BASEMENT IMPACT ASSESSMENT

47D NETHERHALL GARDENS, LONDON

FOR

MR CHAIM KLEIN

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APPROVAL & DISTRIBUTION SHEET

PROJECT DETAILS	
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FOREWORD

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1. NON-TECHNICAL SUMMARY

The site location is at 47d Netherhall Gardens, Hampstead NW3 5RJ.

The subject site is occupied by a two-storey house (10m wide by 9m long) that is semi attached to 47b Netherhall Gardens to the north and rear of the property. To the front of the house is a paved patio area that is about 8m wide.

The proposed development comprises construction of a single storey basement under the existing house and extending into the front patio area by about 5.3m. The roof of the basement will comprise a terrace. The excavation for the basement will be about 3.3m below existing ground level including an allowance for the floor slab. The construction method proposed is a concrete underpinning retaining wall with a basement slab.

The ground and groundwater conditions beneath the site (beneath a mantle of Made Ground) comprise the Claygate Member that was encountered to between 3.55m and 6m depth, which overlies the London Clay Formation which was proved in the ground investigations to 12.45m depth. A groundwater level of 2.65mbgl and 2.13mbgl were measured in the monitoring standpipes installed in the boreholes.

The BIA has identified the following potential impacts:

- The ground investigation shows that the London Clay Formation is present beneath the Claygate Member. These strata are not expected to cause a slope stability hazard as the house is located on relatively flat land with the surrounding slopes having been confirmed to be less than the 7 degree upper limit;

- The site is on the Claygate Member that has a medium-volume change potential and will be prone to shrinkage/swelling. The proposed basement will extend to below the depth of observed root penetration. Contingencies have been allowed for if there is evidence for desiccation deeper than encountered in the boreholes. The reader should refer to the 'Geotechnical Report on the Ground investigation' for a detailed description. Heave as a result of unloading is expected to occur and can be mitigated by the basement slab design;

- The property is within the zone of influence of the Hampstead Heath rail tunnel. The crown of the tunnel is about 35m below the level of the site and located outside the footprint of the proposed basement so will not be within the zone of excavation. However, ground movements as a result of construction will need to be considered. Network Rail will need to be informed of the proposed development and an asset protection agreement put in place;

- The site is shown to be located above a Secondary A Aquifer and groundwater was measured at 2.65m and 2.13m below ground level in the monitoring standpipes indicating the proposed basement will extend below the groundwater table. The strata above and immediately below founding level are expected to have a low permeability, with the horizontal permeability being significantly higher than the vertical permeability due to stratification of the strata, and minimal groundwater flow would therefore be expected at the level of the proposed basement. Therefore, it is considered unlikely that the basement would cause any significant adverse impact on groundwater flows. In light of the CampbellReith audit, consideration could be given to the inclusion of gravel fill or a geotextile drainage blanket to improve groundwater flow around the basement obstruction. Groundwater level monitoring readings should be taken during the detailed design period and prior to construction; and

- Construction of the basement will result in lowering of the foundations compared to adjacent sites and excavation of the basement will result in some ground movements. The affect of this has been assessed in ground movement and damage criteria assessments. Based upon the maximum displacements predicted by PDISP analyses, Damage Criteria Assessments were undertaken for the worst-case scenarios in the adjoining properties and these combined with the ground movements alongside the basement in response to the vertical stress changes are as predicted by the CIRIA publication C760. The assessed walls were within the 1 in 500 angular distortion criteria proposed by Bjerrum (1963). No further Damage Category Assessments have been carried out as other structures in the vicinity are further away to the proposed basement and therefore considered lower risk. Use of best practice construction methods will be essential to ensure that the ground movements are kept in line with the above predictions. Pre-construction condition surveys of neighbouring properties are also recommended, and a system of monitoring adjoining and adjacent structures should be established before the works start.

- The BIA has identified a low flood risk for the proposed development and no mitigation measures are proposed.

2. INTRODUCTION

2.1 General introduction

This report presents a Basement Impact Assessment (BIA), Ground Movement Assessment (GMA) and Damage Category Assessment (DCA) for a proposed basement development at 47d Netherhall Gardens, Hampstead ('the site'). The site is located at postcode NW3 5RJ within the London Borough of Camden as shown on Figure A1.

This report has been carried at the request of the house owner, Mr Chaim Klein.

This BIA has been produced specifically to meet the requirements of London Borough of Camden (LBC), including Planning Guidance - Basements (Camden Planning Guidance CPG, March 2018) - and the Local Plan (A5 Basements, July 2017). The report structure follows guidance for BIAs set out in the Camden Borough CPG4 (2015). The CPG4 requires desk study, screening and scoping stages, a site investigation and interpretation as well as ground movement assessment and impact assessment.

The BIA evaluates the geological, hydrogeological and hydrological conditions and assesses the potential detrimental ground stability, groundwater and surface water impacts the proposed development may have on the surrounding area and neighbouring properties.

Attention is drawn to the fact that whilst every effort has been made to ensure the accuracy of the data supplied and any analysis derived from it, there is a potential for variations in ground and groundwater conditions between and beyond the specific locations investigated. No liability can be accepted for any such variations. Furthermore, any recommendations are specific to the client's requirements as detailed herein and no liability will be accepted should these be used by third parties without prior consultation with CET Infrastructure.

2.2 Authors

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Principal Geotechnical Engineer

2.3 Sources of Information

The following baseline data have been referenced to complete the BIA in relation to the proposed development:

- Site walkover conducted during a ground investigation in May 2019;
- Current/historical mapping contained in an Envirocheck report;
- The site's geological setting is based on the British Geological Survey (BGS) Geological Map Sheet 256 (North London 1: 50,000 scale solid and drift, 2006), the BGS digital geology maps that utilises the most up to date names of geological units (www.bgs.ac.uk/data), and the Geology of London Memoir (Ellison et al., 2004);
- Online flood risk mapping by the Environment Agency;
- LB Camden, Strategic Flood Risk Assessment (produced by URS, 2014);
- LB Camden, Planning Guidance (CPG) – Basements (March 2018);
- LB Camden, Camden Geological, Hydrogeological and Hydrological Study – Guidance for Subterranean Development GHHS (produced by Arup, 2010); and
- LB Camden, Local Plan Policy A5 Basements (2017).

2.4 Existing site location and layout

The subject site is located at approximate Ordnance Survey grid reference TQ263852 (see Figure A1) and comprises a two-storey residential property situated on 47d Netherhall Gardens, London, NW3 5RJ. The house is semi-detached and shares a party wall with 47c Netherhall Gardens to the north that is of a similar size and construction.

The existing house occupies the northern/rear half of the property's footprint with the remaining area to the south occupied by private gardens of predominately hard landscaping that border Netherhall Gardens. There are two London plane trees within the site boundary that are about 8m high and about 6m from the proposed development.

2.5 Topography

The topographic map contained in the GHHS and an online topographic map source (http://en-gb.topographic-map.com) shows that the general area of the site is located at about 85mAOD. The general area slopes downwards from northwest to southeast away from Hampstead Heath. An estimation of the gradient of slope for the area surrounding the site indicates a slope angle of 4°. A topographic survey has been undertaken to assess the accurate gradient of slope in light of the CampbellReith audit.

2.6 Proposed development

Based on the provided drawings (Appendix B), the proposed development includes the construction of a single storey basement about 3m below ground level beneath the existing house footprint and extending 5.3m into the private terrace to the front of the property.

The approximately dimensions are as follows but reference should be made to the Construction Method Statement for actual dimensions:

- The existing house is about 8.5m long and 10m wide (footprint of about 85m^2). Under the house the basement will occupy 100% of the existing footprint (85m^2);
- The total area of the basement will be about 12.5m long by 10m wide (about 125m^2). Therefore, the proposed basement will be less than 1.5 times the existing floor area of the house;
- The proposed basement will extend about 5.3m into the front garden, which is 8m deep. Therefore the basement will extend about 66% into the garden that measures about 8m deep

by 9m wide (72m^2) so the new basement area (48m^2) will be about 66% of the existing garden space;

- The depth of the existing house is 8.5m and the basement will extend under the front garden by about 62% of the depth of the house;

- The top of the basement will comprise a hard-terraced surface with rainwater run-off. However, the existing front garden is already paved with bricks so already generates run-off; and

- The proposed finished floor level of the basement will be set at approximately 3m below existing ground level of the garden that includes an allowance for construction of the floor slab. The perimeter walls will comprise pile or reinforced concrete (RC) retaining walls.

In preparing this report the existing and proposed drawings provided by William Tozer Associates are included in Appendix B.

2.7 Neighbouring properties and structures

The house is semi-detached and boarders 47c Netherhall Gardens to the north with the properties sharing a party wall.

To the northwest is 47b Netherhall Gardens that is about 3.5m away from the proposed basement.

To the northeast is 49 Netherhall Gardens that is a four-storey house of brick construction, which includes a partial lower ground floor. The nearest wall of this building will be about 1m away from the proposed basement.

To the west is a shared driveway with 47, 47b, and 47c Netherhall Gardens.

To the south is highway forming Netherhall Gardens.

A Network Rail tunnel (Hampstead Tunnel) lies at depth under Netherhall Gardens and runs parallel with the roadway in a southwest to northeast direction. According to Network Rail drawings (Figure A2), the outside line or extrados of the tunnel is located close to the front property boundary at a level of around 50mAOD, suggesting it is about 35m below existing ground level. The tunnel contains a 15m wide 'zone of influence' on either side that in plan-view covers most of the 47d Netherhall Gardens curtilage except for a small area to the rear of the property.

3. DESK STUDY

Information in this section has been obtained from the sources outlined in Section 2.3. The background information has been used to undertake a screening and assessment of potential basement impacts.

3.1 Site History

Historical maps have been obtained for the area and are presented in the Envirocheck Report in Appendix C. Notable developments are detailed below:

- 1871 to 1879: The earliest map available showed the site was undeveloped land and part of a larger property. The nearest development was about 250m to the east of the site. The map showed the head of a stream or gully on the site that drained towards the south (Figure A5). A rail tunnel portal was shown about 300m to the southwest of the site (Hampstead tunnel);
- 1896: The highway forming Netherhall Gardens is in place and contains residential developments. There were houses present on 47 and 47d Netherhall Gardens, but not on 47b or 47c Netherhall Gardens;
- 1915/1916: Houses appeared on 47b and 47c Netherhall Gardens. There was no change to the surrounding site; and
- 1916 to present: No visible change to the subject site or immediately surrounding properties was observed.

3.2 Geology

Reference to the publications of the British Geological Survey indicates that the site is underlain by the deposits of the Claygate Member, which overlies the London Clay Formation. No superficial deposits are recorded. Typically, these deposits may be described as follows:

Table 3-1: Geological Summary

Stratum	Description
Claygate Member	Dark grey CLAY with sand laminae, passing up into thin alternations of clay, silts and fine-grained sand, with beds of bioturbated silt. Ferruginous concretions and septarian nodules occur in places.
London Clay Formation	Grey over-consolidated CLAY that weathers to a characteristic brown colour near the surface. Layers of claystone (septarian) nodules are

	common within the London Clay Formation, as is the presence of selenite.

The online BGS geological map extract displaying the geology is presented in Figure A4.

Logs from four shallow BGS boreholes from 1959 located about 1km northeast of the site were available for review. The boreholes show below a mantle of Made Ground: grey, sandy, silty CLAY (described as ‘Claygate Beds’) overlying grey, sandy silty CLAY with shell fragments (descibed as ‘London Clay’) below about 5.8m depth. Groundwater observations from the borehole indicate a level of approximatley 2m below ground level.

The actual ground conditions have been assessed by a site specific ground investigation and are discussed later in this report.

3.3 Hydrogeology

Groundwater information obtained from the BGS boreholes recorded dry conditions or a deep seepage.

Hydrogeological information provided by the GHHS and Envirocheck report (Figures A7 to A8) is summarised below:

- **Aquifer Category (as defined by the Environment Agency)** – No Superficial Deposits aquifer present. The bedrock aquifer designation is a Secondary A Aquifer;
- **Nearest groundwater abstraction licence** – None within 500m;
- **Source Protection Zone (SPZ)** – None present at the site. Zone II Outer source protection zone about 742m southeast of the site;
- **Groundwater vulnerability and soil leaching potential** – Combined High potential; and
- **Groundwater flooding susceptibility** – Limited potential.

3.4 Hydrology

Hydrological information provided by the Envirocheck report and GHHS (Figures A7 to A8) is summarised below:

- **Surface water features** – None within 600m (nearest is 992m to the south);
- **Surface water abstraction licences** – None within 500m;
- **River and coastal Zone 2 or 3 flooding** – Site is not on a Zone 2 or 3 floodplain and none are identified within 500m;

- **Risk of flooding from rivers or seas** – Very low;
- **Risk of flooding from surface water** – No risk;
- **Flood defences** – None within 250m; and
- **Flood storage areas** – None within 250m.

The book 'The Lost Rivers of London' (Barton, 1992) shows the head of a small stream immediately down gradient to the west and south of Netherhall Gardens (Figure A5). The historical map in the Envirocheck report from 1870-1879 shows a stream head located within the site boundary that is likely to be the same stream shown by Barton. The stream head was likely to have been shallow feature and is probably now non-existent due to the residential developments undertaken since 1879.

3.5 Flooding

The flood risk from rivers and seas from the Environment Agency flood map for planning service is shown on Figure A6 and shows a low risk.

The URS 2014 LBC strategic flood risk assessment report identified the following risk ratings (Figures A9 to A12):

- Very low risk for surface water (<1: 1000 years) and very low flood hazard for 1: 1000 year event;
- No surface water bodies (open of culverted) near the site;
- No risk from internal sewer flooding; and
- Risk of 1 property affected from external sewer flooding (Zone NW 3 5).

3.6 Site Conditions Summary

A conceptual site model for the site has been developed using the information obtained from the desk study and site investigation for use during the Scoping and Impact Assessment stages.

The conceptual site model can be summarised as follows:

- **Excavation Depth** – Approximately 3.3m below ground level;
- **Site Topography** – Relatively flat at 85mAOD;

- **Surface Water Bodies** – None within 500m;
- **Flood Risk** – Low from flooding and very low from surface water;
- **Ground Conditions**
    - Made Ground to variable depths;
    - Claygate Member to 5.8m; and
    - London Clay Formation below 5.8m depth to c. 10m depth.
- **Aquifer** – Secondary A Aquifer; and
- **Groundwater** – Indicated as c. 2m.

4. SCREENING

Screening has been carried out using the criteria outlined in CPG4 to identify any matters of concern relating to slope stability, groundwater flow and surface water flow/flooding that should be carried forward to the scoping stage. The screening process uses the background site information provided in Section 2 and Section 3 of this report to complete flow charts provided in CPG4. The flow charts are reproduced in the tables below. Items requiring scoping, investigation and impact assessment are highlighted in yellow and are addressed in subsequent sections of this report.

4.1 Slope Stability

The slope stability screening flowchart from CPG4 is displayed in Table 4-1.

Table 4-1: Screening – Slope Stability

Slope stability screening chart	
1. Does the existing site include slopes, natural or manmade, greater than 7 degrees? (approx. 1 in 8)	No. The site is relatively level with a slope of less than 7 degrees.
2. Will the proposed re-profiling of landscaping at site change slopes at the property boundary to more than 7 degrees? (approx. 1 in 8)	No. No re-profiling is planned.
3. Does the development neighbouring land, including railway cuttings and the like, with a slope greater than 7 degrees? (approx. 1 in 8)	No. The surrounding area slopes at less than 7 degrees.
4. Is the site within a wider hillside setting in which the general slope is greater than 7 degrees? (approx. 1 in 8)	The publicly available data suggests that the site has a gradient of less than 7 degrees. However, at the recommendation of CampbellReith a topographic survey has been undertaken.
5. Is the London Clay the shallowest strata at the site?	Yes. The geological map shows the Claygate Member of the London Clay Formation is present and maybe encountered during construction.
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.
7. Is there a history of seasonal shrink-swell subsidence in the local area, and/or evidence of such effects at site?	The Envirocheck Report indicates a 'moderate' shrink-swell hazard rating. No evidence of shrink-swell subsidence has been provided.
8. Is the site within 100m of a watercourse or a potential spring line?	No. There are no current watercourses or spring lines identified within 100m of the site.

Slope stability screening chart	
9. Is the site within an area of previously worked ground?	No. There is no evidence of any previously worked ground on the site.
10. Is the site within an aquifer? If so, will the proposed basement extend beneath the water table such that dewatering may be required during construction?	Yes, the bedrock is designated as a Secondary A Aquifer. The desktop study has identified the potential for shallow groundwater. The groundwater level will therefore need to be determined from a site-specific ground investigation.
11. Is the site within 50m of the Hampstead Heath Ponds	No.
12. Is the site within 5m of a highway or pedestrian right of way?	No. The proposed excavation is about 5m from the pedestrian right of way.
13. Will the proposed basement significantly increase the differential depth of foundations relative to neighbouring properties?	Yes. The neighbouring property to the north is likely to be set on shallow foundations at ground floor level and the proposed basement will extend to 3.3m below current ground level.
14. Is the site over (or within the exclusion zone of) any tunnels, e.g. railway lines?	Yes, the site is within the zone of influence of the Hampstead tunnel.

4.2 Subterranean (Groundwater) Flow

The subterranean (groundwater) flow screening flowchart from CPG4 is displayed in Table 4-2.

Table 4-2: Screening – Subterranean (groundwater) Flow

Subterranean (groundwater) flow screening chart	
1. a) Is the site located directly above an aquifer?	Yes, the bedrock is designated as a Secondary A Aquifer.
b) Will the proposed basement extend beneath the water table surface?	The publicly available data suggests that there is the potential for shallow groundwater. However, the data available from the historical boreholes is insufficient to make an accurate estimate of groundwater level. A site investigation is required to assess groundwater levels.
2. Is the site within 100m of a watercourse, well (used/disused) or potential spring line?	No.
3. Is the site within the catchment of the pond chains on Hampstead Heath?	No.
4. Will the proposed basement development result in a change in the proportion of hard surfaced / paved external areas?	No. The basement will occupy an area already covered by brick hardstanding.
5. As part of the site drainage, will more surface water (e.g. rainfall and runoff) than at present be discharged	No. The basement will occupy an area already covered by brick hardstanding.

to the ground (e.g. via soakaways and/or SUDS)?	
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. There are not existing ponds or spring lines identified in the vicinity of the site.

4.3 Surface Flow and Flooding

The surface flow and flooding screening flowchart from CPG4 is displayed in Table 4-3.

Table 4-3: Screening – Surface Flow and Flooding

Surface flow and flooding screening chart	
1. Is the site within the catchment of the pond chains on Hampstead Heath?	No.
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. Existing drains will be used to collect surface water.
3. Will the proposed basement development result in a change in the proportion of hard surfaced/paved external areas?	No. The basement will occupy an area already covered by brick hardstanding.
4. Will the proposed basement result in changes to the profile of the inflows (instantaneous and long term) of surface water being received by adjacent properties or downstream watercourses?	No. There are no nearby watercourses.
5. Will the proposed basement result in changes to the quality of surface water being received by adjacent properties or downstream watercourses?	No. There are no nearby water courses.
6. Is the site in an area identified to have surface water flood risk or is it at risk from flooding, for example because the proposed basement is below the static water level of nearby surface water feature?	No. The site is in an area of low flood risk and there are no nearby water courses.

4.4 Screening Non-Technical summary

The following items have been identified from the screening stage as requiring assessment:

Slope stability:

Slope stability screening chart	
4. Is the site within a wider hillside setting in which the general slope is greater than 7 degrees? (approx. 1 in 8)	The publicly available data suggests that the site has a gradient of less than 7 degrees. However, at the recommendation of CampbellReith a topographic survey has been undertaken.
5. Is the London Clay the shallowest strata at the site?	Yes. The geological map shows the Claygate Member of the London Clay Formation is and may be encountered during construction.
7. Is there a history of seasonal shrink-swell subsidence in the local area, and/or evidence of such effects at site?	The Envirocheck Report indicates a 'moderate' shrink-swell hazard rating. No evidence of shrink-swell subsidence has been provided.
10. Is the site within an aquifer? If so, will the proposed basement extend beneath the water table such that dewatering may be required during construction?	Yes, the bedrock is designated as a Secondary A Aquifer. The groundwater level will need to be determined from a site-specific ground investigation.
13. Will the proposed basement significantly increase the differential depth of foundations relative to neighbouring properties?	Yes. Following review of available information, the neighbouring property to the north is likely to be set on shallow foundations at ground floor level and the proposed basement will extend to 3m current ground level.
14. Is the site over (or within the exclusion zone of) any tunnels, e.g. railway lines?	Yes, the site is within the zone of influence of the Hampstead tunnel.

Sub surface groundwater flow

Subterranean (groundwater) flow screening chart	
1. a) Is the site located directly above an aquifer?	Yes, the bedrock is designated as a Secondary A Aquifer.
b) Will the proposed basement extend beneath the water table surface?	Unknown. The data available from the historical boreholes is insufficient to make an accurate estimate of groundwater level. A site investigation is required to assess groundwater levels.

Surface flow and flooding

None.

5. SCOPING

The Scoping stage identifies the potential impacts of the proposed scheme that are shown by the Screening stage. Items that have been identified as having a potential impact have been taken forward into the Impact Assessment stage.

The following impact assessments are based on concerns identified previously and the CPG4 screening assessments in Section 4.0.

5.1 Slope Stability

The potential impacts identified in the slope stability CPG4 Stage 1 Screening Assessment, Table 4-1, have been addressed in Table 5-1.

Table 5-1: Scoping – Slope Stability Impact Assessment

Slope stability scoping chart		
Screening Question	**Scoping**	**Impact Assessment**
4. Is the site within a wider hillside setting in which the general slope is greater than 7 degrees? (approx. 1 in 8)	Publicly available topographic data taken from multiple sources indicates that the slope around the site is 4 degrees.	A topographic survey of the site indicates that the maximum slope angle is 5.6 degrees. Therefore, no further assessment has been carried out.
5. Is the London Clay the shallowest strata at the site?	The ground investigation shows that the Claygate Member and London Clay Formation is present near the surface. These strata are not expected to cause a slope stability hazard as the house is located on relatively level ground with no significant slopes noted.	No further impact assessment required.

7. Is there a history of seasonal shrink-swell subsidence in the local area, and/or evidence of such effects at site?	The Envirocheck Report indicates a 'moderate' shrink-swell hazard rating. No evidence of shrink-swell subsidence has been provided. The site review has shown bedrock includes the Claygate Member, which has a medium-volume change potential. This has the potential to be affected by moisture changes causing shrink/swell.	The shrink-swell potential of the Claygate Member has been assessed during a site investigation. The base of the proposed basement footings will be deeper than the observed depth of root penetration. A suspended floor slab has been recommended to prevent the adverse effects associated with seasonal shrink/swell. It has been recommended that the basement slab design should account for ground heave from unloading and groundwater pressures.
10. Is the site within an aquifer? If so, will the proposed basement extend beneath the water table such that dewatering may be required during construction?	Yes, the bedrock is designated as a Secondary A Aquifer. The groundwater level measured in a monitoring installation was 2.65m on the 6th June 2019 and 2.13m on the 16th December 2020. The proposed basement walls at 5m depth will extend to below the groundwater table by up to c. 3m.	Due to the relatively low permeability nature of the clay subsoil, groundwater flow will be minimal, so large scale dewatering is not expected to be required. This will need to be assessed by the Designers and Contractor when deciding the construction method.
13. Will the proposed basement significantly increase the differential depth of foundations relative to neighbouring properties?	Yes, the neighbouring property to the north is likely to be set on shallow foundations at ground level. The property to the northeast is also located close to the basement. Excavation and formation of the basement could cause ground movement affecting these properties.	The basement design and construction will need to consider the neighbouring properties. The impacts and potential mitigation are discussed in more detail below. A Damage Category Assessment has been carried to assess the potential damage to neighbouring properties (see Section 7.0).

14. Is the site over (or within the exclusion zone of) any tunnels, e.g. railway lines?	Yes, the site is within the zone of influence of the Hampstead tunnel. The crown of the tunnel is about 35m below the site but located outside the footprint of the proposed basement so will not be within the zone of excavation. However, ground movements as a result of construction will need to be considered.	Network Rail will need to be informed of the proposed development and an asset protection agreement put in place. A ground movement assessment may be requested Network Rail.

Ground movement related to forming the basement excavation is a potential hazard. A Damage Criteria Assessment (DCA) has been completed to assess the effects of the excavation and construction of the proposed basement on neighbouring properties.

The excavation and construction of the proposed basement will inevitably cause some ground movement. The magnitude of movements when using underpinning techniques will primarily depend on the geology, the adequacy of temporary support to both the underpinning excavations and the partially complete underpinning prior to installation of full permanent support as well as the quality of workmanship when construction the permanent structure.

It is crucial therefore that the use of best practice methods of temporary support and high-quality workmanship are used to control ground movements alongside the basement excavations. Prior to excavations for the underpinning works begin all cracks in load-bearing walls that have weakened structural integrity should be fully repaired in accordance with recommendations from the appointed structural engineer.

Under UK standard practice the design and implementation of temporary works is the Contractor's responsibility. It is considered essential that the Contractor employed for these works has successfully completed similar schemes. Therefore, it is recommended to carefully pre-select the Contractors invited to tender for the works. The Contractor's temporary works should be fully detailed in the works method statements.

5.2 Subterranean Groundwater Flow

The potential impacts identified in the subterranean flow CPG4 Stage 1 Screening Assessment, Table 4-2, have been addressed in Table 5-2.

Table 5-2: Scoping and Impact Assessment – Subterranean (Groundwater) Flow Impact Assessment

Subterranean (groundwater) flow scoping chart		
Screening Question	**Scoping**	**Impact Assessment**
1a) Is the site located directly above an aquifer? 1b) Will the proposed basement extend beneath the water table surface?	The bedrock is designated as a Secondary A Aquifer. The groundwater level measured in a monitoring installation was 2.65m on the 6th June 2019 and 2.13m on 16th December 2020. The proposed basement footings at 5m depth will extend to below the groundwater table.	The groundwater table was encountered in the Claygate Formation, which is underlain by the London Clay Formation that has a relatively low permeability. Groundwater flow at the site is expected to be slow. In light of this, the proposed basement is not anticipated to have any significant impact on groundwater flows/levels and therefore no significant impact on neighbouring properties would be expected. There are no identified directly adjoining basements and therefore ‘coffering’, which is the extensive damming of groundwater by adjoining or closely spaced basements, is not considered to be an issue. Accordingly, no mitigation measures are considered necessary in relation to groundwater flow. Subsequently, CampbellReith has asked for consideration to be given to the affect of the basement on the ‘wider hydrogeological environment’. The portion of the basement under the building is directly downslope from an existing basement which already obstructs flow over that area. The area of the basement under the front garden is not inline with another basement, and therefore will likely restrict flow in the short- to medium term. Due to the stratification of the Claygate Formation the horizontal permeability of this strata is likely to be significantly greater than the vertical permeability and the basement construction is therefore considered unlikely to have a significant impact on groundwater flow. However, if further mitigation measures are required consideration could be given to inclusion of a vertical drainage blanket, either gravel or a drainage geotextile, around the outside of the walls to improve flow. This will require further consideration in the detailed design stage. This hydrogeological regime (i.e. groundwater levels and pressures) will be affected by long-term climatic variations as well as seasonal fluctuations and other man-induced influences, all of which must

		be considered by the designers when selecting a design water level for the permanent works. No long term, multi-seasonal groundwater monitoring data is available, so a conservative approach will be needed, as required by current geotechnical design standards.

5.3 Surface Water

No potential impacts have been noted.

6. SITE INVESTIGATION

A site investigation stage has been undertaken to develop an understanding of the site and its immediate surroundings and for use in assessing matters of concerns identified during the Screening stage. The results have been used to address the matters of concern in the Scoping and Impact Assessment stages.

6.1 Intrusive Ground Investigation

A ground investigation (GI) was completed by CET in January 2019, May 2019, with a follow up investigation in October 2020. The initial investigations comprised one window sampler borehole (WS01) to 6.1m depth and trial pits around the perimeter of the property's foundations. The original window sampler borehole was undertaken at the back of the property outside of the Network Rail zone of influence and contains a groundwater monitoring installation with screened section from 1m to 6m below ground level. The follow up investigation involved the drilling of a 12.45m deep cable percussion borehole within the front garden with a groundwater monitoring well installed with a response zone from 1m to 6m below ground level. The stratigraphic units described during the first round of the investigation have been updated in light of the conditions encountered in BH01.

6.2 Ground and Groundwater Conditions

A summary of the ground conditions encountered during the GI is presented in the table below. The borehole log is presented in Appendix D.

Table 6-1: Summary of Ground Conditions

Strata name	Depth to top of strata (mbgl)	Thickness (m)	Description
Made Ground	0	0.6 to 1.7	Dark brown CLAY, with varying minor constituents of sand and gravel; clayey gravelly SAND or sandy GRAVEL of flint, brick, chalk, concrete, possible coal/clinker, and ceramic tile. A low to medium cobble content of brick was also encountered.
Claygate Member	0.6-1.7	2.5 to 5	Soft becoming firm with depth, light orange brown mottled light grey, fine sandy, silty CLAY; and Firm locally stiff and soft, greyish brown, light grey and orange brown mottled, slightly fine sandy, slightly gravelly, locally silty CLAY.
London Clay Formation	3.55 to 6	Proved to 12.45m depth	Firm becoming very stiff with depth, dark grey, locally micaceous, fine sandy, locally silty CLAY with localised shell fragments.

A groundwater seepage was noted at 5m below ground level in WS01 and 7m below ground level in BH01 on 14th May 2019 and 29th October respectively. No rise in the groundwater level was recorded after 20 minutes of monitoring. A groundwater level of 2.65m below ground level and 2.13m below ground level was measured during post fieldwork monitoring visits on 6th June 2019 and 16th December 2020. It should be appreciated that the groundwater table may vary both seasonally and in the long-term, and further monitoring to establish a longer-term groundwater regime may be required as part of any planning condition and certainly prior to construction.

7. GROUND MOVEMENT ASSESSMENT

7.1 Introduction

Oasys PDISP software has been used to undertake the analyses of heave and settlement ground movements arising from changes in vertical stresses caused by excavation of the basement. The analysis is based on Boussinesq's theory of analysis for calculating stresses and strains in soils due to vertically applied loads with the predicted ground movements being derived by integration of vertical strains derived from Boussinesq's equations. These preliminary analyses have not modelled the horizontal forces on the retaining walls and so have simplified the stress regime significantly. In addition, consistent with Boussinesq theory, the soils are assumed to comprise a semi-infinite isotropically homogeneous elastic medium.

