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Basement Impact Assessment

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Rev	Date	Author	Checker	Comment
-	21/02/19	SB	GW	Issue for comment
1	13/09/19	SB	GW	Update following Audit

Contents

Basement Impact Assessment for 108a Goldhurst Terrace

1. Non-Technical Summary

1.1. Existing Property, Site & Neighbouring Sites

108a Goldhurst terrace is located in the Swiss Cottage Ward of the London Borough of Camden. The site comprises a four-storey semi-detached residential property with a front and a rear garden. The building is known to have been constructed in the beginning of the 20th century, from masonry load bearing walls and timber floors and roof. The neighbouring buildings are of a similar age and construction.

The land within the site boundary is stepped. Due to the nature of the site, the lowest floor (Lower Ground Floor) is just below street level. Immediately to the rear of the property there is a patio. This steps up to the garden which is at a higher level.

1.2. Proposed Development

The proposed development involves the construction of a new basement below the existing building footprint. The existing front lightwell will be lowered to incorporate the new basement level.

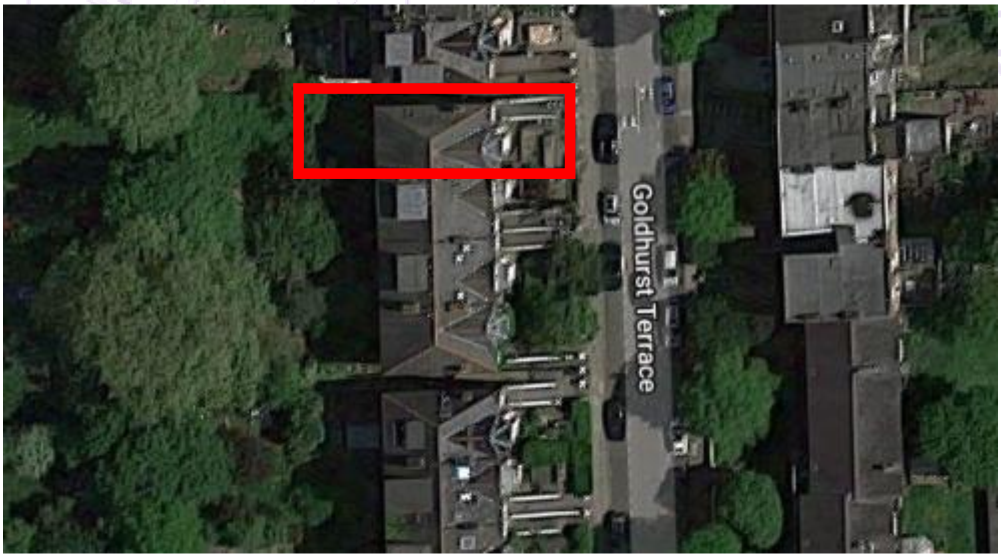

Figure 1: Aerial view with approx. site area indicated

1.3. Geology and Land Stability

The assessment of impacts relating to Geology and Land Stability have been summarised in the combined Land Stability and Hydro-geology BIA by Ground & Water Ltd. This is reproduced in part below.

The following geotechnical concerns have been formulated:

- Temporary works whilst underpinning;
- Differential foundation depths – It is understood that the neighbouring properties most likely do not have basements, however they have a lower ground floor of the same construction with the existing property. The formation levels of the proposed basement were understood to be at approximately ~3.35 - 3.65m bgl. The ground level at the front and rear parts of the site were approximately the same. Party walls are present.
- Basement excavation and land stability given neighbouring properties and roads;
- Any retaining walls should be appropriately designed.

ASSESSMENT OF GROUND MOVEMENT

Ground movement assessment was carried out on the neighbouring properties within Section 7.8 of the full ground investigation report (GWPR2929/GIR/BIA/February 2019). The process was based on CIRIA C760 guidance. In terms of building damage assessment and with reference to Burland et al, 1977, the 'Description of typical damage' given the calculated movements it is likely to fall within category of damage '0' Negligible. A soft to firm clay analysis was considered the most appropriate given the retained as well as founding strata of the basement. Mitigation measures to minimise potential movements are provided.

1.4. Hydro-geology

The assessment of impacts relating to Geology and Land Stability have been summarised in the combined Land Stability and Hydro-geology BIA by Ground & Water Ltd. This is reproduced in part below.

Groundwater was not encountered during the intrusive investigation and WS1 was noted to be dry on the return monitoring visit. Therefore, it is considered unlikely that significant amounts of groundwater would be encountered during foundation excavation and the basement will not affect the saturated aquifer underlying the site. Perched water maybe encountered within the Made Ground or/and sand/silt pockets of the Head Deposits / London Clay Formation, especially after period of prolonged rainfall. The cumulative effects of basements in groundwater are not a consideration at this site.

1.5. Drainage, Surface Water & Flooding

The BIA identified the following issues that should be carried forward to Scoping Stage:

- It is noted that the road had been flooded in 1975 and 2002. It is understood that this was due to a blockage in the storm-water drain restricting the normal disbursement of surface water.

Further assessment of the site and the development concluded that the basement will not increase the risk of flooding and further assessment of surface water and drainage is not necessary.

2. Introduction

The London Borough of Camden requires a BIA (Basement Impact Assessment) to be prepared for developments that include basements and lightwells. This document forms the main part of the BIA and gives details on the impact of surface water flow. The scheme design for the proposed subterranean structure is also included.

This document should be used in conjunction with the Land Stability and Groundwater BIA [GWPR2929/GIR/BIA/February2019]. This is a separate report and is referred to, where relevant, within this document.

This BIA follows the requirements contained within Camden Planning Guidance Basements (March 2018). In summary, the council will only allow basement construction to proceed if it does not cause significant harm to the built or natural environment and local amenity.

In order to comply with the above clauses, a BIA must undertake five stages detailed in the Camden Planning Guidance. This report has been produced in line with the guidance and associated supporting documents such as DP23, DP26, DP25 and DP27. Technical information from 'Camden geological, hydrogeological and hydrological study - Guidance for subterranean development', Issue 01, November 2010 (GSD, hereafter) was also used and is referred to in this assessment.

2.1. Report Authors and Qualifications

Croft has appointed the following suitably qualified professional to review the impacts related to Land Stability and Hydro-geology:

Francis Williams
MGeol (Hons.) CGeol CEnv AGS FGS MSoBRA .

The following individuals have reviewed the impacts related to Surface Water and Flooding:

Phil Henry
BEng MEng MICE

Chris Tomlin
MEng CEng MIStructE

2.2. Site & location

108a Goldhurst terrace is located in the Swiss Cottage Ward of the London Borough of Camden.

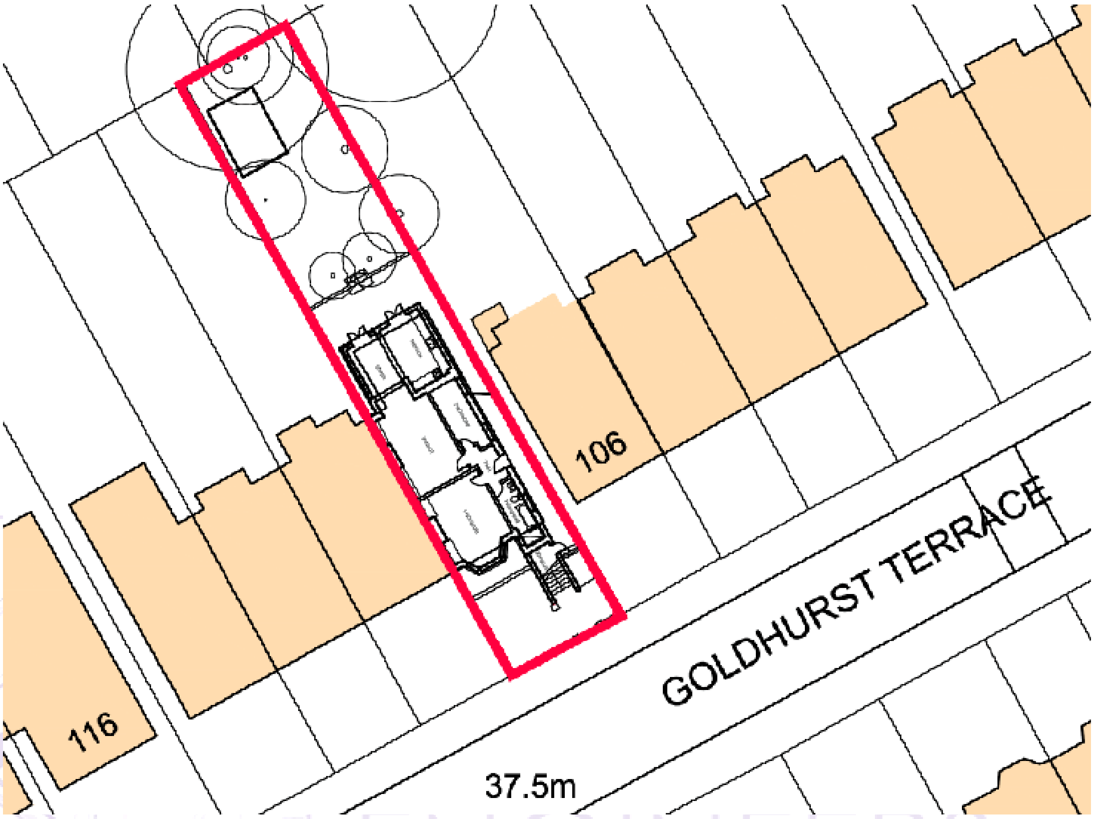

Figure 2: Site Location Plan (approx. area outlined in red) and the surrounding properties

For further information refer to the Desk Study Section.

2.3. Proposed works

The proposed development involves the construction of a new basement below the full existing buildings footprint. The basement will extend partially into, and below, the rear garden, in line with the rear additional, and into the front garden as a lightwell.

Plans showing the extent of the structural alterations and the temporary works construction sequence for the new basement level are presented in Appendix D. Architectural drawings that show the extent of the proposed alterations have been produced by NCW Architecture and are available separately.

A site location plan is shown above. This site is indicated. In addition to the basement area, this also includes areas that are likely to be temporarily occupied for construction purposes.

3. Desk Study & Walk over Survey

3.1. General Desk Study

An aerial view of the property and the surrounding area is shown below.

Figure 3: Aerial view with approx. site area indicated

3.1.1. Site History

The history of the site has been presented, with references to historical maps, by Ground & Water. Refer to the Hydrogeology and Landstability BIA by Ground & Water for details.

3.1.2. Listed buildings

The existing building is not listed. Data from Historic England shows that there are no listed buildings close by.

Figure 4: Extract showing listed buildings

The site is in the South Hampstead conservation area.

3.1.3. London Under Ground and Network Rail Infrastructures

The site is more than 100m away from the nearest national rail line and the nearest subterranean train line. These are unlikely to be affected by the new basement.

Figure 3: Extract from satellite map showing proximity of rail lines

Network rail have been informed of this proposal. An initial response from them has confirmed that they do not require Network Rail Asset Protection to be considered at design stage due to the distance from the railway line and the infrastructure between it.

3.1.4. Highways

The site is within 5m of the public highway. However, the proposed construction will be over 5m away from the pavement.

3.1.5. UK Power Network

There are no significant items of electrical infrastructure (such as pylons, substations or tunnels) in the immediate vicinity.

3.1.6. Utility Search

A Thames Water Asset Location Search was undertaken and shows no public sewers will be affected by the proposed construction works. The Thames Water Asset Locations are shown below.

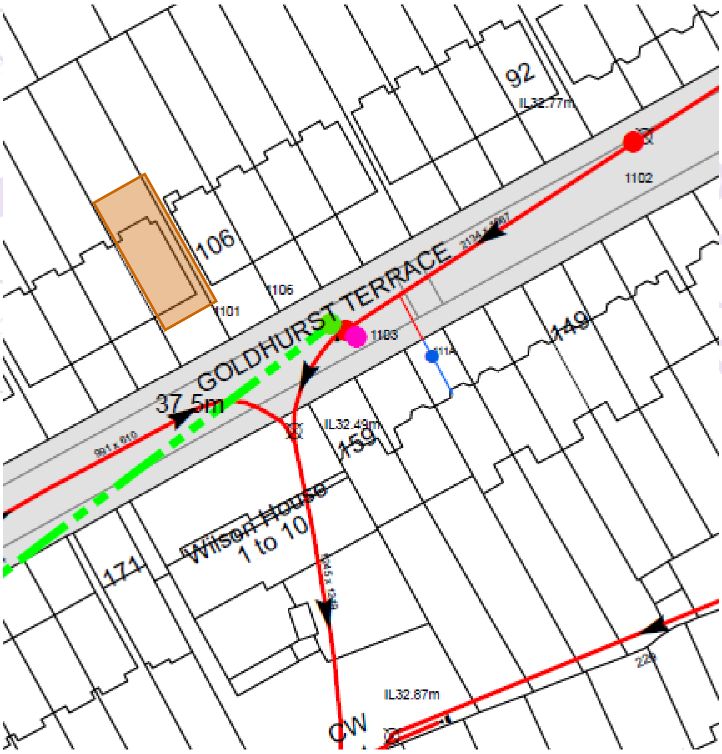

Figure 5: Thames Water Asset Location Search

After planning permission is granted, and before construction, the contractor should carry out a survey to determine the locations of any other services below ground level.

3.2. Walk Over Survey

A structural engineer from Croft Structural Engineers visited the site on the 20th of December 2018.

3.2.1. Site and Existing Property

The site encompasses a Victorian semi-detached multi-occupancy property, constructed from traditional building materials (brickwork and timber) with a front yard and a rear garden. The main building is four storeys high. This includes a Lower Ground floor below street level. To the front of this, there is a lightwell and the remaining area is paved.

Some cracks to the front façade were noted during the site visit. None of which were determined to be structural.

Figure 6: Front Elevation

The entrance to the rear area garden opens out onto a small paved area which is at a lower level than the street level. This then steps up to main garden area which is primarily comprised of soft landscaping save for a small 'garden room' at the rear of the garden. The existing layouts are shown on architectural drawings by NCW Architecture drawing number P01.

Figure 7: Rear Elevation

3.2.2. Proximity of Trees

Mature trees are present within the site boundary. This includes a mature Acer pseudoplatanus, about 18.5m away from the basement proposed at the rear.

3.2.3. Adjacent Properties

The external facades of the neighbouring properties have been inspected.

Handed descriptions of the properties below are given when facing the properties from the road.

3.2.3.1. 110 Goldhurst Terrace – Property to Right

110 Goldhurst Terrace is a semi-detached multi-occupancy dwelling of a similar age and construction to No. 108. From observing the external façade of the building, there were no visible signs of movement. A search on Camden Council's website has shown that no basements have been proposed since the original construction.

