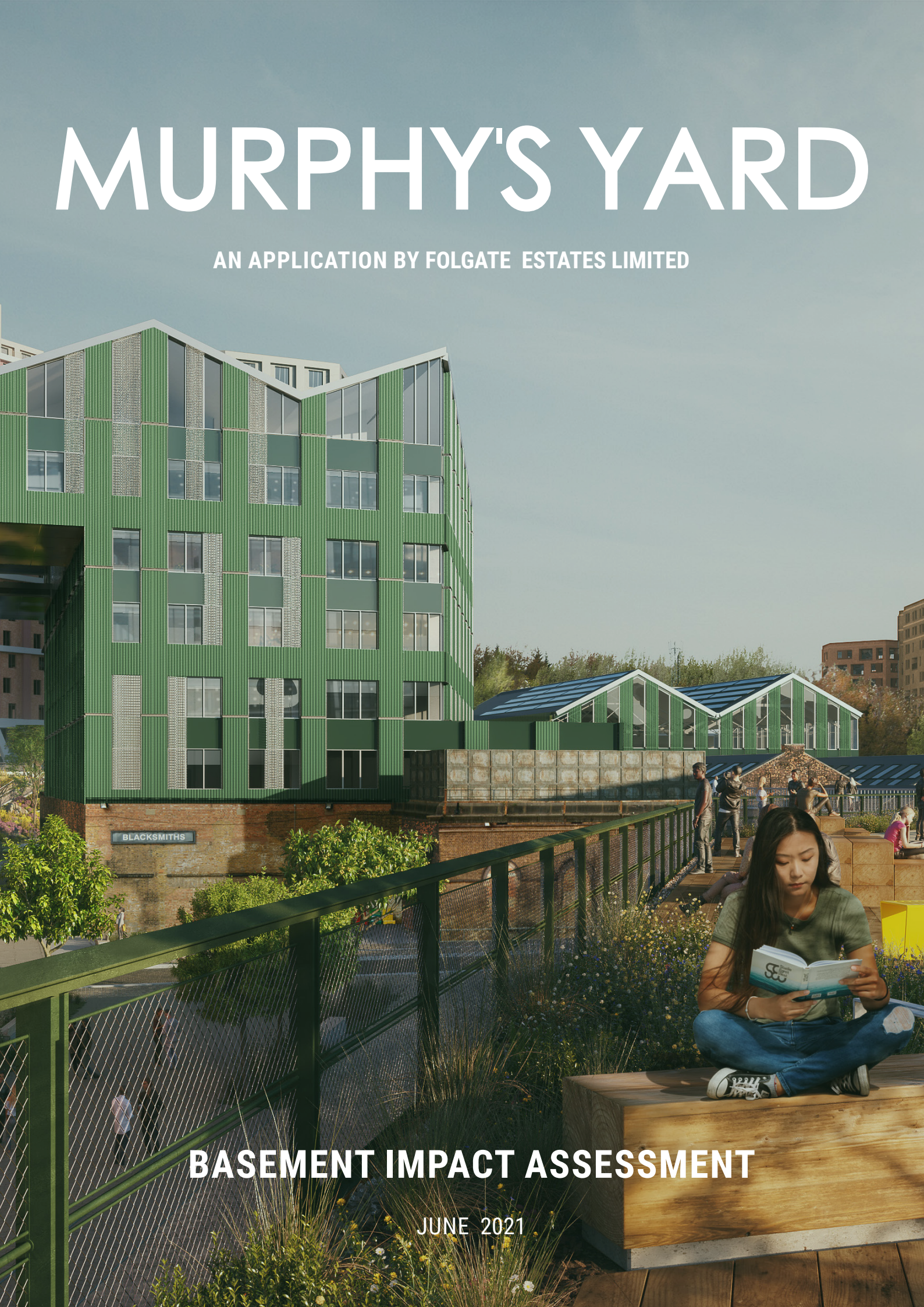
MURPHY'S YARD

AN APPLICATION BY FOLGATE ESTATES LIMITED



BASEMENT IMPACT ASSESSMENT

JUNE 2021


FOLGATE
ESTATES
LIMITED

Studio
Egret
West

dp9

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ARUP

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AND

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Murphy's Yard

Basement Impact Assessment

MUR-ARP-ZZ-XX-RP-CX-0002

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Appendices

1 Executive Summary

Ove Arup & Partners Limited ("Arup") has been commissioned to prepare a Basement Impact Assessment in support of the Outline Planning Application associated with land to the south of Gordon House Road bounded by railway lines to the east, west and south, known as Murphy's Yard.

This executive summary is an overview of the key findings of the report and forms the non-technical summary of the BIA required under Camden guidance. The full body of the report should also be consulted for further detail and to give appropriate context.

The report relies on the factual data given in the Ground Investigation report prepared by Ian Farmer and Associates. The recommendations made in this report include further site investigation as part of the development of the detailed design.

The report follows the approach laid out in Camden Planning Guidance 'Basements' (January 2021) in assessment of the impact of the basement development. This report includes assessment of the following:

- Surface flow and flooding;
- Groundwater flow; and
- Ground stability and ground movements.

Murphy's Yard consists of 18 plots of mixed use development. The outline planning application is seeking permission for the demolition of existing buildings and structures and redevelopment to be carried out in phases comprising the following mix of uses: residential, industrial, commercial and community, Sui Generis, cycle and vehicle parking, refuse and recycling storage, highway and access improvements, amenity space, landscape and public realm improvements. The maximum height across the development is a height of +113.45 AOD, of approximately 18 storeys.

The screening exercise identifies 5 key plots across the development with respect to basement assessment. Plots C, K and L are proposed to have a single storey basement and Plots S & Q, which although have a ground floor entrance, have a change of level across their footprint requiring retention of soil. Due to the number of rail assets and the Fleet Sewer in the vicinity of the site, a full site, conceptual, ground movement assessment was undertaken to assess the level of impact. This ground movement assessment will be refined alongside the detailed design and in accordance with the asset protection processes of TfL and Thames Water. Further site investigation will also be required, after planning, to assess existing geometry and condition of the assets. The further investigation will also inform detailed contamination remediation to be developed.

The key issues scoped for assessment included:

- the ground movements and their impacts on the rail infrastructure, Fleet Sewer and neighbouring buildings to the South-East of the site.
- the basement acting as an impermeable barrier to potential water flow

After a comprehensive review of both issues, this report concludes that the risk from the proposed basement works on neighbouring properties and assets is low in line with the requirements of the Camden Guidance Document.

The small changes in groundwater due to localised damning, predicted by the assessment are negligible and are expected to be within the normal range of seasonal fluctuations. The construction of the contiguous pile walls around the basement development are therefore expected to have no impact on adjacent structures or basements surrounding the Site.

The impact of ground movements has been assessed for the following surrounding infrastructure and structure:

Train lines and assets

Movements at the site boundary in the long term typically vary from about 0mm to 10mm settlement. For settlements up to 10mm, gradient of settlement = 1 in 3000. Locally this increases to 1 in 1500 adjacent to the Network Rail Line on the south side of the site. These movements and gradients are small and will not have a significant impact on surrounding structures.

It is considered that the small impact on the Network Rail Lines will be acceptable. Approvals will be sought from Network Rail in accordance with their formal process.

Fleet Sewer

Preliminary movements, radius of curvature and subsequent strains have been developed on the basis of a conservative loading and ground model. The criteria understood to be acceptable by Thames Water for tensile strain have been reviewed and it is considered that movements are likely to be acceptable. A detailed impact assessment will be carried out as part of Thame Water approvals in conjunction with a condition survey.

Greenwood Centre & Christ Apostolic Church

Resulting contours of vertical ground movement from wall installation and basement excavation haven been calculated, with settlements at both Greenwood Centre and the church of less than 1mm. It is found that assessment of damage to buildings across the road from the site is within Category 0 “Negligible”.

2 Site Context

2.1 Location

The Site is located in the London Borough of Camden (LBC) between Gospel Oak and Kentish Town train stations. The Site has a postcode of NW5 1TN and Ordnance Survey National Grid Reference TQ 28597 85563.

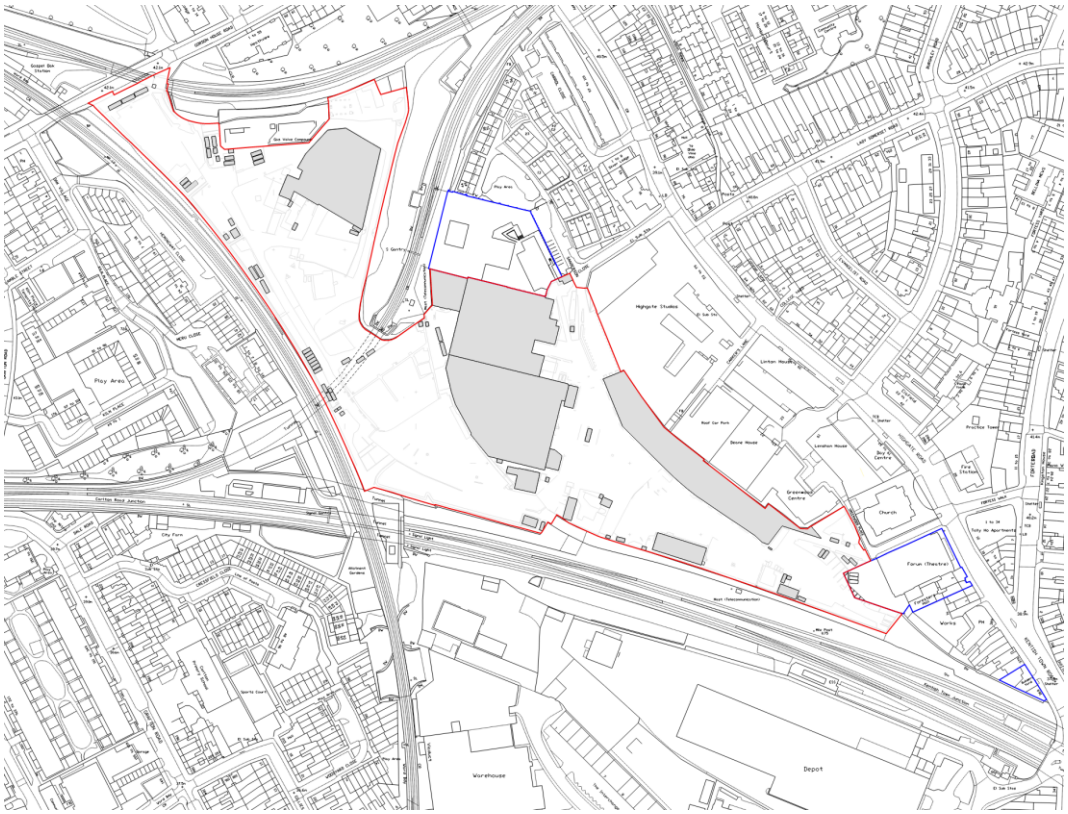


Figure 1 - Site Location/Red Line Boundary (Reference: 0360-SEW-ZZ-ZZ-DR-A-PL6000)

The proposed redevelopment encompasses an area of 62,288m^2 (6.23Ha). It is bounded by Network Rail tracks to the east, north-west and south and by Highgate Road to east. An additional Network Rail line bisects the Site from north to south before running underground. A small proportion of protected natural reserve and wildlife occupies the Site as well as two listed buildings.

Chapter 3.1 provides a summary on the neighbouring properties and assets.

2.2 Topography

The existing levels vary across the Site with high points of around 46.0-46.5mAOD within the western portion of the Site to low points of around 33.0m AOD in the east.

The eastern (33.500-34.500mAOD) and western (42.500-44.500mAOD) portions of the Site are largely flat with the change in levels facilitated by a steep slope (1:12.5) in the centre of the Site with a change of circa 10m.

A contour diagram showing the existing site levels can be found in Appendix A.

2.3 Existing Site Structures

According to a Ground Investigation Report by Ian Farmer Associates (2019), from 1873 onward, the Site was been historically used for industrial activities such as railway cuttings, gas works and oil processing plants and comprised of associated infrastructure such as railway sheds and coal sheds. A waste transfer facility was recorded around 1982 which was accepting commercial, construction and demolition wastes. There is also a record of potentially infilled land on the Site and contaminated land under Part IIA EPA 1990 within 200m to the east with no records of soil remediation.

The Site is currently brownfield with general industrial uses within classes E(g)(iii), B2 and B8 with ancillary office.

The Site is occupied by a large operational depot owned by J Murphy and Sons's, with its headquarters and courtyard to the east, car parking, car wash and jet washing facility in the centre. Most of the Site is hardstanding with only 5-10% of the Site vegetated. An existing buildings area schedule is provided in Table 1below:

Table 1: Existing Buildings Area Schedule

Existing Building	GIA	GEA
Shed 2	4,733	5,002
Shed 3	6,176	6,696
Workshops and Offices	3,838	3,959
Building Q	2,649	2,748
Thames Water	727	735
Training Centre	105	140
Security Gate	74	92
Total	18,303	19,373

2.4 Geology

The British Geological Society (BGS) geological mapping indicates that the Site is underlain with the London Clay formation (Bedrock). The client has informed the team that significant levels of made ground has historically been placed to link the North and South parts of the site.

Details on the site geology, following the site investigation can be found in Chapter 5. Further site investigation will be required once the proposed development plans have had planning granted.

2.5 Hydrology

The bedrock geology at the Site is classified by the Environment Agency (EA) as "Unproductive Strata", defined as "rock layers or drift deposits with low permeability that have negligible significance for water supply or river base flow".

During onsite investigations, it was found that there was a significant depth of Made Ground up to 9m in some areas and groundwater associated with the Made Ground was observed in the south eastern part of the Site at depths of between 0.50m and 0.70m bgl. In the north western part of the Site, groundwater also associated with the Made Ground was observed at depths of between 0.60m and 3.00m bgl. The groundwater in borehole WS6 was described as oily, indicating contaminated soils.

Given the underlying London Clay this groundwater may indicate localised perched water.

The Site does not lie within a Groundwater Source Protection Zone (SPZ).

According to the LBC SFRA the Site is not located in an area of increased susceptibility to elevated groundwater flooding and there is no recorded history of flooding from groundwater flood incidents with the Site boundary.

