Camden Lock Market

Planning Application

Basement Impact Assessment

Prepared by CGL
On Behalf of Castlehaven Row Ltd

August 2015

CGL

Stanley Sidings Limited

Camden Lock (Canal) Market, London

Basement Impact Assessment – Middle Yard Building

August, 2015

Card Geotechnics Limited
4 Godalming Business Centre, Woolsack Way,
Godalming, Surrey, GU7 1XW
Telephone: 01483 310 600
www.cgl-uk.com

Author	Gerasimos Sfaellos *MEng MSc*		
Checked	Richard Ball, Associate Director *MSc BSc CEng MICE FGS*		
Approved	Ian Marychurch, Director *MSc BSc CEng MICE CGeol FGS CMgr MCMI MIoD Dip IoD*		Ian Marychurch
Reference	CG/18510	Revision	Issue Date August 2015

CONTENTS

FIGURES

APPENDICES

1. INTRODUCTION

It is proposed to demolish the existing "Middle Yard Building" and some of the road infrastructure at Camden Lock (Canal) Market and replace them with a medium to high rise development with a single and double storey basement within the range of 5m to 7.5m below existing ground level.

Card Geotechnics Limited (CGL) has been instructed by Stanley Sidings Limited (the client) to undertake a Basement Impact Assessment (BIA) for the proposed development to assess the potential impact on surrounding buildings, infrastructure and hydrological features.

Camden Guidance CPG4[1] requires Basement Impact Assessments to be undertaken for new basements in the borough and sets out 5 stages:

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

This report is intended to address the screening, scoping and impact assessment processes set out in CPG4 and the Camden geological, hydrogeological, and hydrological study (CGHHS)[2]. It identifies key issues relating to land stability, hydrogeology and hydrology as part of the screening process (Stage 1). CGL has previously scoped and completed an extensive ground investigation[3] for the neighbouring site, Camden Lock Village, which is 40 m east of the site, (Stage 2 and Stage 3), and as such the scoping process comprises a summary of the findings of the neighbouring site investigation and derivation of an appropriate ground model and design parameters for the site to allow the ground movement and damage assessment calculations to be undertaken (Stage 4).

[1] Camden Planning Guidance, CPG4, Basements and Lightwells, September 2013.
[2] Ove Arup and Partners Limited (2010). *London Borough of Camden. Camden geological, hydrogeological and hydrological study. Guidance for subterranean development.* Issue 01, November 2010.
[3] Card Geotechnics Limited. (2015) Camden Lock Village, London. *Geotechnical and Geoenvironmental Interpretative Report*. Ref: CG/18067A. January 2015.

2. SITE CONTEXT

2.1 Site location

The site is situated off Camden High Street in Camden, northwest London. The Ordnance Survey Grid Reference for the approximate centre of the site is 528681E, 184123N.

A site location plan is presented as Figure 1.

2.2 Site layout

The site is approximately square in shape and is bordered by the *Grand Union Towpath* and *Regent's Canal* to the south, a neighbouring National Rail viaduct to the north, a commercial retail area (Camden Lock Market) to the west, and retail buildings to the east of the site, which are three storeys high with a lower ground floor. At the time of writing, these buildings were occupied by *Gekko* 207, *Irregular Choices* 209-210, and *Superga* 218, Chalk Farm Road Camden, London, NW1 8AB.

The site itself is currently occupied by Camden Lock Market, which comprises a large number of single storey wooden market stalls, with additional two and three storey retail buildings.

A site layout plan is presented within Figure 2. This layout also shows the outline of the site within which Middle Yard Building is proposed. Exploratory hole locations, to the east of the site, completed during the neighbouring site's investigation are also presented on Figure 2.

London Underground Limited (LUL) tunnels (Northern Line) run below Chalk Farm Road approximately 20m to the east of the site. The National Rail viaduct to the north is located more than 20m from the site boundary. The Gilgamesh shops and the Stables Market shops are located across the north boundary of the site being at a distance of approximately 15m due to the Camden Lock Pace pedestrian road. Existing basements at the north site of Camden Lock Place also shown are in Figure 2.

Additionally, National Grid cable infrastructure runs along the southern site boundary and follows the profile of the canal wall.

2.3 Proposed development

The proposed development is to comprise the demolition/removal of the existing structures/market stalls and construction of a multi storey building with a single- to two-storey basement beneath the building. The development will include retail areas, office space and restaurant areas.

The proposed basement across the building is between 5m to 7.5m deep, with the double storey basement Structural Slab Level (SSL) 22.7mOD and its approximate basement formation floor level (FFL) 22.0mOD. It is currently proposed to construct the basement using bottom up construction methods within a contiguous piled wall. The pile wall capping beam level is assumed to be at 29.6mOD, and ground level across the site ranges from 29.0mOD to 30mOD. Contiguous piled walls of 0.75m diameter at 0.9m spacing are currently proposed to support the double basement excavation, and a piled wall of 0.6m diameter at 0.75m spacing is proposed for the single storey basement.

The above information is taken from current sketches and drawings provided by Walsh Associates and Pierce & Company, respectively. These are presented within Appendix A.

2.4 Historical Development

The area around Camden Canal (Lock) Market[4] was used as agricultural land until the *Regent's Canal* was constructed in the early 1800s. Warehouses and other buildings were constructed along the canal banks in the following few years and were in operation up until the 1950s. After this, it is likely that the buildings were used as craft workshops. In the 1990s, some of these craft workshops were renovated and converted into shops.

2.5 Bomb damage and unexploded ordnance

The site experienced no recorded bombing during the Second World War. The closest structure that appears to have bomb damage is 146m from site and was damaged beyond repair.

[4] http://www.camdenlock.net/camdenlock/history/history.html (assessed August 2015)

2.6 Anticipated ground conditions

2.6.1 Published and unpublished geology

The British Geological Survey (BGS) map sheet 256 (North London)[5] indicates that the site is directly underlain by the London Clay Formation, which consists of stiff blue grey silty clay, weathering to brown silty clay near the surface.

The BGS holds records of a number of historical ground investigations within 300m of the site. Selected logs are summarised in Table 1 and details are included in Appendix B.

Table 1 - Summary of BGS historical borehole records

BH record reference	Distance (m)	Direction	Base of BH (mbgl)	Ground water level (mbgl)	Depth to top of stratum (mbgl)				
					MG	London Clay Formation	Lambeth Group	Thanet Sand	Chalk
TQ28SE5	159	E	91.4	NR	-	0.0	42	NR	64
TQ28SE26	78	S	13.7	-	0.0	3.2	-	-	-
TQ28SE2264	144	S	10.0	-	0.0	0.70	-	-	-
TQ28SE2272	141	S	1.1	-	0.0	0.35	-	-	-
TQ28SE2270	145	S	1.3	-	0.0	0.4	-	-	-
TQ28SE2269	168	S	1.8	1.14	0.0	0.35	-	-	-
TQ28SE2271	163	SE	1.8	1.40	0.0	0.38	-	-	-
TQ28SE2265	170	S	4.0	0.23	0.0	0.25	-	-	-
TQ28SE2268	170	S	0.6	0.32	0.0	0.58	-	-	-
TQ28SE2266	176	S	1.8	0.88	0.0	1.7	-	-	-
TQ28SE2267	176	S	1.8	1.05	0.0	0.4	-	-	-

The historical borehole records generally recorded Made Ground ranging in thickness between 0.0 m and 1.7 m over the London Clay. The surface of the Lambeth Group was encountered in borehole TQ28SE5 at 42mbgl to 44.8mbgl and it was directly underlain by the Chalk encountered at 64mbgl.

Generally shallow groundwater was noted within the southern historical boreholes and encountered within the range of 0.2m to 1.4m below the ground level. Recharge tests undertaken for the historical boreholes indicate that the infiltration rate of perched water

[5] British Geological Survey. (1994) North London. Sheet 256. Solid and Drift Geology 1:50,000.

is effectively negligible, with water levels within the boreholes recovering by approximately 50mm over a four hour monitoring period.

2.7 Hydrogeology

The Environment Agency[6] has produced an aquifer designation system consistent with the requirements of the Water Framework Directive. The designations have been set for superficial and bedrock geology and are based on the importance of aquifers for potable water supply and their role in supporting surface water bodies and wetland ecosystems.

The underlying London Clay Formation is classified as 'Unproductive Strata' and the site is not within a Groundwater Source Protection Zone (SPZ).

2.8 Hydrology

The '*Lost Rivers of London'* map produced by Barton[7] indicates that a number of springs outcrop at the base of the Bagshot Formation to the north of the site, flowing through various drainage channels and in various directions into the watercourses of the district (most of which are now diverted underground) including the River *Westbourne*, *Tyburn* and *River Fleet*. The map indicates that the *River Fleet* runs approximately 178 m north of the site boundary and continues east where it links up with another tributary of the *River Fleet* and continues southeast at a distance of approximately 252 m from the site towards the *River Thames*. Additionally, the *Regent's Canal* forms the southern boundary of the site aligned in a west to east direction. The canal is located a minimum of 5 m from the proposed basement footprint.

With reference to CPG4, the site is approximately 2.2km southeast of the catchment for the pond chains on Hampstead Heath.

With reference to the Environment Agency[8] EA website, the site is not within a Flood Risk Zone.

Current mapping (Figure 15 CPG4) indicates that roads impacted by flooding in 1975 are located approximately 120 m north and 170 m west of the site. The site is not within a region that was impacted by 2002 flooding or areas with potential to be at risk of surface water flooding.

---

[6] www.environment-agency.gov.uk (September 2014)
[7] Nicholas Barton, *The Lost Rivers of London*, Historical Publications Ltd; 3rd Revised edition edition (7 Dec. 1992)
[8] Environment Agency maps, [online]: http://www.environment-agency.gov.uk (assessed August 2015)

3. SCREENING (STAGE 1)

3.1 Introduction

A screening assessment has been undertaken in accordance with CPG4, based on the flowcharts presented in that document. Responses to the questions posed by the flowcharts are presented below, and where 'yes' or 'unknown' may be simply answered, with no analysis required, these answers have been provided.

3.2 Subterranean (Groundwater) flow

This section answers questions posed by Figure 1 of CPG4, in Table 2.

Table 2. Responses to Figure 1 of CPG4

Question	Response	Action Required
1a. Is the site located directly above an aquifer?	No The site is underlain by the London Clay Formation.	None
1b. Will the proposed basement extend beneath the water table surface?	Yes The proposed development extends the shallow level of the groundwater table as recorded from the historical boreholes	Investigation and assessment
2. Is the site within 100m of a watercourse, well, or potential spring line?	Yes The *Regent's Canal* forms the southern site boundary and is located approximately 5 m from the proposed basement footprint.	Investigation and assessment
3. Is the site within the catchment of the pond chains on Hampstead Heath?	No	None
4. Will the proposed basement development result in a change in the proportion of hard surfacing?	No The site is currently covered by hardstanding and it is expected to keep similar proportion of hard surfacing after the site redevelopment.	None
5. As part of site drainage, will more surface water than at present be discharged to ground (e.g. via soakaways and/or SUDS)?	No All surface water is likely to be discharged to the sewer network through existing connections.	None
6. Is the lowest point of the proposed excavation close to, or lower than, the mean water level in any local pond or spring lines?	Yes The basement is likely to be lower than the water level in the *Regent's canal*.	Investigation and assessment

In summary, the site is underlain by the relatively impermeable London Clay Formation. Regional groundwater flow is likely to be to the south towards the *Regent's Canal* and *River Thames*, evidenced by the spring lines shown on Barton's 'Lost Rivers of London'. However, flow rates are considered to be extremely slow within the effectively impermeable London Clay, and there is no water table or general flow that is likely to be affected by basement construction.

There is the potential for localised and small quantities of perched water within the Made Ground or within sandy/silty horizons in the London Clay Formation and groundwater seepage is likely between the Made Ground and London Clay Formation interface. However, the impact is expected to be negligible

The proposed development will not increase the proportion of impermeable surfaces and as such there is likely to be no material change to recharge to the ground above that of the existing hydrogeological regime.

3.3 Slope/land stability

This section answers questions posed by Figure 2 of CPG4, in Table 3.

Table 3. Responses to Figure 2 of CPG4

Question	**Response**	**Action required**
1. Does the site include slopes, natural or man-made, greater than about 1 in 8?	No The site is relatively flat	None
2. Will the proposed re-profiling of the landscaping at site change slopes at the property boundary to greater than about 1 in 8?	No	None
3. Does the development neighbour land including railway cuttings and the like with a slope greater than about 1 in 8?	No	None
4. Is the site within a wider hillside setting in which the general slope is greater than about 1 in 8?	No The topography of the surrounding region is relatively flat	None
5. Is the London Clay Formation the shallowest stratum on site?	Yes The London Clay Formation is expected to be present beneath a thin layer of Made Ground.	Investigation and assessment
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 Current drawings do not indicate the removal of any trees and there are no known trees within the proposed basement footprint.	None

Question	Response	Action required
7. Is there a history of shrink/swell subsidence in the local area and/or evidence of such at the site?	Unknown The London Clay Formation is susceptible to seasonal shrink/swell movements and it is likely that these will occur, particularly in close proximity to high water demand trees. The impact of this on the proposed development and adjacent properties should be assessed.	Investigation and assessment
8. Is the site within 100m of a watercourse or a potential spring line?	Yes The *Regent's Canal* forms the southern site boundary and is located minimum of approximately 5 m from the proposed basement footprint.	Investigation and assessment
9. Is the site within an area of previously worked ground?	No	None
10. Is the site within an aquifer?	No The London Clay Formation is classified as an 'Unproductive Strata'.	None
11. Is the site within 50 m of the Hampstead Heath Ponds?	No The site is more than 2 km downslope of the Hampstead Chain Catchment.	None
12. Is the site within 5m of a highway or pedestrian right of way?	Yes The site is adjacent to Chalk Farm Road, Camden Lock Place and a pedestrian walkway along Grand Union Canal.	Impact assessment
13. Will the proposed basement significantly increase the differential depth of foundations relative to neighbouring properties?	Yes The neighbouring properties to the east of the site are known to have shallow foundations.	Impact assessment
14. Is the site over (or within the exclusion zone of) any tunnels?	No The Northern Line tunnels run below Chalk Farm Road. However, these are considered to be outside the zone of influence from the basement and corresponding ground movements associated with excavation and construction. This will be reviewed within the ground movement assessment sections of this report.	None

In summary, an investigation and impact assessment is required to confirm ground conditions and assess the magnitude of ground movements that may result from basement excavation and construction as these may affect adjacent structures and infrastructure.