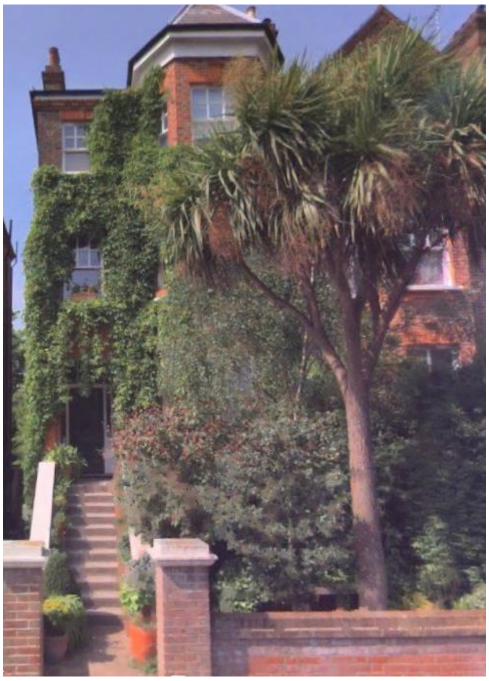

Figure 8: 110 Goldhurst Terrace Front Elevation

3.2.3.2. 106 Goldhurst Terrace – Property to Left

106 Goldhurst Terrace is a terrace, multi-occupancy dwelling of a similar age and construction to No. 108. From observing the external façade of the building, there were no visible signs of movement. A search on Camden Council's website has shown that no basements have been proposed since the original construction.

Figure 9: 106 Goldhurst Terrace Front Elevation

3.3. Land Stability and Hydro-geology: Ground Investigation

The ground investigation report, which has data from initial site investigations and data from subsequent monitoring, is available as a separate report [GWPR2929/GIR/BIA/February2019].

3.4. Surface Water and Drainage Walk Over Survey

3.4.1. Hardstanding

The rear of 108 Goldhurst terrace opens out onto a paved area which is lower then the main garden area.

Figure 10: Rear of 108 Goldhurst Terrace

The paving continues round though the side passage of property to the front garden area with is also fully paved.

Figure 11: Side passage between 108 & 110 Goldhurst Terrace

3.4.2. Site Drainage

Rainwater from the roof is noted to discharge, via rain water pipes, into the sewer. From inspection of the record drawing of the drainage (referred to previously), surface water and foul water discharge into a combined sewer.

3.4.3. Surface Water

No areas of surface water in the form of ponds lakes, streams or rivers were noted on the site.

3.4.4. Summary Surface Water and Drainage Walk

A walk over survey has confirmed that there are no surface water features, either within or close to the site. The survey has also confirmed that hard surfaces are present around the perimeter of the building.

4. Screening Stage

This stage identifies any areas for concern that should be investigated further.

4.1. Geology and Land Stability

For the screening of features relating to Land Stability, refer to the combined Land Stability and Hydro-geology BIA by Ground & Water Ltd.

4.2. Hydro-geology

For the screening of features relating to Land Stability, refer to the combined Land Stability and Hydro-geology BIA by Ground & Water Ltd.

4.3. Surface Flow and Flooding

Question 1: Is the site within the catchment of the pond chains on Hampstead Heath?

No. The site lies outside the areas denoted by Figure 14 of the GSD (extract shown below)

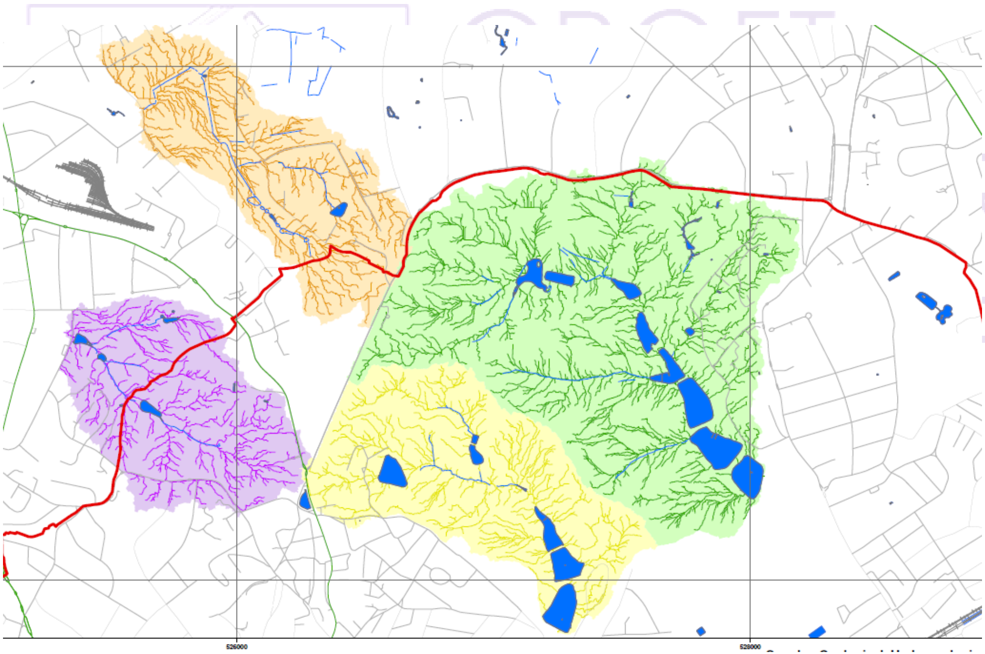

Figure 12: Extract from Figure 14 of the GSD (site lies to the south of the shaded areas)

Question 2. As part of the proposed site drainage, will surface water flows (e.g. volume of rainfall and peak run-off) be materially changed from the existing route?

No – The surface water that flows from the proposed development will be routed the same way as before: water is and will be collected from hard surfaced areas and enter the existing drainage system.

Question 3. Will the proposed basement development result in a change to the hard surfaced /paved external areas?

No. The amount of hard standing will remain unchanged

Question 4. Will the proposed basement result in changes to the inflows (instantaneous and long term) of surface water being received by adjacent properties or downstream watercourses?

No. The amount of surface water being received by adjacent properties or downstream watercourses will not be changed.

Question 5. Will the proposed basement result in changes to the quality of surface water being received by adjacent properties or downstream watercourses?

No. Collected surface water will be from building roofs and paving, as before. The quality of the water received downstream will therefore not change.

Question 6. Is the site in an area identified to have surface water flood risk according to either the Local Flood Risk Management Strategy or the Strategic Flood Risk Assessment or is it at risk from flooding, for example because the proposed basement is below the static water level of nearby surface water feature?

Yes. The area has been noted to have been flooded in the Flood Asset Register in 1975 and 2002.

<u>Summary</u>

The answers to Questions 1-5 above indicate that the issues related to surface water flow and flooding are not increasing in significance. These questions therefore do not have to be carried forward to Scoping Stage. However, the response to Question 6 highlighted that road had flooded in 1975 and 2002 so the this will be carried though to the Scoping stage.

5. Scoping Stage

5.1. Geology and Land Stability

For the scoping of features relating to Land Stability, refer to the combined Land Stability and Hydro-geology BIA by Ground & Water Ltd.

5.2. Hydro-geology

For the scoping of features relating to Land Stability, refer to the combined Land Stability and Hydro-geology BIA by Ground & Water Ltd.

5.3. Surface Flow and Flooding

5.3.1. Conceptual Model

The BIA from Ground & Water identified that a historic drainage channel was present to the east of the site. This was concluded to have been backfilled and is not a risk to the proposed development.

The same BIA also identifies clay being present below the structure. This has a low level of permeability.

Rising groundwater may lead to surface water flooding. However a low water table was recorded in the ground investigation. The Hydrogeology BIA concludes that the cumulative effects of the basement groundwater are not a consideration at this site. There will be no related increase in the effect on rising ground water.

Perched water may become present. This would be within the layer of made ground. This layer is already interrupted by the footprint of the building. The inclusion of a basement will therefore not change this: water in this layer will be able to pass around the structure as before.

The land immediately in front and behind the existing structure is below street level and is covered with hard surfaces. The basement will not increase the amount of hard surfaces and will therefore not increase the rainwater load on the existing sewer system.

In conclusion, the risk of flooding of down-stream properties will not increase. A detailed flood risk assessment is therefore not considered necessary for this development.

<u>Further assessment is not required for surface flow and flooding.</u>

6. Site Investigation / Additional Assessments

Investigations for Land Stability and Hydrogeology are described within the BIA by Ground & Water. This BIA proposed that an arboricutural assessment should be carried out. The relevant trees were been surveyed by Trevor Heaps Arboricultural Consultancy Ltd. The report for this (Ref TH 1891, dated 23rd January 2019) is under a separate cover.

As mentioned previously, not further assessments are required for Surface Water and Flooding.

7. Construction Methodology and Engineering Statements

7.1. Loading and Geotechnical Design Parameters

From the geological report, the following soil properties are proposed:

Soil density = 19 kN/m³

Active and passive co-efficients for overall stability:

K_a = 0.42

K_p = 2.37

Allowable bearing pressure 100kN/m²

7.1.1. Intended Use & Loadings

	UDL kN/m²	Concentrated Load kN
Domestic Single Dwellings	1.5	2.0

Below ground level, the reinforced concrete retaining walls are designed to carry the lateral loading applied from above.

The lateral earth pressure exerts a horizontal force on the retaining walls. The retaining walls will be checked for resistance to the overturning force this produces.

Lateral forces will be applied from:

- Soil loads
- Hydrostatic pressures
- Surcharge loading from behind the wall

These produces retaining wall thrust. This will be restrained by the opposing retaining wall.

7.1.1.1. Surcharge Loading

The following will be applied as surcharge loads to the front/ front lightwell retaining walls:

- $10kN/m^2$ if within 45° of road
- 100kN point loads if under road or within 1.5m
- $5kN/m^2$ if within 45° of Pavement
- Garden Surcharge $2.5kN/m^2$ + 1 m of soil (if present above basement ceiling) $20kN/m^2$
- Surcharge for adjacent property $1.5kN/m^2$ + $4kN/m^2$ for concrete ground bearing slab

Adjacent Properties:

All adjacent property footings within 45° to have additional geotechnical engineers' input. A line at 45° from the base of the neighbours' wall footing would be intersected by the basement retaining wall. This should be accounted for in the design.

7.1.1.2. Hydrostatic pressure

The investigations show that no water is present to the depth of 12.45m below ground level. The walls however will be designed to resist a hydrostatic pressure. Design of retaining walls should account for the anticipated worst-case scenario for ground water levels. It is possible that a water main may break causing a local high-water table. To account for this, the wall is designed for water 1m from the top of the wall. This will be applied to the front basement which is likely to be in proximity of the incoming water mains. This is more conservative than the applying hydrostatic loads from perched water which was anticipated in the Groundwater BIA.

The design also considers floatation as a risk. The design has accounted for the weight of the building and the uplift forces from the water. The weight of the building is greater than the uplift, resulting in a stable structure.

The central slab of the basement should be designed to resist local uplift.

7.2. Permanent Design Proposals

The foundation of the basements will consist of reinforced concrete cantilevered retaining walls to the front, rear and sides. These will be designed to resist the lateral loads around the perimeter of the basement. The reinforced concrete walls will also transfer vertical loads to the ground. Reinforced concrete propped cantilevered retaining walls will therefore form the new foundation of the property and for the party wall shared with 110 Goldhurst Terrace.

The top of the retaining walls will be propped by a new ground floor concrete/metal-deck and steel beam structure. This is illustrated on drawings in Appendix D.

Appendix A shows the calculations of one of the most heavily loaded retaining wall. The most critical parameters have been used for this.

7.2.1. Temporary works

Walls are designed to be structural stable with top and bottom propping. Temporary propping details will be required to be provided by the contractor and must be completed by a suitability qualified professional.

To demonstrate the feasibility of the works, a proposed basement construction sequence is appended.

7.3. Ground Movement Assessment

All excavations cause minor movement in the surrounding ground. The degree of movement is partly dependent on depth of the excavation and the control of the construction procedures. For an analysis of the predicted ground movement, refer to the combined Land Stability and Hydrogeology BIA by Ground & Water Ltd.

7.4. Control of Construction Works

7.4.1. Construction Management Plan

A Construction Management Plan has been completed by Croft and will be submitted as part of the planning application.

7.4.2. Monitoring

In order to safeguard the existing structures during underpinning and new basement construction, movement monitoring using total stations or similar is to be undertaken.

Before the works begin, a detailed monitoring report is required to confirm the implementation of the monitoring. The items that this should cover are:

- Risk Assessment to determine level of monitoring
- Scope of Works
- Applicable standards
- Frequency of Monitoring
- Specification for Instrumentation
- Monitoring of Existing cracks
- Monitoring of movement
- Reporting

We would recommend that the monitoring frequency should follow:

Pre-construction: Monitored once.

During construction: Monitored after every pin is cast for first 4 no. pins to gauge effect of underpinning. If all is well, monitor after every other pin.

Post construction works: Monitored once.

Trigger values and contingency actions are noted in the table below. Monitoring locations are noted on the drawing which is included in the Appendix F.

MOVEMENT		CATEGORY	ACTION
Vertical	Horizontal		
0mm-4mm	0-3mm	Green	No action required
4mm-6mm	3-6mm	AMBER	Detailed review of Monitoring: Check studs are OK and have not moved. Ensure site staff have not moved studs. If studs have moved reposition. Relevel to ensure results are correct and tolerance is not a concern. Inform Party Wall surveyors of amber readings. Double the monitoring for 2 further readings. If stable revert back. Carry out a local structural review and inspection. Preparation for the implementation of remedial measures should be required. Double number of lateral props
6mm-10mm	6-8mm		Implement remedial measures review method of working and ground conditions
>10mm	>8mm	RED	Implement structural support as required; Cease works with the exception of necessary works for the safety and stability of the structure and personnel; Review monitoring data and implement revised method of works

8. Basement Impact Assessment

8.1. Conceptual Site Model

A conceptual site model has been presented in the BIA by Ground & Water.

- Differential foundation depths – It is understood that the neighbouring properties most likely do not have basements, however they have a lower ground floor of the same construction with the existing property. The formation levels of the proposed basement were understood to be at approximately ~3.35 - 3.65m bgl. The ground level at the front and rear parts of the site were approximately the same. Party walls are present.
- Any retaining walls should be appropriately designed.
- Mitigation measures to minimise potential movements are provided. This includes the use of suitably designed temporary works while underpinning
- The cumulative effects of basements in groundwater are not a consideration at this site.

Examples of permanent design calculations and temporary works proposals are appended.

8.2. Land Stability

For impacts relating to Land Stability, refer to the combined Land Stability and Hydro-geology BIA by Ground & Water Ltd.

