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256 GRAYS INN ROAD

BASEMENT IMPACT ASSESSMENT (PLOT 1)

Revision History

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Ramboll
240 Blackfriars Road
London SE1 8NW
United Kingdom

tel +44 (0)20 7631 5291
london@ramboll.co.uk

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Scope	
Purpose of the report	This Basement Impact Assessment has been prepared by Ramboll UK in connection with the proposed refurbishment and redevelopment of 256 Grays Inn Road to deliver a new world-leading dementia and neurology research centre, as well as additional academic floorspace for University College London. This Basement Impact Assessment (BIA) has been prepared to comply with the Camden Council Policy A5 requirements for basement development. This BIA is for the basement that is to be constructed for Plot 1; the basement that is to be constructed for Plot 3 is to be covered in a separate application.
Proposed development	The first phase of the proposed development comprises the partial redevelopment of the former Royal Free Hospital (Plot 1) to deliver a world-leading medical research facility to tackle dementia and neurological diseases such as: • Alzheimer's Disease; • Multiple Sclerosis; • Huntington's Disease; • Parkinson's Disease; • Motor Neurone Disease; • Stroke; and • Epilepsy. The new dementia and neurology research facility would host the central hub of UK Dementia Research Institute (DRI) and University College London's Queen Square Institute of Neurology (IoN), alongside related neurological NHS outpatient services provided by University College London Hospitals NHS Foundation Trust. The project is rooted in central government's 2020 Challenge on Dementia and is backed by the Medical Research Council, Alzheimer's Research UK and the Alzheimer's Society. The aim is to provide the most comprehensive, coordinated neuroscience research centre in the world, from research at laboratory benches to patient care. The new research centre is collectively referred to as the IoN/DRI. The proposed development for Plot 1 comprises the demolition of the Sussex, Victoria and New Wings, and the construction of a 9-storey development; this comprises a 2-storey basement (approximately 12m bgl) and a 7-storey superstructure, inclusive of 2-storeys for plant. Subsequent phases of the proposed development comprise the refurbishment of the grade II listed Eastman Dental Clinic (referred to as Plot 2) and the erection of a new building on the site of the Levy Wing (referred to as Plot 3) to deliver additional academic space for UCL. This academic space is likely to be occupied by the newly established UCL Institute of Mathematics and Statistical Science, which will complement the University's vision for creating a world class environment for education and academic research. The new academic floorspace will form part of the wider complementary academic uses that will further strengthen London's cluster of academic institutions that form part of its Knowledge Quarter, whilst also collaborating with the dementia and neurology research. The proposed development would also deliver a comprehensive landscaping scheme to open up new publicly accessible spaces within the site, and new public connections across it. Only minor works are proposed to the existing student accommodation at Frances Gardner House, comprising the installation of photovoltaic panels on the roof, and alterations to the landscaping within the courtyard.

Site Information			
Grid Ref	TQ 30720 82429	***Site Area***	*1.207 hectares*
Current Site Description	The application site at 256 Grays Inn Road is 1.207ha in area, and is bounded to the west by Grays Inn Road, to the north by the Calthorpe Project and the New Calthorpe Estate, to the east by Langton Close, and to the south by Trinity Court and St Andrew's Gardens. The main part of the site is currently occupied by the Eastman Dental Hospital, which is due to vacate the site and relocate to a new development at Huntley Street in 2019. The Eastman Dental Hospital is made up of a group of buildings comprising: • the former Royal Free Hospital (Plot 1) • the grade II listed Eastman Dental Clinic (Plot 2); and • the Levy Wing (Plot 3). The rear part of the application site includes the existing student accommodation at Frances Gardner House. Plot 1 is the former Royal Free Hospital which comprises the four wings (Alexandra (west), Sussex (north), Victoria (east), New (south)) with a central court yard. There is a small asphalted parking area to the east of Victoria Wing. The courtyard in Plot 1 hosts a fully-grown tree to the south and a fountain structure in the centre. Sections of the site currently include a one-storey basement which houses laboratories and plant rooms. The main site entrance is through the Alexandra Wing along Grays Inn Road. The ground is generally level across the site, with existing elevations approximately in the order of +20.5m above ordnance datum (AOD).		
Site History	Maps dating back to 1874 show the presence of the Royal Free Hospital in the north of the site with wards surrounding a central courtyard. The south of the site was occupied by a Percussion Cap and Cartridge Manufactory, and later labelled an Ammunition Manufactory on maps from 1895-1896. This site later became part of the Eastman Dental Institute, present on maps from 1953 onwards. By 1916 the Royal Free Hospital expanded with buildings to the east (the Helena Building). The surrounding land use was predominantly occupied by terraced housing, with industrial land use along the north and eastern site boundary. A builders yard was located adjacent to the eastern boundary of the site in 1874, later a timber yard 1895-1896, with unlabelled buildings to the north. The land to the north and east of the site boundary was later occupied by garages, 2no. engineering works and a clothing factory in maps dated 1953-1971. The land occupied by the works was cleared by 1979, with residential housing, and		

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	the current Calthorpe Estate present in 1982. Land approximately 90m east of the site on Pakenham Street was also occupied by industrial premises, with a printing works and warehouse annotated on maps from 1953, and a depot present on maps from 1960.
Report Content	
	The information in this document makes reference to a number of other documents prepared by Ramboll or the wider project team. These include; • A detailed Desk Top Site Appraisal including site history, utilities, and existing buildings and structures. • Summary of the site-specific information including geology, hydrogeology, and hydrology. • Appraisal of the impact of underground structures within the locality. • Appraisal of the existing structure as it relates to the works and the final proposal. • Illustrative and quantitative details of the proposed structure to be further developed in the Detailed Design Phase. • Outline construction sequence to be further developed by the Contractor. • Predicted ground movements, discussion of the implications and proposed mitigations. • The proposed Architectural planning drawings, by Hawkins/Brown. • Results of the utilities survey. • Flood Risk Assessment Report by Ramboll. • Historic Environment Desk Based Assessment, Pre-Construct Archaeology, April 2018. • Initial Heritage Assessment, Alan Baxter, February 2018. • Movement Monitoring Strategy, Ramboll, October 2018.
Summary of the Impact Assessment	
Screening	A flood risk assessment was carried out by Ramboll, which indicates the site is in Zone 1 of the EA (Environment Agency) flood risk map, and there is a low risk of flooding from surface water drainage and other man-made sources. The proposed basement will be founded on London Clay. The Envirocheck Report indicates a moderate potential for shrinking or swelling clay ground stability hazards on site. A ground investigation has been completed for the site. It indicates that the ground water level is variable but that the basement formation level may be just below the groundwater level (water table). Groundwater levels are potentially influenced by the higher level of the London Clay encountered and the relatively minor extent of the River Terrace Deposits on the site. The River Terrace Deposits are classified as a Secondary Aquifer and the London Clay as an unproductive stratum. Perched water and groundwater in both of these shallow deposits and also the Made Ground may be encountered during construction. Temporary dewatering may be required. Based on the ground conditions encountered from the site-specific ground investigation, the site appears to be situated on a localised high geological point for the London Clay from geological folding. Groundwater flows in the River Terrace Deposits would tend to be away and/or around the site, therefore the risk for planning and the substructure impact is low. Evidence from ground investigations show this shallow aquifer is thin and absent in places and no groundwater strikes were encountered during drilling. The London Clay is also reasonably elevated at the site and proven to be of low permeability. Therefore, the basement will only be constructed within a thin inconsistent shallow aquifer and mostly in the low permeability strata of the London Clay. Overall, the basement is not considered to have a significant impact on the local shallow hydrogeology mainly due to the absence of a plausible shallow aquifer beneath the site. The proposed basement will increase differential depth of foundations to neighbouring properties, especially the Eastman Dental Clinic. The proposed basement will extend to a significant depth relative to the existing foundations of the neighbouring properties and will need to be designed to ensure the stability of the site and any potentially sensitive structures that are significantly influenced by development of the site.
Scoping	Consideration has been given to the impact of the proposed development on groundwater flow, land stability and surface water flows. Issues and proposed mitigation measures are summarised below: The construction of the proposed redevelopment of the UCL site could lead to minor focussing of surface run off waters, and greater interception levels increasing the total amount of surface run off. This issue will be mitigated by utilising a sustainable drainage system which will lead to an overall betterment of the surface water run-off rate from the site, reducing the downstream flood risk. Reference should be made to the Drainage Philosophy document prepared by Ramboll. The site is underlain by London Clay which has a high-volume change potential. Given the nature of the ground conditions, provision for heave mitigation will be considered within the foundation design, during the detailed design stage.
Ground Movement and Damage Assessment	The proposed basement site is in the close proximity to a number of surrounding structures including the Grade II Listed Eastman Dental Clinic; therefore, it is envisaged that appropriate propping and temporary works would be installed during the basement construction to limit the effect of ground movements to the surrounding properties. Based on the assumed construction methodology, ground movements have been calculated at the nearby building locations and the resultant preliminary damage assessment based on CIRIA 760 methodology has been undertaken. The maximum vertical and horizontal movements due to the installation of the proposed secant pile retaining wall and the excavation of the basement have been calculated to be in the order 12mm and 18mm respectively, around the whole site, gradually reducing with distance from the site boundary.

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Generally, the movement derived damage predicted falls between Category 0 (Negligible) and Category 1 (Very Slight) based on typical damage categories for masonry buildings and the corresponding tensile strains based on Burland et al. (1977) and Boscardin and Cording (1989) categorisation, included in the appendices. For structures directly adjacent to and bounding the proposed secant pile retaining wall boundary line, a damage Category of 1 has been estimated. It is recommended that movement monitoring is carried out on the structures that have been calculated to be within Damage Category 1 prior to and during the proposed basement construction. It should be noted that the existing retaining wall bounding the north of the site, the east of the site where the current car park is located and parallel to Seddon Street will be demolished over the majority of the length, therefore is not considered wthin the ground movement assessment calculations.

Conclusions

Based on the work undertaken as outlined within this report through conservative modelling of the basement construction, the impact of the basement construction on surrounding structures can be mitigated through design and construction methods.

Consideration has been given to the impact of the proposed development on groundwater flow, land stability and surface water flows. Residual risks were shown to be present and the design implications associated have been discussed in the Scoping section (Section 5).

There are no major concerns relating to subterranean groundwater flow, surface flow and flooding, and slope stability.

On the basis of the assumed construction methods and sequence, a ground movement assessment has been undertaken for the proposed development. It confirms that ground movements could affect the surrounding structures, and any damage to neighbouring assets can be limited to 'Very Slight' (Burland Category 1).

To ensure the movements remain within acceptable limits, movement monitoring has been proposed. The Contractor will be required to carry out detailed monitoring of the surrounding properties to record ground movements and take appropriate action should the movement not be as expected.

The final construction sequence will be developed to take account of limitations established during the detailed design phase. Should the contractor propose to carry out the works in a different sequence to that assumed in our design then a further assessment of the predicted movement will be required, and the proposal only accepted if there is no significant change to the scale of predicted movement.

A Draft Construction Management Plan (CMP) has been developed by the project advisor which will include the scope of the monitoring requirements set out in the Ramboll movement monitoring strategy. A monitoring action plan for various stages of the project can be considered to monitor the existing structure and foundations, new walls and foundations and the adjacent Grade II Listed buildings. Trigger levels should also be set prior to construction phase to identify limits on monitored results and to define actions and mitigation measures if these limits are reached and/or exceeded. The traffic light approach could be adopted with green, amber, and red trigger levels set.

The following next steps will be undertaken as the design of the site is further developed;

- Construction methods are developed with the Contractor to feed into the ground movement analysis once the sequence of works is developed. To include for best practice control methods during piling including but not limited to 'hit one, miss three' approach and good quality workmanship;
- A pre and post works condition survey to be undertaken in relation to potentially affected surrounding properties and assets;
- If further information is obtained identifying historical foundation locations for Plot 1 and surrounding assets this will be incorporated into to analysis.
- An Approval in Principle (AiP) for the basement construction is required from LB Camden Highways due to the proximity to TfL road networks, namely Grays Inn Road. Asset protection agreements will be included within the AiP including utilities asset owners information.;
- Given the setting of the site and the derived Low to Medium Risk, it is recommended that consideration should be given to the potential risks to any below ground works posed by UXOs in accordance with CIRIA C681. Contractors to consider UXO mitigation during probing, piling and excavation works;
- Undertake Stage 4 foundation and retaining wall analyses and design;
- Consider the effects of heave based on the proposed development and extent of excavation for the scheme;
- Development of the Specification for Piling and Embedded Retaining Walls and further consultation with specialist contractors;
- Agreement through the Planning application process from London Borough of Camden on the proposed methodologies and analysis within the BIA.

1. INTRODUCTION

1.1. Brief

This Basement Impact Assessment (BIA) has been prepared by Ramboll UK in connection with the proposed refurbishment and redevelopment of 256 Grays Inn Road to deliver a new world-leading dementia and neurology research centre, as well as additional academic floorspace for University College London.