7.2 Proposed Basement Layout

The basement layout has been based on drawing 2018-540-01A by Elite Designers (Figure 1). The proposed basement is up to about 12m long by 10m wide with excavation extending up to a depth of about 3.3m below ground level, including the floor slab. The proposed basement construction is therefore estimated to have an overall soil pressure unloading of about 63kN/m^2.

Gross pressure changes across the development have been estimated based on information provided by the structural engineer. The load zones, positive and negative, used to model the proposed basement in PDISP are displayed in Figure 1. These include the excavation and loads on the underpin retaining walls, excavation of central area from existing ground level and construction of the basement. Table 7-1 presents the nett changes in vertical pressure for each load zone for the four major stages in the sequence of stress changes that will result from excavation and construction of the basement as outlined below:

- Stage 1: Construction of underpins and retaining walls – Short-term (undrained) condition;
- Stage 2: Bulk excavation to basement formation level – Short-term (undrained) conditions;
- Stage 3: Construction of the basement – Short-term (undrained) conditions; and
- Stage 4: Construction of the basement – Long-term (drained) conditions.

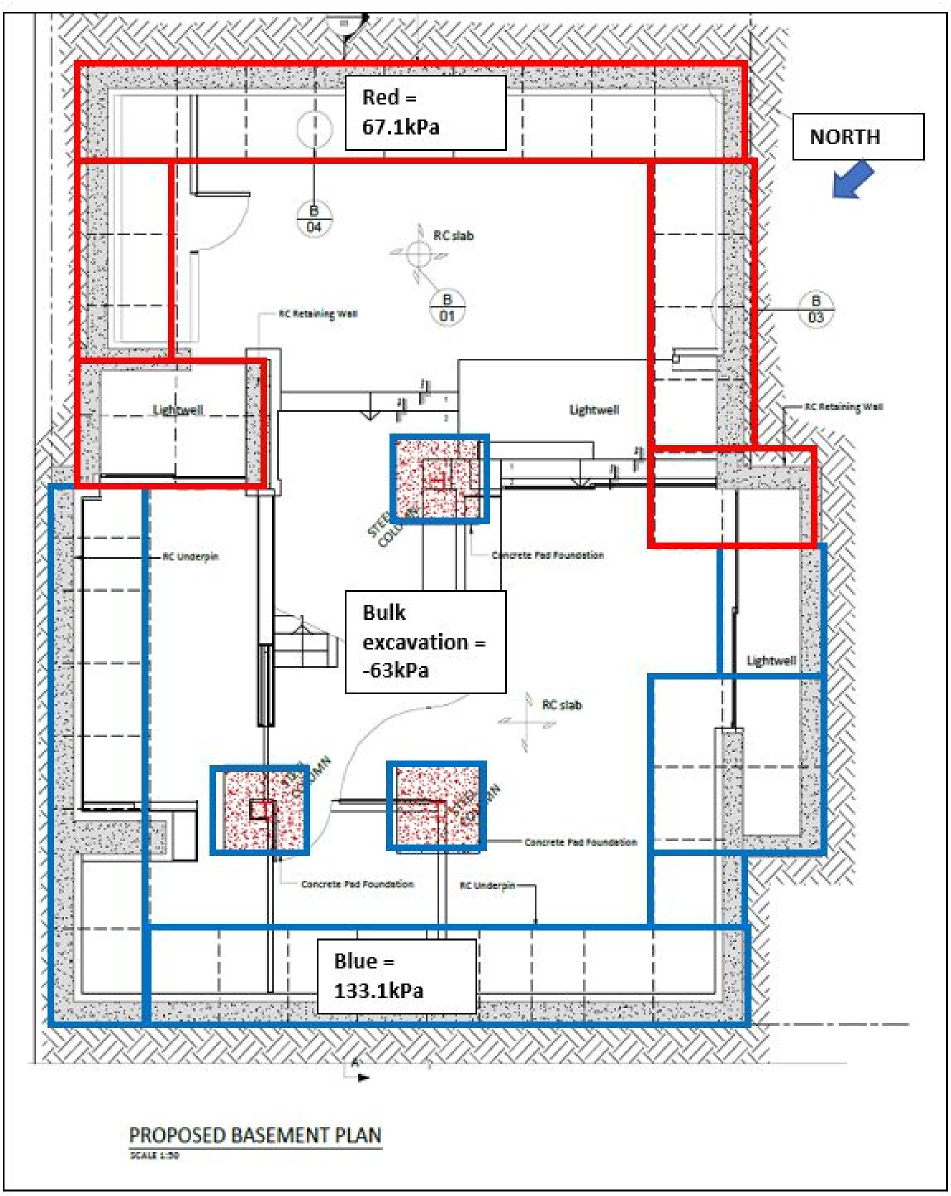


Figure 1: Load zones introduced to PDISP.

Table 7-1: Net bearing pressures for PDISP

Strip/Pad Zone	Net change in vertical pressure (kN/m^2)		
	Stage 1 Underpins and retaining wall	Stage 2 Bulk Excavation	Stages 3 & 4 Basement construction short and long term
Garden Retaining Wall	67.1	67.1	67.1
House/Party wall Retaining Wall	133.1	133.1	133.1
Pad	133.1	133.1	133.1
Bulk excavation	0	-63	-53

7.3 Ground Conditions

The ground conditions are based on the CET ground investigation that is summarised in Table 7-2 with the engineer's logs located in Appendix D. The proposed basement will be constructed within the Claygate Member. Existing foundations to the property were found to be about 1m deep based on the limited number of trial pits.

Table 7-2: Ground Conditions

Strata name	Depth to top of strata (mbgl)	Thickness (m)	Description
Made Ground	0	0.6 to 1.7	Dark brown CLAY, with varying minor constituents of sand and gravel; clayey gravelly SAND or sandy GRAVEL of flint, brick, chalk, concrete, possible coal/clinker, and ceramic tile. A low to medium cobble content of brick was also encountered.
Claygate Member	0.6-1.7	2.5 to 5	Soft becoming firm with depth, light orange brown mottled light grey, fine sandy, silty CLAY; and Firm locally stiff and soft, greyish brown, light grey and orange brown mottled, slightly fine sandy, slightly gravelly, locally silty CLAY.
London Clay Formation	3.55 to 6	Proved to 12.45m depth	Firm becoming very stiff with depth, dark grey, locally micaceous, fine sandy, locally silty CLAY with localised shell fragments.

A groundwater seepage was noted at 5m below ground level in WS01 and 7m below ground level in BH01 on 14th May 2019 and 29th October respectively. No rise in the groundwater level was recorded after 20 minutes of monitoring. A groundwater level of 2.65m below ground level and 2.13m below ground level was measured during post fieldwork monitoring visits on 6th June 2019 and 16th December 2020.

The short-term and long-term geotechnical properties used in the analysis are summarised in Table 7-3. These were based on the results of the ground investigation. The London Clay Formation and Claygate Member Young's modulus properties were calculated assuming undrained Young's modulus, $E_u = 500 \times c_u$, and drained Young's modulus, $E' = 0.75 \times E_u$.

All Made Ground will be excavated and therefore only the change in vertical pressure, due to its excavation, is required for the PDISP analyses. Geotechnical parameters for the Made Ground are not used in the analysis.

A Poisson's ratio of 0.5 in the undrained and 0.2 in the drained condition has been adopted for the Claygate Member and London Clay Formation over the modelled thickness.

Table 7-3: Soil Parameters for PDISP Analyses

Strata	Depth (m bgl)	Bulk Density (kN/m³)	Cu (kPa)	Short-term, undrained Young's Modulus, Eu (MPa)	Long-term, drained Young's Modulus, E' (MPa)	Poisson's Ratio in the Undrained Condition	Poisson's Ratio in the Drained Condition
Made Ground	0 to 0.6	19	Not used	Not used	Not used	Not used	Not used
Claygate Member	0.6 to 6	19	33 to 73	16.5 to 36.5	12.4 to 27.4	0.5	0.2
London Clay Formation	6 to 12.45	19	73 to 115.5	36.5 to 57.8	27.4 to 43.4	0.5	0.2

7.4 PDISP Analysis

Three dimensional analyses of vertical displacements have been undertaken using PDISP software and the basement geometry, loads/stresses and ground conditions outlined above to assess the potential magnitudes of ground movements (heave or settlement) that may result from the vertical stress changes caused by excavation of the basement. PDISP analyses have been carried out as follows:

- Stage 1: Construction of underpins and retaining walls – Short-term (undrained) condition;
- Stage 2: Bulk excavation of central area to basement formation level – Short-term (undrained) conditions;
- Stage 3: Construction of the basement slab (suspended) – Short-term (undrained) conditions; and
- Stage 4: Construction of the basement slab (suspended) – Long-term (drained) conditions.

The results of the analyses for Stages 1, 2, 3 and 4 are presented as contour plots in Appendix E.

7.5 Heave and Settlement Analysis

Excavation of the basement and construction of the underpinning will cause immediate elastic heave/settlements in response to the stress changes, followed by long term plastic swelling/settlement as the underlying clay takes up groundwater or consolidation occurs. The rate of plastic swelling/consolidation will be determined largely by the availability of water and as a result, given the assumed low permeability of the clay strata, can take many years to reach equilibrium. The basement slab will need to be designed to enable it to accommodate the swelling displacements/pressures developed underneath it.

The ranges of predicted short-term and long-term movements for each of the main sections of the proposed basement are presented in Table 7-4. All values are approximate owing to the simplification of the stress regime and include only displacements caused by stress changes in the ground beneath the basement.

All the short-term elastic displacements would have occurred before the basement slab is cast, so only the post-construction incremental heave/settlements, the difference from Stages 3, short-term, to 4, long-term, are relevant to the slab design.

Table 7-4: Summary of Predicted Ground Movements from PDISP

Location / Building Element	**Stage 1 (short term)** **Retaining walls and Underpins**	**Stage 2 (short term)** **Bulk Excavation**	**Stage 3 (short term)** **Basement construction**	**Stage 4 (long term)** **Basement construction**
Underpins / retaining wall perimeter along northeast side	6mm to 0mm settlement	5mm to 0mm settlement	5mm to 0mm settlement	10mm to 0mm settlement
Underpins / retaining wall perimeter along southeast side	3mm to 0mm settlement	2mm to 0mm settlement	2mm to 0mm settlement	4mm to 0mm settlement
Underpins / retaining wall perimeter along southwest side boundary	10mm to 0mm settlement	9mm to 0mm settlement	9mm to 0mm settlement	17mm to 0mm settlement
Underpins / retaining wall perimeter along northwest boundary	6mm to 0mm settlement	5mm to 0mm settlement	5mm to 0mm settlement	10mm to 0mm settlement
Basement slab area	1mm to 0mm settlement	6mm to 0mm heave	5mm to 0mm heave	8mm to 0mm heave

8. DAMAGE CRITERIA ASSESSMENT

8.1 Introduction

Behaviour of the ground will depend on the quality and methods of construction, so rigorous calculations of predicted ground movements are not practical.

To relate the predicted ground movements to possible damage to adjacent properties, it is necessary to consider the the angular distortion (as a deflection ratio) that may be generated using the method proposed by Bjerrum (1963), which developed earlier work by Skempton.

8.2 Critical Damage Category Locations

As detailed earlier, no evidence has been provided that the neighbouring property's at Nos. 47b or 47c Netherhall Gardens have a basement, and No. 49 has a lower ground floor about 1.5mbgl with the level of the foundations being at a greater depth. Due to the uniform founding level beneath the proposed basement the potentially critical locations will be determined by the displacements predicted by the PDISP analyses, and the geometries and distances of the neighbouring properties.

As ground movements reduce with distance away from the proposed basement and the relative founding depths, the worst-case scenarios are displayed in Figure 2.

Figure 2: Critical Damage Criteria Assessed Wall (DCA) Locations (assessed walls shown as brown lines)

8.3 Affected Widths of Critical Locations

The damage criteria assessments will consider the PDISP analyses of ground movements from vertical stress changes and ground movements alongside the proposed underpinning retaining walls caused by relaxation of the ground in response to the excavations.

CIRIA C760 (Gaba et al., 2017) details that ground movements associated with the construction of retaining walls in clay extend up to four times the depth of excavation. A settlement of 0.35% of the maximum excavation depth is predicted by CIRIA C760 for worst case 'low support stiffness' walls in stiff clay, which is considered appropriate for the development. The relevant geometries of the assessed locations have been obtained from the available drawings or approximated using maps and aerial images. The relevant geometries and affected widths and predicted settlements of the critical locations are detailed in Table 8-1.

Table 8-1: Geometries, Affected Widths and Predicted Settlements of Critical Locations

Netherhall Gardens house no.	47c NE wall	47c NW wall	49 SW wall
Relative depth of foundations beneath ground floor	1m (assumed)	1m (assumed)	1.5m (assumed)
Depth of excavation (below existing foundation level)	3.3 – 1.0 = 2.3m	3.3 – 1.0 = 2.3m	3.3 – 1.5 = 1.8m
Zone of influence behind basement wall	2.3 x 4 = 9.2m	2.3 x 4 = 9.2m	1.8 x 4 = 6.4m
Distance from proposed basement	0m	0m	1m
Ground surface movement due to excavation in front of basement wall (CIRIA 760 Table 6.3)	0.35% of max excavation depth	0.35% of max excavation depth	0.25% of max excavation depth
Approximate length of assessed wall (L)	7m	12m	13m
Height of affected building, H	6m (approximate average height)	6m (approximate average height)	12m (approximate average height)
CIRIA predicted settlement due to excavation	8.0mm	8.0mm	3.2mm

8.4 Displacements Along Assessed Walls

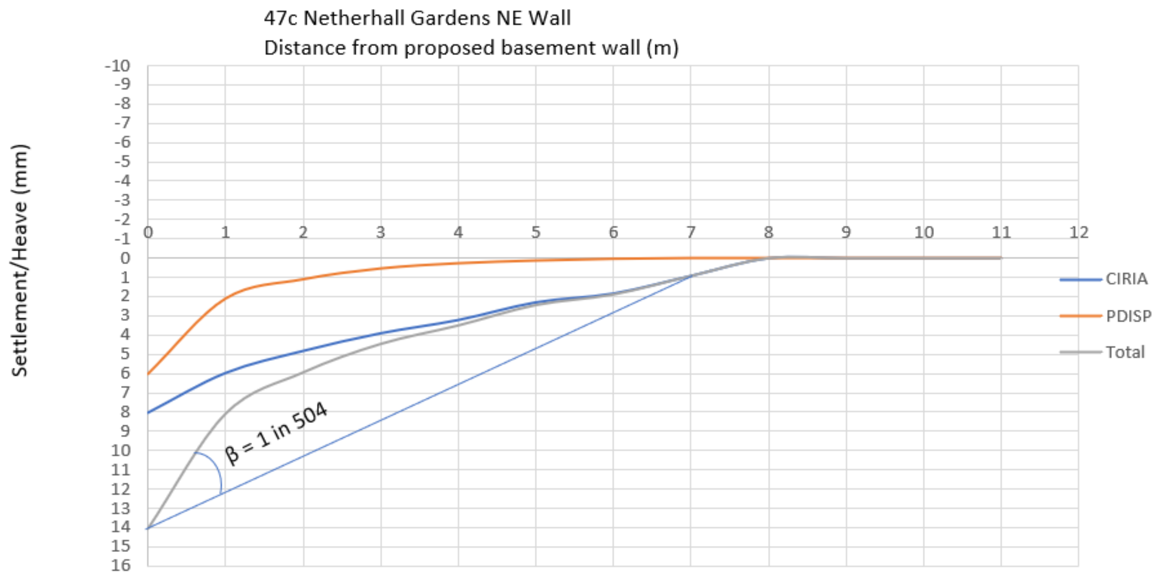
Provided that the temporary support follows best practice, then industry experience has shown that the horizontal movements of the ground alongside underpinning for a single storey basement at a nominal depth 3.3m below ground should be negligible, provided there is not base failure or bearing failure beneath the underpinning blocks. Reference should be made to the separately reported 'Geotechnical Report on Ground Investigation' report for consideration of the underlying soils bearing capacity. A factor of safety of three has been adopted to protect against bearing capacity failure, and the calculated presumed net bearing values are in excess of the expected loads.

Table 8-2: Displacements of Assessed Walls at Closet Point

	47c NE wall	47c NW wall	49 SW wall
Horizontal displacement	Negligible	Negligible	Negligible
Maximum PDISP settlement	6.9mm	9.2mm	1.6mm
Minimum PDISP settlement	0mm	0mm	0mm
Maximum CIRIA settlement	8.0mm	8.0mm	3.2mm
Minimum CIRIA settlement	1mm	0mm	0mm
Maximum Combined CIRIA and PDISP settlement	13.9mm	17.2mm	4.8mm

The settlement profile produced by PDISP along the assessed wall locations must be added to the settlement profile presented in Figure 6.15b of CIRIA Report C760, which is appropriate for the underpinned retaining wall construction method. The combined maximum settlements, at the closest point of the assessed walls are displayed in Table 8-2.

In order to assess the potential risk of damage to the building using the method proposed by Bjerrum (1963), the angular distortions along each of the assessed walls must be calculated. Angular distortion is measured as total length of the assessed wall (L) over the difference in vertical displacement (δ) ($\beta = L/\delta$) and is expressed as a slope gradient. Figure 3 presents the maximum angular distortions which are likely to occur based on the predicted ground movements given from the CIRIA guidance and from the Pdisp analysis.


47c Netherhall Gardens NE Wall
Distance from proposed basement wall (m)
Settlement/Heave (mm)
β = 1 in 504
CIRIA
PDISP
Total

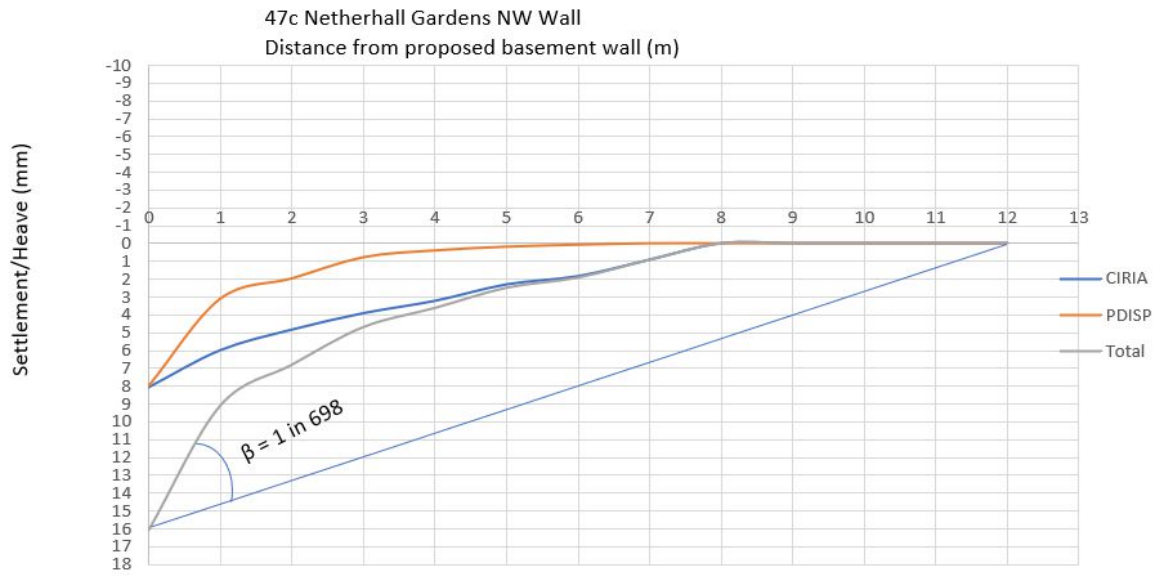

47c Netherhall Gardens NW Wall
Distance from proposed basement wall (m)
Settlement/Heave (mm)
β = 1 in 698
CIRIA
PDISP
Total

Figure 3: Predicted displacements for the affected walls

The maximum angular distortions, from the settlement curves are displayed in Table 8-3.

Table 8-3: Angular Distortions

	47c NE wall	47c NW wall	49 SW wall
Difference in Settlement Over the Assessed Wall Length	13.9mm	17.2mm	4.8mm
Assessed wall length (L)	7m	12m	13m
Angular distortion (β)	1 in 504	1 in 698	1 in 2708

8.5 Damage Criteria Rating

The damage criteria ratings are based on the reference chart found in Figure 4

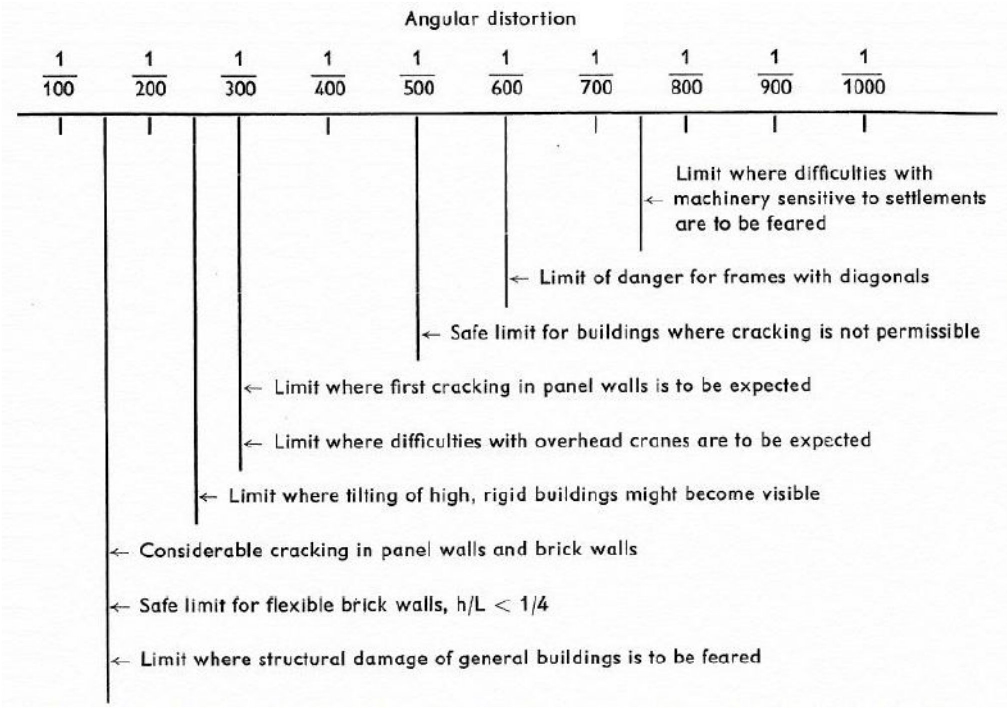


Figure 4: Damage Criteria Ratings

The results show the assessed affected walls all have a slope gradient of greater than 1 in 500, as shown in Table 8-3, which is the limit for buildings at which point cracking is not permissible. Therefore, the anticipated cracking due to the proposed construction is within tolerable limits.

Use of best practice construction methods will be essential to ensure that the ground movements are kept in line with the above predictions. Pre-construction condition surveys of neighbouring properties are also recommended, and a system of monitoring adjoining and adjacent structures should be established before the works start.

9. BASEMENT IMPACT ASSESSMENT CONCLUSIONS AND SUMMARY

This Summary includes the principal aspects and primary findings of this assessment. The whole report should be read to obtain a full understanding of the matters considered.

Location: 47d Netherhall Gardens, Hampstead NW3 5RJ.

9.1 Stage 1: Screening

The screening exercise has been carried out in accordance with CPG4 and has identified issues that need to be taken forward to Stage 3 (Scoping). Items requiring assessment were:

Slope stability:

Slope stability screening chart	
4. Is the site within a wider hillside setting in which the general slope is greater than 7 degrees? (approx. 1 in 8)	The publicly available data suggests that the site has a gradient of less than 7 degrees. However, at the recommendation of CampbellReith a topographic survey has been undertaken.
5. Is the London Clay the shallowest strata at the site?	Yes. The geological map shows the Claygate Member of the London Clay Formation is and may be encountered during construction.
7. Is there a history of seasonal shrink-swell subsidence in the local area, and/or evidence of such effects at site?	The Envirocheck Report indicates a 'moderate' shrink-swell hazard rating. No evidence of shrink-swell subsidence has been provided.
10. Is the site within an aquifer? If so, will the proposed basement extend beneath the water table such that dewatering may be required during construction?	Yes, the bedrock is designated as a Secondary A Aquifer. The groundwater level will need to be determined from a site-specific ground investigation.
13. Will the proposed basement significantly increase the differential depth of foundations relative to neighbouring properties?	Yes. Following review of available information, the neighbouring property to the north is likely to be set on shallow foundations at ground floor level and the proposed basement will extend to 3m current ground level.
14. Is the site over (or within the exclusion zone of) any tunnels, e.g. railway lines?	Yes, the site is within the zone of influence of the Hampstead tunnel.

Sub surface groundwater flow

Subterranean (groundwater) flow screening chart	
1. a) Is the site located directly above an aquifer?	Yes, the bedrock is designated as a Secondary A Aquifer.

b) Will the proposed basement extend beneath the water table surface?	Unknown. The data available from the historical boreholes is insufficient to make an accurate estimate of groundwater level. A site investigation is required to assess groundwater levels.

Surface flow and flooding

None.

9.2 Site Investigation

A ground investigation (GI) was completed by CET in January 2019, May 2019, with a follow up investigation in October 2020. The investigation comprised one window sampler borehole (WS01), foundation trial pits around the perimeter of the house and one cable percussion borehole to 12.45m below ground level. The boreholes encountered the following ground conditions:

Strata name	Depth to top of strata (mbgl)	Thickness (m)	Description
Made Ground	0	0.6 to 1.7	Dark brown CLAY, with varying minor constituents of sand and gravel; clayey gravelly SAND or sandy GRAVEL of flint, brick, chalk, concrete, possible coal/clinker, and ceramic tile. A low to medium cobble content of brick was also encountered.
Claygate Member	0.6-1.7	2.5 to 5	Soft becoming firm with depth, light orange brown mottled light grey, fine sandy, silty CLAY; and Firm locally stiff and soft, greyish brown, light grey and orange brown mottled, slightly fine sandy, slightly gravelly, locally silty CLAY.
London Clay Formation	3.55 to 6	Proved to 12.45m depth	Firm becoming very stiff with depth, dark grey, locally micaceous, fine sandy, locally silty CLAY with localised shell fragments.

A groundwater seepage was noted at 5m below ground level in WS01 and 7m below ground level in BH01 on 14th May 2019 and 29th October respectively. No rise in the groundwater level was recorded after 20 minutes of monitoring in either case. A groundwater level of 2.65m below ground level and 2.13m below ground level was measured during post fieldwork monitoring visits on 6th June 2019 and 16th December 2020.

9.3 Site Model

The conceptual site model can be summarised as follows:

- **Excavation Depth** – Approximately 3.3m below ground level;
- **Site Topography** – Relatively flat at 85mAOD;
- **Surface Water Bodies** – None within 500m;
- **Flood Risk** – Low from flooding and very low from surface water;
- **Ground Conditions**
    - Made Ground to variable depths up to 1.7m;
    - Claygate Member to 6m; and
    - London Clay Formation below 6m depth.
- **Aquifer** – Secondary A Aquifer; and
- **Groundwater** – Groundwater at 2.65 to 2.13mbgl.

9.4 Scoping and Impact Assessment

A summary of issues identified in the scoping stage is provided below.

- The ground investigation shows that the London Clay Formation is present beneath the Claygate Member. These strata are not expected to cause a slope stability hazard as the house is located on relatively flat land with the surrounding slopes having been confirmed to be less than the 7 degree upper limit;

- The site is on the Claygate Member that has a medium-volume change potential and will be prone to shrinkage/swelling. The proposed basement will extend to below the depth of observed root penetration. Contingencies have been allowed for if there is evidence for desiccation deeper than encountered in the boreholes. The reader should refer to the 'Geotechnical Report on the Ground investigation' for a detailed description. Heave as a result of unloading is expected to occur and can be mitigated by the basement slab design;

- The property is within the zone of influence of the Hampstead Heath rail tunnel. The crown of the tunnel is about 35m below the level of the site and located outside the footprint of the proposed basement so will not be within the zone of excavation. However, ground movements as a result of construction will need to be considered. Network Rail will need to be informed of the proposed development and an asset protection agreement put in place;

- The site is shown to be located above a Secondary A Aquifer and groundwater was measured at 2.65m and 2.13m below ground level in the monitoring standpipes indicating the proposed basement will extend below the groundwater table. The strata above and immediately below founding level are expected to have a low permeability, with the horizontal permeability being significantly higher than the vertical permeability due to stratification of the strata, and minimal groundwater flow would therefore be expected at the level of the proposed basement. Therefore, it is considered unlikely that the basement would cause any significant adverse impact on groundwater flows. In light of the CampbellReith audit, consideration could be given to the inclusion of gravel fill or a geotextile drainage blanket to improve groundwater flow around the basement obstruction. Groundwater level monitoring readings should be taken during the detailed design period and prior to construction; and

- Construction of the basement will result in lowering of the foundations compared to adjacent sites and excavation of the basement will result in some ground movements. The affect of this has been assessed in ground movement and damage criteria assessments. Based upon the maximum displacements predicted by PDISP analyses, Damage Criteria Assessments were undertaken for the worst-case scenarios in the adjoining properties and these combined with the ground movements alongside the basement in response to the vertical stress changes are as predicted by the CIRIA publication C760. The assessed walls were within the 1 in 500 angular distortion criteria proposed by Bjerrum (1963). No further Damage Category Assessments have been carried out as other structures in the vicinity are further away to the proposed basement and therefore considered lower risk. Use of best practice construction methods will be essential to ensure that the ground movements are kept in line with the above predictions. Pre-construction condition surveys of neighbouring properties are also recommended, and a system of monitoring adjoining and adjacent structures should be established before the works start.

- The BIA has identified a low flood risk for the proposed development and no mitigation measures are proposed.