8.3. Hydro-geology

For impacts relating to Hydrogeology have been summarised in the combined Land Stability and Hydro-geology BIA by Ground & Water Ltd.

8.4. Surface Water & Flooding

As described previously, there are no impacts relating to surface water and flooding that need to be considered for further assessment. However, the planning requirements focus mainly on the potential for the development to cause flooding to other properties and assets; they do not assess the potential for flooding within the subject property.

There is a risk of flooding from failure of infrastructure, such as flooding due to unexpected failure of the drainage, water mains, etc. This risk is inherent in the construction of all subterranean structures. At detailed design stage, suitable features should be incorporated to reduce the hazards associated with this risk.

8.4.1. Internal Flooding - Mitigation Measures

To mitigate the risks associated with flooding, Croft would recommend the following mitigation measures:

- A pumping mechanism should be installed for the proposed basement. There is a likelihood that this may fail and allow excess water to accumulate. If this were to occur, the build-up of water would be gradual and noticeable before it becomes a significant life-threatening hazard.

- The pumping system should be a dual mechanism to maintain operation in the event of a failure. This should include a battery backup and a suitable alarm system for warning purposes. After the planning application is concluded, the design team should seek consent from Thames Water to pump and discharge water into the sewer.

- Route all electrical wiring at high level.

- Ensure that the basement structure is adequately waterproofed during construction.

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Appendix A : Structural Calculations

Building Regulations will be required after planning. As part of the building control pack full calculations must be undertaken and provided at detailed design stage once planning permission is granted. The calculations must be completed to a recognised Standard (BS or Euro Codes). The calculations must take into account the findings of this report and the recommendations of the auditors.

The design must resist:

- Vertical loads from the proposed works and adjacent properties
- Lateral loads from wind, soil water and adjacent properties
- Loadings in the temporary condition
- All other applied loads on the building
- Uplift forces from hydrostatic effects and soil heave

The final proposed scheme must:

- Provide stability in the temporary condition to all forces
- Provide stability to all forces in the permanent condition

As part of the planning Croft structural engineers has considered some of the pertinent parts of the basement structure to ensure that it can be constructed. The following calculations are not a full set of calculations for the final design which must be provided for building regulations.

RETAINING WALL ANALYSIS & DESIGN (EN1992/EN1996/EN1997)

RETAINING WALL ANALYSIS

In accordance with EN1997-1:2004 incorporating Corrigendum dated February 2009 and the UK National Annex incorporating Corrigendum No.1

Tedds calculation version 2.9.07

Retaining wall details

Stem type	Propped cantilever
Stem height	h_{stem} = **3000** mm
Prop height	h_{prop} = **3000** mm
Stem thickness	t_{stem} = **350** mm
Angle to rear face of stem	α = **90** deg
Stem density	γ_{stem} = **25** kN/m^3
Toe length	l_{toe} = **1800** mm
Base thickness	t_{base} = **350** mm
Base density	γ_{base} = **25** kN/m^3
Height of retained soil	h_{ret} = **3000** mm
Angle of soil surface	β = **0** deg
Depth of cover	d_{cover} = **0** mm
Height of water	h_{water} = **2000** mm
Water density	γ_w = **9.8** kN/m^3

Retained soil properties

Soil type	Soft clay
Moist density	γ_{mr} = **19** kN/m^3
Saturated density	γ_{sr} = **19** kN/m^3
Characteristic effective shear resistance angle	$\phi'_{r.k}$ = **18** deg
Characteristic wall friction angle	$\delta_{r.k}$ = **9** deg

Base soil properties

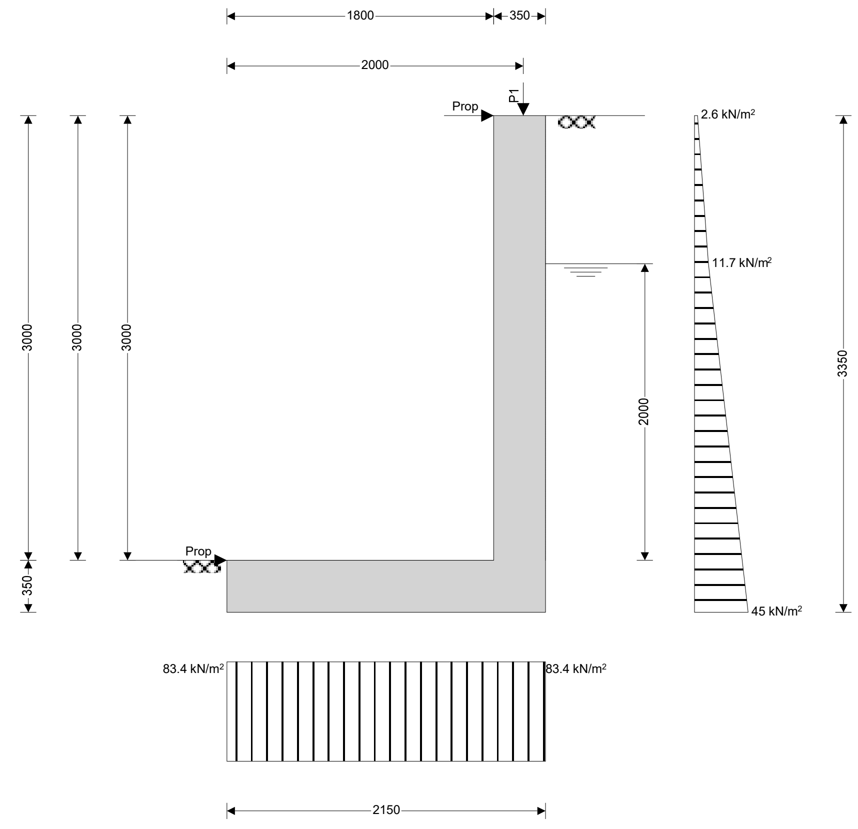
Soil type	Soft clay
Soil density	γ_b = **19** kN/m^3
Characteristic effective shear resistance angle	$\phi'_{b.k}$ = **18** deg
Characteristic wall friction angle	$\delta_{b.k}$ = **9** deg
Characteristic base friction angle	$\delta_{bb.k}$ = **12** deg
Presumed bearing capacity	$P_{bearing}$ = **100** kN/m^2

Loading details

Variable surcharge load	$Surcharge_Q$ = **5.5** kN/m^2

Vertical line load at 2000 mm P_{G1} = **116.9** kN/m

P_{Q1} = **17.3** kN/m



General arrangement

Calculate retaining wall geometry

Base length	$l_{base} = l_{toe} + t_{stem}$ = **2150** mm
Saturated soil height	$h_{sat} = h_{water} + d_{cover}$ = **2000** mm
Moist soil height	$h_{moist} = h_{ret} - h_{water}$ = **1000** mm
Length of surcharge load	$l_{sur} = l_{heel}$ = **0** mm
- Distance to vertical component	$x_{sur\_v} = l_{base} - l_{heel} / 2$ = **2150** mm
Effective height of wall	$h_{eff} = h_{base} + d_{cover} + h_{ret}$ = **3350** mm
- Distance to horizontal component	$x_{sur\_h} = h_{eff} / 2$ = **1675** mm
Area of wall stem	$A_{stem} = h_{stem} \times t_{stem}$ = **1.05** m^2
- Distance to vertical component	$x_{stem} = l_{toe} + t_{stem} / 2$ = **1975** mm
Area of wall base	$A_{base} = l_{base} \times t_{base}$ = **0.753** m^2
- Distance to vertical component	$x_{base} = l_{base} / 2$ = **1075** mm

Using Coulomb theory

Active pressure coefficient — $K_A = \sin(\alpha + \phi'_{r.k})^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta_{r.k}) \times [1 + \sqrt{[\sin(\phi'_{r.k} + \delta_{r.k}) \times \sin(\phi'_{r.k} - \beta) / (\sin(\alpha - \delta_{r.k}) \times \sin(\alpha + \beta))]}]^2) =$ **0.483**

Passive pressure coefficient — $K_P = \sin(90 - \phi'_{b.k})^2 / (\sin(90 + \delta_{b.k}) \times [1 - \sqrt{[\sin(\phi'_{b.k} + \delta_{b.k}) \times \sin(\phi'_{b.k}) / (\sin(90 + \delta_{b.k}))]}]^2) =$ **2.359**

Bearing pressure check

Vertical forces on wall

Wall stem	$F_{stem} = A_{stem} \times \gamma_{stem} =$ **26.3** kN/m
Wall base	$F_{base} = A_{base} \times \gamma_{base} =$ **18.8** kN/m
Line loads	$F_{P\_v} = P_{G1} + P_{Q1} =$ **134.2** kN/m
Total	$F_{total\_v} = F_{stem} + F_{base} + F_{P\_v} + F_{water\_v} =$ **179.3** kN/m

Horizontal forces on wall

Surcharge load	$F_{sur\_h} = K_A \times \cos(\delta_{r.k}) \times Surcharge_Q \times h_{eff} =$ **8.8** kN/m
Saturated retained soil	$F_{sat\_h} = K_A \times \cos(\delta_{r.k}) \times (\gamma_{sr} - \gamma_w) \times (h_{sat} + h_{base})^2 / 2 =$ **12.1** kN/m
Water	$F_{water\_h} = \gamma_w \times (h_{water} + d_{cover} + h_{base})^2 / 2 =$ **27.1** kN/m
Moist retained soil	$F_{moist\_h} = K_A \times \cos(\delta_{r.k}) \times \gamma_{mr} \times ((h_{eff} - h_{sat} - h_{base})^2 / 2 + (h_{eff} - h_{sat} - h_{base}) \times (h_{sat} + h_{base})) =$ **25.8** kN/m
Base soil	$F_{pass\_h} = -K_P \times \cos(\delta_{b.k}) \times \gamma_b \times (d_{cover} + h_{base})^2 / 2 =$ **-2.7** kN/m
Total	$F_{total\_h} = F_{sur\_h} + F_{sat\_h} + F_{water\_h} + F_{moist\_h} + F_{pass\_h} =$ **71.1** kN/m

Moments on wall

Wall stem	$M_{stem} = F_{stem} \times x_{stem} =$ **51.8** kNm/m
Wall base	$M_{base} = F_{base} \times x_{base} =$ **20.2** kNm/m
Surcharge load	$M_{sur} = -F_{sur\_h} \times x_{sur\_h} =$ **-14.7** kNm/m
Line loads	$M_P = (P_{G1} + P_{Q1}) \times p_1 =$ **268.4** kNm/m
Saturated retained soil	$M_{sat} = -F_{sat\_h} \times x_{sat\_h} =$ **-9.5** kNm/m
Water	$M_{water} = -F_{water\_h} \times x_{water\_h} =$ **-21.2** kNm/m
Moist retained soil	$M_{moist} = -F_{moist\_h} \times x_{moist\_h} =$ **-37.2** kNm/m
Total	$M_{total} = M_{stem} + M_{base} + M_{sur} + M_P + M_{sat} + M_{water} + M_{moist} =$ **257.8** kNm/m

Check bearing pressure

Propping force to stem	$F_{prop\_stem} = (F_{total\_v} \times l_{base} / 2 - M_{total}) / (h_{prop} + t_{base}) =$ **-19.4** kN/m
Propping force to base	$F_{prop\_base} = F_{total\_h} - F_{prop\_stem} =$ **90.6** kN/m
Moment from propping force	$M_{prop} = F_{prop\_stem} \times (h_{prop} + t_{base}) =$ **-65.1** kNm/m
Distance to reaction	$\bar{x} = (M_{total} + M_{prop}) / F_{total\_v} =$ **1075** mm
Eccentricity of reaction	$e = \bar{x} - l_{base} / 2 =$ **0** mm
Loaded length of base	$l_{load} = l_{base} =$ **2150** mm

Bearing pressure at toe $q_{toe} = F_{total\_v} / l_{base} \times (1 - 6 \times e / l_{base})$ = **83.4** kN/m^2

Bearing pressure at heel $q_{heel} = F_{total\_v} / l_{base} \times (1 + 6 \times e / l_{base})$ = **83.4** kN/m^2

Factor of safety $FoS_{bp} = P_{bearing} / \max(q_{toe}, q_{heel})$ = **1.199**

PASS - Allowable bearing pressure exceeds maximum applied bearing pressure

RETAINING WALL DESIGN

In accordance with EN1992-1-1:2004 incorporating Corrigendum dated January 2008 and the UK National Annex incorporating National Amendment No.1

Tedds calculation version 2.9.07

Concrete details - Table 3.1 - Strength and deformation characteristics for concrete

Concrete strength class C28/35

Characteristic compressive cylinder strength f_{ck} = **28** N/mm^2

Characteristic compressive cube strength $f_{ck,cube}$ = **35** N/mm^2

Mean value of compressive cylinder strength $f_{cm} = f_{ck} + 8$ N/mm^2 = **36** N/mm^2

Mean value of axial tensile strength $f_{ctm} = 0.3$ N/mm$^2 \times (f_{ck} / 1$ N/mm$^2)^{2/3}$ = **2.8** N/mm^2

5% fractile of axial tensile strength $f_{ctk,0.05} = 0.7 \times f_{ctm}$ = **1.9** N/mm^2

Secant modulus of elasticity of concrete $E_{cm} = 22$ kN/mm$^2 \times (f_{cm} / 10$ N/mm$^2)^{0.3}$ = **32308** N/mm^2

Partial factor for concrete - Table 2.1N γ_C = **1.50**

Compressive strength coefficient - cl.3.1.6(1) α_{cc} = **0.85**

Design compressive concrete strength - exp.3.15 $f_{cd} = \alpha_{cc} \times f_{ck} / \gamma_C$ = **15.9** N/mm^2

Maximum aggregate size h_{agg} = **20** mm

Ultimate strain - Table 3.1 ε_{cu2} = **0.0035**

Shortening strain - Table 3.1 ε_{cu3} = **0.0035**

Effective compression zone height factor λ = **0.80**

Effective strength factor η = **1.00**

Bending coefficient k_1 K_1 = **0.40**

Bending coefficient k_2 $K_2 = 1.00 \times (0.6 + 0.0014/\varepsilon_{cu2})$ = **1.00**

Bending coefficient k_3 K_3 =**0.40**

Bending coefficient k_4 $K_4 = 1.00 \times (0.6 + 0.0014/\varepsilon_{cu2})$ =**1.00**

Reinforcement details

Characteristic yield strength of reinforcement f_{yk} = **500** N/mm^2

Modulus of elasticity of reinforcement E_s = **200000** N/mm^2

Partial factor for reinforcing steel - Table 2.1N γ_S = **1.15**

Design yield strength of reinforcement $f_{yd} = f_{yk} / \gamma_S$ = **435** N/mm^2