The impact assessment will determine potential damage caused by ground movements to adjacent structures and infrastructure, and will recommend measures to mitigate potentially damaging movements.

The impact assessment will focus primarily on the impact of ground movements on the adjacent buildings to the east of the site, and the National Grid cables and canal wall along the southern boundary of the site.

3.4 Surface flow and flooding

This section answers questions posed by Figure 3 of CPG4, in Table 4.

Table 4. Responses to Figure 3 of CPG4

Question	Response	Action required
1. Is the site within the catchment of the pond chains on Hampstead Heath?	No	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 It is understood all surface water will be discharged to the sewer network through existing connections.	None
3. Will the proposed development result in a change in the proportion of hard surfaced/paved external areas?	No The site is currently covered by hardstanding and is underlain by the relatively impermeable London Clay Formation.	None
4. Will the proposed basement result in a change to the profile of the inflows of surface water being received by adjacent properties or downstream watercourses?	No	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 known to be at risk from surface flooding or is it at risk from flooding because the proposed basement is below the static water level of a nearby surface water feature?	No The site is not in a Flood Risk Zone according to Camden Flood Risk Management maps[9] and is not identified as a street that flooded in 1975 and 2002.	None

In summary, the proposed basement is to be constructed in areas of existing hardstanding and is therefore not anticipated to impact surface water flow. Additionally, the site is not

[9] The Local Borough of Camden flood risk management strategy (2013), Managing flood risk in Camden; *Camden Flood Risk Management Strategy*.

known to be at risk from flooding and is underlain by the relatively impermeable London Clay Formation.

4. SCOPING (STAGE 2)

This section of the report provides the scoping process (Stage 2) of CPG4, which is used to identify potential impacts of the new basement as set out in the screening process in Section 3 of this report, and to recommend an appropriate investigation strategy.

The items summarised below in Table 5 were identified as part of the Stage 1 screening process.

Table 5. Summary of Basement Impact Assessment requirements

Item	Description
1.	Subterranean (Groundwater flow) Assess the potential impact on the *Regent Canal* forming the southern boundary and investigate the groundwater levels in the Made Ground
2. 3.	*Slope and land stability* Assessment of potential movements associated with construction in the London Clay Formation, including short and long term heave movements, settlement associated with retaining wall deflections, and ground movements around the basement perimeter. Shrink/swell behaviour is a possibility. An assessment of the impact that the proposed excavation and basement installation could have on neighbouring structures, their foundations, and on NG cables across the canal wall.
-	*Surface flow and flooding* *No issues for scoping identified during screening.*

An extensive investigation has recently been completed by CGL between 3rd and 17th December 2014 on the adjacent Camden Lock site to the east. The findings from this investigation will be used in the assessment for Camden Lock (Canal) Market.

The ground conditions will be confirmed as appropriate when demolishing this site.

5. GROUND INVESTIGATION (STAGE 3)

5.1 Introduction

An investigation was undertaken on the neighbouring site, Camden Lock Village, between 3rd and 17th December 2014. The investigation comprised three rotary boreholes to a maximum depth of 30mbgl.

The borehole arisings were recorded and representatively sampled by a suitably qualified geotechnical engineer from CGL in order to obtain samples for laboratory testing, and to characterise the near surface ground conditions across the site. Soil samples were obtained for chemical and geotechnical laboratory analysis. Standpipes were installed in all boreholes to enable subsequent gas and groundwater monitoring to be undertaken. Full details of the site investigation are provided in the Geotechnical and Geoenvironmental Interpretative Report prepared by CGL3.

Another site investigation was undertaken by CGL[10], also, on the neighbouring site in the north, Stables Market block, in September 2006. The records of this investigation support the ground conditions encountered in the vicinity of the site regarding the recent site investigation in the east.

The scope of the ground investigation is considered acceptable to satisfy the requirements of Stage 2 (Scoping and Investigation) of CPG4 for the current site.

5.2 Summary

The ground conditions encountered during the investigation of the neighbouring site, Camden Lock Village, are summarised in Table 6. Reference should be made to the CGL site investigation report3 for detailed findings of the current site investigation and the exact exploratory hole locations are presented in Figure 2.

Table 6. Summary of ground conditions encountered

Stratum	Top of stratum (mOD) [mbgl][a]	Typical thickness (m)
MADE GROUND Concrete overlying loose to medium dense dark brown sandy gravelly silt and soft to firm sandy gravelly clay. Sand is fine to coarse. Gravel is fine to coarse subrounded to subangular of brick, flint and occasional concrete.	27.07 to 28.64 [0.0]	1.2 to 1.8

[10] Card Geotechnics Limited. (2006) Stables Market Blocks A & B, Camden. *Factual information on ground conditions for tender purposes*. Ref: CG/04137. October 2006

Stratum	Top of stratum (mOD) [mbgl][a]	Typical thickness (m)
Firm dark orange brown slightly silty CLAY with occasional fine selenite crystals [WEATHERED LONDON CLAY FORMATION].	25.67 to 27.44 [1.2 to 1.8]	4.6 to 7.2
Stiff becoming very stiff and hard at depth closely fissured dark grey silty CLAY. Frequent fine selenite crystals noted. [LONDON CLAY FORMATION]	19.12 to 22.64 [4.6 to 7.2]	Base not proven at 30mbgl

a. mOD = metres above Ordnance Datum

Further details of the soils encountered are provided in the following sections. A plot of SPT 'N' versus level (mOD) is presented in Figure 3 and a plot of Undrained Shear Strength, c_u (kPa) versus level (mOD) is presented in Figure 4.

5.2.1 Made Ground

During the neighbouring site investigation, the Made Ground was found to be relatively consistent across the majority of the site and comprised concrete or paving slabs overlying brown sandy gravelly silt or sandy gravelly clay. No visual or olfactory evidence of contamination was noted.

5.2.2 London Clay Formation

The top of the London Clay was encountered at 25.67mOD (1.40mbgl) to 27.44mOD (1.20mbgl). The London Clay Formation was proved to a maximum depth of 30mbgl in the vicinity. The upper 4.6m to 7.2m of the clay was found to consist of firm brown silty clay (Weathered London Clay Formation), becoming stiff and grey (unweathered) from 19.12mOD to 22.64mOD. Due to the method of drilling, no Standard Penetration Testing (SPT) were undertaken in this area, however SPT was undertaken in nearby boreholes in the vicinity of the site. The SPT 'N' values recorded for this stratum in the other boreholes ranged from 5 to greater than 50 increasing with depth. Undrained shear strength values can be derived from these values using established Stroud correlations[11]. These values range from 22.5kPa to >225kPa.

Laboratory testing on samples of undisturbed samples from the London Clay Formation recorded undrained shear strength (c_u) values of 47kPa to 533kPa, increasing with depth.

The Moisture content and Atterberg Limits recorded within the clay are summarised in Table 7.

[11] Tomlinson, M.J. (2001) *Foundations Design and Construction (7th Ed.)*. Pearson Prentice Hall

Table 7. Summary of Moisture Content and Atterberg Limits

Strata	Moisture content (%)	Liquid limit (%)	Plastic limit (%)	Modified plasticity index, I' (%)
London Clay Formation	20 to 33	48 to 75	20 to 31	28 to 49

These indicate that the material at this site is a high to very high plasticity clay of medium to high volume change potential.

5.3 Groundwater

No groundwater strikes were recorded in the boreholes during drilling and boreholes generally remained dry when left overnight. However, groundwater was present in all boreholes during subsequent monitoring visits and as summarised in Table 8.

Table 8. Summary of groundwater monitoring undertaken to date

Borehole [Surface level mOD]	Groundwater level (mOD) [Level of base of well (mOD)]		
	18/12/14	08/01/15	13/01/15
BH8 (28.64m0D)	12.12 [2.64]	18.39 [3.38]	18.39 [3.61]
BH9 (28.12mOD)	1.12 [-3.25]	20.35 [-1.36]	20.42 [-1.96]
BH10 (27.07)	25..07 [3.07]	27.04 [4.42]	27.12 [4.44]

It is considered that the groundwater in the boreholes during monitoring is likely to be due to water seepage at the interface between the Made Ground and London Clay Formation and also potentially due to very slow seepage within the silty sandy layers/pockets within the upper weathered London Clay Formation.

Recharge tests undertaken during current monitoring visits indicate that the infiltration rate of perched water is effectively negligible with water levels within the boreholes recovering by less than 50mm over a four hour monitoring period.

5.4 Geotechnical Design Parameters of the proposed site

Geotechnical design parameters are recommended based on the information from the intrusive investigation and published data from the well-studied London geology. These are summarised in Table 9. The values are unfactored (Serviceability Limit State) parameters and are considered to be characteristic values for the local soils.

It should be noted that the soil stratigraphy and the thickness of each stratum correspond to the average findings from the ground investigation of the neighbouring site. The site ground floor elevations are adapted from the relevant application drawings (Appendix A).

Table 9. Geotechnical design parameters for Camden Lock (Canal) Market

Stratum	**Depth to surface (mbgl)** **Level [mOD]**	**Bulk Unit Weight γ_b (kN/m^3)**	**Undrained Cohesion c_u (kPa) [c']**	**Friction Angle ϕ' (°)**	**Young's Modulus E_u (MPa) [E']**
Made Ground	0 [29.6]	18	30 [0]	26[d]	18[a] [13.5]
London Clay Formation	1.5 [28.1]	20	50 + 6z[e] [5]	24[d]	30 + 3.6z[b] [22.5 + 2.7z][c]

a. *Bowles, J.E., Foundation Analysis and Design.*
b. *Based on 600c_u - 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. Increased to 1000 c_u for London Clay Formation within retaining wall deflection calculations.*
c. *Based on 0.75Eu - 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. *BS 8002:1994 Code of practice for Earth retaining structures, British Standards institution.*
e. *z = depth below surface of London Clay Formation.*

Based on the above and taking account of the close proximity of the canal, a long term design water level of 28.6mOD is recommended within a conservative approach (i.e. approximately 1mbgl). The water level in the canal is indicated in the drawings at more than 3mbgl.

5.5 Conceptual site model (Stage 3)

A conceptual site model (CSM) has been developed based on the available data and in accordance with the recommendations of the Camden Geological, Hydrogeological and Hydrological Study[12] (CGHHS) report as well as the Construction Management Plan[13] from Mace.

A basement plan is shown in Figure 5, and Figure 6 and Figure 7 present the critical cross-sections (Section 2-2 and Section 3-3) through the identified critical constraints around the

[12] Ove Arup and Partners Limited (2010). *London Borough of Camden. Camden geological, hydrogeological and hydrological study. Guidance for subterranean development.* Issue 01, November 2010.
[13] Mace (2015). *Camden Lock Market Stanley Sidings Ltd, Construction Management Plan*, Rev. 1.

perimeter of the basement. The main construction activities that could potentially cause movement of the neighbouring properties and infrastructure are summarised below;

1. Vertical and lateral ground movements due to contiguous piled wall installation.

2. Stress relief and heave movements due to excavation of the basement within the piled wall. This will be considered over the short and long term.

3. Ground settlement due to piled wall deflection during excavation in front of the wall.

6. BASEMENT IMPACT ASSESSMENT – LAND STABILITY (STAGE 4)

6.1 Introduction

This section describes calculations undertaken to assess ground movements that may result from the construction of the proposed basement and to assess how these may affect the adjacent structures and infrastructure. It is understood that a 0.75m diameter, 0.9m spacing contiguous piled wall will form the temporary and permanent support system for the double basement excavation at the west part of the proposed development. A piled wall of 0.6m diameter at 0.75m spacing is proposed for the single basement excavation in the east.

6.2 Critical sections for analysis

Based on discussions held with the structural engineers (Walsh Associates) and with reference to current development drawings, a number of constraints have been identified (see Figure 6 and Figure 7) that will be considered within the ground movement analysis and damage assessment sections of this report. The identified constraints and critical sections that will be assessed are summarised in the following sections.

LUL tunnels (Northern Line) run below Chalk Farm Road and the National Rail viaduct to the north are located sufficiently away (i.e. more than 20m or outside the 45 degrees zone of influence from the piled wall, and more than 30m, respectively) of the proposed development and hence are not expected to be affected by the development of the site. Also, it is noted that the existing façades to the north of the site (e.g. Gilgamesh building) are not considered to have an impact by the proposed development due to their distance from the piled wall (10m across the pedestrian road of Camden Lock Place).

National Grid cable infrastructure runs along the southern site boundary and follows the profile of the canal wall.

Adjacent properties to the east of the site are also considered in the impact assessment.

6.2.1 Section 1-1, 2-2: Double and single basement adjacent to the existing properties at the east of the site

The site is bordered to the east by existing buildings as described in Section 2.2 of this report. Current drawings indicate that the proposed basement piled wall will not come closer than 1m from the adjacent boundary walls. Neighbouring footings are assumed to be embedded at approximately 29mOD (i.e. 0.6m below the ground floor level).

