Appendix C

CGL Basement Impact Assessment

Providing Ground Solutions

Morph Structures

22 Lawn Road, Camden

Basement Impact Assessment

December, 2021

Card Geotechnics Limited
4 Godalming Business Centre
Woolsack Way, Godalming GU7 1XW
Telephone: 01483 310600
www.cgl-uk.com

Author	Annabel Maxted, Graduate Engineer *BSc (Hons) ACSM* Madeleine Monnickendam, Graduate Engineer *MSci (Hons) GMICE FGS* Madeleine Groves, Chartered Senior Engineer *MSci (Hons) CEng MICE*		
Checked	Nick Langdon, Business Director *MSc BEng DIC CEnv CEng FICE FGS* Adam Branson, Associate *MGeol (Hons) CGeol FGS CMgr MCMI GMICE*		
Approved	Richard Ball, Technical Director *MSc BSc CEng MICE FGS*		
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NON – TECHNICAL SUMMARY

Card Geotechnics Limited (CGL) was instructed by Morph Structures Limited ("the Client") to undertake a Basement Impact Assessment (BIA) for a proposed development at 22 Lawn Road, London Borough of Camden, London, NW3 2XR. The proposed development is understood to comprise the extension of the lower ground rear garage space to the back line of the main house, and the demolition of the conservatory and subsequent replacement with a single storey extension. The following section summarises the evidence, conclusions and recommendations contained within the report.

1. The site is comprised of a lower ground level garage at the rear of the property, and the main mid-terraced house has a ground, first and second floor. There are gardens present at the front and rear of the property. The front garden does not have a change in elevation from the pavement on Lawn Road. The rear garden has four different levels; an elevated wooden deck, a slab covered deck above the garage, the original level of the garden below the deck and the lower garage level. The existing topographic survey is included in Appendix A.

2. The proposed development at 22 Lawn Road comprises the extension of the lower ground rear garage space to the back line of the main house, the demolition of the conservatory which is to be replaced with a single storey extension. The proposed development drawings can be seen in Appendix B.

3. The site shares party walls to the north and south by the neighbouring terraced houses, 23 and 21 Lawn Road, respectively. To the west, the site is bound by the pavement on Lawn Road and to the east is bound by the private road.

4. The Belsize Tunnel and associated railway tracks runs roughly south-west to north-east beneath the site. CGL in house information indicates the crown of the tunnel is inferred to be at approximately 47mOD (however this should be confirmed with Network Rail), approximately 8m below the proposed excavation level on site. It is noted that air raid shelters are attached to the Belsize tunnel. Available records indicate entrances to these shelters are present around 200m west of the site.

5. The trial pit findings indicate the party wall between 22 Lawn Road and 23 Lawn Road has a foundation formation level of some 7.06mSD at the east of the proposed development area. In the west of the proposed development area on site, the party wall foundation of 22 Lawn Road and 23 Lawn Road is approximately 8.62mSD.

6. At 21 Lawn Road the foundation formation level was found to be between 8.04mSD and 7.53mSD.

7. An intrusive ground investigation was undertaken by CGL in October 2021 comprising five hand-dug foundation inspection pits. The ground conditions beneath the site comprised of up to 0.5m of Made Ground over the London Clay Formation which was proven to a depth of 1.2mbgl on the lowest ground level present on the site. No borehole was drilled on the site due to the underground railway tunnel.

8. Groundwater was not encountered in any of the foundation inspection pits during the ground investigation. The London Clay Formation is designated as an unproductive stratum.

9. A screening and scoping exercise has been carried out to identify the issues requiring detailed assessment. This includes a Ground Movement Assessment (GMA) which has been carried out to assess the impact of the proposed development on the party structures, neighbouring properties and the railway tunnel below.

10. The BIA has identified no significant potential hydrogeological impacts and no impacts to the wider hydrogeological environment.

11. The BIA has identified that the site is not in an area at risk of flooding and does not significantly affect the surface water flow and flooding.

12. The predicted building damage categories at 23 Lawn Road (where no lower ground floor is present) and 21 Lawn Road are Category 0 ‘negligible’ damage. Where a lower ground floor is present at 23 Lawn Road it is considered that the damage category can be limited to Category ‘0’ assuming lateral movements from underpin construction of 1mm, which is considered to be achievable given underpins at this section are anticipated to be ~0.35m deep.

13. Vertical movements at the private gated road to the east of the site are approximately 1mm and are not considered significant.

14. A preliminary review of ground movements at the Belsize tunnel predicted movements at the approximate tunnel crown of less than 1mm. A detailed assessment on the railway may be required.

1. INTRODUCTION

Card Geotechnics Limited (CGL) was instructed by Morph Structures ("the Client") to undertake a Basement Impact Assessment (BIA) for the proposed extension to an existing basement level garage at 22 Lawn Road, London Borough of Camden, London, NW3 2XR.

The BIA approach follows the current planning procedure for basements adopted by the London Borough of Camden[1]. This requires a Basement Impact Assessment (BIA) to be undertaken for new basements in the Borough and sets out five stages for a BIA to "*enable the Borough to assess whether any predicted damage to neighbouring properties and the water environment is acceptable or can be satisfactorily ameliorated by the developer*". The five stages are set out below:

1. Screening
2. Scoping
3. Site investigation
4. Impact assessment
5. Review and decision making

A desk study and site investigation have been carried out by CGL in 2021, the factual findings of these are included in this report and used to inform the basement impact assessment.

This report identifies the key issues relating to land stability, hydrogeology and hydrology as part of the screening process (Stage 1) and includes a review and interpretation of site investigation data and local ground conditions to establish a conceptual site model (Stages 2 and 3). The report provides an impact assessment (Stage 4) of potential ground movements on adjacent structures and the hydrogeology of the surrounding area for the purposes of planning.

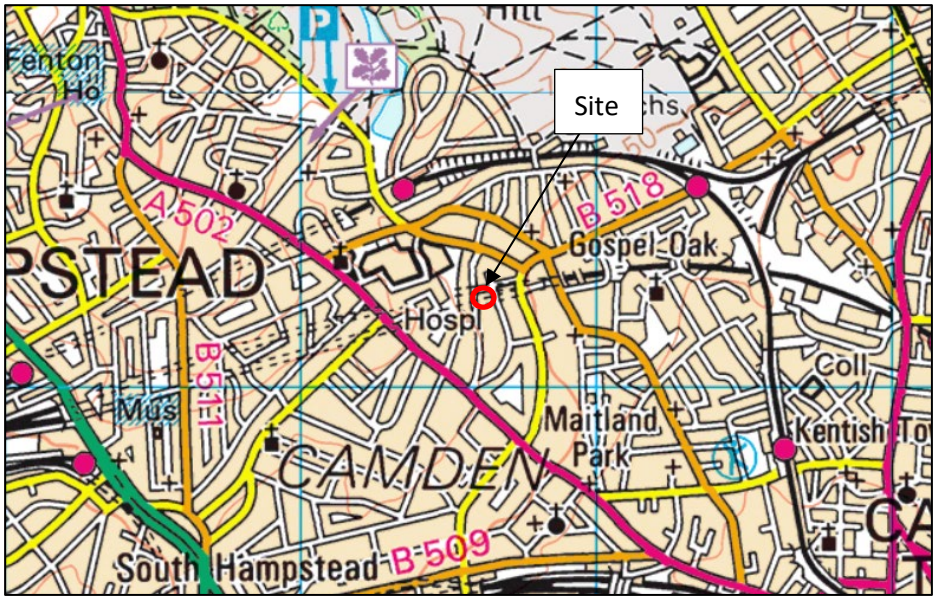
[1] London Borough of Camden. (2021). *Camden Planning Guidance – Basement*. January 2021.

2. SITE CONTEXT

2.1 Site Location

The site is located at 22 Lawn Road, NW3 2XR in the London Borough of Camden in London. Approximate National Grid coordinates for the site are 527567E, 185247N. A site location plan is presented in Plate 1.

Plate 1: Site location plan.



2.2 Site Description

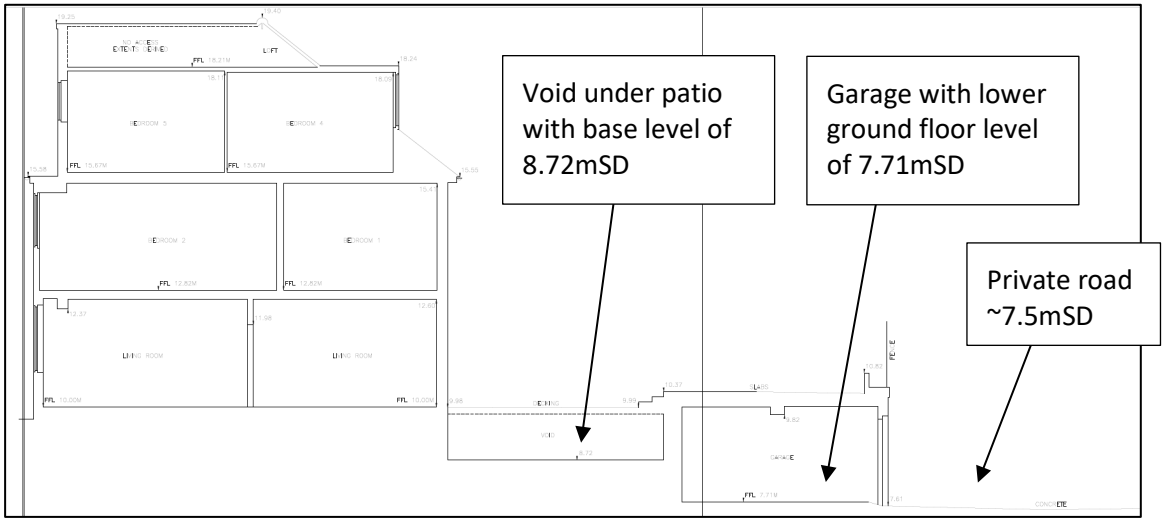
The site is approximately 0.016 hectares in area and rectangular in shape. A site layout is displayed in Figure 1. The site is bound to the north by 23 Lawn Road and to the south by 21 Lawn Road, which the property shares party walls with. It is bound to the west by Lawn Road and to the east by the private road that fronts onto residential houses. A railway tunnel, Belsize Tunnel, runs beneath the site. Based on CGL in house information the tunnel crown level is anticipate to be at approximately 47mOD, however this should be confirmed by Network Rail. Opposite the site are the Isokon Flats, a Grade I listed building. These are approximately 30m from the proposed basement and are not anticipated to be affected by the development. Belsize Park Deep air raid shelters are attached to the Belsize tunnel, with available records indicating entrances to these shelters are present around 200m west of the site.

The topographic survey of the site is presented in Appendix A. The survey is recorded in metres above site datum (mSD) where the ground floor level of the existing building is 10mSD.

The site is occupied by a three storey mid-terrace house, 22 Lawn Road, with soft landscaping at the front of the property. At the back of the property there is a conservatory, patio area and garage. The garage fronts onto a private road that runs from 28 Lawn Road to 22 Lawn Road and is accessed from

Garnett Road north of the site. A site layout is shown in Figure 1. The patio, with a floor level of 9.99mSD, is covered with a decking and has a void beneath to a level of 8.72mSD, as shown in Plate 2. The garage is at a lower floor level of 7.71mSD. The level of the floor above the garage in 10.37mSD.

Plate 2: Section through existing site.

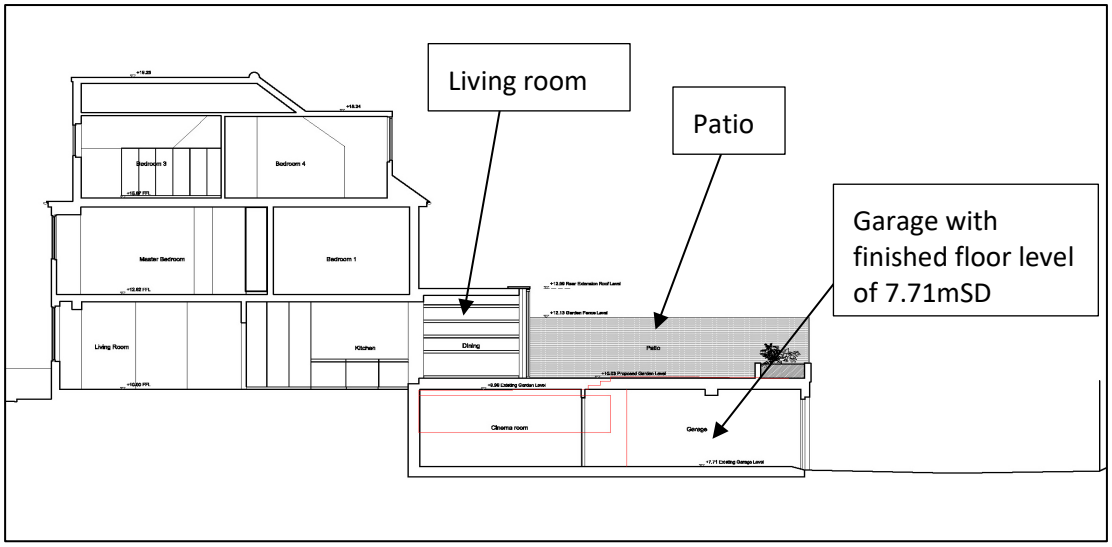


2.3 Proposed Development

It is understood that the proposed development comprises the extension of the lower floor garage west to the boundary of the existing building and the extension of the existing building above part of the new garage, as shown in

Plate 3. The excavation level for the proposed basement extension is indicated by drawing 3197-MORPH-ZZ-BB-DR-S-5001 to be at some 7.01mSD (0.7m below a FFL of 7.71mSD). The foundations are proposed to be a 250mm thick reinforced concrete slab with local thickenings. Where thickenings in the slab are not present, heave protection will underly the 250mm slab. The proposed development will involve an excavation from the existing void level of 8.72mSD to 7.01mSD, some 1.71m.

Plate 3: Section through proposed development.



The basement excavation sequence comprises removing the existing timber decking above the patio void, underpinning the void to the new lower ground floor level, excavation to the new lower ground floor level and installation of the retaining walls, concrete floor slab and heave protection. Then, the upper floor beam and block floor will be installed.

The proposed development plans, excavation sequence and loads are included in Appendix B.