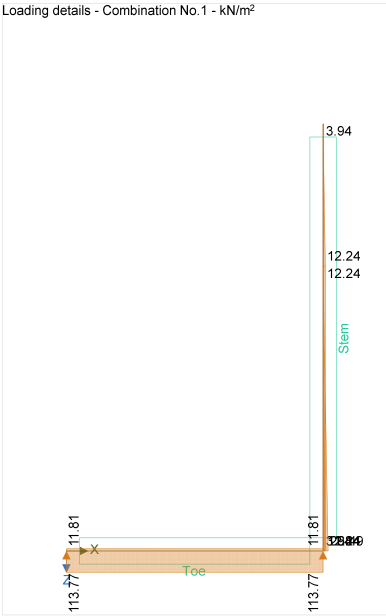
Cover to reinforcement

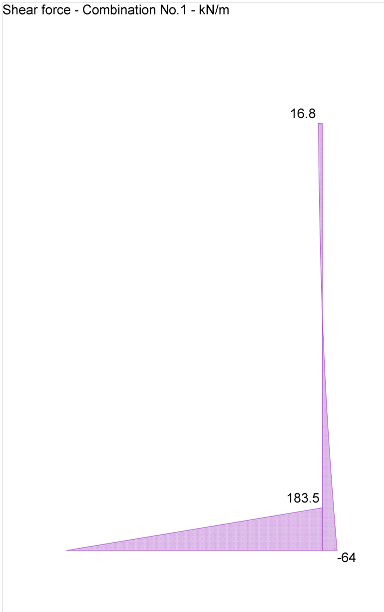
Front face of stem c_{sf} = **40** mm

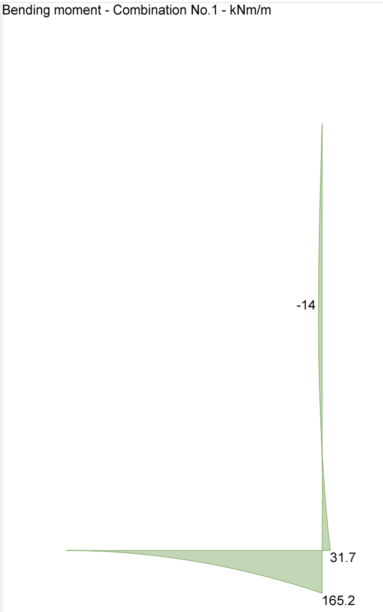
Rear face of stem c_{sr} = **50** mm

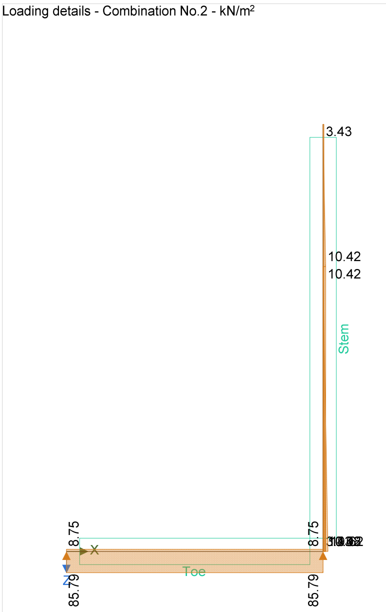
Top face of base c_{bt} = **50** mm

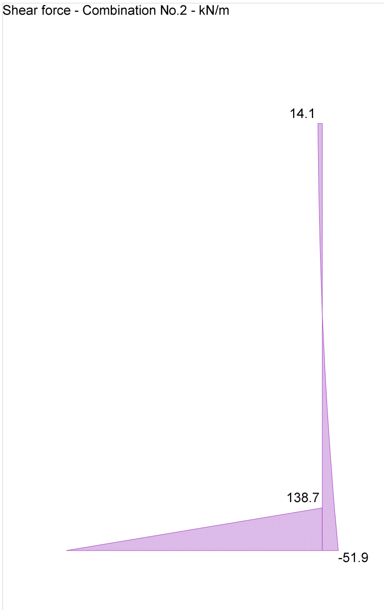
Bottom face of base c_{bb} = **75** mm

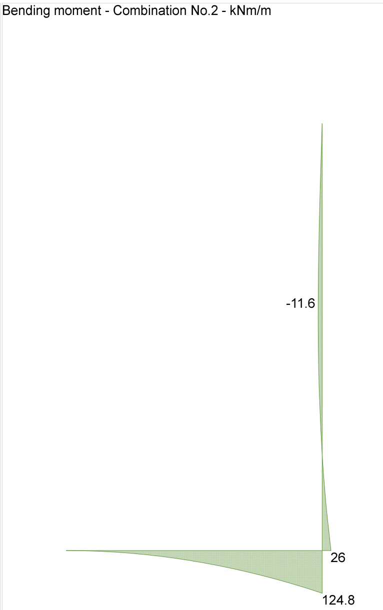












Check stem design at 1655 mm

Depth of section h = **350** mm

Rectangular section in flexure - Section 6.1

Design bending moment combination 1 — $M = \mathbf{14}$ kNm/m

Depth to tension reinforcement — $d = h - c_{sf} - \phi_{sx} - \phi_{sfM} / 2 = \mathbf{292}$ mm

$K = M / (d^2 \times f_{ck}) = \mathbf{0.006}$

$K' = (2 \times \eta \times \alpha_{cc}/\gamma_C)\times(1 - \lambda \times (\delta - K_1)/(2 \times K_2))\times(\lambda \times (\delta - K_1)/(2 \times K_2))$

$K' = \mathbf{0.207}$

K' > K - No compression reinforcement is required

Lever arm — $z = \min(0.5 + 0.5 \times (1 - 2 \times K / (\eta \times \alpha_{cc} / \gamma_C))^{0.5}, 0.95) \times d = \mathbf{277}$ mm

Depth of neutral axis — $x = 2.5 \times (d – z) = \mathbf{37}$ mm

Area of tension reinforcement required — $A_{sfM.req} = M / (f_{yd} \times z) = \mathbf{116}$ mm²/m

Tension reinforcement provided — 12 dia.bars @ 200 c/c

Area of tension reinforcement provided — $A_{sfM.prov} = \pi \times \phi_{sfM}^2 / (4 \times s_{sfM}) = \mathbf{565}$ mm²/m

Minimum area of reinforcement - exp.9.1N — $A_{sfM.min} = \max(0.26 \times f_{ctm} / f_{yk}, 0.0013) \times d = \mathbf{420}$ mm²/m

Maximum area of reinforcement - cl.9.2.1.1(3) — $A_{sfM.max} = 0.04 \times h = \mathbf{14000}$ mm²/m

$\max(A_{sfM.req}, A_{sfM.min}) / A_{sfM.prov} = \mathbf{0.743}$

PASS - Area of reinforcement provided is greater than area of reinforcement required

Library item: Rectangular single output

Deflection control - Section 7.4

Reference reinforcement ratio — $\rho_0 = \sqrt{(f_{ck} / 1 \text{ N/mm}^2)} / 1000 = \mathbf{0.005}$

Required tension reinforcement ratio — $\rho = A_{sfM.req} / d = \mathbf{0.000}$

Required compression reinforcement ratio — $\rho' = A_{sfM.2.req} / d_2 = \mathbf{0.000}$

Structural system factor - Table 7.4N — $K_b = \mathbf{1}$

Reinforcement factor - exp.7.17 — $K_s = \min(500 \text{ N/mm}^2 / (f_{yk} \times A_{sfM.req} / A_{sfM.prov}), 1.5) = \mathbf{1.5}$

Limiting span to depth ratio - exp.7.16.a — $\min(K_s \times K_b \times [11 + 1.5 \times \sqrt{(f_{ck} / 1 \text{ N/mm}^2)} \times \rho_0 / \rho + 3.2 \times \sqrt{(f_{ck} / 1 \text{ N/mm}^2)} \times (\rho_0 / \rho - 1)^{3/2}], 40 \times K_b) = \mathbf{40}$

Actual span to depth ratio — $h_{prop} / d = \mathbf{10.3}$

PASS - Span to depth ratio is less than deflection control limit

Crack control - Section 7.3

Limiting crack width — $w_{max} = \mathbf{0.4}$ mm

Variable load factor - EN1990 – Table A1.1 — $\psi_2 = \mathbf{0.3}$

Serviceability bending moment — $M_{sls} = \mathbf{9.1}$ kNm/m

Tensile stress in reinforcement — $\sigma_s = M_{sls} / (A_{sfM.prov} \times z) = \mathbf{57.9}$ N/mm²

Load duration — Long term

Load duration factor — $k_t = \mathbf{0.4}$

Effective area of concrete in tension — $A_{c.eff} = \min(2.5 \times (h - d), (h - x) / 3, h / 2)$

	$A_{c.eff}$ = **104500** mm²/m
Mean value of concrete tensile strength	$f_{ct.eff} = f_{ctm}$ = **2.8** N/mm²
Reinforcement ratio	$\rho_{p.eff} = A_{sfM.prov} / A_{c.eff}$ = **0.005**
Modular ratio	$\alpha_e = E_s / E_{cm}$ = **6.19**
Bond property coefficient	k_1 = **0.8**
Strain distribution coefficient	k_2 = **0.5**
	k_3 = **3.4**
	k_4 = **0.425**
Maximum crack spacing - exp.7.11	$s_{r.max} = k_3 \times c_{sf} + k_1 \times k_2 \times k_4 \times \phi_{sfM} / \rho_{p.eff}$ = **513** mm
Maximum crack width - exp.7.8	$w_k = s_{r.max} \times \max(\sigma_s - k_t \times (f_{ct.eff} / \rho_{p.eff}) \times (1 + \alpha_e \times \rho_{p.eff}), 0.6 \times \sigma_s) / E_s$
	w_k = **0.089** mm
	w_k / w_{max} = **0.223**

PASS - Maximum crack width is less than limiting crack width

Check stem design at base of stem

Depth of section	h = **350** mm

Rectangular section in flexure - Section 6.1

Design bending moment combination 1	M = **31.7** kNm/m
Depth to tension reinforcement	$d = h - c_{sr} - \phi_{sr} / 2$ = **294** mm
	$K = M / (d^2 \times f_{ck})$ = **0.013**
	$K' = (2 \times \eta \times \alpha_{cc}/\gamma_C)\times(1 - \lambda \times (\delta - K_1)/(2 \times K_2))\times(\lambda \times (\delta - K_1)/(2 \times K_2))$
	K' = **0.207**

K' > K - No compression reinforcement is required

Lever arm	$z = \min(0.5 + 0.5 \times (1 - 2 \times K / (\eta \times \alpha_{cc} / \gamma_C))^{0.5}, 0.95) \times d$ = **279** mm
Depth of neutral axis	$x = 2.5 \times (d - z)$ = **37** mm
Area of tension reinforcement required	$A_{sr.req} = M / (f_{yd} \times z)$ = **261** mm²/m
Tension reinforcement provided	12 dia.bars @ 200 c/c
Area of tension reinforcement provided	$A_{sr.prov} = \pi \times \phi_{sr}^2 / (4 \times s_{sr})$ = **565** mm²/m
Minimum area of reinforcement - exp.9.1N	$A_{sr.min} = \max(0.26 \times f_{ctm} / f_{yk}, 0.0013) \times d$ = **423** mm²/m
Maximum area of reinforcement - cl.9.2.1.1(3)	$A_{sr.max} = 0.04 \times h$ = **14000** mm²/m
	$\max(A_{sr.req}, A_{sr.min}) / A_{sr.prov}$ = **0.748**

PASS - Area of reinforcement provided is greater than area of reinforcement required

Library item: Rectangular single output

Deflection control - Section 7.4

Reference reinforcement ratio	$\rho_0 = \sqrt{(f_{ck} / 1 N/mm^2)} / 1000$ = **0.005**

Required tension reinforcement ratio	$\rho = A_{sr.req} / d =$ **0.001**
Required compression reinforcement ratio	$\rho' = A_{sr.2.req} / d_2 =$ **0.000**
Structural system factor - Table 7.4N	$K_b =$ **1**
Reinforcement factor - exp.7.17	$K_s = \min(500\ N/mm^2 / (f_{yk} \times A_{sr.req} / A_{sr.prov}), 1.5) =$ **1.5**
Limiting span to depth ratio - exp.7.16.a	$\min(K_s \times K_b \times [11 + 1.5 \times \sqrt{(f_{ck} / 1\ N/mm^2)} \times \rho_0 / \rho + 3.2 \times \sqrt{(f_{ck} / 1\ N/mm^2)} \times (\rho_0 / \rho - 1)^{3/2}], 40 \times K_b) =$ **40**
Actual span to depth ratio	$h_{prop} / d =$ **10.2**

PASS - Span to depth ratio is less than deflection control limit

Crack control - Section 7.3

Limiting crack width	$w_{max} =$ **0.4** mm
Variable load factor - EN1990 – Table A1.1	$\psi_2 =$ **0.3**
Serviceability bending moment	$M_{sls} =$ **21.1** kNm/m
Tensile stress in reinforcement	$\sigma_s = M_{sls} / (A_{sr.prov} \times z) =$ **133.5** N/mm^2
Load duration	Long term
Load duration factor	$k_t =$ **0.4**
Effective area of concrete in tension	$A_{c.eff} = \min(2.5 \times (h - d), (h - x) / 3, h / 2)$
	$A_{c.eff} =$ **104417** mm^2/m
Mean value of concrete tensile strength	$f_{ct.eff} = f_{ctm} =$ **2.8** N/mm^2
Reinforcement ratio	$\rho_{p.eff} = A_{sr.prov} / A_{c.eff} =$ **0.005**
Modular ratio	$\alpha_e = E_s / E_{cm} =$ **6.19**
Bond property coefficient	$k_1 =$ **0.8**
Strain distribution coefficient	$k_2 =$ **0.5**
	$k_3 =$ **3.4**
	$k_4 =$ **0.425**
Maximum crack spacing - exp.7.11	$s_{r.max} = k_3 \times c_{sr} + k_1 \times k_2 \times k_4 \times \phi_{sr} / \rho_{p.eff} =$ **547** mm
Maximum crack width - exp.7.8	$w_k = s_{r.max} \times \max(\sigma_s - k_t \times (f_{ct.eff} / \rho_{p.eff}) \times (1 + \alpha_e \times \rho_{p.eff}), 0.6 \times \sigma_s) / E_s$
	$w_k =$ **0.219** mm
	$w_k / w_{max} =$ **0.547**