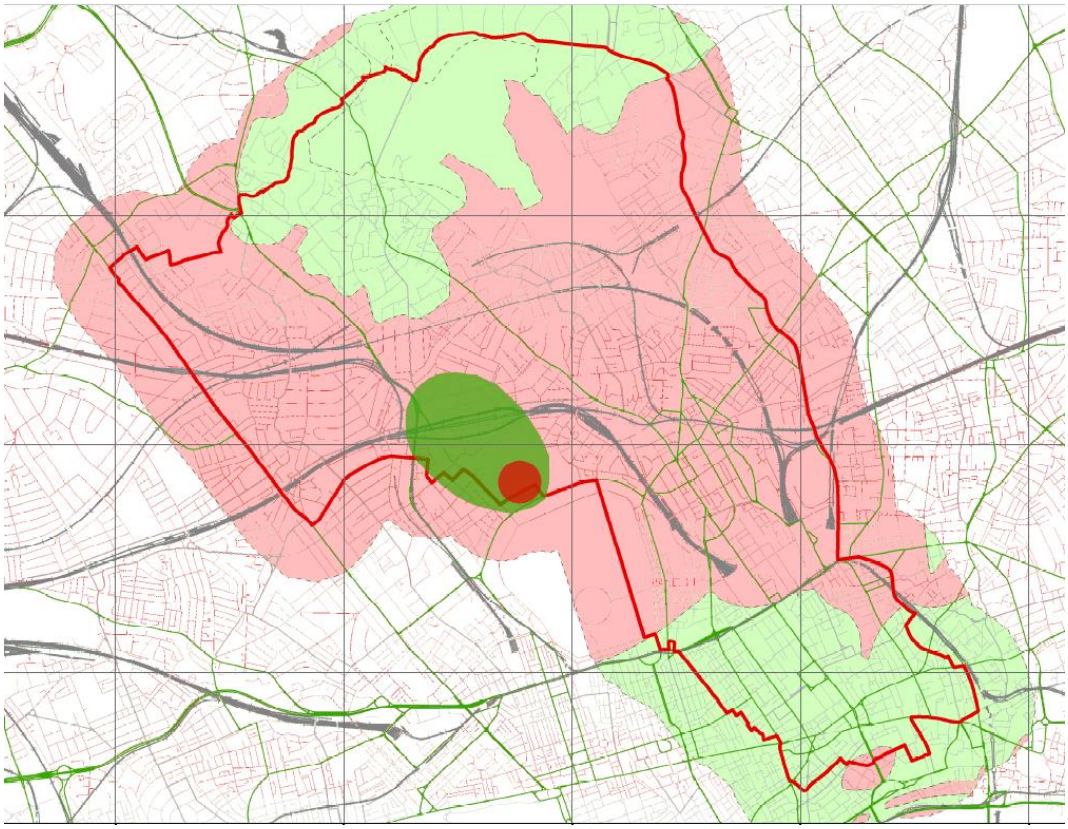


Figure 2 - Extract from Camden Aquifer Designation Map

2.6 Existing Rivers/Water Bodies

With reference to the Camden Geological, Hydrogeological and Hydrological Study in Figure 3, the southern end of the site appears to be very close to the approximate position of the old branch river from Highgate Pond to the River Fleet. This branch is now understood to have been intercepted by the High Level Interceptor Sewer constructed after the creation of the Metropolitan Board of Works in 1855 which led to a transformation of the Fleet in its now enclosed form. This links in to the main Fleet Sewer. The Fleet Storm Relief Sewer was built in the 1870s in order to give extra capacity to the Fleet Sewer in high flow events.

The nearest current surface water is the Highgate ponds, which are located approximately 760 metres north from the site. The site is not within catchment of the pond chains on Hampstead Heath, nor the Golder's Hill Chain.

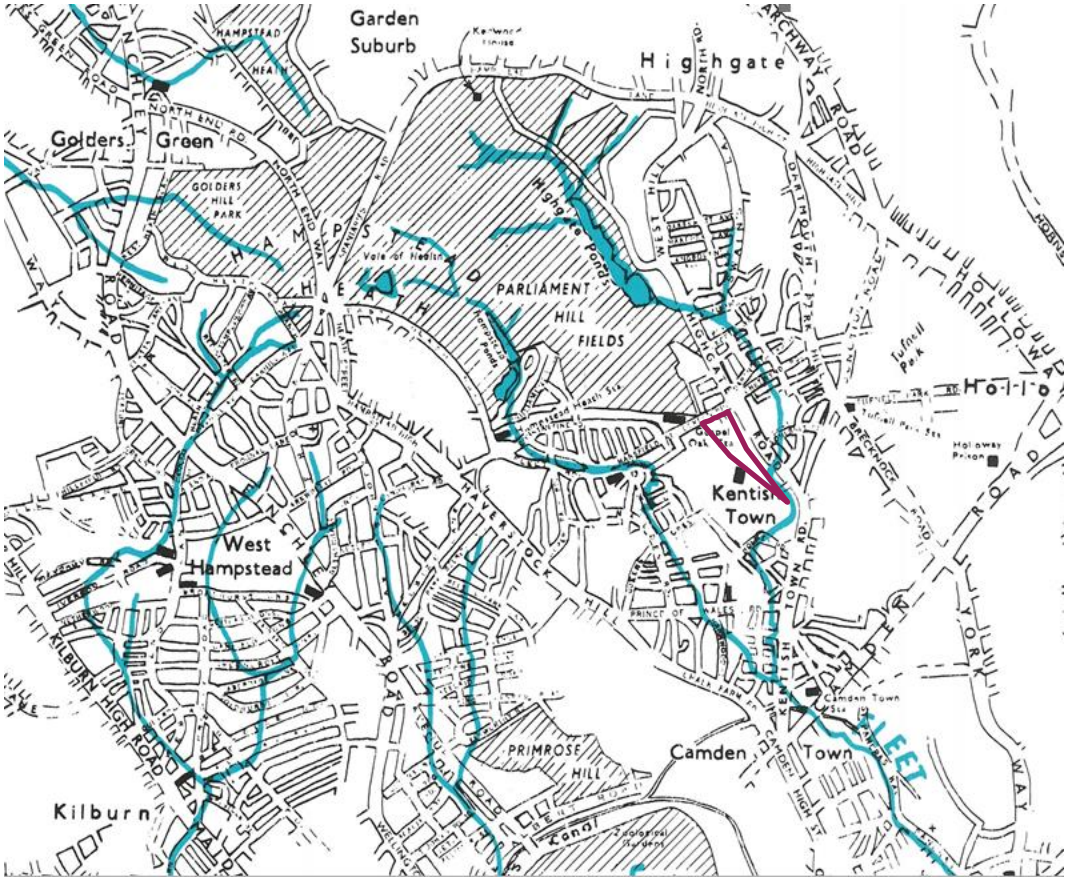


Figure 3 - Watercourses (Extract from Fig 11 of Camden Geological, Hydrogeological and Hydrological Study)

3 The Proposed Development

3.1 Description Overview

The redevelopment proposal for Murphy's Yard, is to be completed in four phases. The redevelopment proposals comprise of an outline planning application seeking:

- Outline planning permission with all matters reserved for the demolition of existing buildings and structures and redevelopment to be carried out in phases (with each phase being an independent act of development) comprising the following mix of uses: residential (Use Class C3), residential institution (Use Class C2), industrial (Use Class B2 and/or B8), commercial floorspace (Class E), flexible commercial and Sui Generis floorspace (Use Class E and/or Sui Generis Use), Community (F1 and/or F2), Sui Generis, and cycle and vehicle parking, refuse and recycling storage, plant, highway and access improvements, amenity space, landscape and public realm improvements, and all associated works.

The figure below shows the planning application boundary in red and the ownership boundary in blue. The development will be phased as outlined in Chapter 3.4.

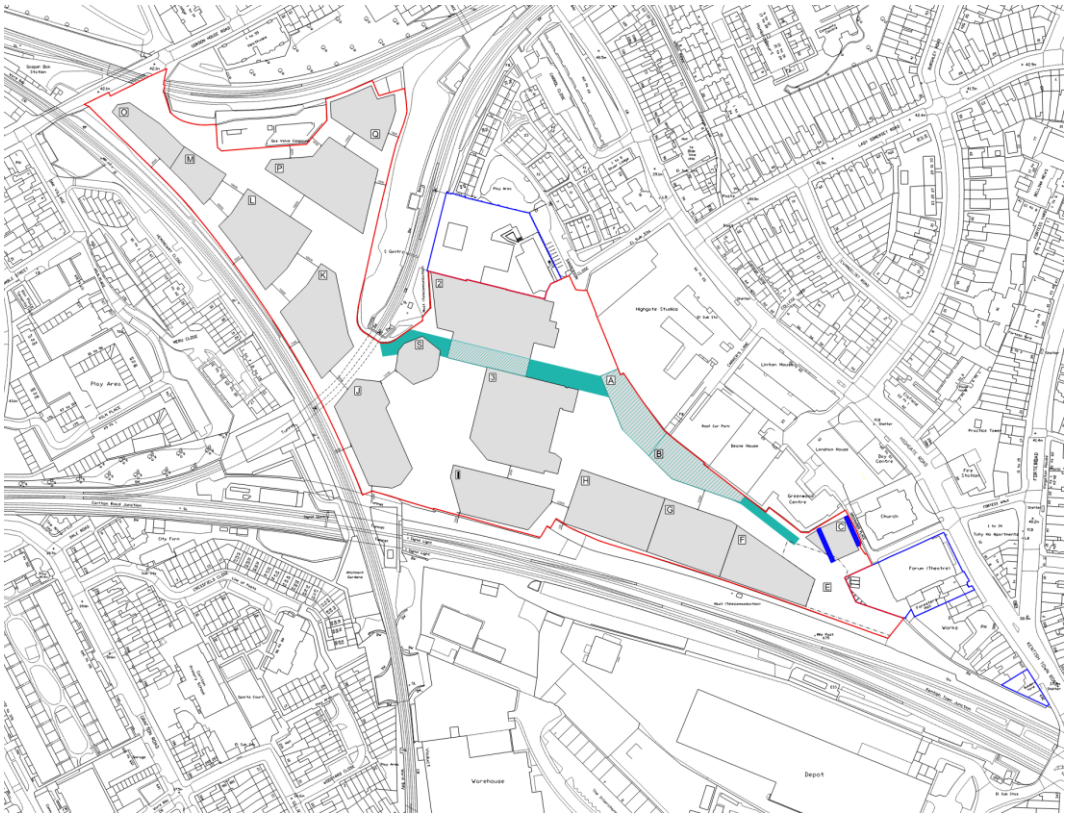


Figure 4. Planning boundary (Ref: 0360-SEW-ZZ-ZZ-DR-A-PL6003)

The site boundaries are adjacent to the following structures and infrastructure as illustrated in Figure 5:

- Network Rail lines along the western and southern boundaries

- Network Rail Line along the northern boundary
- There is a Network Rail Line that runs in tunnel and cutting through the middle of the site
- Domestic and commercial properties along the east boundary. In particular, in the vicinity of a single storey basement in the south of the site are the Greenwood Centre and the Christ Apostolic Church.
- Fleet Sewer running below Plot F and alongside Plot I (refer Figure 6)

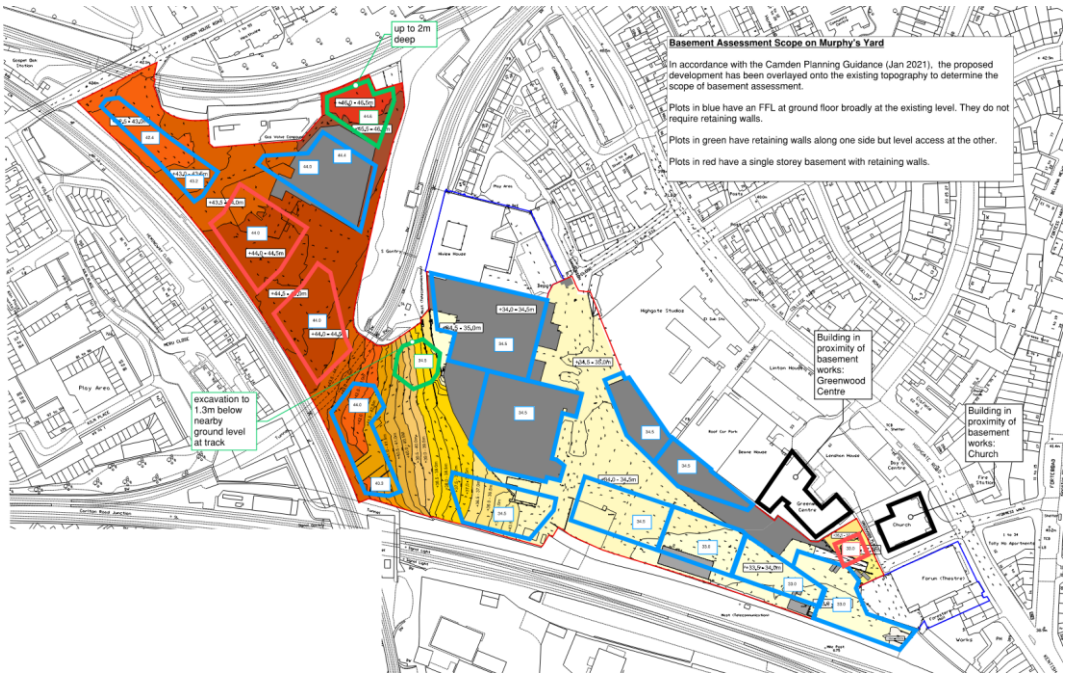


Figure 5 - Proposed works and buildings adjacent to the site

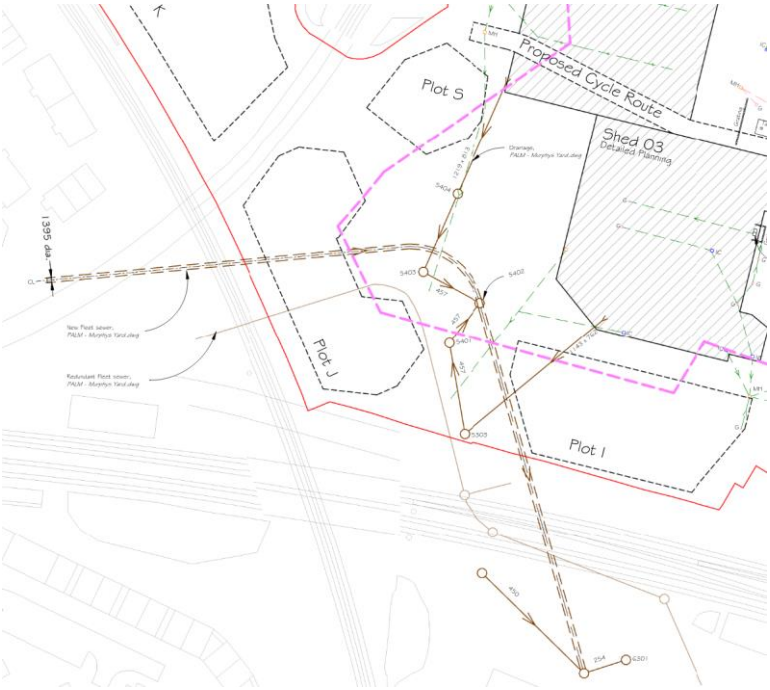


Figure 6 - Location of Fleet Sewer through SW of site

3.2 Proposed Topography

The landscape plans aim to provide better linkage across the site and level access into the defined plots. This means raising levels in the South East (to provide level access to the Forum, Greenwood place and Kentish Town Road), stepping levels in the centre of the site (similar to existing) and maintaining a broadly flat site to the North West.