2.4 Neighbouring Structures

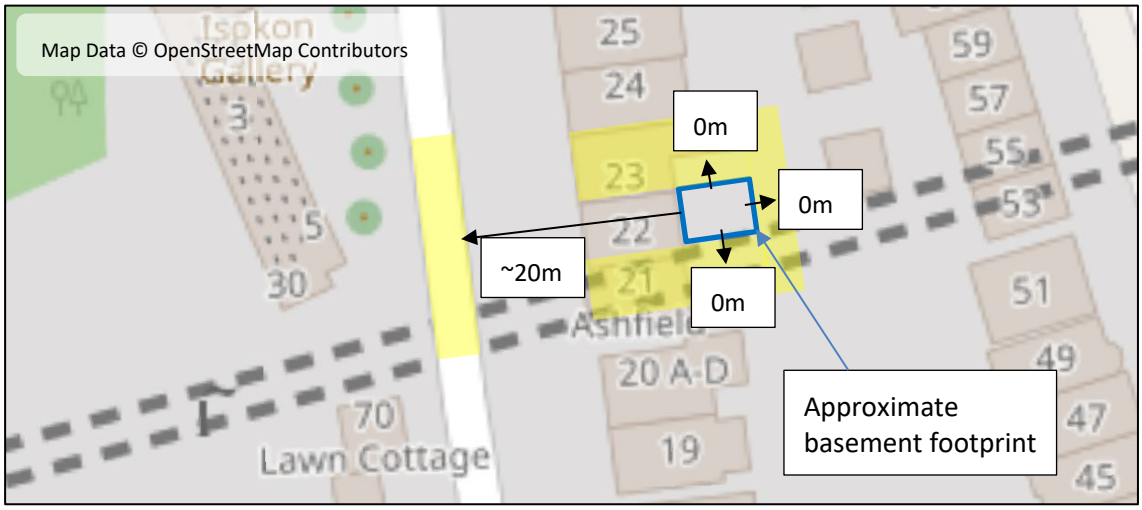
There are 3 structures/assets adjacent to the site to be considered for assessment which may potentially be affected by construction of the proposed basement:

- 23 Lawn Road north of the site;
- 21 Lawn Road south of the site; and
- Private gated road at the east of the building.

The locations of these neighbouring structures are highlighted in yellow in

Plate 4, below, with approximate distances included. Lawn Road is additionally highlighted; however this is located some 20m from the proposed development therefore it is considered the proposed development will not have a significant impact on this.

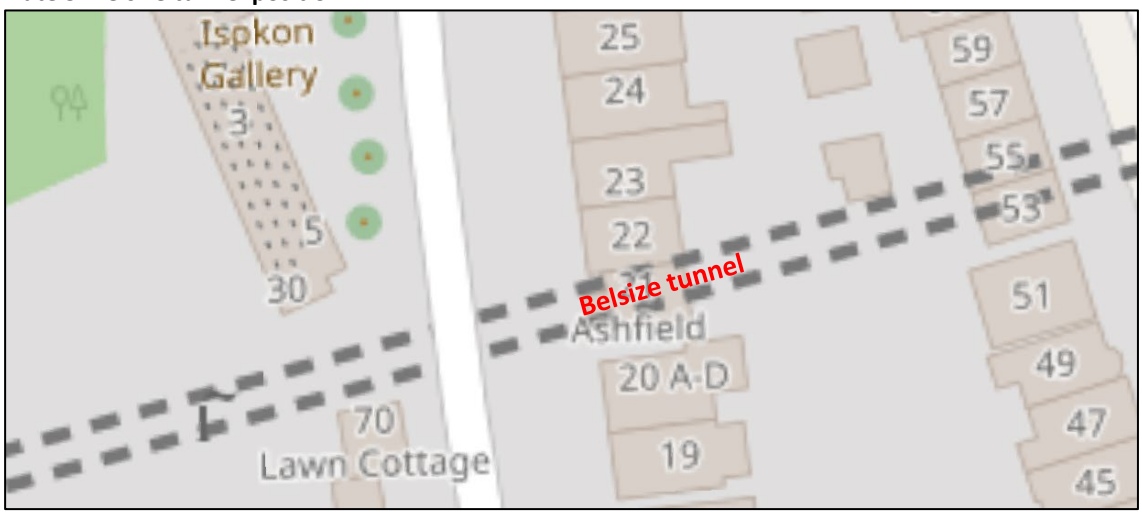
Plate 4: Location and distance of adjacent structures (highlighted in yellow) considered for the assessment.



2.5 Buried Infrastructure

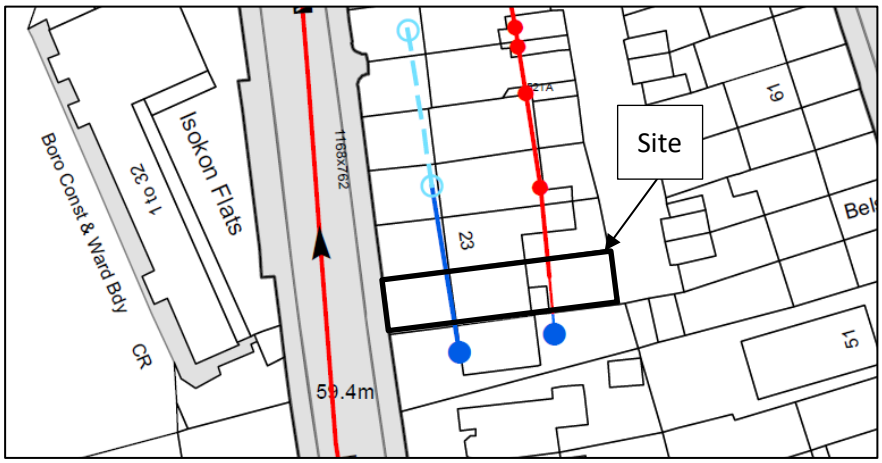
The Belsize Tunnel and railway tracks run roughly south-west to north-east beneath the site as shown on Plate 5. CGL in house information indicates the crown of the tunnel is inferred to be at approximately 47mOD, however this should be confirmed with Network Rail. The proposed excavation area is small, includes no piling and is shallow with the proposed floor level equal to the existing garage floor level. The risk is therefore anticipated to be very low. A preliminary assessment of movements at the approximate tunnel position will be provided in this report, however a detailed assessment is outside the scope of this report.

Plate 5. Belsize tunnel position



A Thames Water Asset Location Search has been provided by Morph Structures Limited and is included in Appendix C. It indicates that the patio/garage is underlain by a Thames Water combined sewer and that the front of the property is underlain by a combined sewer not operated/maintained by Thames Water. The impact of the proposed development on the sewers is not considered in this report.

Plate 6: Excerpt from Thames Water Asset Location Search.



3. DESK STUDY

3.1 Sources of Information

The desk study is based on a review of available records, historical mapping (Appendix D), a Groundsure Enviro Insight and Geo Insight Report (Appendix E) and published and unpublished geological, hydrological and hydrogeological records.

3.2 Site History

The historical development of the site has been traced from Ordnance Survey maps dating between 1871 and 1874 provided by Groundsure. The maps were produced on scales ranging from 1:1056 to 1:10560 and are presented in Appendix D.

Details of the site history and the surrounding area are summarised in Table 1 and Table 2 below, with approximate distances taken from the boundary of the site.

Table 1. Summary of onsite development

Historical Feature	*Area of Site*	*First Date Mapped*	*Last Date Mapped*	*Comments*
Belsize Railway Tunnel	Beneath the site, running east to west	1870	2021	Part of the Midland Main Line, this stretch was constructed between 1865 and 1867 linking Bedford to London St Pancras. LiDAR tiles indicate that track level 180m east of the site is at approximately 38mOD.
Terraced house	Entire site	1951	2021	The property on site appears to have been constructed very soon after the Second World War

Table 2. Summary of pertinent offsite development.

Historical Feature	*Distance/Direction from Site*	*First Date Mapped*	*Last Date Mapped*	*Comments*
North Western Fever Hospital	200m north-west	1894	2021	Renamed 'Fever Hospital' in 1920 extract. Renamed 'Royal Free Hospital' in 1953 extract.
Tramway Depot	90m north-east	1896	1896	
London Street Tramway Company's Depot	200m north-west	1896		Renamed "Tramway Depot (L.C.C.)" in 1915 to 1916 extract.
Play Ground	80m north	1896	1915-1916	
Air Shaft	90m north-west	1896	Present day	
Air Shaft	180m east	1896	1991-1995	
Air Shaft	180m east	1896	1963-1966	
Schools	200m north	1896	1935-1936	
Nursery	250m south-west	1896	1963-1966	
Laundry	200m north	1896	1935	
Nursery	180m east	1915-1916	1991-1995	
London Street Tramway Company's Depot	250m north-west	1896	1958	
Tube Station	250m south-west	1915-1916	Present day	Renamed "Station (L. P. T. B.)" in 1935-1936 extract

Historical Feature	*Distance/Direction from Site*	*First Date Mapped*	*Last Date Mapped*	*Comments*
				Renamed "Belsize Park Station (London Transport)" in 1953-1953 extract
Paper Mill	200m north	1936	1970	'Paper Goods Works' or 'Works' in extracts from 1952 onwards
Cardboard Box Works	110m north-east	1952	1954	No significant changes noted
Deep Shelter (Belsize Park Deep Shelter)	225m west	1952-1953	1991-1995 (not within map area for more recent maps)	
Tank	240m south-west	1952-1953	1963-1966	
Belsize New Tunnel	40m north	1952-1953	Present day	
Warehouse	90m north-west	1952-1953	1952-1954	
Real Haulage Depot	90m north-west	1952-1953	1952-1954	
Electricity Sub-Station	200m south-west	1969-1974	1991-1995	
	200m north	1969-1974	1991-1995	
Ambulance Station	230m north	1981-1985	2010	
Ambulance Station	230m north	1952-1953	1969-1974	Renamed "North West Ambulance Station" in 1965 extract

3.2.1 Planning History

CGL undertook a search of planning history on 22 Lawn Road using the London Borough of Camden planning search tool[2]. This returned one record with application number 2021/4953/P registered on the 19th November 2021 pertaining to the replacement of the existing extension with a full width extension, raising of rear garden decking and minor alternations to the residence.

3.3 Unexploded Ordnance (UXO)

The Preliminary UXO Risk Assessment Report by 1st Line Defence is provided in Appendix F. The report assessed the risk from unexploded ordnance on site to be low/minimal and that it is not recommended to take any further action for this site.

3.4 Anticipated Ground Conditions

3.4.1 Published Geology

With reference to the British Geological Survey (BGS) digital mapping[3] and the Groundsure GeoInsight Report (included as Appendix E), the site is directly underlain by the London Clay Formation. The London Clay Formation typically comprises overconsolidated, fissured, firm to stiff, becoming stiff to very stiff silty clay, with occasional sand partings and claystone nodules.

[2] https://planningrecords.camden.gov.uk/Northgate/PlanningExplorer/GeneralSearch.aspx [Accessed November 2021]
[3] British Geological Survey. *Geology of Britain Viewer*. https://mapapps.bgs.ac.uk/geologyofbritain/home.html

3.4.2 Unpublished Geology

With reference to the BGS website[4], six borehole records with depths greater than 5m are located within the vicinity of the site. A summary of these records is presented in Table 3. The borehole records and a borehole location plan are presented in Appendix G.

Table 3. Summary of BGS borehole records.

BGS Reference	Distance and Direction from site	Base of borehole (mbgl)	Grid Reference	Depth to Top of Stratum (mbgl) [Level (where included, mOD)]					
				Topsoil	Made Ground	London Clay Formation	Lambeth Group	Thanet Formation	Chalk
TQ28NE277	250m NW	177	527390E 185380N	-	-	0.0 [+59.28]	69.0 [-9.72]	90.0 [-30.72]	101.0 [-41.72]
TQ28NE48	250m SW	43	527370E 185100N	-	0.0	4.0	-	-	-
TQ28NE77	250m N	15.25	527540E 185500N	-	0.0 [+52.30]	0.3 [+52.00]	-	-	-
TQ28SE1163	500m S	20	527680E 184850N	0.0	0.1	2.5	-	-	-
TQ28SE1490	500m SE	119	527890E 184940N	-	-	0.0	68.0	86.6	95.1
TQ28SE3106	600m SW	110	527116E 184876N	-	0.0	1.5	90.0	105.0	-

The BGS borehole records show that the ground conditions comprise Made Ground overlying the London Clay Formation, Lambeth Group, Thanet Formation and Chalk, in succession. The top of the London Clay Formation is encountered between ground level and 4.0m below ground level (mbgl), likely due to variations in the thickness of Made Ground and topography across the area.

The records show that the London Clay Formation underlying the site is anticipated to be some 70m thick.

The groundwater conditions encountered within the BGS borehole records are presented in Table 4. The groundwater encountered in TQ28NE48 is likely a perched water body within the Made Ground, sitting just above the impermeable London Clay Formation.

Table 4. BGS historic borehole logs - Groundwater Strikes

Borehole	Depth (mbgl)	Coordinates	Groundwater Strike (mbgl)	Standing Water Level (mbgl)
TQ28SE1163	20	527680E 184850N	NE*	-
TQ28NE277	177	527390E 185380N	95.65	95.65
TQ28NE48	43	527370E 185100N	2.43	-
TQ28NE77	15.25	527540E 185500N	NE*	-
TQ28SE1490	119	527890E 184940N	NE*	-
TQ28SE3106	110	527116E 184876N	NE*	-

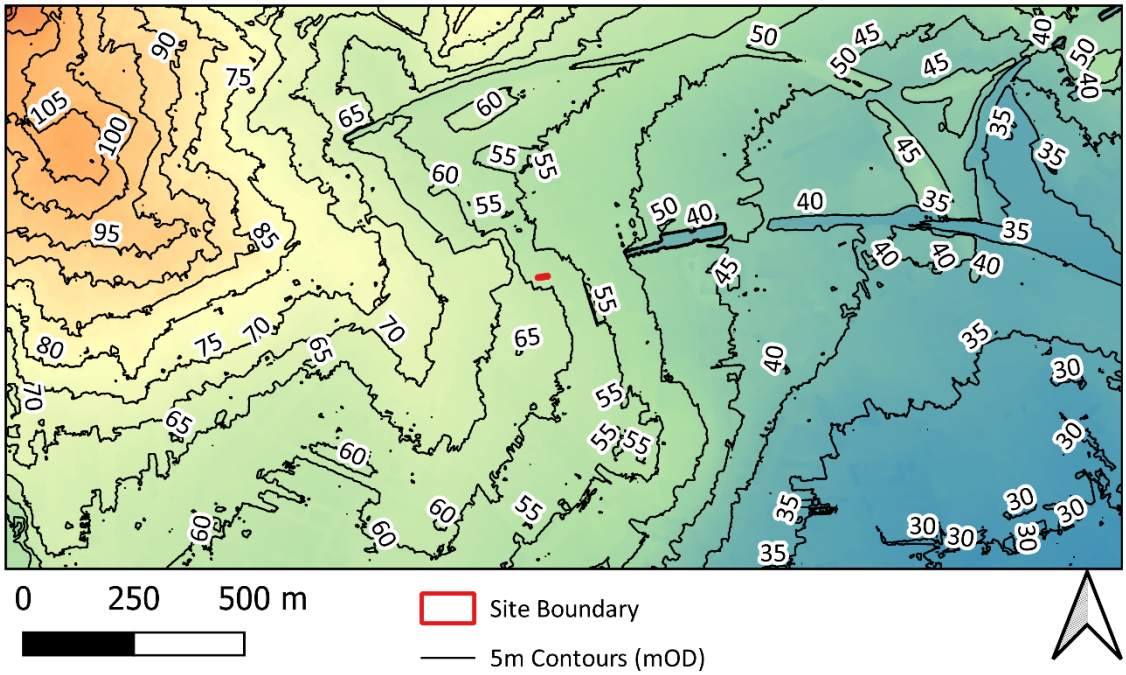
[4] BGS. http://mapapps2.bgs.ac.uk/geoindex/home.html [accessed November 2021]

*NE = Not Encountered

3.4.3 Topography

Topography surrounding the site is shown in Plate 7. The surrounding ground slopes down from Hampstead in the north-west to the south-east. The site appears to be at a level of approximately 58mOD. Assuming this relates broadly to the road level of 22 Lawn Road, relative to a site datum, at some 10mSD, and the proposed basement excavation level is at some 7.01mSD site datum, the basement excavation level in mOD is anticipated to be in the region of 55mOD, some 8m above the anticipated crown level of the Belsize tunnel (at ~47mOD).