The proposed development includes the construction of a new circa 17,500m^2 research building to house the UCL Institute of Neurology and Dementia Research Institute (IoN/DRI).

This document describes the anticipated basement impacts on the surrounding area, which includes a multi-storey Grade II Listed building, the Eastman Dental Clinic (EDC).

This document presents information regarding the current understanding of the site, describes the recommended structural options for the basement and discusses some of the potential risks and opportunities associated with the proposal.

Various assumptions have been made in the design, these are stated in relevant sections of text. These will be reviewed by the project team and agreed prior to moving to the detailed design stage.

1.2. Scope

The main part of the site is currently occupied by the Eastman Dental Hospital, which is due to vacate the site and relocate to a new development at Huntley Street in 2019. The Eastman Dental Hospital is made up of a group of buildings comprising:

- the former Royal Free Hospital (Plot 1)
- the grade II listed Eastman Dental Clinic (Plot 2); and
- the Levy Wing (Plot 3).

The redevelopment is currently planned to take place in three phases;

- Phase 1; post partial demolition of the former Royal Free Hospital (RFH) and complete demolition of the Levy Wing and infill building between the RFH and EDC, this phase comprises the full delivery of the Plot 1, partial enhancement works to EDC, relocation of the Memorial Fountain and partial delivery of external landscape works.
- Phase 2; Restoration to the full façade of the EDC and internal modifications.
- Phase 3; Construction and delivery of Plot 3, and completion of proposed external landscape works.

The scope of this BIA covers the Phase 1 works which includes the basement to Plot 1. The proposed basement on Plot 3 is covered in BEMP-RAM-P3-XX-RP-CG-00-0001 as part of this application.

1.3. London Borough of Camden Requirements

In line with LBC planning policy, a BIA is required for planning applications to demonstrate that the scheme:

a. Maintains the structural stability of the building and neighbouring properties;

b. Avoids adversely affecting drainage and run off or causing other damage to the water environment; and,

c. Avoids cumulative impacts upon structural stability or the water environment in the local area.

The purpose of this report is to evaluate the impacts of the proposed basement considering the issues of hydrology, hydrogeology, and land stability through a staged methodology. This report has been structured to follow through the incremental stages of:

- Screening (Section 4)
- Scoping (Section 5)
- Ground Movement Assessment (Section 10)

This report considers the full screening, scoping, and basement impact assessment stages. It relies upon readily available desk study information, an intrusive ground investigation carried out in August 2018 and publicly available information to identify and appraise the nature and magnitude of potential impacts, together with appropriate mitigation measures. It is intended that this document supports the application of UCL in gaining planning permission for the development.

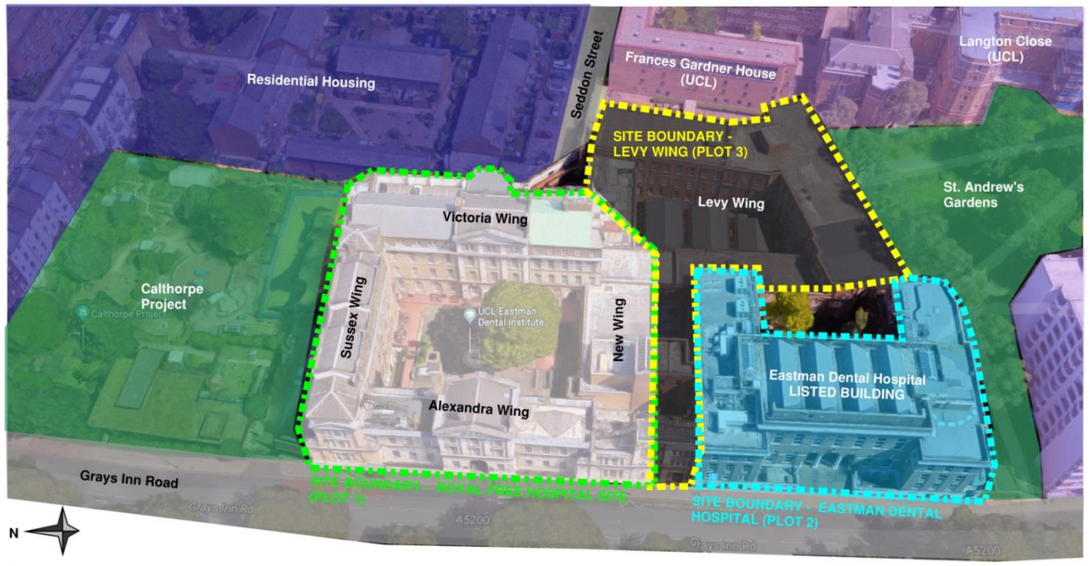


Figure 1: Site Plot Division

1.4. Supporting Documents

This report forms part of the submission of the application for planning permission and listed building consent and should be read in conjunction with the following supporting documents:

a) Completed planning and listed building application form;
b) Completed Community Infrastructure Levy Form;
c) Planning Statement prepared WSP | Indigo;
d) Health Impact Assessment prepared by WSP | Indigo;
e) Economic Impact assessment prepared by WSP | Indigo;
f) Application drawings prepared by Hawkins\Brown;
g) Design and Access Statement prepared by Hawkins\Brown;
h) Feasibility Options Appraisal prepared by Hawkins\Brown;
i) Draft Phasing Strategy prepared by Hawkins\Brown;
j) Statement of Community Involvement prepared by Comm Comm UK;
k) Lighting Strategy prepared by Hoare Lea;
l) Energy Statement prepared by Hoare Lea;
m) Eastman Dental Clinic Conservation Plan prepared by Alan Baxter Limited;
n) Heritage Statement prepared by Alan Baxter Limited;
o) Basement Impact Assessment prepared by Ramboll;
p) Structural Strategy Statement prepared by Ramboll;
q) Geotechnical Desk Study prepared by Ramboll;

r) Drainage Strategy prepared by Ramboll;
s) Flood Risk Assessment prepared by Ramboll;
t) Draft Construction Management Plan prepared by Blue Sky Building;
u) Site Waste Management Plan prepared by Blue Sky Building;
v) Transport Assessment prepared by Momentum;
w) Framework Travel Plan prepared by Momentum;
x) Draft Delivery and Servicing Management Plan prepared by Momentum;
y) Outline Construction Logistics Plan prepared by Momentum;
z) Arboricultural Report prepared by Thomson Ecology;
aa) Preliminary Ecology Appraisal prepared by Thomson Ecology;
bb) Landscaping Statement prepared by Plincke;
cc) Academic Needs Report prepared by Nicholas Hare Architects;
dd) Sustainability Statement incorporating BREEAM Assessments prepared by Expedition;
ee) Fire Strategy prepared by Buro Happold;
ff) Desk Based Archaeology Assessment by prepared by PCA
gg) Environmental Statement coordinated by Trium Environmental Consulting, and containing technical assessment chapters on:
    a. Socio-economics prepared by WSP | Indigo;
    b. Traffic and Transport prepared by Momentum;
    c. Air Quality prepared by Air Quality Consultants;
    d. Noise and Vibration prepared by Ramboll;
    e. Wind prepared by RWDI Consulting Engineers;
    f. Daylight, Sunlight, Overshadowing and Light Pollution prepared by GIA;
    g. Townscape and Visual Impact Assessment prepared by Peter Stewart Consultancy; and
    h. Built Heritage prepared by Alan Baxter Limited.

2. SITE DESCRIPTION

2.1. Site description and layout

The application site at 256 Grays Inn Road is 1.207ha in area, and is bounded to the west by Grays Inn Road, to the north by the Calthorpe Project and the New Calthorpe Estate, to the east by Langton Close, and to the south by Trinity Court and St Andrew's Gardens. The main part of the site is currently occupied by the Eastman Dental Hospital, which is due to vacate the site and relocate to a new development at Huntley Street in 2019. The Eastman Dental Hospital is made up of a group of buildings comprising:

- the former Royal Free Hospital (Plot 1)
- the grade II listed Eastman Dental Clinic (Plot 2); and
- the Levy Wing (Plot 3).

The rear part of the application site includes the existing student accommodation at Frances Gardner House.

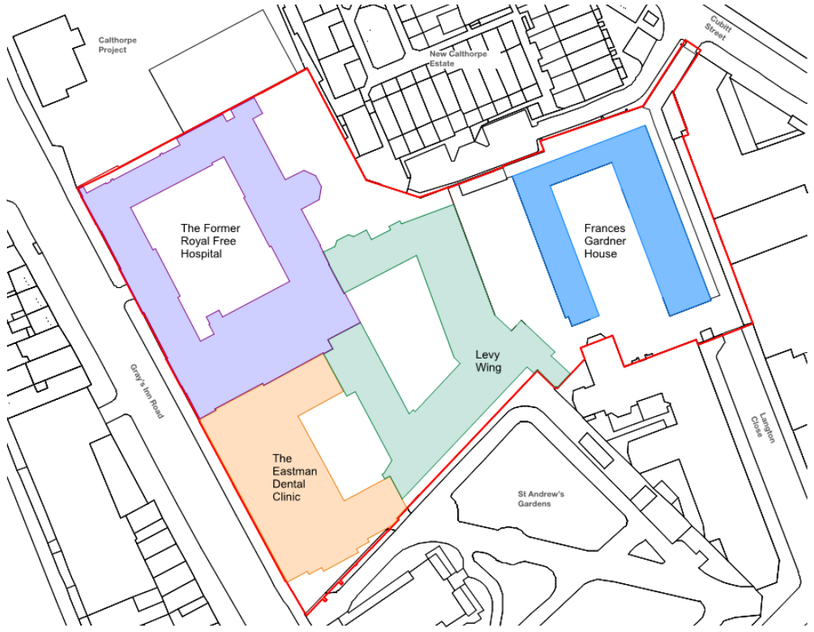


Figure 2: Site Plan Identifying Existing Buildings

2.2. Surrounding Land-Use

Grays Inn Road borders the site along the entire western boundary with commercial and residential properties the other side of the road. Beyond these is Mecklenburgh Street which runs parallel to Grays Inn Road, numbers 1-8 Mecklenburgh Street are Grade II Listed five-storey buildings. To the north of the site is the Calthorpe Project a community garden and centre. To the northeast is residential housing, to the south east is the approximately five-storey Frances Gardner House owned by UCL. Seddon Street runs perpendicular to the site between the residential housing and Frances Gardner House. To the south of Plot 2 and 3 is St. Andrew's Gardens, and Trinity Court a nine-storey residential apartment building.

2.3. Proposed development

The first phase of the proposed development comprises the partial redevelopment of the former Royal Free Hospital (Plot 1) to deliver a world-leading medical research facility to tackle dementia and neurological diseases such as:

- Alzheimer's Disease;
- Multiple Sclerosis;
- Huntington's Disease;
- Parkinson's Disease;
- Motor Neurone Disease;
- Stroke; and
- Epilepsy.

The new dementia and neurology research facility would host the central hub of UK Dementia Research Institute (DRI) and University College London's Queen Square Institute of Neurology (IoN), alongside related neurological NHS outpatient services provided by University College London Hospitals NHS Foundation Trust. The project is rooted in central government's 2020 Challenge on Dementia and is backed by the Medical Research Council, Alzheimer's Research UK and the Alzheimer's Society. The aim is to provide the most comprehensive, coordinated neuroscience research centre in the world, from research at laboratory benches to patient care. The new research centre is collectively referred to as the IoN/DRI.

The proposed development for Plot 1 comprises the demolition of the Sussex, Victoria and New Wings, and the construction of a 9-storey development; this comprises a 2-storey basement (approximately 12m bgl) and a 7-storey superstructure, inclusive of 2-storeys for plant.

Subsequent phases of the proposed development comprise the refurbishment of the grade II listed Eastman Dental Clinic (referred to as Plot 2). Finally, the erection of a new building on the site of the Levy Wing (referred to as Plot 3) is to deliver additional academic space for UCL. The current proposals envisage a new multi-storey building. The construction includes an extended basement; shallower than Plot 1. This academic space is likely to be occupied by the newly established UCL Institute of Mathematics and Statistical Science, which will complement the University's vision for creating a world class environment for education and academic research. The new academic floorspace will form part of the wider complementary academic uses that will further strengthen London's cluster of academic institutions that form part of its Knowledge Quarter, whilst also collaborating with the dementia and neurology research.

The proposed development would also deliver a comprehensive landscaping scheme to open up new publicly accessible spaces within the site, and new public connections across it.

Only minor works are proposed to the existing student accommodation at Frances Gardner House, comprising the installation of photovoltaic panels on the roof, and alterations to the landscaping within the courtyard.