A surcharge load of 200kPa accumulated from the superstructure on the adjacent boundary wall and 10kPa for the ground floor slab is assumed for use within the ground movement calculations. These adjacent properties have widths within the range of 10m to 14m perpendicular to the proposed basement.

6.2.2 Section 3-3: Adjacent to National Grid cables and Grand Union Canal wall

A concrete encasement containing National Grid (NG) cable infrastructure is located along the southern site boundary and follows the profile of the canal wall. The impact of predicted ground movements on this infrastructure will be assessed. Current draft drawings indicate that the cable run and canal wall come within 3m and 6.5m of the proposed basement wall respectively. It will be conservatively assumed within the assessment that the concrete encasement for the cable route is founded at 28.5mOD (approximately 1m below the ground level). The encasement measures approximately 1.2m wide by 0.8m deep.

Through discussion with the Client it is understood that the allowable deflection criterion for the cable run is 5mm of differential movement per 5m span i.e. angular distortion of 1:1000. This will be assessed for both lateral and vertical ground movement profiles.

The movement of the canal wall will also be assessed with a similar ground movement profile expected for that calculated for the National Grid infrastructure. Movements in the region of 10mm vertical and horizontal are considered to be tolerable for the canal wall. With reference to current drawings and information provided by the Client, the canal wall is a gravity retaining structure and is founded at approximately 22.6mOD.

6.3 Ground movements arising from basement excavation

The soils at basement formation level will be subject to stress relief during excavation, as some 7.5m of overburden is to be removed to form the new double storey basement in the west of the site and also some 5m of overburden is to be removed to form the singe basement in the east of the site. This is likely to give rise to a degree of elastic heave over the short term and potential heave or settlement over the long term as pore pressures recover in the London Clay Formation.

The magnitude of these movements has been calculated using OASYS Limited VDISP (Vertical DISPlacement) analysis software. VDISP assumes that the ground behaves as an elastic material under loading, with movements calculated based on the applied loads and the soil stiffness (Eu and E') for each stratum input.

The proposed bulk basement excavation gives rise to a net unloading of the underlying strata both during construction and over the long term. The excavation will unload the soils by 100kPa and 150kPa with regards to the basement formation level. This value assumes a typical bulk unit weight of 20kN/m^3 for the excavated soils.

The combined effects of both the immediate undrained unloading and the long-term drained recovery of pore pressures have been analysed and the results are presented as displacement contour plots within Figure 8 and Figure 9 for the short and long term respectively. The ground movements within the contour plots are taken from a single displacement grid applied at FFL 22mOD i.e. double basement formation level.

Displacement lines have been added to the VDISP models corresponding to the line of the critical sections identified. These displacement profiles will be used to illustrate the ground movement profile at these locations and to undertake a damage assessment for the relevant structure. Due to the curvature of the National Grid infrastructure on plan, displacement points have been modelled at 1m centres (and at a level of 28.5mOD) along the centre line of the service run.

Heave movements will be counteracted by ground settlement behind the piled wall due to pile installation and deflection, the effects of which are considered in subsequent report sections.

The presence of stiff piles and pile caps in the soil below formation level has been ignored in the analysis. These elements will help to reduce heave movements further, therefore the values predicted in the analysis are likely to be greater than actual movements.

The presence of the contiguous piled wall around the perimeter of the excavation has also been ignored in the analysis. It is anticipated that the skin friction of the piled wall would further reduce heave movements around the perimeter of the basement.

The results of the analysis are summarised in Table 10 below for both short and long term. The VDISP output can be provided separately upon request.

Table 10. Summary of maximum heave movements within excavation and at constraint locations

Stage	Double basement Centre of excavation (mm)	Single basement Centre of excavation (mm)	NG cable & dock wall [b] (mm)
Short term heave movement	20	14	<4
Long term heave movement	40	22	<10

a. Based on results of displacement line at level and plan location of constraint
b. Based on results of displacement points at 1m centres along line of cable run

6.4 Ground movement due to retaining wall deflection

This section presents the results of a retaining wall analysis undertaken to provide predictions of ground movement behind basement walls in the location of the critical sections. The proposed construction methodology and sequence has been derived based on discussions with Walsh Associates and with reference to current drawings (Appendix A).

6.4.1 Proposed construction sequence

It is proposed to adopt a bottom up construction sequence. Given the size of the wall, depth of excavation and position of adjacent buildings at the east- north of the site (adjacent party walls should be 1m distance from the retaining pile wall) it is proposed a high level propped piled wall is constructed along the site boundary for use in both the temporary and permanent conditions. Along the southern site boundary and where the canal and National Grid infrastructure comes within 3m to 6.5m, of the wall it is proposed to construct a temporary berm and install high level propping to control ground movement.

The typical construction sequence for the general piling arrangement of the site is summarised below.

1. Install contiguous piled wall, comprising 600mm diameter piles at 750mm spacing for the single storey basement and 750mm diameter piles at 900mm spacing for the double storey basement.

2. Excavate to 28mOD (on passive side) to allow sufficient space to construct capping beam and temporary propping, and excavate a temporary berm for the canal section (on active site). Top of capping beam is assumed at 29.6mOD.

For the canal section, it is assumed that the berm will be 1m wide at the top and 5m wide at the base.

3. Install (raking) temporary propping at 29.0mOD for all the sections.

4. Excavate to formation level (FFL 22.0mOD) and construct basement slab for the double storey basement at SSL 22.7mOD, or excavate to formation level (FFL 24.5mOD) for the single storey basement and construct basement slab SSL 25.2mOD.

5. Construct first basement floor slab at 25.2mOD (for the north-west part of the site) and ground floor slab SSL 29.6mOD prior to removing temporary prop at 29.0mOD.

In total, three different wall analyses have been undertaken and three critical sections considered.

1. Sections 1-1, 2-2 model the neighbouring party walls with a surcharge of 200kPa at a distance of 1m from the wall and at a level of 29.6mOD.

2. Section 3-3 models the presence of the canal wall and a nominal surcharge of 10kPa between the canal and piled wall.

6.4.2 Analysis results

Analysis of the retaining wall has been undertaken using WALLAP embedded retaining wall analysis software. Serviceability limit state (SLS) criteria have been used to determine wall deflections. Calculation sheets are provided within Appendix C and are summarised within Table 11. The corresponding ground settlements at the critical sections are also provided.

The distance to negligible lateral movements behind the wall has been calculated assuming the ground movement occurs within a soil wedge based on a 45 degree load spread from the base of the excavation depth.

Vertical ground movement has been calculated by taking 50% of the displacement profile predicted from WALLAP. This is in line with the results of finite element analysis reported within *CIRIA C580 – Embedded retaining wall design 2003.*

Table 11: Results of WALLAP analysis

Section	Maximum wall deflection (mm)	Level of maximum deflection [mOD]	Lateral deflection at location/level of constraint (mm)	Vertical settlement below location of constraints (mm)
Section 1-1 Double storey basement	8	[23.0]	negligible	negligible
Section 2-2 Single storey basement	7	[26.5]	7	3.5
Section 3-3 Double basement-Canal wall	8	[23.5]	5	2.5

The analysis indicates that an embedment of 5m below formation level meets the global stability considerations of the propped wall sections (i.e. 17mOD for the double basement and 19mOD for the single basement). This embedment is also meets ULS criteria. It should be noted that where the basement wall is required to carry vertical columns from the proposed superstructure development the pile embedment may be governed by these loads. Final detailed pile design will be undertaken by the piling contractor awarded the works.

Based on the above, it will be assumed for the purpose of this assessment that piles within the contiguous wall will be typically 12.5m long for the double storey basement and 10.5m long for the single storey basement.

In regard to indicative wall displacements that may be expected during excavation, it should be noted that WALLAP uses a Winkler spring analysis to determine the wall displacements. In a Winkler medium springs are used to represent a continuum and there is no transfer of shear stresses between the springs. In general, the application of this concept leads to an overestimation of structural deformations; hence the resulting wall displacements and corresponding impact on the nearby structures and infrastructure may be over-predicted by the WALLAP program.

6.5 Ground movement due to retaining wall installation

With reference to CIRIA C580[14], vertical and horizontal surface movements due to installation of a contiguous piled wall are generally in the region of 0.04% of the wall depth assuming a good standard of workmanship. The distance behind the wall to negligible movement is 1.5 times wall depth for horizontal movements and 2 times wall depth for vertical movements.

Based on the ground conditions, CGL's experience with similar projects[15] and by adopting a 'hit and miss' pile installation sequence onsite, the maximum ground movements due to piled wall installation are likely to be in the region of 0.02% of the wall depth. The value of 0.02% will be adopted for this assessment.

The WALLAP analysis indicates that the pile length will be in the region of 12.5m. This pile length would give rise to a predicted horizontal and vertical movement of 2.5mm immediately adjacent to the piled wall.

Predicted installation movements are summarised in Table 12. The corresponding ground movement at the location of adjacent constraints is summarised below.

Table 12. Vertical movement due to pile installation

Section 3-3	**Ground movement (mm)** [a]	**Distance behind wall to negligible movement (m)**	**Deflection at NG cable & canal wall (mm)** [b]
Vertical movement	2.5	25	3mm to negligible movement
Lateral movement	2.5	18.75	1.8mm to negligible movement

[a] Ground movement immediately behind piled wall
[b] NG cable & canal wall located parallel to contiguous wall between 3m and 6.5m offset from the basement wall i.e. inside zone of influence

6.5.1 Ground movement due capping beam deflection

The potential ground movement due to the lateral deflection of the capping beam for the contiguous piled wall adjacent to the National Grid infrastructure has been assessed. This information will be used within the assessment of the horizontal displacement profile.

[14] CIRIA C580 (2003) *Embedded Retaining Walls – guidance for economic design*
[15] Ground Engineering (September 2014). Prediction of party wall movements using CIRIA Report C580

An Indicative deflection value has been calculated using standard beam deflection formula for uniformly loaded sections.

Free span for the capping beam between temporary propping has been assumed to be 5m. Loading values (kN/m) have been obtained from the results of the WALLAP analysis. The size of the reinforced concrete capping beam has been assumed regarding structural drawings from similar applications. The results are summarised in Table 13 below.

Table 13. Capping beam deflection

Critical section Reference	Capping beam size (mm)	Free span (m)	Load (kN/m)	Max. deflection (mm)
NG cable & dock wall	Reinforced concrete 900 x 500	5	70[a]	2

[a] Obtained from WALLAP analysis applied on the ground floor slab

It will be assumed for the purpose of the damage assessment, as a worst case ground movement scenario, that the National Grid cable run and canal wall will deflect laterally 2mm where they come within 2.5m of the piled wall. The impact of capping beam deflection on the National Grid infrastructure and canal wall is assumed to be negligible when the offset distance is greater than 5m (i.e. beyond 45 degree zone of influence).

7. DAMAGE ASSESSMENT

The calculated ground movements have been used to assess potential 'damage categories' that may apply to neighbouring structures and infrastructure due to the proposed basement construction method and assumed construction sequence. The methodology proposed by Burland and Wroth[16] and later supplemented by the work of Boscardin and Cording[17] has been used, as described in *CIRIA Special Publication 200*[18] and *CIRIA C580*.

General damage categories are summarised in Table 14 below:

Table 14. Classification of damage visible to walls (reproduction of Table 2.5, CIRIA C580)

Category	Description
0 (Negligible)	Negligible – hairline cracks
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).
3 (Moderate)	The cracks require some opening up and can be patched by a mason. Recurrent cracks can be masked by suitable linings. 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 windows (crack width 15mm to 25mm but also 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).

The above assessment criteria are primarily relevant for assessing masonry structures founded on shallow footings. Therefore, this methodology will be adopted within the damage assessment for the east neighbouring properties, i.e. Section 2-2, 3-3. The movement of the National Grid cables will be assessed against assessment criteria provided i.e. allowable differential of 5mm over 5m run. It is understood that movements in the region of 10mm are acceptable for the canal wall.

[16] Burland, J.B., and Wroth, C.P. (1974). *Settlement of buildings and associated damage*, State of the art review. Conf on Settlement of Structures, Cambridge, Pentech Press, London, pp611-654

[17] Boscardin, M.D., and Cording, E.G., (1989). *Building response to excavation induced settlement*. J Geotech Eng, ASCE, 115 (1); pp 1-21.

[18] 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.

7.1 Impact Assessment – *Section 1-1 and Section 2-2*

Table 16 incorporates superimposed vertical movements derived from both the pile wall installation, wall deflection, short term heave due to excavation and heave/settlement over the long term due reapplication of structural loads. The method of deriving these values and establishing an appropriate deflection ratio for the neighbouring structures to the east of the site is illustrated graphically in Figures 10 and 11 .The width of the adjacent structures has been assumed from development plans to be approximately 10m for the north east adjacent properties and 14m for the east adjoining structures. For the purpose of this assessment, the horizontal strain of the piled wall is limited to 3mm.

Table 16: Summary of ground movements and corresponding damage category

Boundary-Party Wall Reference	Maximum deflection (mm)	Horizontal Strain ε_η (%)	Deflection ratio Δ/L^b (%)	Damage category
Section 1-1: North-east adjacent properties	0.1	0.03	0.001	0 - Negligible
Section 2-2: East adjacent properties	5	0.021	0.036	0 - Negligible

a. See Figure 2.18 (a) CIRIA C580 (2003) Embedded retaining walls guidance for economic design. (L = length of adjacent structure in meters, perpendicular to basement; Δ = relative deflection)

b. See Box 2.5 (v) CIRIA C580 (2003) Embedded retaining walls guidance for economic design. (δ_h = horizontal movement in metres

Based on the above, with good construction practices, it can be assumed that the maximum damage category imposed on the neighbouring party wall properties due to the proposed basement development can be controlled to within 'Category 0' corresponding to negligible damage. The building interaction chart for the adjacent party wall structures is presented in Figure 12.