Plate 7: Topography surrounding the site.



3.5 Hydrogeology and Hydrology

The Environment Agency (EA)[5] has produced an aquifer designation system consistent with the requirements of the Water Framework Directive. The designations have been set for superficial and bedrock geologies and are based on the importance of aquifers for potable water supply and their role in supporting surface water bodies and wetland ecosystems.

With reference to the mapping included in the Groundsure Enviro Insight report (see Appendix E), the London Clay Formation is designated an Unproductive aquifer (stratum with low permeability that have negligible significance for water supply or river base flow). The site is not located within a Source Protection Zone and there are no groundwater abstractions within 1km of the site.

[5] https://magic.defra.gov.uk/MagicMap.aspx [Accessed November 2021].

The nearest surface water feature to the site is approximately 600m to the north-west, and upslope of the site, and is the Hampstead No. 1 Pond, the closest of three bathing ponds at Hampstead Heath park.

The Groundsure Enviro+Geo Insight Report (Appendix E) and Government long term flood risk map[6] indicates that the site is at very low risk from flooding from rivers or the sea, low risk from flooding from surface water and negligible risk from groundwater. The site is not within Flood Zone 2 or 3. With respect to the Camden Geological, Hydrogeological and Hydrological Study[7] Flood Map, Lawn Road was not recorded as a flooded street in the 2002 or 1975 flood, and is not in an area with potential to be at risk of surface water flooding. With respect to the London Borough of Camden Strategic Flood Risk Assessment[8], Lawn Road is not within a Local Flood Risk Zone.

3.6 Ground Hazards

The risks associated with potential geological hazards have been assessed using the GeoInsight Report (see Appendix E). The geological hazard potential for the site is summarised in Table 5.

Table 5: Geological Hazards.

Hazard	*Risk*
Shrink-swell clays	Moderate
Landslides	Very Low
Ground Dissolution	Negligible
Compressible Deposits	Negligible
Collapsible Deposits	Very Low
Running Sands	Very Low

3.7 Environmental Setting

The Groundsure Enviro+Geo Insight Report (Appendix E) provides information on the environmental setting of the site and possible sources of ground contamination. A summary of pertinent points is set out below:

- 86 records of potentially contaminative industrial land uses within 500m of the site. One of these is within the site boundary and relates to Belsize Tunnel currently underlying the site,

[6] https://www.gov.uk/check-long-term-flood-risk [Accessed November 2021]
[7] Arup (2010) *Camden Geological Hydrogeological and Hydrological Study*. Ref. 213923
[8] URS Infrastructure & Environment UK Limited (2014) *London Borough of Camden Strategic Flood Risk Assessment*. Ref. 47070547

present since 1870. Off site uses include Tramway Depot 90m north-east of the site and North Western Fever Hospital 200m north-west of the site

- 28 records of historical energy features are recorded within 500m of the site. None of these are on site. The closest was 200m south-west of the site, present between 1974 and 1991.

- 13 records of historical tanks are recorded within 500m of the site. None of these are on site. The closest was an unspecified tank 110m south-east of the site, present between 1952 and 1991.

- 9 records of historical waste sites within 500m of the site. None of these are on site. The four relate to Waste Rag Works between 60m and 105m north of the site, dated between 1952 and 1953. The other five relate to a Scrap Yard 202m east of the site, with records between 1952 and 1965.

- 15 records of waste exemptions within 500m of the site. None of these are on site. Two are 229m north of the site at 100 Fleet Road described as sorting and de-naturing of controlled drugs for disposal. This is possibly associated with Pharmacy Republic currently located there. Three records are associated with the Royal Free Hospital on Pond Street, 300m north-west of the site. One record is 433m south-east of the site for Bouygues (UK) Ltd for use of waste in construction. Six are located 480m north-west of the site at 35 South End Road described as sorting and de-naturing of controlled drugs for disposal. This is possibly associated with the Hampstead Heath Pharmacy located there. The last three are located 494m north-east of the site at Macey Chemist, 68 Mansfield Road, also for sorting and de-naturing of controlled drugs for disposal.

- 3 records of recent industrial land uses within 500m of the site. None of these are on site. These include a pest and vermin control company, Zapem Pest Control London, 65m south of the site, an air shaft 80m north-west of the site and an electricity substation 200m south-west of the site.

- 38 records of radioactive substance authorisations within 500m of the site. These relate to the disposal or keeping and use of radioactive materials from the Royal Free Hospital or Royal Free Campus for the University College London (UCL), 290m north-west of the site with one record 256m north of the site.

- 10 records of licensed pollutant release within 500m of the site. Eight of these relate to dry cleaning companies, the closest of which is Top Choice Dry Cleaners, 220m north of the site.

One related to the Royal Free Hospital 290m north-west of the site for combustion and incineration. The last record is for a petrol station Belsize Park Service Station, 365m west of the site, for unloading of petrol into storage.

- One pollution incident record within 500m of the site. This is recorded 321m north-west of the site with a recorded Category 4 (No Impact) impact to water, land and air.
- Two records of pollution inventory radioactive waste within 500m of the site. One is located at the Royal Free Hospital 290m north-west of the site and one is 300m north-west of the site for the Royal Free Campus for UCL.
- The site is within a Sites of Special Scientific Interest (SSSI) Impact Risk Zone.
- The site is within the Parkhill and Upper Park Conservation Area.

3.8 Radon

Groundsure Enviro+Geo Insight Report (Appendix E) indicates that the site is in an area where it is estimated that less than 1% of properties in the area are likely to be affected by Radon, and therefore no Radon protection measures will be necessary.

4. SCREENING

4.1 Introduction

A screening assessment has been undertaken to assess the potential risk posed to local hydrology, hydrogeology and land stability due to the proposed basement garage construction. The assessment is undertaken in the form of a series of tables, setting out the questions with regard to the primary concerns associated with the proposed construction. Where 'yes' or 'unknown' can be simply answered with no analysis, these answers have been provided.

4.2 Subterranean (Groundwater) Flow

This section answers the questions relating to subterranean (groundwater) flow in Table 6 below.

Table 6. Subterranean (groundwater) flow

Question	*Response*	*Action Required*
1a. Is the site located directly above an aquifer?	No. The site is underlain by the London Clay Formation which is designated as an Unproductive aquifer. The site may be underlain by a small thickness of Made Ground which is not an aquifer.	None
1b. Will the proposed basement extend beneath the water table?	No. Groundwater may be present as isolated lenses or perched water in Made Ground that may be present above the London Clay Formation. It is not anticipated that there is a groundwater table in the London Clay Formation because it is impermeable.	None
2. Is the site within 100m of a watercourse, well (used/disused) or potential spring line?	No. The nearest surface water body is Hampstead No. 1 Pond, some 600m north of the site.	None
3. Is the site within the catchment of any local ponds or water courses?	No. The nearest surface water body is Hampstead No. 1 Pond, some 600m north of the site and up-hydraulic gradient from the site.	None
4. Will the proposed basement development result in a change in the proportion of hard surfaced/paved areas?	No. The proposed basement is in an area currently covered with timber decking and will therefore not increase the proportion of hard surfaced/paved areas. In addition the site is underlain by impermeable London Clay and the proposed development is not anticipated to generate additional surface runoff.	None
5. As part of the site drainage, will more water (e.g. rainfall and run-off) than at present be discharged to the ground (e.g. via soakaways and/or SUDs)?	No. No change to drainage is proposed.	None
6. Is the lowest point of the proposed excavation (allowing for any drainage and foundation space under the basement floor) close to, or lower than, the mean water level in any local pond or spring line.	No.	None

4.2.1 Non-Technical Summary: Subterranean (Groundwater) Flow

The site is underlain directly by the London Clay Formation which is impermeable and an Unproductive aquifer. The site may be underlain by Made Ground which is not an aquifer. Because the London Clay Formation is impermeable it is not considered that there is a water table in the London Clay. If Made Ground is present, any water present is likely to be isolated and perched and not a consistent water table. Therefore, the proposed basement will not extend beneath the water table.

The nearest surface water body is Hampstead No. 1 Pond, some 600m north of the site. The water in the pond is higher than the proposed excavation, however, the site is underlain by impermeable London Clay Formation and is therefore not in continuity with the pond.

The proposed basement extension is into an area currently covered with timber decking. No change to the existing site drainage is proposed. Therefore, there it is not proposed to increase the amount of water discharged to the ground.

4.3 Slope/Land Stability

This section answers questions relating to slope/land stability in Table 7.

Table 7. Slope/Land Stability

Question	*Response*	*Action Required*
1. Does the site include any slopes, natural or manmade, greater than 7° (approximately 1 in 8)?	No. With respect to the Camden Geological, Hydrogeological and Hydrological Study[7], the slope of the site is not greater than 7°.	None
2. Will the proposed re-profiling of landscaping at site changes slopes at the boundary to more than 7° (approximately 1 in 8)?	No. The proposed development does not include reprofiling of the landscape.	None
3. Does the development neighbour land, including railway cutting and the line, that has a slope greater than 7° (approximately 1 in 8)?	No.	None
4. Is the site within a hillside setting in which the slope is greater than 7° (approximately 1 in 8)?	No. The surrounding ground slopes downwards from the north-west to the south-east at a gradient of approximately 1:25.	None
5. Is the London Clay the shallowest strata at the site?	Yes. Confirmatory investigation required.	Ground Investigation – Section 6
6. Will any trees be felled as part of the proposed development and/or are any works proposed within any tree protection zones where trees are to be retained?	No.	None
7. Is there a history of seasonal shrink-swell subsidence in the local area, and/or evidence of such effects at the site?	Unknown. The London Clay Formation is susceptible to shrink/swell. The impact of this on the proposed development and adjacent properties should be assessed, though as no trees are to be felled the development will not significantly change the ground/structure interaction.	Ground Investigation – Section 6 / Impact Assessment – see Section 8.
8. Is the site within 100m of a watercourse or potential spring line?	No.	None

Question	*Response*	*Action Required*
9. Is the site within an area of previously worked ground?	No. The railway tunnel beneath the site is anticipated to be in the region of ~8m below the proposed basement excavation level and sits in the London Clay Formation. The tunnels were formed via shaft access when constructed in mid 19th century.	None
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.	No. The London Clay Formation is an Unproductive stratum.	None
11. Is the site within 50m of the Hampstead Heath ponds?	No. The ponds are located approximately 600m to the north.	None
12. Is the site within 5m of a highway or pedestrian right of way?	The garden at the front of the property is bounded by the pavement in Lawn Road, however the proposed basement development is approximately 20m from the footpath. The proposed basement is within 5m of a private gated road.	Impact assessment for private gated road.
13. Will the proposed basement significantly increase the differential depth of foundations relative to neighbouring properties?	Yes. The underpinning of the basement will deepen the foundations relative to the existing foundations. The level of the neighbouring foundations should be investigated and used to inform a impact assessment.	Foundation investigation and impact Assessment – see Section 8.
14. Is the site over (or within the exclusion zone of) any tunnels, e.g. railway lines?	Yes. The Belsize Tunnel runs directly beneath the site.	Detailed assessment required in a separate report.

4.3.1 Non-Technical Summary: Slope/Land Stability

The ground surrounding the site slopes down from the north-west to the south-east at a gradient of approximately 1:25, shallower than 1:8. The proposed development does not include reprofiling of the landscape.

London Clay is the shallowest stratum on site, however it may be overlain by Made Ground. No trees are proposed to be felled as part of the development. The London Clay is susceptible to shrink/swell movements. The impact of this is considered in the ground investigation and movement assessment.

The site is not within 50m of the Hampstead Heath ponds.

The proposed basement is not within 5m of the highway/pedestrian path at Lawn Road, however it is within 5m of a private gated road. The proposed basement will also deepen the foundations of the existing buildings relative to the neighbouring properties. The impact of the proposed basement on these assets has been assessed in Section 8.

The site underlain by Belsize Tunnel. A detailed assessment may be required by the relevant statutory bodies and is not assessed in this report.

4.4 Surface Flow and Flooding

This section answers the questions relating to surface flow and flooding in Table 8.

Table 8. Surface water and flooding

Question	*Response*	*Action Required*
1. Is the site within the catchment of the pond chains on Hampstead Heath?	No. The ponds are approximately 600m north, up hydraulic gradient from the site.	None
2. As part of the proposed site drainage, will surface water flows (e.g. volume of rainfall and peak run-off) be materially changed from the existing route?	No. The proposed basement extension is in an area currently covered with timber decking and the conservatory and underlain by impermeable London Clay.	None
3. Will the proposed basement development result in a change in the proportion of hard surface/paved external areas?	No. The proposed basement extension is in an area currently covered with timber decking or the conservatory.	None
4. Will the proposed basement result in a change to the profile of inflows (instantaneous and long-term) of surface water being received by adjacent properties or downstream watercourses?	Unlikely. There is no proposed increase to hard surfaced areas or site drainage.	None
5. Will the proposed basement result in changes to the quality of surface water being received by adjacent properties or downstream watercourses?	No.	None
6. Is the site in an area identified to have surface water flood risk according to either the Local Flood Risk Management Strategy or the Strategic Flood Risk Assessment or is it at risk from flooding, for example because the proposed basement is below the static water level of nearby features?	No. The site is not located in Flood Zone 2 or 3. The site is not located in an area with historic flooding and is at low risk of surface water flooding. The proposed basement also does not neighbour any surface water features.	None

4.4.1 Non-Technical Summary: Surface Flow and Flooding

The site is not within the catchment of the pond chains on Hampstead Heath. The proposed basement extension is beneath an area currently covered with timber decking or the conservatory and no change to the drainage is proposed. Therefore, the surface water flows are not anticipated to be materially changed from the existing route or to change the profile of inflows of surface water received by adjacent properties.