Partial redevelopment of Eastman Dental Hospital, comprising:

a. Within the former Royal Free Hospital (Plot 1), the demolition of the New, Sussex and Victoria Wings and the retention of the Alexandra Wing, with a single storey upward extension and reinstatement of the southern pediment on the Alexandra Wing, and the erection of a five storey building (plus two storeys of plant above and two storey basement below) to the rear of the Alexandra Wing to provide a dementia and neurology research facility (Use Class D1);

b. Alterations to the Grade II listed Eastman Dental Clinic (Plot 2), including the part rebuilding of the northern façade, replacement of windows, and internal alterations associated with its conversion to education use (Use Class D1);

c. The demolition of the Levy Wing (Plot 3) and erection of a part 4 storey, part 7 storey building (plus single storey basement below) to provide education space (Use Class D1);

d. The relocation of the Grade II listed Riddell Memorial Fountain from the courtyard of the former Royal Free Hospital to the courtyard of the Eastman Dental Clinic;

e. The installation of photovoltaic panels on the roof of Frances Gardner House;

f. Associated landscaping arrangements including the creation of a new public square and pedestrian connections to St Andrew's Gardens, Cubitt Street and Langton Close;

g. Associated access, servicing, landscaping, and parking arrangements.

Figure 3: Site Plan Identifying Plots

3. ENVIRONMENTAL SETTING

3.1. Geology

The site geology and environmental setting is fully detailed in Ramboll's Geotechnical and Geoenvironmental Desk Study Report and Ground Investigation Report which should be referred to. A summary is provided below.

Based on the ground investigation data and the British Geological Sheet for the area (Sheet 256, North London 1:50000 Geological Survey of England and Wales), the stratigraphy comprises Made Ground over superficial deposits of Alluvium and River Terrace Deposits of variable extent. The solid geology consists of London Clay (with a weathered upper section), Lambeth Group, Thanet Sand, and the Upper Chalk.

A summary of the stratigraphy encountered can be seen in Table 3.1: Summary of Site Stratigraphy

The Envirocheck report indicates a moderate potential for shrinkage or swelling clay ground stability hazard on site this will be associated with the London Clay.

3.2. Topography

A topographic survey for the site has been completed by Gleeds Building Surveying Ltd. It indicates the ground is generally level across the site, with existing elevations of approximately +20.5m above Ordnance Datum (AOD) observed. There is an evident reduction in elevation between the boundary between Plot 1 and Plot 3 i.e. the adjacent land between the parking area and Levy Wing, where the elevation reduces to approximately +17.0m AOD to +18.0m AOD.

3.3. Hydrogeology and Hydrology

The hydrogeology is divided into two units comprising an upper Secondary Aquifer, which is primarily formed by an unsubstanstial layer of River Terrace Deposits, and a lower aquifer which is primarily formed below the London Clay and Lambeth Group, comprising the Thanet Sands and Upper Chalk, which are classified as Principal Aquifers. During the drilling for the ground investigation no water strikes were encountered.

Evidence from ground investigations show this shallow aquifer is thin and absent in places and no groundwater strikes were encountered during drilling. The London Clay is also reasonably elevated at the site and proven to be of low permeability. Therefore, the basement will only be constructed within a thin inconsistent shallow aquifer and mostly in the low permeability strata of the London Clay. Groundwater within strata beneath the London Clay is confined and likely to have a potentiometric surface (water level) that rises up (e.g. not too dissimilar to an artesian well). However the basement will not be excavated into aquifers beneath the London Clay (i.e. this deeper groundwater will not be encountered). Overall, the basement is not considered to have a significant impact on the local shallow hydrogeology mainly due to the absence of a plausible shallow aquifer beneath the site.

Falling Head Testing was carried out in BH04 during drilling between 3.00m bgl and 12.02m bgl, targeting the weathered London Clay and the unweathered London Clay, confirming the very low permeability of the clay.

It has been interpreted that a groundwater level of approximately +9.4m AOD is estimated for the site. At this level however, the groundwater profile is below hydrostatic pressure conditions, gradually draining through the London Clay and Lambeth Group to the Chalk. For the lower aquifer the data indicates that the groundwater elevation is in hydrostatic conditions at -30m AOD which is below the top of the Chalk and matches well with published Environment Agency (EA Annual Report Summary) data.

The River Thames is situated approximately 1.75km south of the site. The Regent's Canal system is located to the north, with the closest point approximately 935m away from the site. The River Fleet Relief sewer is subterranean culverted watercourse passing adjacent to the site.

Based on the ground conditions encountered from the site-specific ground investigation, the site appears to be situated on a localised high geological point for the London Clay from geological folding. Groundwater flows in the near surface minor aquifer would tend to be away and/or around the site, therefore the impact risk of the proposed development is considered **low**.

3.4. Flooding

A flood risk assessment has been undertaken by Ramboll. The EA's flood map data shows the site to be located within Flood Zone 1, indicating the site has a less than 0.1% annual probability of river or sea flooding in any year. The flood risk from surface water and drainage, groundwater, reservoirs, canals and other artificial sources is considered to be low. The Camden Flood Risk maps put it in a "critical drainage area" but outside "local flood risk zones".

Table 3.1: Summary of Site Stratigraphy

Stratum		Elevation at Top of Stratum (m AOD)	Thickness (m)	Exploratory Holes where Stratum Encountered
Made Ground		+20.56 – +16.35	4.70 to 0.70	All
River Terrace Deposits		+18.06 - +16.87	2.00 to 0.25	BH02C, WS02, TP09
Weathered London Clay		+18.14 - +15.81	5.20 to 1.90	BH01, BH02A, BH02C, BH03, BH04, WS01, WS02, WS03, OP01
London Clay		+13.95 – +12.43	14.20 to 12.70	BH0, BH02C, BH03, BH04, WS01, WS02, WS03,
Lambeth Group	Upper Mottled Beds	+0.01 - -0.76	7.18 to 6.10	BH01, BH02C, BH03, BH04
	Laminated Beds	-6.44 - -7.45	2.70 to 0.50	BH01, BH02C, BH03, BH04
	Lower Mottled Beds	-6.94 – -9.56	7.50 to 5.20	BH01, BH02C, BH03, BH04
	Mottled Upnor Formation	-13.57 - -15.56	3.70 to 1.63	BH01, BH02C, BH04
	Upnor Formation	-13.29 - -18.56	5.40 to 1.00	BH01, BH02C, BH03, BH04
Thanet Sands		-19.56 - -20.57	4.90 to 3.00	BH01, BH02C, BH04
Chalk Formation		-22.99 - -24.46	Base not proven	BH01, BH02C, BH03, BH04

3.5. Site History

From the second half of the 19th century the site was occupied by the Royal Free Hospital in the north and a Percussion Cap and Cartridge Manufactory to the south. A flying bomb impacted the southeast of Plot 1 in 1944; This building section was later redeveloped and known to be founded on piles, and adjoins to the Levy Wing following the bomb damage. By the 1980's to 90's the southern "New Wing" is constructed with other sections refurbished.

Since the earliest sourced historic map from 1874, the surrounding area was predominantly residential terraced housing with some industrial land use including Builders Yards, timber yards, foundry, brewery, and railways and tramways. By 1953 a clothing factory, engineering works, paint and printing ink factory are noted near the site. Around this time the Foundling Hospital and Trinity Church located nearby were demolished. By the 1980's industrial warehouses directly to the north of the site were converted into residential developments. The park where the Calthorpe project currently is was present by this time also. The UCL Frances Gardner house building was constructed in 2003.

3.6. Tree Information

The courtyard at the centre of Plot 1 hosts a fully-grown tree towards the south which is proposed to be removed.

3.7. Underground Services

A Landmark utilities report has been completed for the site. It found the majority of utilities are below Grays Inn Road with some feeding the site. A Thames Water combined sewer and storm relief sewer main is known to run beneath Grays Inn Road, approximately 10m west of the outer boundary of site (20m from the proposed secant retaining wall boundary line).

4. SCREENING

An initial screening exercise has been undertaken in relation to Subterranean Flow (Table 4.1), Slope Stability (Table 4.2), and Surface Flow and Flooding (Table 4.3). The following appraisal is based on the proposed new basement construction, the extent of which is indicated on the project drawings.

The screening exercise is based on the ground model identified in the Ground Investigation Report (GIR) (Report no. BEMP-RAM-P1-XX-RP-CG-00-0015) and summarised in Section 5 of this report.

Table 4.1: Screening of Subterranean Flow

Number	Question	Answer	Comments
1a	Is the site located directly above an aquifer	Yes	The site is underlain by Made Ground over an inconsistent layer of River Terrace Deposits which are classed as a Secondary A Aquifer by EA designations.
1b	If yes to 1a), will the proposed basement extend beneath the water table surface?	Yes	Groundwater level is anticipated to be at approximately +9.4m AOD. The proposed basement foundation level is +7.8m AOD (top of raft) with formation level varying between +5.8m AOD to +6.5m AOD.
2	Is the site within 100m of a watercourse, well (used/disused) or potential spring line?	No	No watercourses are within 100m, however the culverted River Fleet Relief Sewer is located 10m to the west of the site.
3	Will the proposed basement development result in a change in the proportion of hard surfaced/paved areas?	No	There will be an increase in built footprint as a result of the development however there will be no increase in impermeable areas as the existing site is almost entirely hardstanding.
4	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 Sustainable Urban Drainage?)	No	A drainage strategy design note has been prepared by Ramboll that will reduce the current surface water discharge using a sustainable urban drainage system, and agreed with the LLFA.
5	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 or spring line.	No	No such features are present within 100m of the site, as discussed in Question 2 above.

Table 4.2: Screening of Slope Stability

Number	Question	Answer	Comments
1	Does the existing site include slopes, natural or manmade, greater than 7°?	No	The site of the basement is covered by a topographic map. It shows that there is no slope greater than 7°. With the elevation staying between +20.00m AOD and +21.00m AOD for the majority of the site.
2	Will the proposed re-profiling of the landscape at the site change slopes at the property boundary to more than 7°?	No	The current plans detailed in the planning documents do not indicate landscape reprofiling.
3	Does the development neighbour land, including railway cuttings and the like, which slopes greater than 7°?	No	The development does not neighbour any railway cuttings or sites with slopes greater than 7°.
4	Is the site in a wider hillside setting with a slope of more than 7°?	No	Ordnance Survey maps do not show a hillside setting to the site.
5	Is the London Clay the shallowest strata at this site?	Yes	The shallowest strata is London Clay in areas of the site where Alluvium or River Terrace Deposits are not present (see Section 3.1).
6	Will any tree(s) be felled as part of the proposed development and/or any works proposed within any tree protection zones where trees are to be retained?	Yes	The mature tree within the courtyard will be felled in order to enable the construction of the basement.
7	Is there a history of shrink-swell subsidence in the local area, and/or evidence of such effects at the site?	Yes	The Envirocheck Report indicates a moderate potential for shrinking or swelling clay ground stability hazards on site.
8	Is the site within 100m of a watercourse or potential spring line?	No	Refer to Question 2 in Table 1
9	Is the site in an area of previously worked ground?	No	By reference to online BGS Geology maps the site is not in an area of recorded worked ground. However, the ground investigation revealed Made Ground to be present to an average depth 3.1m bgl.
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?	Likely	Anticipated groundwater level is approximately +9.4m AOD vs a proposed basement foundation level of +7.8m AOD (top of raft). There were no recorded water strikes in the exploratory holes during the ground investigation. The pore water pressure was also interpreted to be below hydrostatic indicating it was draining below through the London Clay and Lambeth Group into the Upper Chalk. London Clay, was found to have a low permeability thus the risk of flooding during excavation is low. The development may however encounter limited volumes of perched groundwater in the strata above the London Clay, and as a result temporary dewatering may be required.
11	Is the site within 50m of highway or pedestrian right of way?	Yes	Ordnance Survey maps indicate that the site is within 50m of Grays Inn Road, Seddon Street, Mecklenburgh Street, and Heathcote Street.

Number	Question	Answer	Comments
12	Will the proposed basement significantly increase the differential depth of the foundations relative to neighbouring properties?	Yes	There will be an increase in differential depth between the basement and the ground floor of Eastman Dental Clinic
13	Is the site over or within the exclusion zone of any tunnels.	No	The Metropolitan Railway (Clerkenwell cut-and-cover tunnel) runs in a southeasterly direction, from King's Cross to Farringdon Station within 250m east of the site. The nearest London Underground tunnel is the Hammersmith and City Line approximately 60m away from the closest section of the proposed site boundary. The site is outside the exclusion zone. Kingsway Tram Tunnel is noted to be >800m away from the site and is outside the exclusion zone. The Royal Mail Tunnels are understood to be located south of the site, with the postal museum and depot approximately 250m and outside the exclusion zone.

