Basement Impact & Structural Impact Assessment

Prepared by Heyne Tillett Steet

Submitted on behalf of Lab Selkirk House Ltd

Selkirk House, 166 High Holborn and 1 Museum Street, 10-12 Museum Street, 35-41 New Oxford Street and 16A-18 West Central Street, London, WC1A 1JR

June 2023

A-squared Studio

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Basement Impact Assessment

May 2023

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Project Name	Selkirk House, 166 High Holborn and 1 Museum Street, 10-12 Museum Street, 35-41 New Oxford Street and 16A-18 West Central Street, London, WC1A 1JR
Project Number	2633
Client	Heyne Tillett Steel Ltd on behalf of Lab Selkirk House Ltd
Document Name	Basement Impact Assessment

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Appendices

1. Non-Technical Summary

1.1.1. The site location is the land at Selkirk House, 166 High Holborn and 1 Museum Street, 10-12 Museum Street, 35-41 New Oxford Street and 16A-18 West Central Street, London, WC1A 1JR.

1.1.2. The 1 Museum Street site currently comprises the 17-storey Selkirk House tower and NCP car park with two levels of basement and a further partial basement level. The West Central Street site is currently occupied by four terraced three- to four-storey residential, commercial and retail buildings with a single-level shared basement.

1.1.3. The proposed development at the 1 Museum Street site comprises the demolition of Selkirk House, excavation of the Vine Lane basement, and construction of the 19-storey Museum Street, six-storey High Holborn and five-storey Vine Lane buildings. The development at West Central Street will comprise a series of new and refurbished buildings rising to ground plus five storeys.

1.1.4. The following foundation systems will be implemented across the site.

- **Museum Street**: Within the existing basement, new discrete shallow footings at column locations and a new hybrid piled raft foundation system beneath the core will be constructed approximately 2m above the lowest point of the top of the existing raft, with large portions of the existing basement refurbished and reused. Several bearing piles will also be constructed for columns landing outside of the basement to the north and east, and within the basement in the southeast corner.
- **Vine Lane**: A new raft foundation system will be constructed, replacing any existing substructure elements present in that location. The raft will be tied into a new secant wall toed approximately 4m below the proposed formation level.
- **High Holborn**: A new raft foundation system will be constructed on the top of the existing raft. The existing single-storey basement will be backfilled above the new raft to ground level.
- **West Central Street**: The existing basement and foundations will be retained below new columns, with limited basement extensions via underpinning above the anticipated groundwater table and new raft foundations introduced where required.

1.1.5. The proposed Vine Lane bulk excavation and construction of permanent works elements will take place following the installation of all retention systems, i.e. utilising a *bottom-up* methodology.

1.1.6. Temporary propping / shoring measures are likely to be required at ground level, prior to proceeding with bulk excavation works at Vine Lane and demolition of substructure elements in the existing Selkirk House basement. The props will increase the stiffness of the retention systems during construction and reduce the risk of adversely affecting neighbouring structures and/or third-party assets, due to excessive ground movement.

1.1.7. The following assessments are presented in the current document:

- Screening.
- Scoping.
- Additional evidence/assessments (as required), including:
  - Ground movement assessment – adjacent buildings.
  - Construction methodology and management plan.
  - Architectural and structural drawings.
- Basement Impact Assessment.

1.1.8. The site and the general surrounding areas are relatively flat. The site has an external elevation of approximately 25.0mOD.

1.1.9. Based on a review of site-specific ground investigation works, British Geological Survey data and historical planning information from the London Borough of Camden Planning Portal, the ground conditions beneath the site comprise:

- **Made Ground**: to a depth of up to 4m below ground level, comprised of variable anthropogenic deposits.
- **Lynch Hill Gravels**: to a depth of approximately 7m below ground level, comprising medium dense to dense sandy gravels.
- **London Clay Formation**: approximately 21m-thick (to a maximum depth of approximately 28m below ground level) comprising stiff to very stiff silty clay.
- **Lambeth Group**: to depths of approximately 45m below ground level, comprising a variable sequence of clay with silt, sand, and gravels.
- **Thanet Sands**: to depths of approximately 51m below ground level (approximately 6.5m thick) comprising grey-brown fine-grained silty / clayey sand.
- **Chalk**: at least 100m thick. The thickness of the Chalk stratum has not been proven by site-specific ground investigation works but is not considered to be of engineering significance to the proposed scheme.

1.1.10. The hydrogeological conditions at the site, relevant to the proposed development, comprise:

- Local, potentially finite, perched bodies of water within the Made Ground and superficial deposits.
- Shallow groundwater table within the Lynch Hill Gravels (Secondary A Aquifer).
- A hydrostatic becoming underdrained pore water pressure distribution within the London Clay Formation.

1.1.11. The Basement Impact Assessment has assessed land stability, and the impacts of the proposed development on the neighbouring structures will be limited to *Category 1 - Very Slight*, in accordance with the Burland Scale.

1.1.12. The Basement Impact Assessment has concluded that there will be low risk to the development and/or neighbouring properties associated with the risk of land and slope instability.

1.1.13. The Basement Impact Assessment has concluded that there is a low risk of groundwater flooding.

1.1.14. The Basement Impact Assessment has identified that the proposed Vine Lane basement pile wall and underpins will create a cut-off to any existing groundwater flow paths that currently pass through the site, as they will be embedded within the underlying low permeability London Clay Formation. Based on a review of currently available ground investigation information, a hydrogeological gradient across the site is not anticipated. The presence of a hydrogeological gradient will be confirmed during post-planning ground investigation works, and, if non-static groundwater is identified, the requirement for a hydrogeological assessment will be reviewed.

2. Introduction

2.1. Overview

2.1.1. A-squared Studio Engineers Ltd (A-squared) were engaged by Meinhardt (UK) Ltd on behalf of Lab Selkirk House Ltd ('the Applicant') to prepare a Basement Impact Assessment (BIA) for the proposed redevelopment of the land at Selkirk House, 166 High Holborn and 1 Museum Street, 10-12 Museum Street, 35-41 New Oxford Street and 16A-18 West Central Street, London, WC1A 1JR ('the site').

2.1.2. This report has been prepared in support of the detailed planning application being submitted by the Applicant to the London Borough of Camden ('the Council') for the redevelopment of the site.

2.1.3. The detailed planning application seeks planning permission for the following description of development:

"Redevelopment of Selkirk House, 166 High Holborn and 1 Museum Street following the substantial demolition of the existing NCP car park and former Travelodge Hotel to provide a mixed-use scheme, providing office, residential, and town centre uses at ground floor level. Works of part- demolition and refurbishment to 10-12 Museum Street, 35-41 New Oxford Street, and 16A-18 West Central Street to provide further town centre ground floor uses and residential floorspace, including affordable housing provision. Provision of new public realm including a new pedestrian route through the site to link West Central Street with High Holborn. Relocation of cycle hire docking stations on High Holborn (Phased Development).

Listed Building Consent application for:

Alterations, including part-demolition, to 10-12 Museum Street and 35 and 37 New Oxford Street, to provide flats and townhouses. Demolition of modern rear extension to 11-12 Museum Street from first to third floors, rebuilding of rear wall. Removal of non-original staircase and internal walls to 11-12 Museum Street along with new layouts and thermal upgrades including internal wall insulation, to facilitate new flats. New bridge links to 12 Museum Street from 16a-18 West Central Street. Removal of non-original partition walls to 35 and 37 New Oxford Street, reinstatement of historic room layouts, thermal upgrades. Across listed buildings: New kitchens, bathrooms and sanitaryware; Introduction of slimline double-glazed retrofit vacuum glazing to existing window joinery, limited replacement frames; New internal and external doors; Façade refurbishment works; Conservation and restoration of historic joinery, plasterwork, fireplaces and other features of heritage importance. Courtyard garden linking buildings at first floor level above ground floor shared services, with new and amended openings to listed buildings to provide access. New and restored retail frontages to all buildings."

2.1.4. The proposed development has evolved through an extensive pre-application and wider stakeholder consultation process, which has included collaborative discussions with the Council, Greater London Authority, Transport for London, Historic England, and a number of other key stakeholders.

2.1.5. The proposed development provides the opportunity to regenerate this strategically important site through the demolition and refurbishment of the existing poor-quality buildings and replacement with a highly sustainable mixed-use development. The proposed development will deliver all the key master planning requirements and uses specified by the Local Plan (2017), the Holborn Vision and Urban Strategy (2019), and the Draft Site Allocations Plan (2020), providing the opportunity to deliver a wide range of planning and public benefits. The *Basement Impact Assessment Audit* prepared by Campbell Reith Hill LLP (January 2023) undertaken for a previous Planning application for the site has also been reviewed.

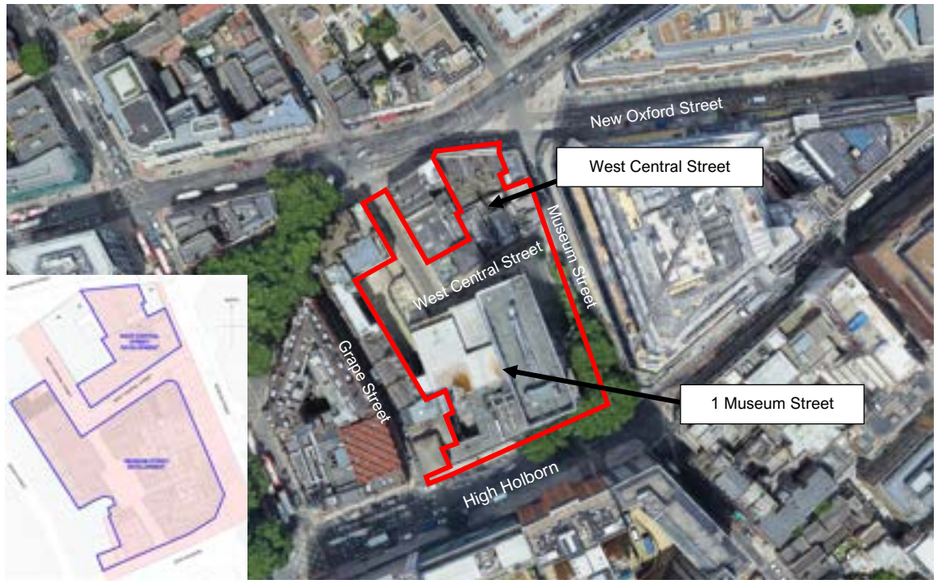
2.1.6. The purpose of this assessment is to consider the potential effects of the proposed works at the site on the local hydrology, geology and hydrogeology, and the potential impacts to neighbours and the wider environment.

2.1.7. The location of the proposed development is shown in Figure 2.1.

2.1.8. The BIA has followed the approach developed by the London Borough of Camden, which is considered to represent current industry best practice.

2.1.9. The BIA comprises the following elements:

- Screening.
- Scoping.
- Additional evidence / assessments (as required), including:
  - Architectural and structural drawings.
  - Ground movement assessment (GMA).
- Basement impact assessment.



Approximate site boundary marked in red.

Figure 2.1 Museum Street site location

2.2. Credentials

2.2.1. The BIA has been reviewed by Alex Nikolic. Alex is a Chartered Member of the Institution of Civil Engineers (MICE) with over 20 years of industry experience in geotechnical design and construction of ground engineering works. Alex has attained post-graduate qualifications, including a Master of Science in Soil Mechanics (MSc DIC) from the Imperial College London and a Master of Studies (MSt Cantab) in Interdisciplinary Design and Sustainable Development from the University of Cambridge. Alex was formerly the Head of the Ground Engineering discipline at Buro Happold Ltd.

2.2.2. The BIA has been approved by Tony Suckling. Tony is a Chartered Fellow of the Institution of Civil Engineers (FICE) and a Fellow of the Geological Society (FGS). Tony has a Master of Science (MSc) in Geotechnical Engineering from City University. Tony is

a Registered Ground Engineering Professional (RoGEP) with 30 years of industry experience in geotechnical design and construction of ground engineering works. Tony has previously held the position of Technical Director for Balfour Beatty Ground Engineering Ltd. Tony has been a past Chairman of the Federation of Piling Specialists Technical Committee and a Board Member of the Deep Foundation Institute Europe. Tony was part of the steering group for CIRIA C760 Guidance on Embedded Retaining Wall Design.

2.3. Sources of Information

2.3.1. The following baseline data has been referenced to complete the BIA in relation to the proposed development:

Design Reports and Drawings

- *Geotechnical and Geo-environmental Desk Study Report* prepared by A-squared Studio Engineers Ltd, dated May 2023 (ref. 2633-A2S-XX-XX-RP-Y-0001-00).
- *Structural Engineer Report to Supplement BIA – 1 Museum Street, Vine Lane and High Holborn* prepared by Meinhardt (UK) Ltd, dated June 2022 (ref. 2413-MHT-ST-RP-008 Issue 3).
- *10-12 Museum Street, 35-41 New Oxford Street and 16A-18 West Central Street Structural Report* prepared by Heyne Tillett Steel Ltd, dated May 2023.
- Architectural drawings produced by DDSHA, dated October 2019, July and August 2020, and April and June 2022.
- RIBA Stage 2 drawings of proposed 1 Museum Street and West Central Street developments produced by Meinhardt (UK) Ltd, dated April 2022.
- RIBA Stage 2 drawings of proposed West Central Street developments produced by Heyne Tillett Steel Ltd, dated April 2023.
- *Structural, Civil & Geotechnical Stage 2 Redesign Report* prepared by Meinhardt (UK) Ltd, dated May 2022 (ref. 2413-S-RP-012).
- Archive drawings of the existing Selkirk House development provided by Meinhardt (UK) Ltd.
- *Preliminary Basement Extension Secant Wall Assessment* technical note prepared by A-squared Studio Engineers Ltd, dated December 2019 (ref. 1084-A2S-XX-XX-TN-Y-0005-00).
- *Existing Basement Reuse Groundwater Considerations* technical note prepared by A-squared Studio Engineers Ltd, dated November 2020 (ref. 1084-A2S-XX-XX-TN-Y-0008-01).
- *Substructure Bearing and Pile Capacities* technical note prepared by A-squared Studio Engineers Ltd, dated November 2020 (ref. 1084-A2S-XX-XX-TN-Y-0009-00).
- *Tree Protection Zone Pile Design and Construction Considerations* technical note prepared by A-squared Studio Engineers Ltd, dated December 2020 (ref. 1084-A2S-XX-XX-TN-Y-0010-00).
- *Retaining Wall Pressure Assessment* technical note prepared by A-squared Studio Engineers Ltd, dated December 2020 (ref. 1084-A2S-XX-XX-TN-Y-0011-00).
- *Museum Street Piled Raft Foundation Design Summary* technical note prepared by A-squared Studio Engineers Ltd, dated June 2022 (ref. 1084-A2S-XX-XX-TN-Y-0013-01).
- *Party Wall etc. Act 1996 Phase 1 Report* prepared by Pulsar Building Consultancy, dated October 2019.