The site is not within Flood Zone 2 or 3 and the site is at low risk of flooding from surface water.

4.5 Non-technical Summary of Screening Process

The screening process has identifiedissues that require assessment. These are summarised in Table 9 below.

Table 9. Summary of screening findings

Section	*Issue*
Slope/Land Stability	Confirm that the London Clay Formation is the shallowest stratum present below the site Determine the volume-change potential of the formation level soil. The proposed development will increase the differential foundation depth between the new basement and the neighbouring properties, impact assessment is required. The proposed development is above a railway tunnel, impact assessment is required – this is not within the scope of this report.

5. SCOPING

5.1 Introduction

Based on the finding of the screening process, the following issues have been brought forward to scoping for further assessment.

5.2 Slope/Land Stability Q.05

Confirmation that the London Clay Formation is the shallowest stratum present below the site.

It is understood from the desk study section (Section 3) that the London Clay Formation is the shallowest stratum present on the site. A site investigation will need to be carried out to confirm that this is the case.

5.3 Slope/Land Stability Q.07

Determine the impact of the proposed basement on the volume-change potential of the surrounding soil, particularly from nearby trees.

The underlying geology is anticipated to be the London Clay Formation. A site investigation will need to be carried out to determine the volume change potential of this stratum on site. Based on the proposed development plans included within Appendix B, it is understood that no vegetation will be removed as part of the basement development.

5.4 Slope/Land Stability Q.12 / Q.13

Increasing the differential foundation depth with the neighbouring properties.

The construction of the basement will increase the differential foundation depth and may cause ground movements to the neighbouring properties. An impact assessment has been carried out in Section 8 to assess potential movements.

5.5 Slope/Land Stability Q.14

Presence of a railway tunnel beneath the proposed development.

The proposed development is located over the top of the Belsize railway tunnel that runs between Kentish Town and West Hampstead Thameslink stations. The changes made by the proposed basement could cause ground movements which may result in damage to this underground tunnel. At the anticipated depth of the tunnel crown (in the region of 8m below the proposed excavation level – though this should be confirmed) it is anticipated that the impact of the proposed development on the

tunnel will potentially be very modest. However, a detailed Ground Movement Assessment (GMA) may be required in order to assess the potential impact the basement will have on the Belsize Tunnel. This assessment is not within the scope of this report.

6. GROUND INVESTIGATION

6.1 Fieldwork

An intrusive ground investigation was undertaken by CGL on the 6 and 7 October 2021, comprising five foundation inspection pits (TP01 to TP05) to a maximum depth of 1.2mbgl.

The arisings and inspection pits were logged by a suitably qualified CGL engineer. The foundation inspection pit records are provided in Appendix H. The locations of the exploratory holes are presented in Figure 1.

In-situ testing was undertaken in TP05, in the form of Hand Shear Vane (HSV) tests. Disturbed and bulk samples were collected for geotechnical testing.

A borehole was proposed during the initial planning of the ground investigation, but approval was not given by Network Rail due to the underground railway beneath the property.

6.2 Laboratory Testing

6.2.1 Geotechnical

A total of 4 samples were scheduled for testing at Geolabs Limited and i2 Analytical Limited (UKAS and MCERTS accredited) for classification, and sulphate and pH testing. The following tests were carried out:

- Moisture content;
- Atterberg Limited testing including Plastic Limit (PL), Liquid Limit (LL) and Plasticity Index (PI); and
- pH and sulphate testing.

The laboratory results are provided in Appendix I.

7. GROUND AND GROUNDWATER CONDITIONS

7.1 Ground Conditions

The ground conditions encountered during the CGL site investigation are summarised in Table 10 below.

Table 10. Summary of Ground Conditions encountered.

Stratum	*Depth to Top (mbgl)*	*Typical Thickness (m)*
Hardstanding materials, including paving slabs and concrete. [MADE GROUND] *Present in all five pits.*	0.0	Between 0.14m and 0.87m
Predominantly cohesive materials of silt or clay, with some sand and gravels of brick and concrete. [MADE GROUND] *Present in all pits except TP04.*	0.14 to 0.2	Between 0.12m and 0.93m
Firm to stiff mottled orange brown and light grey, slightly silty slightly gravelly clay. Gravel is angular to subangular, fine of flint and brick. [MADE GROUND / REWORKED LONDON CLAY FORMATION] *Present in TP05*	0.3	0.2
Mottled orangish brown and light grey CLAY. [LONDON CLAY FORMATION] *Present in TP05 and possibly TP04.*	0.5	Base depth not proven

7.1.1 Made Ground

The Made Ground on site generally comprised sandy gravelly silts and clays. Gravel was angular to subangular, fine to coarse of predominantly brick and flint, with occasional concrete. Sand is fine to medium, with occasional coarse grains.

Three Atterberg limit tests were undertaken on disturbed soil samples taken from the Made Ground, the results of which are summarised in Table 11 below. A test was additionally carried out in a sample from TP05 at 0.3mbgl, this sample was considered to be Made Ground / Reworked London Clay Formation.

Table 11. Summary of Atterberg Limit testing in Made Ground.

Stratum	*Moisture Content (MC, %)*	*Liquid Limit (LL, %)*	*Plastic Limit (PL, %)*	*Modified Plasticity Index (PI, %)*	*Material <425µm (%)*
Made Ground	19.0 to 29.7	40 to 52	19 to 26	11.78 to 26.7	61 to 89
Made Ground/Reworked London Clay Formation	30.5	53	21	27.2	85

These results indicate that the Made Ground on site is of intermediate to high plasticity with a low to medium volume change potential[9]. Hand shear vane testing was undertaken in the Made Ground at

[9] NHBC. (2013). *NHBC Standards. Chapter 4.2 – Building Near Trees.*

TP05, the recorded undrained shear strengths were between 45kPa and 70kPa, corresponding to a consistency of 'firm'[10]. Hand shear vane testing undertaken in the Made Ground / Reworked London Clay Formation at TP05 recorded undrained shear strengths between 50kPa and 60kPa, corresponding to a consistency of 'firm'[11].

The sample of Made Ground / Reworked London Clay Formation on site is of high plasticity with a medium volume change potential.

7.1.2 London Clay Formation

On site, the London Clay Formation was firm to stiff mottled orange brown and light grey slightly silty clay, and was recorded with a top of strata depth of 0.5mbgl at TP05.

7.2 Groundwater

No groundwater was encountered during the CGL ground investigation.

7.3 Geotechnical Sulfate Analysis

Four disturbed Made Ground soil samples were scheduled for sulfate and pH testing, and the results are summarised in Table 12 below.

Table 12. pH and Sulphate Analysis Summary.

Sample Depth (mbgl)	*Moisture Content (%)*	*pH*	*Total Sulphate as SO_4 (mg/kg)*	*Water Soluble SO4 16hr extraction (mg/l)*	*Total Sulphur (mg/kg)*
0.3 (TP01)	18	7.8	1300	730	590
1.10 (TP01)	16	8.1	390	86	220
0.3 (TP03)	20	8.0	750	60	500
0.3 (TP05)	19	8.1	260	96	150

The results from this laboratory testing indicate that concrete installed within the Made Ground should be designed to design sulphate (DS) class DS-2 and Aggressive Chemical Environmental for Concrete (ACEC) class AC-2.

7.4 Foundation Inspection Pits

Five foundation inspection pits (FIPs) were excavated to determine the depth and composition of the existing foundations below 22 Lawn Road. The FIP records are provided in Appendix H and the locations are indicated in Figure 2.

The findings of the FIPs are summarised in Table 13 below.

[10] British Standards Institution. (2015). *Code of practice for ground investigations*. BS5930:2015.
[11] British Standards Institution. (2015). *Code of practice for ground investigations*. BS5930:2015.

Table 13. Summary of trial pit foundation formation levels

Pit reference	*Ground level at pit (mSD)*	*Foundation base depth (mbgl)*	*Foundation type*	*Foundation formation level (mSD)*	*Formation level soils*
TP01	8.72	0.87	0.4m deep concrete	7.85	Made Ground
TP02	8.84	0.80	0.8m deep concrete	8.04	Made Ground
TP03	8.72	0.10	0.1m deep concrete	8.62	Made Ground
TP04	7.71	0.65	0.65m deep concrete	7.06	Possible London Clay Formation (foundation depth proven by pilot hole)
TP05	7.71	0.18	0.18m deep concrete	7.53	Made Ground

The trial pit findings indicate the party wall between 22 Lawn Road and 23 Lawn Road has a foundation formation level of some 7.06mSD at the east of the proposed development area (in the lower ground floor garage area of 22 Lawn Road). In the west of the proposed development area on site, the party wall foundation of 22 Lawn Road and 23 Lawn Road is approximately 8.62mSD.

At 21 Lawn Road the foundation formation level was found to be between 8.04mSD and 7.53mSD.

7.5 Geotechnical Design Parameters

Geotechnical parameters for this report have been derived from the soil descriptions, geotechnical laboratory testing and published data for the well-studied London geology. Geotechnical data for the London Clay formation was not available from the site investigation, therefore the London Clay undrained shear strength design line is taken based on a typical design line from published data[12]. The derived parameters are presented in Table 14. Ground level is taken as the floor level of the existing garage. For the purpose of Table 14 the design levels are taken assuming 0.5m of Made Ground will be present from the formation level of the proposed basement.

Table 14: Geotechnical design parameters.

Stratum	*Design Level (mbgl) [mSD]*	*Bulk Unit Weight, γ_b (kN/m^3)*	*Undrained Shear Strength, c_u (kPa) [c']*	*Friction Angle, φ'*	*Undrained Young's Modulus, Eu (MPa)*	*Drained Young's Modulus, E' (MPa)*
Made Ground (predominantly cohesive)	0.0 [7.01]	18	50 [0]	27 [b]	22.5 [c]	16.9 [d]
London Clay Formation (cohesive)	0.5 [6.51]	20	50 + 5z[a] [5]	22	30+3z [e]	22.5+2.25z

a. Based on Burland, Standing J.R., and Jardine F.M. (eds) (2001), Building response to tunnelling, case studies from construction of the Jubilee Line Extension London, CIRIA Special Publication 200.

[12] Burland, Standing J.R., and Jardine F.M. (eds) (2001), *Building response to tunnelling, case studies from construction of the Jubilee Line Extension London, CIRIA Special Publication 200.*

b. British Standard Institution. (2015). Code of practice for Earth retaining structures. BS 8002:2015.

c. $E_u = 450c_u$ Based on Burland, Standing J.R., and Jardine F.M. (eds) (2001), Building response to tunnelling, case studies from construction of the Jubilee Line Extension London, CIRIA Special Publication 200.

d. $E' = 0.75E_u$ Based on Burland, Standing J.R., and Jardine F.M. (eds) (2001), Building response to tunnelling, case studies from construction of the Jubilee Line Extension London, CIRIA Special Publication 200.

e. $E_u = 600c_u$ Based on Burland, Standing J.R., and Jardine F.M. (eds) (2001), Building response to tunnelling, case studies from construction of the Jubilee Line Extension London, CIRIA Special Publication 200.

8. GROUND MOVEMENT ASSESSMENT

8.1 General

A ground movement assessment has been carried out to consider the impact of the proposed development on neighbouring structures. The proposed construction methodology is summarised below:

- Removal of timber decking above the patio void;
- Propping of the void at the existing void ground level (8.72mSD) if necessary;
- Underpinning to the new lower ground floor level;
- Excavation to the new lower ground floor level and propping at new lower ground floor level;
- Installation of new lower ground floor slab and retaining walls;
- Removal of lower ground floor propping;
- Installation of ceiling beam and block floor;
- Removal of prop from existing ground level.

The proposed development has the potential to generate movements through the following mechanisms:

- Heave movements: the London Clay Formation is susceptible to short term heave movements and time dependant swelling on unloading, which will occur as a result of basement excavation, generating upward ground movements.
- Long term ground movement: The net loading on formation soils under foundations will generate ground movement, which could affect adjacent foundations. This takes into account existing stress conditions, additional loads from the basement structure and the weight of soil removed.
- Settlement of underpins: Some settlement of underpins following construction is anticipated, however this can be limited by following good construction practice.

- Underpin workmanship: The construction of underpins has potential to cause vertical movement. For the purpose of this analysis it is assumed that settlement at underpins is 5mm and decreases to negligible over the width of the structure/asset assessed.

- Underpin deflection: Underpins act as stiff concrete retaining walls, which limits the potential for wall deflection. Appropriate temporary works are critical in controlling lateral movements and, provided a high standard of workmanship is applied together with an appropriate temporary works sequence, lateral movements are expected to be negligible for underpinning in this ground.

An assessment of ground movements has been undertaken using OASYS Limited *PDISP* (***P****ressure* ***DISP****lacement*) analysis software. *PDISP* assumes that the ground behaves as an elastic material under loading, with movements calculated based on the applied loads and the soil stiffness (E_u and E') for each stratum input by the user. The analysis details will be discussed in the following sections.

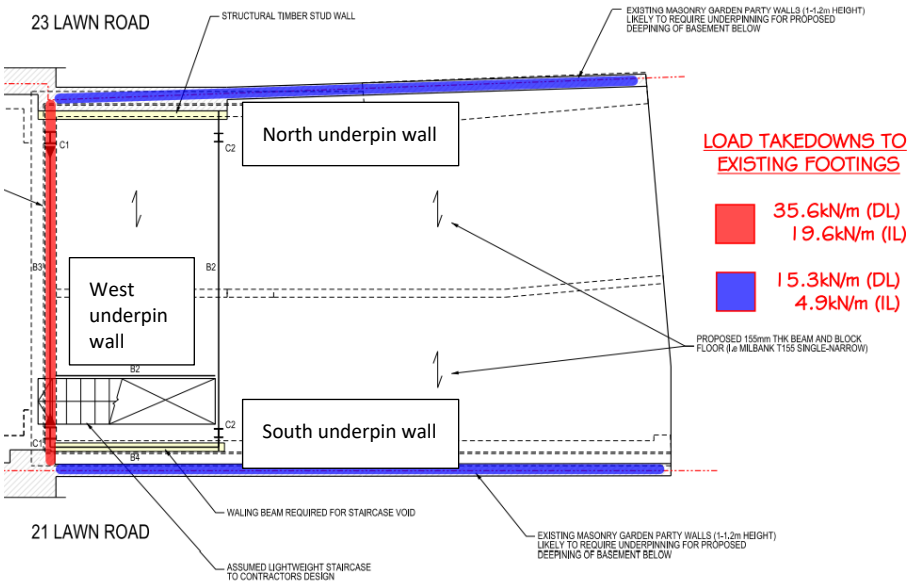
8.2 Underpin Construction and Loading

The north, east and south perimeters of the proposed basement extension will be underpinned in the development. Sections provided indicate an underpin formation level at some 0.3m below the proposed formation level of 7.01mSD, therefore underpin formation level is taken at 6.71mSD. Based on the encountered foundation levels the underpin depths are summarised in Table 15 below.