Table 4.3: Screening of Surface Flow and Flooding

Number	Question	Answer	Comments
1	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?	Yes	Refer to Question 4, Table 4.1. The route will not change and will continue to be discharged to the Thames Water sewer system. The rate of flow will change.
2	Will the proposed basement development result in a change in the proportion of hard surface/paved external areas?	No	Refer to Question 3, Table 4.1.
3	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 water courses?	Yes	The installation of a sustainable drainage system for the plot will affect the profile of inflows of surface water being received by adjacent properties or watercourses. All surface water discharge will be via the local sewer system.
4	Will the proposed basement result in changes to the quality of surface water being received by adjacent properties or downstream water courses?	No	The site is not envisaged to provide any additional surface water pollution. The water quality may improve following the installation of a sustainable drainage system with treatment stages.
5	Is the site in an area known to be at risk from surface water flooding, or is it at risk from flooding, for example because the proposed basement is below the static water level of a nearby surface water level of a nearby surface water features?	No	The Flood Risk Assessment states that the site is at low risk of surface water flooding. There are no nearby surface water features.

5. SCOPING

The scoping stage considers the steps necessary to assess the impact of the issues identified during the screening phase. Table 5.1 below reviews those issues and addresses the potential impacts and necessary actions to mitigate these issues.

Table 5.1: Scoping of the Issues Identified in the Screening Stage

Table and question number	Question	Potential Impact and Actions
4.1 – 1a	Is the site located directly above an aquifer?	**Potential Impact:** Groundwater flooding. Given the low permeability of the London Clay and the thickness and limited extent of the River Terrace Deposits it is likely to be from perched groundwater, if any. **Actions:** Dewatering may be required during construction. Limit contamination pathways if groundwater encountered. Basement construction comprises a full secant pile box extending into the London Clay and providing a barrier to water ingress
4.1 – 1b	If yes to 1a), will the proposed basement extend beneath the water table surface?	**Potential Impact:** Groundwater flooding. As above. **Actions:** Dewatering. As above.
4.2 - 5	Is the London Clay the shallowest strata at this site?	**Potential Impact:** Could cause shrink – swell subsidence in the area. **Actions:** Take this into account when designing the foundations of the structure.
4.2 - 7	Is there a history of shrink-swell subsidence in the local area, and/or evidence of such effects at the site?	**Potential Impact:** The site is underlain by London Clay which has a high volume change potential. **Actions:** Take this into account when designing the foundations of the structure.
4.2 - 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?	**Potential Impacts:** Flooding of the excavation. **Actions:** Dewatering may be required if perched groundwater is encountered. The low permeability of the London Clay means waterproofing is unlikely to be necessary.
4.2 - 11	Is the site within 50m of highway or pedestrian right of way?	**Potential Impacts:** The construction of a basement can result in ground movements detrimental to roads and any infrastructure contained therein such as is known to exist beneath Grays Inn Road. Health and safety risk to members of the public. **Actions:** The owners of these assets, along with the owner of the highway, should be consulted to determine any constraints to design, for example, easements, surcharge loadings on the basement walls and limiting values on ground movement. Such matters will need to be considered in the design of the basement and another estimate of likely ground movement and damage caused made during the detailed design phase. There will be a need for support to the excavation. This is considered to be of moderate significance. Take appropriate health and safety measures to protect the public and staff members on site.
4.2 - 12	Will the proposed basement significantly increases the differential depth of the foundations relative to neighbouring properties?	**Potential Impacts:** The proposed SSL foundation level of the basement is approximately +7.8m AOD. Whilst the level of foundations of the Eastman Dental Clinic will be investigated in a later phase of ground investigation works. An increase in differential depth can lead to increased soil movement. It is considered that EDC basement SSL level is approximately +16.0m OD. **Actions:** Investigation into foundation depths of surrounding buildings and modelling of any potential impacts the proposed development will have on surrounding assets.
4.3 - 1	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?	**Potential Impacts:** Increased levels of surface water flows can lead to an increased risk of flooding. **Actions:** A sustainable drainage system will be used on site to reduce the rate of peak run-off and improve the drainage conditions from their current state. Refer to the Drainage Strategy for more details on the proposed sustainable drainage systems.
4.3 - 3	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 water courses?	**Potential Impacts:** Profile of inflows of surface water to surrounding properties will be affected by the development of the site. Potentially leading to increased levels of surface runoff and increased risk of flooding. **Actions:** The use of a sustainable drainage system will lead to an improved inflow profile of surface water to surrounding properties. Refer to the Drainage Strategy for more details on the proposed sustainable drainage systems.

6. CONCEPTUAL GROUND MODEL

The ground conditions are summarised in **Error! Reference source not found.** using information from the GIR.

A groundwater level of +9.4m AOD is anticipated. The basement formation level is proposed to be at approximately +6.5m AOD, with top of B2 slab at approximately +7.8m AOD (SSL). Formation level is lower under the core and where the drainage tank is located. Shallow foundations are predicted for nearby buildings. There are no known rail tunnels beneath or near the site. It is undertood there are 1no. storey basements for the Grayland Court (1), Eastman Dental Clinic (5) and 1-8 Mecklenburgh Street (7) developments; these have been accounted for within the damage assessment analysis. The Metropolitan Railway (Clerkenwell cut-and-cover tunnel) runs in a southeasterly direction, from King's Cross to Farringdon Station within 250m east of the site. The closest tunnel is the Hammersmith and City Line which is approximately 60m to the northeast of the proposed extended site boundary.

A utilities report by Landmark found there to be a number of services running beneath Grays Inn Road. They include electricity and telecoms line, gas pipes, and water/sewerage pipes.

Surrounding assets in proximity to Plot 1 that have been assessed for the proposed basement excavation and retaining wall installation are highlighted in Figure 4.

Table 6.1: Conceptual Ground Model of the Plot 1 site

Strata		Average level at top of Stratum (m AOD)	Average thickness (m)	Typical Description
Made Ground		20.4	3.1	Brown/ greyish, clayey/silty/gravelly, sub-angular to sub-rounded fragments of flint, brick, and concrete.
River Terrace Deposits		17.3	1.3	Medium dense, brown sandy clayey sub-angular fine to coarse flint GRAVEL.
Weathered London Clay		16.0	3.55	Firm, brown mottled bluish grey silty CLAY, with occasional pockets of silty fine sand.
Un-weathered London Clay		12.45	13.05	Stiff extremely closely fissured brownish grey slightly micaceous CLAY, with occasional pockets of dark grey silt and fine sand.
Lambeth Group	Upper Mottled Beds	-0.60	6.4	Stiff to very stiff, brown mottled bluish grey CLAY.
	Laminated Beds	-7.0	1.2	Stiff to very stiff, dark grey silty CLAY with extremely closely spaced laminations of light brown silt and fine sand.
	Lower Mottled Beds	-8.2	6.3	Very stiff dark grey to light bluish grey sandy silty CLAY, with occasional calcrete cemented silt nodules
	Mottled Upnor Formation	-14.5	1.8	Very stiff, greenish grey mottled sandy silty CLAY. Sand is fine and glauconitic.
	Upnor Formation	-16.3	4.7	Very stiff dark grey slightly gravelly silty CLAY, with occasional pockets of light grey and green fine sand.
Thanet Sands		-20.0	3.8	Very dense brown SAND with occasional pockets of dark grey clay.
Chalk Formation		-23.8	-	Weak to medium strong, medium to high density CHALK. Grade Dm to B3/B4

Figure 4: Site Layout and Position of Surrounding Structures Assessed

7. EXISTING NEARBY STRUCTURES

Figure 5 highlights the locations of nearby structures. In particular, the Eastman Dental Clinic is a Grade II Listed building, along with residential assets associated with 1-8 Mecklenburgh Street and the fountain in the courtyard of Plot 1. According to CIRIA C760 ground movements associated with the construction of the basement and retaining walls could theoretically extend to the properties mentioned below.

1. The Alexandra Wing of the FRF on Plot 1 is to be retained. The proposed basement does not extend beneath the Alexandra Wing. It is a combination of brick and stone masonry construction. Built in the 1800s. It is composed of up to three storeys above ground with 1no. storey basement.
2. Eastman Dental Clinic is part of the site and constitutes Plot 2. It was built between 1926 and 1931. It is a steel structure with masonry walls spread over four storeys above ground with 1no. storey basement.
3. Grayland Court northwest of Plot 1 is a masonry built apartment block built in the early 1990s comprising five storeys including an undercroft / 1no. storey basement floor.
4. The Calthorpe Project centre is a community facility to the north of Plot 1. A single-storey structure (assumed timber) and considered to be built in the 1980s – 1990s.
5. Two buildings of the New Calthorpe Estate border Plot 1. They are two and three storey masonry constructed terraced residential properties likely built in the 1980s.
6. Hubbards Cupboards is a single-storey retail building the other side of Grays Inn Road. It is unclear form historical maps when it was built. It is a masonry construction.
7. 1-8 Mecklenburgh Street is the other side of Hubbards Cupboards. It is a five-storey masonry structure including 1no. storey basement floor, comprising eight terrace houses now converted into flats. Historical maps appear to indicate it was built in the 1800s.

The closest distances of the assets adjacent and within the anticipated influence zone of the proposed development boundary is included within Figure 5.

In addition it should be noted that the existing retaining wall bounding the north of the site, the east of the site where the current car park is located and parallel to Seddon Street will be demolished over the majority of the length. Demolition of the wall is proposed where the Good's Yard adjoins into B1 level of the proposed development on the east of site. The demolished zone is indicated within Figure 5. The proposed secant wall piling line is aligned with the current retaining wall bounding the north of the site. In the temporary case, the existing wall will be supported by props for stability, and the wall condition assessed with the opportunity to repair and monitor if required.

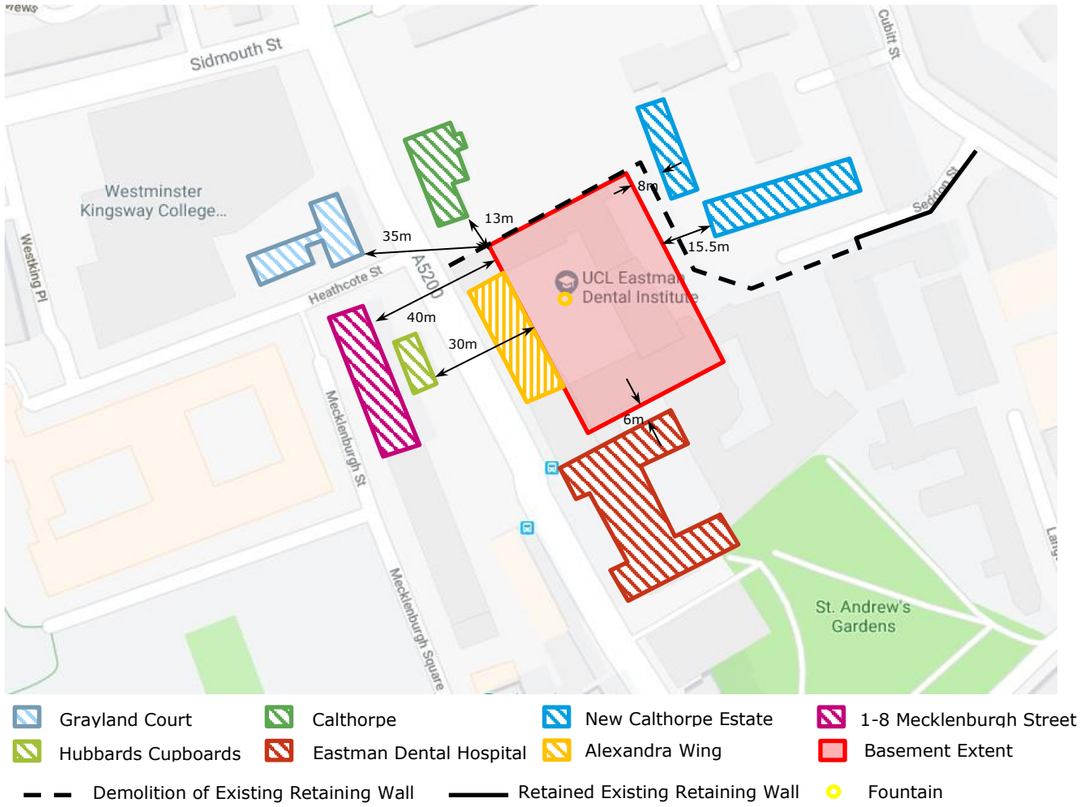


Figure 5: Identified Sensitive Nearby Buildings

8. PROPOSED WORKS

The proposed Plot 1 works and design are shown on the Planning drawings. A summary of the works within the Plot 1 redevelopment for which this BIA relates to is provided below.

8.1. Alexandra Wing

The Alexandra Wing of the former RFH is to be retained and refurbished, providing administration and office accommodation of the IoN/DRI. This area currently comprises a single level of basement which will be retained as plant and storage space. To the north and south of the Alexandra Wing, the Sussex Wing Grays Inn Road elevation and southern pediment facades are to be retained with new structure behind. A new vertical extension on the northern and southern wings of the Alexandra Wing are to be constructed from a lightweight steel frame and roof. Internally the refurbishment works will work with the existing structural wall wherever possible with minimal breaking out and modification of load paths.