10. REFERENCES

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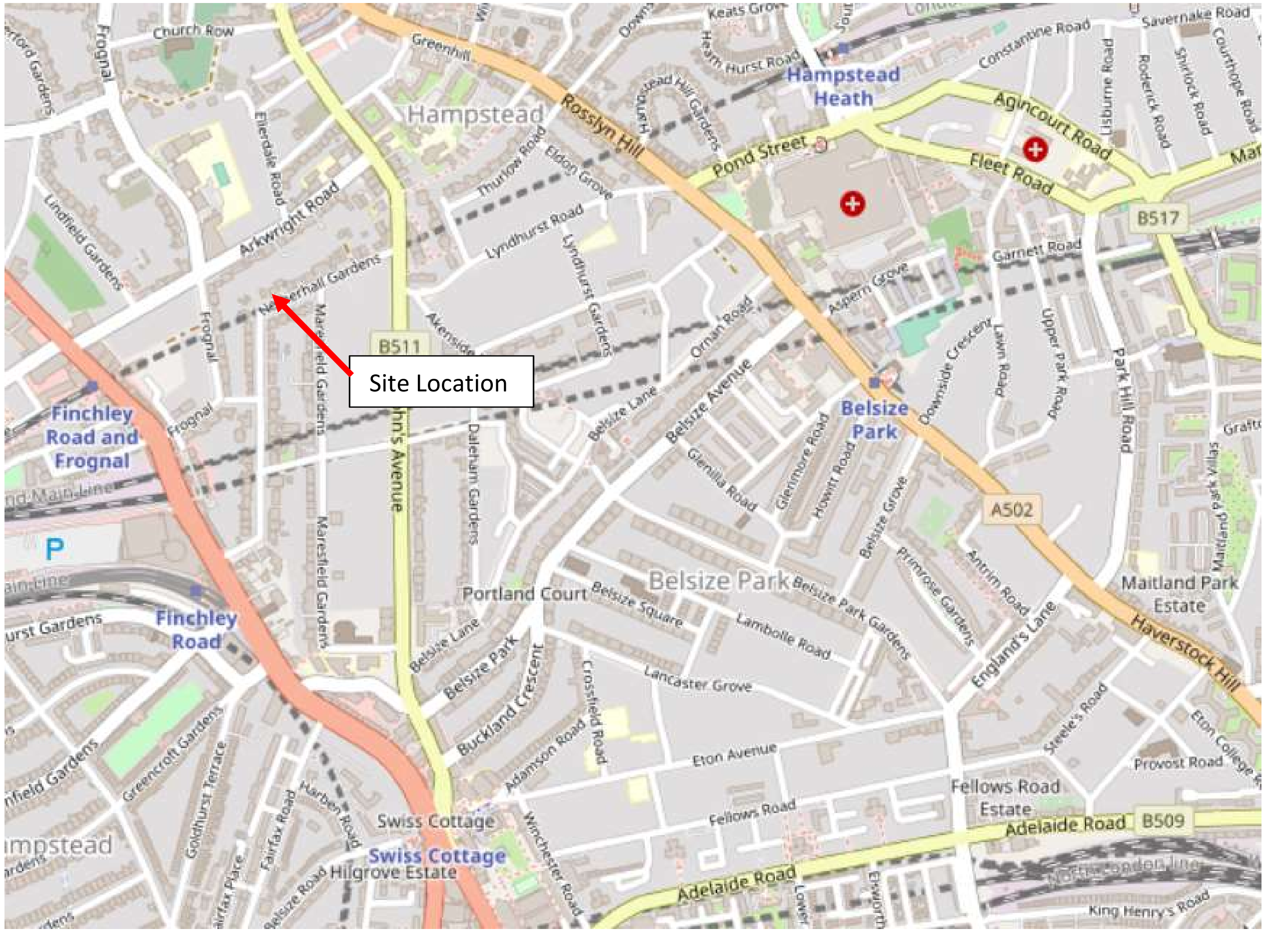
APPENDIX A FIGURES

CET INFRASTRUCTURE
Giving our all

Northdown House, Ashford Road, Harrietsham, Maidstone
Kent, ME17 1QW
Telephone: 01622 858545 Facsimile: 01622 858544

47d Netherhall Gardens, Hampstead

Lead No.	491846
Created By: GRH	Checked: PTE
Approved: PTE	Date: July 2019



North

© OpenStreetMap Contributors

Site Location Plan

Scale: NTS

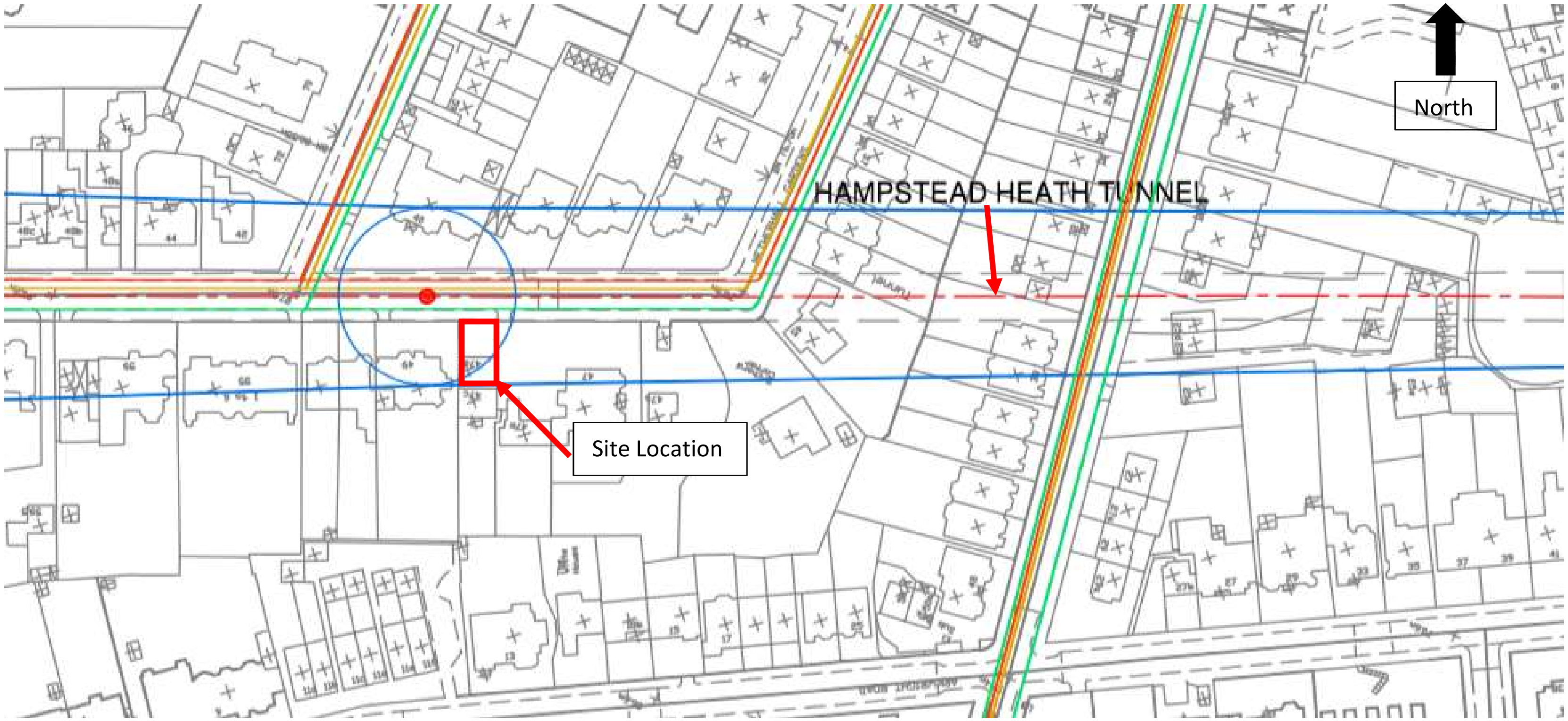
FIGURE A1

CET INFRASTRUCTURE
Giving our all

Northdown House, Ashford Road, Harrietsham, Maidstone
Kent, ME17 1QW
Telephone: 01622 858545 Facsimile: 01622 858544

47d Netherhall Gardens, Hampstead

Lead No.			491846
Created By: GRH	Checked: PTE	Approved: PTE	Date: July 2019



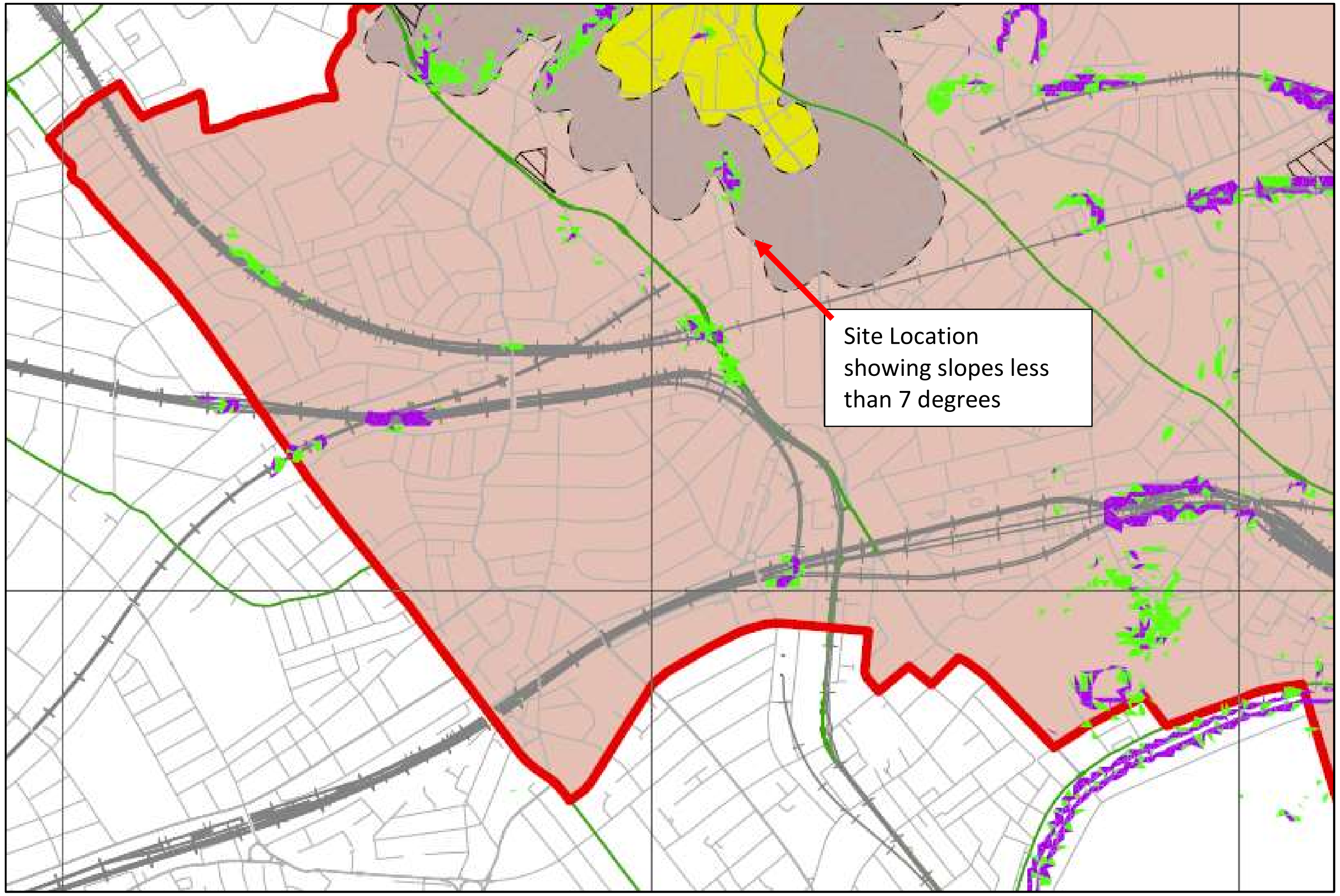
Network Rail Sourced Drawing

Tunnel Asset Locations

Scale: NTS

FIGURE A2

CET INFRASTRUCTURE Giving our all	47d Netherhall Gardens, Hampstead			Lead No. 491846
Northdown House, Ashford Road, Harrietsham, Maidstone Kent, ME17 1QW Telephone: 01622 858545 Facsimile: 01622 858544	Created By: GRH	Checked: PTE	Approved: PTE	Date: July 2019



North

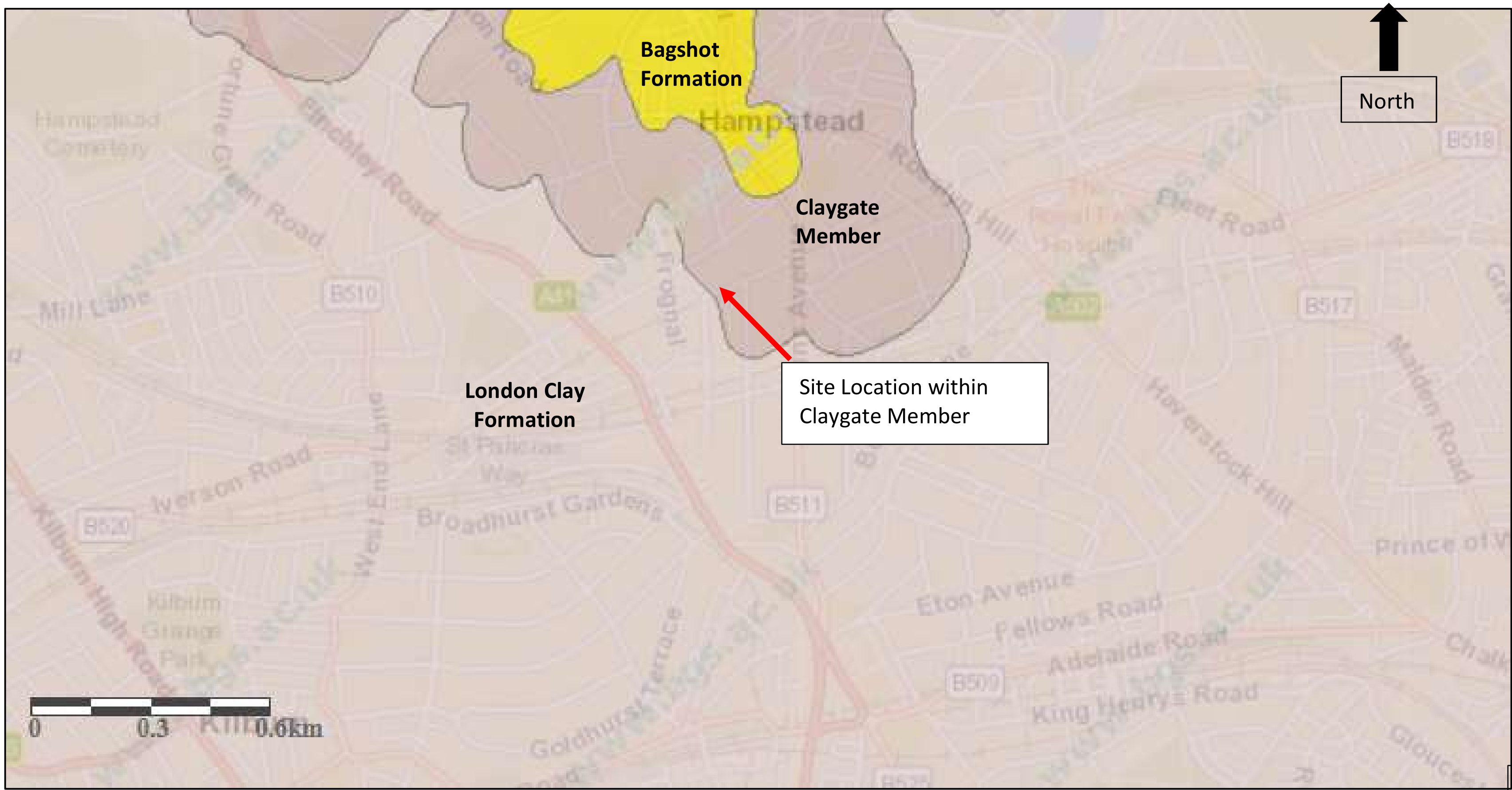
GHHS Fig 16

Slope Angle Map

Scale: NTS

FIGURE A3

CET INFRASTRUCTURE Giving our all Northdown House, Ashford Road, Harrietsham, Maidstone Kent, ME17 1QW Telephone: 01622 858545 Facsimile: 01622 858544	47d Netherhall Gardens, Hampstead			Lead No. 491846
	Created By: GRH	Checked: PTE	Approved: PTE	Date: July 2019

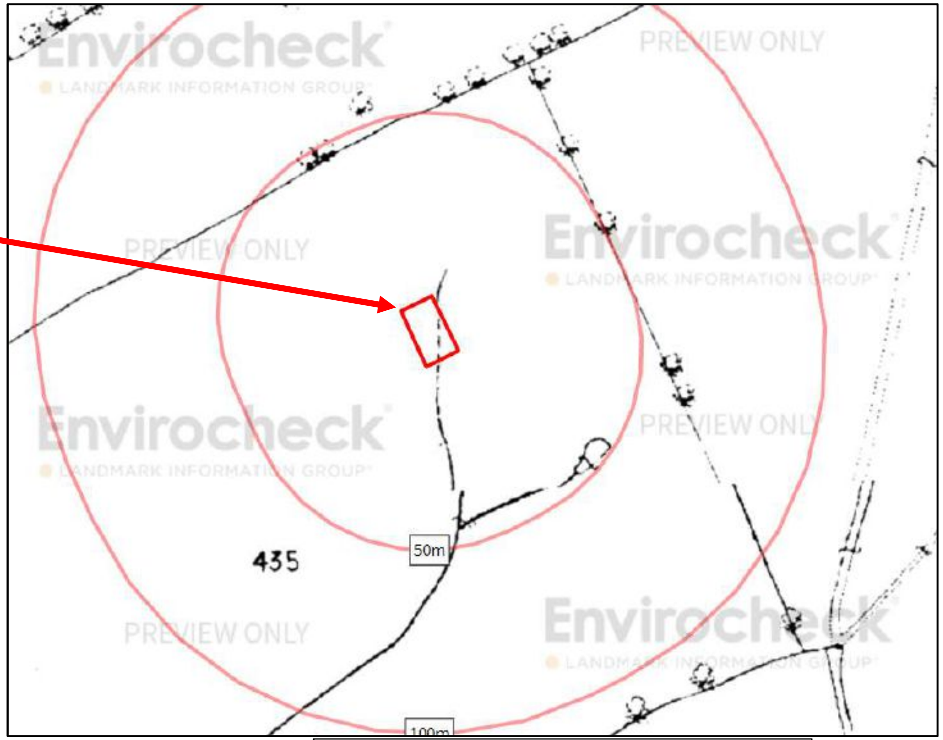


Geological Map	Scale: As shown
	FIGURE A4

CET INFRASTRUCTURE Giving our all Northdown House, Ashford Road, Harrietsham, Maidstone Kent, ME17 1QW Telephone: 01622 858545 Facsimile: 01622 858544	**47d Netherhall Gardens, Hampstead**			Lead No. **491846**
	Created By: **GRH**	Checked: **PTE**	Approved: **PTE**	Date: **July 2019**

'The Lost Rivers of London' by Barton

North



1871/1879 Historical Drawing

Lost Rivers

Scale: NTS

FIGURE A5

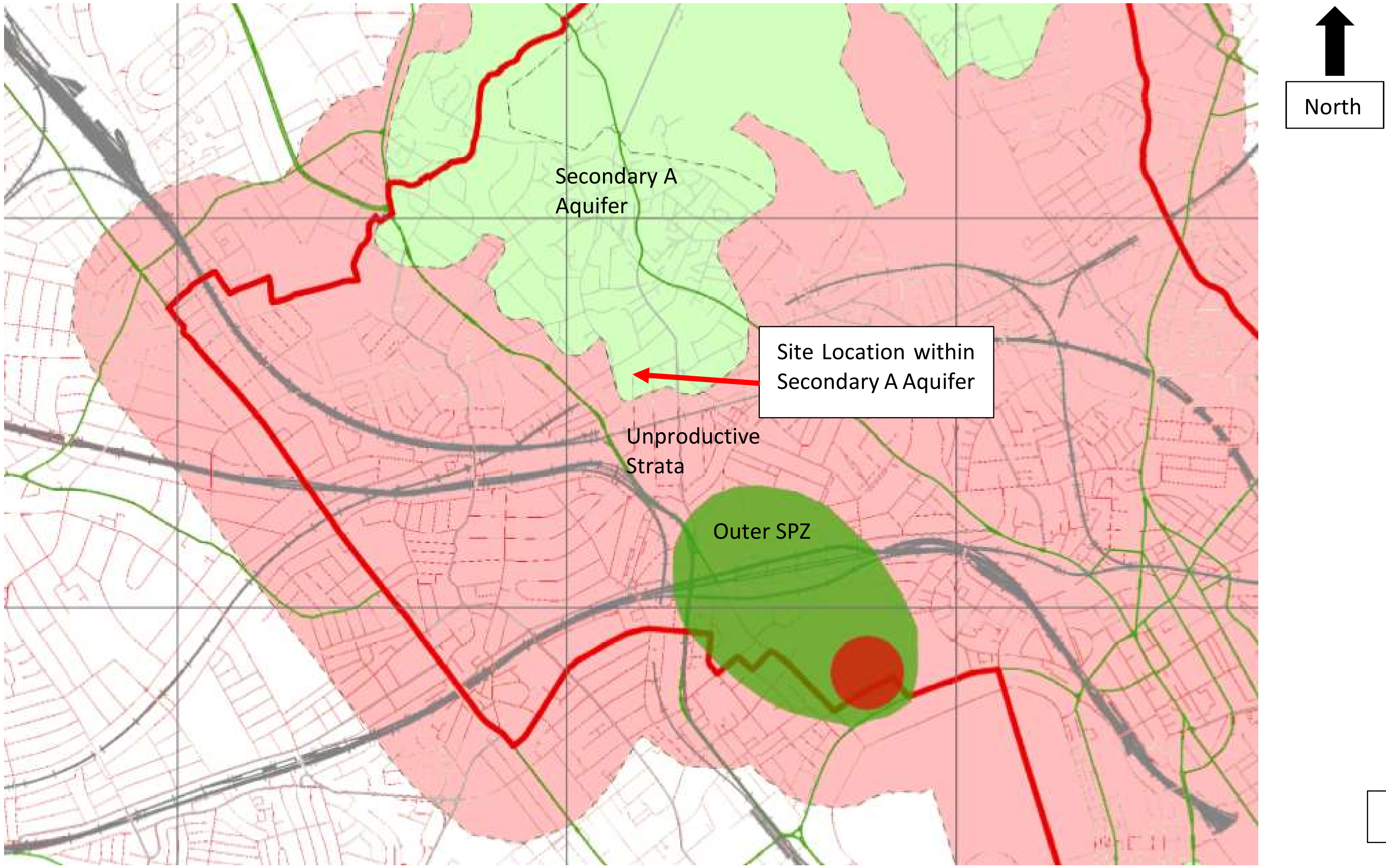
CET INFRASTRUCTURE Giving our all	47d Netherhall Gardens, Hampstead		Lead No. 491846
Northdown House, Ashford Road, Harrietsham, Maidstone Kent, ME17 1QW Telephone: 01622 858545 Facsimile: 01622 858544	Created By: GRH	Checked: PTE	Approved: PTE	Date: July 2019

Flood Zone Map	Scale: As shown
	FIGURE A6

CET INFRASTRUCTURE Giving our all

Northdown House, Ashford Road, Harrietsham, Maidstone
Kent, ME17 1QW
Telephone: 01622 858545 Facsimile: 01622 858544

47d Netherhall Gardens, Hampstead			Lead No. 491846
Created By: GRH	Checked: PTE	Approved: PTE	Date: July 2019



Groundwater Aquifers

Scale: NTS

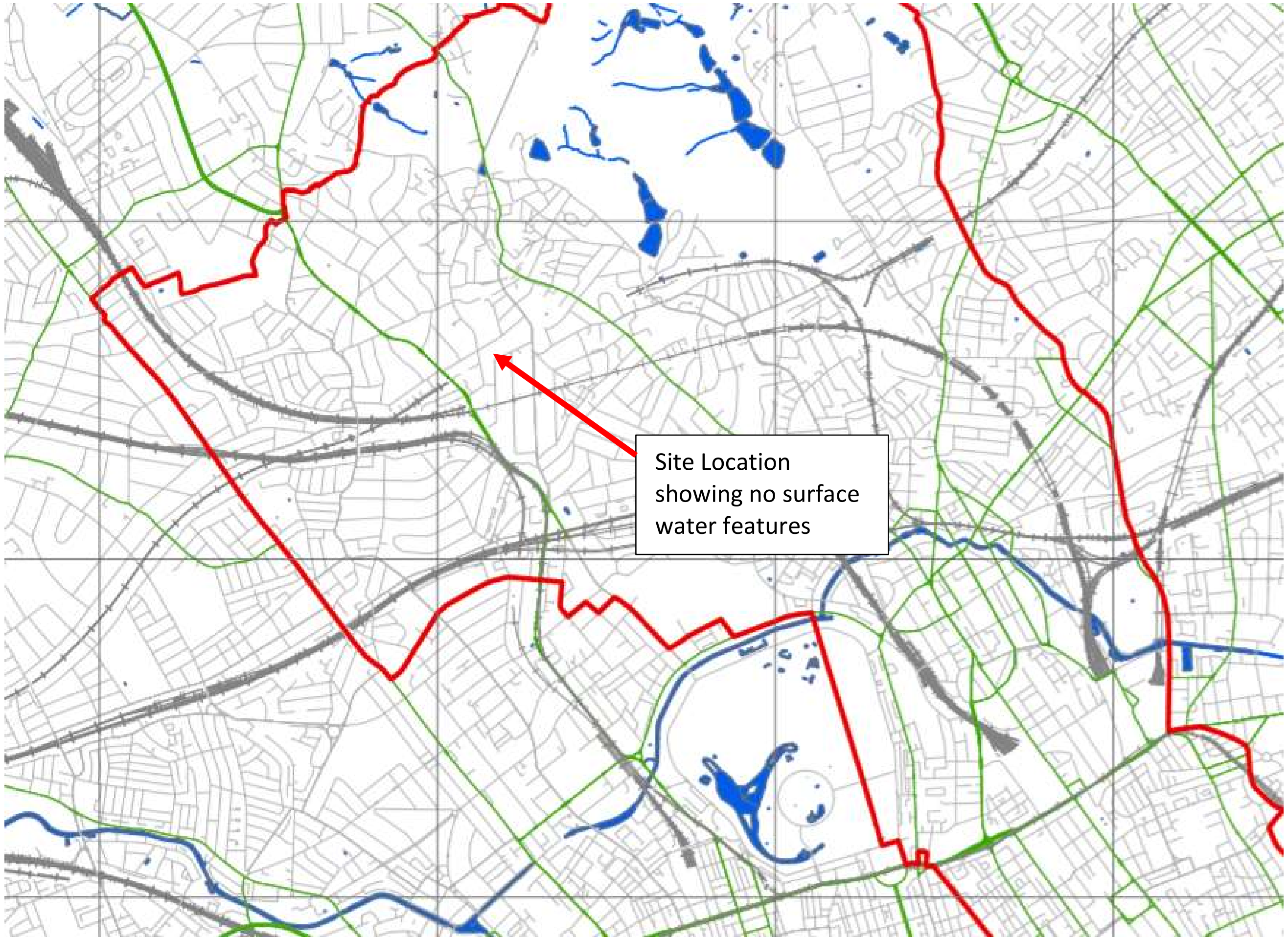
FIGURE A7

CET INFRASTRUCTURE
Giving our all

Northdown House, Ashford Road, Harrietsham, Maidstone
Kent, ME17 1QW
Telephone: 01622 858545 Facsimile: 01622 858544

47d Netherhall Gardens, Hampstead

Lead No.			491846
Created By: GRH	Checked: PTE	Approved: PTE	Date: July 2019



North

GHHS Fig 12

Surface Water Features

Scale: NTS

FIGURE A8

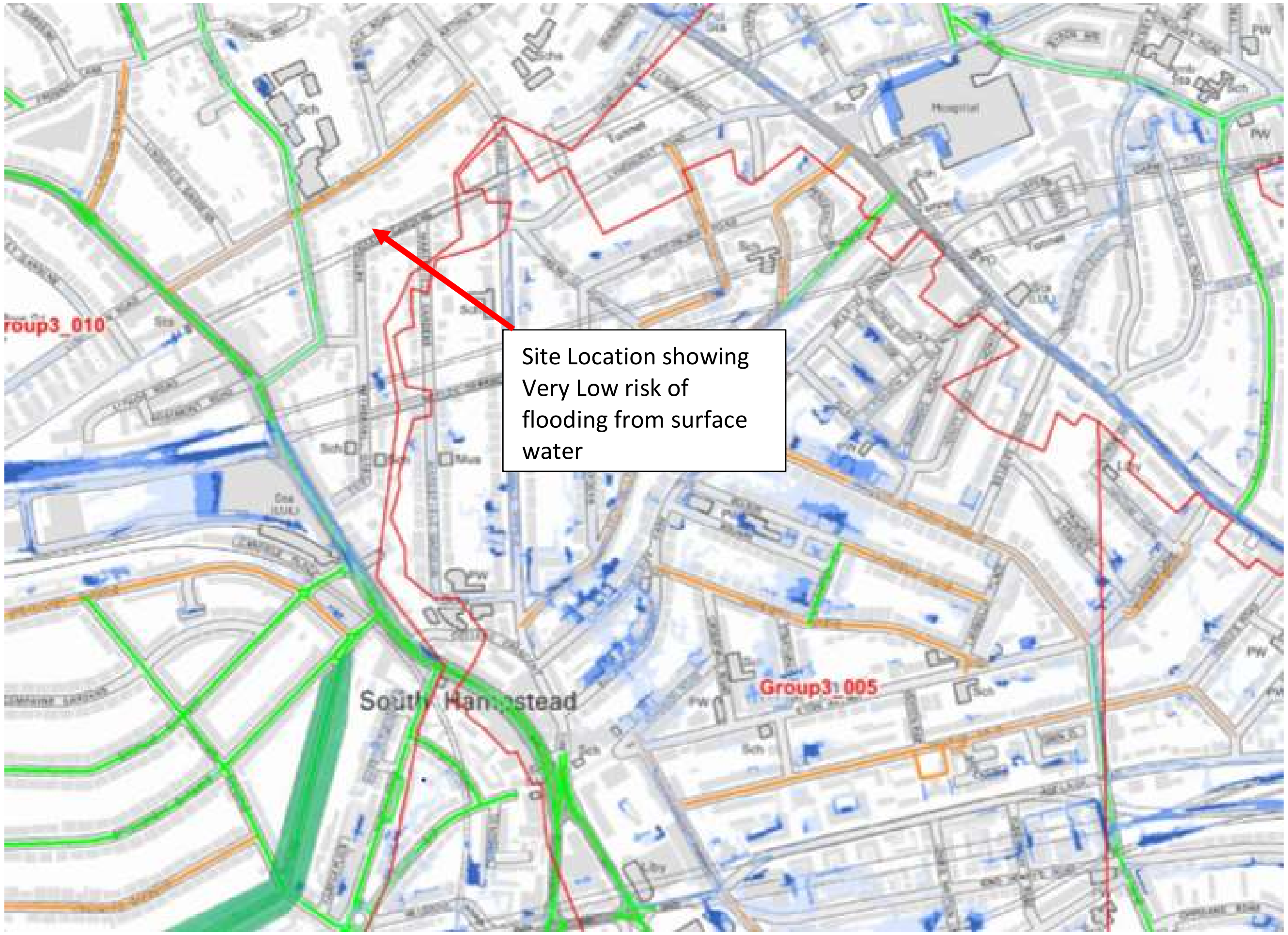
INFRASTRUCTURE
Giving our all

Northdown House, Ashford Road, Harrietsham, Maidstone
Kent, ME17 1QW
Telephone: 01622 858545 Facsimile: 01622 858544