Ground Movement Assessment Reports

- *Preliminary Post Office Tunnels Ground Movement Assessment* technical note prepared by A-squared Studio Engineers Ltd, dated November 2020 (ref. 1084-A2S-XX-XX-TN-Y-0002-03).
- *Preliminary Post Office Tunnels GMA – Addendum 3* technical note prepared by A-squared Studio Engineers Ltd, dated December 2019 (ref. 1084-A2S-XX-XX-TN-Y-0006-00).
- *Post Office Tunnels Ground Movement Assessment Report* prepared by A-squared Studio Engineers Ltd, dated June 2022 (ref. 1084-A2S-XX-XX-RP-Y-0002-01).
- *LUL Ground Movement Assessment Report* prepared by A-squared Studio Engineers Ltd, dated February 2021 (ref. 1084-A2S-XX-XX-RP-Y-0003-00).
- *Crossrail Assets Ground Movement Assessment Report* prepared by A-squared Studio Engineers Ltd, dated June 2022 (ref. 1084-A2S-XX-XX-RP-Y-0004-01).
- *Thames Water Utilities Ground Movement Assessment Report* prepared by A-squared Studio Engineers Ltd, dated June 2022 (ref. 1084-A2S-XX-XX-RP-Y-0005-01).
- *UKPN Ground Movement Assessment Report* prepared by A-squared Studio Engineers Ltd, dated February 2021 (ref. 1084-A2S-XX-XX-RP-Y-0006-00).
- *Building Damage Ground Movement Assessment Report* prepared by A-squared Studio Engineers Ltd, dated May 2023 (ref. 2633-A2S-XX-XX-RP-Y-0003-00).

Ground Investigation Information

- *1 Museum Street and West Central Street Ground Investigation Specification* prepared by A-squared Studio Engineers Ltd, dated October 2020 (ref. 1084-A2S-XX-XX-SP-Y-0001-00).
- *Geo-environmental Soil Sampling* letter report prepared by Jomas Associates Ltd, dated November 2020 (ref. P3094J2084/JWT v1.1).
- *Ground Investigation Factual Report* prepared by Jomas Associates Ltd, dated August 2021 (ref. P3094J2084/JWT Final v1.0).
- Structural Investigation Report prepared by Swantest, dated November 2020 (ref. SC-2354-SI-01).

Publicly Available Information

- *Ground Investigation and Basement Impact Report for West Central Street* produced by Geotechnical & Environmental Associates Ltd, dated November 2015 (ref: J15190, Ground Investigation - BIA and Ground Movement), downloaded from London Borough of Camden Planning Portal October 2019.
- *Ground Movement and Central Line Tunnel Capacity Calculations* produced by Ove Arup and Partners Ltd, dated June 2015 (ref: REP/GEO/05), downloaded from London Borough of Camden Planning Portal October 2019.
- Public domain geological mapping from British Geological Society Geology of Britain Viewer and Borehole Viewer.
- Flood map for planning – Environment Agency.
- Hydrogeological data obtained by Envirocheck.
- LB Camden, Strategic Flood Risk Assessment (produced by URS, 2014).
- LB Camden, Floods in Camden, Report of the Floods Scrutiny Panel (2013).
- LB Camden, Planning Guidance (CPG4) – Basements (March 2018).
- LB Camden, Camden Geological, Hydrogeological and Hydrological Study – Guidance for Subterranean Development (produced by Arup, 2010) (GHHS).
- LB Camden, Local Plan Policy A5 Basements (2017).
- LB Camden's Audit Process Terms of Reference.

2.4. Existing Site and Development

2.4.1. The site is located within the Holborn and Covent Garden Ward of the London Borough of Camden (the Council). The site comprises a number of individual different buildings within the red line area, which includes Selkirk House (1 Museum Street), 10-12 Museum Street, 35-41 New Oxford Street and 16A-18 West Central Street.

2.4.2. The site is generally flat at 25.0mOD and is bounded by High Holborn to the south, Museum Street to the east and New Oxford Street to the north, with the rear of the properties fronting Grape Street forming the western boundary. West Central Street dissects the site and separates out Selkirk House from the New Oxford Street and West Central Street block (known as the West Central Street component of the site).

2.4.3. Selkirk House comprises a 17-storey building, which includes two basement levels and a further partial basement level, supported by a stepped shallow raft foundation and discrete pad footings. Selkirk House is occupied by the former Travelodge Hotel building and NCP car park. The former Travelodge building provided overspill accommodation from the primary Travelodge hotel building on the opposite side of High Holborn, however, the hotel uses at the site ceased all operation in June 2020. At lower levels there is an NCP car park set across basement to second floor level.

2.4.4. The West Central Street buildings are predominantly in retail use at ground floor level fronting New Oxford Street. The basement, first and second floors of No. 39-41 are in office use with the upper floors of 35-37 being in residential use. No's 16a, 16b and 18 West Central Street were previously in use as a nightclub at basement level with offices above. All West Central Street building are founded on shallow strip and pad footings.

2.4.5. The West Central Street component of the site falls within the Bloomsbury Conservation Area. There are two listed buildings on the site, and Grade II listed buildings adjoin the site boundary at 43-45 New Oxford Street and 16 West Central Street. No. 33-41 New Oxford Street, 10-12 Museum Street and 16A-18 West Central Street are each identified as 'positive contributors' in the Conservation Area Appraisal. The shopfronts at numbers 10 and 11 Museum Street are identified separately as positive contributors to the Conservation Area. Selkirk House sits outside of the Conservation Area boundary which runs along West Central Street.

2.4.6. The site is located in close proximity to a number of well known, large-scale developments including Centre Point, Central St Giles, and the Post Office Building development directly adjacent. Notably, further to the north of the site lies the British Museum.

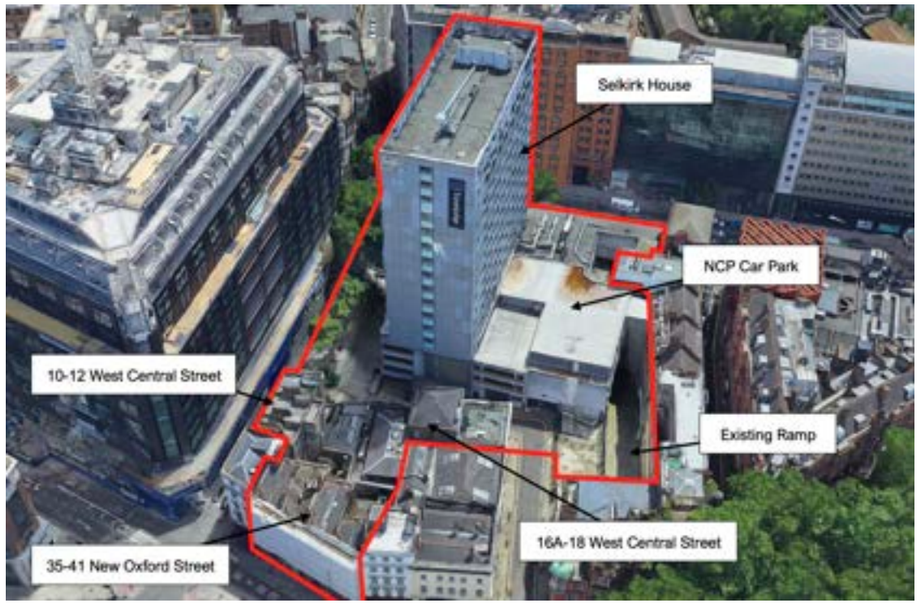


Figure 2.2 Existing structures on site

2.4.7. The site benefits from a PTAL rating of 6b being close to three underground stations, namely Holborn to the east, Tottenham Court Road to the south-west (also including the future Crossrail station) and Covent Garden to the south. This area of London is very well served by bus routes on High Holborn and New Oxford Street. High Holborn and New Oxford Street are also on the London Cycle Network and experience high levels of commuter cycling.

2.5. Neighbouring Properties and Infrastructure

Party Walls

2.5.1. The boundaries of the site share Party Walls with the adjacent buildings listed below. Please refer to the *Party Wall etc. Act 1996 Phase 1 Report* prepared by Pulsar Building Consultancy in Appendix D for more information on the nature of these buildings.

- 33 and 43 New Oxford Street.
- 14 and 16 West Central Street.
- 5, 7, 8, 11, 13, 15 and 17 Grape Street.
- 167 High Holborn.

Listed Buildings

2.5.2. The following listed structures are on and in close proximity to the site and fall within the *zone of influence* of the proposed construction works (40m):

- 35 and 37, New Oxford Street – Grade II Listed (list entry number 1485008).
- 10-12 Museum Street – Grade II Listed (list entry number 1485009).
- 43 and 45, New Oxford Street – Grade II Listed (list entry number 1113170).
- The Bloomsbury Public House – Grade II Listed (list entry number 1271630).
- Queen Alexandra Mansions – Grade II Listed (list entry number 1271622).
- King Edward Mansions and Sovereign House – Grade II Listed (list entry number 1245859).
- Shaftsbury Theatres – Grade II Listed (list entry number 1378647).

Post Office Tunnels

2.5.3. Post Office tunnels, owned by Royal Mail Group Limited, are present in close proximity to the site and also underneath the existing and proposed development footprints, as shown in Figure 2.3.

2.5.4. The Post Office tunnels are railway tunnels of various diameters ranging from 7ft (2.1m) to 29ft (8.8m), and the rail elevation is constant for the majority of rails close to the site at +8.1mOD, approximately 8.5m below the top of the existing raft foundation and approximately 17.0m below ground level (bgl).

Central Line Tunnels

2.5.5. London Underground Limited (LUL) Central Line tunnels are present north of the site underneath New Oxford Street, as shown in Figure 2.3. All three LUL assets are running tunnels, built of bolted cast iron. The three tunnels are all 3.56m in diameter with crown levels between 0.75mOD and 3.00mOD.

Crossrail Tunnels

2.5.6. A Crossrail Limited (Crossrail) running tunnel (eastbound) is present in close proximity to the south of the site beneath High Holborn, shown in Figure 2.3. The tunnel has a 7m diameter with its axis level at +8.85mOD, and is constructed from reinforced concrete.

UK Power Networks Ltd Substations

2.5.7. An existing UK Power Networks Ltd (UKPN) substation in the southwest corner of the site will be temporarily relocated during demolition and construction works.

2.5.8. The substation will be reinstalled on the ground floor of the proposed High Holborn development and a new UKPN substation will be installed in the north portion of the new Vine Lane development following construction of the superstructure.

Utilities and Services

2.5.9. Asset drawings indicate the presence of Thames Water Utilities Limited (TWUL) assets within close proximity to the site beneath High Holborn, New Oxford Street, Museum Street, West Central Street and several other streets surrounding the site.

2.5.10. Other asset owners with existing underground services that may be impacted by the proposed development include the following:

- London Borough of Camden and the Greater London Authority.
- BT (BT Group Plc) and Virgin Media Ltd – Telecoms.
- UK Power Networks Ltd – Electricity Distribution.
- Cadent Gas Ltd and Southern Gas Networks Plc – Gas.

2.5.11. Asset protection teams for the assets listed in this section have been engaged. Where required, separate ground movement assessments have been prepared to meet design assurance requirements.

2.6. Proposed Development

2.6.1. Architectural and structural drawings of the proposed development are included in Appendix B.

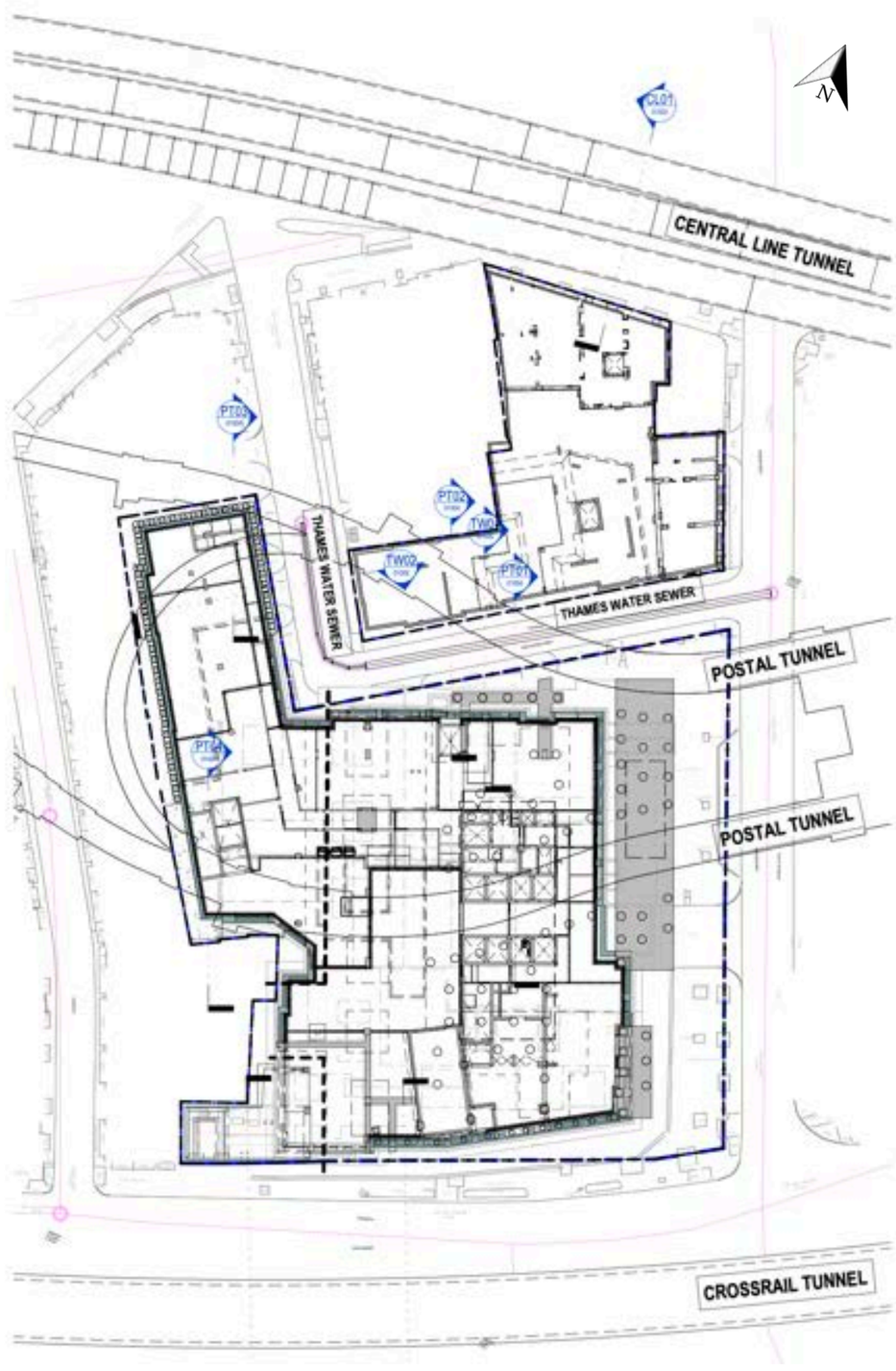
2.6.2. The proposed development for 1 Museum Street comprises the construction of three new buildings with a shared basement: Museum Street, Vine Lane and High Holborn. The locations of each of the three buildings are shown in Figure 2.4.