Justification for the additional storey on the Alexandra Wing has been carried out to assess the current loading which has been compared to the proposed. To structural adequacy of the building and foundations has been analysed through the following methods;

- Historic design loads for the building have been compared to the proposed which are typical of modern office spaces.
- Theoretical and existing bearing pressures under the foundations of the building have compared with the proposed, allow with an assessment of the additional capacity generated by consolidation over time.
- A reduction in the loading on the vertical elements of the structure has been calculated using the principle of BS EN1991.

8.2. New IoN/DRI

Behind the Alexandra Wing, the new build elements of the Plot 1 comprise a five-storey research facility housing wet and dry laboratories, offices, in-patient consultation, seminar rooms and technical research spaces. As a highly serviced and controlled building, there is a significant demand for plant. Consequently, a two-storey basement is proposed. The basement has two below ground levels with an extent which steps out beyond the line of the above ground building. The proposed construction of the basement retaining walls is a secant pile solution with reinforced concrete liner walls to form a resilient and water-resistant box. The depth of the basement is circa 12m below existing Grays Inn Road, however due to the presence of an existing basement over much of the site, the proposed excavation is in the order of 8m deeper than current site conditions. The proposed foundations for the building will be a raft slab at basement formation level (B2). The raft will have a local thickening beneath the core. Adjacent to the core is a 16m x 6.4m drainage void / trench with SSL at +5.3m AOD.

The superstructure is proposed as a reinforced concrete frame designed to maintain a high degree of vibrational stability within the laboratories and imaging rooms. At roof level is a large steel-frame plant enclosure. Stability of the building is provided through the reinforced concrete cores.

8.3. Robustness

Due to the nature of the research and functionality of the new building it is classed as consequence class 3 under the Approved Document A of the Building Regulations. The Alexandra Wing is classed as 2B. The design and detailing be specified to ensure adequate tying and robustness against disproportionate collapse.

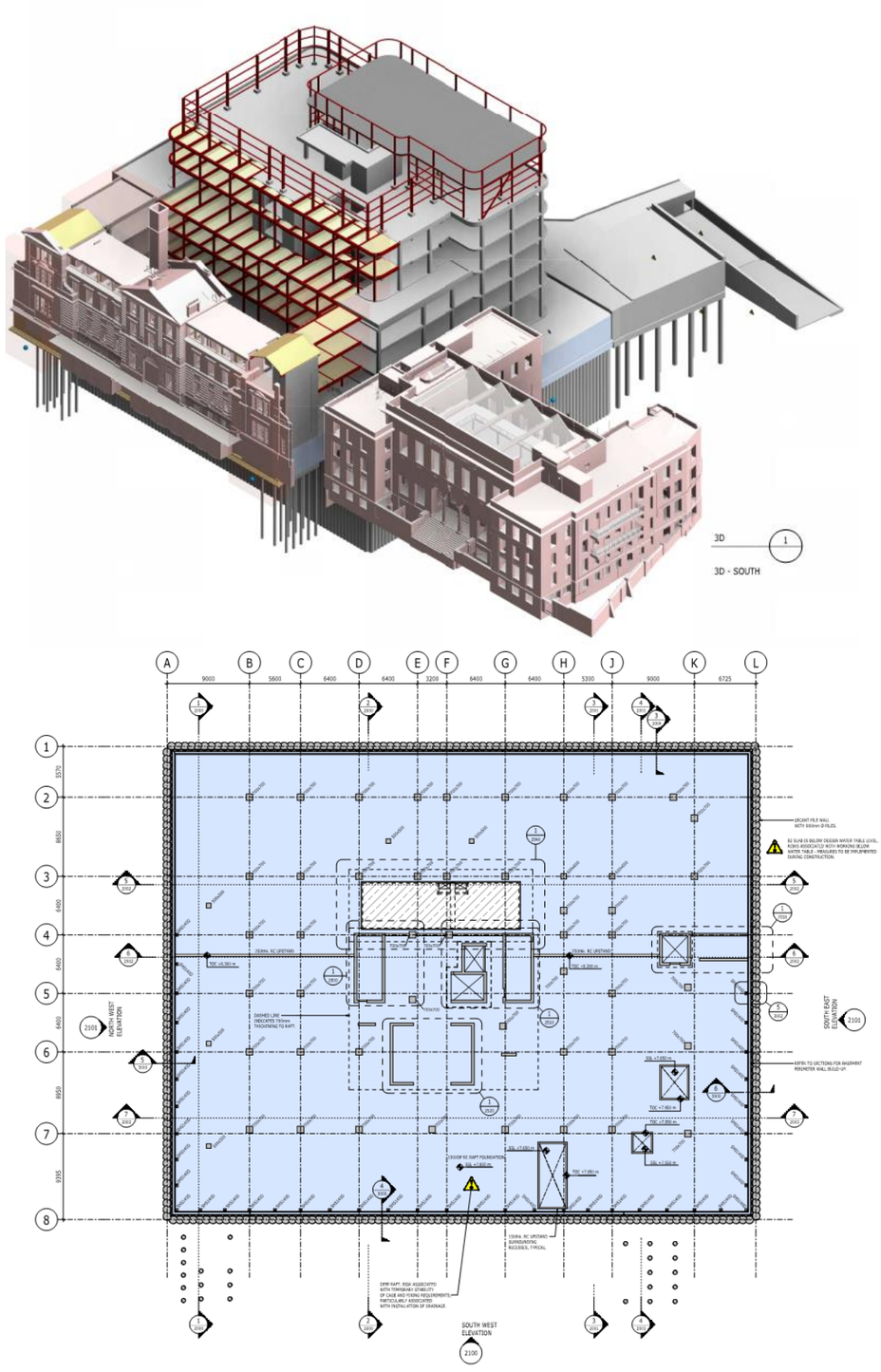


Figure 6: Proposed Structural Model and B2 Level Arrangement

9. CONSTRUCTION SEQUENCE

Given the nature and location of the site, it is proposed to construct the basement using a hard-firm secant piled retaining wall. An outline bottom-up construction sequence is summarised below and broadly representative of the overall excavation and build for the whole site. This involves the following stages:

1. Demolition and remove existing foundations
2. Installation of 900mm secant pile retaining wall (1350mm male-to-male spacing) with short-term ($0.7E_{0I}$) concrete stiffness, where Piling Platform Level (PPL) is considered between +15.5m AOD to +16.8m AOD
3. Excavate to +13.0mOD
4. Insert Temporary Prop 1 at +14.0m OD
5. Excavate to formation level at +6.5m OD
6. Construct B2 raft slab at +7.8m OD (top level) with short-term ($0.7E_0I$) concrete stiffness
7. Construct B1 slab at +15.85m OD (top level) with short-term ($0.7E_0I$) concrete stiffness
8. Remove Temporary Prop
9. Model long-term drained soil behaviour and wall relaxation ($0.5E_0I$)

This sequence of works has been modelled for various sections of the site using Oasys Frew and the resultant ground movement curves have been incorporated into the building damage assessment. This is further discussed in Section 10.

The construction sequence and temporary works will be finalised by the appointed piling contractor. It should be noted that pile cap levels vary around different perimeter sections, between +15.5m OD and +18.5m OD.

Based on the information from the GIR, the basement formation level will be within the London Clay.

It is proposed that a secant pile wall will be required and suitable temporary works will be installed to limit the ground movements during excavation to the basement formation level. As there is a risk of ground swelling due to the excavation, provision for heave mitigation will be considered within the foundation design, during the detailed design stage.

Figure 7 shows a plan view of the site distinguishing between the three plots. There is also a plan of the existing basement shown highlighting areas where the full 12m of excavation will be required. Outside the hatched areas, there is an existing basement reducing the overall unloading effect and impact on surrounding structures. There is also a single storey basement beneath the Alexandra wing. In addition, a void is evident between the Alexandra Wing basement and the existing basement within the courtyard.

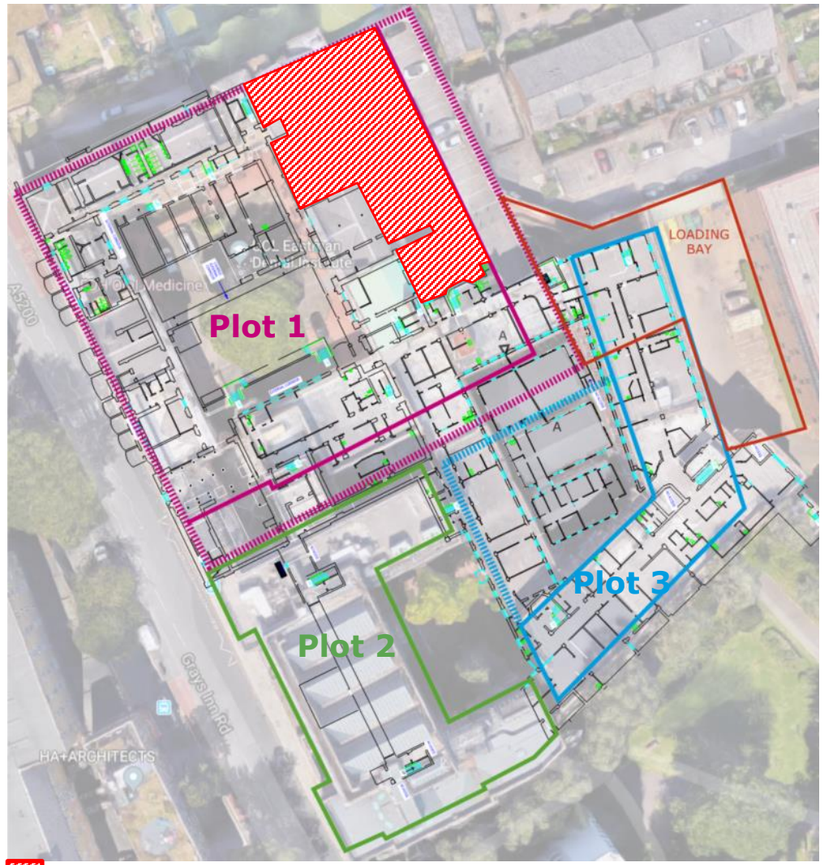


Figure 7: Plan View of the Site showing Plot 1, Plot 2, and Plot 3, along with the Layout of the Existing Basement.

10. GROUND MOVEMENT ASSESSMENT

The key construction activities that will result in ground movement during the works are:

- Installation of basement piled retaining wall;
- Excavation to formation level;
- Construction of new building.

Oasys Xdisp (Version 19.4) is used to calculate the anticipated horizontal and vertical movements due to the installation of the piled wall and excavation of the basement together with the resulting movement seen by the neighbouring properties. As can be seen in Figure 7 a significant section of the site is covered by a one-storey basement. An excavation between pile cap level +15.5m OD to formation level +6.5m OD was modelled over the basement secant pile wall boundary. It should be noted that corner stiffening due to retaining wall installation has been considered within the analyses.

Oasys Frew analysis was undertaken for several sections of the site; Figure 8 shows the concerning cross-sections for site. A pile toe level for the retaining wall is considered to be +2.0m OD for retaining wall stability and remains compliant with providing axial capacity for anticipated loads along the boundary.

- 1 & 2 – Alexandra Wing Sections for different existing and proposed footing loads
- 3 – Eastman Dental Clinic
- 4 – Calthorpe Estate
- 5 – Good's Yard / Loading Bay
- 6 – New Calthorpe Estate

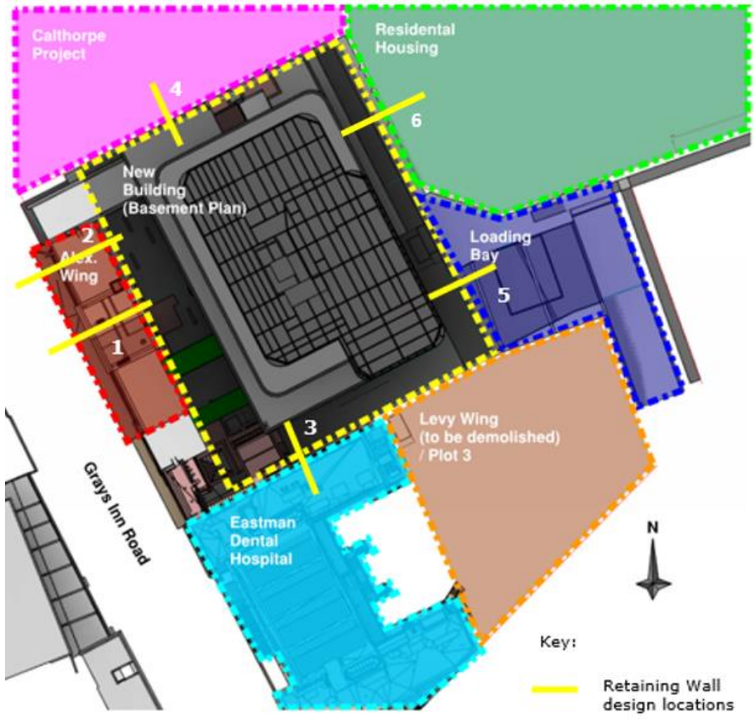


Figure 8: Secant Pile Retaining Wall Sections Analysed in Oasys Frew

The respective vertical soil displacement curves for excavation (worst-case curves used for each perimeter boundary) were input into Xdisp to provide more representative profiles based on site-specific variations, compared with using in-built curves based on derived relationships in CIRIA 580 / 760. A comparison of each critical perimeter wall displacement curve compared with Xdisp inputs is shown in Figure 9.