As per the existing topography the site will have high points of around 46.5mAOD within the western portion of the Site to low points of around 33.0m AOD in the east.

A car park has been designed in the South East corner, which will be constructed from grade but have an accessible roof to allow connection to Greenwood Place. This approach has minimised the quantity of fill in this location.

Appendix A includes plans showing the proposed plots on the existing levels and the proposed levels.

3.3 Extent of Basements

The general approach for the development has been to minimise basements in order to reduce the embodied carbon impact of the works.

In accordance with the basement definition provided in the basement guidance document, the following basements will be assessed as part of the impact assessment.

- Plot C, K & L – a single storey basement. For assessment purposes assumed as 4m deep basement.
- Plot S & Q – both are situated on slopes so have ground floor access on one side of the plot but require retention at the other plot side.

Locations of these sites can be found in Appendix A.

Plot E is being constructed from existing grade so although has a podium above, in the final landscape proposals, is not considered a basement in which excavation and resulting ground movements would occur.

The scoping work has identified that the development neighbours a number of key infrastructure assets such as TfL and Thames Water. For this reason, a conceptual but full site ground movement assessment has been undertaken.

3.4 Construction Methodology

The proposed development is split into 4 phases of work. The plots with basement or significant ground retention have been highlighted in **bold**.

- Phase 1; Plots **C** & F.
- Phase 2; Plots J, **S**, **K** & **L**.
- Phase 3; Plots I, G, H, Shed 2 & Shed 3.
- Phase 4; **Q**, A, B, M, O & P.

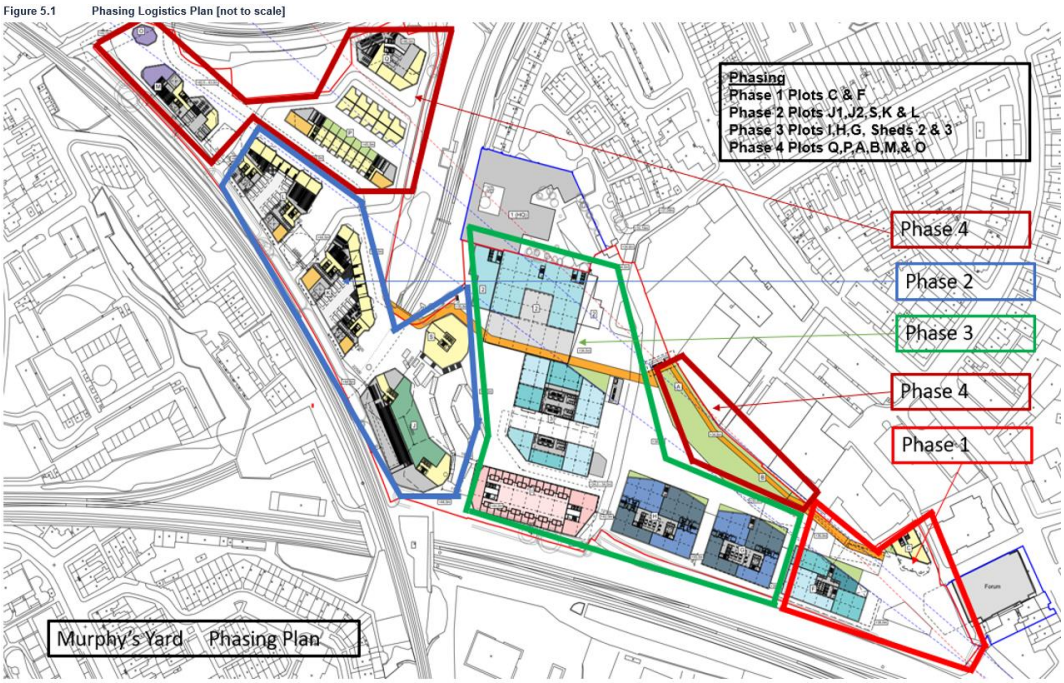


Figure 7. Phasing plots and sequence (Ref; Demo and Construction Chapter)

Table 5.1 Demolition and Construction Programme Summary

Stage	Development Plots	Period (Year)	Duration
Demolition (including enabling works) & Site Clearance	Phase 1 – Development Plots C + F	Year 2	Years 1 to 7
	Phase 2 – Development Plots J1, J2, S, K, L	Year 3	
	Phase 3 – Development Plots I, H, G, Shed 2 & Shed 3	Year 4	
	Phase 4A – Development Plots Q	Year 4	
	Phase 4B – Development Plots P, A, B, M, O	Year 7	
Earthworks Foundations & Substructure	Phase 1 – Development Plots C + F	Year 2 to 3	Years 4 to 8
	Phase 2 – Development Plots J1, J2, S, K, L	Year 4	
	Phase 3 – Development Plots I, H, G, Shed 2 & Shed 3	Year 4 to 5	
	Phase 4A – Development Plot Q	Year 4	
	Phase 4B – Development Plots P, A, B, M, O	Year 7 to 8	
Superstructure	Phase 1 – Development Plots C + F	Year 3	Years 2 to 9 Years 3 to 7
	Phase 2 – Development Plots J1, J2, S, K, L	Year 4 to 6	
	Phase 3 – Development Plots I, H, G, Shed 2 & Shed 3	Year 5 to 6	
	Phase 4A – Development Plot Q	Year 4 to 5	
	Phase 4B – Development Plots P, A, B, M, O	Year 8 to 9	
External Cladding	Phase 1 – Development Plots C + F	Year 3 to 4	Years 2 to 9
	Phase 2 – Development Plots J1, J2, S, K, L	Year 4 to7	
	Phase 3 – Development Plots I, H, G, Shed 2 & Shed 3	Year 6 to 7	
	Phase 4A – Development Plot Q	Year 5 to 6	
	Phase 4 – Development Plots Q, P, A, B, M, O	Year 8 to 9	
Internal Fit Out	Phase 1 – Development Plots C + F	Year 2	Year 4 to 9
	Phase 2 – Development Plots J1, J2, S, K, L	Years 5to 8	
	Phase 3 – Development Plots I,H, G, Shed 2 & Shed 3	Year 6 to 8	
	Phase 4A – Development Plot Q	Year 4 to 5	
	Phase 4B – Development Plots P, A, B, M, O	Year 4 to 9.5	
Testing & Commissioning External Works (including landscaping) and Handover	Phase 1 – Development Plots C and F	Year 4	
	Phase 2 – Development Plots J1, J2, S, K, L	Year 8	
	Phase 3 - Development Plots I, H, G, Shed 2 & Shed 3	Year 8	
	Phase 4A – Development Plot Q	Year 5	
	Phase 4B – Development Plots P, A, B, M, O	Year 8 to 9.5	

Figure 8 - Extract from the TRIUM Demolition and Construction Chapter giving indicative programme dates

Plot C, K & L

The proposed methodology for retaining the ground around the basement includes a permanent contiguous or secant piled wall constructed from the general ground level of the site. For the purposes of assessment, a contiguous piled wall of 8m deep has been considered with a 4m deep basement. All building loads are being supported from piles due to the poor bearing capacity of the top strata.

On plot K the basement wall has been set back from the rail tunnel exclusion zone. Piling methodology will be developed to minimise surcharge on the tunnel.

Plot S

The excavation near the north side of the site varies up to 2m deep. This is a small depth of excavation and ground movements to the rail line to the north will be minimal. An appropriate methodology will be developed (e.g. king post) to ensure compliance with asset protection requirements.

Plot Q

The excavation in the middle of the site varies up to 6.5m deep, but only extends to 1.3m below the ground level adjacent to the NR track. Ground movement impact on the NR track is therefore minimal. For the purposes of assessment, a contiguous piled wall has been assumed to allow the cut and install of a concrete lining wall.

4 Stage 1&2: Initial Screening & Scoping

The first stage in assessing the impact of a proposed basement development is to recognise what issues are relevant to the proposed site and to identify the matters of concern which should be investigated further. This has been carried out using the screening flowchart and guidance found in the Camden Planning Guidance, Basements, January 2021.

4.1 Ground Stability

Screening in accordance with Figure 13 from the Camden Basements document.

No.	Screening Question	Impact	Source/Comment
1.	Does the existing site include slopes, natural or manmade, greater than 7°? (approximately 1 in 8)	No	The eastern and western portion of the site are largely flat with a slope (less than 7°) connecting the two parts at 1:12.5.
2.	Will the proposed re-profiling of landscaping at site change slopes at the property boundary to more than 7°? (approximately 1 in 8)	No	No boundary conditions are being retained.
3.	Does the development neighbour land, including railway cuttings and the like, with a slope greater than 7°? (approximately 1 in 8)	Yes	Embankments to the North and the a central tunnel through the site have steep cuttings.
4.	Is the site within a wider hillside setting in which the general slope is greater than 7°? (approximately 1 in 8)	No	The site is not located within a wider hillside setting and there are no slopes adjacent to the property boundary.
5.	Is the London Clay the shallowest strata at the site?	Yes	London Clay is overlain by Made Ground.
6.	Will any tree/s be felled as part of the proposed development and/or are any works proposed within any tree protection zones where trees are to be retained? (Note that consent is required from LB Camden to undertake work to any tree/s protected by a Tree Protection Order or to tree/s in a Conservation Area if the tree is over certain dimensions).	No	The existing site is brownfield.
7.	Is there a history of seasonal shrink-swell subsidence in the local area (Claygate Beds), and/or evidence of such effects at the site?	No	We are not aware of the area having a history of shrink-swell subsidence. The effects of shrink-swell subsidence are not evident at the site.
8.	Is the site within 100m of a watercourse or a potential spring line?	No	

9.	Is the site within an area of previously worked ground?	Yes	Made Ground and fill above original ground level is present across the site. This is considered to be stable and will be completely supported during the excavation.
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 aquifer designation is defined as 'unproductive' strata, although there may be perched water within the Made Ground.
11.	Is the site within 50m of the Hampstead Heath ponds?	No	-
12.	Is the site within 5m of a highway or pedestrian right of way?	Yes	
13.	Will the proposed basement significantly increase the differential depth of foundations relative to neighbouring properties?	Likely	Ground movements related to deflection of basement retaining walls may affect surrounding properties.
14.	Is the site over (or within the exclusion zone of) any tunnels, e.g. railway lines?	No	-

The following impacts have been identified during screening:

- Basement excavation and superstructure loading have the potential to cause ground movements to the surrounding properties and assets including:
    - The fleet sewer.
    - Rail embankments, a tunnel and surrounding rail lines/assets.
    - The buildings to the South specifically the Greenwood Centre and the and the Christ Apostolic Church.

Scoping:

- A site wide ground movement assessment will be undertaken to assess level of impact and mitigation measures to be incorporated into the design and construction sequence.
- Localised checks to be carried out the retaining wall elements to satisfy the basement and retaining wall design.
- Significant pockets of made ground can be found across the site. A site wide piling strategy will be developed.
- A plot by plot ground investigation will be undertaken post planning to determine ground water levels to develop suitable dewatering strategy.

4.2 Surface flow and flooding

Screening in accordance with Figure 14 from the Camden Basements document.

No.	Screening Question	Impact	Source/Comment
1.	Is the site within the catchment of the pond chains on Hampstead Heath?	No	The site lies well outside the Hampstead Heath surface water catchment area as defined by Figure 14 of LBC guidance [3] and there are no other equivalent sensitive water features in the vicinity of the site.
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	We are reutilising existing sewage connections. Volume and peaks will be controlled
3	Will the proposed basement development result in a change in the proportion of hard surfaced / paved external areas?	No	The existing site is hard surfaced.
4	Will the proposed basement result in changes to the profile of the inflows (instantaneous & long-term) of surface water being received by adjacent properties or downstream water-courses?	No	The development is not increasing the amount of impermeable land and retaining existing sewage connections.
5	Will the proposed basement result in changes to the quality of surface water being received by adjacent properties or downstream water courses?	No	The surface water quality will not be affected by the development. During construction a Construction Management Plan (CMP) will be followed to minimize the risk of excess runoff and contamination of surface water. After completion, runoff will be collected by dedicated surface water runoff systems and discharged to the exuist8ing combined sewer system network, using SUDS where possible.
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 a nearby surface water feature?	Yes	The site has a 'low risk' of surface water flooding with an annual probability between 1 in 100 year and 1 in 1000 year. Refer to the Flood Risk assessment for full details of assessment.

The following impacts have been identified during screening:

- The site has a low risk of surface flooding.

Scoping:

- A flood risk assessment is to be carried out and incorporated into the drainage strategy.

4.3 Subterranean (groundwater) flow

Screening in accordance with Figure 12 from the Camden Basements document.

No.	Screening Question	Impact	Source/Comment
1a.	Is the site located directly above an aquifer?	No	With reference to the Camden Geological, Hydrogeological and Hydrological Study (Figure (a1) in Appendix A) the site is above an Unproductive Strata as designated as by the Environment Agency. No secondary aquifer is present below the site.
1b.	Will the proposed basement extend beneath the water table surface?	Yes	Local groundwater levels appear to range between 2.2 and 6.0mbgl. The proposed basement floor of Plot C level is 3.5mbgl with the water level encountered at about 0.5mbgl.
2.	Is the site within 100m of a watercourse, well (open/disused) or potential spring line?	Yes	Yes within historic path of tributary to River Fleet, but this now runs in sewer.
3	Is the site within the catchment of the pond chains on Hampstead Heath?	No	The site lies well outside the Hampstead Heath surface water catchment areas and there are no other equivalent sensitive water features in the vicinity of the site.
4	Will the proposed basement development result in a change in the proportion of hard-surfaced/paved areas?	No	The existing site is hard surfaced.
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 soak-away and/or SUDS)?	No	The proposed drainage strategy does not have an infiltrating drainage system due to constraints of the nearby railway.
6	Is the lowest point of the 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	

The following possible impacts on groundwater have been identified during screening:

- The site extends below the water surface (Q1b) and so will provide some constraint to groundwater flow.

Scoping:

- Whether the basement works will impact on the groundwater level locally and whether this will impact neighbouring structures and infrastructure.