2.6.3. The Museum Street building will comprise a new 19-storey office tower providing office (Class E(g)(i)) accommodation on upper levels and a range of flexible town centre uses (Class E) at ground level.

2.6.4. The existing ramp will be converted into the five-storey Vine Lane structure with a double height basement providing market residential units with a flexible town centre use (Class E) at ground level.

2.6.5. A six-storey building, High Holborn, will be constructed in the southwest corner of the site, providing residential (Class C3) accommodation on upper levels and a flexible town centre use (Class E) at ground level.

2.6.6. The West Central Street development, shown in Figure 2.4 will comprise a series of new and refurbished buildings rising to five storeys, providing residential accommodation on upper levels (Class C3) and flexible town centre uses (Class E) at ground level.



Source: Meinhardt (UK) Ltd.

Figure 2.3 Existing underground infrastructure adjacent to the proposed development site

Source: DDSHA.

Figure 2.4 Ground floor plan of the proposed Museum Street, Vine Lane, High Holborn and West Central Street developments

2.6.7. The following foundation systems will be implemented across the site.

- **Museum Street**: Within the existing basement, new discrete shallow footings at column locations and a new hybrid piled raft foundation system beneath the core will be constructed approximately 2m above the lowest point of the top of the existing raft, with large portions of the existing basement refurbished and reused. Several bearing piles will also be constructed for columns landing outside of the basement to the north and east, and within the basement in the southeast corner.
- **Vine Lane**: A new raft foundation system will be constructed, replacing any existing substructure elements present in that location. The raft will be tied into a new secant wall toed approximately 4m below the proposed formation level.
- **High Holborn**: A new raft foundation system will be constructed on the top of the existing raft. The existing single-storey basement will be backfilled above the new raft to ground level.
- **West Central Street**: The existing basement and foundations will be retained below new columns, with limited basement extensions via underpinning above the anticipated groundwater table and new raft foundations introduced where required.

2.6.8. The Museum Street settlement-reducing pile layout is shown in Figure **2.5** and will comprise 15no. approximately 25-long 900mm-diameter bored piles toed at -7.5mOD along the perimeter of the Post Office tunnel exclusion zone directly beneath the proposed core, and 44no. approximately 20m-long 900mm-diameter bored piles toed at -2.5mOD to support other areas of the hybrid raft.

2.6.9. Specialist contractor Martello Piling Ltd (Martello) has been engaged to discuss the constructability of the settlement-reducing piles in restricted headroom conditions prior to demolishing the existing superstructure. Following liaison between the project team and Martello, it is understood that construction of all settlement-reducing piles is within their capability.

2.6.10. Temporary props / shoring will be installed at ground level, prior to proceeding with bulk excavation works for the proposed Vine Lane basement. Such measures will increase the system stiffness of the retaining walls and reduce the risk of adversely affecting neighbouring structures and third-party assets, due to excessive ground movement.

2.6.11. Temporary propping will also be installed in the existing Selkirk House basement during demolition of the existing basement slabs and construction of new basement walls and slabs.

2.6.12. The petrol tank chamber room, present directly east of the Selkirk House basement underneath the proposed pile cap, will be infilled and sealed as part of the proposed development. Piles installed within the footprint of the chamber will be bored through the concrete chamber roof and base and the fill material.

2.6.13. The Vine Lane basement excavation will be supported by a secant pile wall along the east, north and northwest perimeter. In the southwest, existing deep underpins will be used, and to the south the excavation will tie into the existing Selkirk House basement.

2.6.14. Limited underpinning works are proposed at West Central Street to deepen the existing basement to install the new raft foundations. The underpins will be of the order of 1.0m deep from the underside of the existing footings. Temporary propping will be installed to facilitate the underpinning.

Post Office tunnels and 2m lateral exclusion zone marked in green. Core raft outlined in magenta.
Blue piles: demolition movement-control and settlement-reducing piles toed at -7.5mOD.
Red piles: settlement-reducing piles toed at -2.5mOD.

Figure 2.5 Museum Street core raft movement-control and settlement-reducing pile layout at B2 level

3. Desk Study

3.1.1. A *Geotechnical and Geo-environmental Desk Study Report* has been undertaken by A-squared Studio Engineers Ltd for the project. The Desk Study report has been used to inform this BIA.

3.1.2. The Desk Study informs further actions in relation to site investigation and ground contamination risks. It is provided in Appendix A.

4. Screening

4.1. Subterranean (Groundwater) Flow, Screening Flowchart

Question		Response	Details
1a.	Is the site located directly above an aquifer?	Yes	The site is underlain by Lynch Hill gravels above the London Clay Formation. The Lynch Hill Gravels are classified as a Secondary A Aquifer, whilst the London Clay is classified as an Unproductive Aquifer.
1b.	Will the proposed basement extend beneath the water table surface?	Yes	A shallow water table is anticipated to be present in the Lynch Hill Gravels aquifer at approximately 20.0mOD. The proposed basement extension at West Central Street is not anticipated to extend beneath the water table surface. The existing High Holborn basement is founded above the water table surface. The proposed basement at Vine Lane will extend below the water table surface. The existing Museum Street basement extends below the water table surface and is founded in the London Clay. The majority of the proposed substructure elements will be founded above the existing raft slab and footings, with limited breaking out to install new footings, rafts and piles. The existing basement walls that extended through the Lynch Hill Gravels aquifer into the London Clay will not be demolished.
2.	Is the site within 100m of a watercourse, well (used / disused) or potential spring line?	No	The site is not within 100m of a watercourse, well or potential spring line.
3.	Is the site within the catchment of the pond chains on Hampstead Heath?	No	The site is not located within the catchment of the pond chains on Hampstead Heath.
4.	Will the proposed basement development result in a change in the proportion of the hard surfaced / paved areas?	No	The majority of the surfaces of the existing development are impermeable, limiting the current potential for rainfall and surface water infiltration into the ground. The proposed development will not introduce additional areas of hard surfacing / paving.
5.	As part of the site drainage, will more surface water (e.g. rainfall and run-off) than at present be discharged to the ground (e.g. via soakaways and / or SUDS)?	No	The proposed development is expected to maintain the existing surface water discharge conditions through attenuation methods such as blue and green roofs. A below basement concrete attenuation tank is also proposed, which will be drained via a pumped solution.
6.	Is the lowest point of the proposed excavation (allowing for any drainage and foundation space under the basement floor) close to, or lower than, the mean water level in any local pond (not just the pond chains on Hampstead Heath) or spring line?	No	The proposed development is not local to any ponds.

4.2. Stability Screening Flow Chart

Question		Response	Details
1.	Does the existing site include slopes, natural or man-made, greater than 7 degrees (approximately 1 in 8)?	No	The site is generally flat.
2.	Will the proposed re-profiling or landscaping at the site change slopes at the property boundary to more than 7 degrees (approximately 1 in 8)?	No	There are no re-profiling / landscaping works proposed that will increase the slopes existing on site to gradients greater than 7 degrees.
3.	Does the development neighbour land, including railway cuttings and the like, with a slope greater than 7 degrees (approximately 1 in 8)?	No	Adjacent properties have a similar flat topography to the site.
4.	Is the site within a wider hillside setting in which the general slope is greater than 7 degrees (approximately 1 in 8)?	No	Figure 10 of the Camden GHHS shows that the site is not within a wider hillside setting and that the topography of the wider area is generally flat.

Question		Response	Details
5.	Is the London Clay the shallowest strata at the site?	No	British Geological Survey (BGS) information and previous site-specific ground investigations proved the presence of Lynch Hill Gravels overlying the London Clay Formation.
6.	Will any trees be felled as part of the development and/or are any works proposed within any tree protection zones where trees are to be retained?	Yes	One Category B tree and eight Category C trees to the east and south of the existing Museum Street basement are proposed to be felled as part of the development works. These removals are not related to the foundation works, and no trees will be felled to facilitate the substructure construction works and for landscape improvement. Works within retained tree protection zones are proposed to construct three bearing piles in the southeast corner of the site.
7.	Is there a history of seasonal shrink-swell subsidence in the local area and/or evidence of such effects at the site?	No	It is anticipated that the moisture of the London Clay Formation underlying the site remains reasonably constant due to the presence of a perched groundwater table within the superficial strata overlying the site.
8.	Is the site within 100m of a watercourse or a potential spring line?	No	The site is not within 100m of a watercourse or potential spring line.
9.	Is the site within an area of previously worked ground?	No	BGS 1:50,000 geological mapping does not show the site to be located in an area of previously worked ground. Historical maps do not show any evidence of worked ground. However, given the recorded phases of development, demolition and redevelopment within the 1 Museum Street site, a layer of Made Ground of up to 4m-thick is anticipated to be present within this area, based on available borehole records.
10.	Is the site within an aquifer? If so, will the proposed basement extend beneath the water table such that dewatering may be required during construction?	Yes	The site is underlain by the Lynch Hill Gravels, which is classified as a Secondary A Aquifer. A shallow water table is anticipated to be present in the Lynch Hill Gravels aquifer at approximately 20.0mOD. The proposed basement extension at West Central Street is not anticipated to extend beneath the water table surface. The existing High Holborn basement is founded above the water table surface. The proposed basement at Vine Lane will extend below the water table surface. The basement will be supported by secant pile walls which will extend into the London Clay formation, creating a groundwater cut-off. Dewatering will be required within the basement footprint during construction, however this will be limited/mitigated by the secant pile wall cut-off. The existing Selkirk House basement extends below the water table surface and is founded in the London Clay. The majority of the proposed substructure elements will be founded above the existing raft slab and footings, with limited breaking out to install new footings, rafts and piles. Pockets of perched groundwater or water-bearing stratum may be encountered where breaking out works will take place. The existing basement walls that extend through the Lynch Hill Gravels aquifer into the London Clay will not be demolished.
11.	Is the site within 50m of the Hampstead Heath Ponds?	No	The site is not within 50m of the Hampstead Heath Ponds.
12.	Is the site within 5m of a highway or pedestrian right of way?	Yes	The site is bounded by High Holborn to the south, Museum Street to the east and New Oxford Street to the north. West Central Street dissects the site.
13.	Will the proposed basement significantly increase the differential depth of foundations relative to neighbouring properties?	Yes	Significant increases in the differential depths of foundations relative to the neighbouring properties are not anticipated for the Museum Street and High Holborn. The new shallow foundation systems in these areas will be founded above existing substructure elements, reducing the differential depths of foundations. Selected areas of the West Central Street existing basement will be excavated 0.3m to 1.2m to facilitate the installation of a new raft, however the increase in foundation depth will not be significant and will be between 0.35m and 0.65m. The proposed Vine Lane basement formation level is approximately 7.0m bgl. Whilst no information is presently available regarding neighbouring basements, it is likely that the differential depth of the foundations relative to neighbouring properties will increase.
14.	Is the site over (or within the exclusion zone of) any tunnels, e.g. railway lines?	Yes	The existing Museum Street basement, proposed Vine Lane basement and the southwest corner of West Central Street are directly over segments of the Royal Mail Group Post Office tunnels, as shown in Figure 2.3. In addition, the northern portion of West Central Street falls within the *zone of influence* of the Central Line tunnels to the north, however the site is not within the tunnel exclusion zone. A Crossrail running tunnel is located to the south the site under High Holborn, however the development does not fall within the tunnel exclusion zone. TWUL utilities are present beneath the streets surrounding the site and fall within the *zone of influence* of the works. UKPN substations will be housed at ground level in High Holborn and in the proposed Vine Lane development.

4.3. Surface Water and Flooding Screening Flowchart

Question		Response	Details
1.	Is the site within the catchment of the ponds chains on Hampstead Heath?	No	The site is not located within the catchment of the pond chains on Hampstead Heath.
2.	As part of the proposed site drainage, will surface water flows (e.g. volume of rainfall and peak run-off) be materially changed from the existing route?	No	The existing route is expected to be incorporated into the scheme.
3.	Will the proposed basement development result in a change in the proportion of hard surfaced / paved external areas?	No	The majority of surfaces within the site are impermeable. The proposed development will not change the amount of hard surfaced / paved area.
4.	Will the proposed basement result in changes to the profile of the inflows (instantaneous and long-term) of surface water being received by adjacent properties or downstream watercourses?	No	The proposed basement is not anticipated to change the surface water discharged from the property. Surface water attenuation methods, such as green roofs, are proposed to manage the discharge.
5.	Will the proposed basement result in changes to the quality of surface water being received by adjacent properties or downstream watercourses?	No	No change in surface water quality is anticipated.
6.	Is the site in an area identified to have surface water flood risk according to either the Local Flood Risk Management Strategy or the Strategic Flood Risk Assessment or is it at risk from flooding, for example because the proposed basement is below the static water level of nearby surface water feature?	No	Based on the Environment Agency Flood Map, the site is in an area with a very low risk of flooding.

4.4. Non-Technical Summary of the Screening Process

4.4.1. The screening process identifies the following issues to be carried forward to scoping for further assessment:

- The proposed Vine Lane basement will extend beneath the water table such that dewatering / groundwater control measures may be required during construction. The existing Selkirk House basement extends below the water table, and groundwater control in localised areas may be required where concrete breaking out works are proposed.
- Nine trees will be felled as part of the proposed works and piling works are proposed to take place within tree protection zones.
- The proposed Vine Lane basement excavation is adjacent to public highways and neighbouring structures and will increase the differential depth of foundations relative to neighbouring properties.
- The site is directly over the Royal Mail Group Post Office tunnels, and additional assets owned by LUL, Crossrail, TWUL and UKPN fall within the *zone of influence* of the proposed works.

4.4.2. The other potential concerns considered within the screening process have been demonstrated to be not applicable or not significant when applied to the proposed development.