PASS - Maximum crack width is less than limiting crack width

Rectangular section in shear - Section 6.2

Design shear force	$V =$ **64** kN/m
	$C_{Rd,c} = 0.18 / \gamma_C =$ **0.120**
	$k = \min(1 + \sqrt{(200\ mm / d)}, 2) =$ **1.825**
Longitudinal reinforcement ratio	$\rho_l = \min(A_{sr.prov} / d, 0.02) =$ **0.002**
	$v_{min} = 0.035\ N^{1/2}/mm \times k^{3/2} \times f_{ck}^{0.5} =$ **0.457** N/mm^2
Design shear resistance - exp.6.2a & 6.2b	$V_{Rd.c} = \max(C_{Rd.c} \times k \times (100\ N^2/mm^4 \times \rho_l \times f_{ck})^{1/3}, v_{min}) \times d$
	$V_{Rd.c} =$ **134.2** kN/m

$V / V_{Rd.c}$ = **0.476**

PASS - Design shear resistance exceeds design shear force

Check stem design at prop

Depth of section h = **350** mm

Rectangular section in shear - Section 6.2

Design shear force V = **16.8** kN/m

$C_{Rd,c} = 0.18 / \gamma_C$ = **0.120**

$k = \min(1 + \sqrt{(200 \text{ mm} / d)}, 2)$ = **1.825**

Longitudinal reinforcement ratio $\rho_l = \min(A_{sr1.prov} / d, 0.02)$ = **0.002**

$v_{min} = 0.035 \text{ N}^{1/2}/\text{mm} \times k^{3/2} \times f_{ck}^{0.5}$ = **0.457** N/mm²

Design shear resistance - exp.6.2a & 6.2b $V_{Rd.c} = \max(C_{Rd.c} \times k \times (100 \text{ N}^2/\text{mm}^4 \times \rho_l \times f_{ck})^{1/3}, v_{min}) \times d$

$V_{Rd.c}$ = **134.2** kN/m

$V / V_{Rd.c}$ = **0.125**

PASS - Design shear resistance exceeds design shear force

Horizontal reinforcement parallel to face of stem - Section 9.6

Minimum area of reinforcement – cl.9.6.3(1) $A_{sx.req} = \max(0.25 \times A_{sr.prov}, 0.001 \times t_{stem})$ = **350** mm²/m

Maximum spacing of reinforcement – cl.9.6.3(2) s_{sx_max} = **400** mm

Transverse reinforcement provided 12 dia.bars @ 200 c/c

Area of transverse reinforcement provided $A_{sx.prov} = \pi \times \phi_{sx}^2 / (4 \times s_{sx})$ = **565** mm²/m

PASS - Area of reinforcement provided is greater than area of reinforcement required

Check base design at toe

Depth of section h = **350** mm

Rectangular section in flexure - Section 6.1

Design bending moment combination 1 M = **165.2** kNm/m

Depth to tension reinforcement $d = h - c_{bb} - \phi_{bb} / 2$ = **265** mm

$K = M / (d^2 \times f_{ck})$ = **0.084**

$K' = (2 \times \eta \times \alpha_{cc}/\gamma_C)\times(1 - \lambda \times (\delta - K_1)/(2 \times K_2))\times(\lambda \times (\delta - K_1)/(2 \times K_2))$

K' = **0.207**

K' > K - No compression reinforcement is required

Lever arm $z = \min(0.5 + 0.5 \times (1 - 2 \times K / (\eta \times \alpha_{cc} / \gamma_C))^{0.5}, 0.95) \times d$ = **244** mm

Depth of neutral axis $x = 2.5 \times (d – z)$ = **53** mm

Area of tension reinforcement required $A_{bb.req} = M / (f_{yd} \times z)$ = **1559** mm²/m

Tension reinforcement provided 20 dia.bars @ 100 c/c

Area of tension reinforcement provided $A_{bb.prov} = \pi \times \phi_{bb}^2 / (4 \times s_{bb})$ = **3142** mm²/m

Minimum area of reinforcement - exp.9.1N $A_{bb.min} = \max(0.26 \times f_{ctm} / f_{yk}, 0.0013) \times d$ = **381** mm²/m

Maximum area of reinforcement - cl.9.2.1.1(3) $A_{bb.max} = 0.04 \times h =$ **14000** mm^2/m

$max(A_{bb.req}, A_{bb.min}) / A_{bb.prov} =$ **0.496**

PASS - Area of reinforcement provided is greater than area of reinforcement required

Library item: Rectangular single output

Crack control - Section 7.3

Limiting crack width	$w_{max} =$ **0.4** mm
Variable load factor - EN1990 – Table A1.1	$\psi_2 =$ **0.3**
Serviceability bending moment	$M_{sls} =$ **120.9** kNm/m
Tensile stress in reinforcement	$\sigma_s = M_{sls} / (A_{bb.prov} \times z) =$ **158** N/mm^2
Load duration	Long term
Load duration factor	$k_t =$ **0.4**
Effective area of concrete in tension	$A_{c.eff} = min(2.5 \times (h - d), (h - x) / 3, h / 2)$
	$A_{c.eff} =$ **98864** mm^2/m
Mean value of concrete tensile strength	$f_{ct.eff} = f_{ctm} =$ **2.8** N/mm^2
Reinforcement ratio	$\rho_{p.eff} = A_{bb.prov} / A_{c.eff} =$ **0.032**
Modular ratio	$\alpha_e = E_s / E_{cm} =$ **6.19**
Bond property coefficient	$k_1 =$ **0.8**
Strain distribution coefficient	$k_2 =$ **0.5**
	$k_3 =$ **3.4**
	$k_4 =$ **0.425**
Maximum crack spacing - exp.7.11	$s_{r.max} = k_3 \times c_{bb} + k_1 \times k_2 \times k_4 \times \phi_{bb} / \rho_{p.eff} =$ **362** mm
Maximum crack width - exp.7.8	$w_k = s_{r.max} \times max(\sigma_s – k_t \times (f_{ct.eff} / \rho_{p.eff}) \times (1 + \alpha_e \times \rho_{p.eff}), 0.6 \times \sigma_s) / E_s$
	$w_k =$ **0.21** mm
	$w_k / w_{max} =$ **0.526**

PASS - Maximum crack width is less than limiting crack width

Rectangular section in shear - Section 6.2

Design shear force	$V =$ **183.5** kN/m
	$C_{Rd,c} = 0.18 / \gamma_C =$ **0.120**
	$k = min(1 + \sqrt{(200\ mm / d)}, 2) =$ **1.869**
Longitudinal reinforcement ratio	$\rho_l = min(A_{bb.prov} / d, 0.02) =$ **0.012**
	$v_{min} = 0.035\ N^{1/2}/mm \times k^{3/2} \times f_{ck}^{0.5} =$ **0.473** N/mm^2
Design shear resistance - exp.6.2a & 6.2b	$V_{Rd.c} = max(C_{Rd.c} \times k \times (100\ N^2/mm^4 \times \rho_l \times f_{ck})^{1/3}, v_{min}) \times d$
	$V_{Rd.c} =$ **191** kN/m
	$V / V_{Rd.c} =$ **0.961**

PASS - Design shear resistance exceeds design shear force

Secondary transverse reinforcement to base - Section 9.3

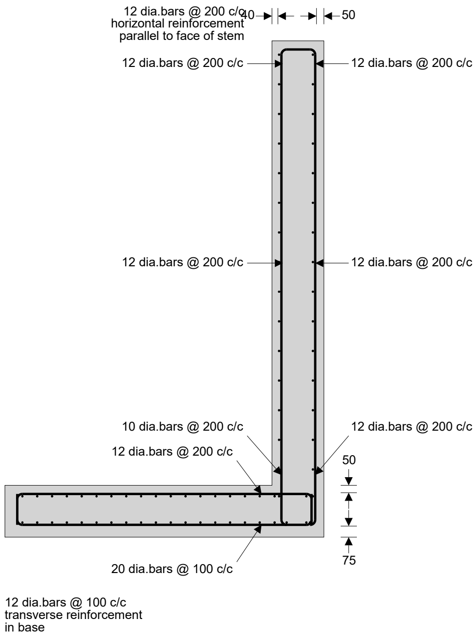
Minimum area of reinforcement – cl.9.3.1.1(2) $A_{bx.req} = 0.2 \times A_{bb.prov} =$ **628** mm²/m

Maximum spacing of reinforcement – cl.9.3.1.1(3) $s_{bx\_max} =$ **450** mm

Transverse reinforcement provided 12 dia.bars @ 100 c/c

Area of transverse reinforcement provided $A_{bx.prov} = \pi \times \phi_{bx}^2 / (4 \times s_{bx}) =$ **1131** mm²/m

PASS - Area of reinforcement provided is greater than area of reinforcement required



Reinforcement details

Appendix B: Construction Programme

<u>The Contractor is responsible for the final construction programme</u>

Outline construction Program (For planning purposes only)																
	Months															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Planning approval																
Detailed Design																
Tender																
Party Walls																
Monitoring of Adjacent structures																
Enabling works																
Basement Construction																
Superstructure construction																

Appendix C : Utilities Searches & Infrastructure Consultations

Thames Water Asset Location Search

Communication with Transport Asset Protectors

Asset location search

Thames Water Property Searches

Croft Structural Engineers
Clockshop Mews,60 Selhurst,Clockshop Mews

LONDON
SE25 5EH

Search address supplied	108a Goldhurst Terrace London NW6 3HR
Your reference	108a Goldhurst Terrace
Our reference	ALS/ALS Standard/2019_3936349
Search date	14 January 2019

Keeping you up-to-date

Notification of Price Changes

From 1 September 2018 Thames Water Property Searches will be increasing the price of its Asset Location Search in line with RPI at 3.23%.

For further details on the price increase please visit our website: www.thameswater-propertysearches.co.uk
Please note that any orders received with a higher payment prior to the 1 September 2018 will be non-refundable.

Thames Water Utilities Ltd
Property Searches, PO Box 3189, Slough SL1 4WW
DX 151280 Slough 13

searches@thameswater.co.uk
www.thameswater-propertysearches.co.uk

0845 070 9148

searchcode

Search address supplied: 108a, Goldhurst Terrace, London, NW6 3HR

Dear Sir / Madam

An Asset Location Search is recommended when undertaking a site development. It is essential to obtain information on the size and location of clean water and sewerage assets to safeguard against expensive damage and allow cost-effective service design.

The following records were searched in compiling this report: - the map of public sewers & the map of waterworks. Thames Water Utilities Ltd (TWUL) holds all of these.

This searchprovides maps showing the position, size of Thames Water assets close to the proposed development and also manhole cover and invert levels, where available.

Please note that none of the charges made for this report relate to the provision of Ordnance Survey mapping information. The replies contained in this letter are given following inspection of the public service records available to this company. No responsibility can be accepted for any error or omission in the replies.

You should be aware that the information contained on these plans is current only on the day that the plans are issued. The plans should only be used for the duration of the work that is being carried out at the present time. Under no circumstances should this data be copied or transmitted to parties other than those for whom the current work is being carried out.

Thames Water do update these service plans on a regular basis and failure to observe the above conditions could lead to damage arising to new or diverted services at a later date.

Contact Us

If you have any further queries regarding this enquiry please feel free to contact a member of the team on 0845 070 9148, or use the address below:

Thames Water Utilities Ltd
Property Searches
PO Box 3189
Slough
SL1 4WW

Email: searches@thameswater.co.uk
Web: www.thameswater-propertysearches.co.uk

Waste Water Services

Please provide a copy extract from the public sewer map.

Enclosed is a map showing the approximate lines of our sewers. Our plans do not show sewer connections from individual properties or any sewers not owned by Thames Water unless specifically annotated otherwise. Records such as "private" pipework are in some cases available from the Building Control Department of the relevant Local Authority.

Where the Local Authority does not hold such plans it might be advisable to consult the property deeds for the site or contact neighbouring landowners.

This report relates only to sewerage apparatus of Thames Water Utilities Ltd, it does not disclose details of cables and or communications equipment that may be running through or around such apparatus.

The sewer level information contained in this response represents all of the level data available in our existing records. Should you require any further Information, please refer to the relevant section within the 'Further Contacts' page found later in this document.

For your guidance:

- The Company is not generally responsible for rivers, watercourses, ponds, culverts or highway drains. If any of these are shown on the copy extract they are shown for information only.
- Any private sewers or lateral drains which are indicated on the extract of the public sewer map as being subject to an agreement under Section 104 of the Water Industry Act 1991 are not an 'as constructed' record. It is recommended these details be checked with the developer.

Clean Water Services

Please provide a copy extract from the public water main map.

Enclosed is a map showing the approximate positions of our water mains and associated apparatus. Please note that records are not kept of the positions of individual domestic supplies.

For your information, there will be a pressure of at least 10m head at the outside stop valve. If you would like to know the static pressure, please contact our Customer Centre on 0800 316 9800. The Customer Centre can also arrange for a full flow and pressure test to be carried out for a fee.

For your guidance:

- Assets other than vested water mains may be shown on the plan, for information only.
- If an extract of the public water main record is enclosed, this will show known public water mains in the vicinity of the property. It should be possible to estimate the likely length and route of any private water supply pipe connecting the property to the public water network.

Payment for this Search

A charge will be added to your suppliers account.

Further contacts:

Waste Water queries

Should you require verification of the invert levels of public sewers, by site measurement, you will need to approach the relevant Thames Water Area Network Office for permission to lift the appropriate covers. This permission will usually involve you completing a TWOSA form. For further information please contact our Customer Centre on Tel: 0845 920 0800. Alternatively, a survey can be arranged, for a fee, through our Customer Centre on the above number.