Table 15. Summary of underpin depth

Pit reference	*Underpinned wall (see reference plan Plate 8)*	*Existing foundation formation level (mSD)*	*Underpin depth (m)*
TP01	East	7.85	1.14
TP02	South	8.04	1.33
TP03	North	8.62	1.91
TP04	North	7.06	0.35
TP05	South	7.53	0.82

Plate 8. Underpin wall references



Loads have been provided by the structural engineers for the perimeter walls which will be transferred to the underpins. These are included on plans in Appendix B.

The loads provided are summarised in Table 16 below. The underpin width has been taken as a width to provide a bearing pressure at or below 100kPa, or if this width would be less than 0.5m, the width is taken as 0.5m. The allowable bearing pressure is taken as 100kPa based on an assumption of an undrained shear strength of 50kPa at the underpin formation level. The underpin areas are indicated on Figure 2.

Table 16. Underpin width and load

Wall reference	DL (kN/m)	LL (kN/m)	Underpin width (m)	Underpin pressure (kPa)
North and south	35.6	19.6	0.55	100
East	15.3	4.9	0.5	40

In addition to vertical ground movements from loading of underpins, for the purpose of this analysis it is assumed that settlement at underpins for workmanship during construction is 5mm and decreases to negligible over the width of the structure/asset assessed.

8.3 Underpin Lateral Movements

Due to relatively high stiffness and shallow depth of the reinforced concrete underpins, long term deflection is considered to be negligible (i.e. <2mm). This is based on CGL's involvement in similar

basement developments across London and review of monitoring data for similar projects. Damage to the neighbouring developments will be governed by vertical heave and settlement due to underpin construction and bulk excavation.

Taking the maximum anticipated underpin depth of 1.91m, a width of 0.5m and section length of 1m, and treating the underpin as a cantilever beam, a UDL of some 875kN/m would be required to generate a deflection of over 5mm. For a retained height of soil of 1.91m, for a unit weight of 20kN/m^3 and friction angle of 22° in the London Clay Formation, the active load on the underpin is calculated as some 16.6kN/m.

Slight elastic movement may occur, however given the relative stiffness of the London Clay Formation and provided the underpins are propped effectively in the short and long term, no significant lateral movements are expected. Lateral propping will be used during excavation in front of the underpins. Propping should be designed to resist lateral forces developed by the retention of surcharge loads.

Lateral movements due to underpinning in London Clay may occur due to lateral expansion of the clay as each successive underpin is excavated, however this is a localised impact that does not directly translate as a uniform strain to the structure above. CGL has previously carried out FE analysis to demonstrate this effect during underpinning in London Clay and it has been found to be minor, not generating substantial movements.

On the basis of the above, for the purposes of this assessment, a lateral movement of 2mm is assumed to be achievable at the underpins, decreasing to negligible over the width of the neighbouring structure. In the following assessments the building damage category will be shown based on a lateral movement of 2mm as well as based on the limiting lateral movement for a Category 1 'very slight' building damage category. Assuming good construction practices and control, horizontal deflections in front of the underpinned wall are expected to be minimal.

8.4 Excavation Unloading

The existing level at the site in the proposed development area varies between ~10mSD where no void or existing garage is present, 7.71mSD at the existing garage and 8.72mSD at the void. The unloading values to reach the proposed formation level of 7.01mSD are summarised in Table 17 below. For these calculations in each area the top 0.5m of soils are assumed to be Made Ground. At the existing garage it is assumed that there is an existing concrete floor slab, taken as 0.25m deep. The unloading areas are indicated on Figure 2.

Table 17. Summary of excavation unloading

Reference	Existing level (mSD)	Proposed level (mSD)	Excavated soil depth (m)	Assumed existing concrete depth (m)	Unloading pressure (kPa)
UL1	8.72	7.01	1.71	NA	33.2
UL2	7.71	7.01	0.45	0.25	14.4
UL3	10	7.01	2.99	NA	58.8

It is noted that for the calculated unloadings, the impact on the Belsize tunnel below the site is considered unlikely to have engineering significance.

8.5 Structural Loading

As well as the loads to be applied to the underpins, loads will additionally be applied for the proposed 250mm thick reinforced concrete floor slab with local thickenings to 500mm. Drawings provided by the structural engineers additionally indicate pressures to be applied 1.5kPa for dead load and 1kPa for live load of the residential floor slab loadings.

It is noted that under the 250mm slab heave protection is proposed. Given the thickness of the slab, this is assumed to be Cellcore Grade 9/13, with a failure stress of 13kPa. The load adopted in the model is based on based on the thickness of the slab plus the 1.5kPa dead and 1kPa live pressures, rather than the Cellcore failure pressure. However, if the failure load was approached, this would not be expected to have a significant impact on the GMA results as the difference in applied load would not be large and the 250mm thick slab areas are in the centre of the basement, not adjacent to the perimeter.

The applied floor loads are summarised in Table 18.

Table 18. Summary of floor loading

Reference	Concrete depth (m)	Applied pressure (kPa)	Dead + live floor pressure (kPa)	Total applied pressure (kPa)
L1	0.50	12.5	2.5	15
L2	0.25	6.25	2.5	8.75

It is noted that for the calculated applied pressures, the impact on the Belsize tunnel below the site is considered unlikely to have a large engineering significance.

8.6 Construction Stages

The development has been modelled in the following stages:

- Stage 1: Underpin loads are applied – Soils are modelled as undrained

- Stage 2: Underpin loads are applied and excavation unloading is applied – Soil are modelled as undrained
- Stage 3: Underpin loads are applied and long term unloading is applied – Soils are modelled as drained.

Drained soils are modelled with a Poisson's Ratio of 0.2. Undrained soils are modelled using 0.495. Positive movements are settlement and negative movements are heave.

PDISP summary sheets are included in Appendix J.

In addition to the PDISP movements, it is assumed that settlement at underpins for workmanship during construction is 5mm and decreases to negligible over the width of the structure/asset assessed.

8.7 Critical Sections

There are 4 structures adjacent to the site to be considered for assessment which may potentially be affected by construction of the proposed basement:

- 23 Lawn Road north of the site;
- 21 Lawn Road south of the site;
- Private gated road at the east of the building.

Lawn Road to the west of the site is not considered a critical section as it is approximately 20m from the proposed development.

The critical sections for these structures are shown on Figure 1. The dimensions and levels of the structures for the assessment are summarised in Table 19 below. Widths and heights are approximate based on publicly available sources and aerial imagery.

Table 19. Summary of critical assessment section lines

Reference	Section	Assessment level (mSD)	Width of structure (m)	Height of structure (m)	Distance from proposed basement (m)	Assumed underpinning depth (m)
A-A	23 Lawn Road - ground	8.62	6.6	12	0	1.91
B-B	23 Lawn Road – lower ground	7.06	6.6	3.5	0	0.35
C-C	Gated road	7.5	6.9	NA	0	NA
D-D	21 Lawn Road	8.04*	6.6	12	0	1.33

* foundation formation recorded on site between 7.52mSD and 8.04mSD

A displacement line has additionally been assessed along the approximate position of the Belsize tunnel at approximately xxm below ground level (xxmSD).

8.8 PDISP Results - Formation Level Movements

The PDISP predicted vertical movements at the proposed basement formation level are presented for the three assessed construction stages in Plate 9 to Plate 11. The movements in the centre of the proposed basement are predicted to be up to some 4mm of heave.

Plate 9. Underpin stage vertical movements at proposed basement formation level

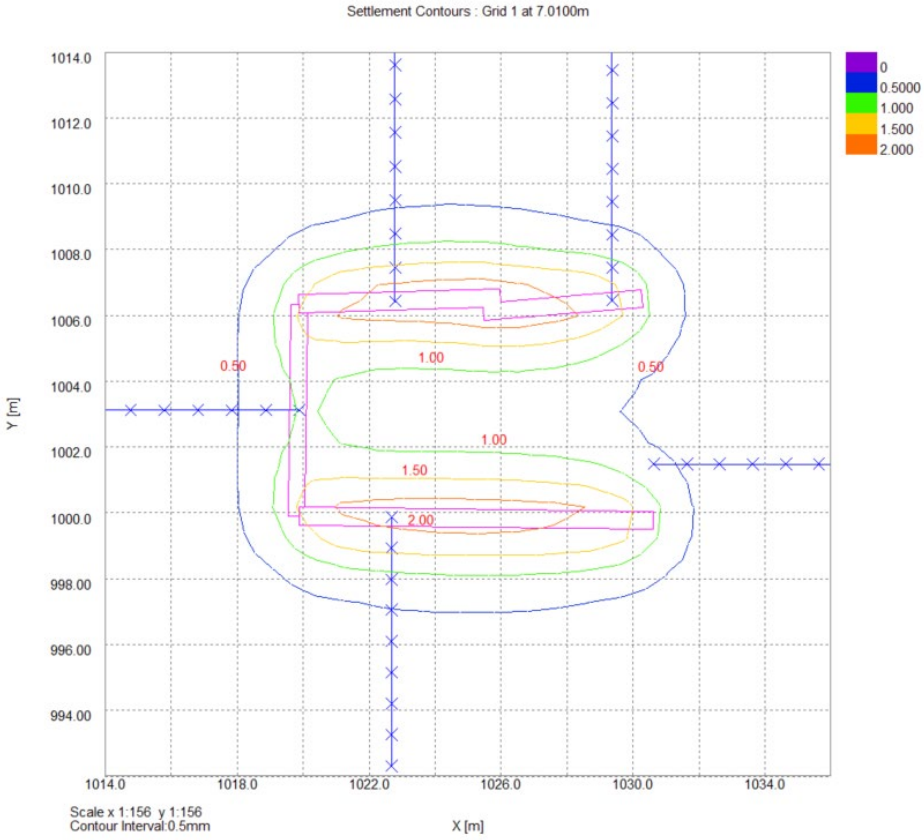


Plate 10. Excavate stage vertical movements at proposed basement formation level

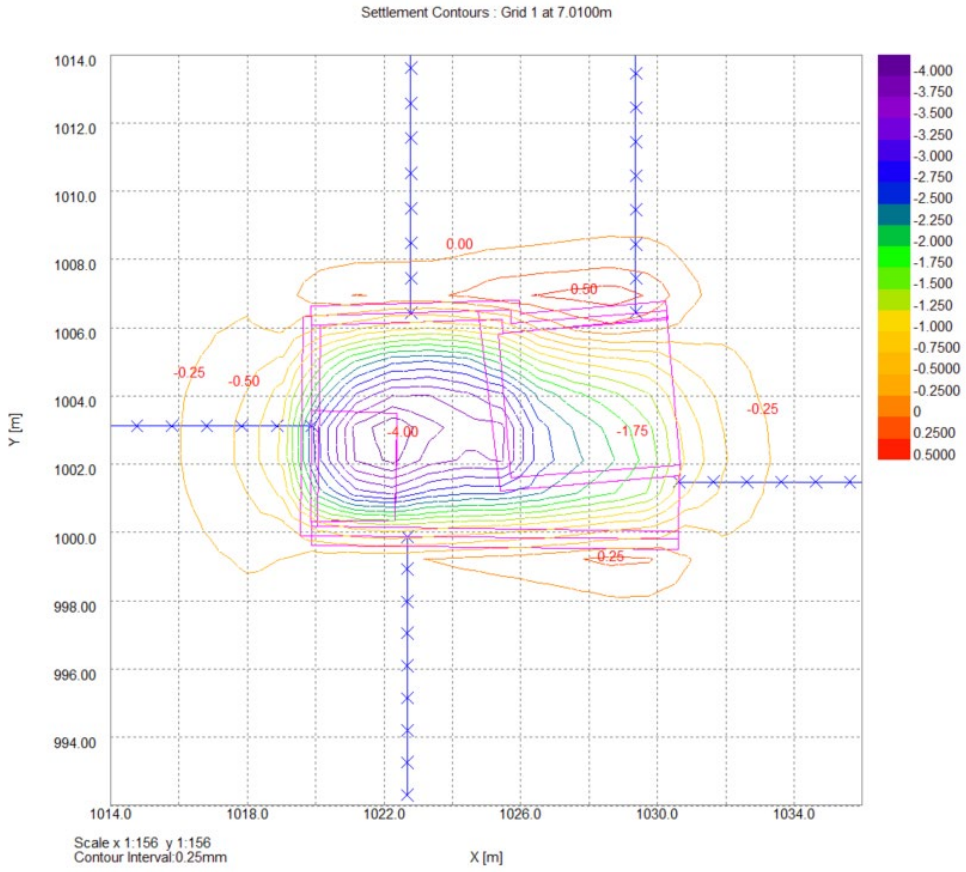
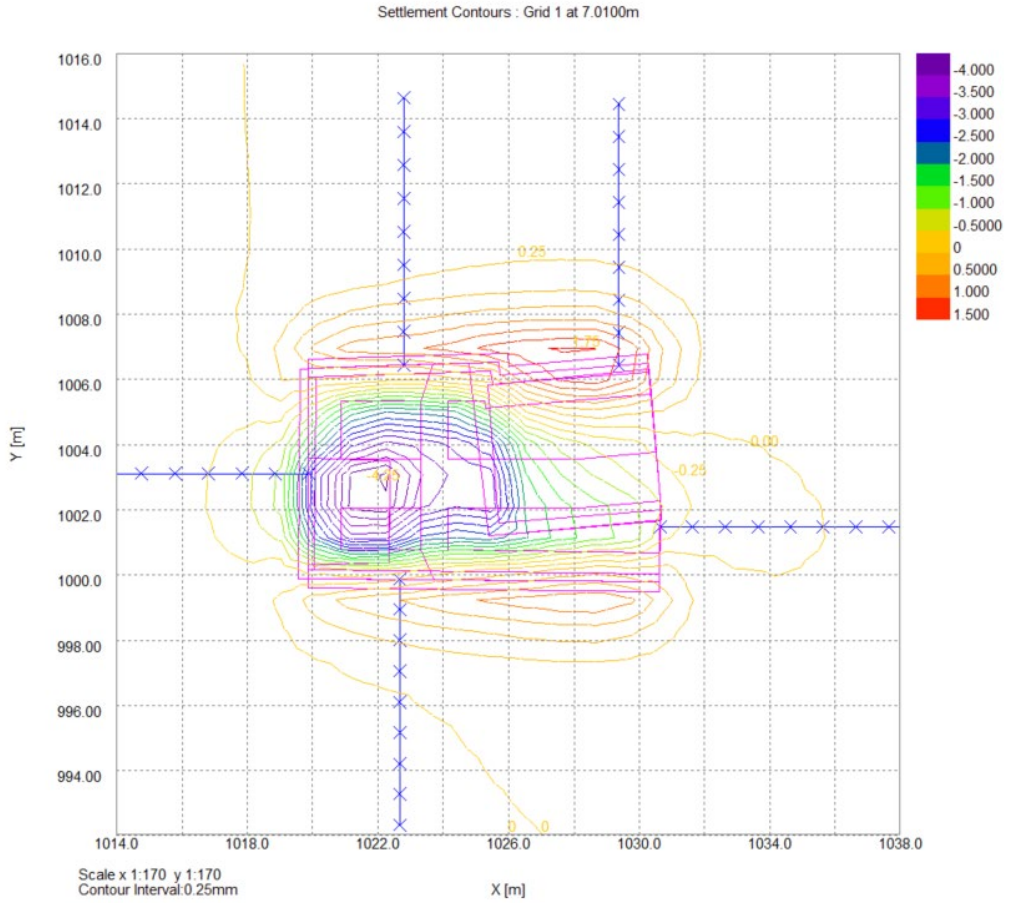


Plate 11. Long term stage vertical movements at proposed basement formation level



8.9 Building Damage Assessment

The calculated ground movements have been used to assess the potential 'damage category' that may apply to the neighbouring structures/infrastructure due to the proposed development. The methodology proposed by Burland and Wroth[13] and later supplemented by the work of Boscardin and Cording[14] has been used, as described in CIRIA Special Publication 200[15] and CIRIA C760[16]. General categories are summarised below in Table 20.