5. Scoping

5.1. Subterranean Flow: Elements of the proposed substructure will extend beneath the water table such that dewatering / groundwater control measures may be required during construction

Hazards

5.1.1. The development site is underlain by superficial deposits of Lynch Hill Gravels. This stratum is expected to be water-bearing and has been classified as a Secondary A Aquifer.

5.1.2. The groundwater flow regime at the site may be affected by construction of the proposed Vine Lane basement.

5.1.3. Groundwater may flow into the Vine Lane basement excavation during construction.

5.1.4. Pockets of perched groundwater or water-bearing stratum may be encountered during local concrete breaking-out works in the existing Selkirk House basement.

Potential Impacts

5.1.5. The Vine Lane basement construction may result in damming of the aquifers and groundwater flow regime.

5.1.6. The alteration of existing flow paths may result in a permanent increase in the local water table upstream of the proposed development due to the damming effect of the basement, and a corresponding drop in groundwater levels downstream. Changes in groundwater head may result in stress changes or instability within the ground.

5.1.7. Ground movements associated with these stress changes in the ground may have an impact on existing properties.

5.1.8. The proposed Vine Lane basement will also be at an increased risk of flooding and damp in the long term due to permanent submergence beneath the groundwater table.

5.1.9. Encountering water-bearing stratum during breaking-out works in the existing Selkirk House basement may result in flooding of the below-ground space or instability of the existing retaining walls.

Mitigating Factors

5.1.10. The proposed Vine Lane basement excavation will be supported by secant pile walls and underpins that will extend into the low permeability London Clay Formation. This will restrict the inflow of water into the excavation in the short-term condition.

5.1.11. Existing groundwater monitoring information from nearby sites indicates that there is no significant groundwater gradient across the site footprint.

5.1.12. The properties directly adjacent to the Vine Lane basement are anticipated to have basement levels and/or substructure elements extending through the Lynch Hill Gravels aquifer into the underlying London Clay. This includes Selkirk House. The addition of the Vine Lane basement is not anticipated to cause a significant change to the surrounding hydrogeological regime.

5.1.13. Based on survey information, archive drawings and the existing basement slab elevations, the Selkirk House basement is anticipated to be founded on the London Clay Formation. This means that any groundwater encountered during breaking out works is unlikely to be in hydraulic connectivity with the Lynch Hill Gravels aquifer. In addition, initial trial pitting and coring works in the basement carried out by Swantest and Jomas did not encounter substantial volumes of groundwater.

Assessments and Further Actions

5.1.14. A site-specific ground investigation will be undertaken in the existing ramp area to enhance the current understanding of the groundwater regime. Pending the outcome of the groundwater monitoring works, additional hydrogeological modelling may be required to validate the potential effects of the Vine Lane basement construction on the groundwater tables.

5.1.15. The presence of any below-ground structures or basements underneath neighbouring properties should be confirmed to determine the risk of groundwater flooding or significant movement due to stress changes in the ground.

5.1.16. Appropriate detailing of the Vine Lane basement retaining wall waterproofing should be provided by a Waterproofing Specialist to mitigate the risk of flooding and damp conditions within the basement.

5.1.17. Regarding the Selkirk House basement, A-squared has prepared an *Existing Basement Reuse Groundwater Considerations* technical note, included in Appendix D, that summarises the risk of encountering groundwater and a tiered groundwater mitigation measures based on potential subgrade and shallow groundwater scenarios. An excerpt of the note, showing the mitigation tiers, is provided in Table 5.1 below.

Table 5.1 Groundwater mitigation tiers based on potential subgrade and shallow groundwater scenarios

Tier	Subgrade Material Type	Subgrade Material Permeability	Hydraulic Connectivity with Superficial Aquifer	Groundwater Head	Mitigation Measures
0	London Clay or mass concrete backfill overlying London Clay	Very low	No hydraulic connectivity	N/A	No mitigation required. Groundwater risk is negligible
1	Lynch Hill Gravels or granular material backfill	High	No hydraulic conductivity (cut-off by existing wall edge detail)	N/A	Removal of isolated limited volumes of groundwater via sumps or pumps
2	Lynch Hill Gravels or granular material backfill	High	Limited hydraulic conductivity (<1.0m thickness)	Low (<2m above breaking out level)	Permeation/injection grouting or installation of trench sheets and local dewatering
3	Lynch Hill Gravels or granular material backfill	High	Limited hydraulic conductivity (<1.0m thickness)	High (>2m above breaking out level)	Injection grouting through the high permeability subgrade materials
3	Lynch Hill Gravels or granular material backfill	High	Significant hydraulic conductivity (>1.0m thickness)	Low (<2m above breaking out level)	Injection grouting through the high permeability subgrade materials
3	Lynch Hill Gravels or granular material backfill	High	Significant hydraulic conductivity (>1.0m thickness)	High (>2m above breaking out level)	Injection grouting through the high permeability subgrade materials

Excerpt from A-squared *Existing Basement Reuse Groundwater Considerations* technical note (ref. 1084-A2S-XX-XX-TN-Y-0008-01).

5.1.18. Site-specific ground investigation works have been undertaken to prove the underlying stratum. The investigation works encountered pockets of perched groundwater in cohesionless Made Ground above London Clay, and connectivity with the Lynch Hill Gravel aquifer is not anticipated to be present. This indicates that a groundwater mitigation tier of 0 is applicable.

5.2. Stability: Nine trees will be felled as part of the works and construction activities are proposed within tree protection zones

Hazards

5.2.1. Shrink / swell behaviour of the underlying cohesive soil masses may be induced by the removal of trees.

5.2.2. Increased surface water run-off into the local drainage system may result from a reduction in uptake from vegetation.

5.2.3. Category A and B tree root protection areas and canopies are in close proximity to proposed pile locations.

Potential Impacts

5.2.4. Additional ground movements from shrink / swell may cause damage to neighbouring structures.

5.2.5. Properties downstream of the development may be subject to increased surface overland flow.

5.2.6. Construction works and piling rig tracking over the root protection areas may permanently damage tree roots, impacting the long-term health of the trees.

5.2.7. Tree canopies in close proximity to the proposed pile locations may interfere with the mast of piling rig and/or may be damaged by the piling rig.

Mitigating Factors

5.2.8. Near-surface deposits are generally anticipated to comprise granular Made Ground and Lynch Hill Gravels, which are not expected to heave or settle significantly due to tree removal.

5.2.9. Any potential changes to the surface water run-off volume are anticipated to be captured by the proposed drainage scheme.

5.2.10. The number of piles required to be installed has been reduced during the development of the design. The majority of piles associated with the pile cap in the southeast corner of th site will be installed in the Selkirk House basement, with only four piles remaining, all of which are outside of the tree root protection areas.

5.2.11. A specialist light-weight low headroom Martello piling rig (MP6002) has been selected to install the four piles. The rig is of the order of 33% the weight of a comparable standard rotary piling rig and is capable of installing the 900mm piles and coring through any concrete obstructions that may be present. The reduced weight of the rig will limit the impact on the underlying tree roots.

5.2.12. Bespoke load protection systems will be adopted to spread the rig track pressures exerted during the piling works. These may take the form of:

- Custom designed sectional metal tracks joined to support vehicle loading.
- Temporary concrete slab cast over existing low-load bearing surfacing, removed once heavy use is finished.
- Proprietary cellular products, such as CORE® or Cellweb®, applicable for piling rigs up to 60 tonnes.
- Proprietary non-cellular products, such as Wrekin ArboRaft.

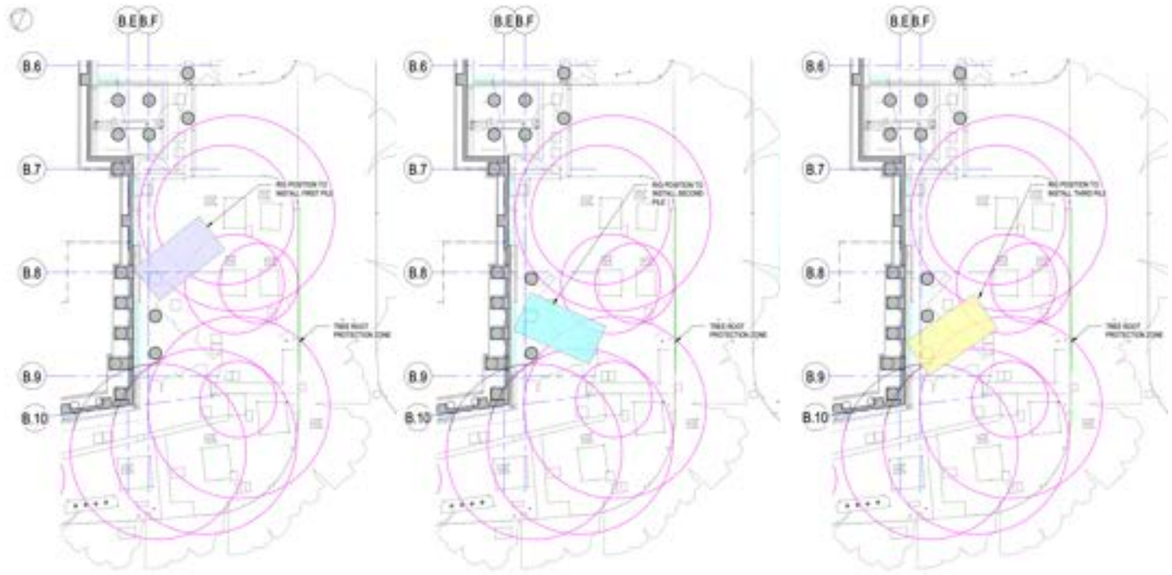
5.2.13. The MP6002 has an operating height of approximately 11.5m and a transit height of 3.2m. The majority of tree branches above the piling works area will be avoided. Where required, localised tying back or trimming of branches will be carried out, under the supervision of the project arboricultural consultant, to allow piling works to take place.

Assessments and Further Actions

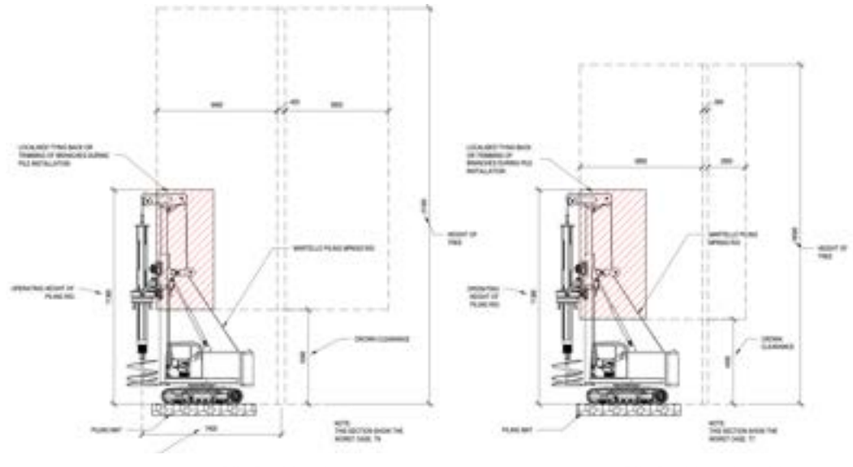
5.2.14. The composition of near-surface deposits in close proximity to the retained tree will be confirmed during a site-specific ground investigation.

5.2.15. A-squared has prepared a *Tree Protection Zone Pile Design and Construction Considerations* technical note (ref. 1084-A2S-XX-XX-TN-Y-0010-00) which, alongside liaison with the project arboricultural consultant, has informed the decisions noted in Clauses 5.2.10 to 5.2.13. This document is included in Appendix D.

5.2.16. Meinhardt has prepared a series of drawings detailing the proposed path of the MP6002 through the tree protections zones and optimal pile installation positions, as advised by Martello. Excerpts of the drawings are presented in the figures below.

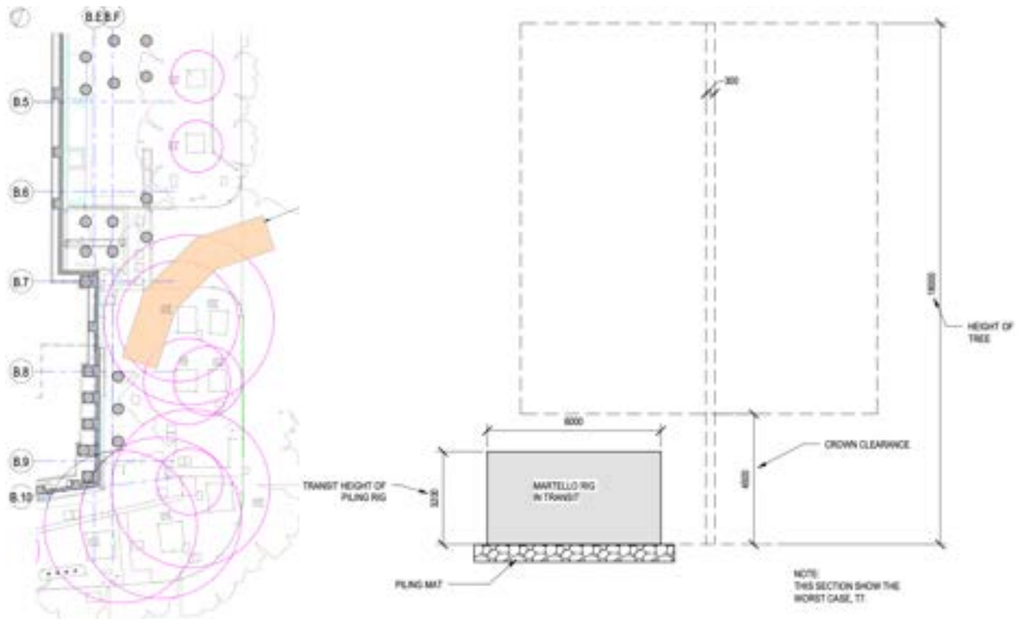


Pile Position 1 **Pile Position 2** **Pile Position 3**



Source: Meinhardt. **Pile Position 1** **Pile Positions 2 and 3**

Figure 5.1 MP6002 piling rig positioning and height requirements relative to retained tree protection zones and canopies



Source: Meinhardt.

Figure 5.2 MP6002 piling rig transit route through retained tree protection zones

5.3. Stability: The proposed Vine Lane basement excavation is adjacent to public highways and neighbouring structures

Hazards

5.3.1. Deep excavations will be carried out adjacent to public highways and neighbouring structures.

5.3.2. Deep excavations will be carried out in close proximity to the Grade II listed structures on site and Bloomsbury Public House and Queen Alexandra Mansions to the north.

Potential Impacts

5.3.3. Collapse of the excavation and associated impact on surrounding assets.

5.3.4. Damage to the road surface or buried services within the public highway easement due to excessive ground movements.