47d Netherhall Gardens, Hampstead

Lead No.	
491846	

Created By:	Checked:	Approved:	Date:
GRH	PTE	PTE	July 2019



North

URS 2014: Fig 3v

Surface Water Flooding

Scale: NTS

FIGURE A9

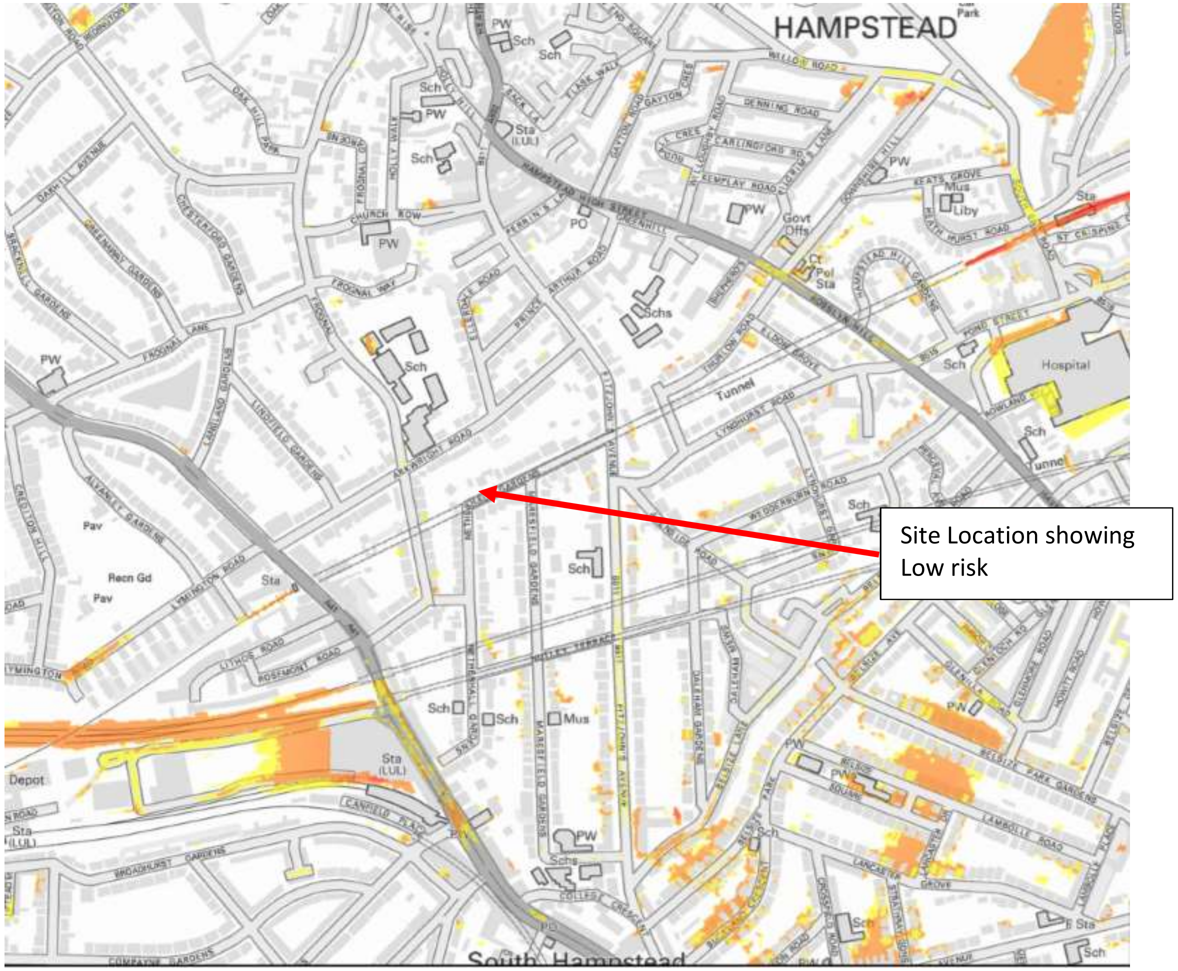
INFRASTRUCTURE
Giving our all

Northdown House, Ashford Road, Harrietsham, Maidstone
Kent, ME17 1QW
Telephone: 01622 858545 Facsimile: 01622 858544

47d Netherhall Gardens, Hampstead

Lead No.	
	491846

Created By:	Checked:	Approved:	Date:
GRH	PTE	PTE	July 2019



North

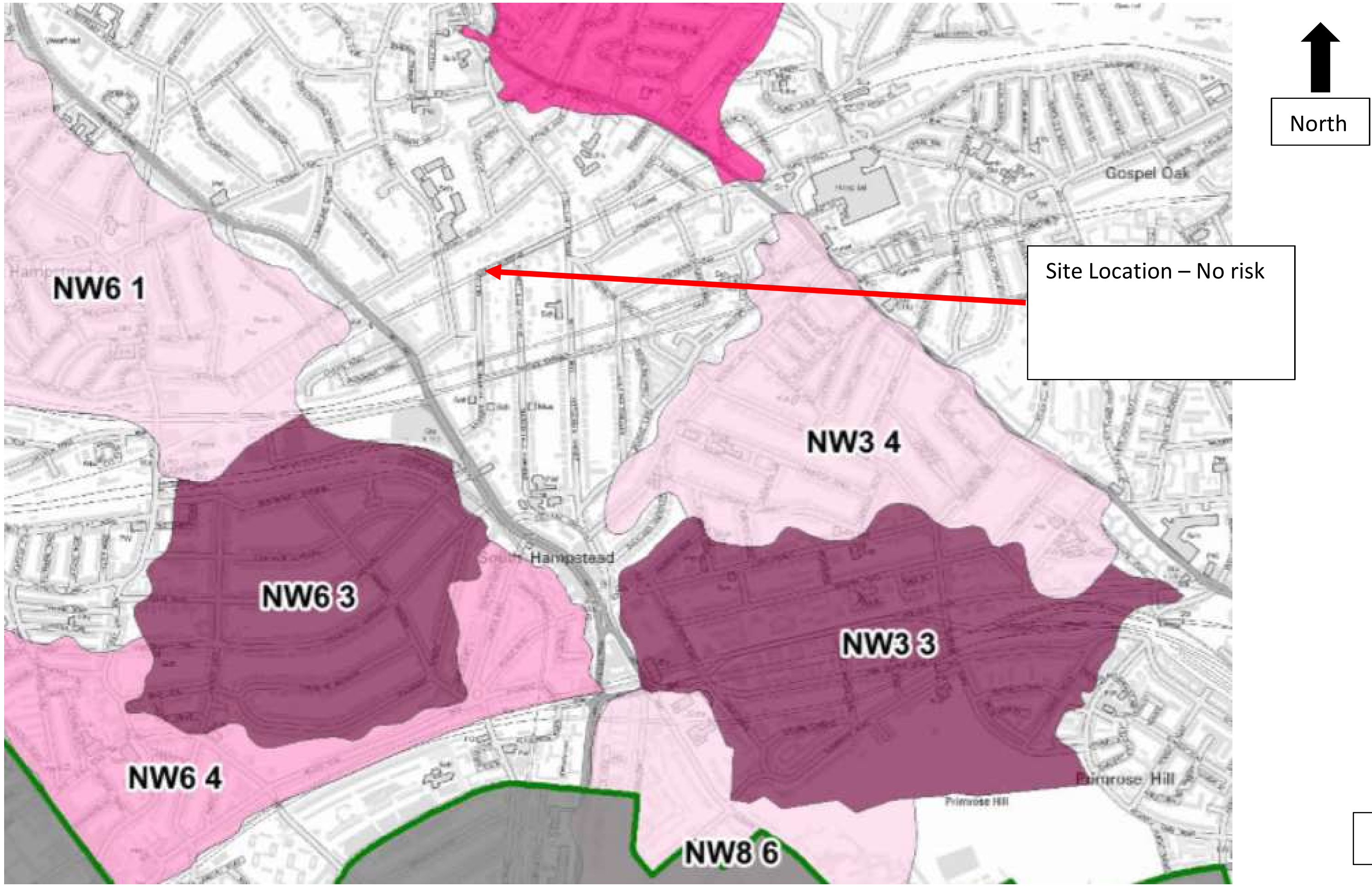
URS 2014: Fig 3ix

Flooding 1:1000 year event

Scale: NTS

FIGURE A10

CET INFRASTRUCTURE Giving our all Northdown House, Ashford Road, Harrietsham, Maidstone Kent, ME17 1QW Telephone: 01622 858545 Facsimile: 01622 858544	47d Netherhall Gardens, Hampstead			Lead No. **491846**
	Created By: **GRH**	Checked: **PTE**	Approved: **PTE**	Date: **July 2019**



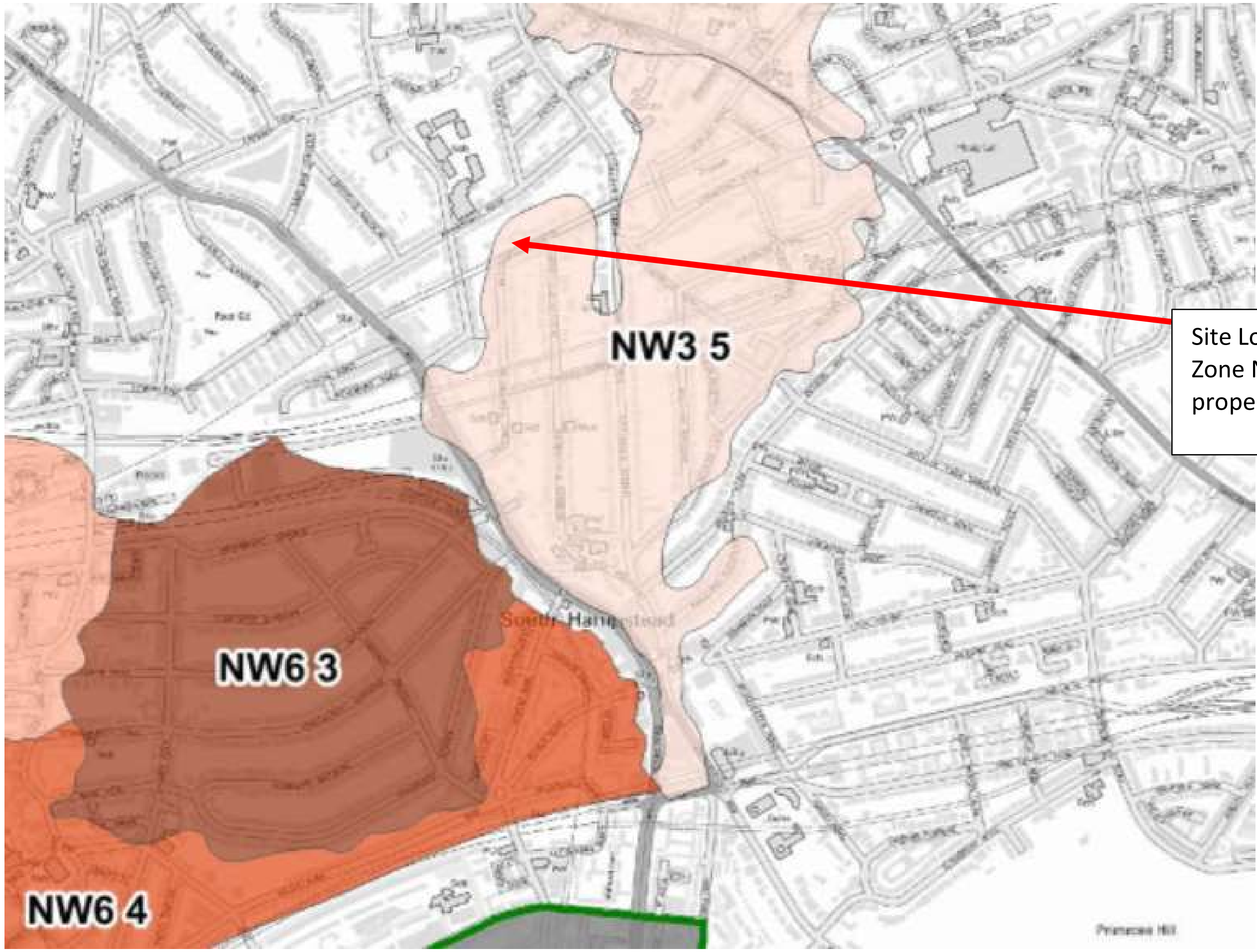
Internal Sewer Flooding	Scale: NTS
	FIGURE A11

INFRASTRUCTURE
Giving our all

Northdown House, Ashford Road, Harrietsham, Maidstone
Kent, ME17 1QW
Telephone: 01622 858545 Facsimile: 01622 858544

47d Netherhall Gardens, Hampstead

Lead No.	491846
Created By: GRH	Checked: PTE
Approved: PTE	Date: July 2019



North

Site Location within Zone NW3 5 (1 property affected)

URS 2014: Fig 5b

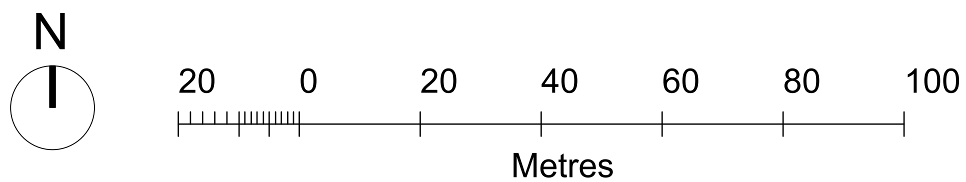
External Sewer Flooding

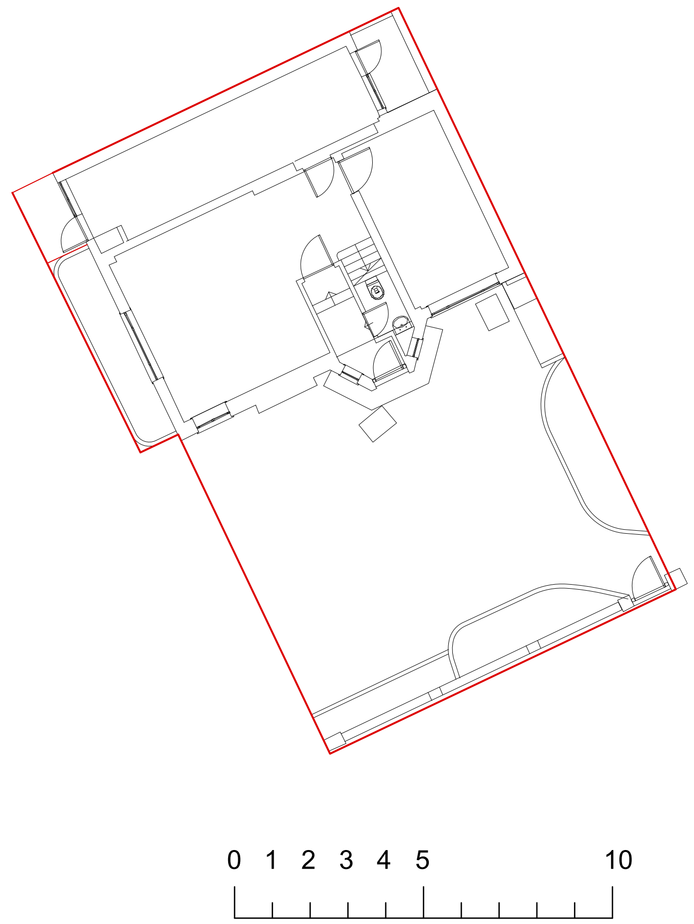
Scale: NTS

FIGURE A12

APPENDIX B PROPOSED DEVELOPMENT PLANS

LOCATION PLAN 1:1250@A3





SITE PLAN 1:200@A3

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Rev		Date
–	stage C: outline proposals 3 -issued for information -client -consultants	09.11.18

DRAWING STATUS **For Information**

Issued only for purpose indicated

This drawing to be read in conjunction with all consultants information.

All dimensions to be checked on site.
Do not scale, except for planning purposes.

JOB NUMBER 216

JOB TITLE
Mount Cottage
47d Netherall Gardens, London, NW3 5RJ

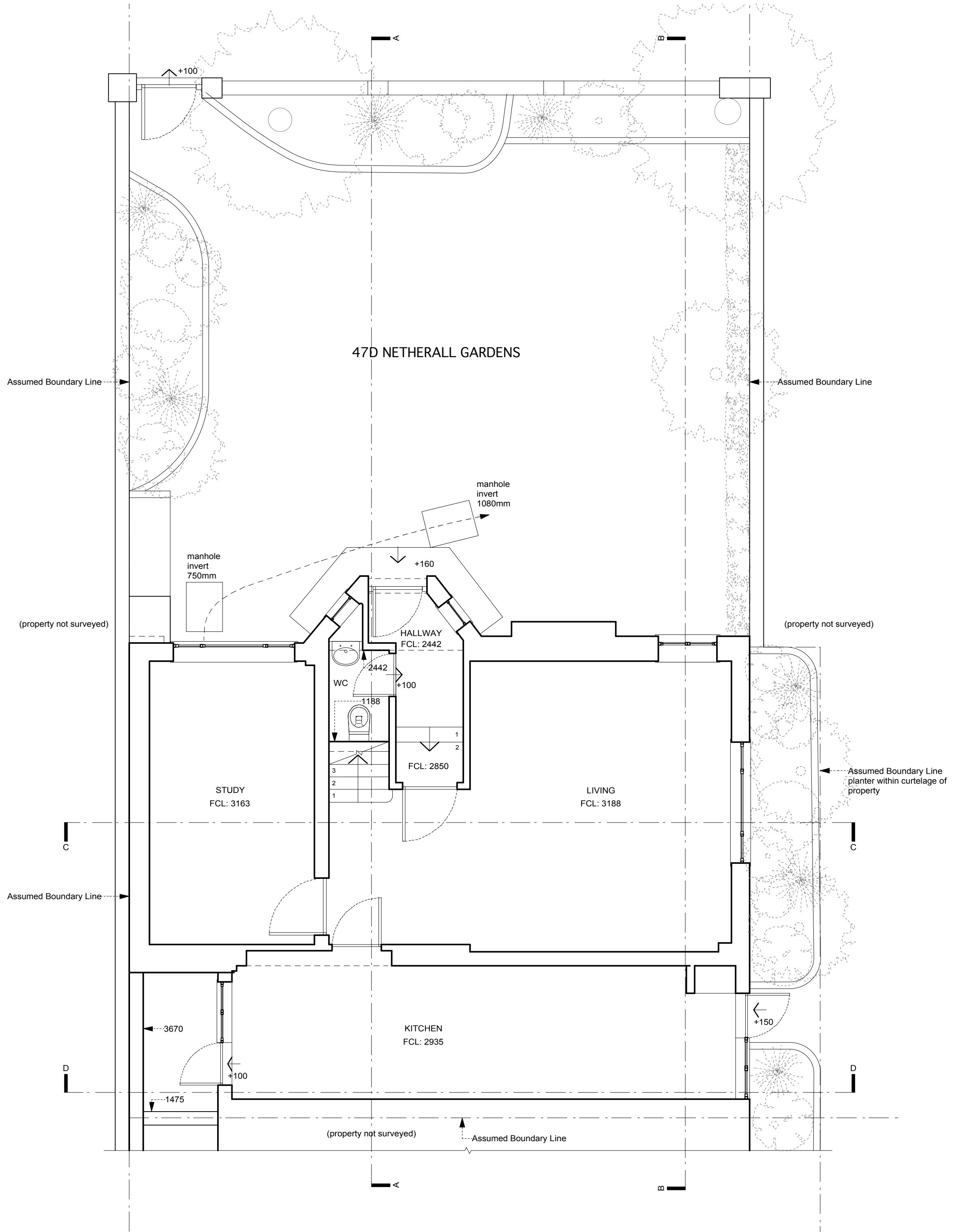
DRAWING TITLE
OS Map and Site Plan

SCALE: varies

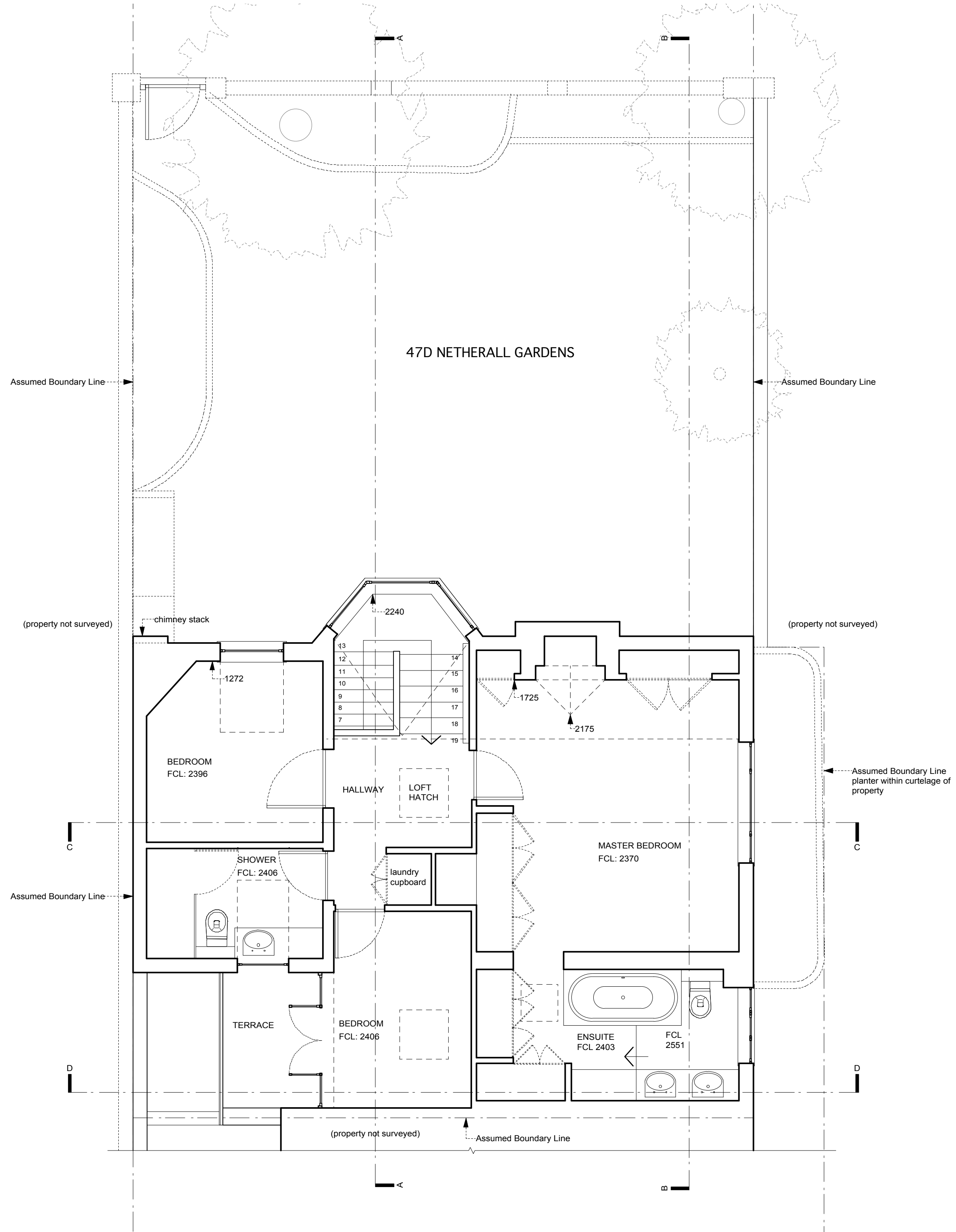
DATE: September 2018

DRAWING NO. A/01/101

REV –

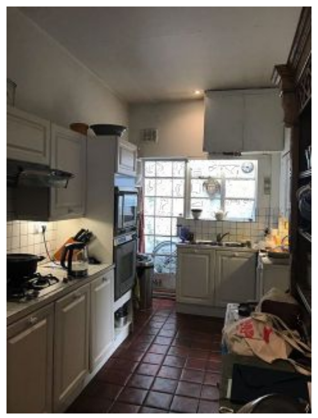


EXISTING GROUND FLOOR



EXISTING FIRST FLOOR

existing site photographs



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0 1 2 3 4m

0 1 2

Rev		Date
A	stage C: outline proposals -issued for information -client	09.11.18
–	stage A&B: site survey -issued for information -client	28.09.18

DRAWING STATUS **For Information**
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JOB NUMBER 216

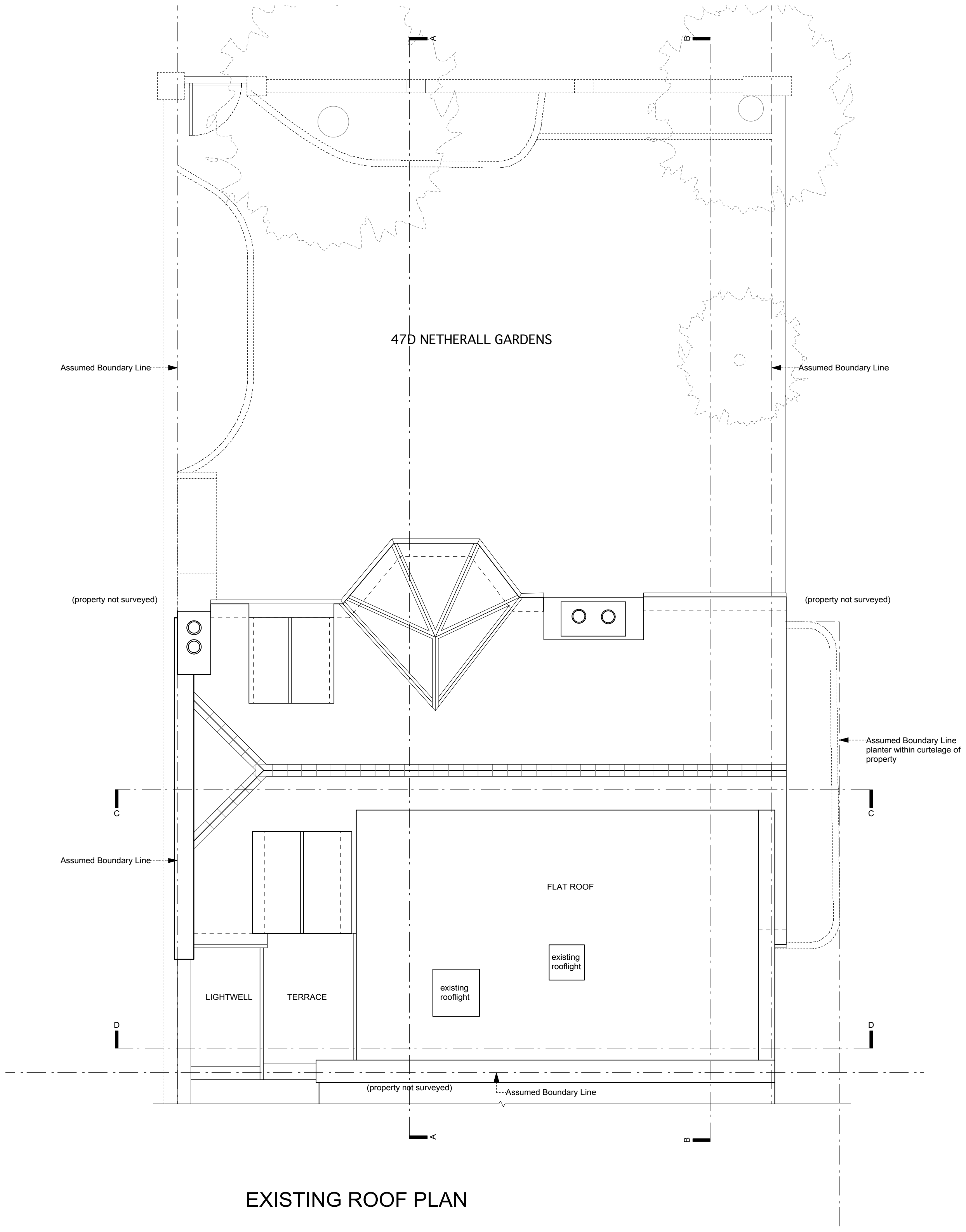
JOB TITLE
Mount Cottage
47d Netherall Gardens, London, NW3 5RJ

DRAWING TITLE
floor plans – ground and first
existing

SCALE: 1:100 @ A3 1:50 @ A1

DATE: September 2018

DRAWING NO. A/01/101 REV A



EXISTING ROOF PLAN

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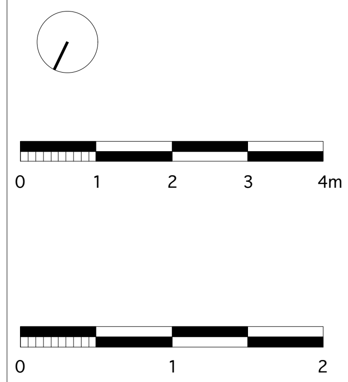

Rev		Date
A	stage C: outline proposals -issued for information -client	09.11.18
–	stage C: outline proposals -issued for information -client	09.11.18

DRAWING STATUS **For Information**
Issued only for purpose indicated

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All dimensions to be checked on site.
Do not scale, except for planning purposes.