Table 20. Classification of damage visible to walls (reproduction of Table 6.4, CIRIA C760)

Category	*Description*
0 (Negligible)	Hairline cracks of less than about 0.1mm are classed as negligible
1 (Very slight)	Fine cracks that can easily be treated during normal decoration (crack width <1mm)
2 (Slight)	Cracks easily filled, redecoration probably required. Some repointing may be required externally (crack width <5mm)

[13] Burland, J.B., and Wroth, C.P. (1974). Settlement of buildings and associated damage, State of the art review. Conference on Settlement of Structures, Cambridge, Pentrech Press, London, pp 611-654.
[14] Boscardin, Standing J.R., and Cording, E.G. (1989). Building response to excavation induced settlement. J Geotech Eng ASCE, 115(1), pp 1-21.
[15] Burland, Standing, J.R., and Jardine, F.M. (eds) (2001). Building response to tunnelling, case studies from construction of the Jubilee Line Extension London, CIRIA Special Publication 200.
[16] CIRIA C760. (2017). *Guidance on embedded retaining wall design.* CIRIA C760.

Category	*Description*
0 (Negligible)	Hairline cracks of less than about 0.1mm are classed as negligible
3 (Moderate)	The cracks require some opening up and can be patched by a mason. Repointing of external brickwork and possibly a small amount of brickwork to be replaced (crack width 5 to 15mm or a number of cracks >3mm)
4 (Severe)	Extensive repair work involving breaking-out and replacing sections of walls, especially over doors and window (crack width 15 to 25mm but depends on number of cracks)
5 (Very severe)	This requires a major repair involving partial or complete re-building (crack width usually >25mm but depends on number of cracks)

Building damage assessments are provided in the sections below for 21 Lawn Road and 23 Lawn Road.

An assessments of the impacts to the road at section C-C' is additionally provided, however at this section only total vertical movement is considered relevant.

8.9.1 Section A-A'

The predicted vertical movement profile and deflection at Section A-A' is presented Plate 12. The maximum movements and deflection are summarised in Table 21 below. The building damage is assessed in Plate 13. Assuming good construction practices and control, horizontal deflections in front of the underpinned wall are expected to be minimal.

Table 21. Summary of Section A-A'

Section	Maximum displacement (mm)*	Deflection (mm)	Deflection ratio	Limiting lateral movement at underpin for Category 0 damage (mm)	Damage category for 2mm lateral movement	Angular distortion (1/)
A-A'	7.1	2	0.030	2.25	Category 0 'negligible'	1/909

*+ve = settlement

Plate 12. Section A-A' vertical movement profile

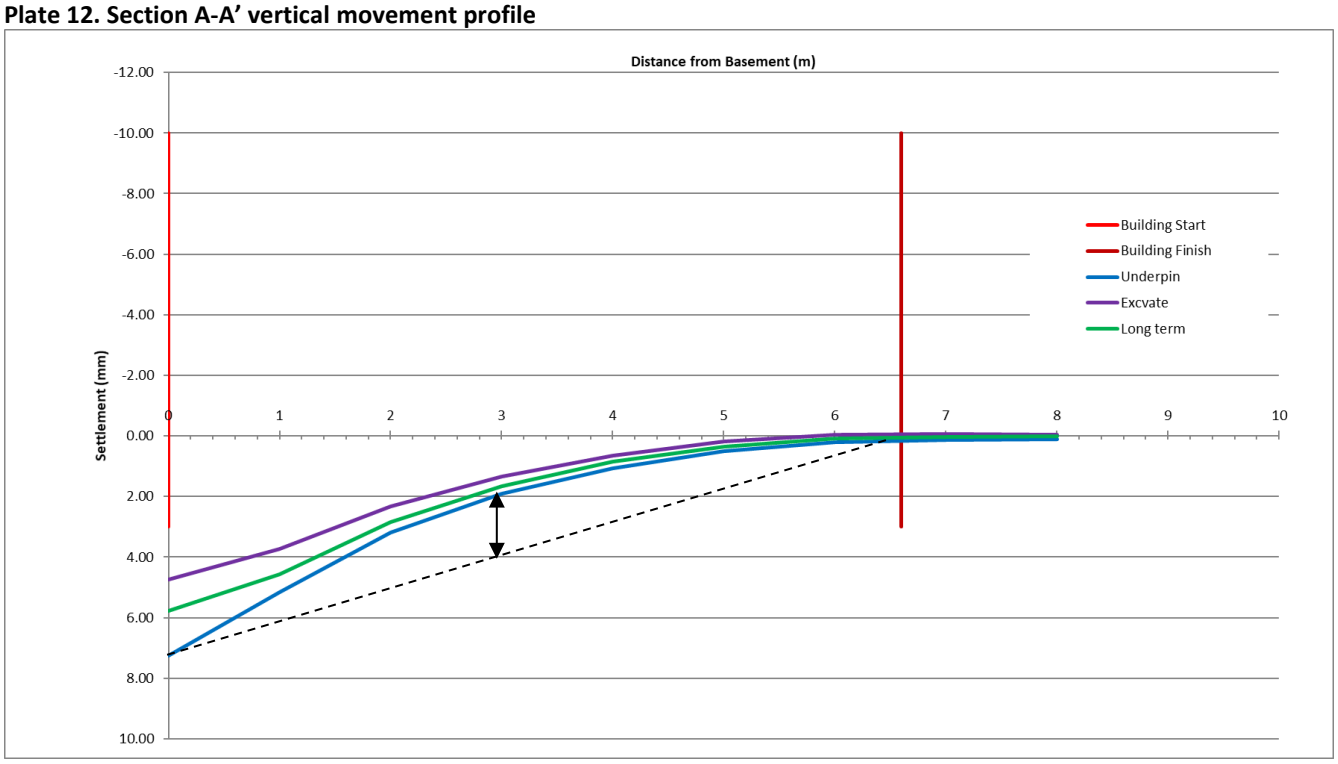
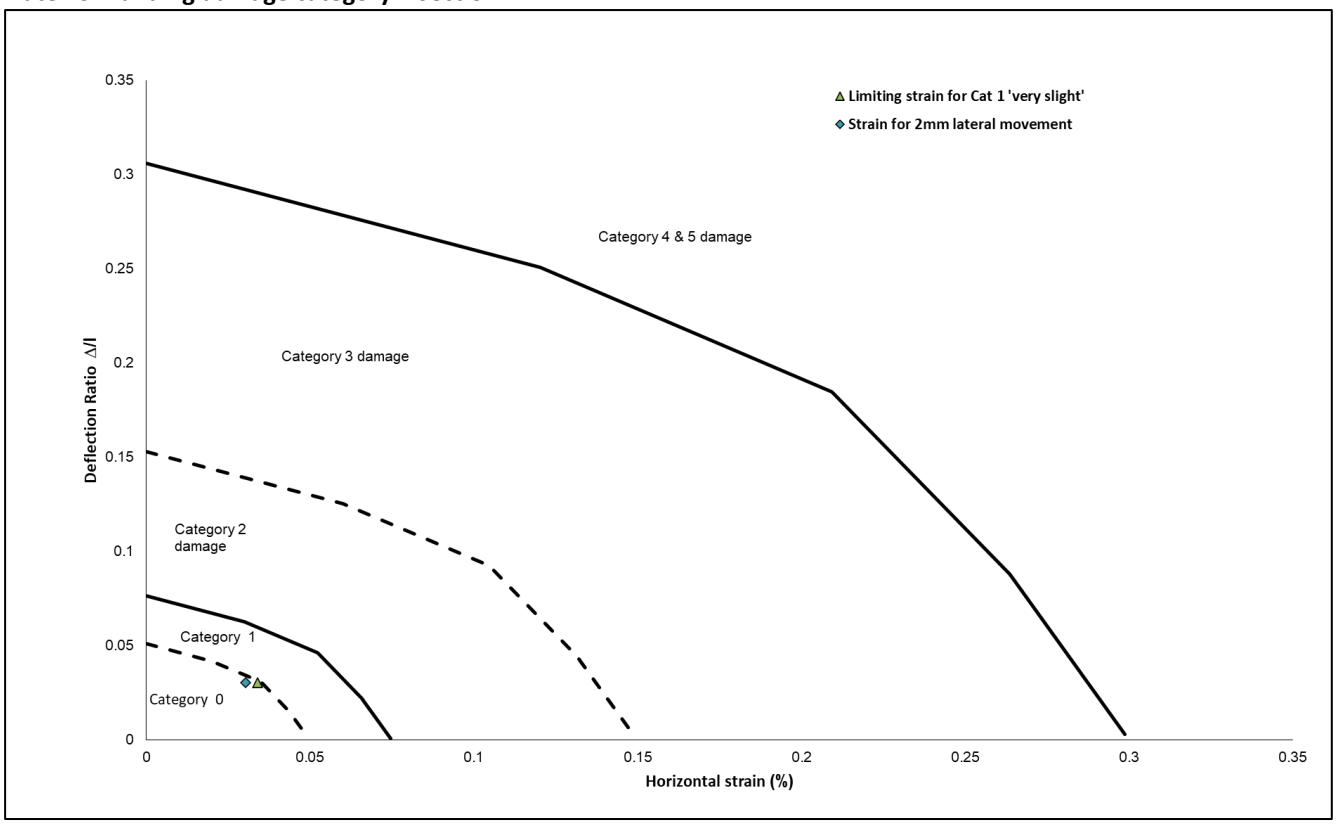


Plate 13. Building damage category – Section A-A'



8.9.2 Section B-B'

The predicted vertical movement profile and deflection at Section B-B' is presented Plate 14. The maximum movements and deflection are summarised in Table 22 below. The building damage is

assessed in Plate 15. It is noted that underpins at this section are anticipated to be ~0.35m deep. Assuming good construction practices and control, horizontal deflections in front of the underpinned wall are expected to be minimal and it would be expected it would be possible to limit lateral movements to ~1mm, which would correspond to Category 0 'negligible' damage..

Table 22. Summary of Section B-B'

Section	Maximum displacement (mm)	Deflection (mm)	Deflection ratio	Limiting lateral movement at underpin for Category 0 damage (mm)	Damage category for 2mm lateral movement	Angular distortion (1/)
B-B'	6.6*	2	0.030	1.0	Category 1 'very slight'	1/973