5.3.5. The proposed development will likely increase the differential foundation depths with neighbouring properties. Ground movements arising due to construction and excavation activities may damage these properties.

Mitigating Factors

5.3.6. The deposits underlying the development are anticipated to be competent natural strata, i.e. medium dense to dense Lynch Hill Gravels and very stiff London Clay Formation.

5.3.7. Numerous basements of similar depth and scale with similar geological conditions and urban settings have been successfully constructed in the vicinity of the site.

5.3.8. The majority of the buildings surrounding the proposed Vine Lane basement have below-ground space, meaning the impact of the basement construction will be reduced. In addition, several existing substructure elements are present beneath the ramp, which may limit the extent of earth retention installation works required.

Assessments and Further Actions

5.3.9. The design of the secant pile wall and temporary propping shall be carried out by an appropriately experienced and qualified specialist / engineer / ground engineering contractor in accordance with relevant Eurocodes / British Standards, Codes of Practice, and industry standards. The design shall allow for appropriate surcharging behind the secant walls and underpinning to accurately reflect the type and intensity of traffic and building loads.

5.3.10. A-squared has prepared a *Preliminary Basement Extension Secant Wall Assessment* technical note (ref. 1084-A2S-XX-XX-TN-Y-0005-00) which contains preliminary secant wall design calculations. 600mm-diameter secondary piles spaced at 900mm centre-to-centre and toed at 16.0mOD have been proven to be the minimum requirement for a stable retention system with lateral movements due to excavation of the order of 15mm. The proposed secant wall is 750mm-diameter spaced at 1050mm centre-to-centre and toed at 14.0mOD, which meets the requirements set out in the technical note.

5.3.11. A ground movement assessment has been carried out to determine the impact of proposed works on the neighbouring highways, pathways, and properties. The assessment predicts a maximum damage classification of *Category 1 – Very Slight* for the neighbouring properties, in accordance with the Burland Scale, and a maximum horizontal and vertical displacement of 13mm and 7mm, respectively, in adjacent highways/pathways due to the installation of embedded retaining structures, bulk excavation and building loading. More information about the assessment can be found in Section 8.2.

5.3.12. It is noted that the results of this assessment represent an unlikely to be exceeded scenario due to the relatively conservative parameters and assumptions adopted. During detailed design development of the earth retention system and temporary works, it is anticipated that the predicted ground movements will be reduced.

5.3.13. Various additional ground movement assessments have been performed to determine the impact of the works on surrounding buried utilities and other third-party assets surrounding the site. These assessments confirm anticipated damage categories in accordance with performance limits set by the relevant third-party asset protection teams.

5.3.14. Appropriate wall and ground movement monitoring will be implemented during construction to assess the performance of the earth retention system (baseline monitoring pre-commencement of the works should be carried out to determine any potential existing movement trends). Allowance will also be made for making good of any cracking / damage to adjacent pavement surfaces (if required).

5.3.15. The earth retention system, temporary works scheme design, and predicted ground movements will be reviewed in detail with the relevant local authorities / asset protection teams (including highways / pavements) as the design development progresses.

5.4. Stability: Royal Mail Group Post Office tunnels are present directly underneath the site

Hazards

5.4.1. Post Office tunnels, owned by Royal Mail Group Limited, are present in close proximity to the site and also underneath the existing and proposed development footprints, as shown in Figure 2.3. The tunnel diameters range from 7ft (2.1m) to 29ft (8.8m) and the rail elevation is constant for the majority of rails close to the site at +8.1mOD, approximately 17.0m below ground level (bgl).

Potential Impacts

5.4.2. Demolition, excavation and construction works may induce excessive ground movement and deformations resulting in damage to the tunnels.

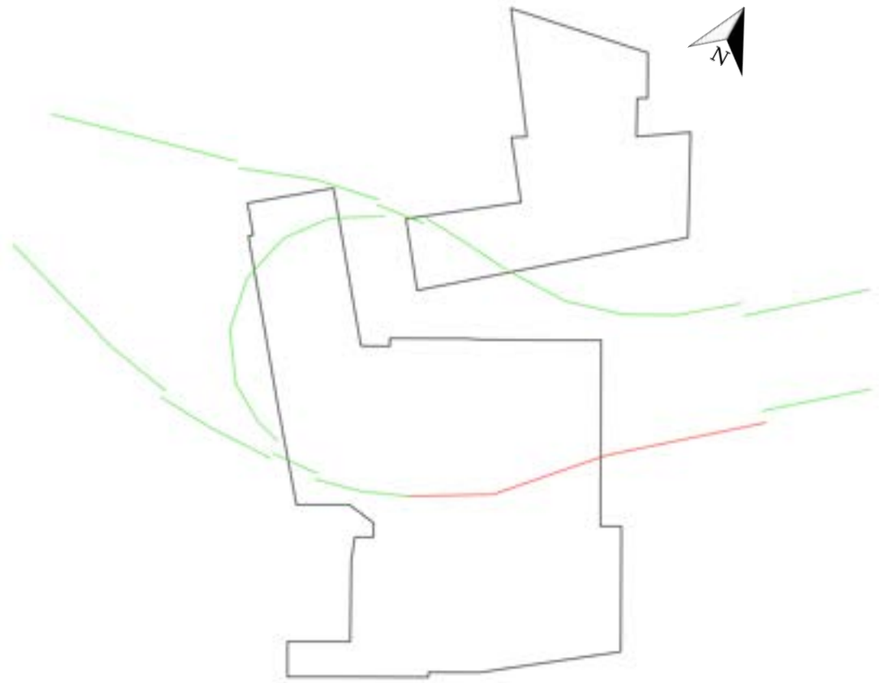
Mitigating Factors

5.4.3. The Royal Mail Group asset protection team has been contacted and the design team is actively liaising with their representatives in order to ensure that their assets are safeguarded.

5.4.4. A-squared carried out an initial preliminary ground movement assessment of the tunnels in October 2019, which was then revised in November 2020 to incorporate the most up-to-date scheme (ref. 1084-A2S-XX-XX-TN-Y-0002-03).

5.4.5. The results of the preliminary assessment are shown in Figure 5.3, which indicated that only the alignment of the Post Office tunnels directly beneath the existing and proposed tower cores was impacted to a greater degree by the development works.

5.4.6. Based on the findings of the preliminary ground movement assessment, tunnel movement control measures beneath the proposed core in the short- and long-term conditions have been incorporated into the substructure design. These will take the form of 15no. movement-control piles installed prior to commencing demolition works on either side of the tunnel alignment beneath the core, and 44no. additional settlement-reducing piles throughout the footprint of the proposed Museum Street development to minimise the impact of the proposed building loading.



Post Office tunnels presented as idealised centreline trajectories (shown in red and green).
Outline of proposed 1 Museum Street and West Central Street development basements shown in black.
Tunnel segments exceeding deformation performance thresholds marked in red.

Figure 5.3 Tunnel segments exceeding deformation thresholds in the preliminary ground movement assessment

5.4.7. The secant pile wall proposed around the perimeter of the new Vine Lane basement will be toed above 14.0mOD and will stay outside of the 4m vertical exclusion zone of the underlying tunnel.

5.4.8. A ground movement assessment to review the impact of the proposed scheme on these tunnels has been carried out by the project team and the findings have been presented to the Royal Mail Group asset protection team. The results of the assessment have also informed the ongoing design process.

Assessments and Further Actions

5.4.9. The ground movement assessment presented to the asset protection team has been based on a ground model development from publicly available information and RIBA Stage 2 redesign information. The assessment will be revised and reissued to the asset protection team, incorporating the findings of the site-specific ground investigation and any relevant changes to the scheme based on the RIBA Stage 3 design.

5.4.10. A preliminary condition survey will be undertaken within the tunnels expected to experience the largest deformations to confirm the condition of the tunnels adopted in the ground movement assessment. A full pre-construction condition survey has also been requested by the Royal Mail asset protection team in advance of construction commencing, and this survey will be undertaken close to the start of demolition works. In addition, intermediate condition surveys during demolition and construction may be undertaken based on feedback from the asset protection team following their review of the findings of the ground movement assessment.

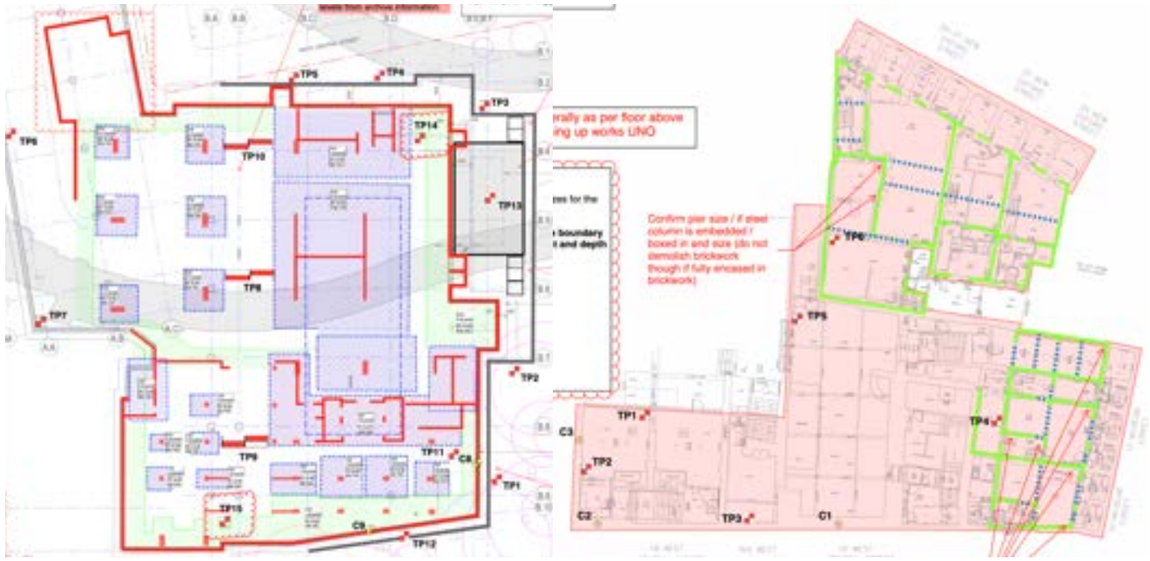
5.4.11. An appropriate monitoring regime will be implemented to ensure the deformations of the Post Office tunnels do not exceed predictions from the ground movement assessment. The exact requirements of the regime will be finalised with the Royal Mail Group asset protection team, but will include the following as a minimum:

- Three months of baseline monitoring pre-demolition, including in advance of any soft stripping.
- Monitoring during demolition, excavation and construction works at a frequency agreed with the Royal Mail Group asset protection team.
- Post-construction monitoring until the tunnel movements reduce to approximately 2mm/year.

6. Site Investigation Works

6.1. Preliminary Investigation Works

6.1.1. An initial breaking out and structural investigation exercise was carried out by Swantest in October and November 2020 under a sub-contract role to Erith Contractors on behalf of the applicant. The works comprised trial pitting and coring through the existing Selkirk House and West Central Street substructures, exploring Party Wall conditions in the existing ramp area, and proving the presence of an embedded sheet wall to the north and east of the Selkirk House basement. The full *Structural Investigation Report* is included in Appendix D and the trial pits locations are shown in Figure 6.1.



Source: Meinhardt.

Figure 6.1 Swantest 2020 structural investigation trial pit locations in Selkirk House (left) and West Central Street (right)

6.1.2. In parallel to the structural investigation works carried out by Swantest, Jomas Associates Ltd (Jomas) took geo-environmental samples from each trial pit opened and carried out geo-environmental laboratory testing. The Jomas letter report containing the results of the geo-environmental testing is included in Appendix D.

6.1.3. The findings of the works within the Selkirk House basement show the presence of mass concrete backfill behind the basement wall and underneath the basement slab around the existing pad footings and raft. The majority of pits in and round the Selkirk House basement footprint refused in the mass concrete obstructions. The presence of the sheet wall was not proven, however groundwater ingress during the coring and pitting works in the basement was not encountered.

6.1.4. An additional trial pit, TP16, was added in the northwest corner of the existing ramp adjacent to existing skylights. The trial pit proved that a void is present beneath this area of the ramp, covered by a 300mm reinforced concrete slab.

6.1.5. The majority of trial pits carried out at West Central Street encountered the base of the footings and a mixture of natural strata and Made Ground backfill. TP3 encountered a 1100mm void above a 950mm-thick layer of concrete. It is noted that TP3 is in an area of West Central where a new raft foundation is proposed.

6.2. Proposed Investigation Works

6.2.1. A-squared prepared a *Ground Investigation Specification* in October 2020 (ref. 1084-A2S-XX-XX-SP-Y-0001-00) detailing works for a full site-specific ground investigation to inform and validate the key assumptions related to the substructure design and ground contamination. The specification is included in Appendix D. The aims of the ground investigation are as follows:

- Provide a ground model and geotechnical parameters for detailed substructure design.
- Prove the bearing stratum of the existing Selkirk House basement and foundations.
- Determine the depths to the underlying Lambeth Group, Thanet Sands and Chalk.
- Prove the thicknesses of Made Ground to the east of the Selkirk House basement and the depth of mass concrete backfill.
- Investigate the materials proposed to be excavated to form the Vine Lane basement.
- Validate the findings of the 2015 West Central Street ground investigation and trial pitting works.
- Determine the chemical conditions of the soil with respect to below-ground concrete.
- Determine the depth of any groundwater, whether a hydraulic gradient is present in the Lynch Hill Gravels aquifer, and the pore water pressure profile in deeper strata.
- Assess the current geo-environmental conditions of the site, including soil and groundwater contamination and the presence of ground gas.

6.2.2. The investigation scope will comprise the primary items listed below. An exploratory hole plan is shown in Figure 6.2.

- 2no. cable percussion boreholes to depths of 50m with hand dug inspection pits.
- 2no. restricted-headroom cable percussion boreholes to depths of 20m with hand dug inspection pits.
- 10no. window samples to depths of 6m with hand dug inspection pits.
- 1no. hand dug trial pit to a depth of 2m followed by a window sample to a maximum depth of 6m.
- 14no. 50mm standpipe installations within BH102, BH103, BH201 and all window samples targeting perched groundwater in the Made Ground and Lynch Hill Gravels.
- 3no. vibrating wire piezometer installations in BH101 at various depths within the London Clay Formation and cohesive Lambeth Group.
- 1no. 19mm standpipe piezometer installation in BH101 targeting the deep groundwater table below the London Clay Formation.
- Appropriate sampling in the form of environmental samples, open tube samples, groundwater samples, ground gas samples, small disturbed samples, and bulk samples.
- Geotechnical and geo-environmental in-situ and laboratory testing.