JOB NUMBER 216

JOB TITLE
Mount Cottage
47d Netherall Gardens, London, NW3 5RJ

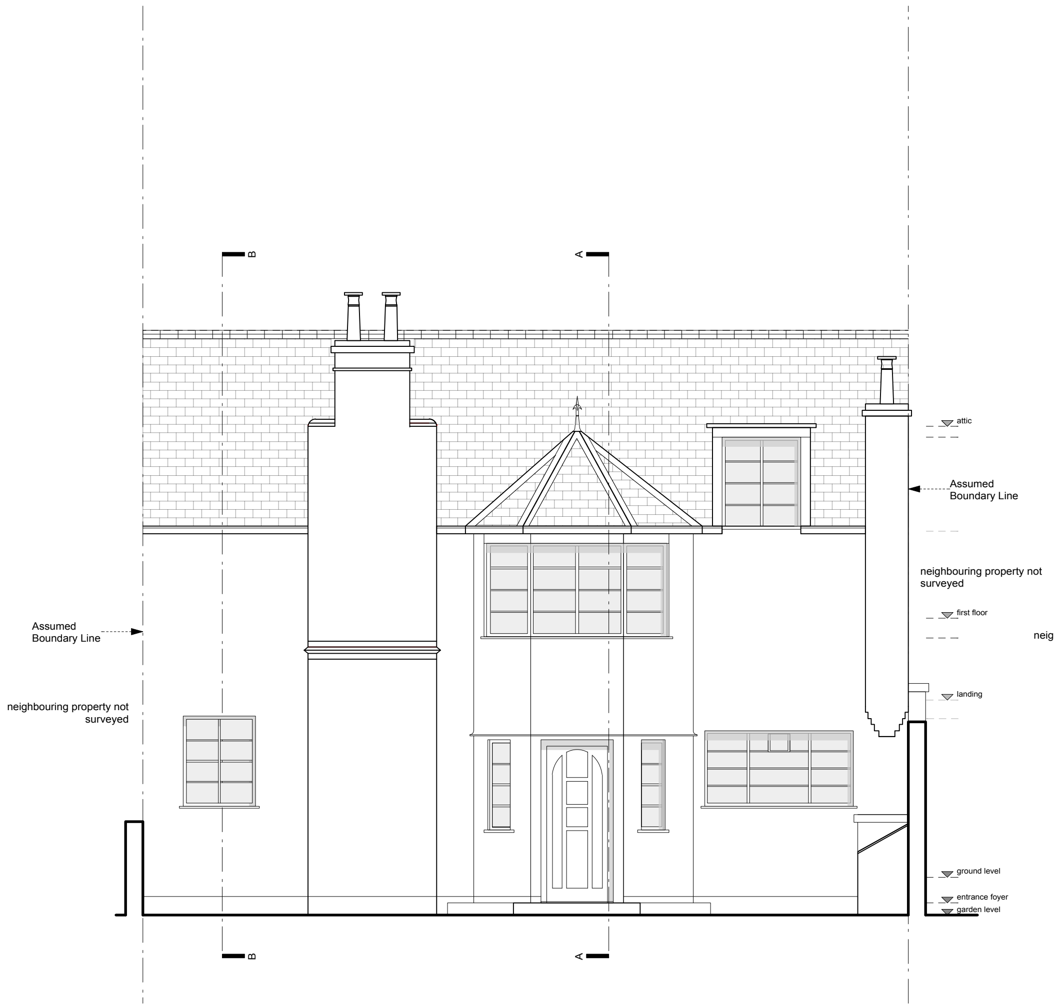
DRAWING TITLE
roof plan
existing

SCALE: 1:100 @ A3 1:50 @ A1

DATE: November 2018

DRAWING NO. A/01/102

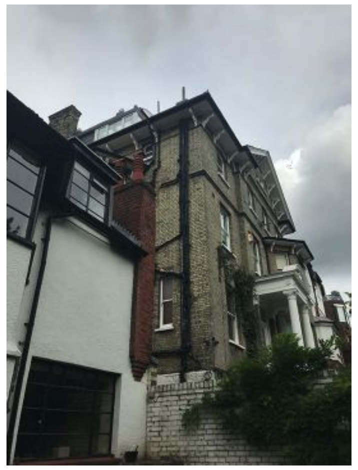
REV A



EXISTING FRONT ELEVATION

EXISTING SIDE ELEVATION

existing site photographs



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0 1 2 3 4m

Rev		Date
A	stage C: outline proposals -issued for information -client	09.11.18
–	stage A&B: site survey -issued for information -client	28.09.18

DRAWING STATUS **For Information**

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All dimensions to be checked on site.
Do not scale, except for planning purposes.

JOB NUMBER 216

JOB TITLE
Mount Cottage
47d Netherall Gardens, London, NW3 5RJ

DRAWING TITLE
elevations – front and side
existing

SCALE: 1:100 @ A3 1:50 @ A1

DATE: September 2018

DRAWING NO. A/01/103

REV A

EXISTING FRONT ELEVATION

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0 1 2

Rev		Date
–	stage C: outline proposals -issued for information -client	09.11.18

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All dimensions to be checked on site.
Do not scale, except for planning purposes.

JOB NUMBER 216

JOB TITLE
Mount Cottage
47d Netherall Gardens, London, NW3 5RJ

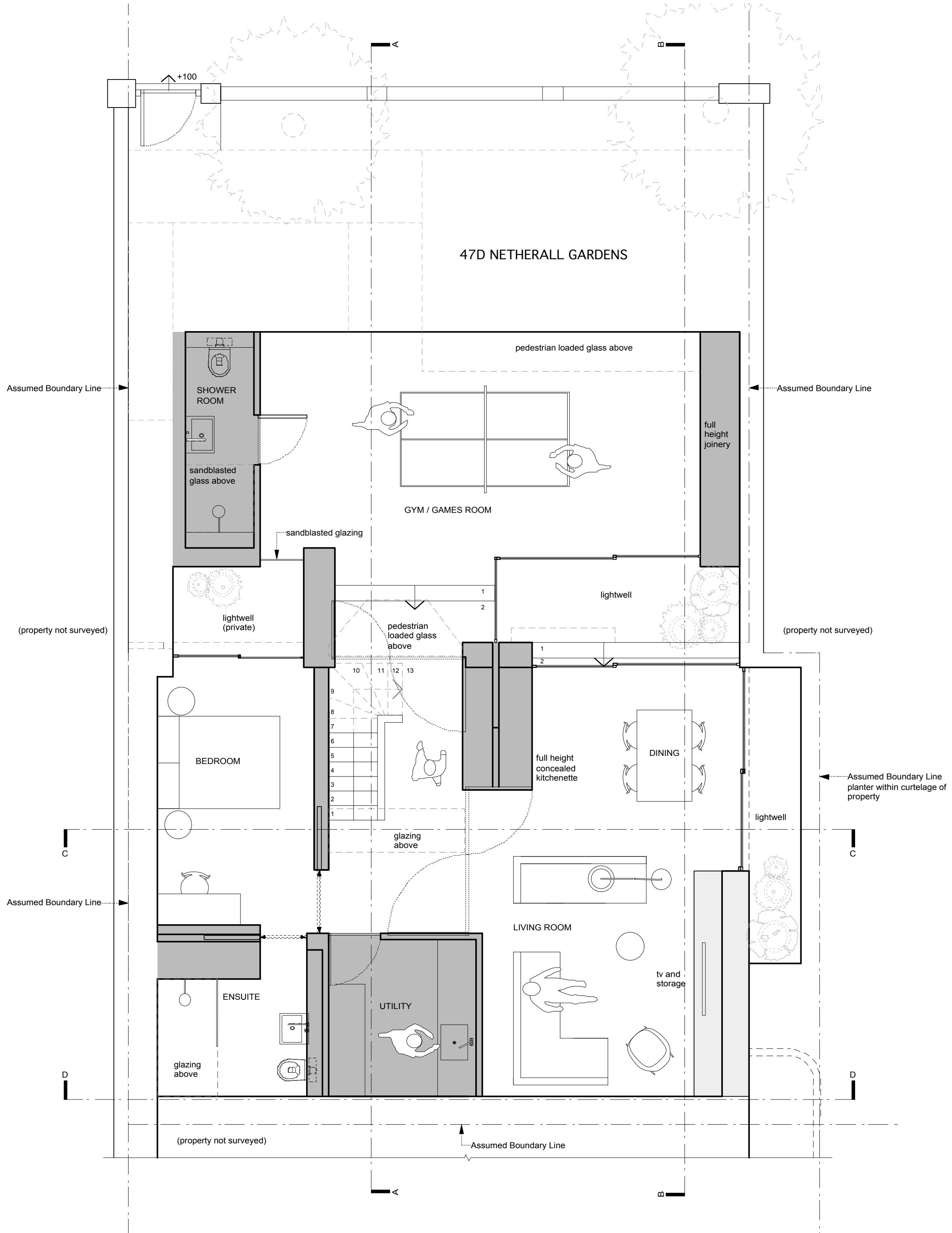
DRAWING TITLE
Section AA
existing

SCALE: 1:50 @ A3

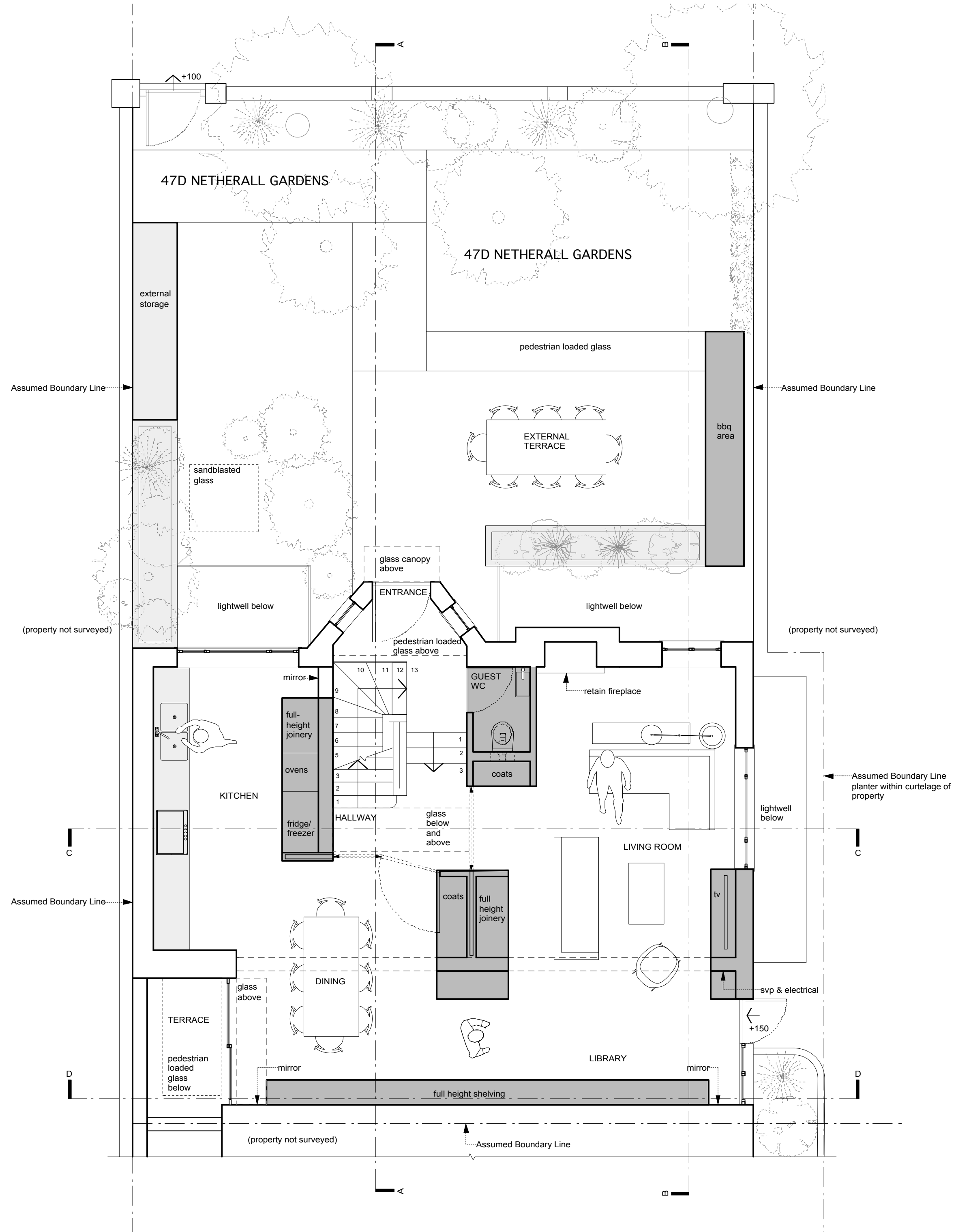
DATE: November 2018

DRAWING NO. A/01/501

REV -

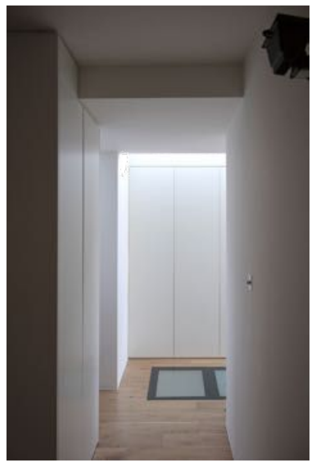


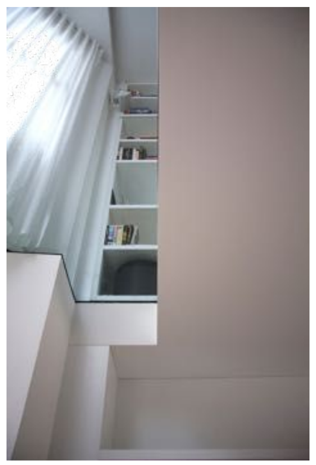
PROPOSED LOWER GROUND FLOOR



PROPOSED GROUND FLOOR

proposed photographs





From left:

01 open riser staircase
02 pedestrian loaded glazing (internal) and bay windows
03 kitchen units
04 library/reading room and living areas

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0 1 2 3 4m

0 0.5 1 2m

Rev		Date
B	stage C2: outline proposals -issued for information -client	15.11.18
A	stage C1: outline proposals -issued for information -client	09.11.18
–	stage C: outline proposals -issued for information -client	26.10.18
–	stage A&B: site survey -issued for information -client	28.09.18

DRAWING STATUS **For Information**

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This drawing to be read in conjunction with all consultants information.

All dimensions to be checked on site.
Do not scale, except for planning purposes.

JOB NUMBER 216

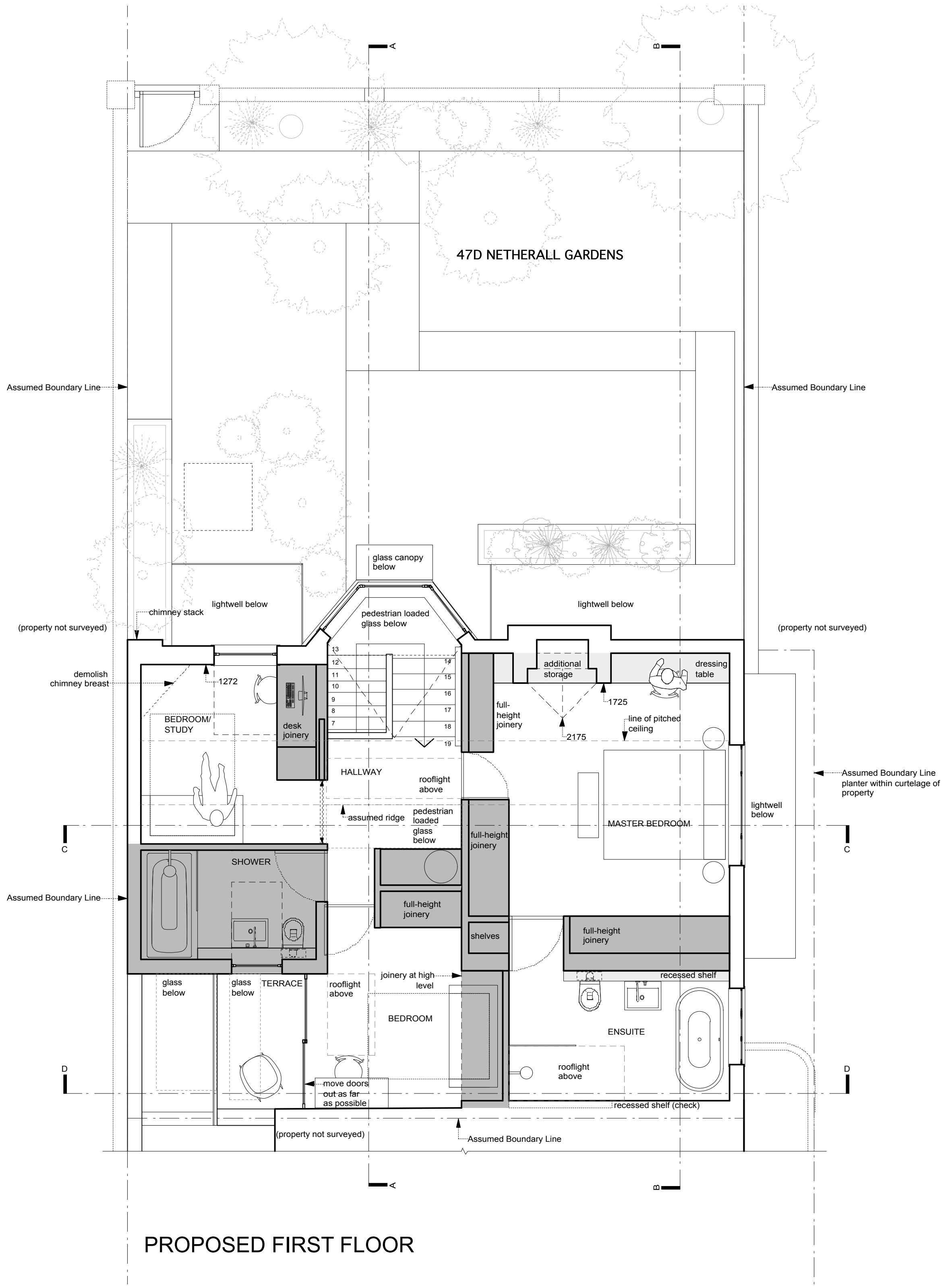
JOB TITLE **Mount Cottage**
47d Netherall Gardens, London, NW3 5RJ

DRAWING TITLE **floor plans – lower ground and ground**
proposed

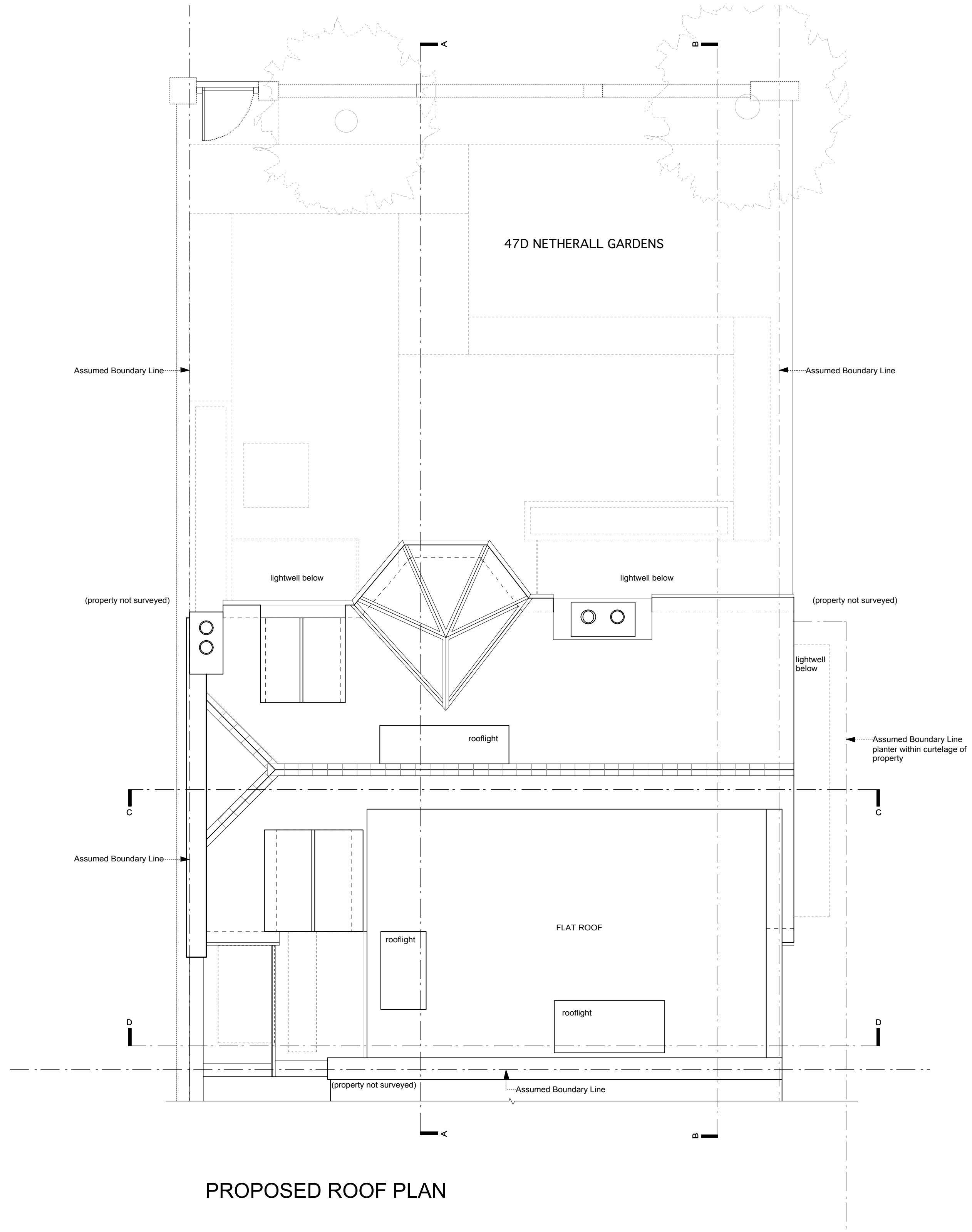
SCALE: 1:100 @ A3 1:50 @ A1

DATE: October 2018

DRAWING NO. A/02/101 REV B



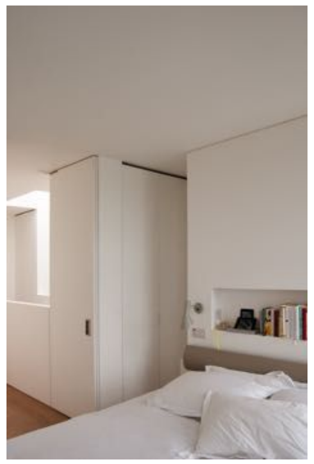
PROPOSED FIRST FLOOR



PROPOSED ROOF PLAN

proposed photographs



From left:

01 blade walls, volumes and planes
02 eaves shower room
03 shower room and freestanding bath
04 study shelving and desk
05 bedroom view with pocket doors and joinery
06 bedroom view with joinery

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0 1 2 3 4m

0 0.5 1 2m

Rev		Date
B	stage C2: outline proposals -issued for information -client	15.11.18
A	stage C1: outline proposals -issued for information -client	09.11.18
–	stage C: outline proposals -issued for information -client	26.10.18
–	stage A&B: site survey -issued for information -client	28.09.18

DRAWING STATUS **For Information**
Issued only for purpose indicated

This drawing to be read in conjunction with all consultants information.

All dimensions to be checked on site.
Do not scale, except for planning purposes.

JOB NUMBER 216

JOB TITLE **Mount Cottage**
47d Netherall Gardens, London, NW3 5RJ

DRAWING TITLE **floor plans – first and roof plan**

SCALE: 1:100 @ A3 1:50 @ A1

DATE: September 2018

DRAWING NO. A/01/102 REV B

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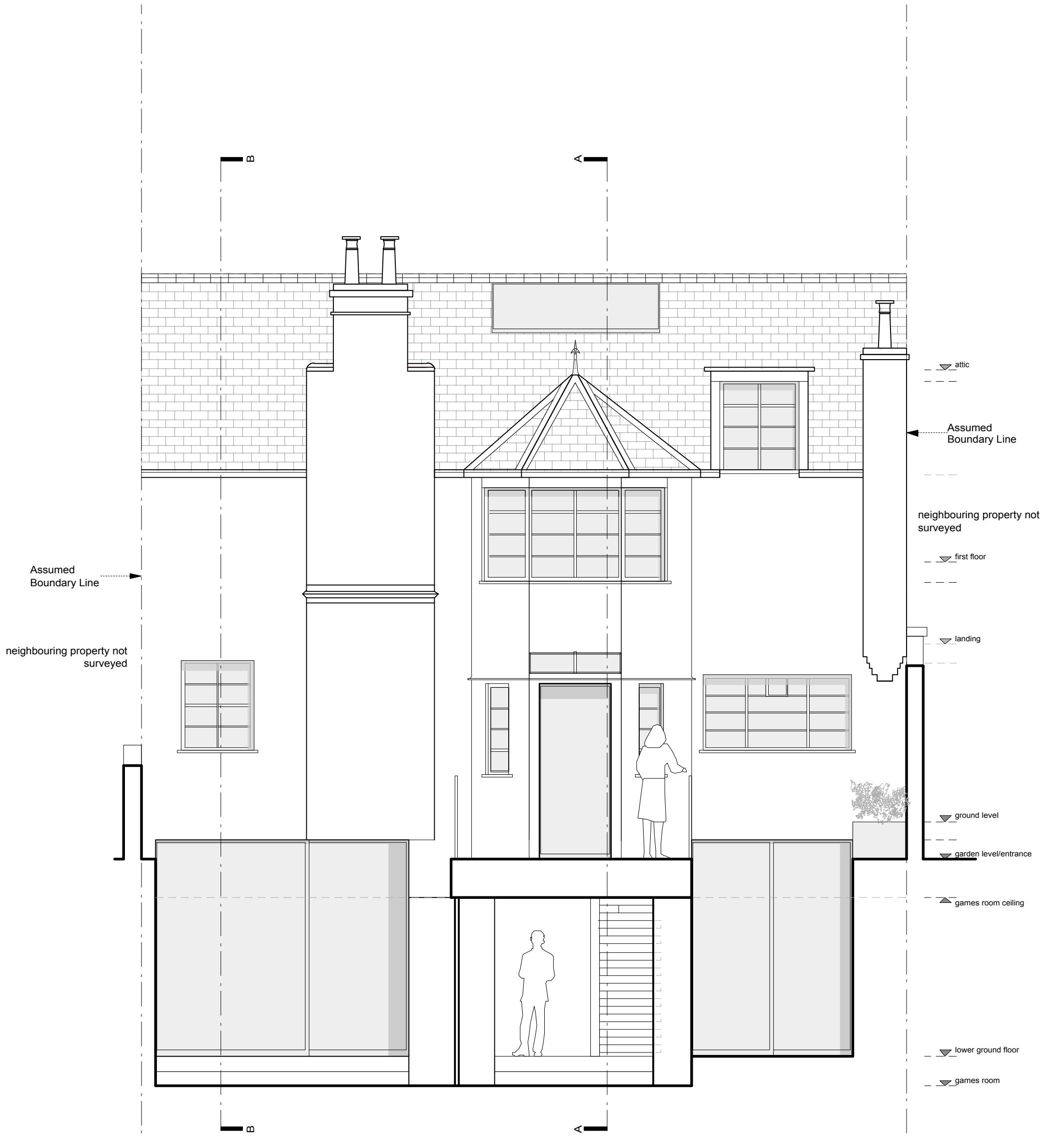
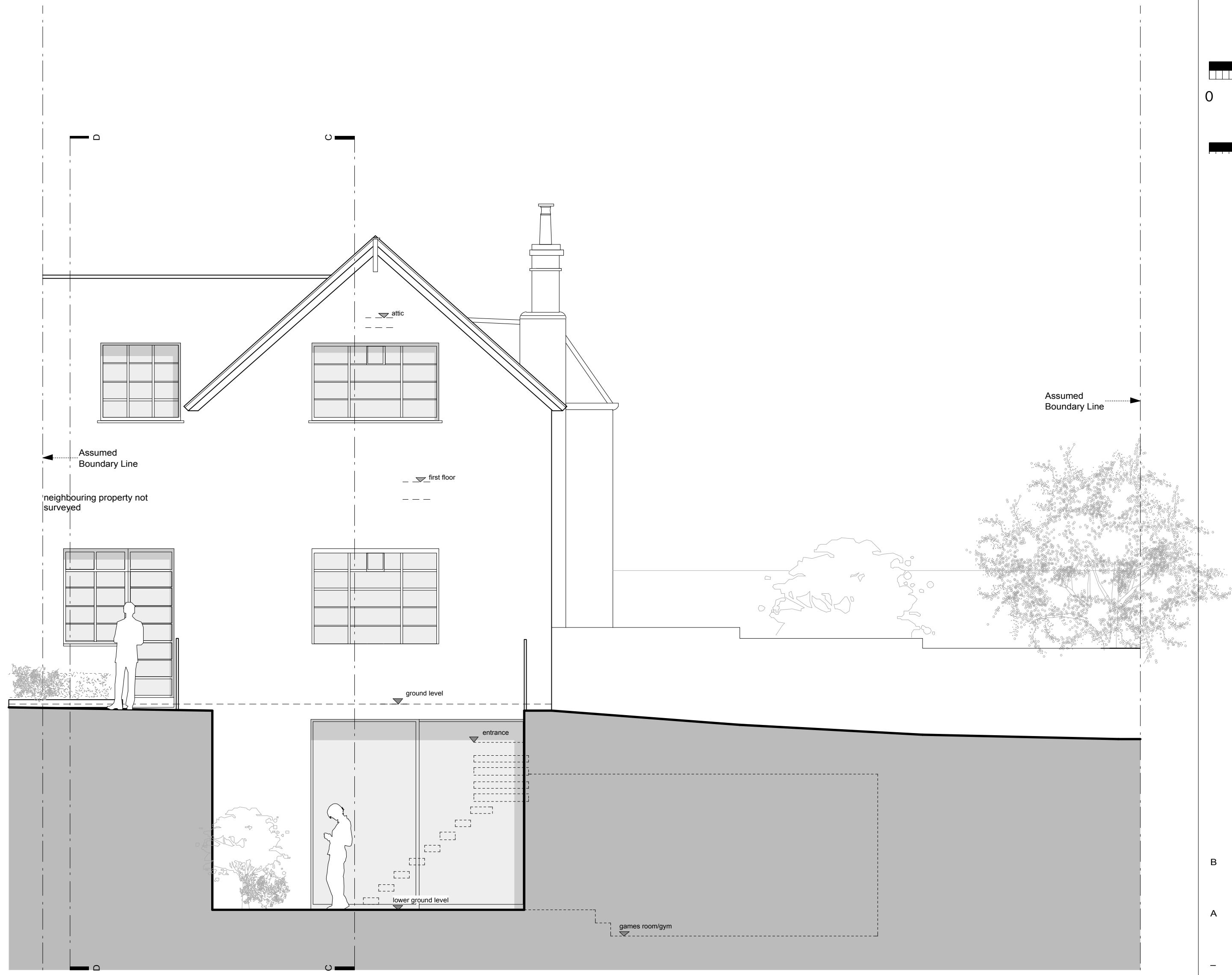


EXISTING FRONT ELEVATION



EXISTING SIDE ELEVATION

0 1 2 3 4m

Rev		Date
B	stage C2: outline proposals -issued for information -client	15.11.18
A	stage C: outline proposals -issued for information -client	09.11.18
–	stage C: outline proposals -issued for information -client	26.10.18
–	stage A&B: site survey -issued for information -client	28.09.18

DRAWING STATUS **For Information**

Issued only for purpose indicated

This drawing to be read in conjunction with all consultants information.