*+ve = settlement

Plate 14. Section B-B' vertical profile

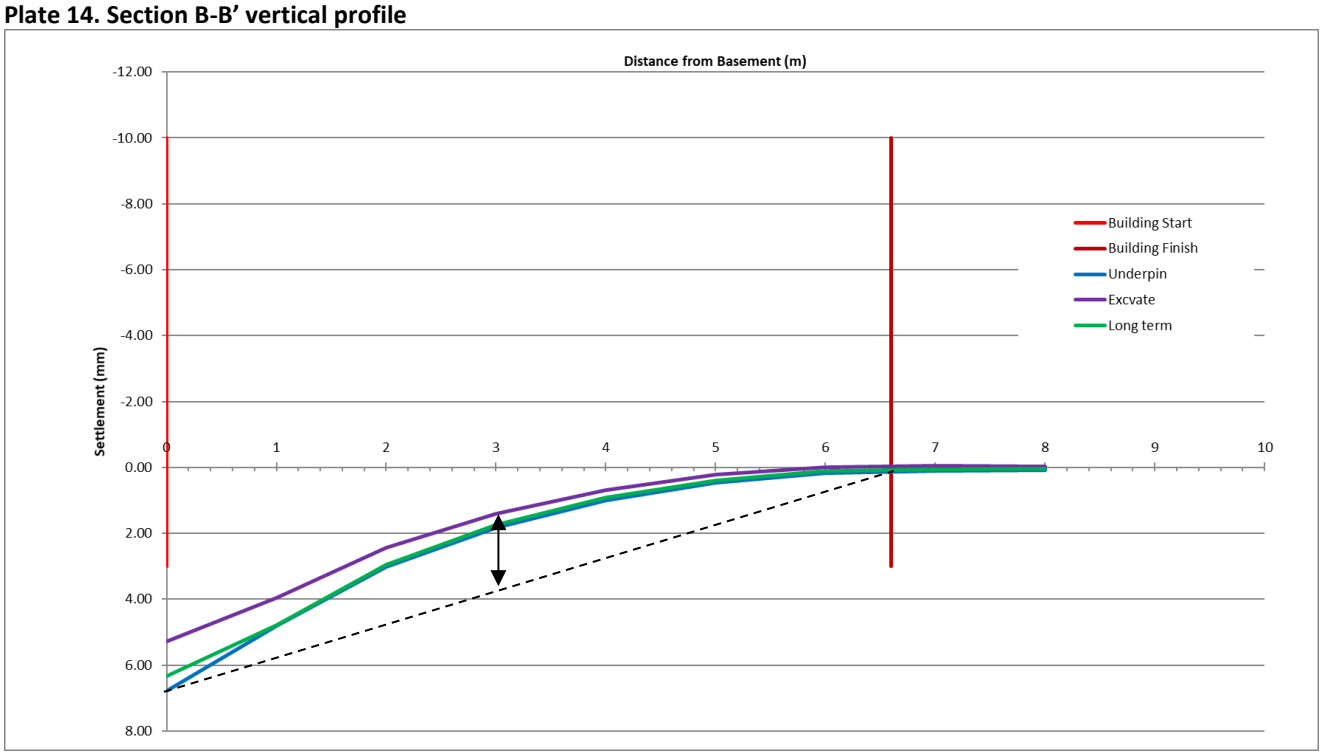
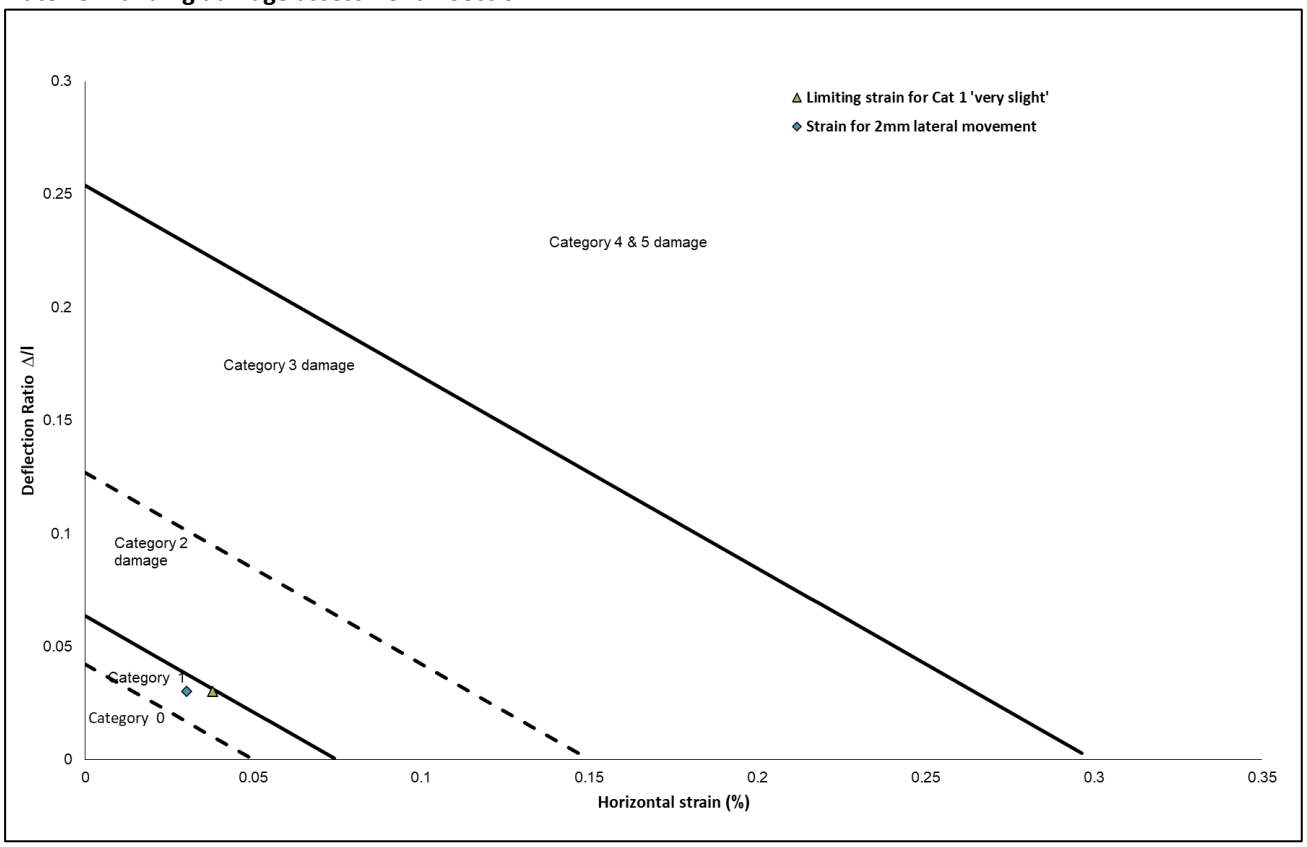


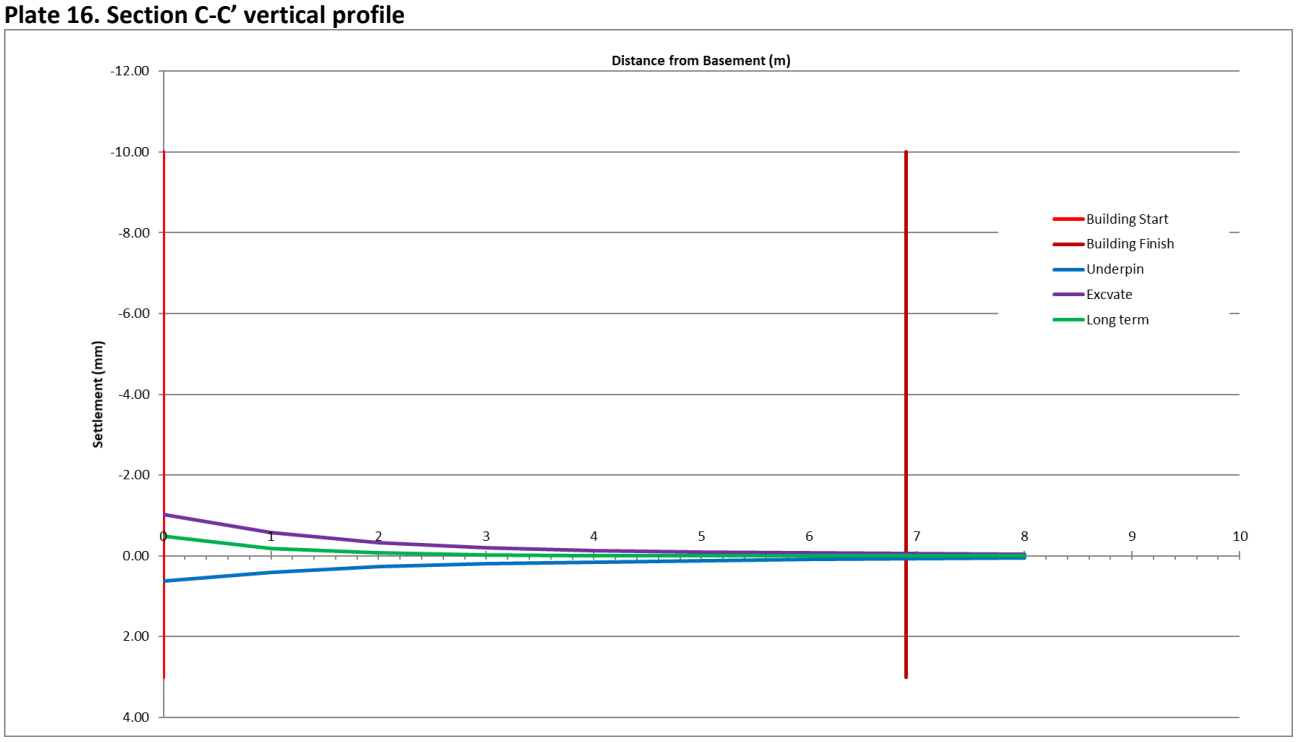
Plate 15. Building damage assessment – Section B-B'



8.9.3 Section C-C'

The predicted vertical movements at the Section C-C' are presented in Plate 16. The predicted movements are of the order of 1mm, therefore the impacts to the private gate road are considered to be negligible.

Plate 16. Section C-C' vertical profile



8.9.4 Section D-D'

The predicted vertical movement profile and deflection at Section D-D' is presented in Plate 17. The maximum movements and deflection are summarised in Table 23 below. The building damage is assessed in Plate 18. Assuming good construction practices and control, horizontal deflections in front of the underpinned wall are expected to be minimal.

Table 23. Summary of Section D-D'

Section	Maximum displacement (mm)	Deflection (mm)	Deflection ratio	Limiting lateral movement at underpin for Category 1 damage (mm)	Damage category for 2mm lateral movement	Angular distortion (1/)
D-D'	7.1*	2.0	0.030	2.3	Category 0 'negligible'	1/911

*+ve = settlement

Plate 17. Section D-D' vertical profile

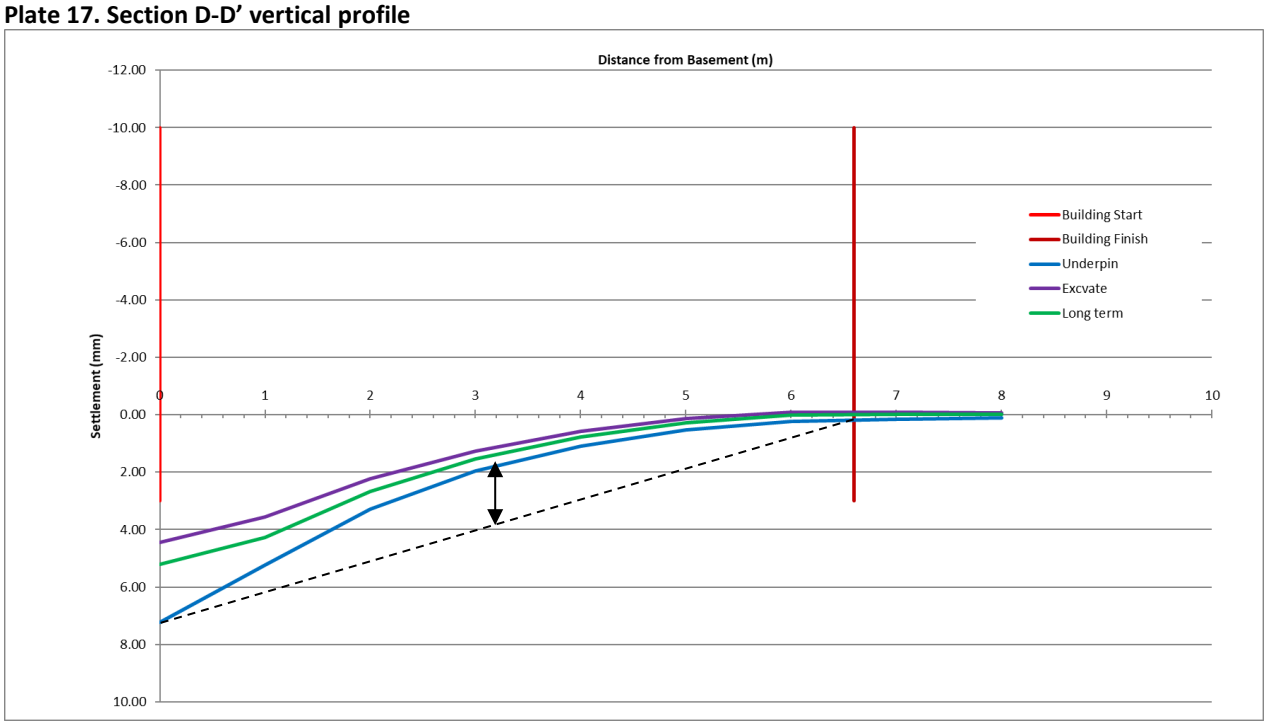
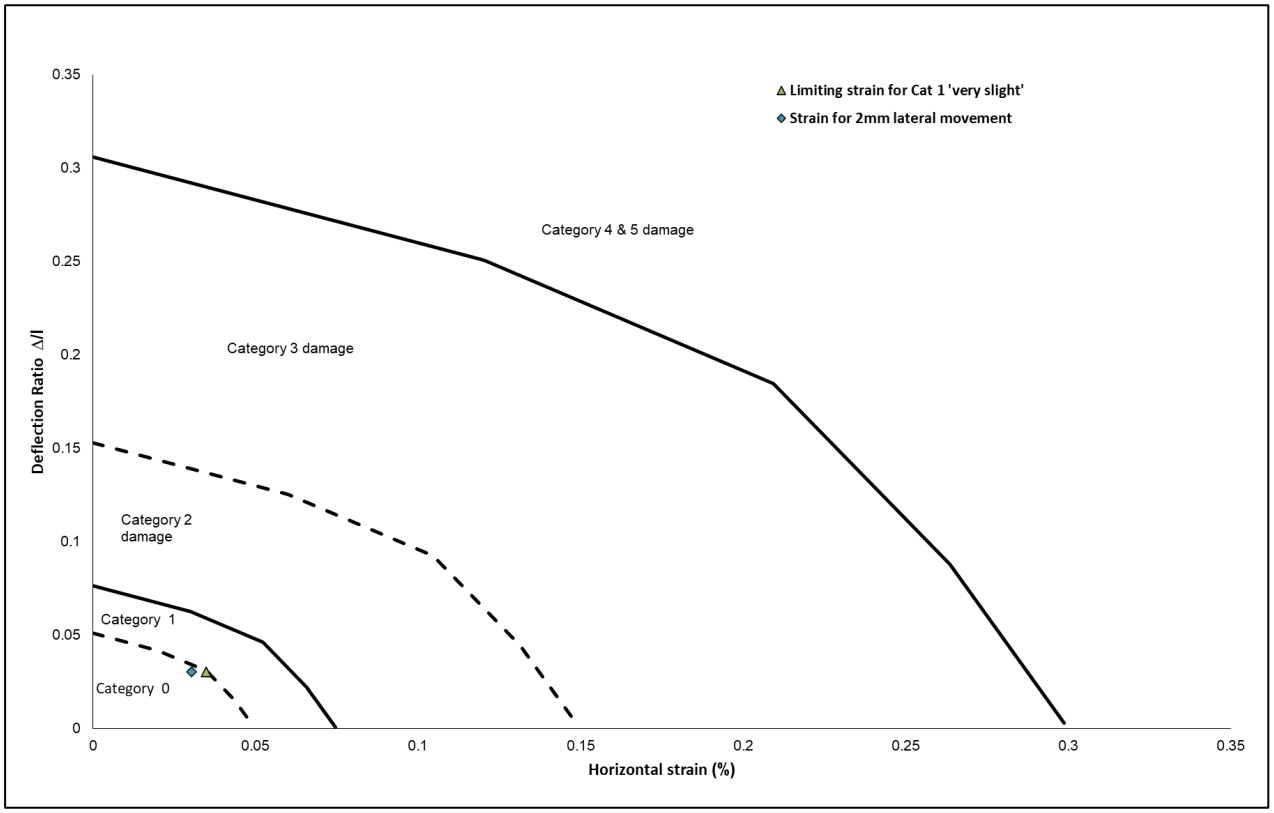


Plate 18. Building damage assessment – Section D-D'