If you have any questions regarding sewer connections, budget estimates, diversions, building over issues or any other questions regarding operational issues please direct them to our service desk. Which can be contacted by writing to:

Developer Services (Waste Water)
Thames Water
Clearwater Court
Vastern Road
Reading
RG1 8DB

Tel: 0800 009 3921
Email: developer.services@thameswater.co.uk

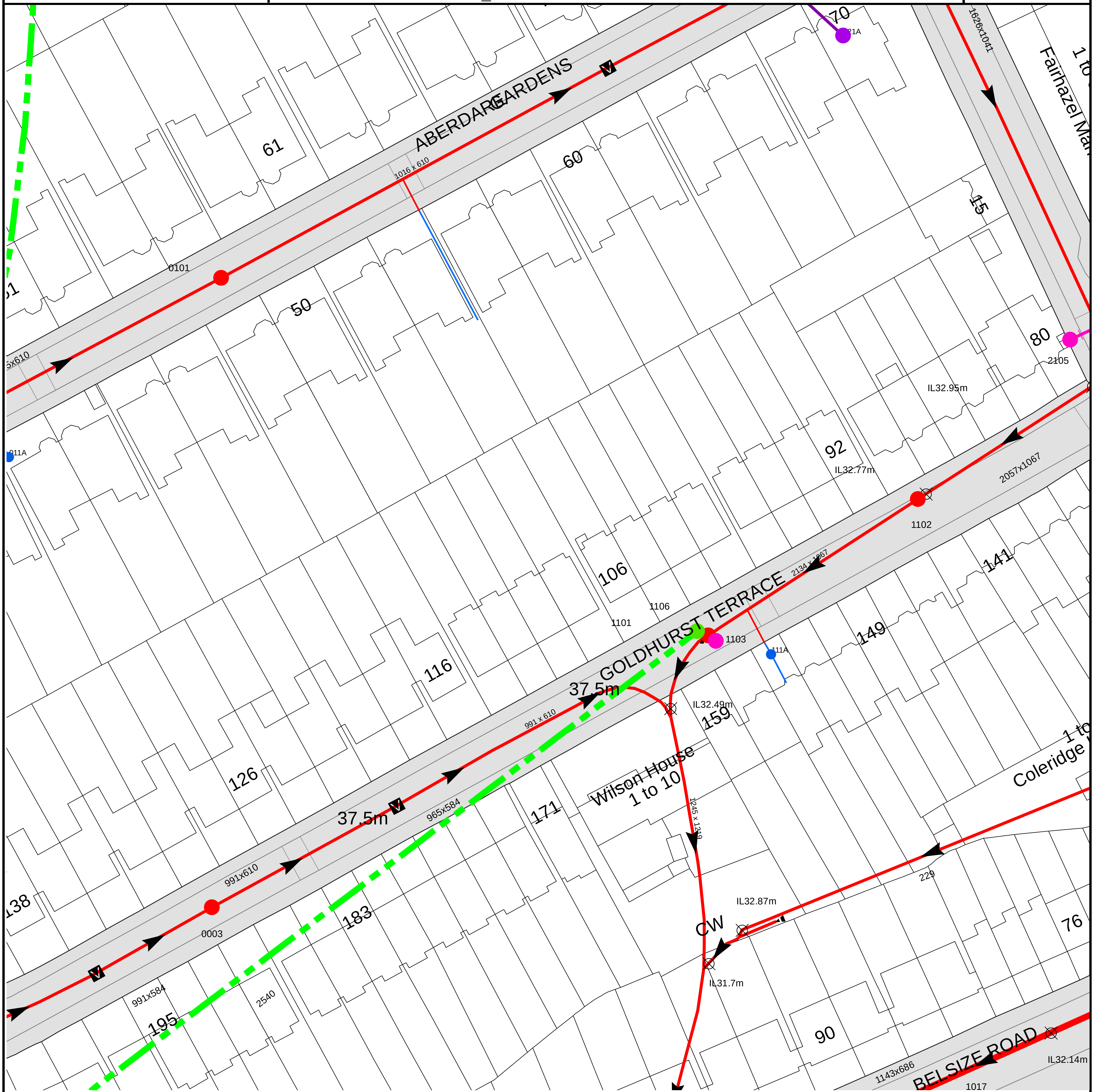
Clean Water queries

Should you require any advice concerning clean water operational issues or clean water connections, please contact:

Developer Services (Clean Water)
Thames Water
Clearwater Court
Vastern Road
Reading
RG1 8DB

Tel: 0800 009 3921
Email: developer.services@thameswater.co.uk

Asset Location Search Sewer Map - ALS/ALS Standard/2019_3936349



The width of the displayed area is 200 m and the centre of the map is located at OS coordinates 526112,184136

The position of the apparatus shown on this plan is given without obligation and warranty, and the accuracy cannot be guaranteed. Service pipes are not shown but their presence should be anticipated. No liability of any kind whatsoever is accepted by Thames Water for any error or omission. The actual position of mains and services must be verified and established on site before any works are undertaken.

NB. Levels quoted in metres Ordnance Newlyn Datum. The value -9999.00 indicates that no survey information is available

Manhole Reference	Manhole Cover Level	Manhole Invert Level
1101	37.5	28.05
1106	37.52	32.57
1103	37.52	n/a
111A	n/a	n/a
1102	37.68	n/a
2105	38.25	n/a
011A	n/a	n/a
0003	n/a	n/a
0101	39.58	35.4
121A	n/a	n/a

The position of the apparatus shown on this plan is given without obligation and warranty, and the accuracy cannot be guaranteed. Service pipes are not shown but their presence should be anticipated. No liability of any kind whatsoever is accepted by Thames Water for any error or omission. The actual position of mains and services must be verified and established on site before any works are undertaken.

ALS Sewer Map Key

Public Sewer Types (Operated & Maintained by Thames Water)

Foul: A sewer designed to convey waste water from domestic and industrial sources to a treatment works.

Surface Water: A sewer designed to convey surface water (e.g. rain water from roofs, yards and car parks) to rivers or watercourses.

Combined: A sewer designed to convey both waste water and surface water from domestic and industrial sources to a treatment works.

- Trunk Surface Water
- Trunk Foul
- Storm Relief
- Trunk Combined
- Vent Pipe
- Bio-solids (Sludge)
- Proposed Thames Surface Water Sewer
- Proposed Thames Water Foul Sewer
- Gallery
- Foul Rising Main
- Surface Water Rising Main
- Combined Rising Main
- Sludge Rising Main
- Proposed Thames Water Rising Main
- Vacuum

Sewer Fittings

A feature in a sewer that does not affect the flow in the pipe. Example: a vent is a fitting as the function of a vent is to release excess gas.

- Air Valve
- Dam Chase
- Fitting
- Meter
- Vent Column

Operational Controls

A feature in a sewer that changes or diverts the flow in the sewer. Example: A hydrobrake limits the flow passing downstream.

- Control Valve
- Drop Pipe
- Ancillary
- Weir

End Items

End symbols appear at the start or end of a sewer pipe. Examples: an Undefined End at the start of a sewer indicates that Thames Water has no knowledge of the position of the sewer upstream of that symbol, Outfall on a surface water sewer indicates that the pipe discharges into a stream or river.

- Outfall
- Undefined End
- Inlet

Other Symbols

Symbols used on maps which do not fall under other general categories

- Public/Private Pumping Station
- Change of characteristic indicator (C.O.C.I.)
- Invert Level
- Summit

Areas

Lines denoting areas of underground surveys, etc.

- Agreement
- Operational Site
- Chamber
- Tunnel
- Conduit Bridge

Other Sewer Types (Not Operated or Maintained by Thames Water)

- Foul Sewer
- Surface Water Sewer
- Combined Sewer
- Gulley
- Culverted Watercourse
- Proposed
- Abandoned Sewer

Notes:

1) All levels associated with the plans are to Ordnance Datum Newlyn.
2) All measurements on the plans are metric.
3) Arrows (on gravity fed sewers) or flecks (on rising mains) indicate direction of flow.
4) Most private pipes are not shown on our plans, as in the past, this information has not been recorded.
5) 'na' or '0' on a manhole level indicates that data is unavailable.
6) The text appearing alongside a sewer line indicates the internal diameter of the pipe in milimetres. Text next to a manhole indicates the manhole reference number and should not be taken as a measurement. If you are unsure about any text or symbology present on the plan, please contact a member of Property Insight on 0845 070 9148.

Asset Location Search Water Map - ALS/ALS Standard/2019_3936349

The width of the displayed area is 200 m and the centre of the map is located at OS coordinates 526112, 184136.

The position of the apparatus shown on this plan is given without obligation and warranty, and the accuracy cannot be guaranteed. Service pipes are not shown but their presence should be anticipated. No liability of any kind whatsoever is accepted by Thames Water for any error or omission. The actual position of mains and services must be verified and established on site before any works are undertaken.

ALS Water Map Key

Water Pipes (Operated & Maintained by Thames Water)

4"

Distribution Main: The most common pipe shown on water maps. With few exceptions, domestic connections are only made to distribution mains.

16"

Trunk Main: A main carrying water from a source of supply to a treatment plant or reservoir, or from one treatment plant or reservoir to another. Also a main transferring water in bulk to smaller water mains used for supplying individual customers.

3" SUPPLY

Supply Main: A supply main indicates that the water main is used as a supply for a single property or group of properties.

3" FIRE

Fire Main: Where a pipe is used as a fire supply, the word FIRE will be displayed along the pipe.

3" METERED

Metered Pipe: A metered main indicates that the pipe in question supplies water for a single property or group of properties and that quantity of water passing through the pipe is metered even though there may be no meter symbol shown.

Transmission Tunnel: A very large diameter water pipe. Most tunnels are buried very deep underground. These pipes are not expected to affect the structural integrity of buildings shown on the map provided.

Proposed Main: A main that is still in the planning stages or in the process of being laid. More details of the proposed main and its reference number are generally included near the main.

PIPE DIAMETER	DEPTH BELOW GROUND
Up to 300mm (12")	900mm (3')
300mm - 600mm (12" - 24")	1100mm (3' 8")
600mm and bigger (24" plus)	1200mm (4')

Valves

- General PurposeValve
- Air Valve
- Pressure ControlValve
- Customer Valve

Hydrants

- Single Hydrant

Meters

- Meter

End Items

Symbol indicating what happens at the end of a water main.

- Blank Flange
- Capped End
- Emptying Pit
- Undefined End
- Manifold
- Customer Supply
- Fire Supply

Operational Sites

- Booster Station
- Other
- Other (Proposed)
- Pumping Station
- Service Reservoir
- Shaft Inspection
- Treatment Works
- Unknown
- Water Tower

Other Symbols

- Data Logger

Other Water Pipes (Not Operated or Maintained by Thames Water)

Other Water Company Main: Occasionally other water company water pipes may overlap the border of our clean water coverage area. These mains are denoted in purple and in most cases have the owner of the pipe displayed along them.

Private Main: Indiates that the water main in question is not owned by Thames Water. These mains normally have text associated with them indicating the diameter and owner of the pipe.

Terms and Conditions

All sales are made in accordance with Thames Water Utilities Limited (TWUL) standard terms and conditions unless previously agreed in writing.

1. All goods remain in the property of Thames Water Utilities Ltd until full payment is received.
2. Provision of service will be in accordance with all legal requirements and published TWUL policies.
3. All invoices are strictly due for payment 14 days from due date of the invoice. Any other terms must be accepted/agreed in writing prior to provision of goods or service, or will be held to be invalid.
4. Thames Water does not accept post-dated cheques-any cheques received will be processed for payment on date of receipt.
5. In case of dispute TWUL`s terms and conditions shall apply.
6. Penalty interest may be invoked by TWUL in the event of unjustifiable payment delay. Interest charges will be in line with UK Statute Law 'The Late Payment of Commercial Debts (Interest) Act 1998'.
7. Interest will be charged in line with current Court Interest Charges, if legal action is taken.
8. A charge may be made at the discretion of the company for increased administration costs.

A copy of Thames Water's standard terms and conditions are available from the Commercial Billing Team (cashoperations@thameswater.co.uk).

We publish several Codes of Practice including a guaranteed standards scheme. You can obtain copies of these leaflets by calling us on 0800 316 9800

If you are unhappy with our service you can speak to your original goods or customer service provider. If you are not satisfied with the response, your complaint will be reviewed by the Customer Services Director. You can write to her at: Thames Water Utilities Ltd. PO Box 492, Swindon, SN38 8TU.

If the Goods or Services covered by this invoice falls under the regulation of the 1991 Water Industry Act, and you remain dissatisfied you can refer your complaint to Consumer Council for Water on 0121 345 1000 or write to them at Consumer Council for Water, 1st Floor, Victoria Square House, Victoria Square, Birmingham, B2 4AJ.

Ways to pay your bill

Credit Card	BACS Payment	Telephone Banking	Cheque
Call **0845 070 9148** quoting your invoice number starting CBA or ADS / OSS	Account number **90478703** Sort code **60-00-01** A remittance advice must be sent to: **Thames Water Utilities Ltd., PO Box 3189, Slough SL1 4WW.** or email **ps.billing@thameswater.co.uk**	By calling your bank and quoting: Account number **90478703** Sort code **60-00-01** and your invoice number	Made payable to '**Thames Water Utilities Ltd**' Write your Thames Water account number on the back. Send to: **Thames Water Utilities Ltd., PO Box 3189, Slough SL1 4WW** or by DX to **151280 Slough 13**

Thames Water Utilities Ltd Registered in England & Wales No. 2366661 Registered Office Clearwater Court, Vastern Rd, Reading, Berks, RG1 8DB.

Search Code

IMPORTANT CONSUMER PROTECTION INFORMATION

This search has been produced by Thames Water Property Searches, Clearwater Court, Vastern Road, Reading RG1 8DB, which is registered with the Property Codes Compliance Board (PCCB) as a subscriber to the Search Code. The PCCB independently monitors how registered search firms maintain compliance with the Code.

The Search Code:

- provides protection for homebuyers, sellers, estate agents, conveyancers and mortgage lenders who rely on the information included in property search reports undertaken by subscribers on residential and commercial property within the United Kingdom
- sets out minimum standards which firms compiling and selling search reports have to meet
- promotes the best practise and quality standards within the industry for the benefit of consumers and property professionals
- enables consumers and property professionals to have confidence in firms which subscribe to the code, their products and services.

By giving you this information, the search firm is confirming that they keep to the principles of the Code. This provides important protection for you.

The Code's core principles
Firms which subscribe to the Search Code will:

- display the Search Code logo prominently on their search reports
- act with integrity and carry out work with due skill, care and diligence
- at all times maintain adequate and appropriate insurance to protect consumers
- conduct business in an honest, fair and professional manner
- handle complaints speedily and fairly
- ensure that products and services comply with industry registration rules and standards and relevant laws
- monitor their compliance with the Code

Complaints
If you have a query or complaint about your search, you should raise it directly with the search firm, and if appropriate ask for any complaint to be considered under their formal internal complaints procedure. If you remain dissatisfied with the firm's final response, after your complaint has been formally considered, or if the firm has exceeded the response timescales, you may refer your complaint for consideration under The Property Ombudsman scheme (TPOs). The Ombudsman can award compensation of up to £5,000 to you if the Ombudsman finds that you have suffered actual loss and/or aggravation, distress or inconvenience as a result of your search provider failing to keep to the code.

Please note that all queries or complaints regarding your search should be directed to your search provider in the first instance, not to TPOs or to the PCCB.