All dimensions to be checked on site.
Do not scale, except for planning purposes.

JOB NUMBER 216

JOB TITLE
Mount Cottage
47d Netherall Gardens, London, NW3 5RJ

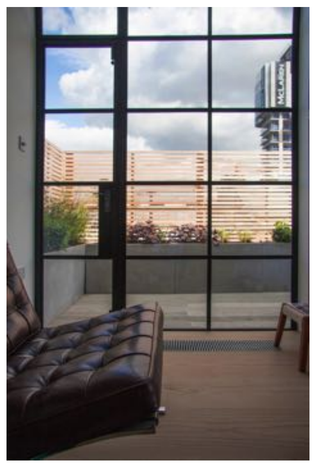
DRAWING TITLE
elevations – front and side
proposed

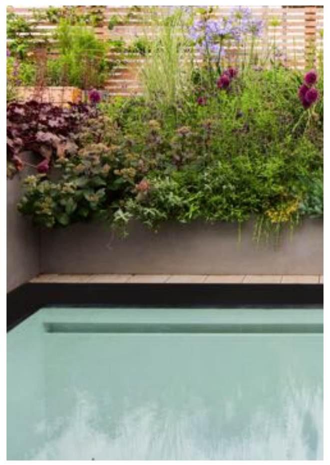
SCALE: 1:100 @ A3 1:50 @ A1

DATE: October 2018

DRAWING NO. A/02/103 **REV** B

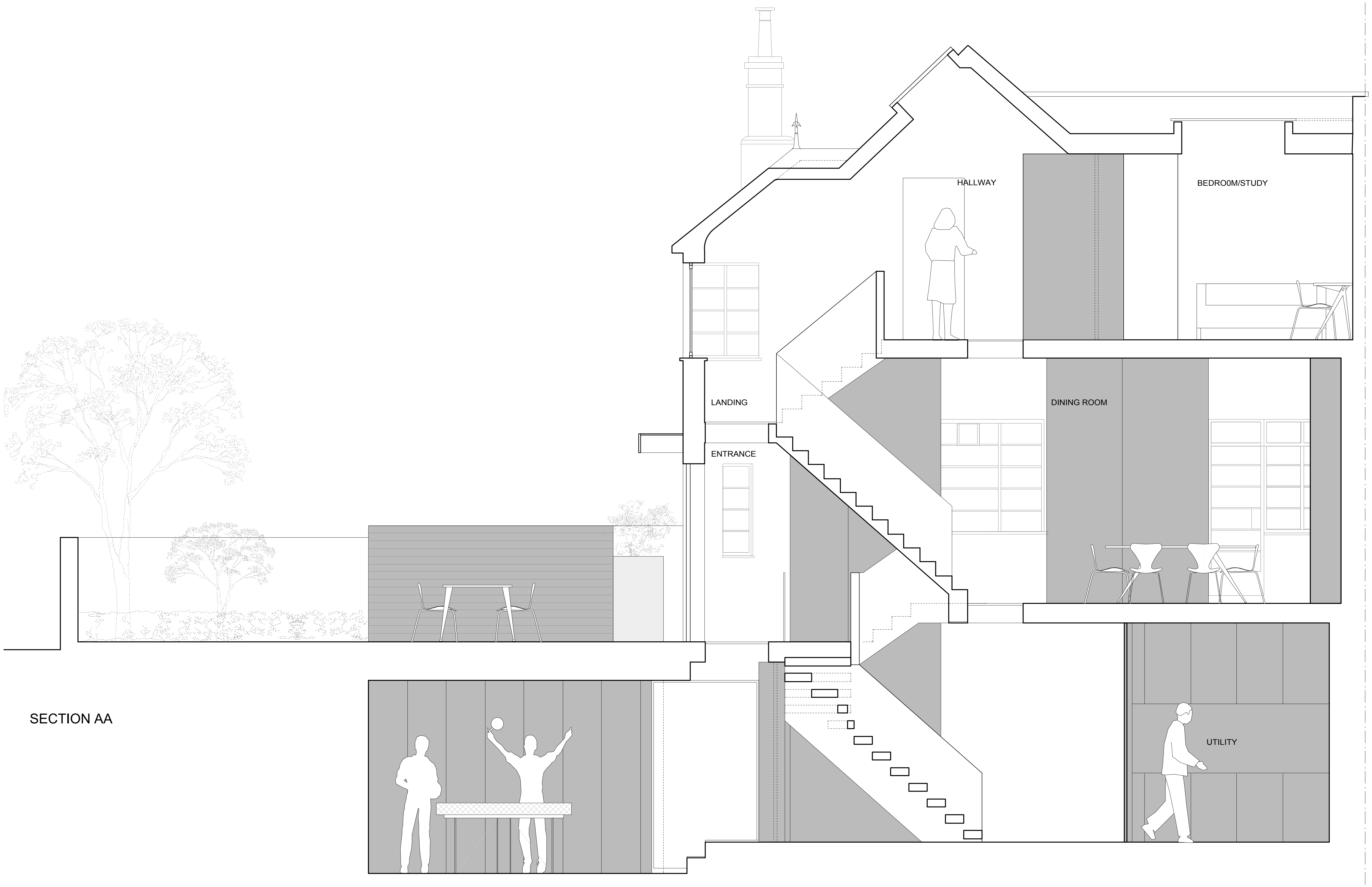
proposed photographs



From left:

01 double height glazing
02 crittal double glazing to existing areas
03 pedestrian glazing and glazed front door
04 glazing and planters
05 hard landscaping, planters and levels
06 potted plants and natural landscaping



SECTION AA

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0 0.5 1 2m

Rev		Date
A	stage C2: outline proposals -issued for information -client	15.11.18
–	stage C1: outline proposals -issued for information -client	09.11.18

DRAWING STATUS **For Information**

Issued only for purpose indicated

This drawing to be read in conjunction with all consultants information.

All dimensions to be checked on site.
Do not scale, except for planning purposes.

JOB NUMBER 216

JOB TITLE
Mount Cottage
47d Netherall Gardens, London, NW3 5RJ

DRAWING TITLE
Section AA
proposed

SCALE: 1:50 @ A3

DATE: November 2018

DRAWING NO. A/02/501

REV A

APPENDIX C ENVIROCHECK REPORT

Issued separately

APPENDIX D SITE INVESTIGATION LOGS

Client: **Chaim Klein**	Hole Diameter (mm): 150 to 12.00m		BOREHOLE NUMBER **BH01**
Method: Cable Percussion	Casing Dia. (mm): 150 to 12.00m		
Date Started: 29/10/2020 Co-ordinates	Ground Level (m AOD)	Ref. No: **491846**	Sheet 1 of 2

Backfill/Well depths (m): 0.10, 1.00, 6.00

Water strike depth (m): 7.00

Samples Depth (m)	Samples Type	In Situ Tests Type	In Situ Tests Results
0.50 - 1.00	B		
1.20 - 1.65	U		
1.70	D		
2.00	D	2.00	N =12
2.00 - 2.45	D		
2.50	D		
3.00	D		
3.00 - 3.45	U		
3.50	D		
4.00	D	4.00	N =6
4.00 - 4.45	D		
4.50	D		
5.00	D		
5.00 - 5.45	U		
5.50	D		
6.00	D	6.00	N =10
6.00 - 6.45	D		
6.50	D		
7.00	D		
7.00 - 7.50	B		
7.50	D		
8.00	D	8.00	N =12
8.00 - 8.45	D		
8.50	D		
9.00	D		
9.00 - 9.50	B		
9.50	D		

Reduced Level (mAOD)	Depth & (Thickness) (m)	Description of Strata
	(0.10) 0.10	Brick paving
	(0.10) 0.20	Yellow, medium and coarse SAND. Common rootlets. (Made Ground)
	(0.35) 0.55	Soft, brown and orange brown, slightly fine and medium sandy CLAY. (Made Ground)
	(0.45) 1.00	Soft, light orange brown mottled light grey, slightly medium and coarse sandy, gravelly CLAY. Gravel is angular fine to coarse tile, brick and asphalt. (Made Ground)
	(5.00) 6.00	Soft locally firm light blue grey and orange brown, slightly fine sandy CLAY with rare, rounded fine and medium gravel size black flint. Rare fine sand size fragments of possible selenite. (Claygate Member)
	(6.45)	Firm becoming stiff with depth, dark grey, silty CLAY with rare fine sand size possible selenite. Possible selenite becoming angular, fine and medium gravel size fragments with depth. From 10m below ground level rare sub-angular to sub-rounded, fine to coarse gravel size shell fragments. (London Clay Formation)

General Remarks:

1. Groundwater seepage encountered at 7m below ground level.
2. Roots and rootlets observed to 3.5m below ground level.

Driller:	SL	**BOREHOLE RECORD** Scale 1:50 See Key Sheet for explanation of symbols, etc.	INFRASTRUCTURE Giving our all
Logged:	HGD		
Checked:		**Mount Cottage, 47d Netherall Gardens**	**FIG A1**
Appr'd:			

Client: **Chaim Klein**	Hole Diameter (mm): 150 to 12.00m	BOREHOLE NUMBER **BH01**
Method: Cable Percussion	Casing Dia. (mm): 150 to 12.00m	
Date Started: 29/10/2020 · Co-ordinates	Ground Level (m AOD) · Ref. No: **491846**	Sheet 2 of 2

Backfill/Well Depth (m)	Backfill/Well Legend	Water Depth (m)	Samples Depth (m)	Samples Type	In Situ Tests Type	In Situ Tests Results	Reduced Level (mAOD)	Depth & (Thickness) (m)	Description of Strata	Legend
			10.00	D	10.00	N =22			Firm becoming stiff with depth, dark grey, silty CLAY with rare fine sand size possible selenite. Possible selenite becoming angular, fine and medium gravel size fragments with depth. From 10m below ground level rare sub-angular to sub-rounded, fine to coarse gravel size shell fragments. (London Clay Formation)	
			10.00 - 10.45	D						
			10.50	D						
			11.00	D						
			11.50	D						
			12.00	D	12.00	N =21				
12.45								12.45	End of Borehole at 12.45m	

General Remarks:
1. Groundwater seepage encountered at 7m below ground level.
2. Roots and rootlets observed to 3.5m below ground level.

Driller:	SL	**BOREHOLE RECORD** Scale 1:50 See Key Sheet for explanation of symbols, etc.	CET INFRASTRUCTURE Giving our all
Logged:	HGD		
Checked:		**Mount Cottage, 47d Netherall Gardens**	**FIG A1**
Appr'd:			

Client: **Chaim Klein**	Hole Diameter (mm): 75mm tapering with depth to 6.1m	BOREHOLE NUMBER **WS01**
Method: Window Sampler		
Date Started: 14/05/2019 · Co-ordinates: E 526379.000 N 185227.000	Ground Level (m AOD) · Ref. No: **491846**	Sheet 1 of 2

Backfill/Well Depth (m)	Water Depth (m)	Samples Depth (m)	Samples Type	In Situ Tests Type	In Situ Tests Results	Reduced Level (mAOD)	Depth & (Thickness) (m)	Description of Strata
0.10							(0.05) 0.05	Asphalt.
		0.60	D				(0.55) 0.60	Dark brown to black, fine to coarse sandy, angular fine to coarse GRAVEL with a medium cobble content of bricks. Gravel is composed of flint, clinker, and ceramic tile. (Made Ground)
1.00		1.00	D					Soft becoming firm with depth, light orange brown mottled light grey, fine sandy silty CLAY, with thin laminations and partings of orange brown fine sand and light grey clayey silt. (Claygate Member)
		1.50	D					
				1.90	pp = 0.5 Vh = 40.0			
		2.00	D				(2.95)	
				2.10	pp = 0.8 Vh = 42.0			
				2.30	pp = 1.5 Vh = 70.0			
		2.50	D					
				2.60	pp = 1.5 Vh = 55.0			
				2.90	pp = 0.5 Vh = 36.0			
		3.00	D					
				3.10	pp = 0.8 Vh = 65.0			
				3.30	pp = 1.5 Vh = 72.0			
							3.55	Firm becoming stiff with depth, dark grey, micaceous fine sandy silty CLAY. (London Clay Formation)
		3.60	D					
				3.70	pp = 1.0 Vh = 58.0			
		4.00	D					
				4.10	pp = 1.2 Vh = 78.0			
				4.30	pp = 1.5 Vh = 74.0			
		4.50	D					
				4.70	pp = 2.0 Vh = 95.0		(2.55)	
	5.00	5.00	D	5.00	pp = 1.5 Vh = 78.0			
				5.10	pp = 1.5 Vh = 65.0			
				5.40	pp = 2.0 Vh = 100.0			
				5.80	pp = 2.2 Vh = 120.0			

General Remarks:
1. Groundwater seepage encountered at 5m below ground level with no rise after 20 minutes.
2. Rootlets observed to 0.6m below ground level.

Driller:	DI	BOREHOLE RECORD
Logged:	GRH	Scale 1:30 · See Key Sheet for explanation of symbols, etc.
Checked:		**Mount Cottage, 47d Netherall Gardens**
Appr'd:		**FIG A2**

INFRASTRUCTURE
Giving our all

Client: **Chaim Klein**	Hole Diameter (mm): 75mm tapering with depth to 6.1m	BOREHOLE NUMBER **WS01**
Method: Window Sampler		
Date Started: 14/05/2019 · Co-ordinates E 526379.000 N 185227.000	Ground Level (m AOD) · Ref. No: **491846**	Sheet 2 of 2

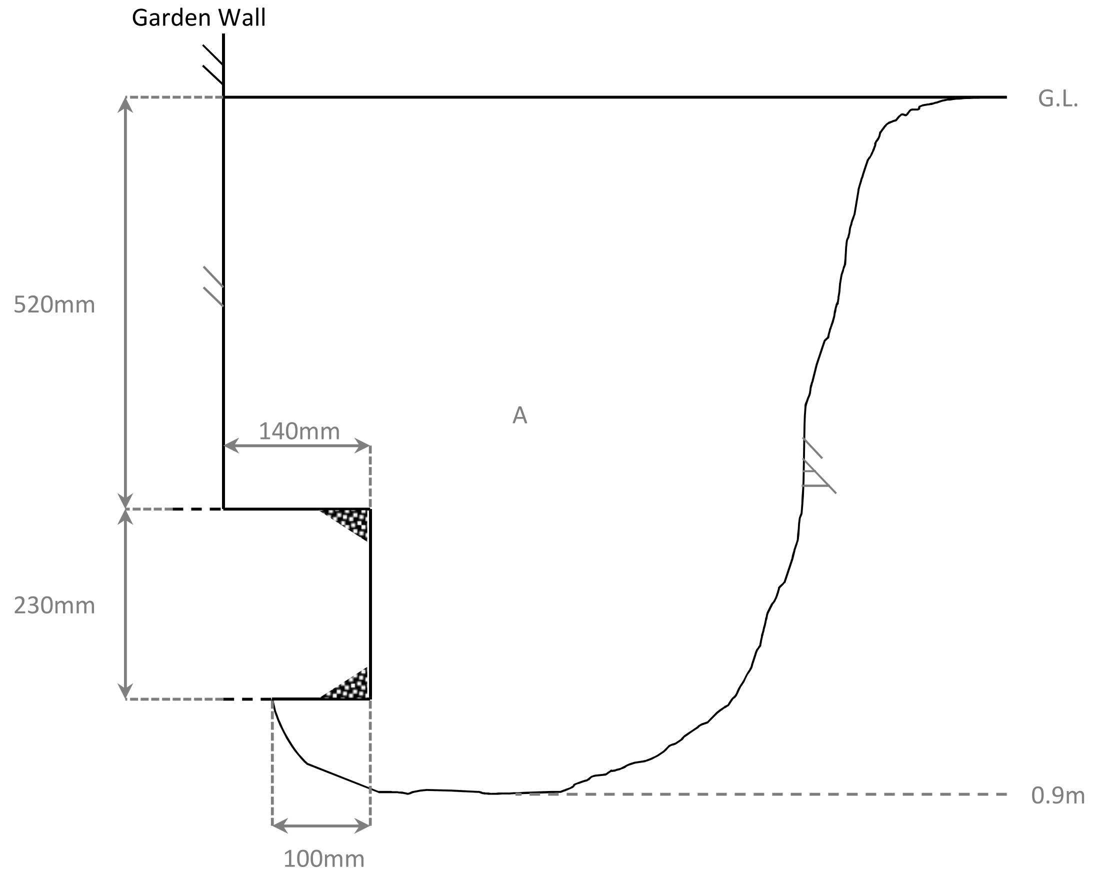
Backfill/Well Depth (m)	Backfill/Well Legend	Water Depth (m)	Samples Depth (m)	Samples Type	In Situ Tests Type	In Situ Tests Results	Reduced Level (mAOD)	Depth & (Thickness) (m)	Description of Strata	Legend
6.10			6.00	D				6.10	Firm becoming stiff with depth, dark grey, micaceous fine sandy silty CLAY. (London Clay Formation)	
									End of Borehole at 6.10m	

General Remarks:

1. Groundwater seepage encountered at 5m below ground level with no rise after 20 minutes.
2. Rootlets observed to 0.6m below ground level.

Driller:	DI	BOREHOLE RECORD Scale 1:30 See Key Sheet for explanation of symbols, etc.	CET INFRASTRUCTURE Giving our all
Logged:	GRH		
Checked:		**Mount Cottage, 47d Netherall Gardens**	**FIG A2**
Appr'd:			

Lead No:	491846	Scale:	N.T.S	Date:	Drawn by:	Checked:	Approved:
Project:	**Mount Cottage**			17/01/2019	JM	PTE	PTE



Ground Conditions:

A. Soft, dark grey, slightly fine to coarse sandy, slightly gravelly CLAY. Gravel is angular to rounded, fine to coarse brick, chalk, concrete, flint and possible coal. (Made Ground)

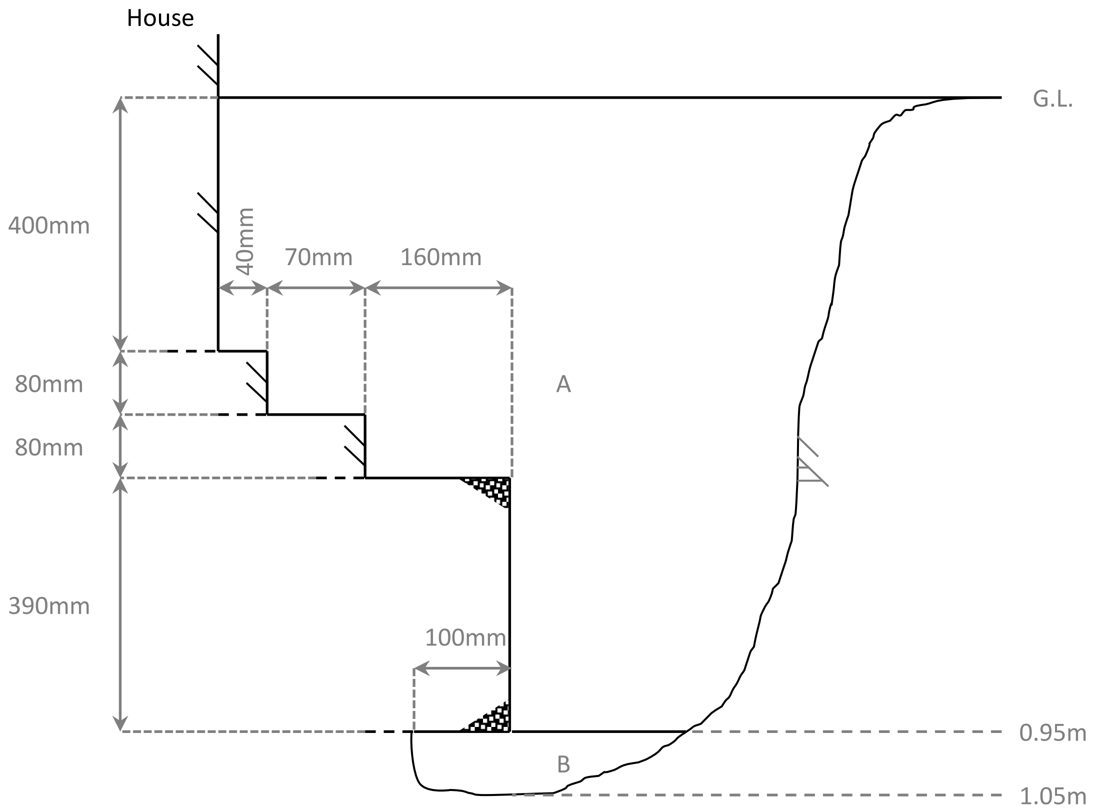
Notes:

1. Exploratory hole remained stable and dry during excavation.
2. Roots and rootlets not observed to 0.9m

TP01
GARDEN WALL

CET INFRASTRUCTURE Giving our all

Lead No:	491846	Scale:	N.T.S	Date:	Drawn by:	Checked:	Approved:
Project:	Mount Cottage			17/01/2019	JM	PTE	PTE



Ground Conditions:

A. Soft, dark grey, slightly fine to coarse sandy, slightly gravelly CLAY. Gravel is angular to rounded, fine to coarse brick, chalk, concrete, flint and possible coal. (Made Ground)

B. Firm, brown mottled grey, slightly gravelly CLAY. Gravel is angular to rounded, fine to coarse flint. (Claygate Member)

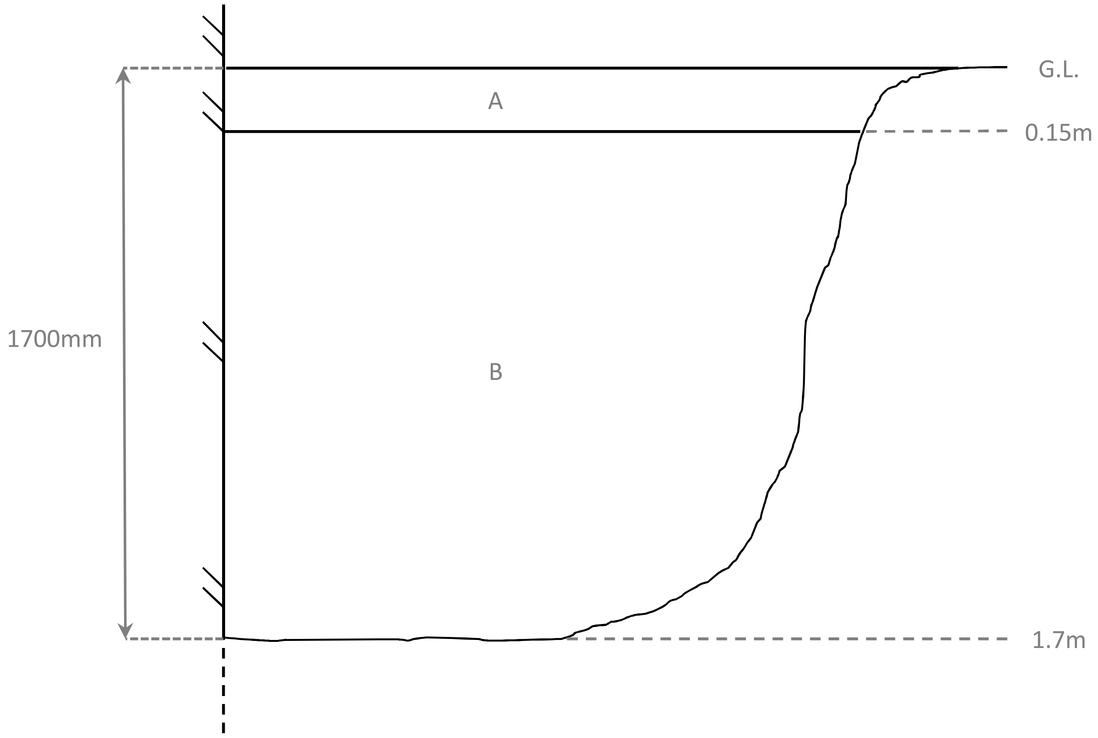
Notes:

1. Exploratory hole remained stable and dry during excavation.
2. Roots and rootlets not observed to 1.05m

TP01
HOUSE

CET INFRASTRUCTURE Giving our all

Lead No:	491846	Scale:	N.T.S	Date:	Drawn by:	Checked:	Approved:
Project:	Mount Cottage			17/01/2019	JM	PTE	PTE



Ground Conditions:

A. Possible Topsoil.

B. Light grey, clayey, slightly gravelly, fine and medium SAND. Gravel is sub-rounded and rounded, fine to coarse flint. (Made Ground)

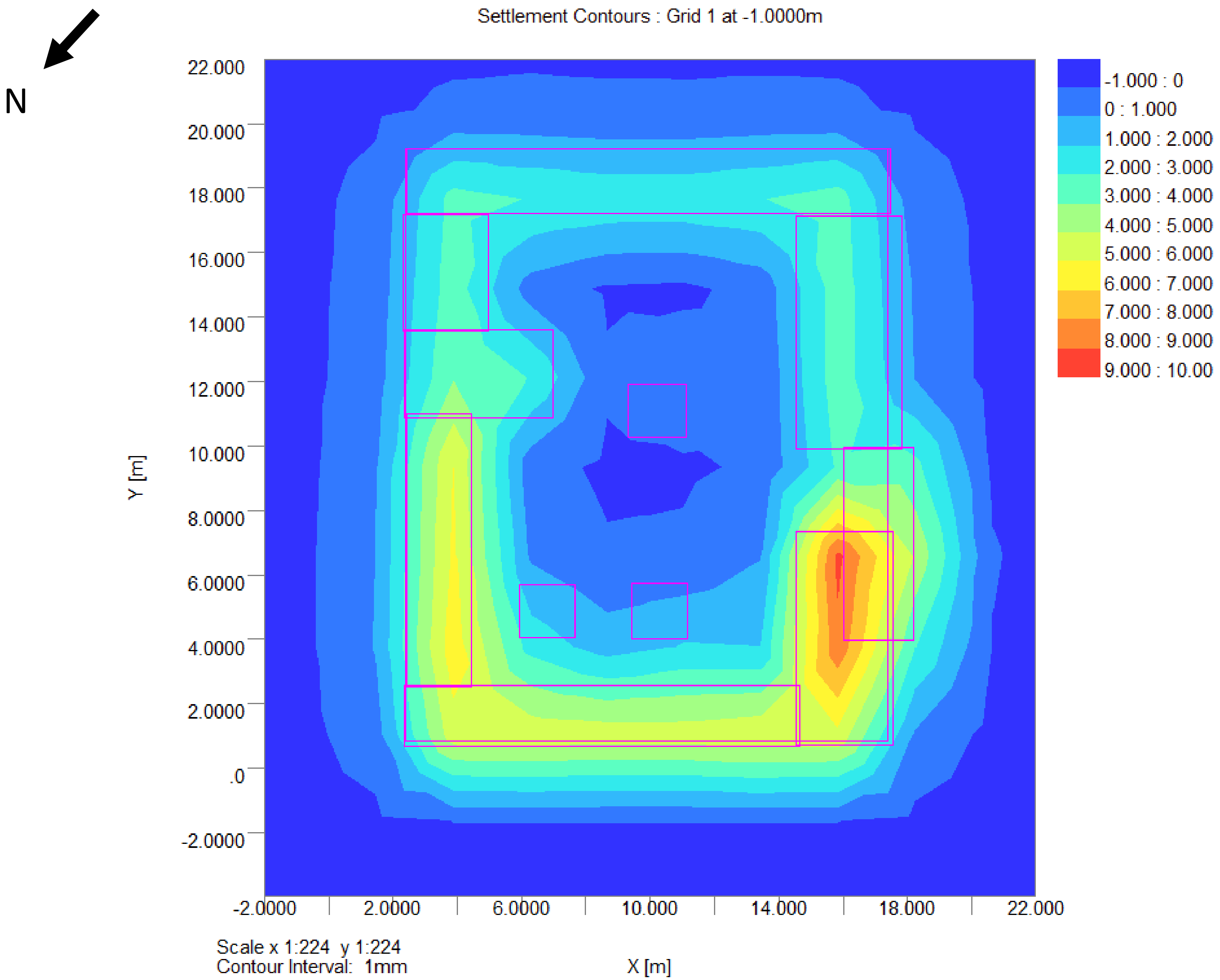
Notes:

1. Exploratory hole remained stable and dry during excavation.
2. Roots and rootlets observed to 0.5m

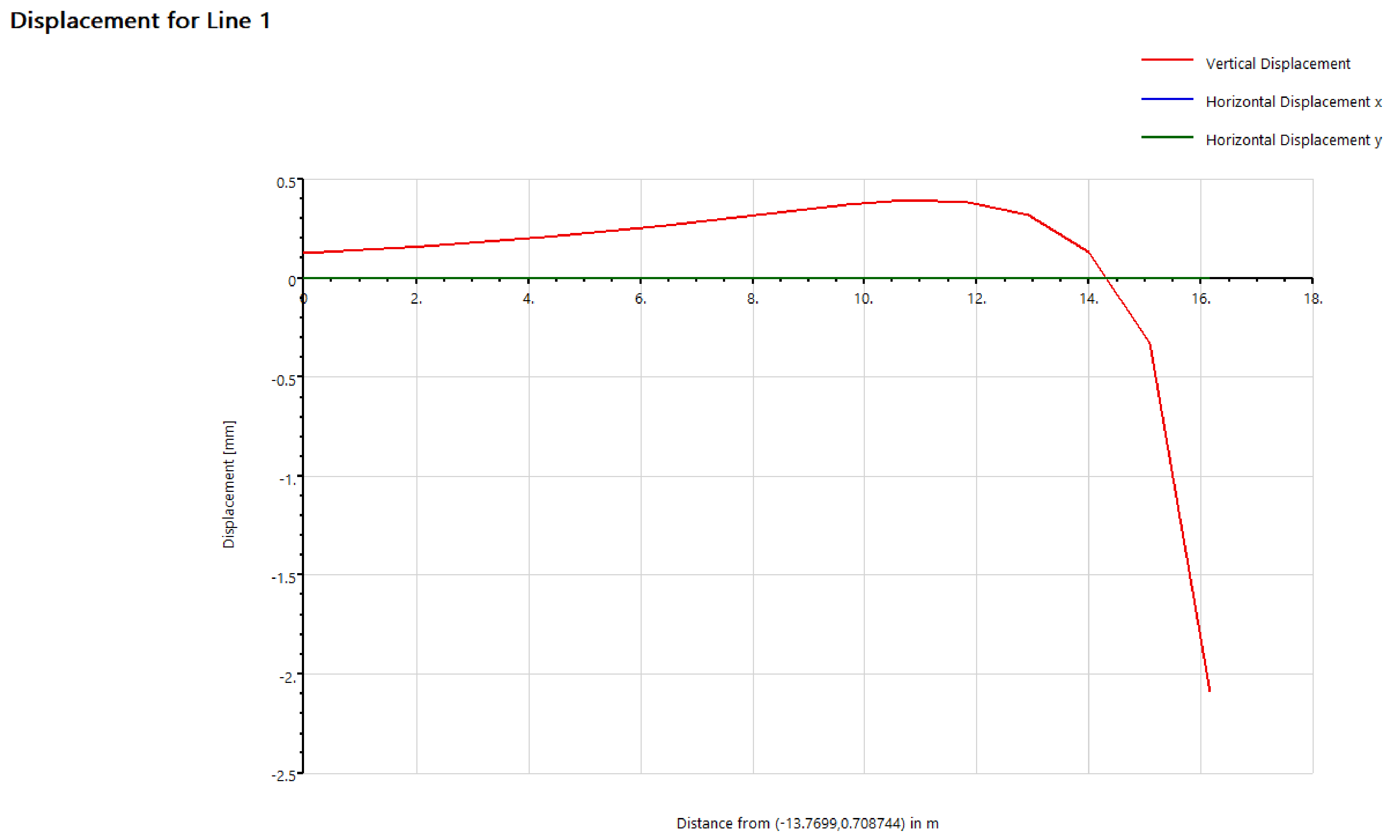
Garden WALL **TP02**	CET INFRASTRUCTURE Giving our all

APPENDIX E PDISP EXPORTS

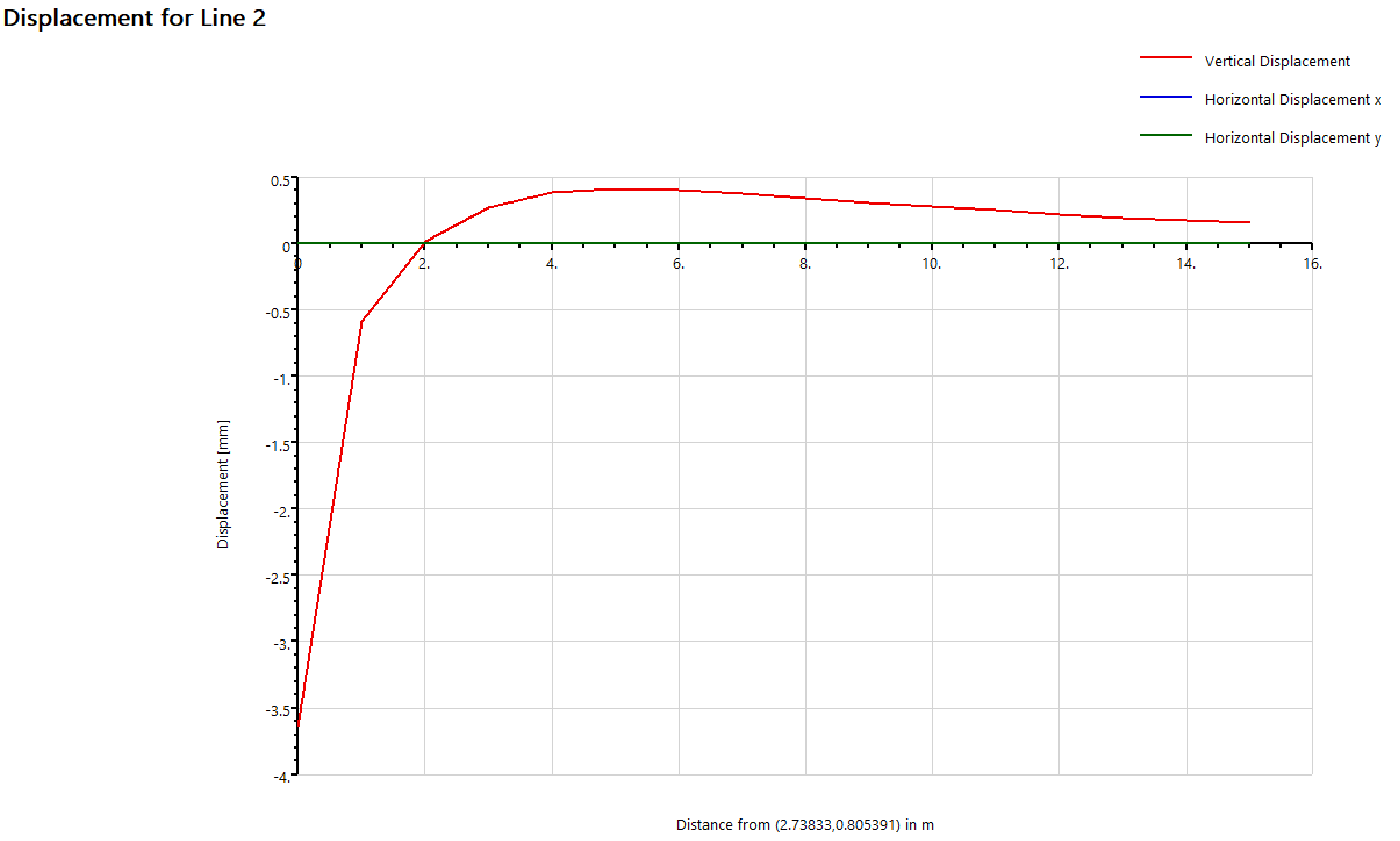
Stage 1:


N
Settlement Contours : Grid 1 at -1.0000m
22.000
20.000
18.000
16.000
14.000
12.000
10.000
8.0000
6.0000
4.0000
2.0000
.0
-2.0000
Y [m]
-2.0000
2.0000
6.0000
10.000
14.000
18.000
22.000
X [m]
-1.000 : 0
0 : 1.000
1.000 : 2.000
2.000 : 3.000
3.000 : 4.000
4.000 : 5.000
5.000 : 6.000
6.000 : 7.000
7.000 : 8.000
8.000 : 9.000
9.000 : 10.00
Scale x 1:224 y 1:224
Contour Interval: 1mm

Stage 1:

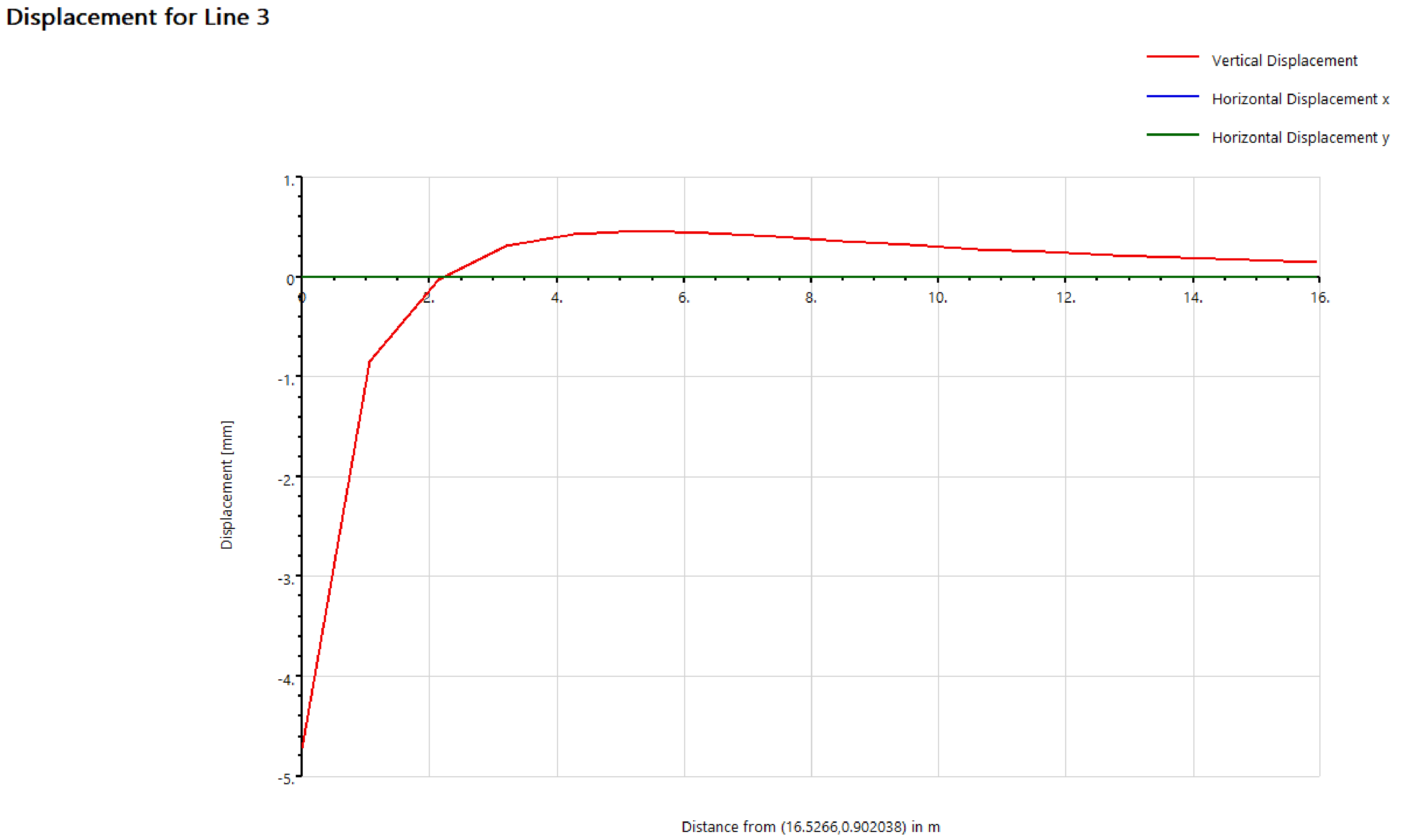

Displacement for Line 1
Vertical Displacement
Horizontal Displacement x
Horizontal Displacement y
0.5
0
-0.5
-1.
-1.5
-2.
-2.5
0
2.
4.
6.
8.
10.
12.
14.
16.
18.
Displacement [mm]
Distance from (-13.7699,0.708744) in m

Stage 1:



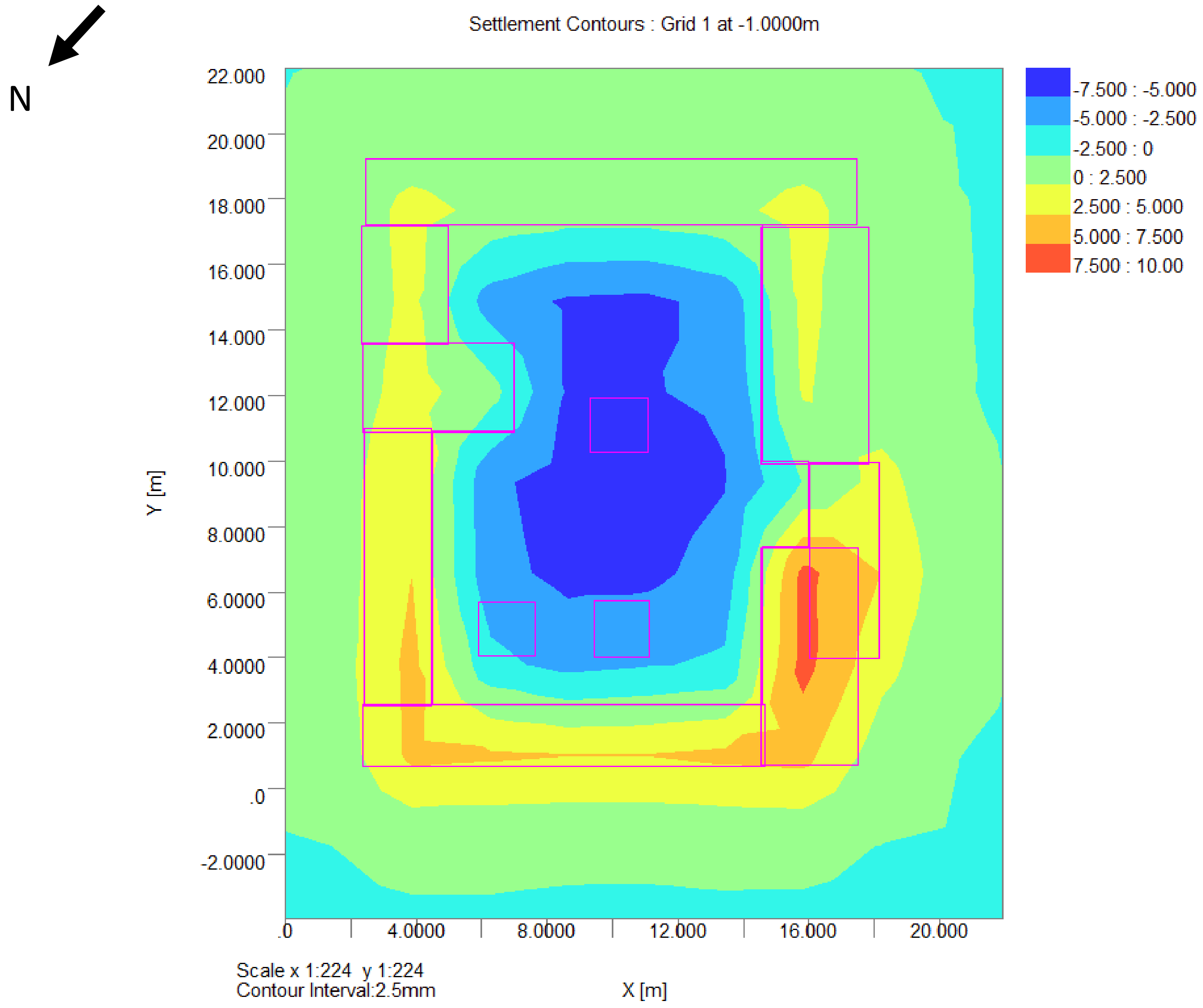
Displacement for Line 2
Vertical Displacement
Horizontal Displacement x
Horizontal Displacement y
0.5
0
-0.5
-1.
-1.5
-2.
-2.5
-3.
-3.5
-4.
0
2.
4.
6.
8.
10.
12.
14.
16.
Displacement [mm]
Distance from (2.73833,0.805391) in m

Stage 1:



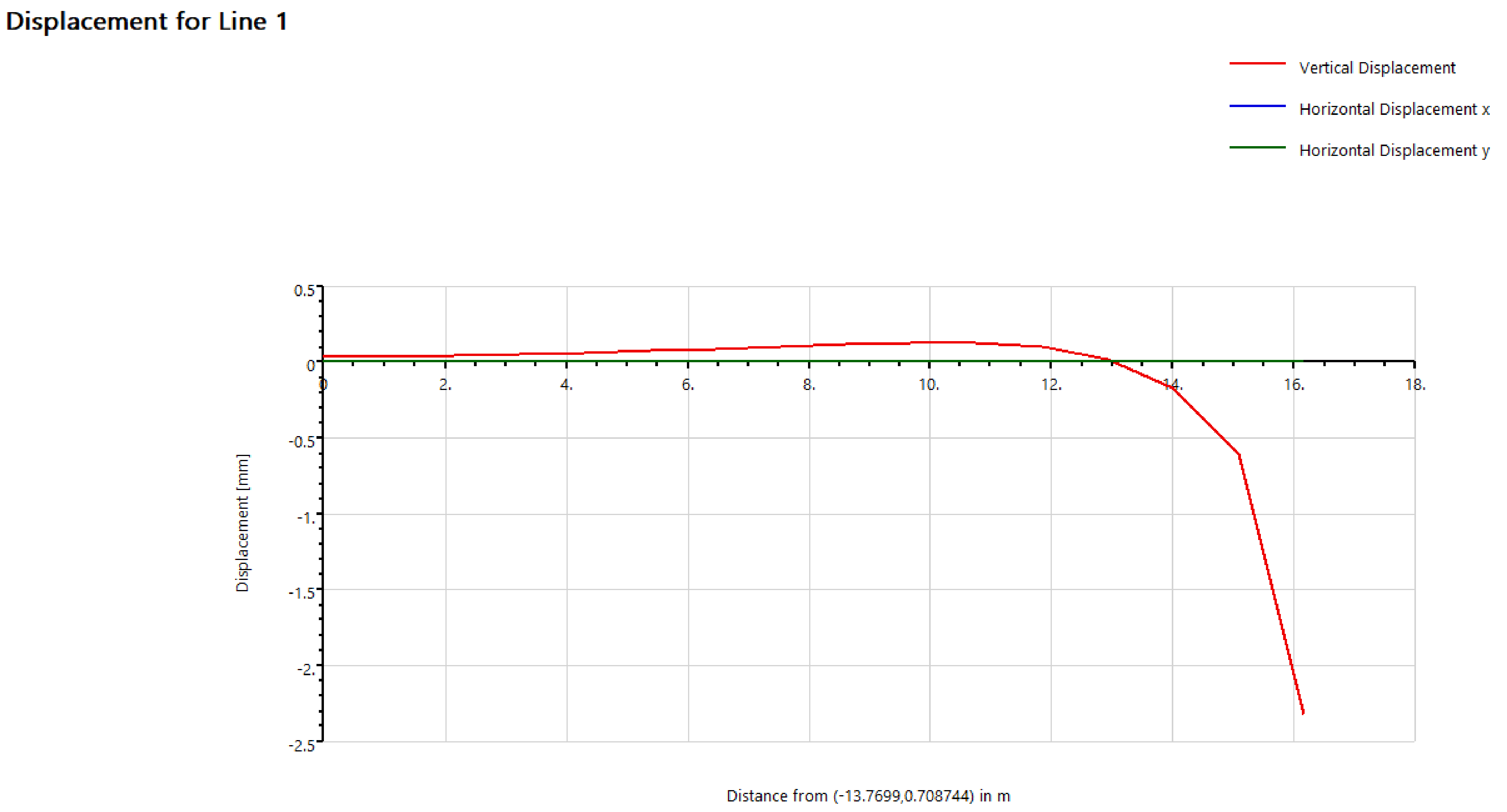
Displacement for Line 3
Vertical Displacement
Horizontal Displacement x
Horizontal Displacement y
1.
0
-1.
-2.
-3.
-4.
-5.
0
2.
4.
6.
8.
10.
12.
14.
16.
Displacement [mm]
Distance from (16.5266,0.902038) in m

Stage 2:



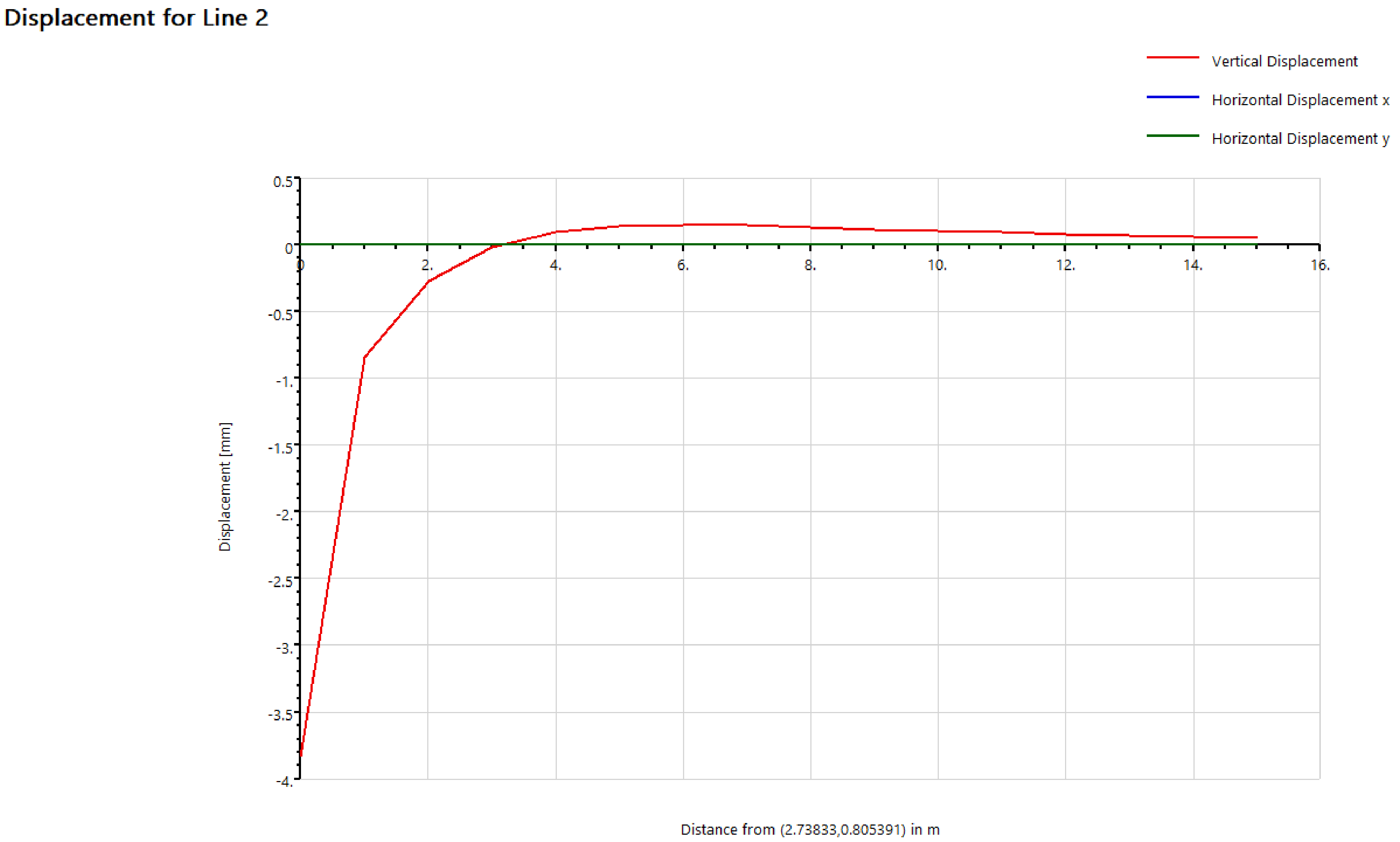
N
Settlement Contours : Grid 1 at -1.0000m
22.000
20.000
18.000
16.000
14.000
12.000
10.000
8.0000
6.0000
4.0000
2.0000
.0
-2.0000
Y [m]
.0
4.0000
8.0000
12.000
16.000
20.000
X [m]
-7.500 : -5.000
-5.000 : -2.500
-2.500 : 0
0 : 2.500
2.500 : 5.000
5.000 : 7.500
7.500 : 10.00
Scale x 1:224 y 1:224
Contour Interval:2.5mm

Stage 2:



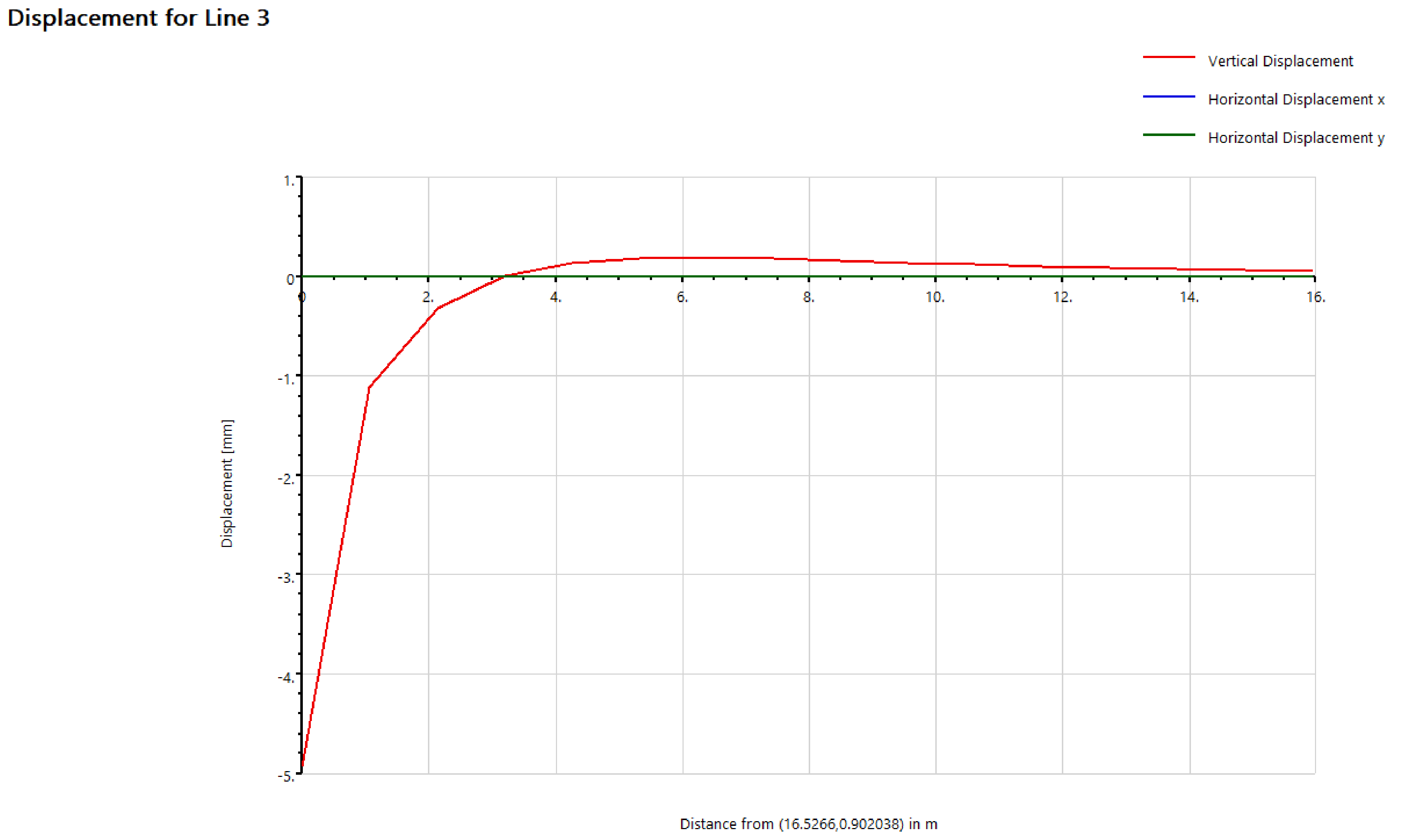
Displacement for Line 1
Vertical Displacement
Horizontal Displacement x
Horizontal Displacement y
0.5
0
-0.5
-1.
-1.5
-2.
-2.5
Displacement [mm]
0
2.
4.
6.
8.
10.
12.
14.
16.
18.
Distance from (-13.7699,0.708744) in m

Stage 2:



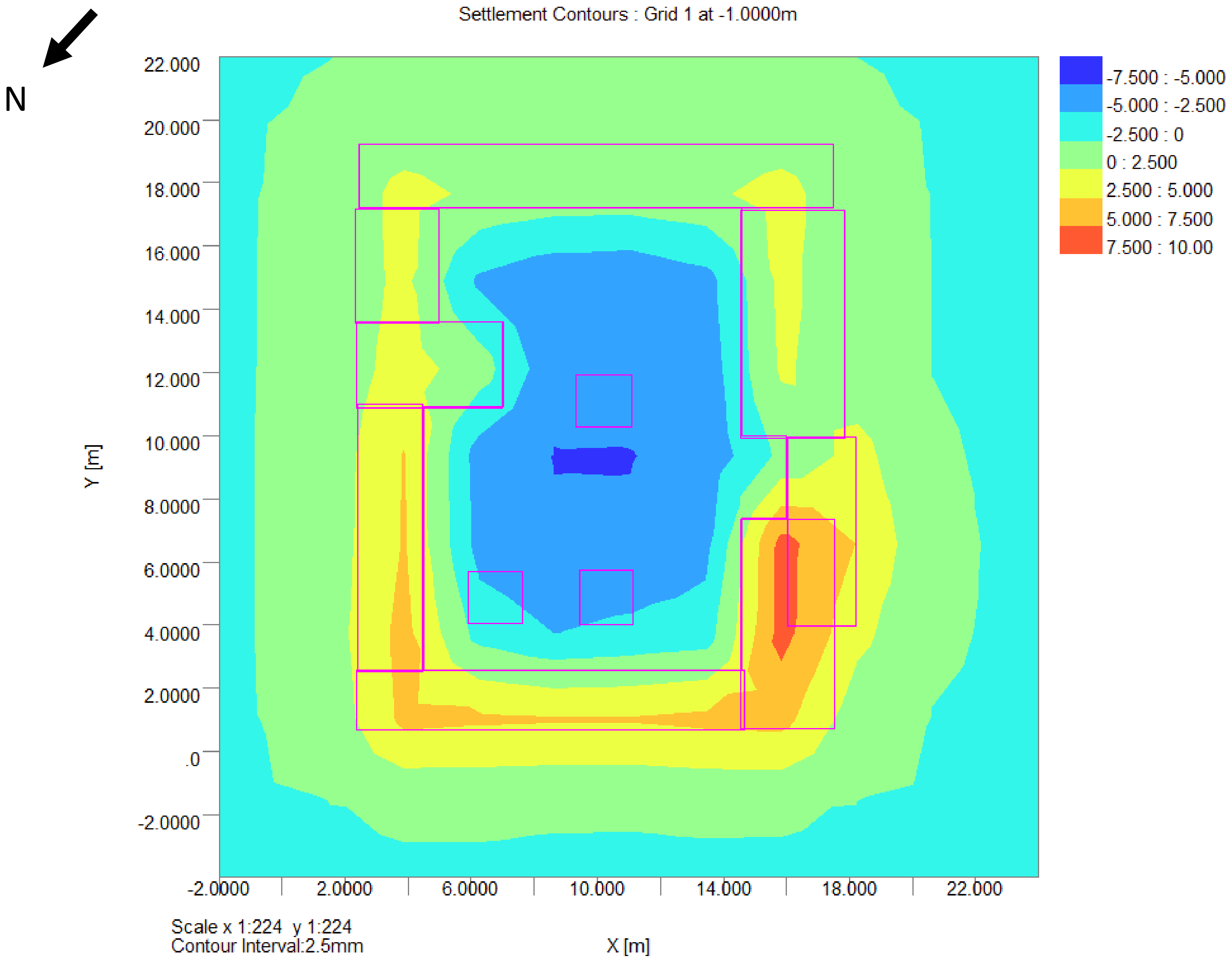
Displacement for Line 2
Vertical Displacement
Horizontal Displacement x
Horizontal Displacement y
0.5
0
-0.5
-1.
-1.5
-2.
-2.5
-3.
-3.5
-4.
0
2.
4.
6.
8.
10.
12.
14.
16.
Displacement [mm]
Distance from (2.73833,0.805391) in m