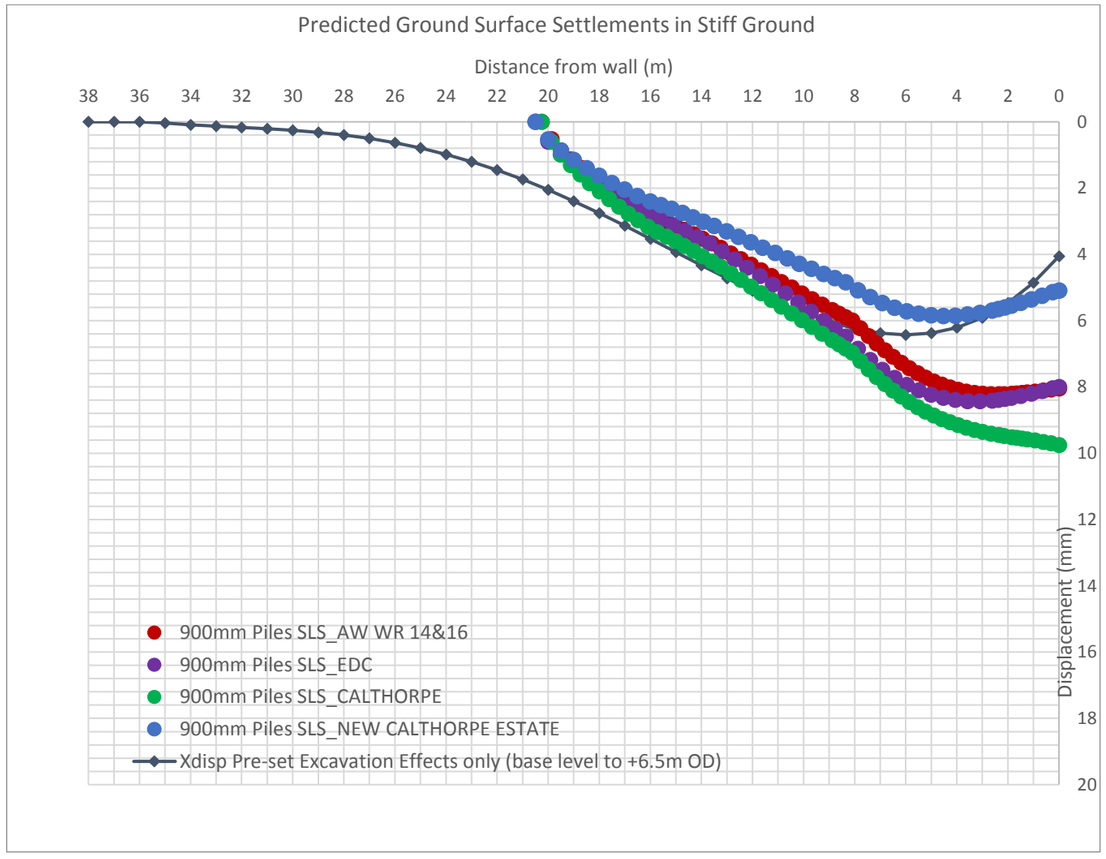


Figure 9: Predicted and Calculated Ground Surface Settlements in Stiff Ground from Lateral (propped) Wall Deflections

In addition, the effects of installation can be considered to be reduced further to several case studies of projects undertaken within London, considering typical London ground conditions. This considers that installation movements can be halved based on piling methodology (hit one, miss three), good quality workmanship and monitoring. References include:

- Prediction of party wall movements using Ciria Report C580 (Ball et. al, 2014)
- Benchmarking Empirical Methods of Prediction of Ground Movement for Deep Excavations (Bologna, 2017)

The software calculates the likely maximum vertical and horizontal strain at the assumed location of the neighbouring properties foundations which then enables an estimation of the building damage category for the neighbouring properties. It should be noted that building damage assessment criteria is based on a damage assessment to masonry assets (Boscardin and Cording, 1989); this is the most onerous and therefore conservative for other structure types. The contribution of the unloading due to the excavation and demolition of the overlying building, on the ground movement assessment has been discounted. Proposed construction

timescales are such that construction will be continuous therefore excavation heave effects will be counteracted relatively promptly by casting the raft and construction of the substructure and superstructure.

The behaviour of the London Clay is highly non-linear therefore would require a higher level of complexity to accurately assess the heave movements, than is proportionate at this stage.

The amount of ground movement caused by these activities relates to the ground conditions, size of walls, presence of props, along with the care and sequence with which the works are carried out. This preliminary analysis has been carried out based on a sequence of construction described in Section 8 i.e. bottom up construction; should the Contractor propose to carry out the works in a different sequence to that assumed in this design then a refined assessment of the predicted ground movements will be required, and the proposal only accepted if there is no significant change to the accepted scale of predicted movements.

In using Oasys Xdisp software, several assumptions are used/made in order to produce a conservative damage assessment. These include:

- Calculating movement at surface level where it is likely to be most onerous and the excavation taking place in greenfield conditions. Oasys Frew retaining wall analyses curves have been used to supersede the CIRIA 580 Fig 2.11 (b) (excavation in front of high stiffness wall in stiff clay). Installation displacement curves have been implemented considering the two references (Ball et al 2014; Bologna, 2017) to supersede the CIRIA 580 Fig 2.8 (b) (installation of secant bored pile wall in stiff clay) to estimate the ground movements due to the installation of the piled wall;
- The average horizontal ground strain is transferred directly into the structure which is independent of building footing level and considers displacements at surface level, however in reality the horizontal ground strain will reduce laterally and with depth to where the footings are actually founded;
- Displacements calculated at ground surface level have been assumed to continue until the assumed underside of Thames Water assets i.e. no displacement degradation with depth is considered. Similarly, displacements will reduce and be dissipated with depth therefore the effects will be reduced; and
- Thames Water assets (the cast iron and brick sewer) have been assigned circular diameters of 0.46m and 1.143m respectively. The brick sewer is known not to be circular however has been assumed as such for ease and conservativeness of modelling.

The existing nearby structures identified in Section 7 were considered on the basis of their proximity and position relative to the basement, where the greatest predicted soil movement will be. As such these represent the properties at greatest risk. A settlement (vertical) contour has been produced, as shown in Figure 10.

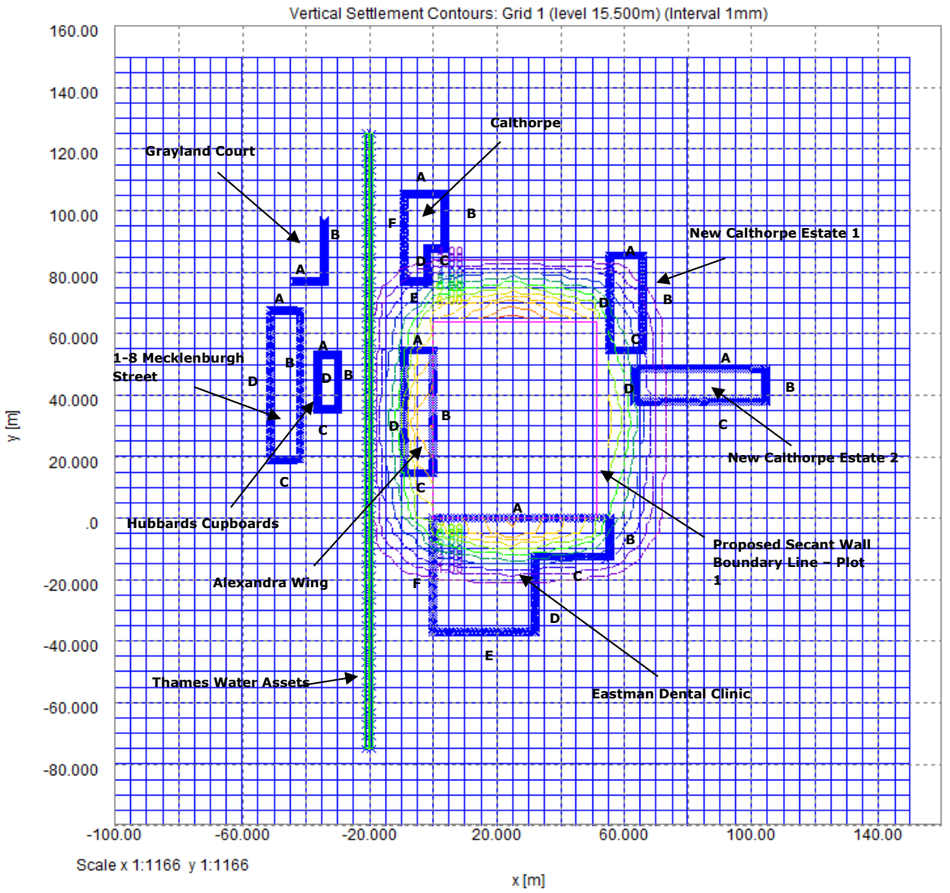


Figure 10: Contour plot of vertical settlement contours at surface level

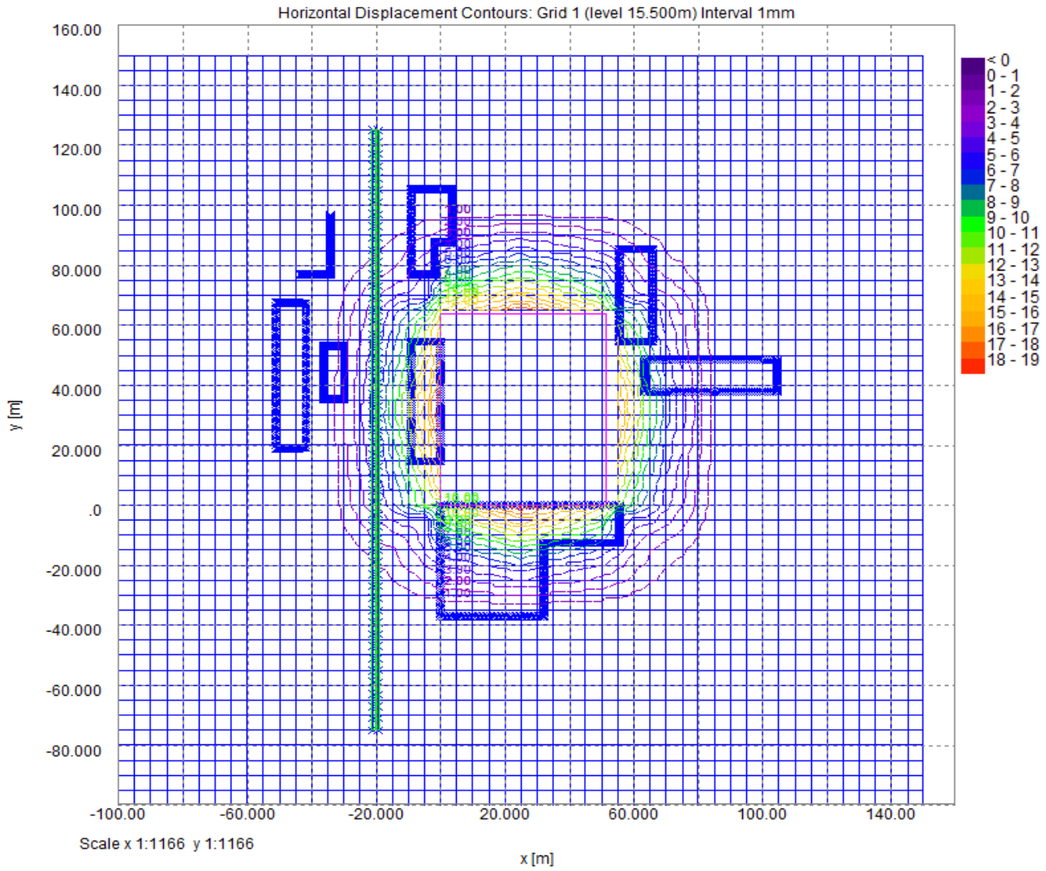


Figure 11: Contour Plot of Horizontal Soil Movement at Surface Level

These assets have been modelled in Xdisp software as displacement lines, therefore ground movements have been calculated at these locations and a damage assessment based on CIRIA 760 methodology has been undertaken.

