 King William Street	Under refurbishment for a Financial Institution.	
A31	75 King William Street	Mixed use Building: Recruitment Agencies, Financial Services, Asset Management, Financial Institutions, Shipping Companies.	Grade II
A32	110 Cannon Street	Under refurbishment	
A33	116-126 Cannon Street - Ground level	Mixed Use Building: Restaurants - Fast Food Retail Stores.	
	Candlewick House, 120 Cannon Street	Mixed Use Building: Financial Services, Management Consulting & Legal Services.	

Building Area Ref.	Occupier Address	Tenant Description	Listed Building
A34	29 Martin Lane	Legal Services.	Grade II
A35	28 Martin Lane	Residential	
	27 Martin Lane	Commercial Business - Hairdressers	
A36	24 Martin Lane	Mixed Use Building: IT Consultants, Legal Watch Dog, And Legal Services & Caterers.	
A37	24 King William Street	Mixed Use Building: Multidiscipline Consultancy, Management Consultancy, Financial Services & Freight Company.	
	28 King William Street	Public House	
A38	33 King William Street	Financial Services.	
A39	Adeleide House, London Bridge	Legal Services.	

Table B.2: Summary of the buildings that may be affected by works

Building Area Ref.	Occupier Address	Tenant Description	Listed Building
B1	1-5 Moorgate	Financial Institution	
B2	5 Lothbury	Financial Institution	
B3	Bank of England	Financial Institution and Museum	Grade I
B4	11 Old Jewry	Mixed Use Building: Financial & Legal Institutions	
	12 Old Jewry	Empty (and gutted)	
B5	1 Queen Victoria Street	Her Majestys Court Services	
B6	Church of St Stephen Woolbrook	Church	
B7	37a Woolbrook	Dinning Club	
B8	Walbrook 11-12 St Swithins Lane Cannon Street	Building currently being developed by Minerva Plc	
B9	13 St Swithins Lane (street level)	Tailor and Barber	
	13 St Swithins Lane (street level)	Cafe	
	13 St Swithins Lane (above shops)	Mixed Use Building: Financial & Legal Institutions	
B10	Five Arrows House 18 St Swithins Lane	Domestic	
B11	115 Cannon Street	Department Store	
	117 Cannon Street	Café	
B12	90 Cannon Street	Financial Institution	
B13	100 Cannon Street (ground floor street facing)	Financial Institution	
	Religar House (entrance on Laurence Pountney Hill) 100 Cannon Street	Mixed Use Building: Financial & Legal Institutions	
B14	108 Cannon Street	Financial Institution	
B15	Martin House	Financial Institution	

Building Area Ref.	Occupier Address	Tenant Description	Listed Building
	5 Martin Lane		
B16	Union House 6 Martin Lane	Domestic	
	6 Martin Lane	Public House	
B17	10 Arthur Street	Mixed Use Building: Financial, Commercial & Legal Institutions	
B18	Fishmongers' Hall London Bridge	The Fishmongers Company	
B19	45 King William Street	Mixed Use Building: Financial, Commercial & Legal Institutions	
	Ground floor King William Street	Restaurant / Fast food	
	Corner of Lower Thames Street and Fish Street Hill	Restaurant / Bar	
	20 Fish Street Hill	Hairdresser	
	Fish Street Hill	Public House	
B20	Dresden House, 70-72 King William Street	Mixed use Building: Financial Services & Management Consulting.	
B21	1 Saint Clement's Court	Church	Grade I
B22	St Clement's House, 27-28 Clement's Lane	Mixed use Building: Recruitment Agencies, Financial Services & Legal Services.	Grade II
B23	6-8 Clements Lane	Financial Institution	Grade II
B24	24 Lombard Street	Financial Institution	Grade II
B25	21 Lombard Street	Financial Institution	
B26	Church of St Edmund the King, Lombard	Church	
B27	60-62 Lombard Street	Mixed Use Building: Financial Services, Management Consulting & Legal Services.	
B28	67 Lombard Street	Currently boarded up. Previously a financial institution.	
B29	68-70 Lombard Street	Mixed Use Building: Financial Services, Management Consulting & Legal Services.	
B30	14 Cornhill	Restaurant / Bar	
B31	77 Lombard	Restaurant - Fast Food	
B32	80 Lombard St	Unknown. Believed to be an extension of 82 Lombard St	
B33	No 1 Cornhill	Mixed Use Building: Financial Services, Management Consulting & Legal Services.	Grade II
B34	St Margrets Church	Church	
B35	6 Lothbury	Financial Institution	