6.2.3. At the time of preparing this document, Jomas have been appointed for the proposed investigation. The investigation has been split into two phases: the first phase comprises the works within the building footprints and existing ramp; and the second phase comprises BH101 and WS106 in the public domain.

6.2.4. Jomas carried out an initial proof drilling exercise in December 2020 at WS101, WS102, WS103, WS110 and BH103 to check for voids and the expected thickness of concrete. The void was proven at the positions of WS102 and WS103. They have also completed the first phase of investigation works, summarised in Section 6.3.

6.2.5. The second phase of investigation works is currently halted due to access restrictions. Investigation works are anticipated to be carried out post-Planning to inform the RIBA Stages 3 and 4 design and the Phase II Geo-environmental Quantitative Risk Assessment.

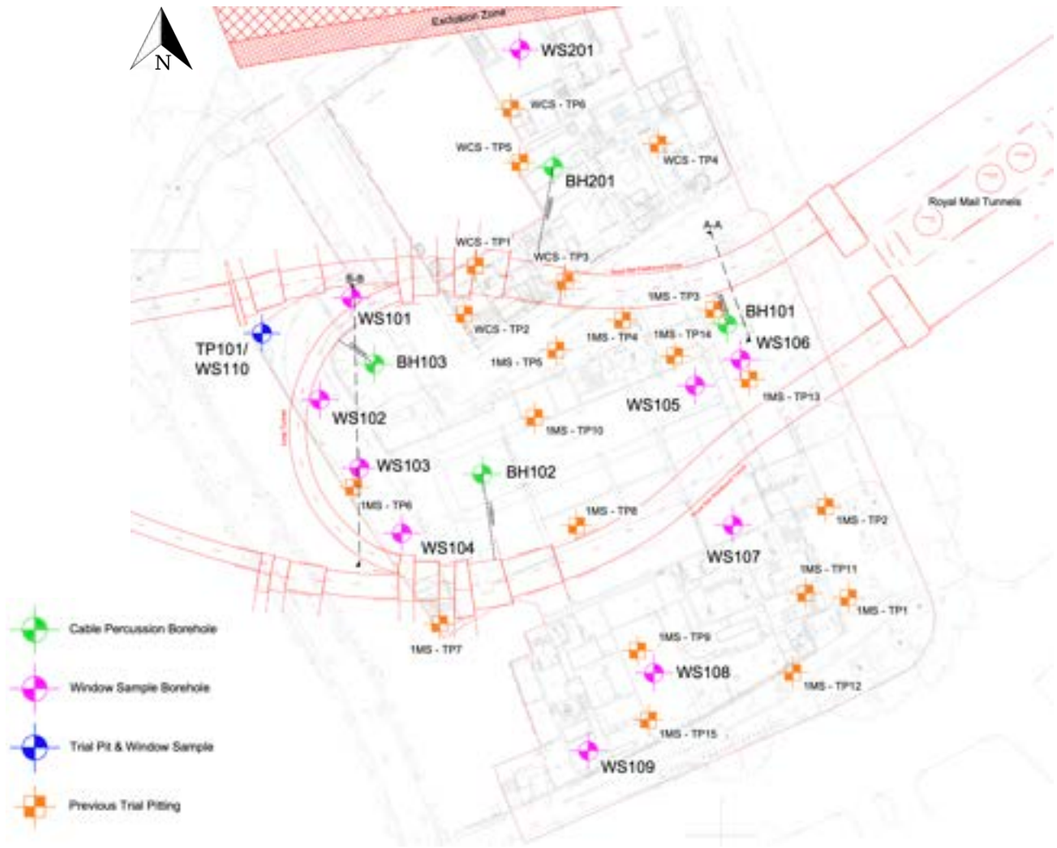


Figure 6.2 Proposed site investigation exploratory hole plan

6.3. Jomas 2021 Site-Specific Ground Investigation

6.3.1. The first phase of the proposed site-specific ground investigation works, specified by A-squared, was undertaken by Jomas in April and May 2021. The works undertaken are summarised below and more information can be found in their *Ground Investigation Factual Report*.

- 1no. cable percussion borehole to 50m near the ramp area (BH103).
- 1no. restricted-headroom cable percussion borehole to 20m within the Selkirk House basement (BH102).
- 9no. window samples to depths of up to 6m across the Selkirk House site and within the existing basement (WS101 to WS105, WS107 to WS110).
- 9no. 50mm standpipe installations within BH102, BH103 and all window samples targeting perched groundwater in the Made Ground and Lynch Hill Gravels.
- Post-fieldwork groundwater and ground gas monitoring.
- Sampling in the form of environmental samples, open tube samples, small disturbed samples, and bulk samples.
- Geotechnical and geo-environmental in-situ and laboratory testing.

6.3.2. The materials encountered during the investigation are summarised in TABLE below.

Table 6.1 Summary of stratigraphy encountered during the 2021 Jomas ground investigation

Strata	Maximum Elevation (mOD)	Minimum Elevation (mOD)	Thickness (m)	Description
Made Ground	25.45	14.55	0.45 to 2.20	Concrete / reinforced concrete / void over brown sandy gravel with low to moderate cobble content / dark brown gravelly sand / dark grey mottled brown clay. Sand is fine to coarse. Gravel consists of fine to coarse angular to sub-rounded brick, concrete, flint and sandstone. Cobbles consist of brick and concrete.
Lynch Hill Gravels	23.67	18.57	5.10	Medium dense to very dense orange brown sandy GRAVEL / gravelly SAND. Sand is fine to coarse. Gravel consists of fine to coarse angular to rounded flint.
London Clay	18.57	-2.59	16.80 to 20.00	Stiff to very stiff consistency grey brown silty slightly sandy CLAY.
Lambeth Group	1.77	-16.13	17.90	Stiff to very stiff consistency multi-coloured silty CLAY with off-white silty sandy layers.
Thanet Sands	-16.13	-24.63	>9.50	Very dense yellow-brown silty slightly gravelly SAND. Sand is fine to coarse. Gravel consists of fine flint.

Variations in elevations of stratigraphy encountered during the Jomas investigation and historical exploratory logs from Crossrail Ltd and the adjacent Post Building development are attributed to engineer judgement and logging differences.

6.3.3. Groundwater was encountered in the Lynch Hill Gravels aquifer at approximately 19.50mOD. Perched groundwater was encountered in cohesionless deposits of Made Ground in monitoring wells installed within the Selkirk House basement.

6.3.4. Geotechnical testing carried out during the investigation works indicate that geotechnical strength and stiffness parameters for the Lynch Hill Gravels, London Clay, Lambeth Group and Thanet Sands adopted based on publicly available information for pre-Planning design are suitable for detailed design of the substructure solution.

6.4. Historical Investigation Information

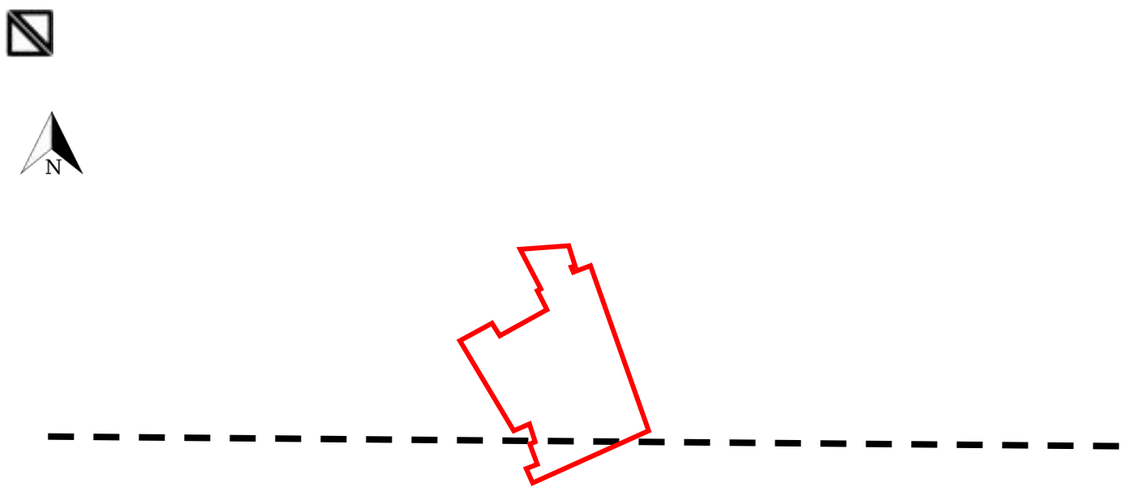
6.4.1. In advance of receiving supplementary geotechnical and geo-environmental information from the site-specific ground investigation works, the design of the proposed substructures has been progressed based on a review of publicly available information from the British Geological Survey and London Borough of Camden Planning Portal. The information used to create a preliminary design ground model is summarised below.

BGS Historical Data

6.4.2. The British Geological Survey Geology of Britain web map services provide access to the geographic locations and logs of historical borehole investigations and well installations. Historical boreholes surrounding the site are shown in Figure 6.3.

6.4.3. The following surrounding shallow and deep BGS boreholes have been indicatively reproduced in Figure 6.4, showing an approximate northwest-southeast geological section through the site, showing the depths and thicknesses of the underlying soils:

- TQ28SE/180 (203m northwest).
- TQ38SW/3592 (74m southwest).
- TQ38SW/159 (23m north).
- TQ38SW/3603 (9m east).
- TQ38SW/3595 (124m east).
- TQ38SW/3596 (142m southeast).
- TQ38SW/2898 (117m northeast).
- TQ38SW4551 (205m east).



Site boundary marked in red. West-east section shown in Figure 6.4 marked by black dotted line.

Figure 6.3 Location of BGS borehole data

Site Location

West-east section.

Figure 6.4 Indicative cross-section through historical borehole data

6.4.4. A *Ground Investigation and Basement Impact Assessment Report* prepared by Geotechnical & Environmental Associates Ltd (GEA) was carried out for the West Central Street site in November 2015 and included ground investigation works.

6.4.5. The ground investigation comprised a single cable-percussive borehole to a depth of 25.0m bgl, including standard penetration tests, groundwater monitoring and laboratory testing. An additional three window samples, single dynamic probe and 25 structural trial pits were included. The full investigation exploratory hole plan is shown in Figure 6.5.

6.4.6. Made Ground, in the form of dark brown clayey sandy silt, was encountered below all of the buildings with the exception of 16 and 18 West Central Street, and was found to extend to a maximum depth of 1.45m below basement level (+21.29mOD). No visual or olfactory evidence of significant contamination was noted.

6.4.7. The ground investigation encountered the Lynch Hill Gravel member (orange-brown silty medium to coarse sand and fine to coarse angular to subrounded gravel) directly below the existing basement slab at +21.95mOD (3.3m bgl), underlain by London Clay from +18.75mOD (6.50m bgl) to the base of the cable percussive borehole at +0.25mOD (25.0m bgl). The structural trial pits noted that the foundations of the buildings on the West Central Street site comprised shallow footings and strips all founded on the Lynch Hill Gravels.

Source: Geotechnical & Environmental Associates Ltd.

Figure 6.5 West Central Street GEA 2015 ground investigation exploratory hole plan

6.4.8. Groundwater was encountered within the Lynch Hill Gravels during drilling at +21.95mOD (3.3m bgl) and +19.25mOD (6.00m bgl). Additional monitoring showed groundwater at approximately +19.35mOD (5.9m bgl).

6.4.9. Soil contamination laboratory testing was carried out on three samples between 0.3m and 0.5m below the basement slab from TP3, TP4 and TP28. The results of the contamination testing did not indicate any elevated concentrations of the contaminants tested.

6.4.10. The findings from the trial pitting have been used to support the development of the West Central Street substructure design.

The Post Building *Ground Movements and Central Line Tunnel Capacity Calculations*

6.4.11. The Post Building (21-31 New Oxford Street), the former Royal Mail Western Central District Sorting Office directly east of the site, has recently been refurbished and converted into a mixed-use retail and commercial building. As part of the works, Ove Arup & Partners Ltd (Arup) prepared a *Ground Movements and Central Line Tunnel Capacity Calculations* report in June 2015, assessing the impact of the proposed Post Building development on the adjacent Central Line tunnels.

6.4.12. The report's *Ground Conditions* chapter references a site-specific ground investigation carried out by Concept Engineering Consultants Ltd between October and November 2013 and a *Geotechnical Interpretive Report* prepared by Arup, which presents a derived a ground model from the investigation data. Whilst this ground investigation and interpretive report are not publicly available, the *Ground Movements and Central Line Tunnel Capacity Calculations* report provides a summary of the derived ground model and geotechnical parameters, shown in Figure 6.6. Geological cross sections produced by Arup across the Post Building site are also shown in Figure 6.7 and Figure 6.8.

6.4.13. Groundwater was encountered within the Lynch Hill Gravels at approximately +20.0mOD, and a typical underdrained profile was proven within the London Clay and cohesive Lambeth Group, as shown in Figure 6.9.