The majority of the assets in proximity to the Plot 1 development have been modelled as simplified polygonal displacement lines. It is considered that displacement lines perpendicular to the excavation experience the greatest differential movement and have the greatest damage potential. The change in horizontal displacements with distance away from the development area are noted to have the most significant change whilst propagating away from the excavation area, as seen in Figure 11.

11. DISCUSSION OF PREDICTED GROUND MOVEMENTS

The structures that are closest to and surrounding the excavation were chosen for assessment as these will experience the greatest movement. This includes assets running beneath Grays Inn Road where exact location and construction materials will need to be confirmed by the asset owners for the detailed analysis completed at a later date. Early liaison with Thames Water (TW) has been made and based on a 20m clearance of the TW assets from the secant pile wall line and the proposed 12m basement excavation depth, TW deem it unnecessary to undertake any form of asset protection impact study. Thames Water will be notified of any scheme change and in such a case where the scheme changes more adversely for Thames Water, the potential need for impact assessments for their assets and possible mitigation measures will be established. Asset protection agreements will be entered into with the asset owners and information included within the AiP. A simple displacement check has been undertaken within this conservative model as shown in Figure 12.

The results of the preliminary ground movement assessment can be seen in Table 11.1. The displacements and resultant damage predicted falls between Category 0 (Negligible) to Category 1 (Very Slight) on the Burland Scale of Damage. It should be noted that only the critical walls for each asset have been summarised in Table 11.1. For structural walls which have not been summarised have a predicted Damage Category 0. A Draft Construction Management Plan (CMP) has been developed by the project advisor for the proposed construction; this will include the monitoring requirements set out in the Ramboll movement monitoring strategy in order to control the predicted movement.

It is proposed that movement monitoring is carried out on the piled wall and basement box along with structures falling under Damage Category 1 prior to and during the proposed basement construction. An initial monitoring strategy has been produced by Ramboll which includes the monitoring proposals for surrounding buildings including the Eastman Dental Clinic and adjacent buildings that may be influenced from the construction of the proposed development.

The differential movement across the width of the surrounding properties could lead to minor cracks appearing in the walls and in the finishes. As explained in this report the scale of movement predicted could lead to fine cracks easily treated during normal redecoration. Finishes to floors, walls, and ceilings can be more susceptible to cracking as a result of this movement, especially brittle finishes. These are considered to be superficial and non-adverse.

The final construction sequence will be developed to take account of limitations established during the detailed design phase. Should the contractor propose to carry out the works in a different sequence to that assumed in our design then a further assessment of the predicted movement will be required, and the proposal only accepted if there is no significant change to the scale of predicted movement.

On the basis of the assumed construction methods and sequence, the ground movement analysis suggests a maximum damage to the neighbouring properties is likely to remain within Category 1 ('Very Slight') damage. To ensure the movements remain within acceptable limits, movement monitoring has been proposed. The Contractor will be required to carry out detailed monitoring of the surrounding properties to record ground movements and take appropriate action should the movement not be as expected.

11.1. Mitigation measures

Measures to mitigate potential damage as a result of ground movements include, but are not limited to:

1) Propping of the retaining wall during construction to limit deflection;
2) Temporary works to ensure stability of existing structures;
3) Movement monitoring and assigned trigger levels and mitigation measures. Trigger levels should also be set prior to construction phase to identify limits on monitored results and to define actions and mitigation measures if these limits are reached and/or exceeded. The traffic light approach could be adopted with green, amber, and red trigger levels set;
4) Monitoring locations are recommended to include, but not limited to:
   a) Façade (Alexandra Wing, EDH, Frances Gardener House, Calthorpe Estate Assets, Chimney);
   b) Retaining Walls;
   c) Raft;
   d) Temporary Props;
   e) Pavement Monitoring;
   f) Groundwater Monitoring including the installation of standpipes around the site to ascertain grounwater levels outside of the excavation. This will be required prior to, during and post development construction. Data should be collected for groundwater levels over the winter months as part of the baseline pre-construction monitoring;
   g) Vibration Monitoring; and
5) Piling methodology (hit one, miss three) and good quality workmanship.

Table 11.1: Maximum settlement and Burland Category of Damage for each nearby structure

Structure	Displacement Line	Settlement (mm)	Burland Category of Damage
Eastman Dental Hospital (EDH)	EDH_D	4.0	1
New Calthorpe Estate 1	FS1_C	6.9	1
New Calthorpe Estate 2	FS2_C	4.6	1
Alexandra Wing	AW_C	9.4	1

Note: Hubbards Cupboards, 1-8 Mecklenburgh Street, Calthorpe and Grayland Court asset walls have a predicted Damage Category of 0 i.e. Negligible

A preliminary check for displacements along the crown of the Thames Water assets comprising the cast iron and brick sewer tunnels, located along Grays Inn Road was undertaken. The initial results are shown in Figure 12. As this is simulated under greenfield conditions i.e. no structural stiffness of assets is considered, the magnitude of displacements and gradient of change in displacement along the tunnel lengths are conservative and it is anticipated these will be reduce with further analysis, nevertheless the magnitudes of movement in Grays Inn Road appear appropriately controlled through the construction philosophy and distance from the excavation.

Dialogue and asset protection agreements with Thames Water has been commenced to establish the acceptability of the proposals. Based on their initial review of the project, currently there is no requirement for an Approval in Principle for their assets based on the distance from the basement excavation. This will be re-confirmed if the development proposals should change significantly. Engagement with Thames Water is included in Appendix A.

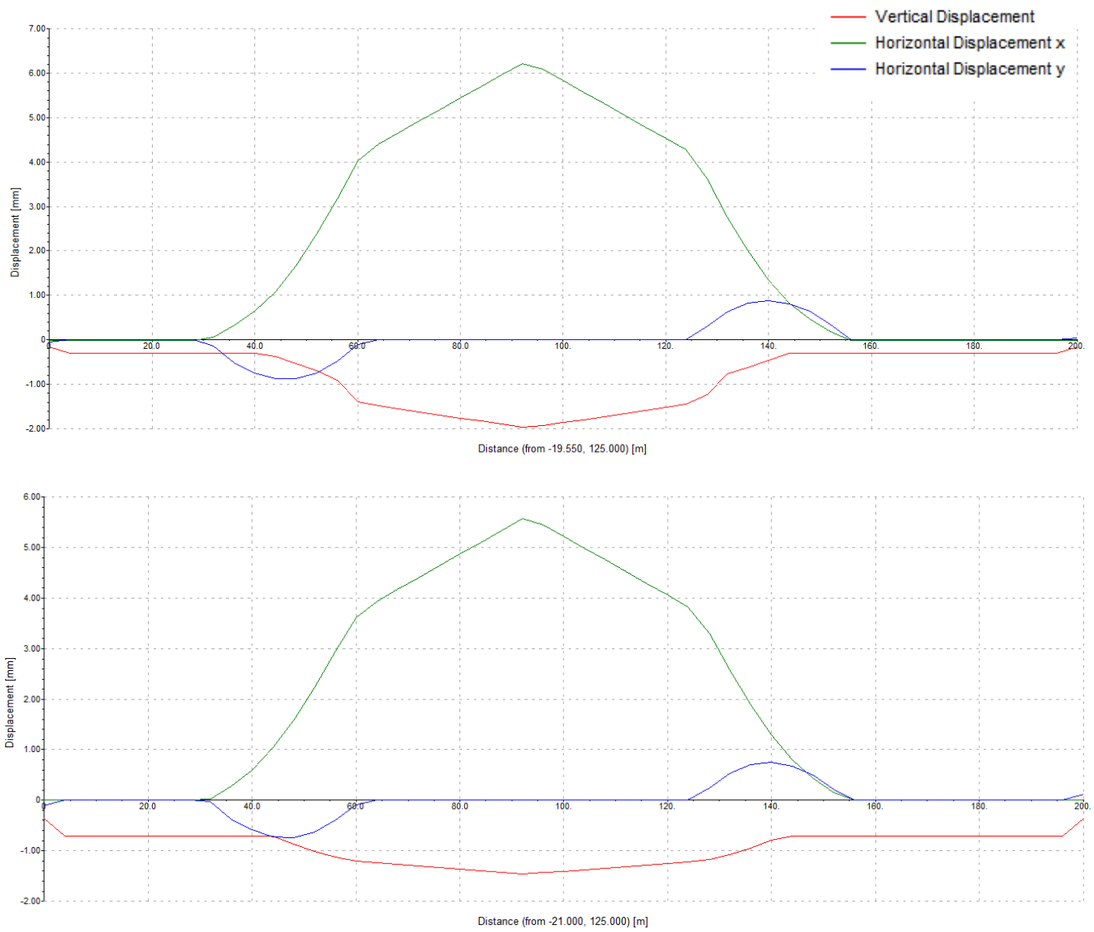


Figure 12: Thames Water asset displacements (cast iron and brick sewer respectively) post excavation and secant pile wall installation

12. NOISE, VIBRATION AND DUST

Vibration and noise can be controlled by adopting appropriate piling techniques, offering minimal vibration and low noise levels. Dust control measures will be implemented to reduce or prevent the surface and air transport of dust during construction including, but not limited to:

- Sheeting and screening - Area will be screened with suitable debris screens and sheets;
- Site traffic - Vehicle movements will be kept to a minimum and vehicle speeds limited;
- Water sprays - Spraying should be carried out prior to and during demolition, and any works causing excess dust expulsion;
- Removal of materials from site - Materials should be removed from the site as soon as is practical;
- Cutting, grinding - Employ equipment and techniques that minimise dust emissions, using best available dust suppression measures.

Further details are set out in the project Draft Construction Management Plan (CMP).

Vibration testing was carried out as part of the site-specific ground investigation works to ascertain background levels for the design of the building for sensitive instrumentation and equipment.

13. TRAFFIC MANAGEMENT AND SITE ACCESS

Traffic Management outlined in the project Draft CMP, inclusive of the Outline Construction Logistics Plan. Main Contractors are to provide traffic management sequences and planning as part of the submissions to meet local authority requirements.

14. HANDLING MATERIALS AND WASTE

Method statements and procedures for the storage and handling of fine, powdery and dry materials will be established and agreed in detail with the contractor. It will include, but not limited to:

- Number of handling operations will be kept to a minimum by ensuring that dusty material isn't moved or handled unnecessarily;
- Use of closed tankers or sheeted vehicles for the transportation of dusty or powdery materials;
- Handling areas will be kept free and clean;
- Drop heights must be kept to a minimum when unloading;
- Fine and dry materials will be stored inside buildings or enclosures with adequate protection from the wind.

15. CONCLUSIONS AND FURTHER INVESTIGATIONS AND MONITORING

Based on the work undertaken as outlined within this report through conservative modelling of the basement construction, it has been demonstrated that the impact of the basement construction on surrounding structures can be mitigated through design and construction methods.

This report has outlined the proposed development scheme and summarised the structural stability of the surrounding building assets through conservative analyses, where the worst-case damage predicted falls between Category 0 (Negligible) to Category 1 (Very Slight) on the Burland Scale of Damage. This report also summarises that there is low risk of adversely affecting drainage and run off or causing other damage to the water environment. It should be noted that ground movements should be reduced by use of a temporary propping scheme for the basement and will be complemented with several forms of monitoring to provide assurance of construction works at several stages of the proposed development.

The risk of movement and potential damage limits have been assessed for several building assets directly adjacent to, and in close proximity to Plot 1. The assessment has been carried out considering the effects of the secant pile retaining wall installation, the worst-case excavation across the whole site, the impact of basement retaining wall movements on neighbouring structures and construction of the new development. Thus far, analysis has used Oasys Xdisp to ascertain initial predicted damage categories for surrounding above ground structural assets. The modelling of the anticipated works at Plot 1 result in a maximum Damage Category 1, equivalent to a 'Very Slight' degree of damage (approximate crack width of 0.1-1mm), at individual walls of the EDC, Alexandra Wing and New Calthorpe Estate structures. This assessment is based on conservative greenfield analysis of the impact of Plot 1 on party walls and assets. The damage risk is driven by the horizontal strains imposed on the wall structures. Additionally, the stiffness and loading from existing foundations of the surrounding buildings and assets have not been taken into consideration during this analysis.