7.2 Impact Assessment – National Grid cables and Grand Union Canal wall

To assess the impact of the proposed basement development on the National Grid infrastructure and canal wall the predicted lateral and horizontal movement profiles have been combined to determine the overall worst case movement.

The vertical movement profile along the line of the National Grid infrastructure and canal wall due to short and long term heave, settlement due to pile installation and deflection is presented within Figure 13. It should be noted that the variation in settlement due to pile installation and deflection takes account of the varying offset distance between the proposed piled wall and existing line of the National Grid infrastructure and canal wall. The corresponding differential movement at typically 5m centres (i.e. assessment criteria) has also been plotted. The maximum allowable movement of the canal wall is 10mm.

The results indicate that the maximum combined vertical movement of the infrastructure is approaching the value of 10mm and the maximum differential movement over a 5m span is 4mm. The overall average differential movement is typically less than 2mm. The results indicate that the vertical movements of the National Grid infrastructure and canal wall fall below the assessment criteria.

The lateral movement profile along the line of the National Grid infrastructure and canal due to pile installation, pile deflection due to excavation and capping beam deflection is presented within Figure 14. It should be noted that the variation in lateral deflection takes account of the varying offset distance between the proposed piled wall and existing line of the NG infrastructure and canal wall. The corresponding differential movement at typically 5m centres (i.e. assessment criteria) has also been plotted.

The results indicate that the maximum combined lateral movement of the infrastructure is 9.5mm and the maximum differential movement over a 5m span is 3mm. The overall average differential movement is typically less than 2mm.

The results of the assessment indicate that the vertical and lateral movement of the National Grid infrastructure and canal wall due to the proposed basement development fall below the assessment criteria.

8. SUBTERRANEAN (GROUNDWATER) FLOW

8.1 Introduction

This section addresses outstanding issues raised by the screening process regarding groundwater flow.

8.2 Impact on groundwater flow

Based on the groundwater observations from the boreholes on and off site, site monitoring data and CGL's experience of groundwater conditions in the area, it is anticipated that little or no groundwater will be encountered during the basement excavation and any seepage that may be encountered will be limited and likely to be encountered at the interface of the London Clay Formation and Made Ground and potentially within sandy layers and pockets within the near surface Weathered London Clay Formation. This should be controllable by adopting localised pump and sump systems.

The hydrogeological regime is typical of London conditions, with the London Clay Formation providing an effectively impermeable barrier to vertical flow in the ground, leaving any lateral flows to occur within the Made Ground. Given the topography of the area, it is likely that hydraulic gradients will be relatively flat and consequent groundwater flow rates will be minimal.

Based on the above, it is considered that the new development will have little impact on localised groundwater flows and generally have a negligible impact on the local groundwater regime.

8.3 Recommendations for groundwater control

It is anticipated that due to the low permeability of the London Clay Formation and presence of a contiguous piled wall around the perimeter, it is likely that inflows during the construction will be relatively minor and generally dewatering will not be required. However isolated and limited perched water may be encountered in the shallow Made Ground or within more sandy partings of the upper layers of the Weathered London Clay Formation. Observations of groundwater should be recorded during excavation and appropriate mitigation strategies put in place if water is encountered.

9. SURFACE FLOW AND FLOODING

It is understood that surface waters will join the existing drainage infrastructure (albeit via basement pumping if a gravity fed solution is not feasible), with no significant changes in peak drainage outflows anticipated from the site.

As already identified, the site lies outside any Environmental Agency designated Flood Zone and is not highlighted as a street that flooded in the 1975 and 2002 events. Current mapping (Figure 15 CPG4) indicates that roads impacted by flooding in 1975 are located approximately 120m north and 150m west of the site. The site is not within a region that was impacted by 2002 flooding or areas with potential to be at risk of surface water flooding.

Based on the above, it is considered that the development will have a negligible impact on surface water flow and flooding. In addition, the basement is likely to provide enhanced attenuation given its requirement to be drained in accordance with Building Regulations.

10. CONSTRUCTION MONITORING

The results of the ground movement analysis suggest that, with good construction control, damage to adjacent structures generated by the assumed construction methods and sequence are likely to be (within Category 0) ‘negligible’. Additionally, movements predicted in the vicinity of the canal wall and the National Grid infrastructure, are generally within allowable limits, subject to confirmation from relevant stakeholders.

A formal monitoring strategy should be implemented across the site and especially in the regions identified as being critical and analysed within this assessment in order to observe and control ground movements during construction, and in particular movements of adjacent NG cable infrastructure.

The system should operate broadly in accordance with the ‘Observational Method’ as defined in CIRIA Report 185[19]. Monitoring can be undertaken by using vertical inclinometers installed within selected contiguous piles to determine wall displacement as excavation and construction progresses, while further use of survey targets affixed to the top of the piled wall and face of the adjacent infrastructure can determine if any horizontal translation of the piled wall or tilt/settlement of the neighbouring structure is occurring. Alternatively, remote tilt beams can be connected to the façade of the east existing properties and top of the National Grid cable run structure to provide ‘real time’ monitoring of this structure as excavation progresses.

Precise levelling can be undertaken at regular intervals around the perimeter of the excavation and in the region between the basement and identified critical constraints to give an early and accurate indication of deviating ground movements. It is recommended that a specialised monitoring contractor is employed to install and monitor the instrumentation on site.

It is recommended that vibration monitoring also be considered during the demolition of the existing building onsite and during the piling works.

Monitoring data should be checked against predefined trigger limits and can also be further analysed to assess and manage the damage category of the adjacent buildings as construction progresses. The data could also potentially be used to undertake back analysis calculations and value engineer certain elements of the construction.

[19] Nicholson, D., Tse, Che-Ming., Penny, C., The Observational Method in ground engineering: principles and applications, CIRIA report R185, 1999.

10.1 Construction monitoring – Installation

Monitoring of adjacent structures/infrastructure should commence a minimum of two weeks prior to piling beginning on site, and incorporate a 'baseline' data set taken prior to any excavation works. Monitoring should be continued regularly throughout pile installation with the data reviewed continuously to update the empirical assumptions made to date. Monitoring points should be established on capping beams, neighbouring properties/infrastructure and the ground between the excavations and identified critical constraints.

10.2 Construction monitoring – Excavation

The monitoring data obtained during pile installation should be reviewed prior to excavation and used to calibrate 'trigger limits'. Trigger values can be provided based upon a review of the ground movements once the design and construction method/sequence is finalised.

Inclinometers should be installed in critical piles at an appropriate spacing for the length of the retained wall.

Reference targets should be installed on capping beams and on neighbouring property/infrastructure where appropriate, with precise levelling points installed along the ground behind the wall to correlate with values from the inclinometers (in the basement walls) and survey targets (on the face of critical neighbouring structures). By adopting this approach the movement of the wall, ground behind and neighbouring property can be compared to that of the VDISP/WALLAP analysis and damage category assessment plots. The presence of remotely read tilt beams will provide early warning signs of movement trends.

In addition, a pre-commencement condition survey of neighbouring structures is recommended with strain/crack gauges applied to any existing defects to monitor changes brought about by construction activities.

Data from building targets and precise levels should be referred back to an appropriate datum (bench marks) positioned outside the zone of influence of ground movement outside the basement.

11. NON-TECHNICAL SUMMARY

11.1 General

The findings of this Basement Impact Assessment are informed by local site investigation data, information regarding construction methods provided by the client and assumed construction sequence and detail.

- From the available information, it is considered that the proposed basement construction will have a negligible effect on groundwater, surface water and flooding at this site.
- The construction of the basement will generate ground movements due to a variety of causes including; heave due to excavation and ground settlement due to pile installation and deflection during excavation.
- An assessment of the results of the ground movement analysis and displacement profiles indicate that these movements could give rise to a damage category within 'Category 1' (very slight damage) for the east neighbouring properties with good construction control and practices.
- Combined vertical and horizontal ground movements predicted along the line of National Grid infrastructure fall within current limits recommended. Additionally, the predicted movement of the canal wall is below the assessment criteria.
- There is the potential for localised perched water within the shallow Made Ground, but this is likely to be limited and underlain by impermeable clay. Observations on groundwater should be carefully recorded during excavation. Should perched groundwater be encountered, a temporary pumping strategy will need to be implemented to ensure the excavation and formation levels are kept dry prior to blinding. This could be achieved by the use of, for example, a localised sump and pump system.
- It is recommended that an appropriate monitoring regime is adopted to manage risk and potential damage to the identified neighbouring constraints.

11.2 Cumulative impacts

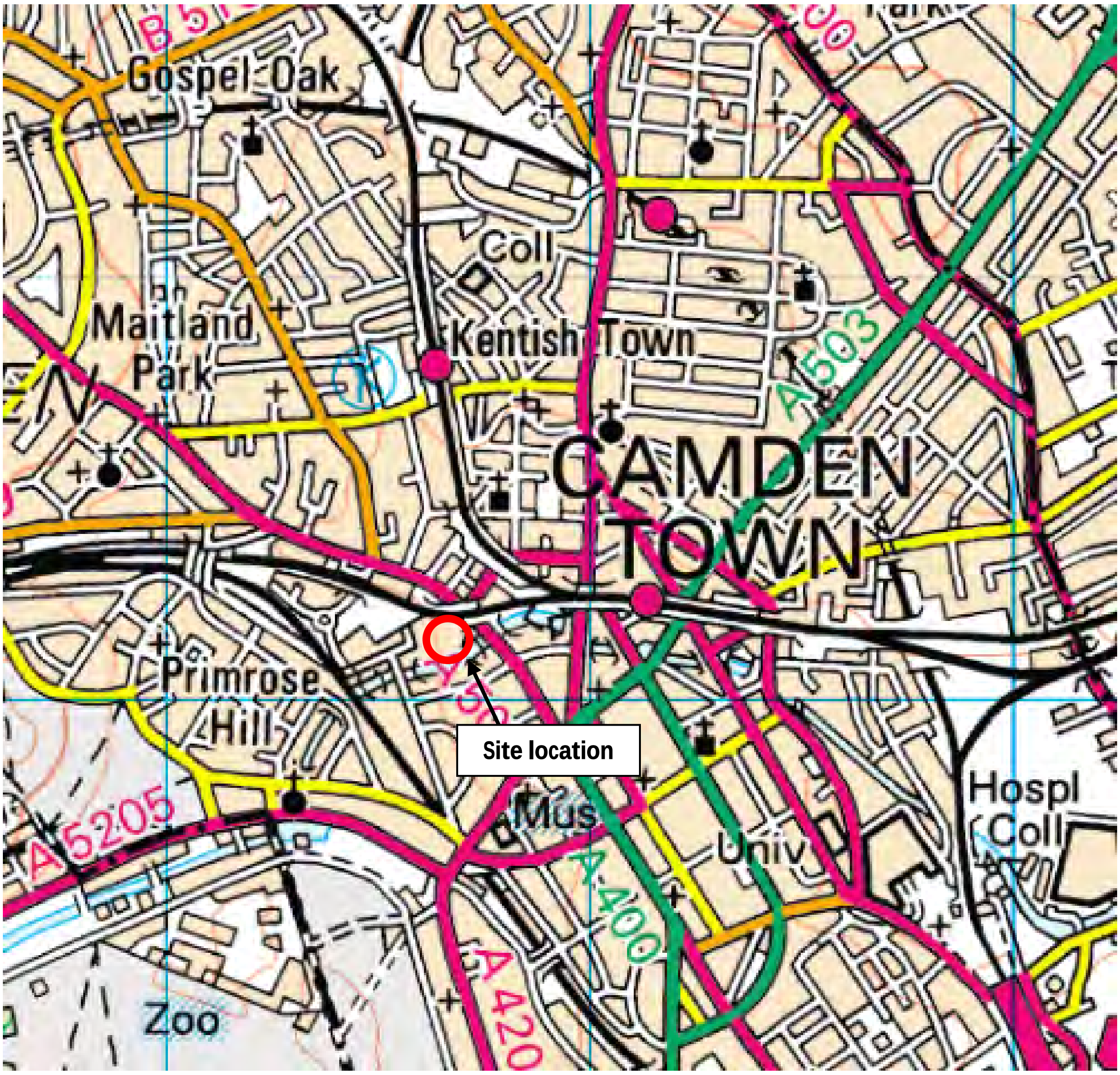
The ground movement and impact assessments have indicated that damage to neighbouring properties will be within allowable limits. Therefore, it is considered that there are no cumulative impacts in respect of ground or slope stability.

Groundwater was not encountered during the investigation and boreholes generally remained dry when left open overnight. Although groundwater was noted in the boreholes during subsequent monitoring, it is considered that the groundwater in the boreholes is due to water seepage at the interface between the Made Ground and London Clay Formation and also potentially due to very slow seepage within the silty sandy layers/pockets within the upper weathered London Clay Formation. Additionally, bailing of the boreholes during current monitoring visits confirms that that the infiltration rate of perched water is negligible. It is assumed based on the above that the development will have no significant impact on the flow of ground water in the region and would not contribute further to any cumulative effects.

It is understood that surface waters will join the existing drainage infrastructure (albeit via basement pumping if a gravity fed solution is not feasible), with no significant changes in peak drainage outflows anticipated from the site. The site is currently covered by hardstanding and is underlain by the relatively impermeable London Clay Formation. On this basis, the development is not considered to contribute to any significant cumulative impact with regard to surface flow or flooding.