5 Stage 3: Site Investigation

A preliminary ground investigation was undertaken by Ian Farmer Associates with a summary report produced in July 2019 and updated in 2021.

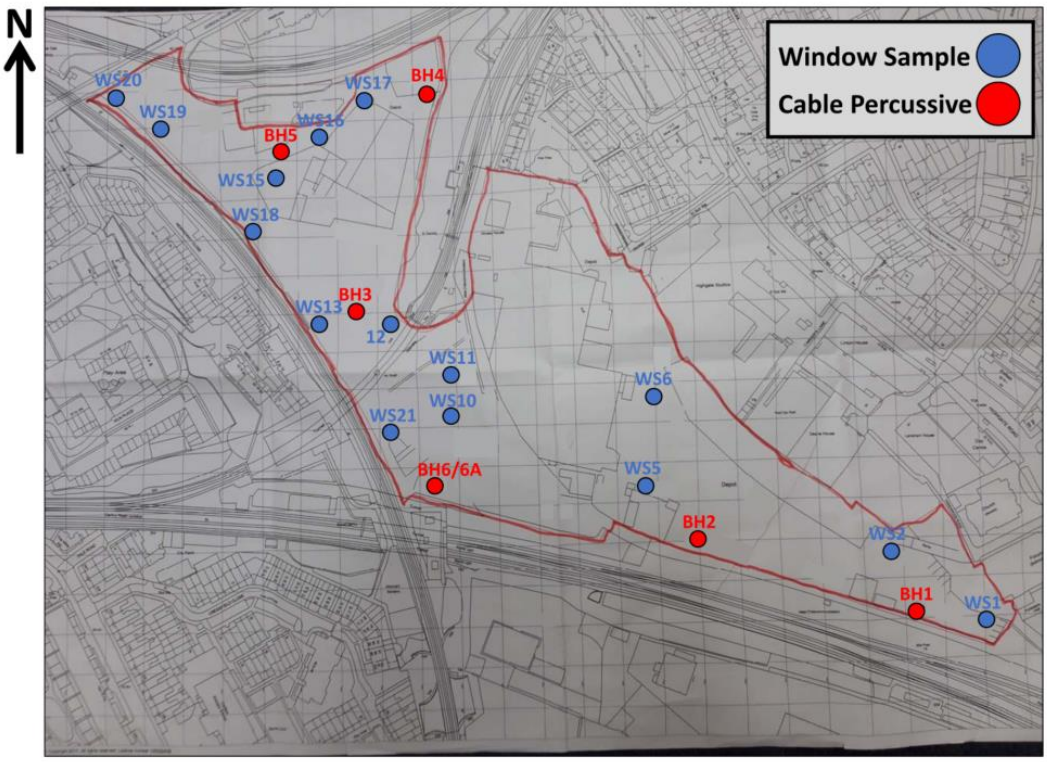
Site works were carried out between the 01st and 10th April 2019, and comprised seven cable percussion boreholes to depths of predominantly 20.45 m below ground level (bgl), and fifteen percussive window sample boreholes to depths of between 0.50m and 6.45m bgl. Gas and groundwater monitoring standpipes were installed in six of the boreholes. Borehole 6 was repositioned to location 6A due to encountering concrete.

The information obtained has been used to establish the ground models and foundation strategy for the plots. Further ground investigation will be undertaken on a plot by plot basis, after planning, to address site specific risk items.

5.1 Ground Investigation Summary

Published geological and hydrogeological records indicate the site to be directly underlain by the negligibly permeable solid geology of the London Clay Formation, which is designated unproductive strata. Superficial deposits are not recorded beneath the site, however there is a propensity for Head deposits recorded directly to the northeast, and therefore, such deposits may be present overlying the London Clay beneath parts or all of the site.

Ian Farmer and Associates concluded that the sequence of the strata encountered in the boreholes during the investigation broadly confirms the anticipated geology as interpreted from the geological map.



Borehole 6 and window sample pits WS10, WS11, WS13 and WS15 were terminated or relocated at depths of between 0.5m and 1.23m bgl due to encountering concrete obstructions or possible underground services.

The assessment identified widespread contamination of the Made Ground in the north western part of the site, with regard to TPH and PAH compounds, together with the presence of a number of VOCs and SVOCs at detectable concentrations across the entire site. Elevated lead was also identified in two locations in the central part of the site. No contamination was within the underlying natural London Clay. Notable concentrations of organic contaminants were recorded in the groundwater encountered within the Made Ground, together with elevated levels of methane gas.

Further investigation will be undertaken on a plot by plot basis following planning approval and remediation strategy developed.

5.2 Conclusions

Stratigraphy; South of Site

The sequence and indicative thicknesses of strata encountered in the south eastern part of the site (BH1, BH2, WS1, WS2, WS5 and WS6) are provided in the table below.

Strata Encountered	Depth Encountered (m bgl)		Strata Thickness (m)
	From	To	
Made Ground	0.00	0.80 to 1.30	0.80 to 1.30
London Clay Formation	0.80 to 1.30	>20.45	>19.65

During the investigation, groundwater associated with the Made Ground was observed in the south eastern part of the site in boreholes WS1, WS2 and WS6 at depths of between 0.50m and 0.70m bgl. The groundwater in WS6 was described as oily. On a return visit, the standpipe in borehole 2, situated in the south eastern part of the site, was recorded as dry to a depth of 6.3m bgl.

Stratigraphy; North of Site

The sequence and indicative thicknesses of strata encountered in the north western part of the site (BH3 to BH6, and BH6A, WS10 to WS13, and WS15 to WS21) are presented in the table below.

Strata Encountered	Depth Encountered (m bgl)		Strata Thickness (m)
	From	To	
Made Ground	0.00	3.50 to 9.00	3.50 to 9.00
Superficial Deposits (BH4 & WS19)	4.50 & 7.40	4.60 & 8.00	0.10 & 0.60
London Clay Formation	3.50 to 9.00	>20.45	>13.45

In the north western part of the site, groundwater also associated with the Made Ground was observed in boreholes 3, WS15, WS16 and WS19 at depths of between 0.60m and 3.00m bgl during the investigation. On return monitoring visits, groundwater was confirmed within the Made Ground deposits in boreholes 3, 5 and WS10, situated in the north western part of the site, at depths of between 0.89m and 2.19m bgl.

6 Stage 4: Impact Assessment

The key issues highlighted in Sections 4.1, 4.2 and 4.3 for which the impacts are considered here are:

- the ground movements and their impacts on the rail infrastructure, Fleet Sewer and neighbouring buildings to the South.
- the basement acting as a potential impermeable barrier to water flow

An initial ground movement assessment and a groundwater flow assessment address these items.

A Flood Risk assessment and drainage strategy have been developed in conjunction with the Camden flood authority and Thames Water to limit surface water drainage into the existing system to acceptable levels. It is noted that the existing site is predominantly hard standing so the proposals will be a betterment.

It has also been identified that further site investigation will be required to inform detailed design with respect to potential dewatering of the made ground and a detailed contamination remediation strategy.

6.1 Stability of basement and Adjacent Structures

Preliminary calculations of ground movements beneath the adjacent infrastructure and structures surrounding the basement have been carried out.

This section describes the main principles and assumptions adopted in the present assessment.

6.1.1 Change in Load

Changes of load on the existing ground would occur due to the following:

- Proposed cut and fill earthworks operations
- Basement excavations for basement construction
- Loading from the construction of new superstructure

A preliminary assessment has been carried out for the surrounding ground movements due to these changes in load on the ground. The analysis was carried out using the Oasys programme PDISP, using a Bousinesq stress distribution and elastic soil parameters. No account is taken in the programme of the stiffness of structural elements. In the PDISP model all changes of load were applied at or below the surface of the London Clay, which was modelled as a flat surface at a typical level of +33mOD.

For the PDISP modelling, the following parameters were selected:

- Undrained stiffness Eu = 500cu, where cu = 70+4.5z kPa below top of London Clay

- Drained stiffness E' = 400 cu
- Rigid boundary taken at 50m below the top of the London Clay, which is understood to be at about the bottom of the London Clay.

Change in Load From Cut/Fill & Basement Excavation

The diagram of the changes in load on the ground due to the earthworks cut and fill operations and the five basement excavations is shown below. These are applied as surface loads.

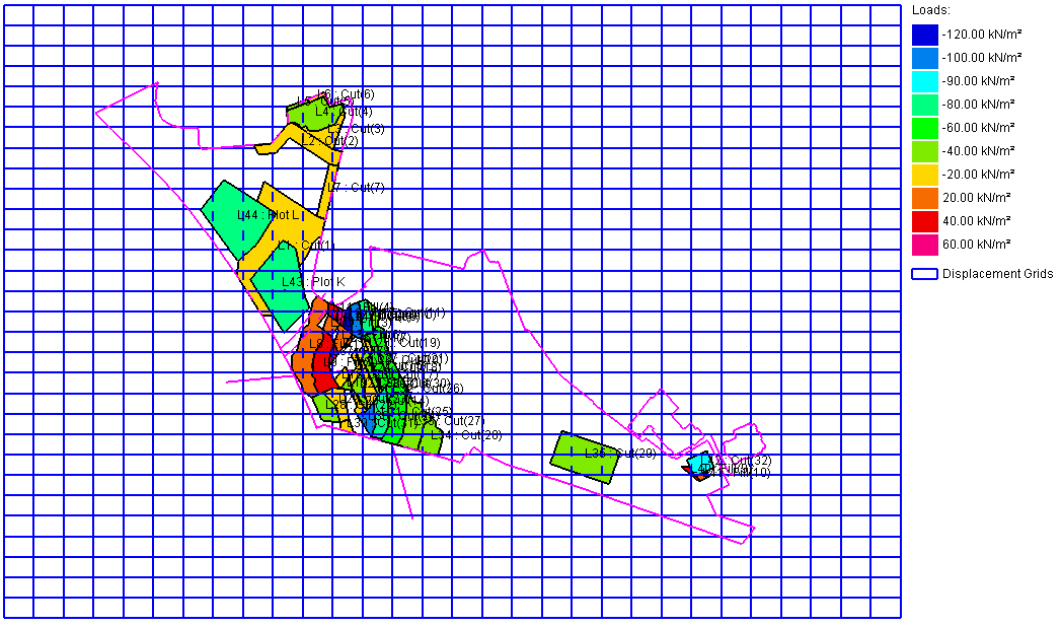


Figure 9 Changes in load modelled in PDISP for the cut and fill operations and the basement excavation

Change in Load From Building Load

The loading applied from the new buildings has been modelled in pdisp as shown in Figure 10 . For the purposes of this preliminary assessment, the buildings were grouped into three categories with loads modelled as follows:

- 1-5 storeys, loads 33-43 kPa. These loads were conservatively applied over the footprint of the building at the top of the London Clay (+33mOD), on the basis that any pile requirements will not be substantial.
- to 11 storeys, loads 60-123kPa. This was applied as an equivalent raft with a load spread of 1 in 4 around the footprint of the building to 2/3 of the length of pile group foundations (conventional pile group load spread), at a level of +20mOD.
- 11 to 19 storeys, loads 154 to 222 kPa. This was applied as an equivalent raft with a load spread of 1 in 4 around the footprint of the building to 2/3 of the length of pile group foundations (conventional pile group load spread), at a level of +9mOD.

Note that pile length estimates were based on groups of 900mm diameter piles designed in accordance with Eurocode 7 and LDSA Guidance for bored piles in

London Clay (without pile testing). Their length was maximised at 36m (L/D of 40) in the London Clay for the heavier buildings. If smaller diameter piles are eventually used it is anticipated that there would be more piles but not significantly shorter. If larger diameter piles are used it is anticipated that there would be fewer piles but not shorter. For the intermediate buildings, shorter 900mm diameter piles have been assumed; if smaller diameter piles are adopted it is likely that they would be longer because opportunity would be taken to maximise length and minimise concrete. Therefore, the levels of application of the equivalent raft foundations in the PDISP calculations are assumed to be reasonably representative.

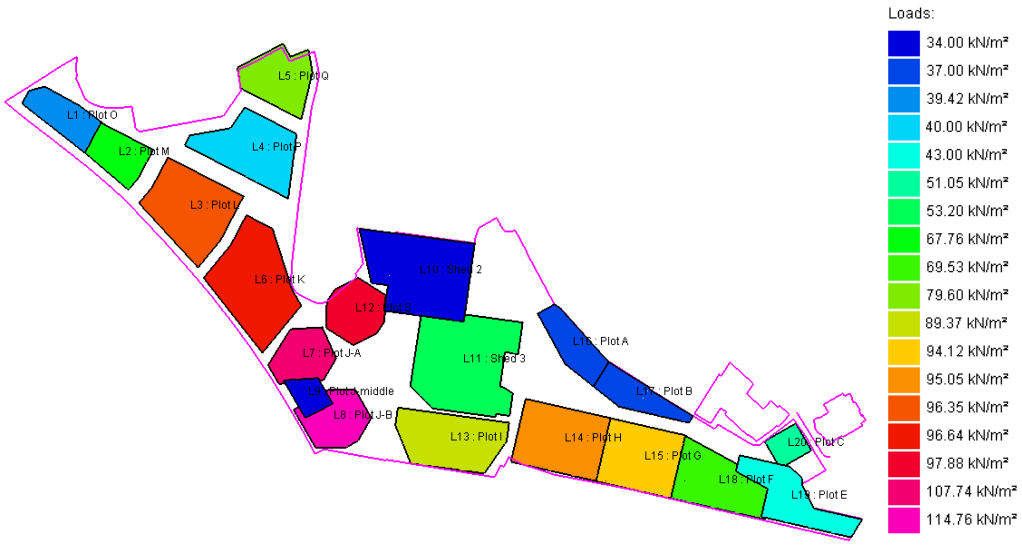


Figure 10 Plan of building pressures applied in pdisp, indicating also the distribution with depth in the ground

6.1.2 Ground Movement Assessment (Site Wide)

A conceptual ground movement model was developed in PDISP with the changes in loading as described. The resulting contours of ground movement at ground level in the short term following construction and in the long term are shown in Figure 11 and Figure 12.