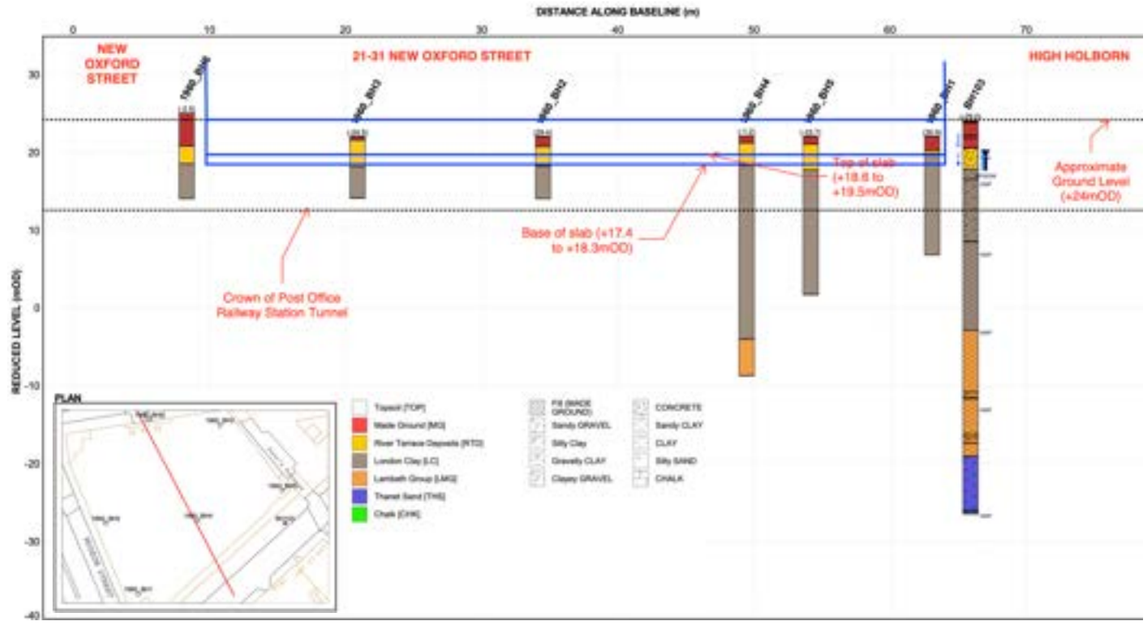
Stratum	Level of top of stratum [mOD]	Thickness [m]
Made Ground	+24.0	3.5
River Terrace Deposits	+20.5	2.5
London Clay	+18.0	21
Lambeth Group	-3.0	16.5
Thanet Sand	-19.5	6.5
Chalk	-26.0	Proven to 0.2m

Stratum	Bulk unit weight (γ kN/m^3)	Angle of shearing resistance, φ' [°]	Effective cohesion, c' [kPa]	Undrained shear strength, c_u [kPa]	Stiffness	
					$E_{u,v}$ [MPa]	E'$_v$ (raft) [MPa]
Made Ground	18	20	0	N/A	N/A	5
River Terrace Deposits	20	34	0	N/A	N/A	50
London Clay	20	24	0	75+8.5z[1]	400c_u	320c_u
Lambeth Group	20	23	0	200	400c_u	320c_u
Thanet Sand	20	37	0	N/A	N/A	400
Chalk	Assume rigid layer					

where:
z is the depth below the top of London Clay (+18mOD)
E_u undrained Young's modulus
E' drained Young's modulus
E_v vertical Young's modulus

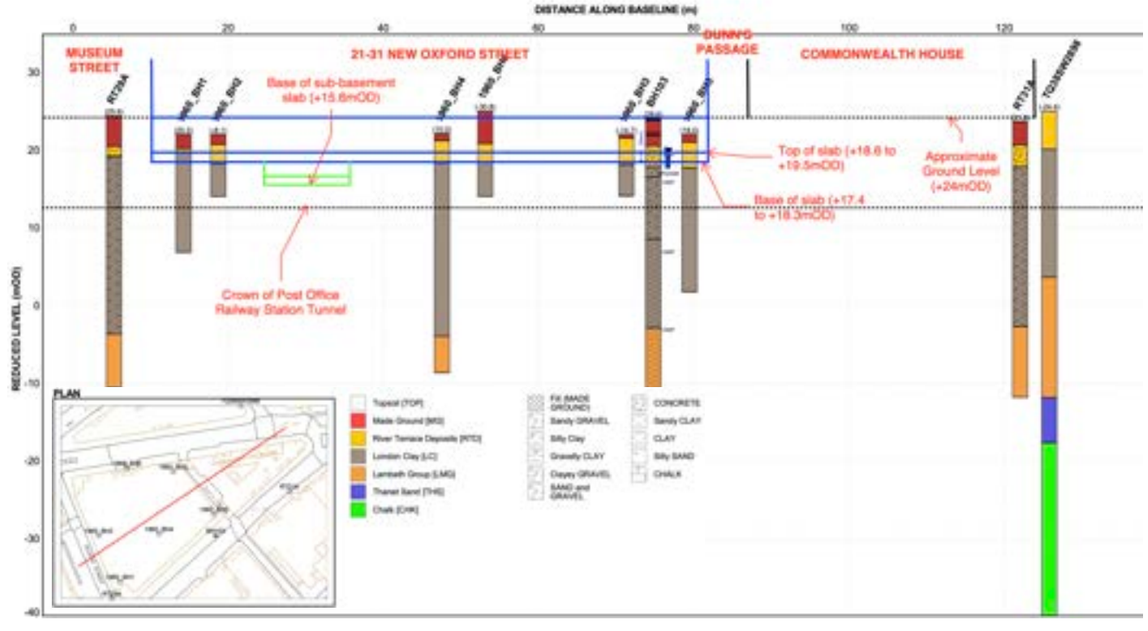
Source: Ove Arup & Partners Ltd.

Figure 6.6 Derived ground model and geotechnical parameters from the adjacent Post Building development



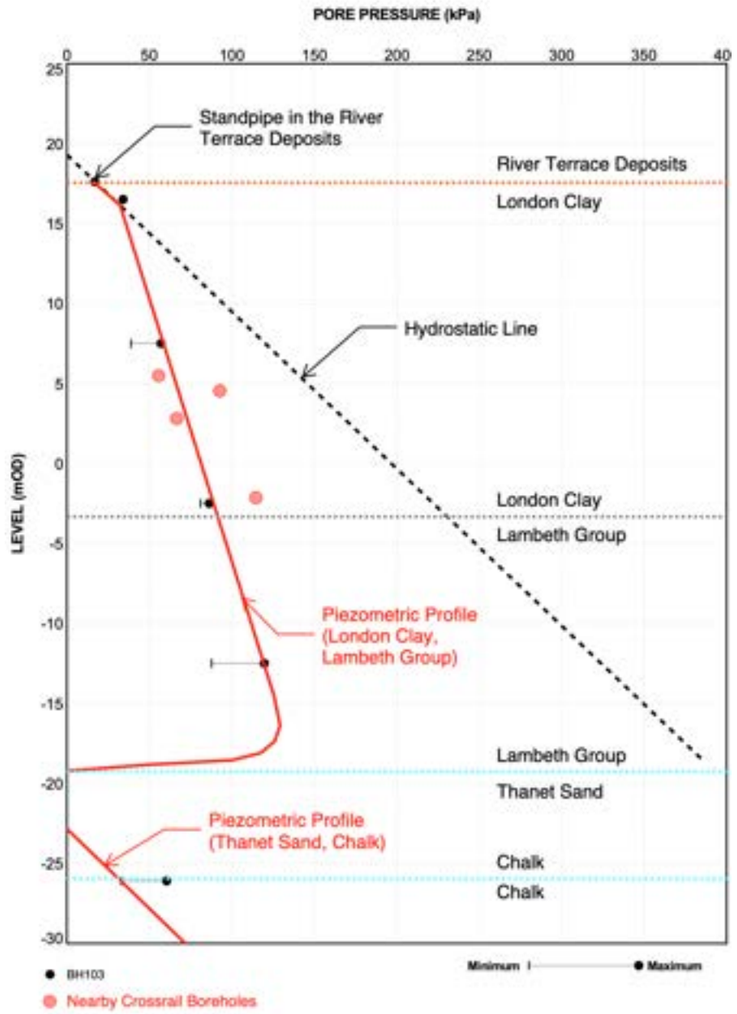
Source: *Ground Movements and Central Line Tunnel Capacity Calculations* report prepared by Ove Arup & Partners Ltd, June 2015.

Figure 6.7 North-south geological cross-section through the Post Building



Source: Ove Arup & Partners Ltd.

Figure 6.8 West-east geological cross-section through the Post Building



Source: Ove Arup & Partners Ltd.

Figure 6.9 Porewater pressure profile within the strata underlying the Post Building

7. Additional Assessments

7.1. Post Office Tunnels Ground Movement Assessment

7.1.1. A ground movement assessment has been conducted to determine the impact of the proposed works on the underlying Post Office tunnels and to address Scoping Point 5.4.

7.1.2. The impact of the construction works associated with the Museum Street, Vine Lane, High Holborn and West Central Street developments has been assessed using a combination of the Oasys Pdisp and Plaxis 3D software packages, in general accordance with thresholds set by the Royal Mail Group asset protection team.

7.1.3. The Oasys Pdisp assessment simulates full *greenfield* conditions, where the effects of any structural stiffness from the proposed development and tunnel lining are not considered. The Plaxis 3D assessment allows full modelling of the effects of the substructure structural stiffness and soil-structure interaction of the proposed movement-control and settlement-reducing piles beneath the Museum Street core, however the impact of tunnel lining stiffness has conservatively not been considered.

7.1.4. The tunnel deformations induced by ground movements have been assessed in the short- and long-term conditions, accounting for time-dependent ground movements and load redistribution.

7.1.5. Soil parameters have been selected based on historical borehole information from BGS and London Borough of Camden Planning Portal and previous experience on projects in the vicinity of the proposed development. These parameters will be validated through post-planning ground investigation works. The assessment will then be revised.

7.1.6. The alignments of the Post Office tunnels have been based on a line and level survey undertaken by SOCOTEC Monitoring UK Limited in September 2020.

7.1.7. The assessment indicates that the induced displacements, radii of curvature and radial distortions of all tunnels are within the Royal Mail Group criteria.

7.2. Central Line Ground Movement Assessment

7.2.1. A ground movement assessment has been conducted to determine the impact of the proposed works on the LUL Central Line assets to the north.

7.2.2. The impact of the construction works associated with the West Central Street development has been assessed using the Oasys Pdisp software package, in general accordance with thresholds set by the LUL asset protection team. The Oasys Pdisp assessment simulates full *greenfield* conditions, where the impact of any structural stiffness from the proposed development and tunnel lining are not considered.

7.2.3. The tunnel deformations induced by ground movements have been assessed in the short- and long-term conditions, accounting for time-dependent ground movements and load redistribution.

7.2.4. Soil parameters have been selected based on historical borehole information from BGS and London Borough of Camden Planning Portal and previous experience on projects in the vicinity of the proposed development. These parameters will be validated through post-planning ground investigation works. The assessment will then be revised if necessary.

7.2.5. The modelled locations of the Central Line tunnels have been modelled based on archive and as-built information provided by LUL.

7.2.6. Whilst the asset protection team has not set specific criteria to be satisfied, the induced displacements, radii of curvature and radial distortions of all tunnels are within generally adopted criteria for similar assessments.

7.3. Crossrail Ground Movement Assessment

7.3.1. A ground movement assessment has been conducted to determine the impact of the proposed works on the Crossrail running tunnel to the south of the site.

7.3.2. The impact of the construction works associated with the Museum Street, Vine Lane and High Holborn has been assessed using the Oasys Pdisp software package, in general accordance with thresholds set by the Crossrail asset protection team. The Oasys Pdisp assessment simulates full *greenfield* conditions, where the impact of any structural stiffness from the proposed development and tunnel lining are not considered.

7.3.3. The tunnel deformations induced by ground movements have been assessed in the short- and long-term conditions, accounting for time-dependent ground movements and load redistribution.

7.3.4. Soil parameters have been selected based on historical borehole information from BGS and London Borough of Camden Planning Portal and previous experience on projects in the vicinity of the proposed development. These parameters will be validated through post-planning ground investigation works and the assessment will then be revised if necessary.

7.3.5. The modelled location of the Crossrail tunnel has been based on as-built information provided by the Crossrail asset protection team.

7.3.6. The assessment indicates that the induced displacements, radii of curvature and radial distortions of all tunnels are within the Crossrail criteria.

7.4. Thames Water Ground Movement Assessment

7.4.1. A ground movement assessment has been conducted to determine the impact of the proposed works on the TWUL assets in close proximity to the site.

7.4.2. The impact of the construction works associated with the Museum Street, Vine Lane, High Holborn and West Central Street has been assessed using the Oasys Pdisp and Xdisp software packages, in general accordance with typical thresholds set by the TWUL asset protection team. The Oasys Pdisp and Xdisp assessments simulate full *greenfield* conditions, where the impact of any structural stiffness from the proposed development and tunnel lining are not considered.

7.4.3. The ground movement assessment has been carried out in general accordance with guidance set out in CIRIA C760 and takes into the account the construction methodology and site-specific ground and groundwater conditions.

7.4.4. The deformations induced by ground movements have been assessed in the short- and long-term conditions, accounting for time-dependent ground movements and load redistribution.

7.4.5. Soil parameters have been selected based on historical borehole information from BGS and London Borough of Camden Planning Portal and previous experience on projects in the vicinity of the proposed development. These parameters will be validated through post-planning ground investigation works and the assessment will then be revised if necessary.

7.4.6. The modelled locations of the TWUL assets have been based on wastewater and clean water utilities plans provided by the asset protection team.

7.4.7. The assessment indicates that the induced displacements, rotations and increases in strain of all assets are within TWUL criteria..

7.5. UKPN Ground Movement Assessment

7.5.1. A ground movement assessment has been conducted to determine the impact of the proposed works on the UKPN substations proposed to be installed on the ground floor of High Holborn and in the north of Vine Lane.

7.5.2. The impact of the construction works associated with the Museum Street, Vine Lane and High Holborn has been assessed using Plaxis 3D, in general accordance with thresholds set by the UKPN asset protection team. The Plaxis 3D assessment allows full modelling of the effects of the substructure structural stiffness and soil-structure interaction of the proposed movement-control and settlement-reducing piles beneath the Museum Street core.

7.5.3. The substations deformations induced by ground movements have been assessed in the long-term conditions, accounting for the increment of ground movement following installation of the substations associated with the dissipation of excess pore water pressure.

7.5.4. Soil parameters have been selected based on historical borehole information from BGS and London Borough of Camden Planning Portal and previous experience on projects in the vicinity of the proposed development. These parameters will be validated through post-planning ground investigation works and the assessment will then be revised if necessary.

7.5.5. The location of the UKPN substations has been based on information provided by the project team.

7.5.6. The assessment indicates that the induced differential settlements are within the UKPN criteria.

8. Construction Methodology / Engineer Statements

8.1. Supplementary Structural Engineer Reports

8.1.1. Supplementary reports prepared by the structural engineer for the proposed development, Meinhardt, are included in Appendix E and contain detailed information regarding the proposed temporary and permanent works, construction sequencing and design criteria.

8.1.2. The following sub-sections summarise construction methodology information and include engineer statements relevant to the Basement Impact Assessment.

8.2. Outline Temporary and Permanent Works Proposals

8.2.1. It is proposed at this stage to construct the Vine Lane basement using a *bottom-up* methodology. The existing ramp will be backfilled to ground level prior to installed the secant pile wall.

8.2.2. The Selkirk House superstructure will be demolished prior to construction works commencing in the existing basement.

8.2.3. The basement extension at West Central Street will be formed by underpinning the existing Party Wall to a minimum of 300mm below the proposed raft formation level.

8.2.4. Standard means and methods of excavation are expected to be suitable to excavate the basement, based on the ground conditions proven by historical site investigation works. This will be confirmed by the upcoming supplementary site-specific ground investigation.

8.2.5. The Vine Lane basement excavation will be restrained by a combination of secant pile walls along the eastern, northern and north-west edges, and existing underpins in the south-west corner.