Stage 2:



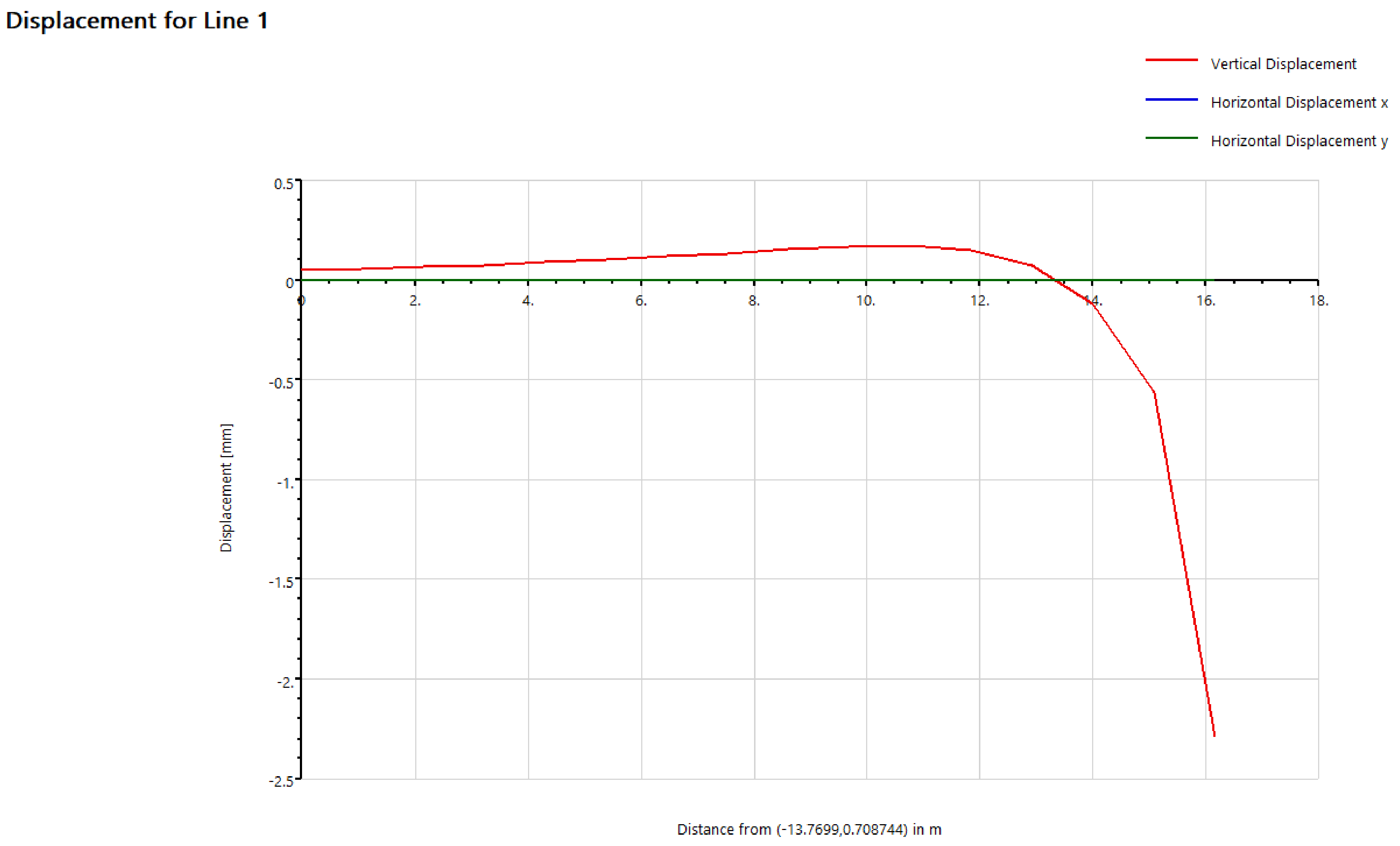
Displacement for Line 3
Vertical Displacement
Horizontal Displacement x
Horizontal Displacement y
1.
0
-1.
-2.
-3.
-4.
-5.
0
2.
4.
6.
8.
10.
12.
14.
16.
Displacement [mm]
Distance from (16.5266,0.902038) in m

Stage 3:



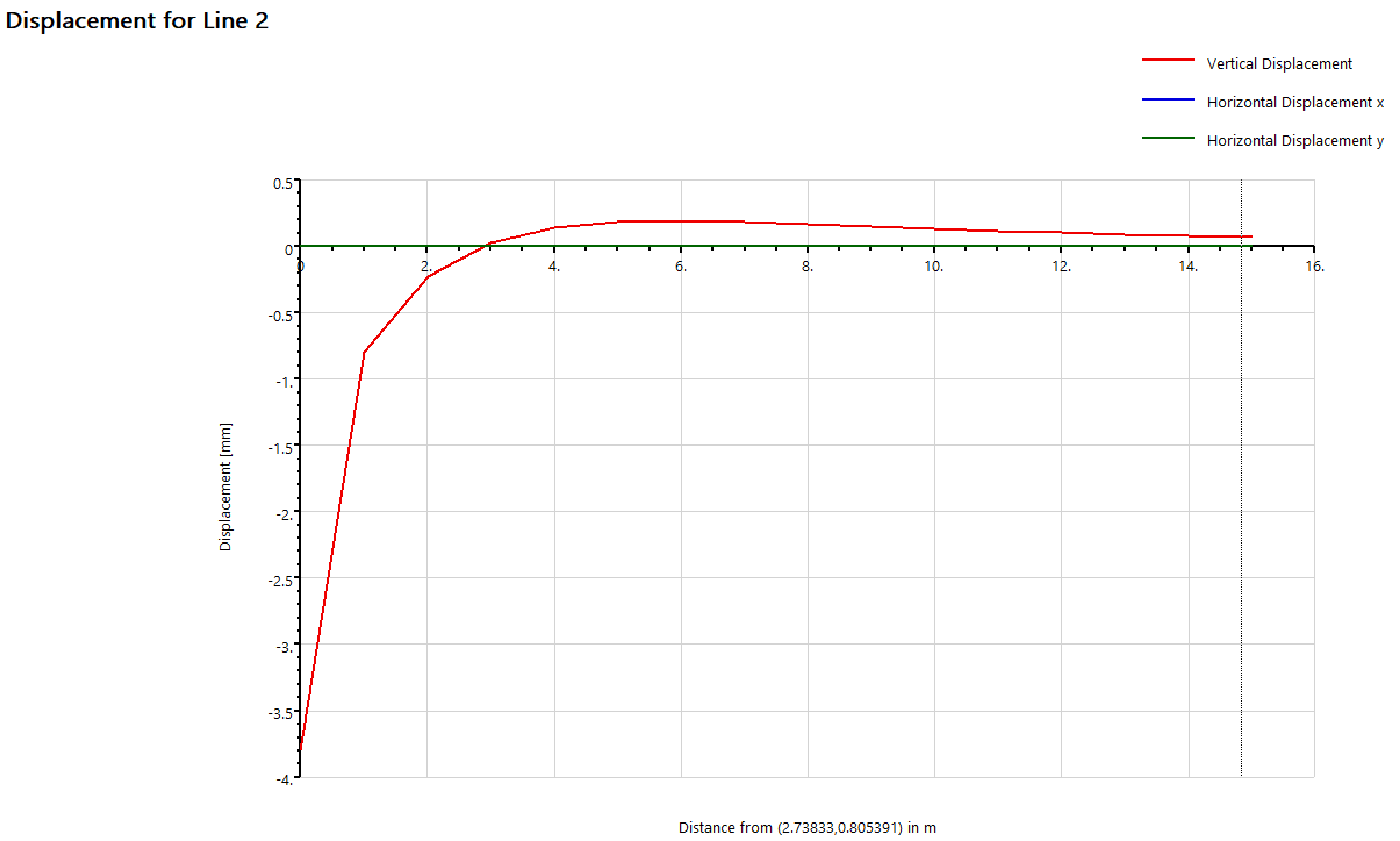
N
Settlement Contours : Grid 1 at -1.0000m
22.000
20.000
18.000
16.000
14.000
12.000
10.000
8.0000
6.0000
4.0000
2.0000
.0
-2.0000
Y [m]
-2.0000
2.0000
6.0000
10.000
14.000
18.000
22.000
X [m]
Scale x 1:224 y 1:224
Contour Interval:2.5mm
-7.500 : -5.000
-5.000 : -2.500
-2.500 : 0
0 : 2.500
2.500 : 5.000
5.000 : 7.500
7.500 : 10.00

Stage 3:



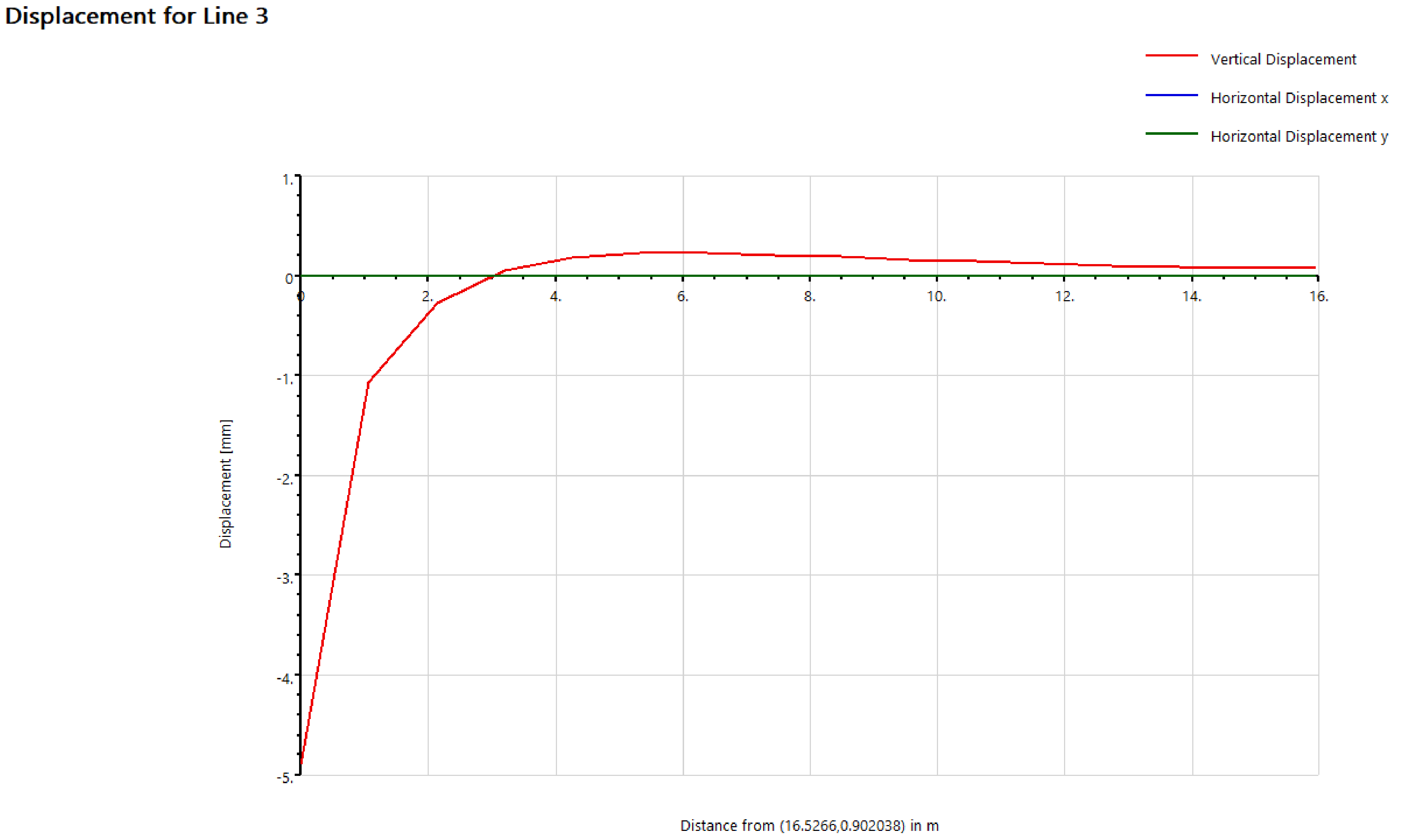
Displacement for Line 1
Vertical Displacement
Horizontal Displacement x
Horizontal Displacement y
0.5
0
-0.5
-1.
-1.5
-2.
-2.5
Displacement [mm]
0
2.
4.
6.
8.
10.
12.
14.
16.
18.
Distance from (-13.7699,0.708744) in m

Stage 3:



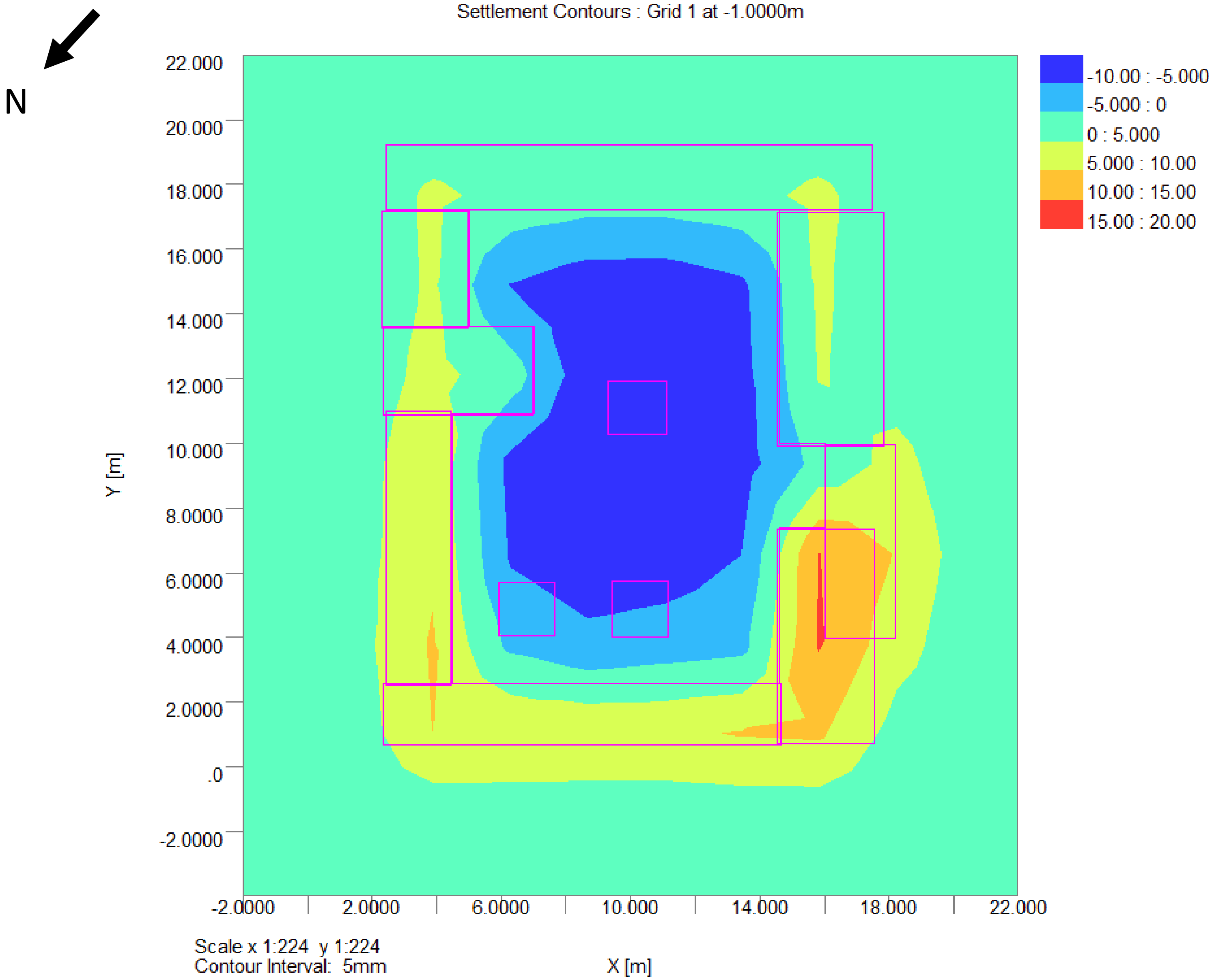
Displacement for Line 2
Vertical Displacement
Horizontal Displacement x
Horizontal Displacement y
0.5
0
-0.5
-1.
-1.5
-2.
-2.5
-3.
-3.5
-4.
0
2.
4.
6.
8.
10.
12.
14.
16.
Displacement [mm]
Distance from (2.73833,0.805391) in m

Stage 3:



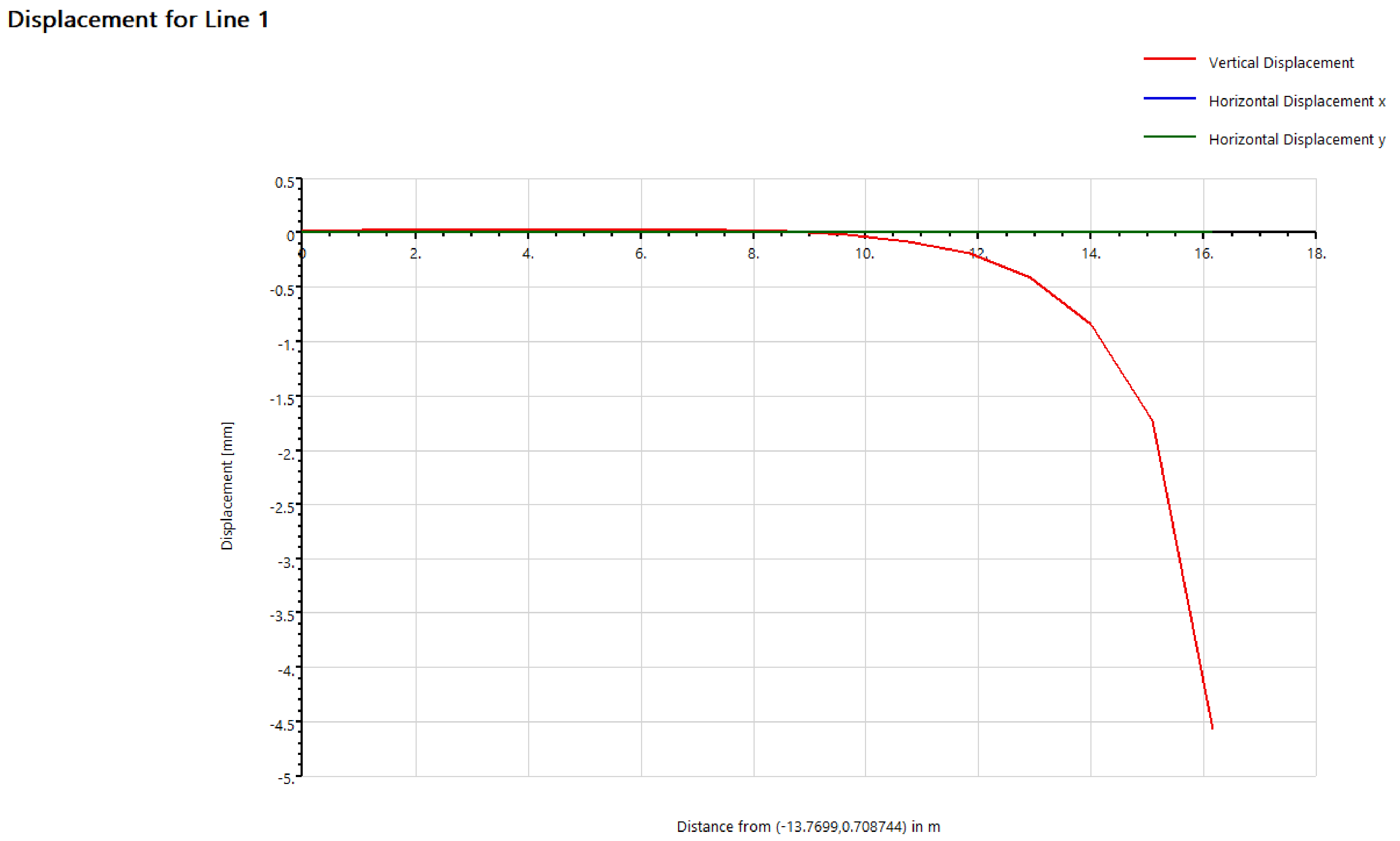
Displacement for Line 3
Vertical Displacement
Horizontal Displacement x
Horizontal Displacement y
1.
0
-1.
-2.
-3.
-4.
-5.
Displacement [mm]
0
2.
4.
6.
8.
10.
12.
14.
16.
Distance from (16.5266,0.902038) in m

Stage 4:

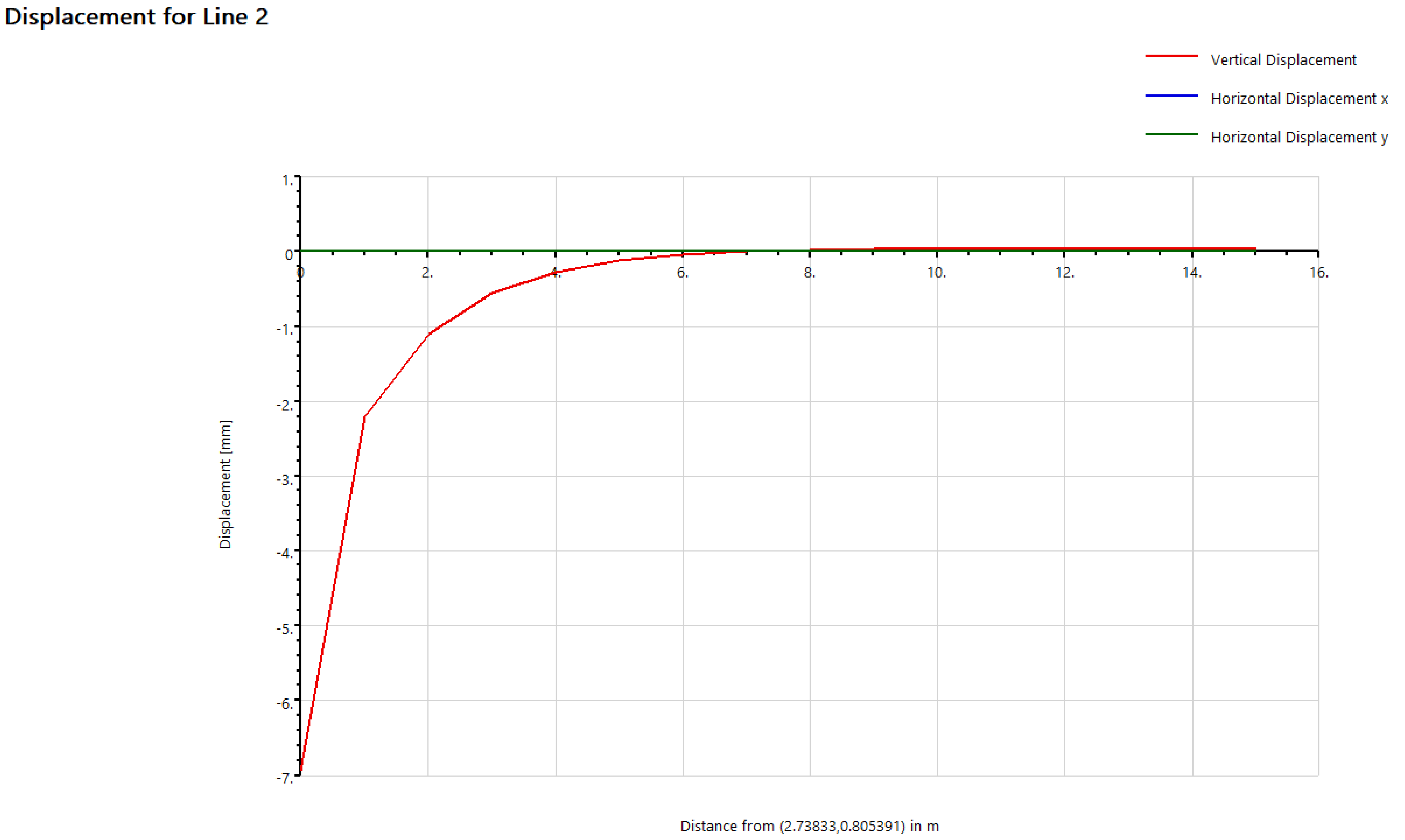


N
Settlement Contours : Grid 1 at -1.0000m
22.000
20.000
18.000
16.000
14.000
12.000
10.000
8.0000
6.0000
4.0000
2.0000
.0
-2.0000
Y [m]
-2.0000
2.0000
6.0000
10.000
14.000
18.000
22.000
X [m]
-10.00 : -5.000
-5.000 : 0
0 : 5.000
5.000 : 10.00
10.00 : 15.00
15.00 : 20.00
Scale x 1:224 y 1:224
Contour Interval: 5mm

Stage 4:

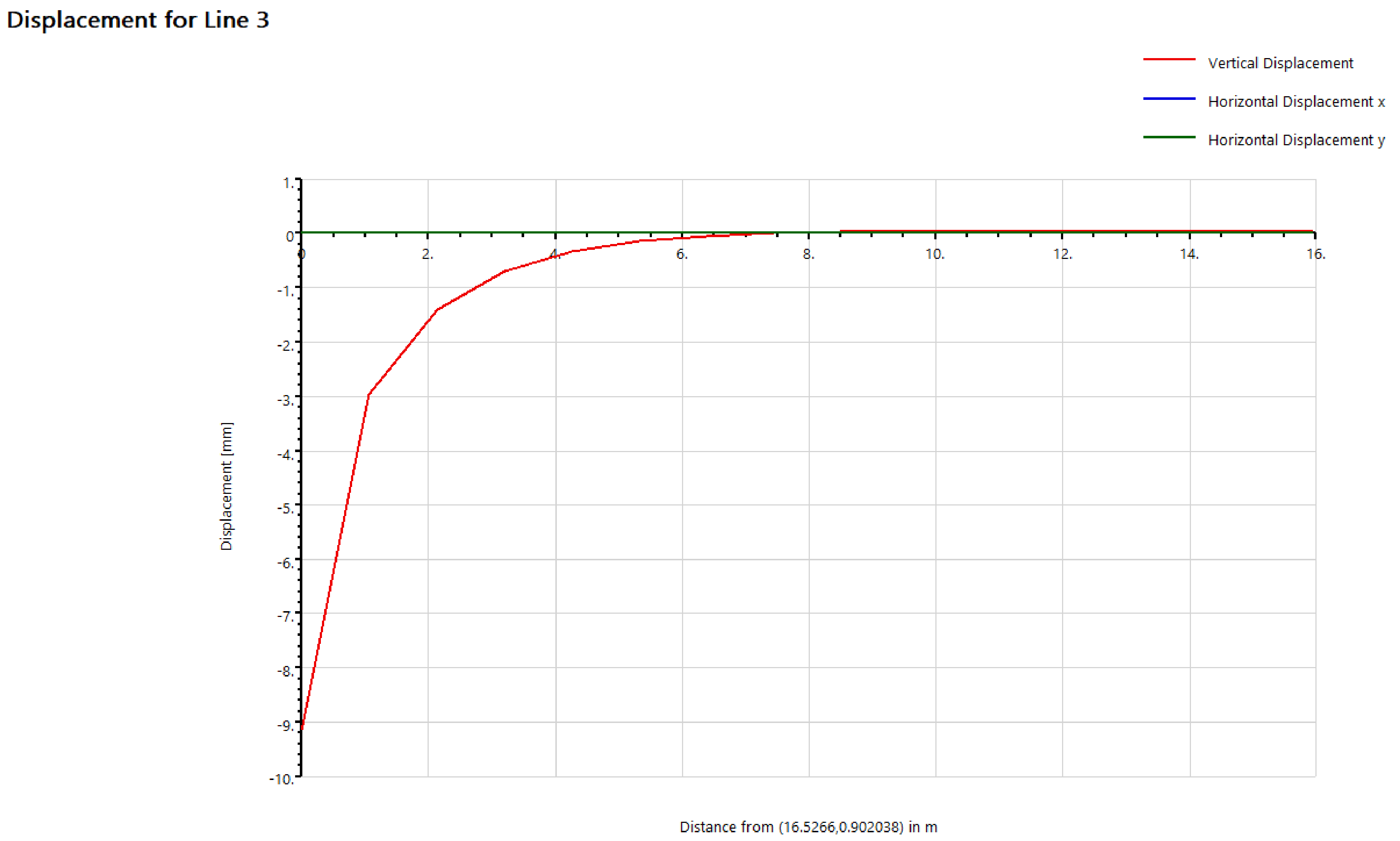

Displacement for Line 1
Vertical Displacement
Horizontal Displacement x
Horizontal Displacement y
0.5
0
-0.5
-1.
-1.5
-2.
-2.5
-3.
-3.5
-4.
-4.5
-5.
0
2.
4.
6.
8.
10.
12.
14.
16.
18.
Displacement [mm]
Distance from (-13.7699,0.708744) in m

Stage 4:



Displacement for Line 2
Vertical Displacement
Horizontal Displacement x
Horizontal Displacement y
1.
0
-1.
-2.
-3.
-4.
-5.
-6.
-7.
Displacement [mm]
0
2.
4.
6.
8.
10.
12.
14.
16.
Distance from (2.73833,0.805391) in m

Stage 4:



Displacement for Line 3
Vertical Displacement
Horizontal Displacement x
Horizontal Displacement y
1.
0
-1.
-2.
-3.
-4.
-5.
-6.
-7.
-8.
-9.
-10.
0
2.
4.
6.
8.
10.
12.
14.
16.
Displacement [mm]
Distance from (16.5266,0.902038) in m