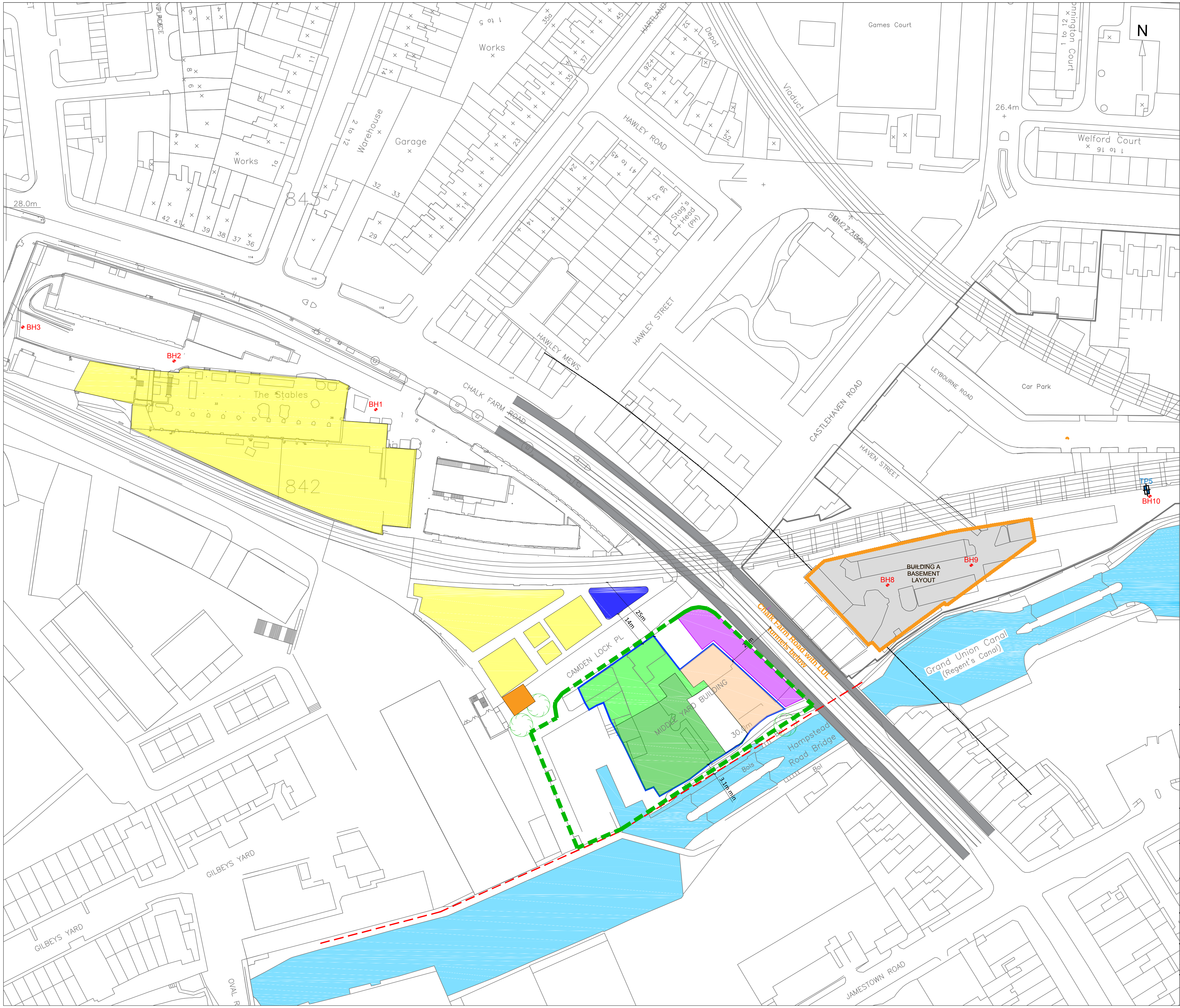
Based on the results of the ground movement assessment and taking account of the distance to the other proposed basement blocks, the cumulative impact of these basements and associated ground movements on adjacent infrastructure will not change considerably compared to current predictions.

FIGURES



N

Client	Project	Job No
Stanley Sidings Ltd	**Camden Lock Market, London**	**CG/18510**
CGL	Title **Site location plan**	**Figure 1**



KEY

Borehole	
Trial Pit	
Basement boundary	
Approximate path of UKPN cable	
Site boundary	
Proposed single storey basement	
Proposed single to double storey basement	
Proposed double storey basement	
Neighbouring buildings, 3 storeys high, likely to have a lower ground floor	
Gilgamesh- Top down basement, 3 storeys	
The Stables Market - Existing basement	
The Stables Market (shops and properties)	

Rev	Date	Comments
*	*	*

CGL

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

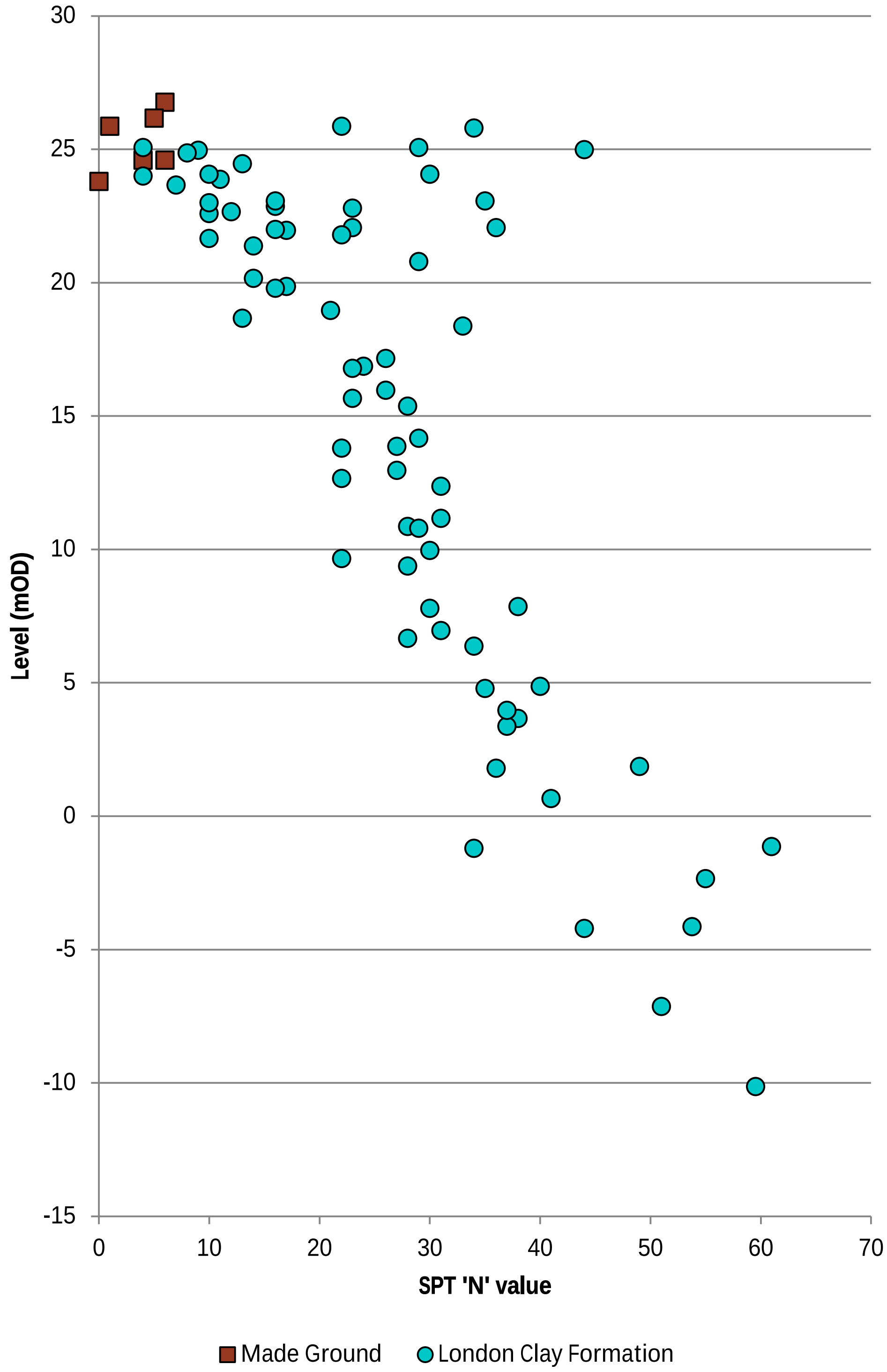
Project: **Camden Lock Market, London**

Client: **Stanley Sidings Limited**

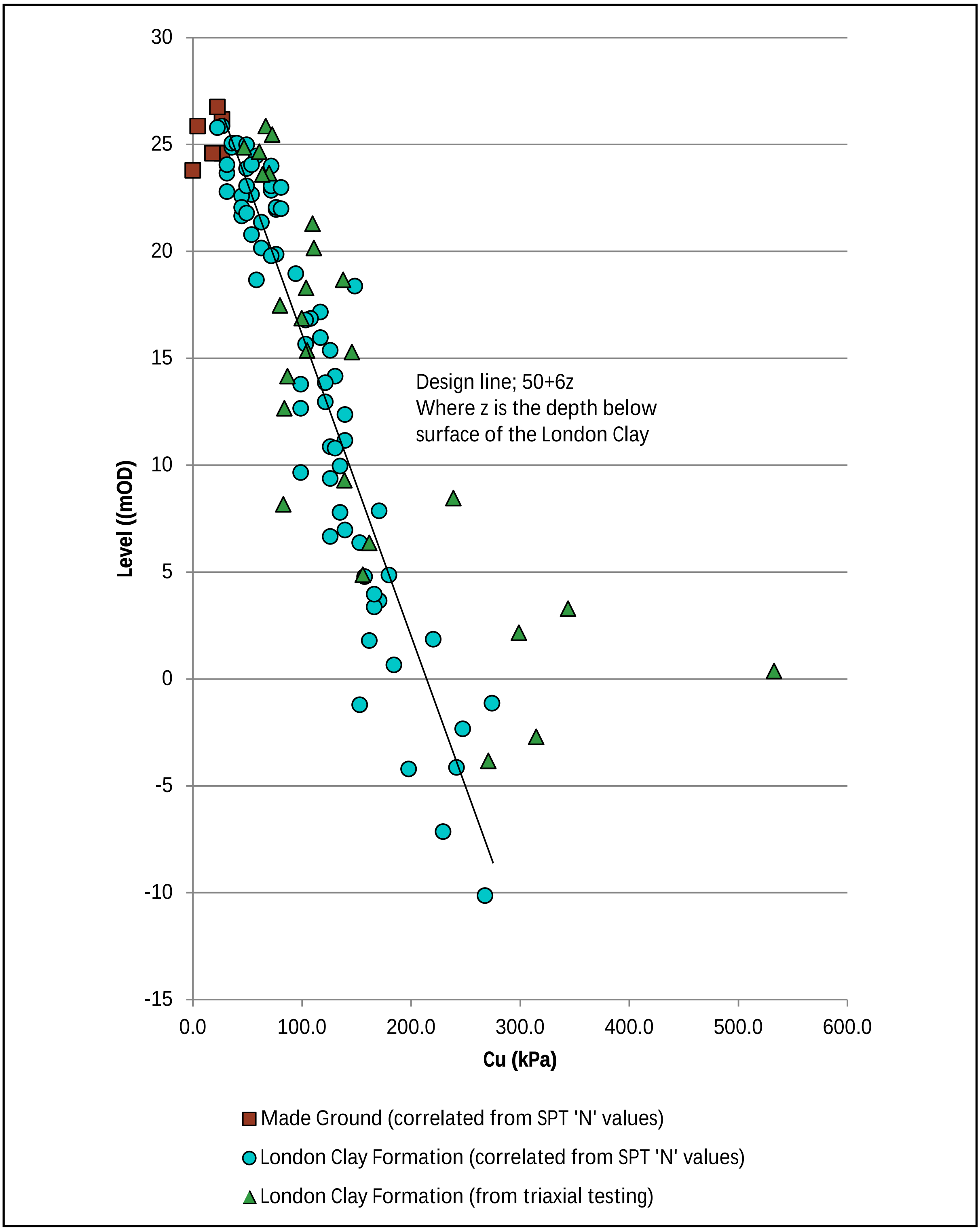
Drawing title: **Figure 2 - Site layout and exploratory hole location plan**