8.2.6. Design of the retaining walls and temporary propping shall be carried out in accordance with the relevant Eurocodes, non-conflicting codes of practice, and associated design best practice.

8.3. Ground Movement and Damage Impact Assessment

8.3.1. A ground movement assessment of the surrounding buildings has been carried out in general accordance with the guidance set out with CIRIA C760 and takes into account the construction methodology and site- specific ground and groundwater conditions. The full assessment report has been included as Appendix C.

8.3.2. All structures / properties within the zone of influence of the proposed development have been assessed.

8.3.3. The following assumptions have been made within the ground movement assessment:

- The existing West Central Street shallow footings and the proposed underpins and raft foundations are founded above the water surface table in the Lynch Hill Gravels.
- The Vine Lane secant pile wall is toed at 14.0mOD (approximately 11m-long) within the London Clay Formation.
- The temporary horizontal propping of the existing Selkirk House basement retaining walls during the proposed local breaking out and infilling works results in negligible additional lateral wall deflection.
- The surrounding buildings included in the ground movement assessment are founded at ground level.
- The walls of the above-mentioned buildings are assumed to behave as equivalent beams.

8.3.4. The ground movements resulting from the works comprise deformations arising from the following mechanisms:

- Installation of the secant pile walls and underpins.
- Bulk excavation works.
- Heave and settlement of the Lynch Hill Gravels and London Clay Formation due to unloading, load redistribution and long-term loading.

8.3.5. The CIRIA C760 ground movement curves adopted to model the installation of the secant piles have been reduced by 50%, in line with guidance from the technical paper published by Ball & Langdon (2014).

8.3.6. The following structures were assessed, having been identified as falling within the zone of influence of the proposed development:

- 236SA.01 – 236SA.05: 236 Shaftsbury Avenue.
- 234SA.01 – 234SA.05: 234 Shaftsbury Avenue.
- 232SA.01 – 232SA.04: 232 Shaftsbury Avenue.
- 230SA.01 – 230SA.06: 230 Shaftsbury Avenue.
- 228SA.01 – 228SA.04: 228 Shaftsbury Avenue.
- 14WCS.01 – 14WCS.04: 14 West Central Street.
- 5GS.01 – 5GS.06: 5 Grape Street.
- 7GS.01 – 7GS.06: 7 Grape Street.
- 9GS.01 – 9GS.06: 9 Grape Street.
- 11GS.01 – 11GS.04: 11 Grape Street.
- 13GS.01 – 13GS.04: 13 Grape Street.
- 15GS.01 – 15GS.08: 15 Grape Street.
- 17GS.01 – 17GS.08: 17 Grape Street
- 167HH.01 – 167HH.04: 167 High Holborn.
- 45NOS.01 – 45NOS.04: 45 New Oxford Street.
- 16WCS.01 – 16WCS.04: 16 West Central Street.
- 43NOS.01 – 43NOS.06: 43 New Oxford Street.
- 33NOS.01 – 33NOS.06: 33 New Oxford Street.
- PO.01 – PO.03: The Post Building.
- 39NOS.01 – 39NOS.08: 39-41 New Oxford Street.
- 10MS.01 – 10MS.04: 10-12 Museum Street.

8.3.7. In accordance with the Burland Scale, the potential damage impacts are assessed not to be greater than *Category 1 – Very Slight*.

8.3.8. The maximum anticipated vertical and horizontal ground movements in the surrounding pathways and highways due to the installation of the embedded retaining structures and excavation of the proposed basement are 7mm and 13mm, respectively. Maximum settlements increase to 25mm in the long-term, after the construction of the proposed structures; the maximum horizontal displacement remains at 13mm. It is noted that these movements represent an upper bound value; actual ground movements are anticipated to be of lesser magnitude.

8.3.9. The expected ground movements resulting from the proposed Vine Lane works are proposed to be limited by a single level of temporary propping, which will be installed during the basement excavation phase.

8.3.10. The following mitigation measures are proposed to reduce ground movements and damage:

- Design of the secant pile wall, underpinning, and temporary propping measures will be carried out in accordance with the relevant Eurocodes, non-conflicting codes of practice, and associated design best practice.
- Construction of the retaining wall will be performed by an experienced ground engineering contractor.
- Construction of the underpins will be performed by an experienced specialist underpinning contractor.
- Frequent monitoring of neighbouring properties is proposed to be carried out during excavation works, to validate ground movement predictions against reality.
- A monitoring-trigger-action plan that identifies trigger levels, responsible personnel and actions to be followed in the event of a trigger level exceedance will be developed.
- Stiff high-level propping will be incorporated into the temporary works design of the Selkirk House basement works and Vine Lane basement excavation so as to provide high stiffness earth retention systems. Design details regarding minimum wall flexural stiffness, prop stiffness and arrangement will be defined as part of detailed design development and will take cognisance of the results of the scheme ground movement assessments.
- Designated areas for stacking and storing materials behind the embedded retaining wall should be identified. These should be located away from sensitive structures. The design of the retaining wall should incorporate an appropriate surcharge load to the rear of the wall, to capture effects of stacking and storing materials, vehicle traffic, existing buildings, etc.
- Additional scheme ground movement assessments have been performed in order to review the impact of the scheme on various third-party assets. These assessments will be further refined based on the ongoing scheme development. Various assets, including Royal Mail Group, LUL, Crossrail, TWUL and UKPN, have been assessed and found to satisfy the deformation criteria / limits set by each asset protection team.

8.4. Control of Construction Works

8.4.1. Following the selection of a Principal Contractor, a Construction Method Statement should be developed, which will cover the items outlined in this section in detail.

8.4.2. Work method statements and logistics strategies will be developed for the main stages of the construction works, outlining the means and methods of safely carrying out the works. Key risks and associated mitigation measures will also be detailed.

8.4.3. Details of temporary propping and temporary works required should be developed to ensure structural stability is maintained throughout demolition, excavation and basement works. Outline construction sequence proposals developed by the design team are included in Appendix B.

8.4.4. Groundwater control and dewatering measures will be developed to ensure that the excavation remains dry throughout the duration of construction works. However, a full groundwater cut-off system at Vine Lane is envisaged at this time, therefore only nominal groundwater inflow is anticipated during the works, which will be dealt with locally by pumping. Similarly, materials in hydraulic connectivity with the Lynch Hill Gravels aquifer are not anticipated to be encountered during breaking out works in the Selkirk House basement. In the instance that hydraulic connectivity is proven during the supplementary site-specific ground investigation works, mitigation measures would be deployed.

8.4.5. Construction traffic management plans and environmental considerations for the site, including site waste management and noise / vibration / dust mitigation, should also be developed.

8.4.6. A detailed structural monitoring strategy will be developed to control construction works and maintain movements / damage impacts that are within the predicted limits and tolerances. This will include the following:

- A structural monitoring layout plan of instrumentation / survey points / critical sections, especially for the Grade II listed 43-45 New Oxford Street, Bloomsbury Public House and Queen Alexandra Mansions in close proximity to the site.
- Monitoring of the earth retention systems (West Central Street underpins, Vine Lane secant pile wall and existing underpins, and Selkirk House reinforced concrete retaining walls) to enable continuous review of vertical and lateral deflections.
- Programme / frequency of monitoring.
- Trigger values derived for each of the structures within the zone of influence of the proposed works.
- Contingency actions and project team lines of responsibility in the management of the monitoring works.

8.5. Foundation Sizing and Design

8.5.1. Sizing and design of the proposed Museum Street, Vine Lane and High Holborn shallow foundations and bearing piles have been carried out in accordance with guidance provided in the *Substructure Bearing and Pile Capacities* technical note prepared by A-squared (ref. 1084-A2S-XX-XX-TN-Y-0009-00), included in Appendix D.

8.5.2. The Museum Street shallow bearing footings have been sized based on an *allowable* bearing capacity of 250kPa in the London Clay, and the serviceability performance of the footings have been verified explicitly by the design team.

8.5.3. The Museum Street bearing pile safe working loads do not consider any shaft-friction generation about 15.5mOD (the underside of the existing Selkirk House raft foundation) due to the potential presence of significant thicknesses of mass concrete backfill. The depth to which concrete backfill is present will be confirmed by post-planning ground investigation works.

8.5.4. The global stability and serviceability performance of the Museum Street core piled-raft hybrid foundation has been verified by A-squared in the *Museum Street Piled Raft Foundation Design Summary* technical note (ref. 1084-A2S-XX-XX-TN-Y-0013-01), included in Appendix D and based on RIBA Stage 3 design and loading information provided by Meinhardt. The maximum absolute and differential settlements of the raft are anticipated to be 43mm and $1_v/600_h$, respectively.

8.5.5. Checks of the performance of the Vine Lane and High Holborn raft foundations are included in the *Museum Street Piled Raft Foundation Design Summary*, and indicate that the foundation systems meet relevant Eurocode 7 ultimate and serviceability limit state criteria.

9. Basement Impact Assessment

9.1. Conceptual Site Model

9.1.1. The ground conditions of the site generally comprise Made Ground and Lynch Hill Gravels overlying the London Clay Formation, Lambeth Group, Thanet Sands and Chalk.

9.1.2. The site and the general surrounding areas are relatively flat. The site has an external elevation of approximately 25.0mOD.

9.1.3. Groundwater monitoring indicates that a perched groundwater table is present within the Lynch Hill Gravels at approximately 19.5mOD.

9.1.4. The 1 Museum Street site currently comprises the 17-storey Selkirk House tower and NCP car park with two levels of basement and a further partial basement level. The West Central Street site is currently occupied by four terraced three- to four-storey commercial and retail buildings with a single-level shared basement.

9.1.5. The proposed development at the 1 Museum Street site comprises the demolition of Selkirk House, excavation of the Vine Lane basement, and constructed of the 19-storey Museum Street, six-storey High Holborn and five-storey Vine Lane buildings. The development at West Central street will comprise a series of new and refurbished building rising to six storeys.

9.1.6. The following foundation systems will be implemented across the site.

- **Museum Street**: Within the existing basement, new discrete shallow footings at column locations and a new hybrid piled raft foundation system beneath the core will be constructed approximately 2m above the lowest point of the top of the existing raft, with large portions of the existing basement refurbished and reused. Several bearing piles will also be constructed for columns landing outside of the basement to the north and east, and within the basement in its southeast corner.
- **Vine Lane**: A new raft foundation system will be constructed, replacing any existing substructure elements present in that location. The raft will be tied into a new secant wall toed approximately 4m below the proposed formation level.
- **High Holborn**: A new raft foundation system will be constructed on the top of the existing raft. The existing single-storey basement will be backfilled above the new raft to ground level.
- **West Central Street**: The existing basement and foundations will be retained below new columns, with limited basement extensions via underpinning above the anticipated groundwater table and new raft foundations introduced where required.

9.1.7. Neighbouring buildings have been conservatively assumed to be founded near surface for the purposes of this BIA.

9.1.8. The development site is bounded by public highways to the north, south and east, with West Central Street dissecting the site. The distance from the proposed basement excavation works to the nearest highway/footpath is approximately 2.5m.

9.1.9. Royal Mail Group Post Office tunnels are present directly beneath the site at a depth of approximately 17m bgl.

9.1.10. LUL Central Line tunnels are present to the north of the site 20-25m beneath New Oxford Street.

9.1.11. A Crossrail running tunnel is present to the south of the site approximately 13m beneath High Holborn.

9.1.12. Various TWUL sewers and clean water pipes surround the site on all sides.

9.1.13. Two new UKPN substations will be installed on site following completion of the superstructure construction: on the ground floor of High Holborn and in the north of Vine Lane .

9.1.14. The proposed development may result in limited impact/cosmetic damage to the neighbouring buildings. Any potential damage will be mitigated by appropriate construction means and methods (such as temporary propping/shoring, controlled excavation operations and robust underpinning proposals).

9.2. Land Stability / Slope Stability

9.2.1. It is assumed that all new substructure elements will be founded on the Lynch Hill Gravels, London Clay Formation or Lambeth Group, which are considered to be suitable founding strata.

9.2.2. A ground movement assessment has concluded that ground movements caused by the demolition, excavation and construction works associated with the proposed development will be limited. The upper bound damage category for surrounding structures within the *zone of influence* of the proposed development has been assessed as *Category 1 - Very Slight*, in accordance with the Burland Scale. The maximum anticipated horizontal and vertical displacements in adjacent highways/pathways due to the installation of embedded retaining structures and bulk excavation are 13mm and 7mm, respectively.

9.2.3. It is noted that due to the adopted parameters, assumptions, and analysis methods, the ground movements outlined in this BIA can be considered as unlikely to be exceeded values. It is anticipated that the actual ground movements will be of a lesser magnitude to the values presented herein.

9.2.4. The BIA presents a summary of the key considerations and design decisions implemented to reduce the impact of the proposed works on the adjacent Category A and B trees. The proposed removal of other Category C trees is noted anticipated to impact the proposed development and surrounding areas.

9.2.5. Assessments of the impact of the proposed works on the Post Office tunnels, Central Line tunnels, Crossrail tunnel, TWUL utilities and UKPN substations within and around the site boundary indicate that induced movements do not exceed the relevant stakeholders' criteria.

9.2.6. The BIA has concluded that the risks to the adjacent properties, slopes, trees, and infrastructure (including ultimate and serviceability limit state considerations) is limited and will be mitigated in a reasonable fashion as part of design development.

9.3. Hydrology and Groundwater Flooding

9.3.1. The BIA has concluded that there is a low risk of groundwater flooding due to the proposed development.

9.3.2. The BIA has concluded that the proposed Vine Lane basement will cut-off any existing perched groundwater flow paths that may currently pass through the permeable Lynch Hill Gravels, as it is embedded within the London Clay Formation. This aspect should be reviewed in detail following the conclusion of the site-specific ground investigation works.

9.3.3. The existing Selkirk House basement is founded in the London Clay Formation with nominal thicknesses of Made Ground. Connectivity with the Lynch Hill Gravel aquifer is not present.

9.3.4. The BIA has identified that the proposed Vine Lane basement pile wall and underpins will create a cut-off to any existing groundwater flow paths that currently pass through the site, as they will be embedded within the underlying low permeability London Clay Formation. Based on a review of currently available ground investigation information, a hydrogeological gradient

across the site is not anticipated. The presence of a hydrogeological gradient will be confirmed during post-planning ground investigation works, and, if non-static groundwater is identified, the requirement for a hydrogeological assessment will be reviewed.

9.4. Hydrology, Surface Water Flooding and Sewer Flooding

9.4.1. The BIA has concluded that there are potential impacts to the wider hydrological environment. It is anticipated that the design of the works will largely mitigate such impacts through a robust scheme surface water drainage design and a Flood Risk Assessment.