The following next steps will be undertaken as the design of the site is further developed;

- Construction methods are developed with the Contractor to feed into the ground movement analysis once the sequence of works is developed. To include for best practice control methods during piling including but not limited to 'hit one, miss three' approach and good quality workmanship;
- A pre and post works condition survey to be undertaken in relation to potentially affected surrounding properties and assets;
- If further information is obtained identifying historical foundation locations for Plot 1 and surrounding assets this will be incorporated into to analysis.
- A Draft Construction Management Plan (CMP) has been developed by the project advisor; this which will include the of monitoring requirements set out in the Ramboll movement monitoring strategy. A monitoring action plan for various stages of the project can be considered to monitor the existing structure and foundations, new walls and foundations and the adjacent Grade II Listed buildings. The extent of monitoring will be considered during the temporary works phase, the main works phase and potentially the post-construction phase;
- An Approval in Principle (AiP) for the basement construction is required from LB Camden Highways due to the proximity to TfL road networks, namely Grays Inn Road. Asset protection agreements will be included within the AiP including utilities asset owners information;
- Given the setting of the site and the derived Low to Medium Risk, it is recommended that consideration should be given to the potential risks to any below ground works posed by UXOs in accordance with CIRIA C681. Contractors to consider UXO mitigation on-site during probing, piling and excavation works;
- Undertake Stage 4 foundation and retaining wall analyses and design;
- Consider the effects of heave based on the proposed development and extent of excavation for the scheme;
- Completion of the Specification for Piling and Embedded Retaining Walls and further consultation with specialist contractors;
- Agreement through the Planning application process from London Borough of Camden on the proposed methodologies and analysis within the BIA.

Appendix A – Thames Water Consultation

Jai Shah

From: Simon Hindle <Simon.Hindle@thameswater.co.uk>
Sent: 27 March 2018 17:31
To: Jai Shah
Cc: Iain Mitchell-Jones; Matt Garner
Subject: RE: IRef:1015857777 FW: UCL IoN/DRI - Thames Water Assets

Jai

Based on the information in your original email (20m clearance from TW assets and 12m basement excavation depth) I would not deem it necessary for yourselves to have to undertake any form of asset protection impact study. Please let me know if the proposals should change significantly.

Thanks

Simon Hindle
Senior Project Engineer
Strategic Partnering

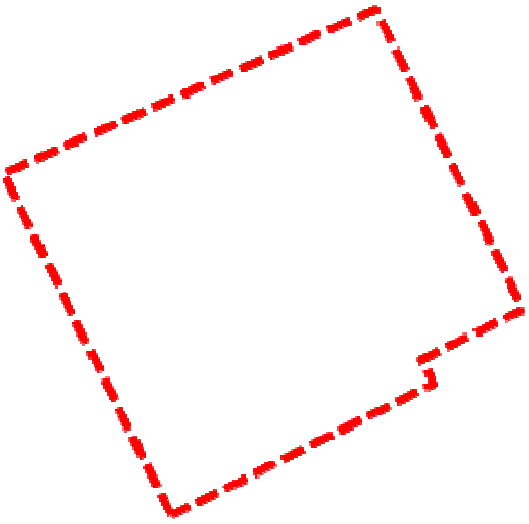
Planning for and enabling growth
Thames Water Utilities Ltd, Clearwater Court, Vastern Road, Reading, Berkshire, RG1 8DB
Mobile: 07747 641 017 simon.hindle@thameswater.co.uk

From: Jai Shah [mailto:Jai.Shah@ramboll.co.uk]
Sent: 27 March 2018 15:41
To: Simon Hindle
Cc: Iain Mitchell-Jones; Matt Garner
Subject: RE: IRef:1015857777 FW: UCL IoN/DRI - Thames Water Assets

Hi Simon,

Please find the annotated aerial shot attached, in addition to the information below.

Please let me know if you require any further information.



Kind regards
Jai Shah

MEng (Hons) CEng MICE
Senior Engineer
Ground Engineering

M +44 (0)7929 039 680
jai.shah@ramboll.co.uk

We are finalists in four categories!

More here:
www.ramboll.co.uk/news/ruk/good-year-for-geotech

From: Simon Hindle [mailto:Simon.Hindle@thameswater.co.uk]
Sent: 27 March 2018 10:23
To: Jai Shah
Cc: Iain Mitchell-Jones; Matt Garner
Subject: RE: IRef:1015857777 FW: UCL IoN/DRI - Thames Water Assets

Jai

The annotated aerial shot of the site shown below does not display correctly in our email (the boxes and text are all offset from the image of the site) – please could you forward this again?

Thanks

Simon Hindle
Senior Project Engineer
Strategic Partnering

Planning for and enabling growth
Thames Water Utilities Ltd, Clearwater Court, Vastern Road, Reading, Berkshire, RG1 8DB
Mobile: 07747 641 017 simon.hindle@thameswater.co.uk

Jai Shah

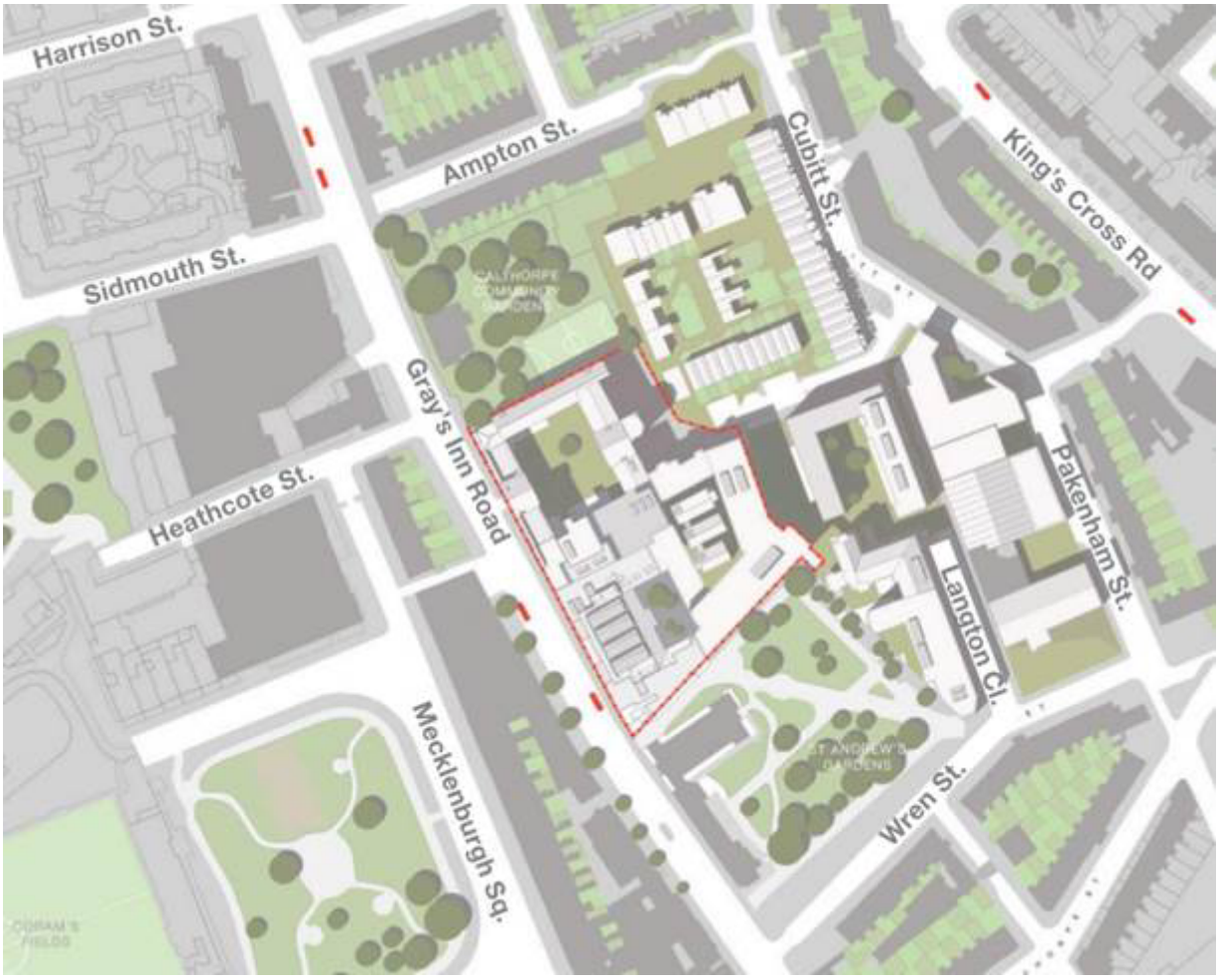
From: Jai Shah
Sent: 20 March 2018 17:38
To: developer.services@thameswater.co.uk
Cc: Robert Ashiley; Iain Mitchell-Jones; Matt Garner
Subject: UCL IoN/DRI - Thames Water Assets
Attachments: Thames Water Asset Location Search - Grays Inn Road.pdf

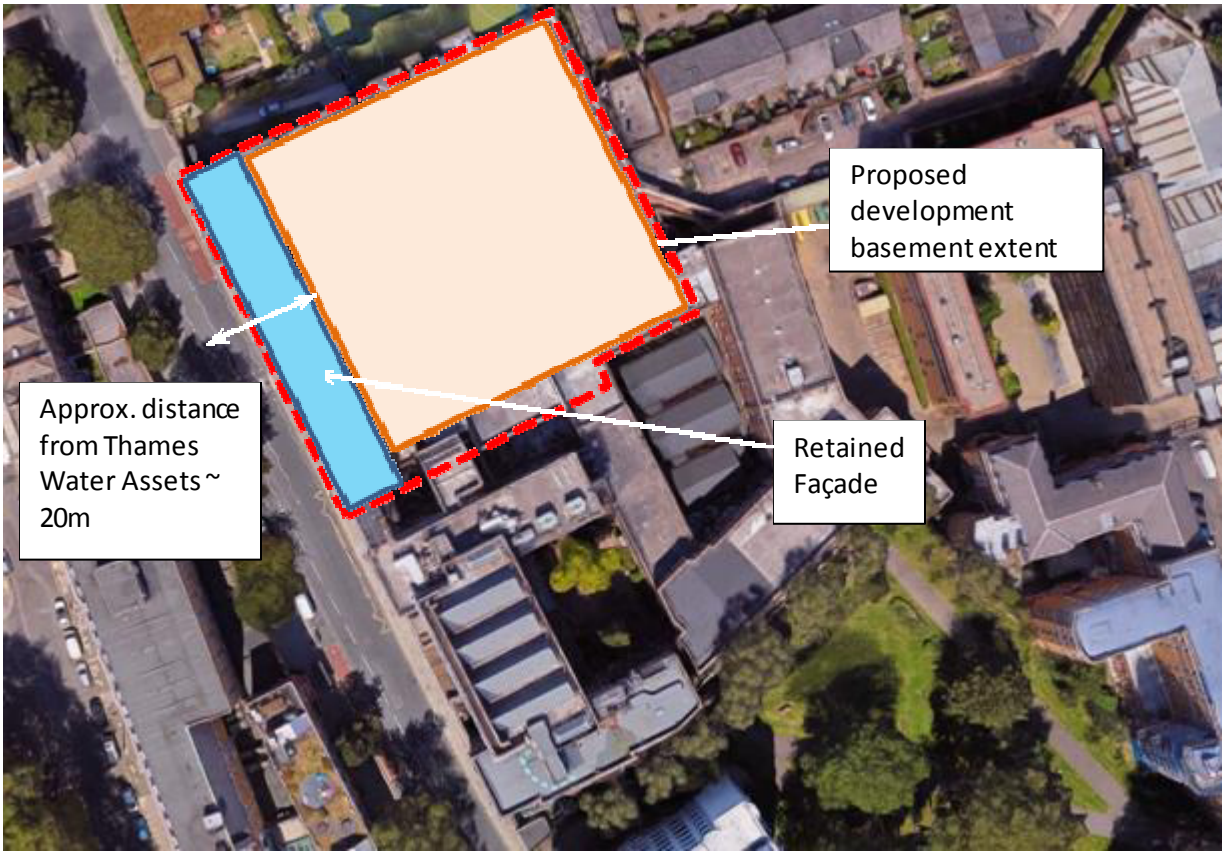
Dear Sir/Madam,

UCL IoN/DRI - 256 Grays Inn Rd, London, WC1X 8LD

Ramboll are the appointed engineers for the development of Royal Free Hospital, London, WC1X 8LD. It is located at approximate National Grid reference TQ 530699 182515.

The proposed development plans are not finalised but may consist of the construction of a four-to-five storey development and two basement levels beneath the footprint, where basement excavation is anticipated to be in the order of 12m below ground level. A plan of the site is attached for your assistance – the development will be located behind the historic façade which is to be retained.





Further to archive information received from the Client, we understand that there are assets (combined sewer) which runs adjacent to the site beneath Grays Inn Road. Please find attached the Asset Location Search information previously received.

We anticipate the approximate distance of demolition and basement excavation to be **in the order of 20m from the Thames Water Assets**. We are currently in the process of tendering out Ground Investigation works which are likely to commence within the next couple of months. Please advise if a meeting could be arranged to discuss the predicted project timescales, scheme and whether the distance of the assets warrants the need for an impact study of the Thames Water Sewer?

If you have any questions or comments, please do not hesitate to contact the undersigned.

Yours Sincerely,

Jai Shah

MEng (Hons) CEng MICE
Senior Engineer
Ground Engineering

M +44 (0)7929 039 680
jai.shah@ramboll.co.uk