Scale(s)	Job No.
NTS	**CG/18510**

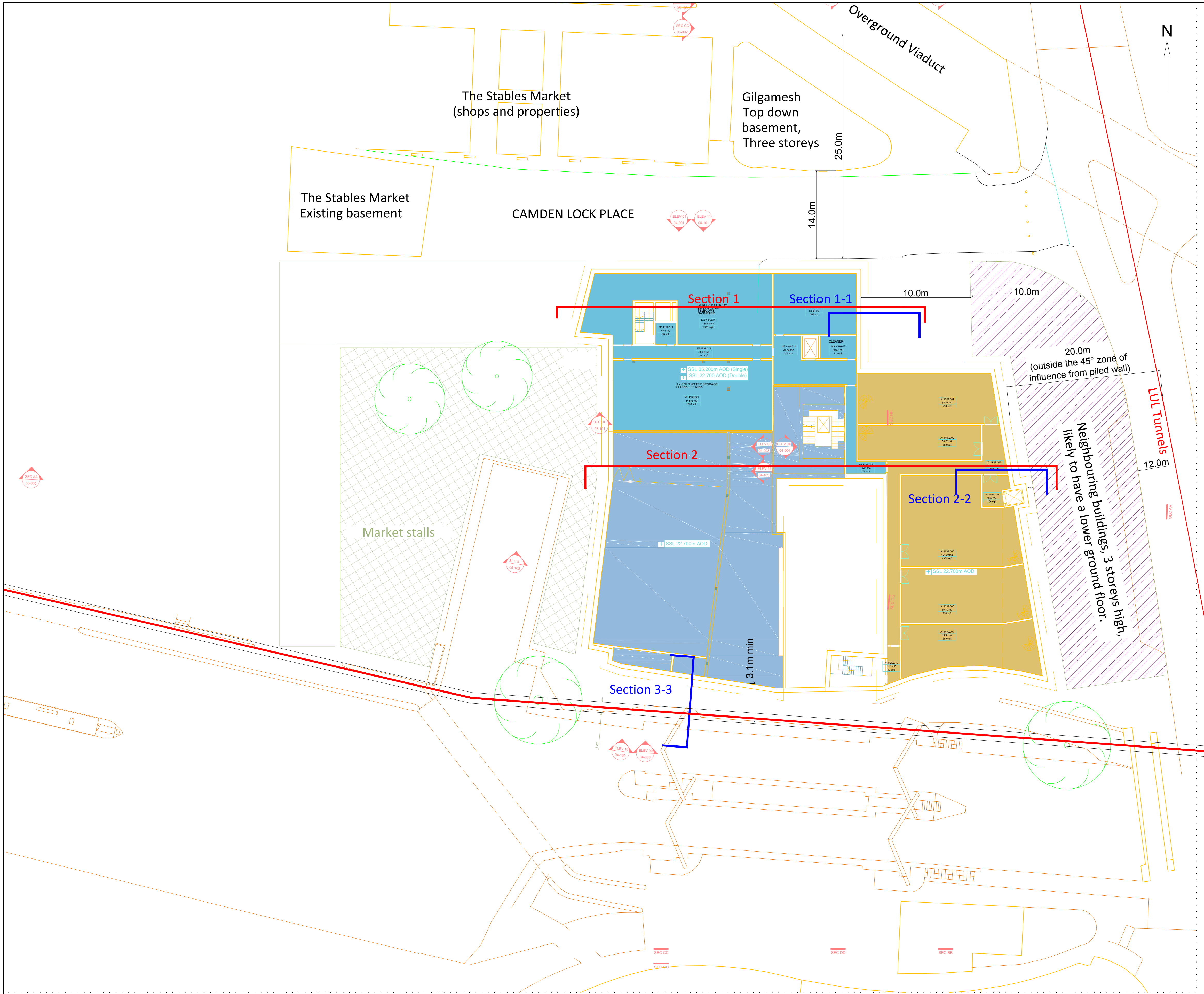
			Dwg No.	Rev.
Drawn	TSB	04/08/15	**CG/18510-002**	*
Checked	GES	05/08/15		
Approved				



Client	Project	Job No
Stanley Sidings Ltd	**Camden Lock Market, London**	**CG/18510**
CGL	Title **Plot of SPT ‘N’ values against level**	**Figure 3**



Client	Project	Job No
Stanley Sidings Ltd	**Camden Lock Market, London**	**CG/18510**
CGL	Title **Plot of undrained shear strength, c_u against level**	**Figure 4**



KEY

NG infrastructure (UKPN)

Rev	Date	Comments
*	*	*

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

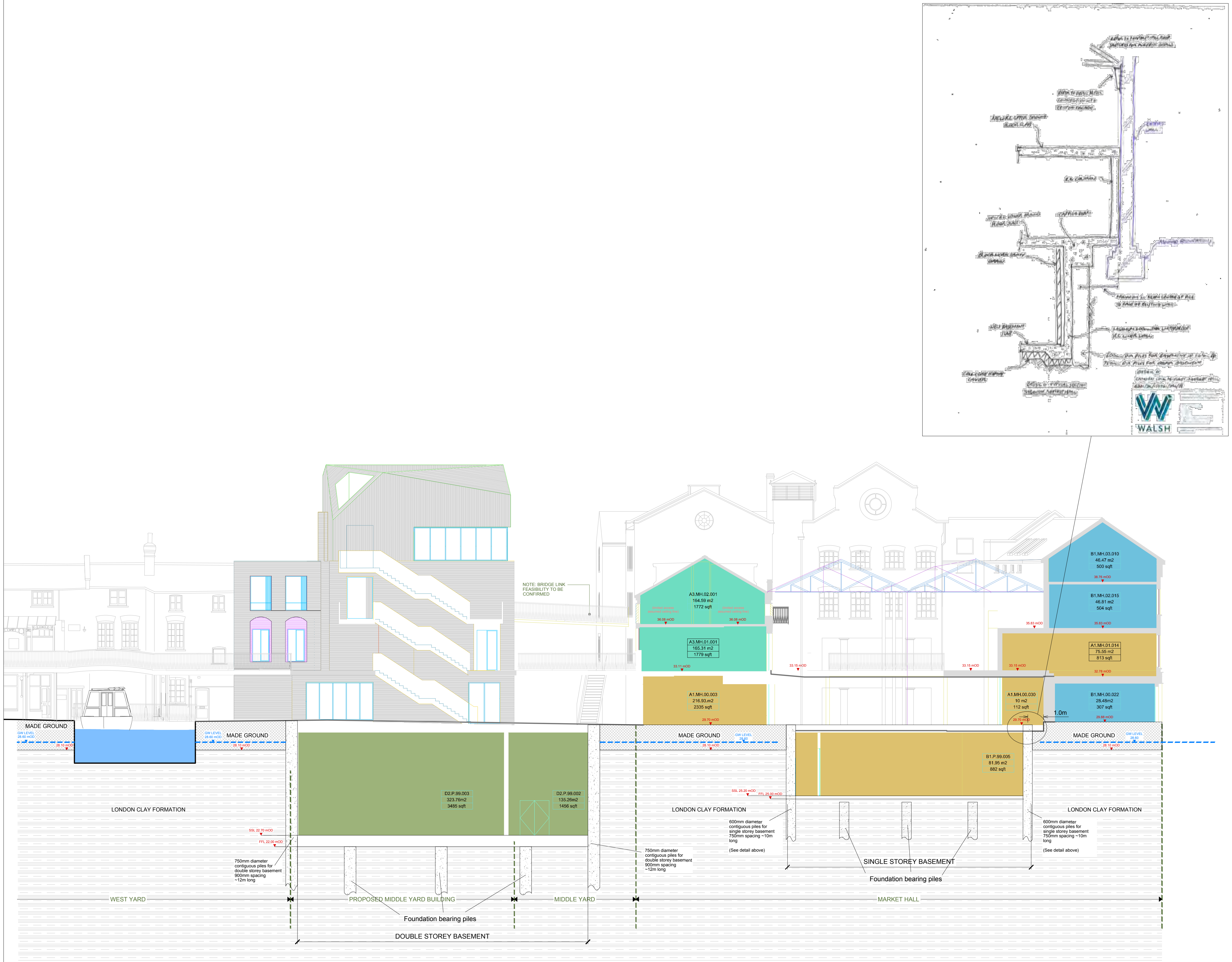
Project: **Camden Lock Market, London**

Client: **Stanley Sidings Limited**

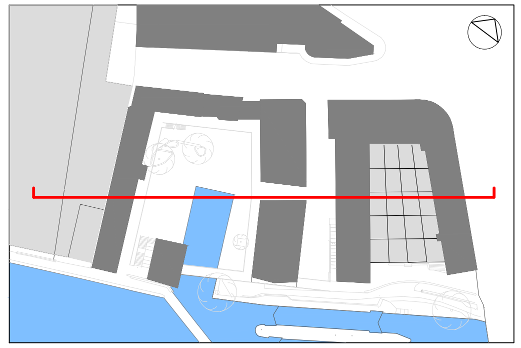
Drawing title: **Figure 5 - Conceptual Site Model - Basement plan and constraints**

Scale(s)	Job No.
NTS	**CG/18510**

			Dwg No.	Rev.
Drawn	TSB	22/07/15	**CG/18510-005**	*
Checked	GES	05/08/15		
Approved				



KEY



Rev	Date	Comments
*	*	*

CGL

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

Project: **Camden Lock Market, London**

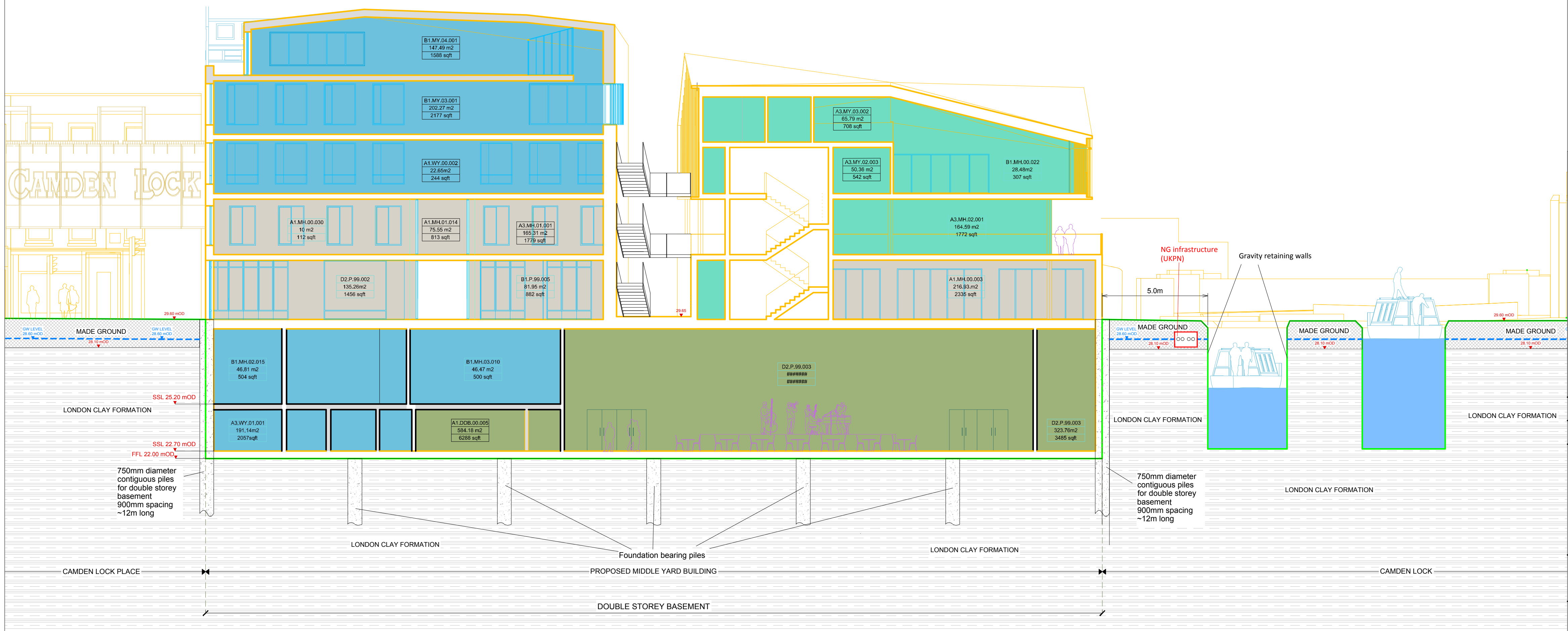
Client: **Stanley Sidings**

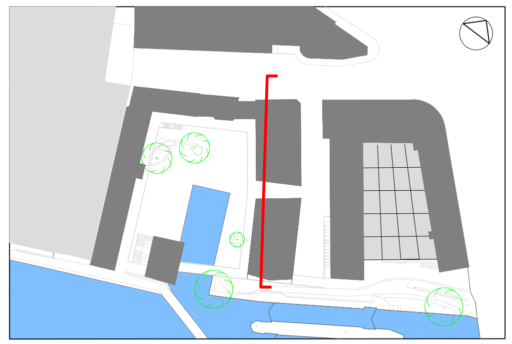
Drawing title: **Figure 6 - Conceptual Site Model - Constraint Section 2-2**