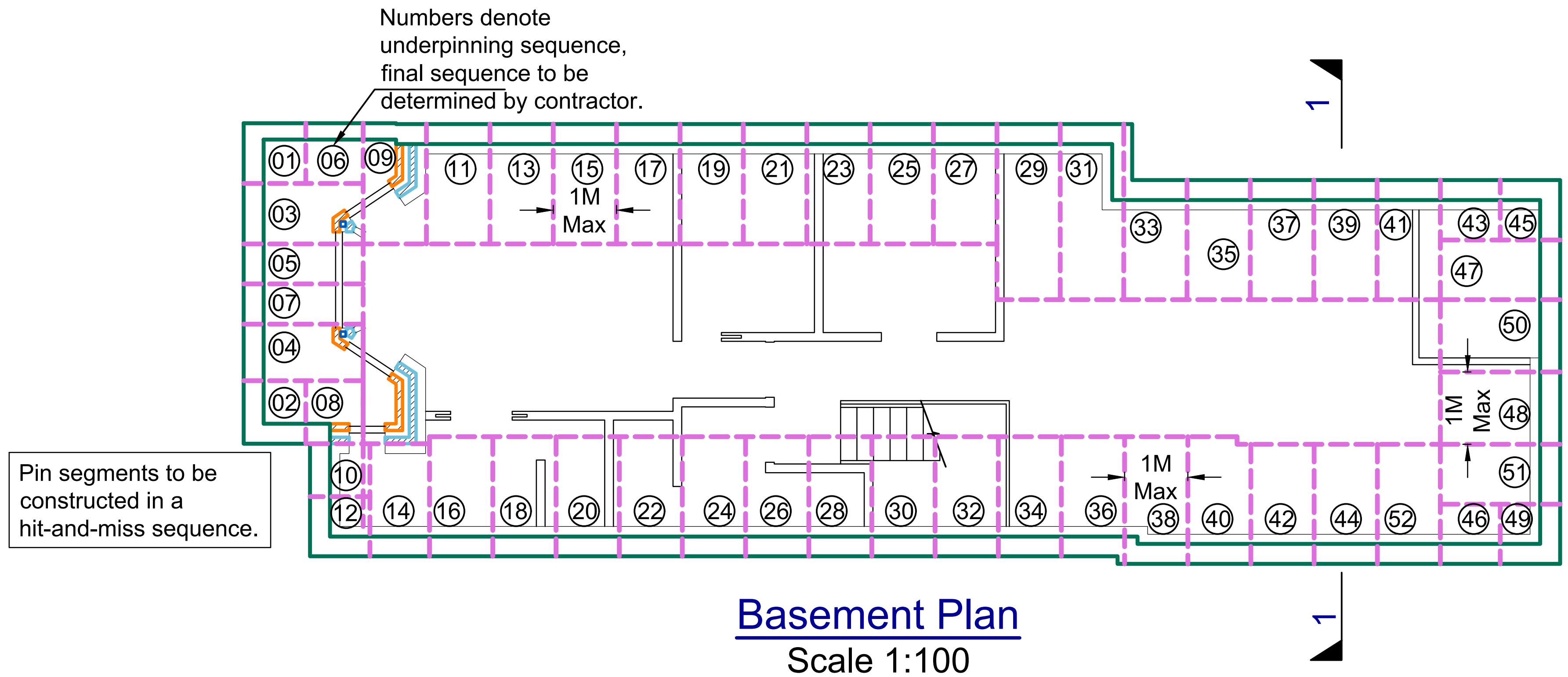
TPOs Contact Details
The Property Ombudsman scheme
Milford House
43-55 Milford Street
Salisbury
Wiltshire SP1 2BP
Tel: 01722 333306
Fax: 01722 332296
Web site: www.tpos.co.uk
Email: admin@tpos.co.uk

You can get more information about the PCCB from www.propertycodes.org.uk

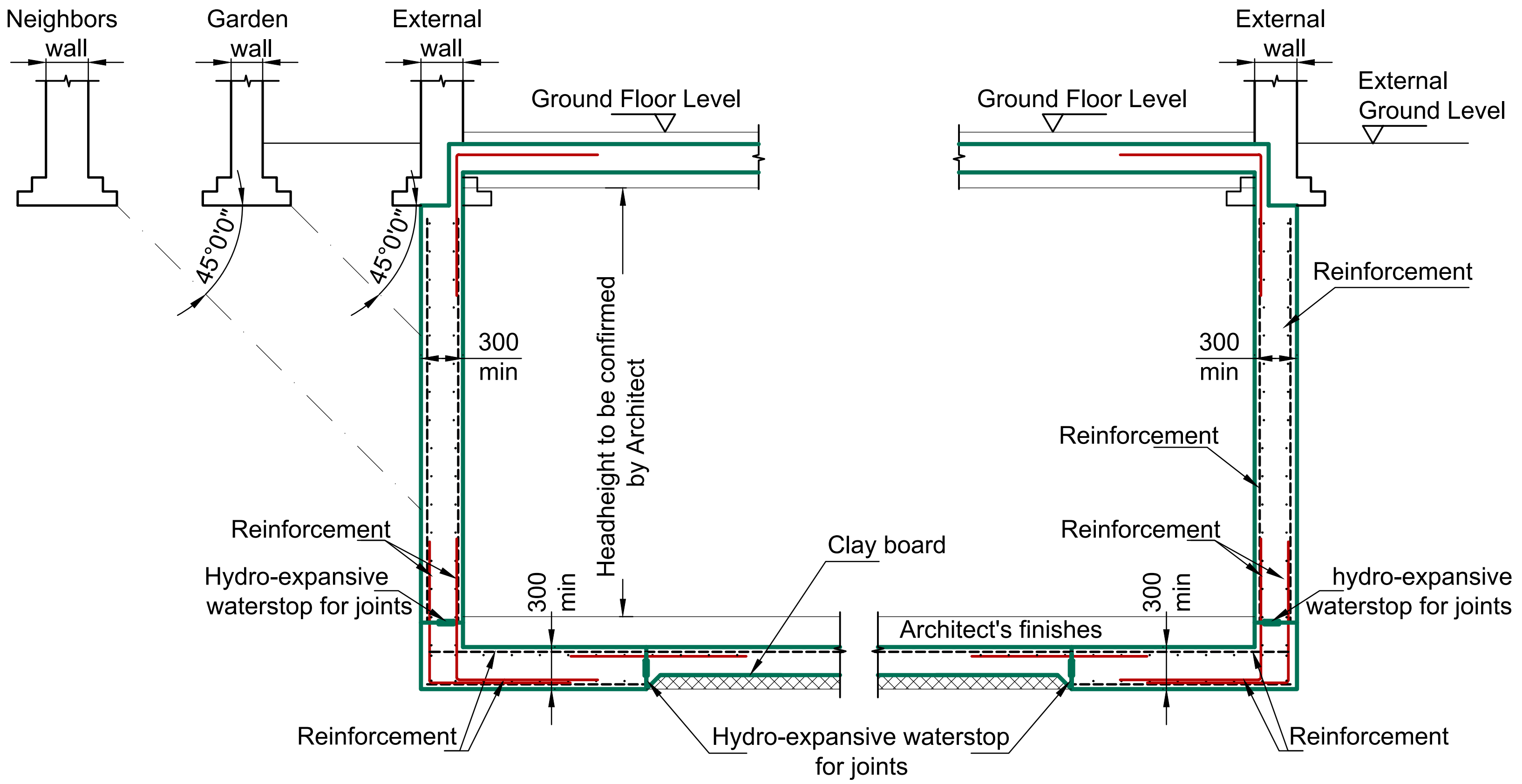
PLEASE ASK YOUR SEARCH PROVIDER IF YOU WOULD LIKE A COPY OF THE SEARCH CODE

Appendix D : Structural Drawings

SL-09 Basement Plan (1:100) & Section (1:50)
SL-10 Lower Ground Floor Plan (1:100) & Section (1:50)



Basement Plan
Scale 1:100



Section 1-1
Scale 1:50

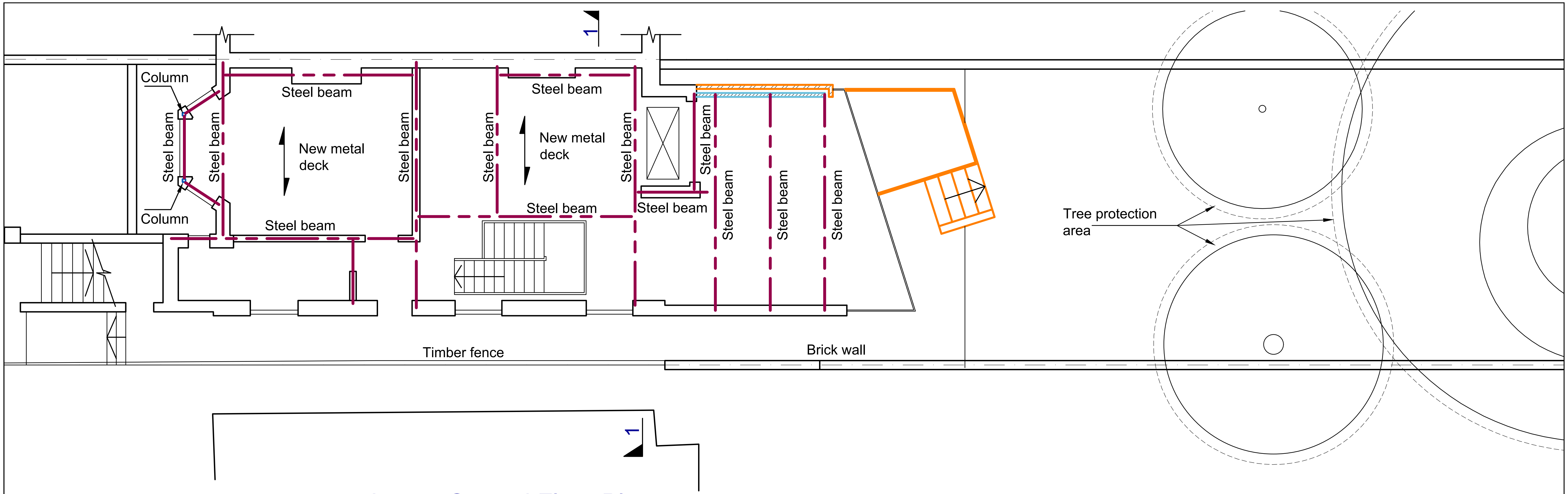
- PLANNING ISSUE -
NOT FOR CONSTRUCTION

Rev	Date	Amendments
-	21/02/2019	First issue for comment

Croft Structural Engineers
Clockshop Mews,
r/o 60 Saxon Rd,
London, SE25 5EH.
020 8684 4744
www.croftse.co.uk

Job Number: 181209
Date: Feb '19
Dwg Number: SL-09
Rev: -
Drawn: SB
Ch'kd: GW
Scale: As shown @ A3

Client: Brad Briggs
Project: 108a Goldhurst Terrace
Title : Basement Plan



Lower Ground Floor Plan

Scale 1:100

- PLANNING ISSUE -
NOT FOR CONSTRUCTION

Rev	Date	Amendments
1	21/02/2019	Garden shown
-	01/02/2019	First issue for comment

Job Number 181209	Date Jan '19
Dwg Number SL-10	Rev 1
Drawn SB	Ch'kd CT
Scale As shown @ A3	

Client: Brad Briggs

Project: 108a Goldhurst Terrace

Title : Lower Ground Floor

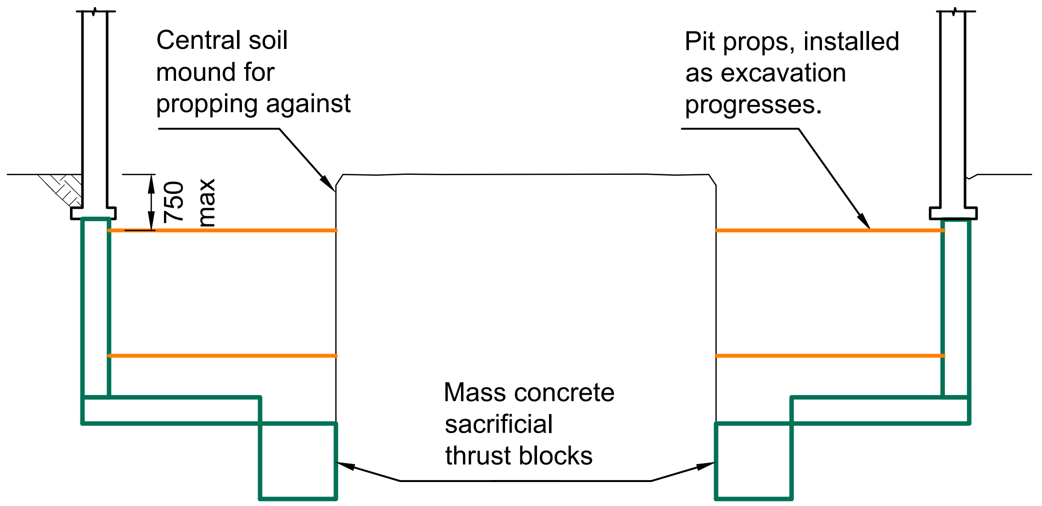
Croft Structural Engineers
Clockshop Mews,
r/o 60 Saxon Rd,
London, SE25 5EH.
020 8684 4744
www.croftse.co.uk

Appendix E : Temporary Works Sequence

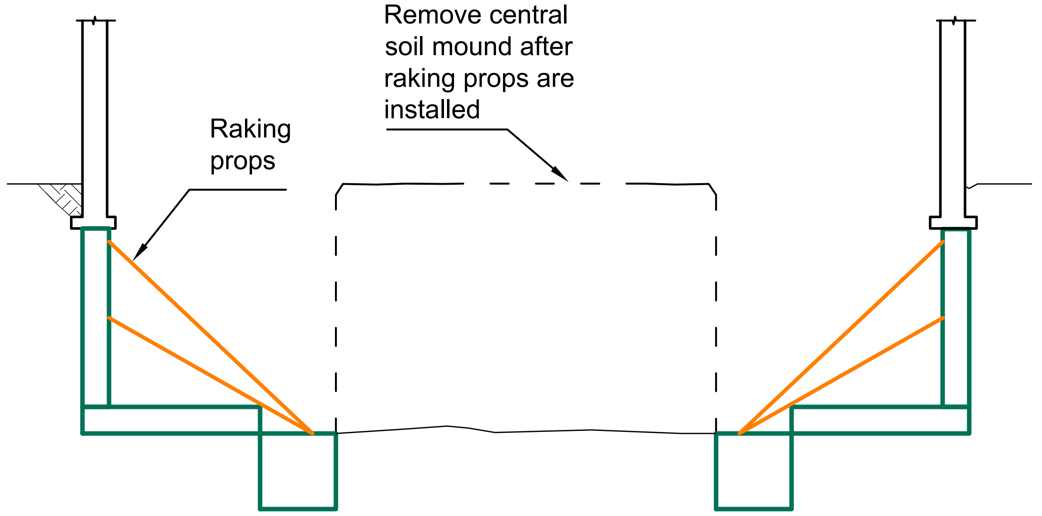
TW-10 Construction Sequence and Temporary Works Proposals