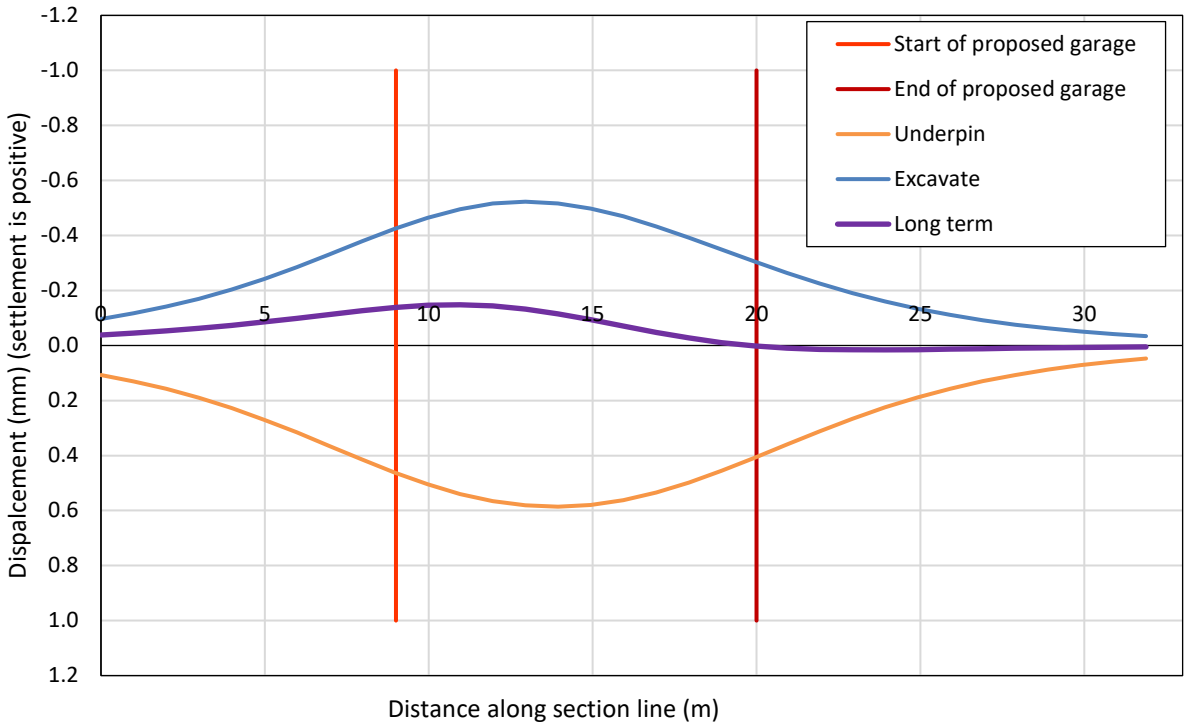


8.10 Belsize Tunnel

Predicted vertical movements along the approximate crown level of Belsize Tunnel is shown in Plate 19. Predicted movements are less than 1mm. The vertical stress change at the approximate tunnel crown is predicted to be of the order of 4kPa of stress increase. Based on these preliminary results the

risk to the tunnel is expected to be very low, however a detailed assessment may be required by the relevant statutory bodies.

Plate 19: Belsize Tunnel Approximate Crown Level Vertical Movements



9. CONCLUSIONS

A Basement Impact Assessment has been carried out for the proposed basement excavation at 22 Lawn Road. The assessment considers the impact on two party wall structures, 21 Lawn Road and 23 Lawn Road. CGL has excavated foundation inspection pits at the site, the findings of these are included in this report as well as a desk study for the site. The desk study and foundation inspection pits have been used to inform the Basement Impact Assessment. The key findings of the assessment are summarised below:

- The site is underlain directly by the London Clay Formation which is impermeable and an Unproductive aquifer. The proposed basement extension will therefore not extend below the water table. If perched water is present within Made Ground on site this is expected to be limited in extent and not laterally persistent, therefore the proposed basement would not impact subterranean water flow.
- The nearest surface water body is Hampstead No. 1 Pond, some 600m north of the site.
- No change to the existing site drainage is proposed. Therefore, there it is not proposed to increase the amount of water discharged to the ground.
- The proposed development does not include reprofiling of the landscape.
- The site underlain by Belsize Tunnel. It is noted that for the calculated changes in loading, the impact on the Belsize tunnel below the site is considered unlikely to have engineering significance.
- Surface water flows aren't anticipated to be materially changed from the existing route or to change the profile of inflows of surface water received by adjacent properties.
- The foundation investigation found the shallowest soils on site to comprise Made Ground. The Made Ground was underlain by the London Clay Formation (at approximately 0.5mbgl).
- Three samples of Made Ground were analysed from the foundation investigation, the results indicate that the Made Ground on site is of intermediate to high plasticity with a low to medium volume change potential. A sample of Made Ground / Reworked London Clay Formation was analysed and found to have a high plasticity with a medium volume change potential.

- The formation levels of party wall foundations have been used in an impact assessment to consider impacts to 21 Lawn Road and 23 Lawn Road. 23 Lawn Road has been assessed at two sections, one where a lower ground floor is present and one where there is no lower ground floor.

- The maximum predicted displacement occurs at the 23 Lawn Road ground floor section and at 21 Lawn Road, and is 7.1mm of settlement.

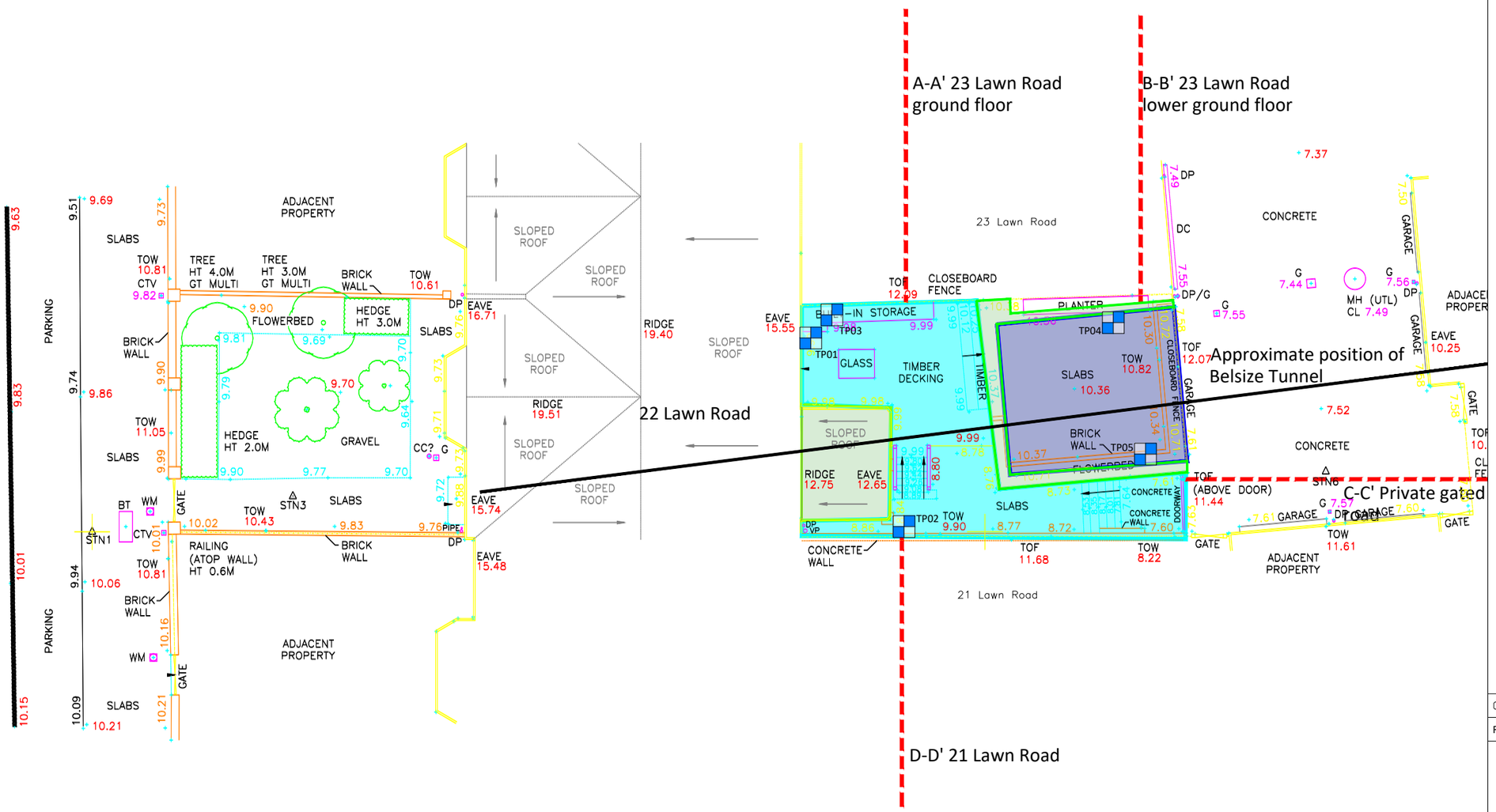
- The predicted building damage category at 23 Lawn Road ground floor level and at 21 Lawn Road is Category 0 'negligible' damage.

- At 23 Lawn Road at lower ground floor level the predicted damage category based on 2mm of lateral movement from underpinning is Category 1 'very slight'. It is noted that underpins at this section are anticipated to be ~0.35m deep. Assuming good construction practices and control, horizontal deflections in front of the underpinned wall are expected to be minimal and it would be expected it would be possible to limit lateral movements to ~1mm, which would correspond to Category 0 'negligible' damage.

- The predicted movements at the private gated road are less than 1mm and are not considered significant.

- A preliminary review of movements at the approximate Belsize tunnel crown level and position indicate movements less than 1mm and vertical stress changes of approximately 4kPa. Based on these preliminary results the risk to the tunnel is expected to be very low, however a detailed assessment may be required by the relevant statutory bodies.

FIGURES



N

KEY

- UL1: Existing level 8.72mSD. Excavation level 7.01mSD.
- UL2: Existing level 7.71mSD. Excavation level 7.01mSD.
- UL3: Existing level ~10mSD. Excavation level 7.01mSD.
- Critical section line
- CGL 2021 Foundation Inspection Pit

Rev	Date	Comments
0	01/12/2021	First issue

Card Geotechnics Ltd
4 Godalming Business Centre
Woolsack Way
Godalming
Surrey
GU7 1XW
T: 01483 310600

Project: **22 Lawn Road, Camden**

Client: **Morph Structures**

Drawing title: **Figure 1 - Site Layout**

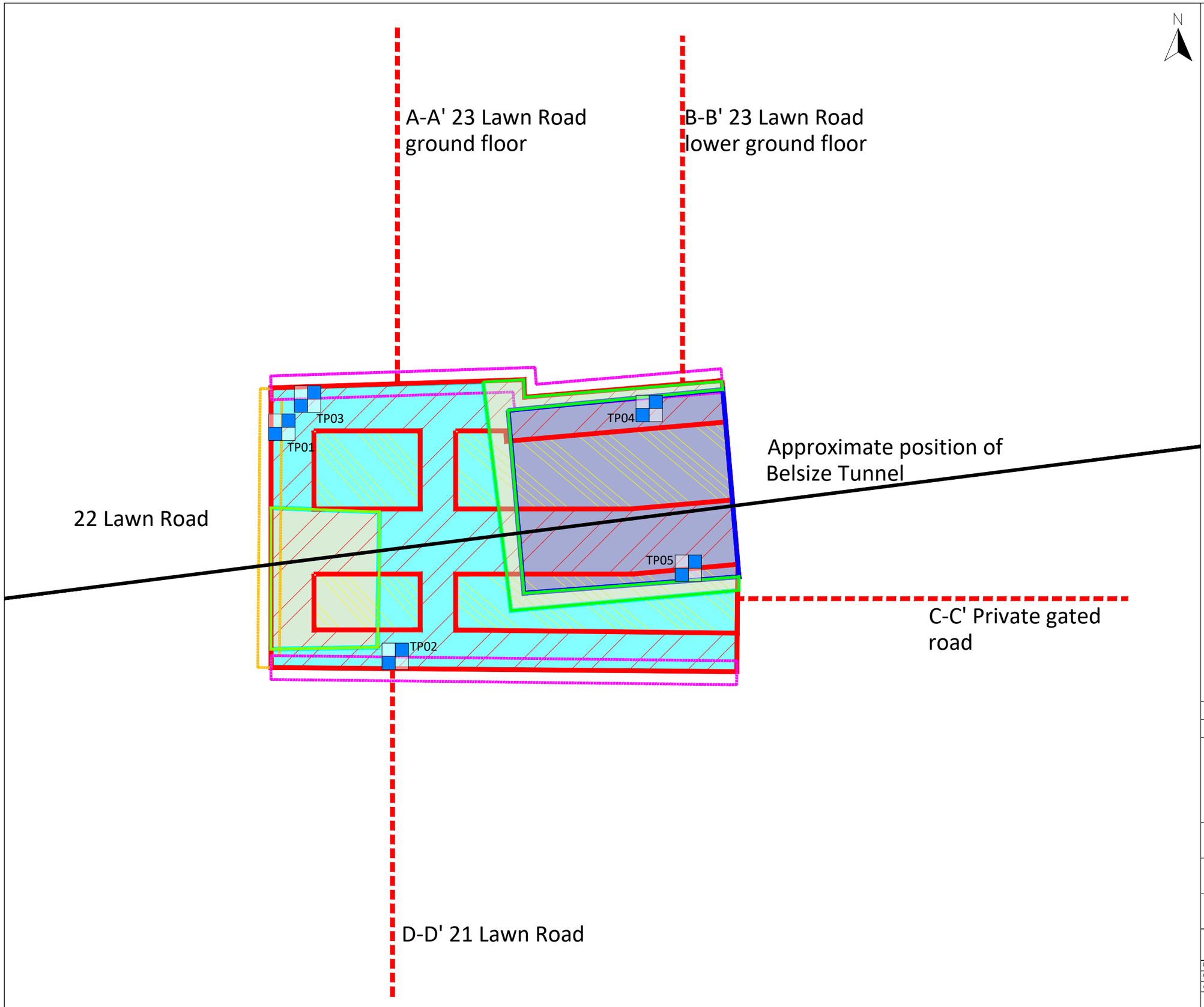
Scale(s): **NTS**

Job No.: **CG/39038**

Drawn	MRG	01/12/2021
Checked	AB	02/12/2021
Approved	RJB	02/12/2021

Dwg No.: **CG/39038_001**

Rev.: **0**



N

KEY

- CGL 2021 Foundation Inspection Pit
- L1: 0.5m thick concrete
- L2: 0.25m thick concrete with heave protection (assumed fail load 13kPa)
- UL1: Existing level 8.72mSD. Excavation level 7.01mSD.
- UL2: Existing level 7.71mSD. Excavation level 7.01mSD.
- UL3: Existing level ~10mSD. Excavation level 7.01mSD.
- North and south underpinned walls (100kPa)
- West underpinned wall (40kPa)

Rev	Date	Comments
#	24/11/2021	###########

Card Geotechnics Ltd
4 Godalming Business Centre
Woolsack Way
Godalming
Surrey
GU7 1XW
T: 01483 310600

Project: **22 Lawn Road, Camden**

Client: Morph Structures

Drawing title: **Figure 2 - PDISP Layout**

Scale(s): **NTS**

Job No.: **CG/39038**

Drawn	MRG	24/11/2021
Checked	NJL	25/11/2021
Approved	RJB	02/12/2021

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Rev.: **#**