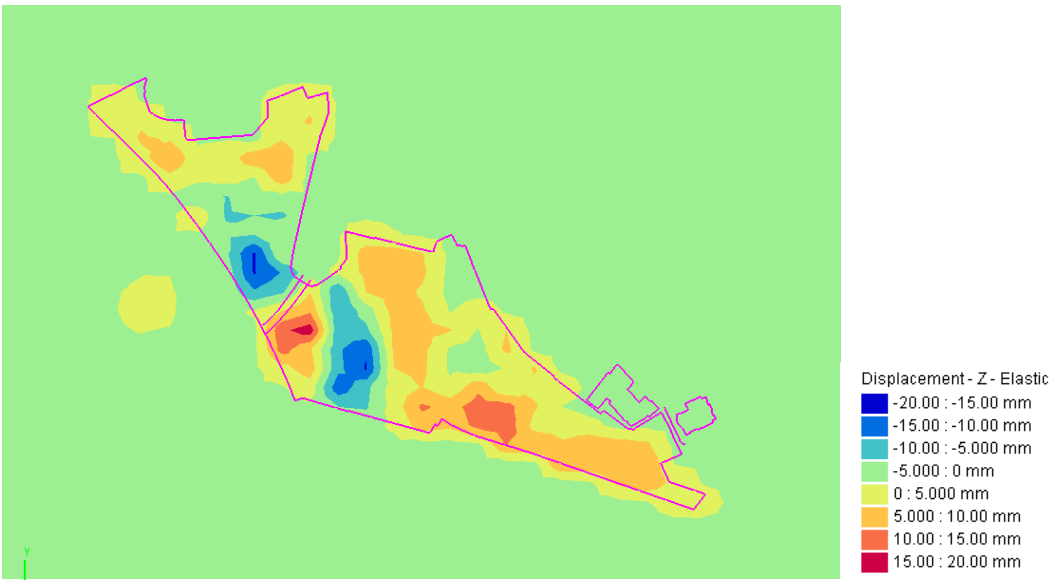


Figure 11 Short term ground movements

Ground movements are largest in the long term. Movements at the site boundary in the long term typically vary from about 0mm to 10mm settlement. Locally along the south side of the site, boundary settlements increase to 20mm, and there are local areas with up to 10mm heave due an area of earthworks cut and the basement excavation at Area K.

The movements at the site boundary reduce to zero over a distance of about 30m. For settlements and heave up to 10mm, gradient of settlement = 1 in 3000. Locally this increases to 1 in 1500 adjacent to the Network Rail Line on the south side of the site.

These movements and gradients are small and will not have a significant impact on surrounding structures.

It is considered that the small impact on the Network Rail Lines will be acceptable. Approvals will be sought from Network Rail in accordance with their formal process.

Note that movements around the perimeter of the Greenwood Centre and the Christ Apostolic Church which are close to the basement excavation in the south of the site are shown in Figure 13 and Figure 14. The movements, which are less than 2mm, are not significant

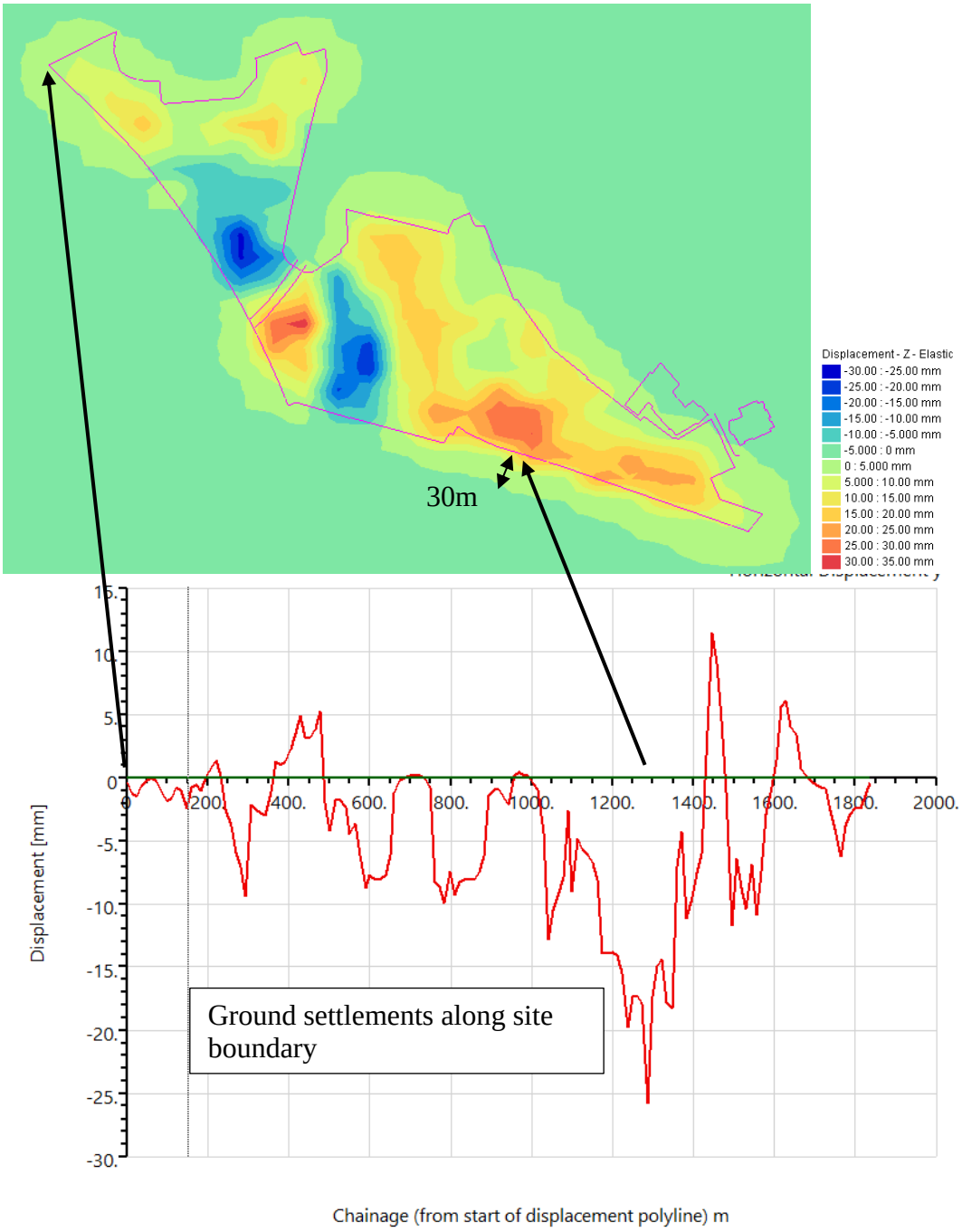


Figure 12 Long term ground movements, including plot of variation of movement, clockwise along site boundary

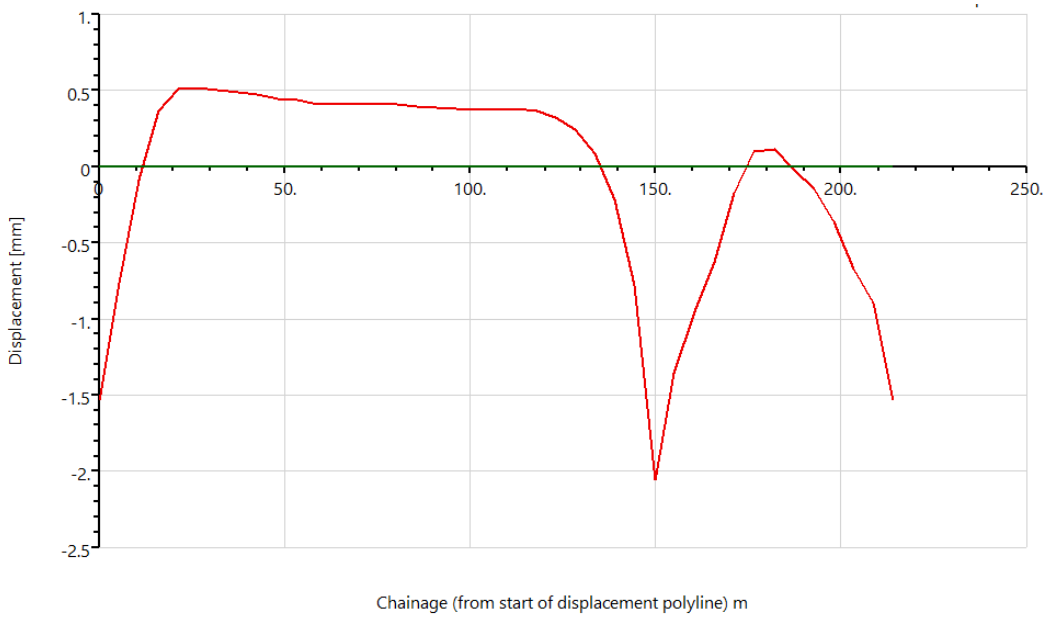


Figure 13 - Ground movement around the perimeter of the Greenwood Centre

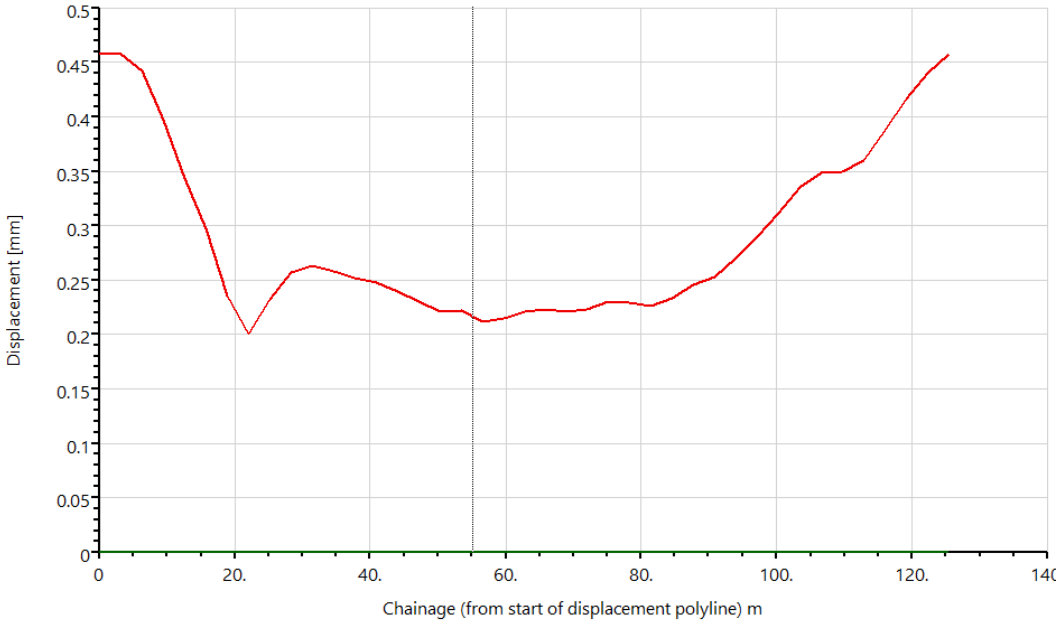


Figure 14 - Ground movement around the perimeter of the Apostolic Church

6.1.3 Ground movements behind excavations

The impact on adjacent structures and infrastructure due to basement excavation within retaining walls has been considered. Of the five basement excavations (see Figure 5):

- The excavation near the north side (Plot Q) of the site varies up to circa 2m deep. This is a small depth of excavation and ground movements to the NR line to the north will be minimal. Therefore, at this stage they have not been analysed, though will be included as part of formal NR approvals.

- The excavation in the middle of the site (Plot S) varies up to 6.5m deep, but only extends to circa 1.3m below the ground level adjacent to the NR track. Ground movement impact on the NR track is therefore minimal. It has not been analysed at this stage but will be included as part of formal NR approvals.
- At the south side of the site (Plot C) there is a basement excavation in the vicinity of the Greenwood Centre and the Christ Apostolic Church (Figure 15). This basement is a single storey of approximately 4m deep. Ground movement impact has been considered here.
- At areas L and K there are proposed basements approximately 4m deep. A small settlement trough is predicted behind the excavations which will cause up to 5mm settlement at the western site boundary (refer to analysis of ground movements shown in Figure 15). Therefore, movements less than 5mm are predicted to the NR line adjacent to the western boundary. These movements are small and will be included in a full impact assessment as part of formal NR approvals.

The ground movement assessment due to the excavation of the 4m deep basement at the south end of the site (Plot C) has been carried out using the programme XDISP in accordance with CIRIA report C760 'Embedded retaining walls guidance for economic design' (London 2017). This report gives empirical data for profiles of ground movements behind retaining walls due to wall installation and excavation in front. These profiles are based on numerous case histories and are widely adopted in the prediction of ground movements behind retaining walls.

As shown in Figure 15 the Greenwood Centre is approximately 9m and the Christ Apostolic Church is approximately 14m from the proposed 4m excavation at Plot C.

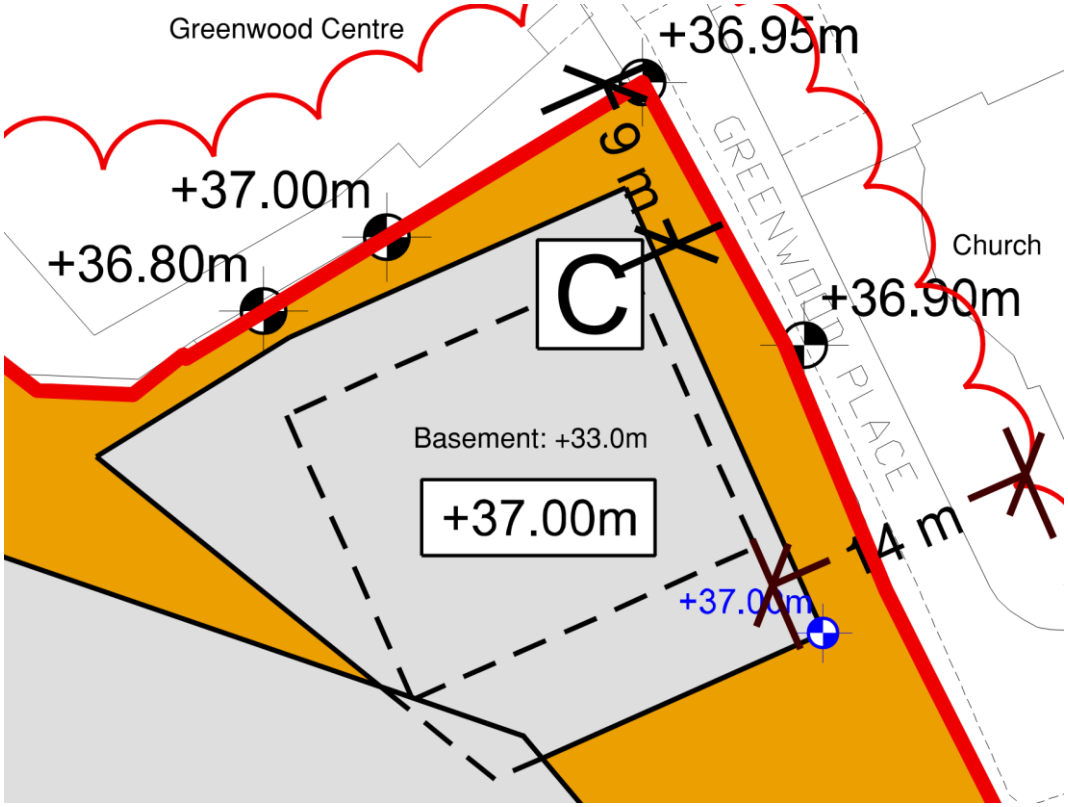


Figure 15 - 4m deep basement at Plot C to the south end of site, in vicinity of Greenwood centre and Christ Apostolic Church

6.1.4 Ground movements due to wall installation

The embedded retaining wall for the circa 4m deep basement is proposed to consist of a contiguous piled wall with piles 8m deep. Settlement and horizontal movement due to wall installation have been considered based on case history data presented in CIRIA C760 (see Figure 16). The empirical curves shown in the figure for contiguous piled walls have been adopted.