Scale(s)	Job No.	
NTS	CG/18510	

			Dwg No.	Rev.
Drawn	TSB	31/07/15	CG/18510-006	*
Checked	GES	05/08/15		
Approved				

KEY





Rev	Date	Comments
*	*	*

CGL

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

Project: **Camden Lock Market, London**

Client: **Stanley Sidings**

Drawing title: **Figure 7 - Conceptual site model - Constraints section 3-3**

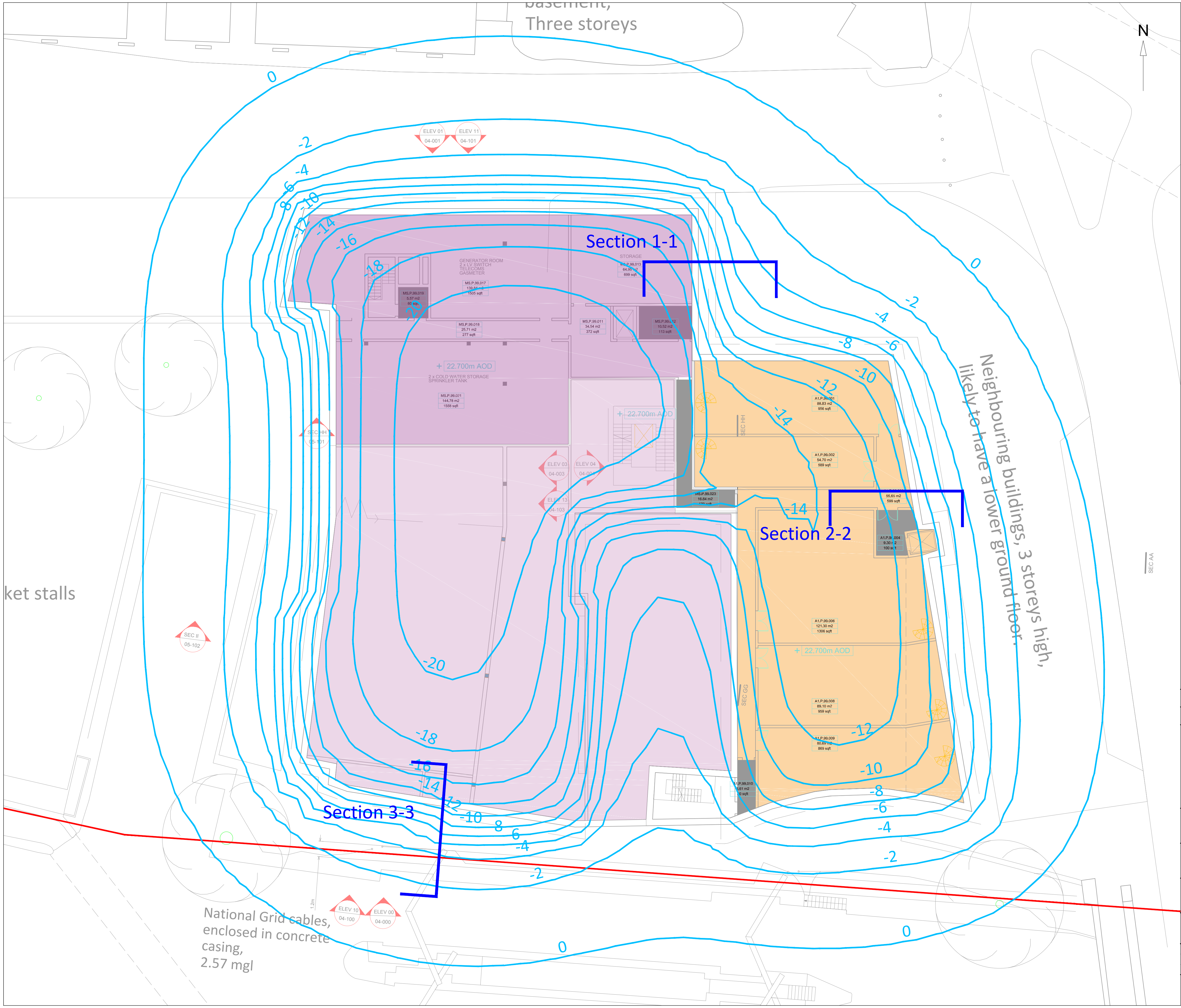
Scale(s): **NTS**

Job No.: **CG/18510**

Drawn	TSB	31/07/15
Checked	GES	05/08/15
Approved		

Dwg No.: **CG/18510-007**

Rev.: *



KEY

Single storey basement

Double storey basement

Rev	Date	Comments
*	*	*

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

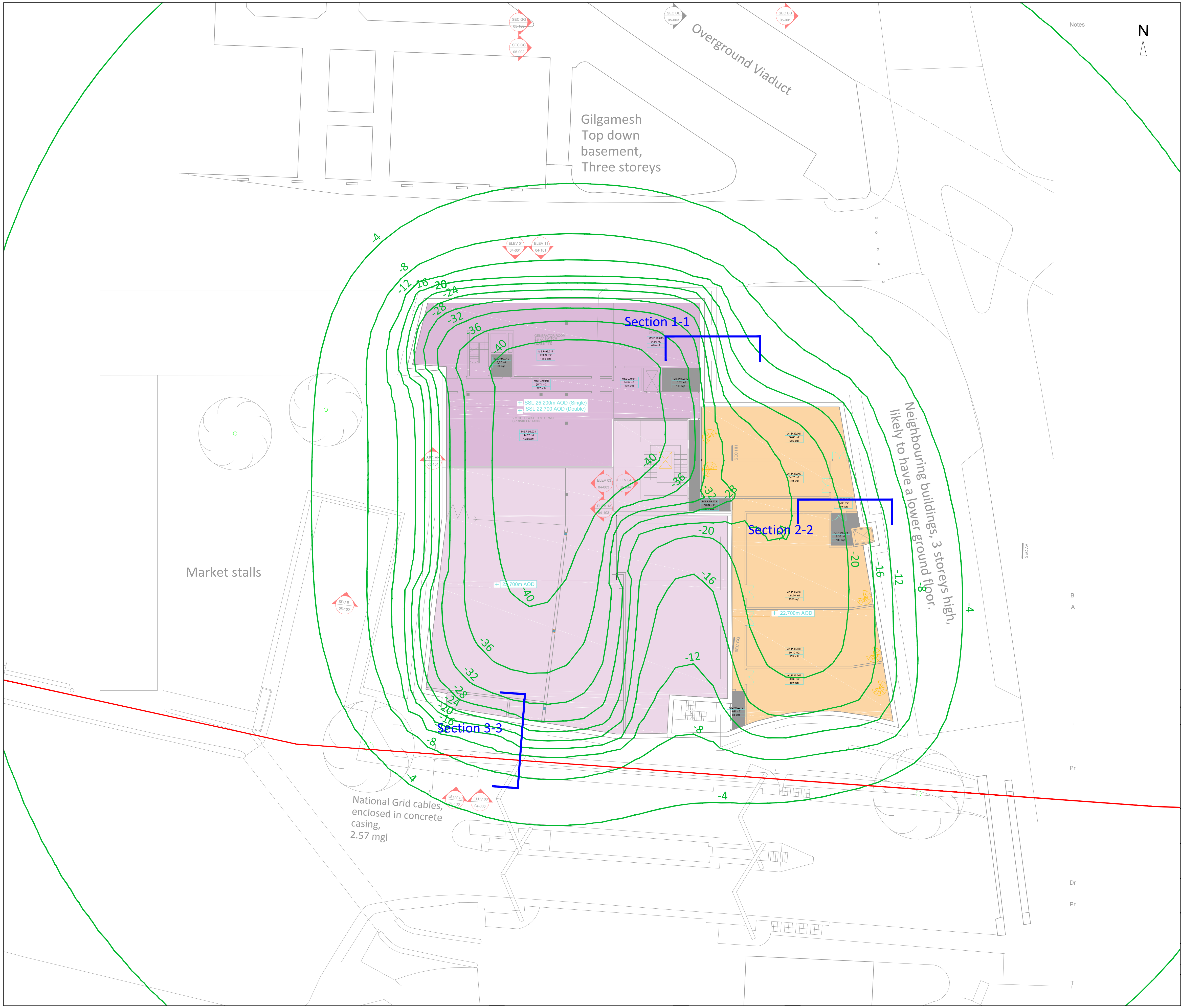
Project: **Camden Lock Market, London**

Client: **Stanley Sidings Limited**

Drawing title: **Figure 8 - Short term ground movement contour plot**

Scale(s)	Job No.
NTS	**CG/18510**

			Dwg No.	Rev.
Drawn	TSB	30/07/15	**CG/18510-008**	*
Checked	GES	05/08/15		
Approved				



Rev	Date	Comments
*	*	*

CGL

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

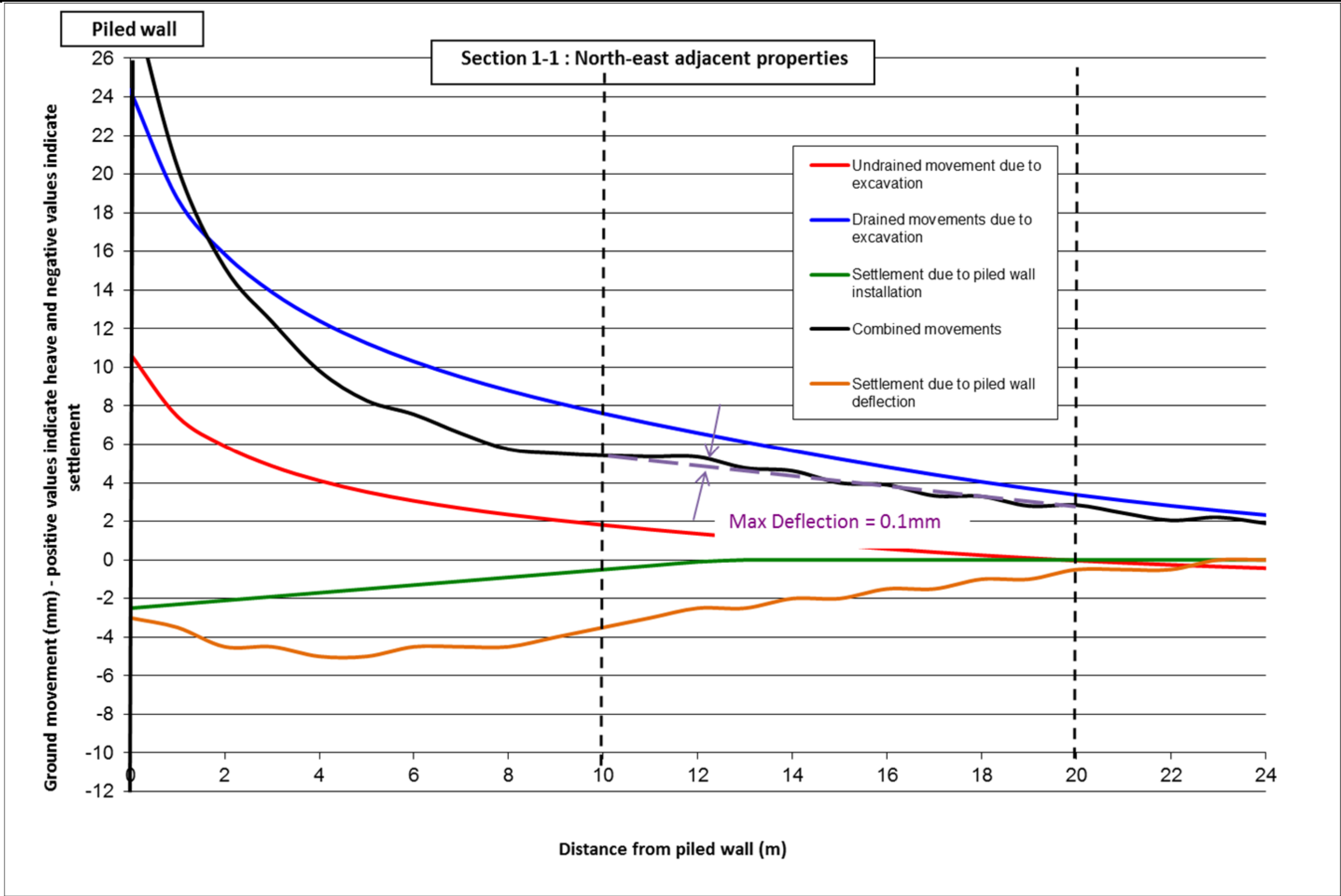
Project: **Camden Lock Market, London**

Client: **Stanley Sidings Limited**

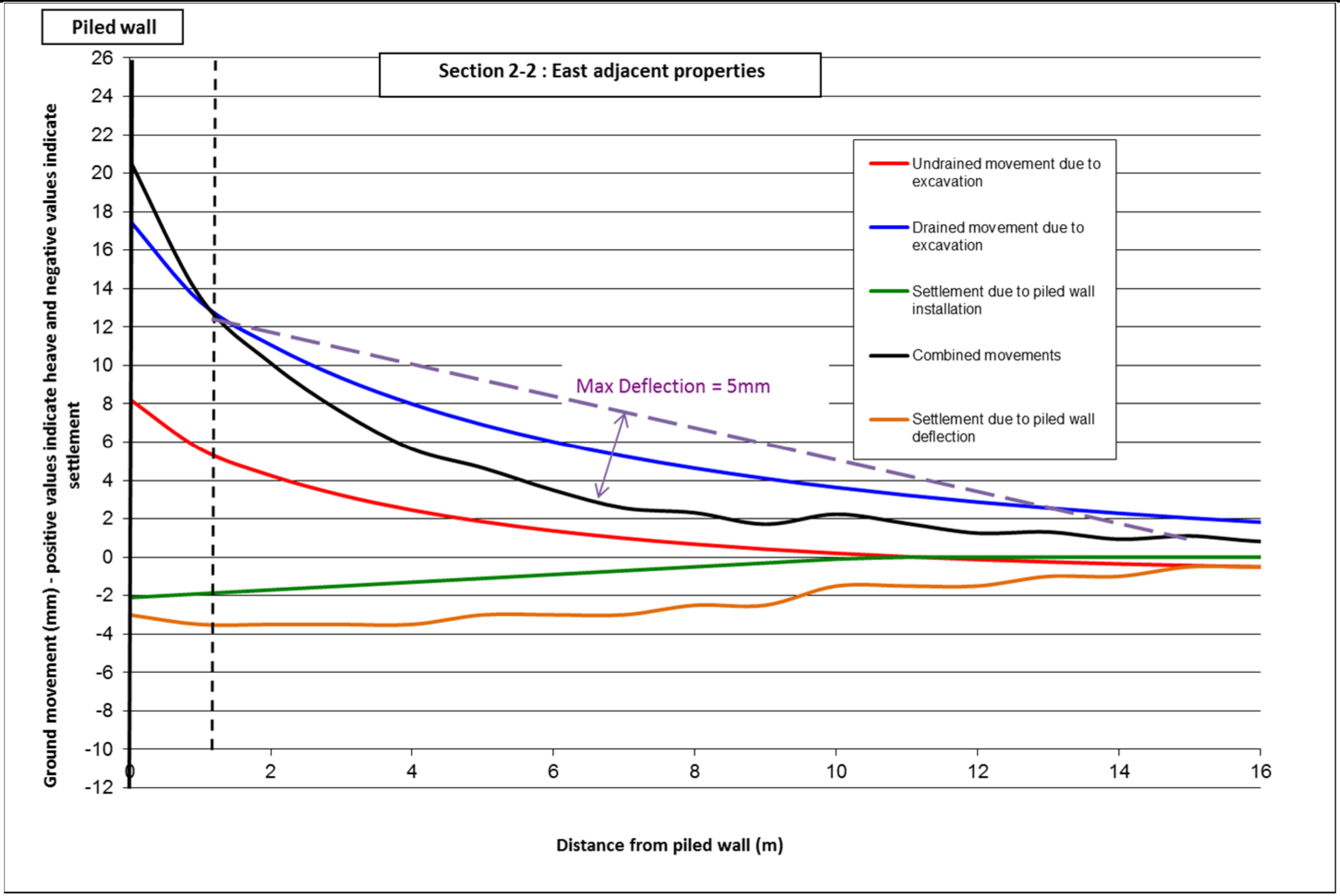
Drawing title: **Figure 9 - Long term ground movement contour plot**