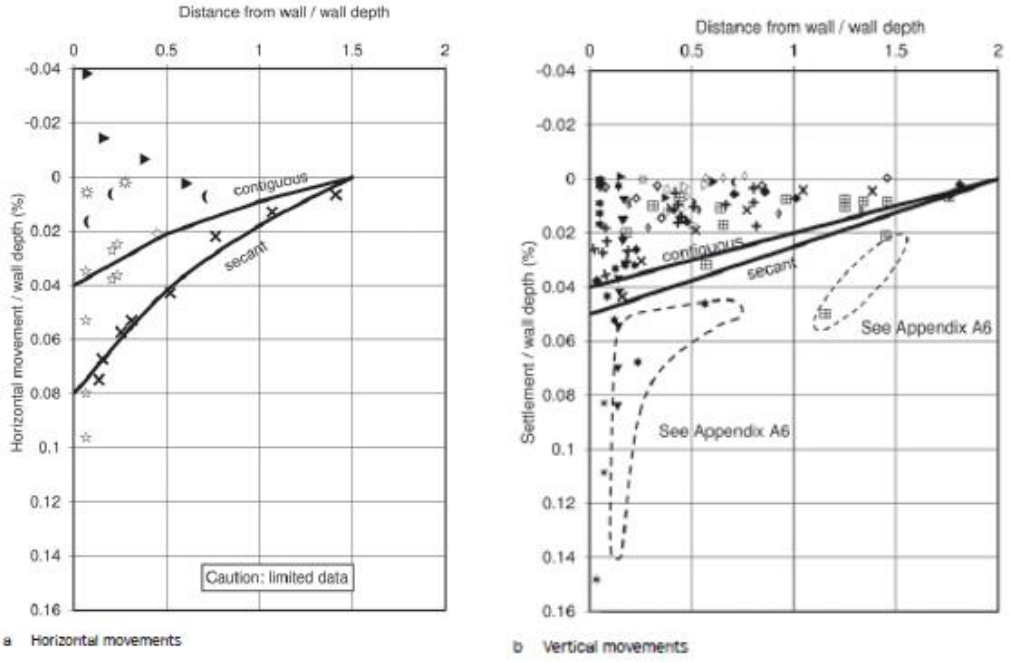


Figure 16 - Data presented in CIRIA C760 (figure 6.8) for ground movements due to wall installation (Horizontal to left. Vertical to right)

6.1.5 Ground Movements due to Excavation

The walls and support system will be designed to provide high stiffness support to the contiguous piled walls. Settlement and horizontal movement due excavation in front of the retaining walls have been considered based on case history data presented in CIRIA C760 (see Figure 17). The empirical curves shown in the figure for high stiffness piled walls have been adopted.

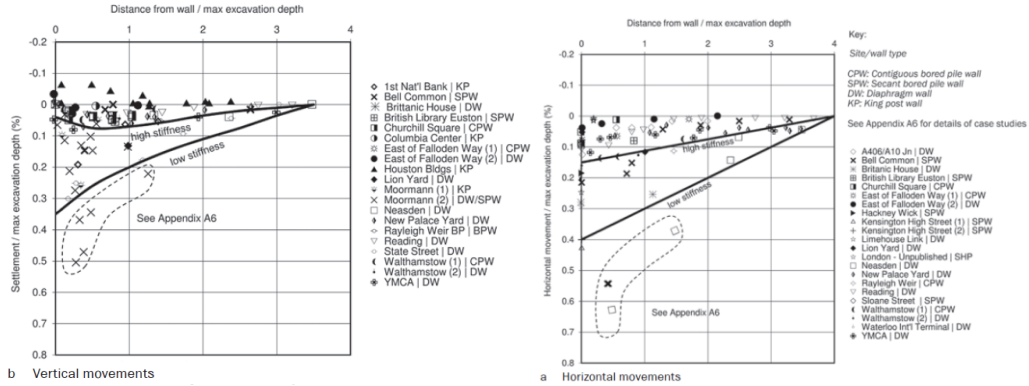


Figure 17 - Ciria 760 Figure 6.15 Ground surface movements due to excavation in front of wall embedded in stiff clay

Resulting contours of vertical ground movement in XDisp from wall installation and basement excavation are shown in Figure 18. Settlements at both Greenwood Centre and the church are less than 1mm.

The profile of vertical and horizontal movements through the Greenwood Centre is shown in Figure 19. This shows both horizontal and vertical movements less than 1mm.

There is no movement calculated beneath the Christ Apostolic Church.

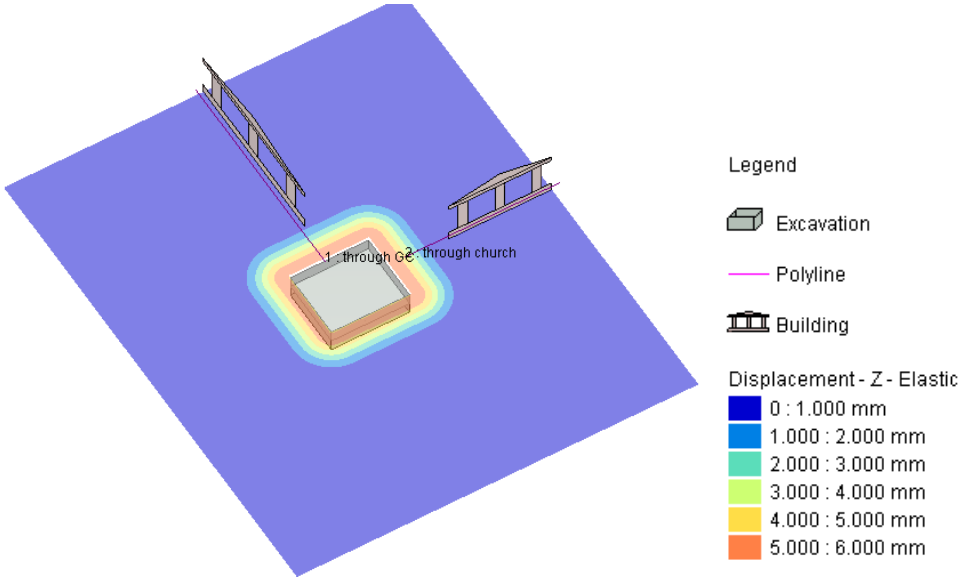


Figure 18 - Contours of ground movement around 4m basement excavation at Plot C

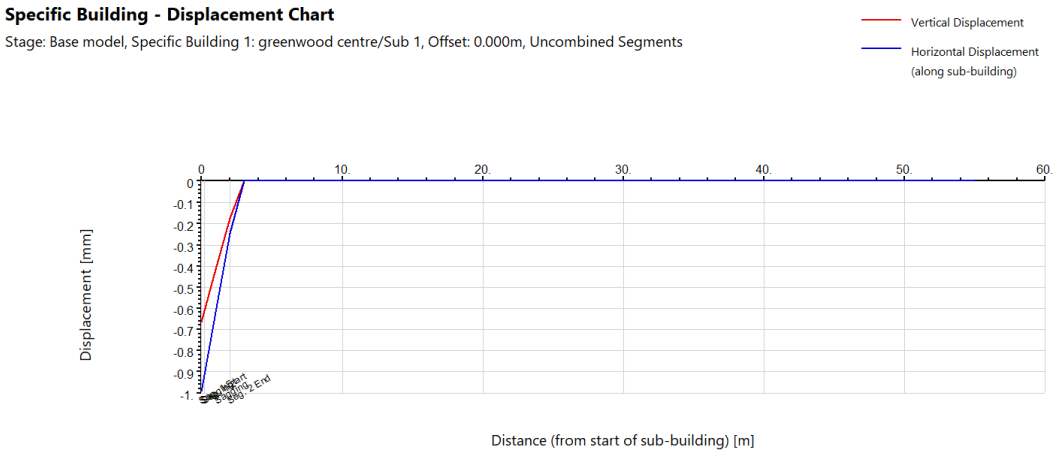


Figure 19 - Vertical and horizontal movements through the Greenwood Centre.

6.2 Damage Assessment on Greenwood Centre and Christ Apostolic Church

It has been shown that no significant movement is predicted to occur to either building due to global ground movement from change in load within the site.

Ground movements due to wall installation and basement excavation have also been shown to be negligible for both buildings.

Nevertheless the very small hogging deflections and tensile strains found using XDisp at the Greenwood Centre have been analysed using the limiting tensile strain approach as described by Burland et al (1977), Boscardin and Cording (1989) and Burland (2001) which is also described in CIRIA Report 760. Through the predicted soil movements at the wall location and basic wall information, such methodology enables estimation of the level of damage for a selected wall. The damage is assessed based on a categorisation, where 0 is least effect and 5 is the greatest effect. Figure 20 shows the relationship between damage category, deflection ratio and horizontal tensile strain (from CIRIA C760).

The result of the preliminary damage assessment is shown in Figure 21 and confirms that the damage is negligible for the Greenwood Centre. No movement and/or damage is predicted at the Christ Apostolic Church.

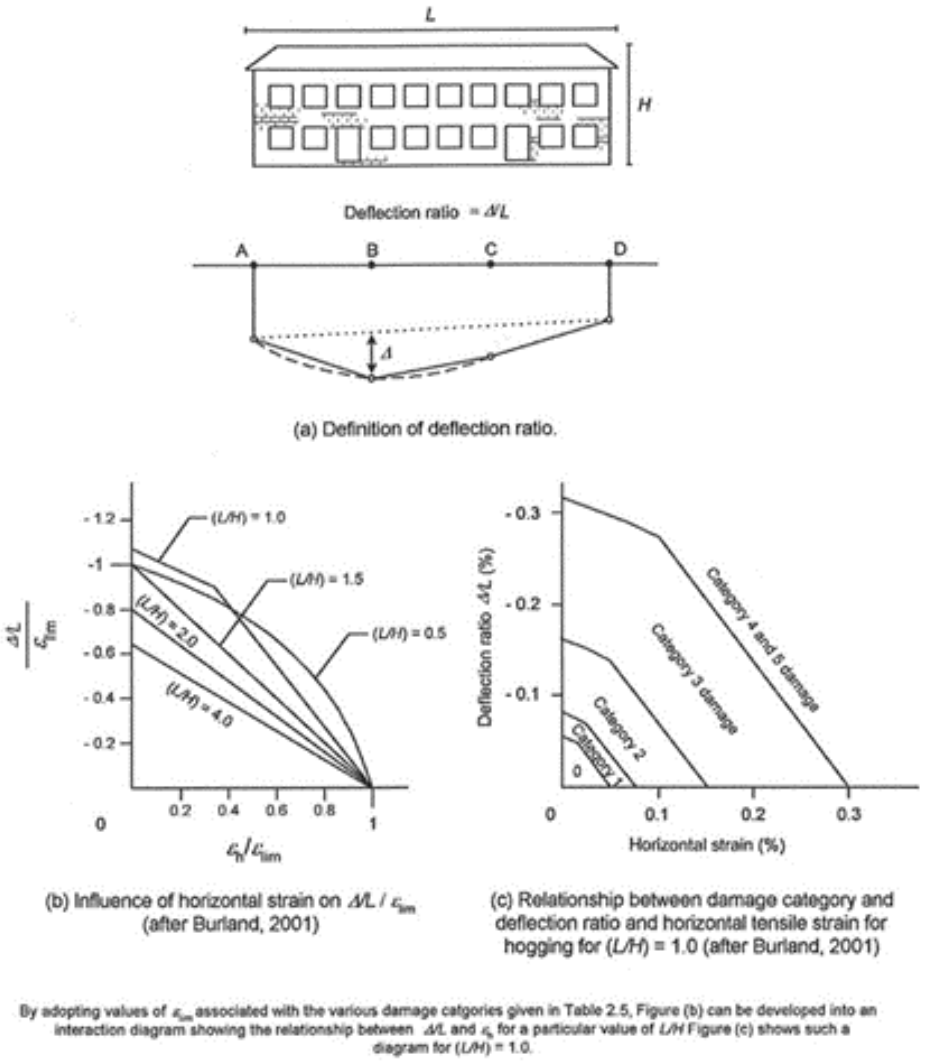


Figure 20 - Relationship between damage category, deflection ratio and horizontal tensile strain (from CIRIA C760)

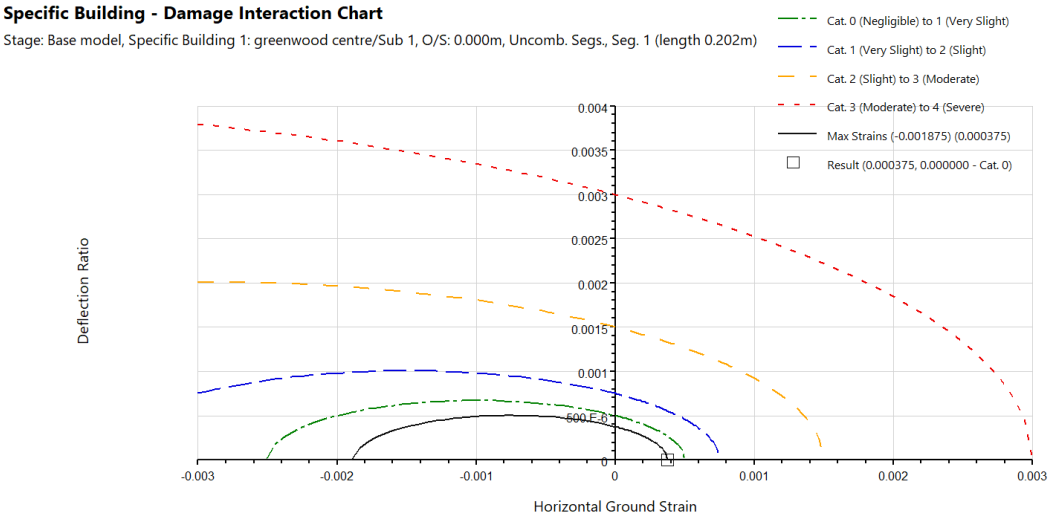


Figure 21 - Preliminary damage category for Greenwood Centre - negligible

6.3 Preliminary Assessment of Impact on the Fleet Sewer

The Western edge of the site overlays the Fleet Sewer at shown in Figure 22. The sewer is understood to be 1.395m in diameter, with invert level at circa +29.3mOD.

Figure 22 - Location of Fleet Sewer

Movements at the centre line of the sewer have been analysed in PDISP and are shown for the occur in the long term case (largest movements) movements in Figure 23. Calculated movement varies from a settlement of 30mm to a heave of 26mm.

It is highlighted that the assessment is considered conservative due to the simplified ways that load is applied onto the sewer. In reality an exclusion zone has been agreed which will further distribute applied load.

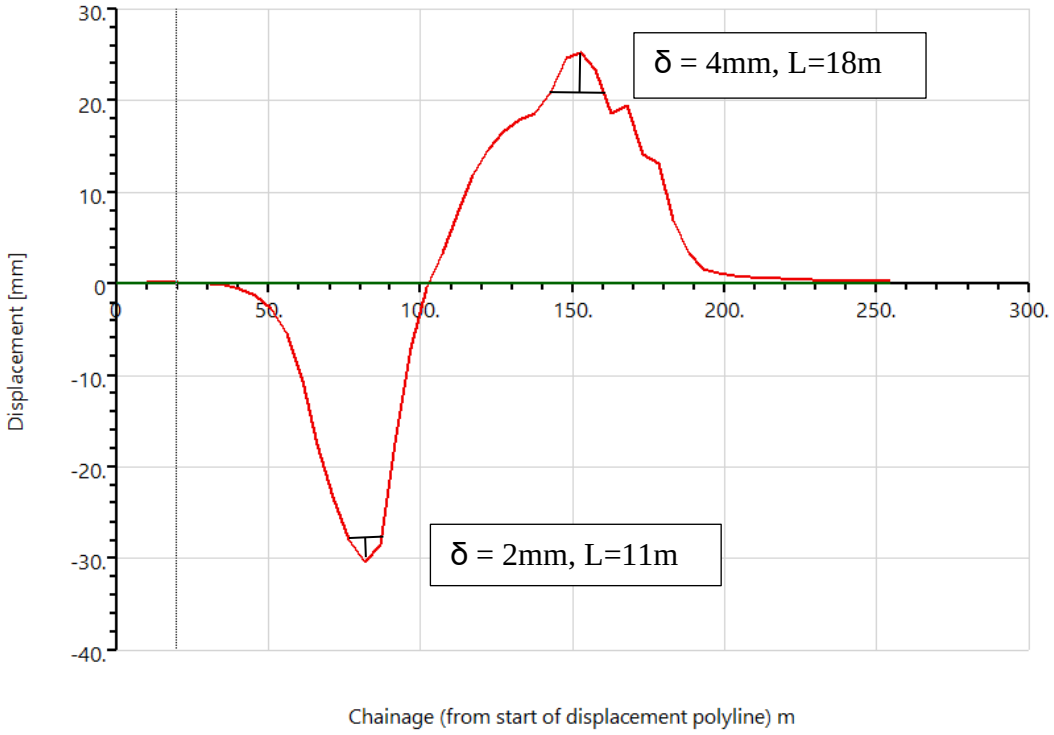


Figure 23 - Displacements of Fleet Sewer in the Long Term

The calculation of Radius of Curvature is shown in Figure Figure 24. Tensile bending strain = sewer radius/ radius of curvature.

For the portion of the sewer in settlement, the highest curvature and tensile bending strain are given by:

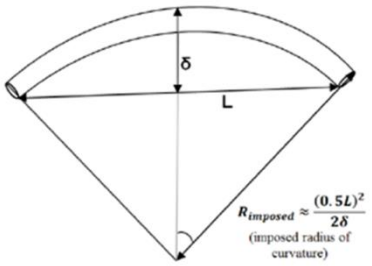
R = (0.5 x 11)2/ (2 x 0.002) = 7,562 m

ε = (1.395/2)/7562 = 92 με

For the portion of the sewer in heave, the highest curvature is given by:

R = (0.5 x 18)2/ (2 x 0.004) = 10,125 m

ε = (1.395/2)/10125 = 69με



Longitudinal deformation and calculation of imposed radius of curvature

Figure 24 - Calculation of radius of curvature

The criteria understood to be acceptable by TW for tensile strain are shown in Figure 25. The sewer is considered likely to be of brick construction, with allowable increase in tensile strain of 500 με. Therefore, it is considered that movements are likely to be acceptable. A detailed impact assessment will be carried out as part of TW approvals.

Table 7 – Water utility assessment criteria existing pipeline and sewer assets

Pipe Type		Diameter (mm)	Allowable Increase in Strain		Rotation (°)	Pullout (mm)	E Modulus (kPa)	Poisson's Ratio	Axial Strain g factor (RF)		Action
			Tension (με)	Compression (με)					Tension	Compression	
Brick sewer	Red/yellow brick	N/A	500[1]	25% of allowable stress*	N/A	N/A	5.20E+06	0.110	1.0	0	Mitigation to be agreed on exceedance of assessment criteria
	Blue brick						1.56E+07	0.160			
Cast iron	Lead-yarn joints (pre-1914)	N/A	100[2]	1200[2]	0.1[2]	15.0[2]	8.00E+07	0.260	0.2	0.2	Mitigation to be agreed on exceedance of assessment criteria
	Lead-yarn joints (spun iron)						1.00E+08				
Ductile iron	Lead-yarn gasket joints	N/A	500[3]	700[3]	0.5[3) 7)]	25[3]	1.74E+08	0.275	0.2	0.2	Mitigation to be agreed on exceedance of assessment criteria
	Rubber gasket joints		500[4]	700[4]	2.0[4]	25[4]					
Steel		N/A	450[4]	450[4]	1.5[4]	25[4]	2.05E+08	0.260	0.2	0.2	Mitigation to be agreed on exceedance of assessment criteria

Vitrified clay	<125	80[7]	400[7]	0.5	7.5	5.00E+07	0.175	0.2	0.2	Mitigation to be agreed on exceedance of assessment criteria
	>125	80[7]	400[5][7]	See Table 8	12.5					Low – Med Criticality: **MON+PPCS** High Criticality: **MON+Replace**
		80[7]								**Replace**
Concrete	<225	20[7]	400[7]	0.5	7.5	5.00E+07	0.175	0.2	0.2	Mitigation to be agreed with TWUL on exceedance of assessment criteria
	225-750	40[7]	400[5][7]	See Table 8	12.5					Low – Med Criticality: **MON+PPCS** High Criticality: **MON+Replace**
		>40								**Replace**
	>750	60[7]	400[5][7]							**Replace**

* - interpreted as equivalent strain, as indicated by British Standard

MON – monitor

PPCS – pre and post construction survey

Figure 25 - TW assessment criteria

6.4 Monitoring

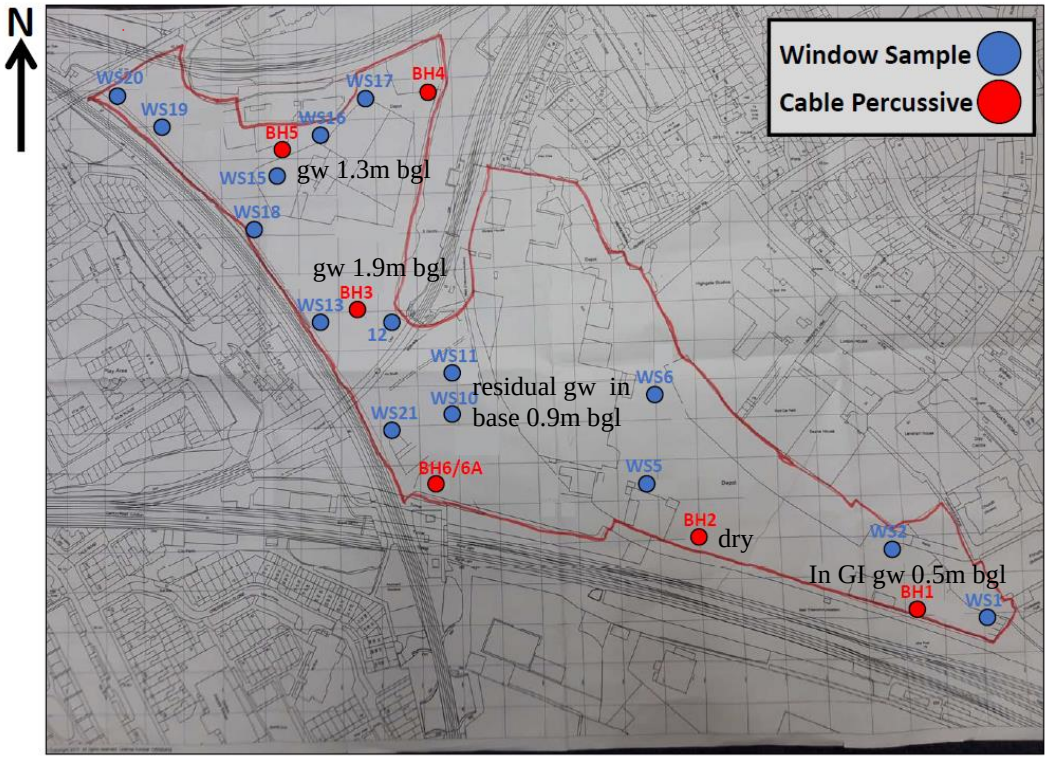
A detailed monitoring strategy will be developed in conjunction with the third parties for both the Fleet Sewer and Rail Tunnel across the site.

Due to the low level of impact, no monitoring will be undertaken to neighbouring properties.

6.5 Groundwater Flow Assessment

The potential impact, which has been considered, is whether the basement works will impact on the groundwater level locally and whether this will impact neighbouring structures and infrastructure.

Groundwater is present within the Made Ground which lies directly above the London Clay. The London Clay is an aquiclude. The perched water sits above the surface of London Clay and follows the topography.



Borehole N°	Date	Response Zone (m)	Water Level (m bgl)	Stratum
BH2 (Standpipe)	18/04/2019	0.50 – 6.50	Dry	Made Ground / London Clay
	30/04/2019		Dry	
	22/05/2019		Dry	
	04/06/2019		Dry	
	18/06/2019		Dry	
	03/07/2019		Dry	
BH3 (Standpipe)	18/04/2019	0.50 – 4.00	2.11	Made Ground
	30/04/2019		2.17	
	22/05/2019		2.15	
	04/06/2019		2.19	
	18/06/2019		1.92	
	03/07/2019		2.02	
BH5 (Standpipe)	18/04/2019	0.50 – 3.50	1.29	Made Ground
	30/04/2019		1.32	
	22/05/2019		NR	
	04/06/2019		NR	
	18/06/2019		NR	
	03/07/2019		NR	
WS10 (Standpipe)	18/04/2019	0.10 – 1.00	NR	Made Ground
	30/04/2019		0.99	
	22/05/2019		0.89	
	04/06/2019		0.89	
	18/06/2019		0.90	
	03/07/2019		0.90	

NR = not read. WS10 – very small amount of residual water detected in bottom of standpipe.

Figure 26 - Summary of groundwater levels measurements in IFA 2019 GI

Groundwater strikes were encountered at exploratory holes in the Ian Farmer GI. Water levels were monitored in the post-fieldwork. The measurements are summarised in Figure 26. Note that the standpipes to the north of the NR tunnel did not extend the full depth of the Made Ground. It is possible and likely that the groundwater level measurements there represent perched groundwater above clay layers within the Made Ground.

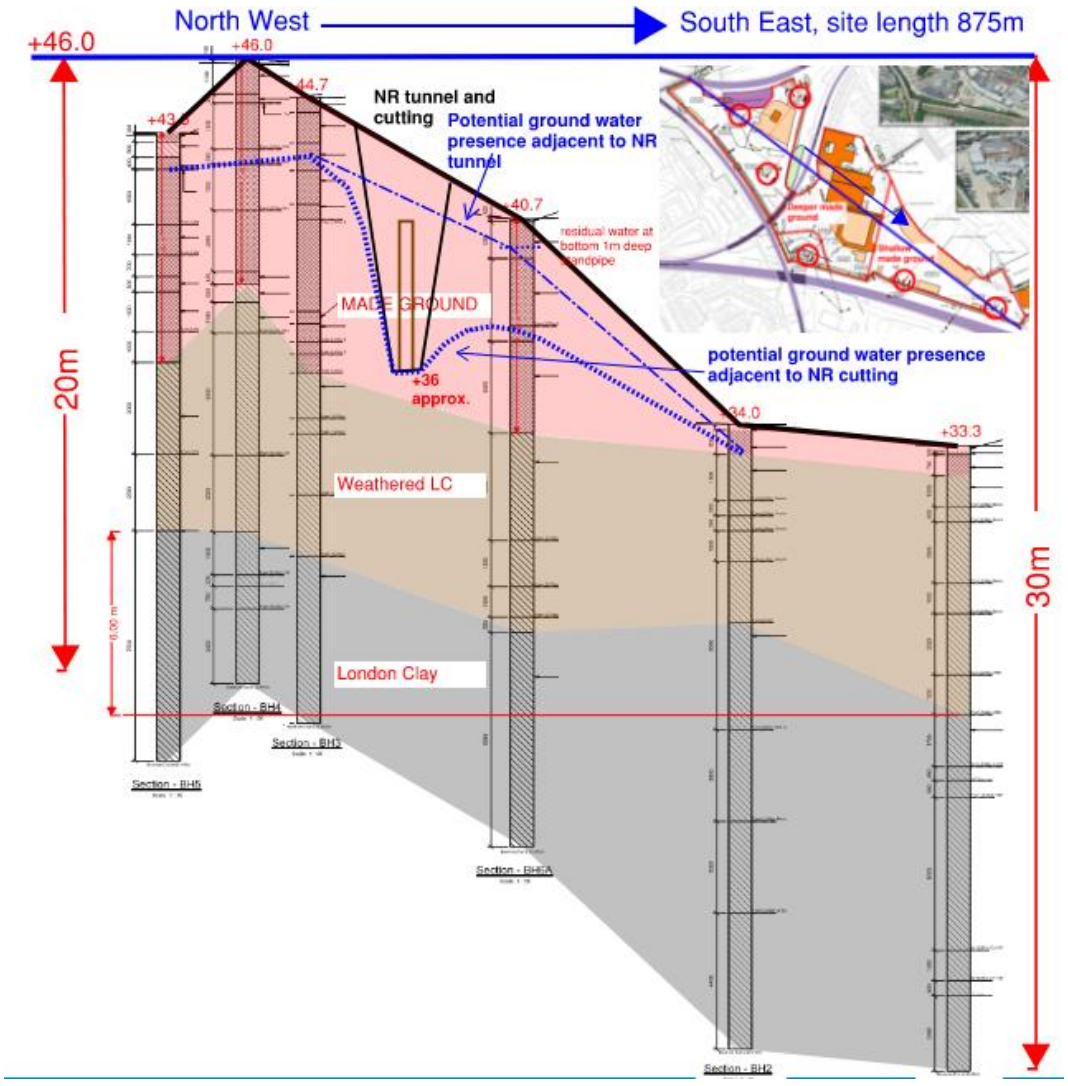


Figure 27 - Interpreted potential presence of groundwater across the site

The interpreted potential ground water levels across the site are shown above. Groundwater table follows the slope of the top of London Clay and topography, groundwater flows in direction of north to south.