Scale(s)	Job No.
NTS	**CG/18510**

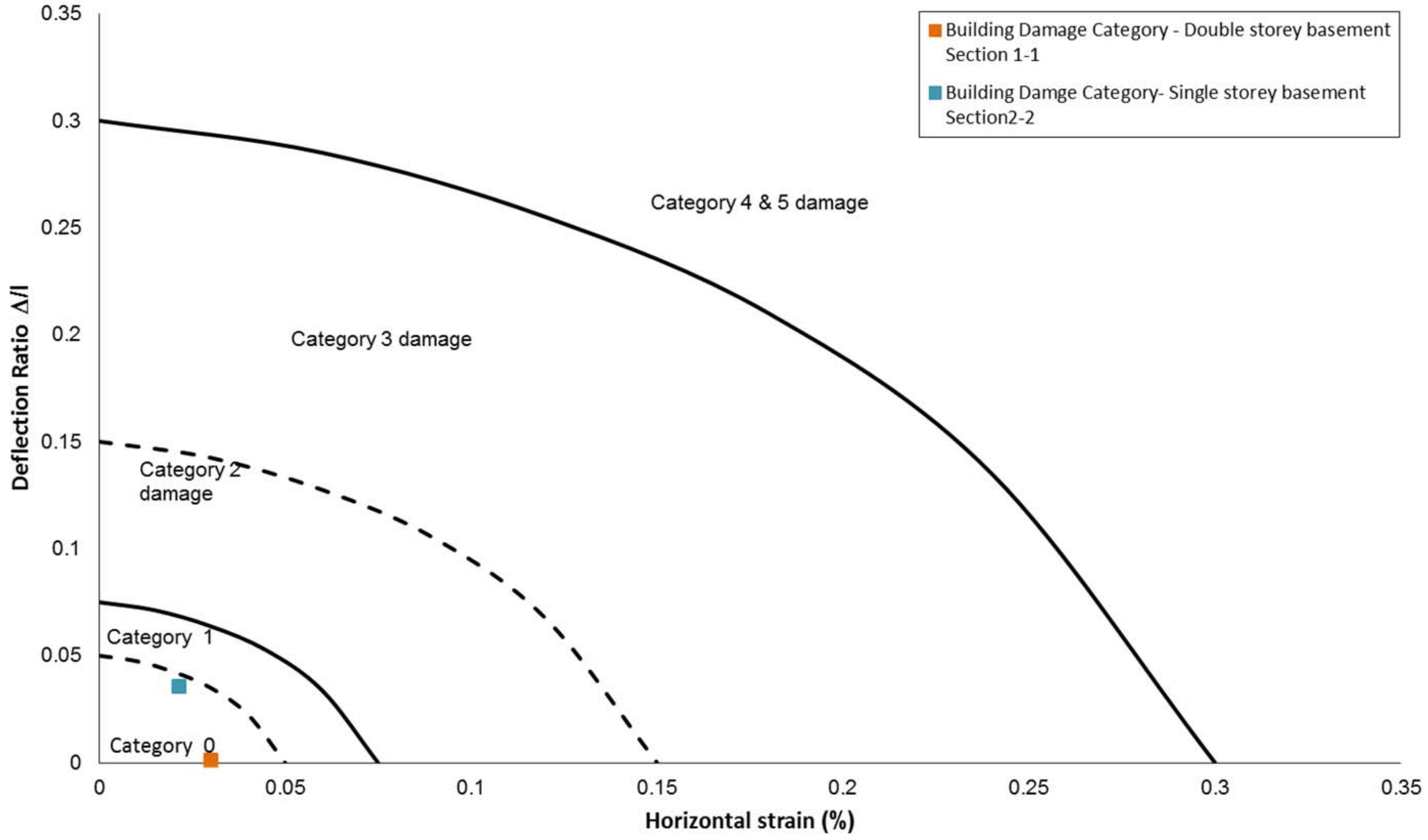
			Dwg No.	Rev.
Drawn	TSB	30/07/15	**CG/18510-009**	*
Checked	GES	05/08/15		
Approved				



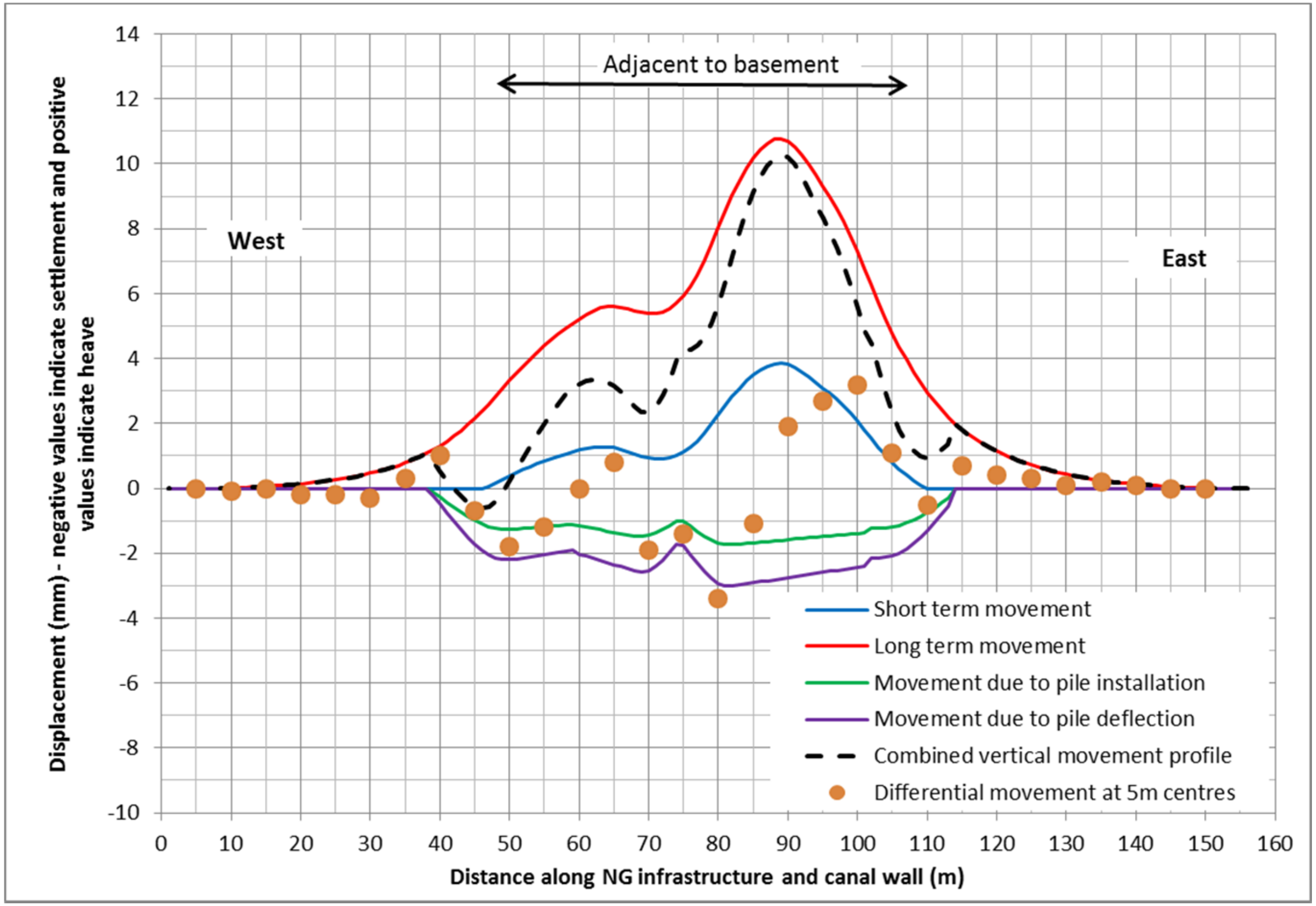
Client	Project	Job No
Stanley Sidings Ltd	**Camden Lock Market, London**	**CG/18510**
CGL	Title **Combined vertical movement profile – Section 1-1**	**Figure 10**



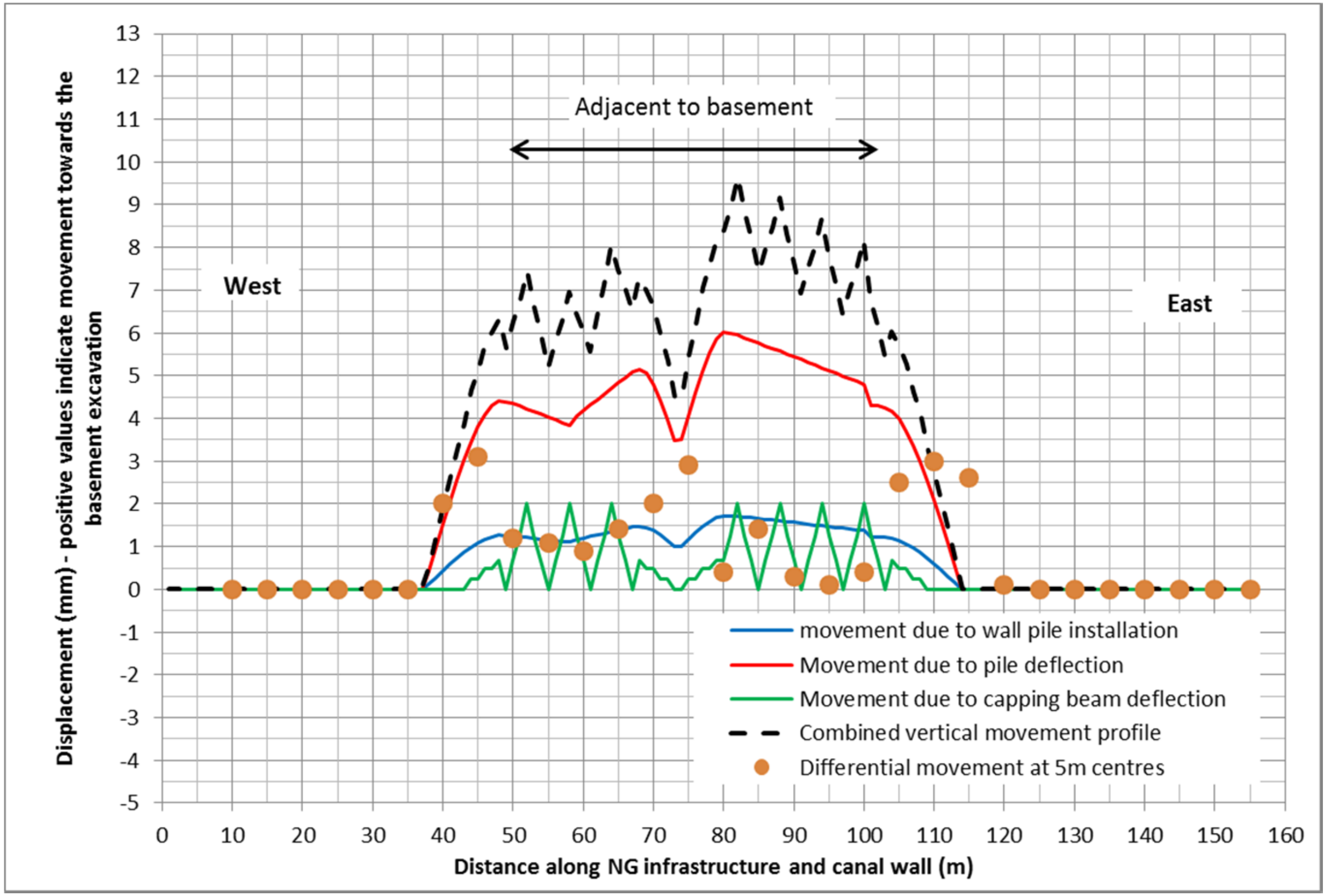
Client	Project	Job No
Stanley Sidings Ltd	**Camden Lock Market, London**	**CG/18510**
CGL	Title **Combined vertical movement profile – Section 2-2**	**Figure 11**



Client	Project	Job No
Stanley Sidings Ltd	**Camden Lock Market, London**	**CG/18510**
CGL	Title **Structure interaction plot**	**Figure 12**



Client	Project	Job No
Stanley Sidings Ltd	**Camden Lock Market, London**	**CG/18510**
CGL	Title **Vertical movement profile – NG infrastructure and canal wall**	**Figure 13**



Client	Project	Job No
Stanley Sidings Ltd	**Camden Lock Market, London**	**CG/18510**
CGL	Title **Lateral movement profile – NG infrastructure and canal wall**	**Figure 14**