Locally, the NR cutting (along with the associated track drainage) is thought to act as a drain for groundwater. As a result, groundwater level is depressed close to the cutting and tunnel. The Network Rail tunnel is also likely to act as a drain. However, an alternative profile of groundwater level is also indicated in Figure 27 if this is not the case. The hydraulic gradient follows the slope of topography, becoming smaller approaching the south end of the site as the slope of the surface and the London Clay surface becomes gentler.

6.5.1 Assessment of basement impact

Plot Q

The proposed ground level for the excavation near the north side of the site is at +44.6mOD. This is above the anticipated ground water level of approximately +42.5mOD at this location. The excavation, which varies in depth up to 2m deep, may be carried out in open cut or with a contiguous piled wall locally, and will be above water table and it will not impede the groundwater flow. It is therefore considered that there will be no impact on the groundwater north to the NR tracks.

Plot S, Plot L, Plot K

The excavation of Plot S in the middle of the site varies up to 6.5m deep. It has a ground floor level at +34.5 mOD, 1.3m below ground level adjacent to the NR tunnel track. Basement depths at Plot L and Plot K may be up to 4m deep, with formation at around +39mOD. The retaining walls of these basements may be secanted or contiguous, but will not be secanted below the formation level. Groundwater can flow beneath the basement as well as around it. It is therefore considered that this excavation will not have a significant impact on ground water level at the adjacent NR track.

Plot C

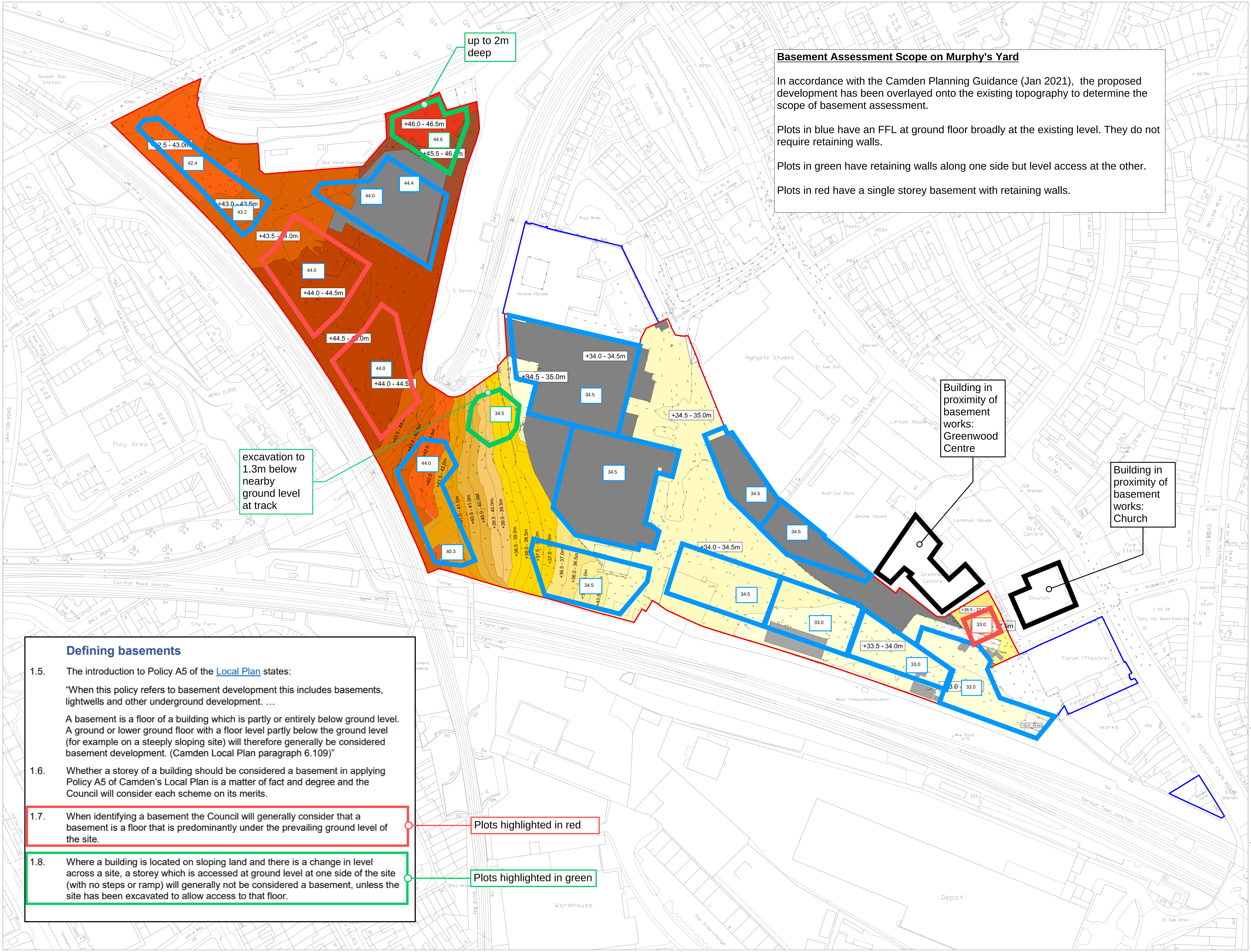
At the south side of the site there is a basement excavation in the vicinity of the Greenwood Centre and the Christ Apostolic Church. This basement is a single storey 4m deep and 25m wide, extending about 1m through Made Ground into the London Clay beneath. The basement will therefore intercept about 0.5m depth of water flowing through the Made Ground.

The Greenwood Centre is located about 9m distance from the proposed basement. The foundations or whether it has a basement are not known. At this distance, any small localised damming effect to the 0.5m depth of groundwater over the 25m length of basement wall will not be significant. The change in water levels are expected to be within normal range of seasonal fluctuations.

The Christ Apostolic Church is located further from the basement and no significant impact is expected

Appendix A

Existing & Proposed Site Topography



Basement Assessment Scope on Murphy's Yard

In accordance with the Camden Planning Guidance (Jan 2021), the proposed development has been overlayed onto the existing topography to determine the scope of basement assessment.

Plots in blue have an FFL at ground floor broadly at the existing level. They do not require retaining walls.

Plots in green have retaining walls along one side but level access at the other.

Plots in red have a single storey basement with retaining walls.

Defining basements

1.5. The introduction to Policy A5 of the Local Plan states:

"When this policy refers to basement development this includes basements, lightwells and other underground development. …

A basement is a floor of a building which is partly or entirely below ground level. A ground or lower ground floor with a floor level partly below the ground level (for example on a steeply sloping site) will therefore generally be considered basement development. (Camden Local Plan paragraph 6.109)"

1.6. Whether a storey of a building should be considered a basement in applying Policy A5 of Camden's Local Plan is a matter of fact and degree and the Council will consider each scheme on its merits.

1.7. When identifying a basement the Council will generally consider that a basement is a floor that is predominantly under the prevailing ground level of the site.

1.8. Where a building is located on sloping land and there is a change in level across a site, a storey which is accessed at ground level at one side of the site (with no steps or ramp) will generally not be considered a basement, unless the site has been excavated to allow access to that floor.

General Notes

No implied licence exists. This drawing should not be used to calculate areas for the purposes of valuation. Do not scale this drawing. All dimensions to be checked on site by the contractor and such dimensions to be their responsibility. All work must comply with relevant British Standards and Building Regulations requirements. Drawing errors and omissions to be reported to the architect.

Notes

For Information:

- Outline Application Boundary
- Ownership Boundary
- Existing Buildings
- +33.00-34.00m
- +34.00-35.00m
- +35.00-36.00m
- +36.00-37.00m
- +37.00-38.00m
- +38.00-39.00m
- +39.00-40.00m
- +40.00-41.00m
- +41.00-42.00m
- +42.00-43.00m
- +43.00-44.00m
- +44.00-45.00m
- +45.00-46.00m

Rev	Date	Reason for Issue	Chk

Keyplan

N

Scale Bar

0 50m

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Client
FOLGATE ESTATES

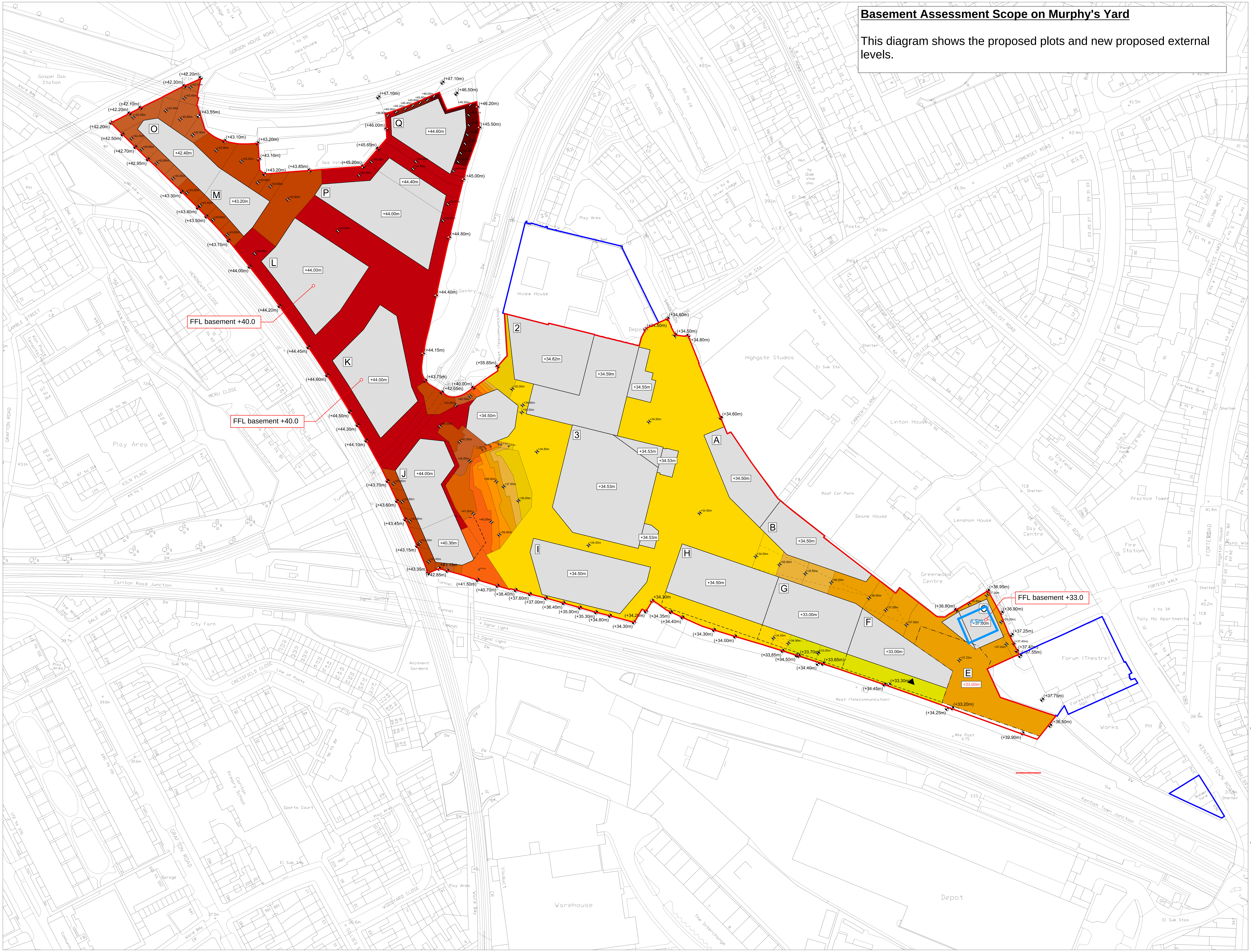
Project
MURPHY'S YARD

Drawing Title
Parameter Plan 02
Existing Site Levels Plan

Project Number	Status
0360	PLANNING
Scale at A1 (A3)	Date
1:1000	28.05.21
Drawn by	Checked by
CR	SEW
Drawing Number	Revision
0360-SEW-ZZ-ZZ-DR-A-PL6001	00

Basement Assessment Scope on Murphy's Yard

This diagram shows the proposed plots and new proposed external levels.



General Notes

No implied licence exists. This drawing should not be used to calculate areas for the purposes of valuation. Do not scale this drawing. All dimensions to be checked on site by the contractor and such dimensions to be their responsibility. All work must comply with relevant British Standards and Building Regulations requirements. Drawing errors and omissions to be reported to the architect.

Notes

For Information:

- Outline application boundary
- Ownership Boundary
- Development Zone
- Development Zone above ground floor
- Below Ground Development Zone

For Approval:

- +33-34m
- +34-35m
- +35-36
- +36-37
- +37-38
- +38-39
- +39-40
- +40-41
- +41-42
- +42-43
- +43-44
- +44-45
- +45-46
- +46-47
- +00.00m Spot level height
- (+00.00m) Existing spot level height
- +xx.xxm Ground floor FFL
- +xx.xxm Ground floor FFL for below ground development zone

Notes:
1. Ground floor FFL's can deviate +/-1.0m.
2. Proposed site levels can deviate +/-1.0m.
3. To be read in conjunction with Design Code and Development Specification.

Rev	Date	Reason for Issue	Chk

Keyplan

Scale Bar 0 50m

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Client
FOLGATE ESTATES

Project
MURPHY'S YARD

Drawing Title
Parameter Plan 06
Proposed Site Levels Plan

Project Number	Status
0360	PLANNING
Scale at A1 (A3)	Date
1:1000	28.05.21
Drawn by	Checked by
CR	SEW
Drawing Number	Revision
0360-SEW-ZZ-ZZ-DR-A-PL6005	00