- Lateral propping
- Sequencing

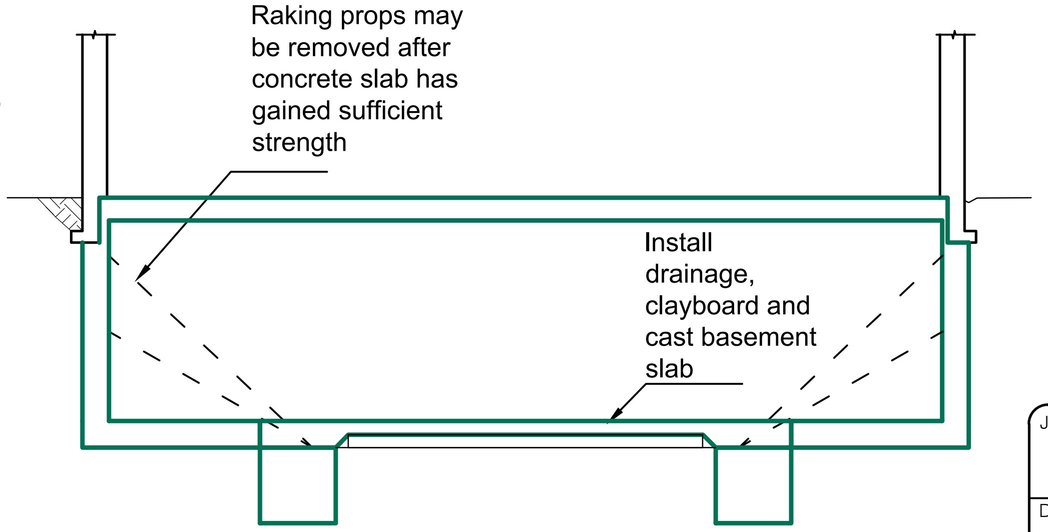
Phase 1



Phase 2



Phase 3



Typical section through building showing construction sequence

(1:100)

PHASE 1

1.1. Demolish and upper floor and provide temporary lateral support to flank walls and internal walls where required
1.2. Needle and prop upper front and rear walls, constructing temporary mass concrete pads where necessary.
1.3. Demolish lower ground floor and excavate to level of existing footings
1.4. Excavate underpins in a hit and miss procedure following the sequence shown in plan on structural engineer's drawing (SL-10)
  1.4.1. Prop pits against central soil mound as excavation progresses
  1.4.2. Do not commence excavation for pin until at least 48 hours after drypacking for adjacent pin is complete (24hours minimum is possible if Conbextra 100 cement accelerator is added to dry pack mix)
  1.4.3. For every second pin, extend excavation to allow for subsequent construction of mass concrete thrust block below formation level

PHASE 2

2.1. Install raking props to wall and prop against thrust blocks.
2.2. Excavate central soil mass

PHASE 3

3.1. Excavate soil between pins
3.2. Install below slab drainage and clayboard
3.3. Construct internal foundations
3.4. Cast concrete floor slab.
  3.4.1. Cast around bases of raking props to allow for removal
3.5. After basement slab has gained sufficient strength, remove raking props.
3.6. Proceed with construction of internal walls and ground floor structure.

- PLANNING ISSUE -
NOT FOR CONSTRUCTION

Rev	Date	Amendments
1	21/02/2019	Further detail given
-	01/02/2019	First issue for comment

Job Number 181209	Date Jan '19
Dwg Number TW-11	Rev 1
Drawn SB	Ch'kd CT
Scale As shown @ A3	

Client: Brad Briggs

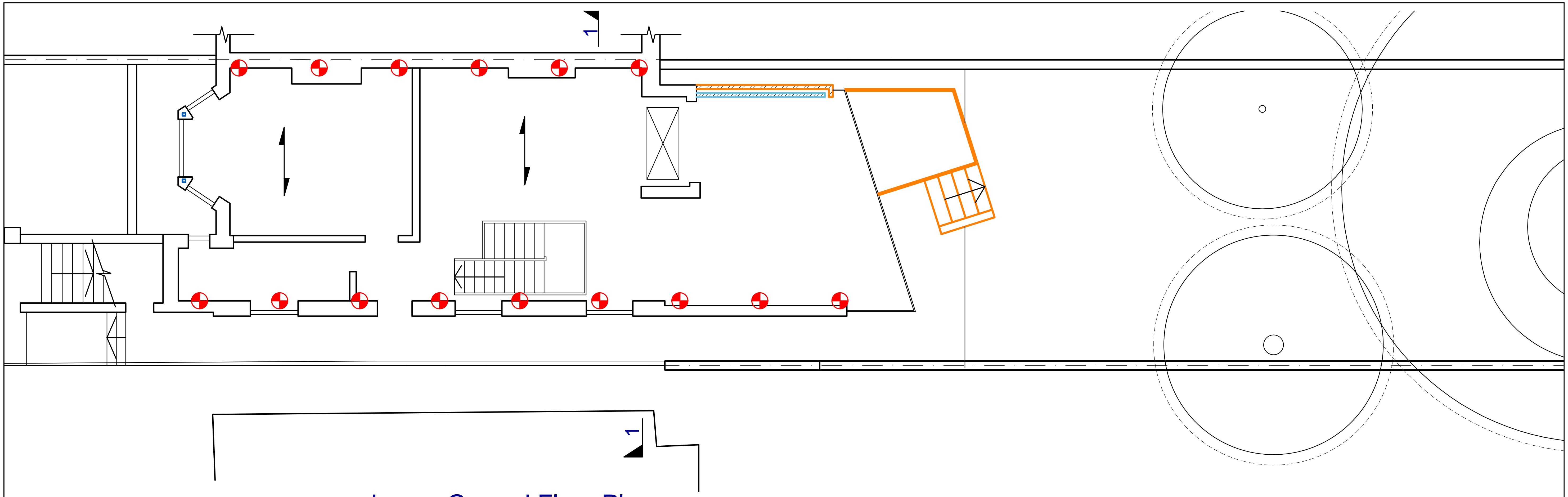
Project: 108a Goldhurst Terrace

Title : Construction Sequence and Temporary Works Proposals

Croft Structural Engineers
Clockshop Mews, r/o 60 Saxon Rd, London, SE25 5EH.
020 8684 4744
www.croftse.co.uk

Appendix F : Monitoring locations

For Trigger values and frequency see BIA report
SL-12 Monitoring plan (1:100)



Lower Ground Floor Plan

Scale 1:100

See Basement Impact Assessment 7.4.2 for monitoring details.

- PLANNING ISSUE -
NOT FOR CONSTRUCTION

Rev	Date	Amendments
-	21/02/2019	First issue for comment

Job Number 181209	Date Feb '19
Dwg Number SL-12	Rev -
Drawn SB	Ch'kd CT
Scale As shown @ A3	

Client: Brad Briggs

Project: 108a Goldhurst Terrace

Title : Lower Ground Floor (Monitoring)

Croft Structural Engineers
Clockshop Mews,
r/o 60 Saxon Rd,
London, SE25 5EH.
020 8684 4744
www.croftse.co.uk

Appendix G : Floor Fisk Assessment

Job Number: 181209

CROFT STRUCTURAL ENGINEERS

Croft Structural Engineers
Clock Shop Mews
Rear of 60 Saxon Road
London SE25 5EH

T: 020 8684 4744
E: enquiries@croftse.co.uk
W: www.croftse.co.uk

Flood Risk Assessment

Property:

Brad Briggs
108a Goldhurst Terrace
London
NW6 3HR

Author	**Reviewed by**
Sam Bunning	Phil Henry CEng MICE

Revision	Date	Comment
-	13.09.2019	First Issue

Contents

Executive Summary

This flood risk assessment for the basement development at 108a Goldhurst Terrace has explored the potential sources of flooding and compared existing and proposed conditions. The assessment has included a detailed study of the site and the surrounding area. The assessment concludes that the proposals will not increase the risk of flooding to nearby properties. The risk of flooding to 108a Goldhurst Terrace can be suitably mitigated by adopting appropriate construction methods.

1. Introduction

A new basement is proposed below an existing property at 108a Goldhurst Terrace. This report comprises a FRA (flood risk assessment) to support the planning application.

The objectives of the FRA is to establish:

- Whether the basement is likely to be affected by current or future flooding from any source
- Whether the basement will increase flood risk elsewhere
- Whether mitigation measures to deal with these effects and risks are feasible and appropriate

This flood risk assessment includes proposed design measures to reduce any risks associated with flooding and mitigate the impacts for the operation of the building, the users, the surrounding properties and the occupants of nearby properties.

Planning Context

While nowhere in the borough is identified by the Environment Agency as being flood prone from rivers or the sea, there are still parts that are identified as being subject to localised flooding from surface water. This is caused during times of heavy rainfall when the local combined sewer system is unable to deal with the volume and rate of flow.

All applications for a basement extension within flood risk areas identified in the LB Camden Flood Risk Management Strategy or in any future updated Strategic Flood Risk Assessment will be expected to include a Flood Risk Assessment

This report is based on information from a desk study, a site visit and relevant parts of the following documents:

- Basements CPG - March 2018
- Water and flooding CPG - March 2019

The scope of the FRA to be commensurate with the scale, nature and location of the development. This proposal described in this assessment is for a multi-occupancy dwelling. The level of analytical detail is limited accordingly.

2. Existing Site Conditions & Proposed Development

The existing property comprises a traditionally built Victorian end-of-terrace building. The structure is three storeys high and is surrounded by a garden. The garden comprises paved lightwells immediately to the front of the building; beyond this there is soft landscaping. From borehole investigations done in 2018, the building is understood to be founded on clay. Flat A, occupies the whole of the Lower Ground Floor and is the subject of this assessment. The site is less than 1 hectare and the site is on a street that was flooded in 1975 and 2002.

The proposal is to form a new single-storey basement below the footprint of the existing property. This will also extend into the garden in line with the proposed rear extension at lower ground floor level.

3. Flood Hazards and Mitigation Measure

The potential hazards related to flooding are as follows:

Tidal and Fluvial Flooding

Given that the site is above 40m AOD, and lies in Flood Risk Zone 1 (defined by the Environment Agency as having low risk of flooding from rivers and seas), the risk of flooding from fluvial and tidal sources is not significant.

Surface Water and Pluvial Flooding

The site is adequately drained, as are the surrounding roads (which are drained by gullies maintained by Thames Water). 108a Goldhurst Terrace and the surrounding roads were noted to of flooded in 1975 & 2002 due to a failure of a storm drain located just on the road just outside the property in question.

The new basement will not involve a significant removal of permeable surfaces (the walk-on roof-light will occupy less than 1m2). Rainwater will be able to infiltrate into the ground as before and will not migrate to alternative locations above ground level.

Groundwater Flooding

Bore hole records (GWPR2929/GIR/September 2019) show that the new basement will be founded on, and be surrounded by clay. Clay has a very low level of permeability. The inclusion of a basement in this strata will therefore have very little effect on the conveyance of groundwater. The increase in risk of flooding from groundwater is therefore negligible.

During construction perched water may be present in made ground or in pockets of gravel within the clay. This can be discharged with active dewatering on site. it is advisable that the contractor monitors the groundwater prior to the start of works and make suitable arrangements for dewatering as necessary.

Infrastructure Flooding

There are no reservoirs nearby which could cause flooding in the event of failure. Furthermore these items are assumed to have a high level of maintenance thus the risk of flooding from these is considered very low.

There are no known cases of flooding from sewers in the local area. There is always a risk that incoming water mains may break, causing significant flood risk to the occupants of the basement. This risk is inherent with all basement structures. Mitigation measures are proposed in the following section.

Mitigation Measures

To mitigate the risks associated with flooding of the basement, Croft would recommend that suitable waterproofing measures be proposed in conjunction with the structural design. A common and anticipated detailed design stage approach is to use internal dimpled membranes (Delta or similar). These will be integral to the waterproofing of the basement.

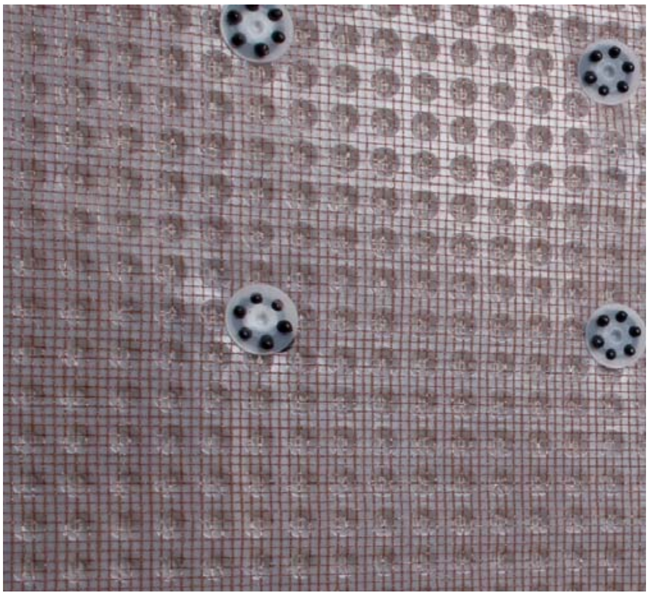


Figure 1: Example of dimpled membrane used for waterproofing basements

Any water from this will enter a drainage channel below the slab. This will be pumped and discharged into the exiting sewer system.

It is recommended that a waterproofing specialist is employed to ensure all the water proofing requirements are met. The waterproofing specialist must name their structural waterproofer. The structural waterproofer must inspect the structural details and confirm that he is happy with the robustness.

Due to the segmental construction nature of the basement, it is not possible to waterproof the joints. All waterproofing must be made by the waterproofing specialist. He should review the structural engineer's design stage details and advise if water bars and stops are necessary.

The waterproofing designer must not assume that the structure is watertight. To help reduce water flow through the joints in the segmental pins, the following measures should be applied:

- All faces should be cleaned of all debris and detritus
- Faces between pins should be needle hammered to improve key for bonding
- All pipe work and other penetrations should have puddle flanges or hydrophilic strips

The design of the services could include the following:

- A pumping system should be installed for the proposed basement. There is a likelihood that this may fail and allow excess water to accumulate. If this were to occur, the build-up of water would be gradual and noticeable before it becomes a significant life-threatening hazard.

- The pumping system should be a dual mechanism to maintain operation in the event of a failure. This should include a battery backup and a suitable alarm system for warning purposes.

Figure 2: Example of sump pump used commonly used for basement drainage

- Non-return valve to avoid the risk of backflow

- Install all electrical wiring at high level

SUDS Considerations

There is plentiful soft landscaping in the rear garden which allow and will continue to allow rainwater to discharge into the ground. This mechanism will be maintained: there are no proposals to change the landscaping in the rear garden. The use of artificial mechanisms such as attenuation tanks is therefore not considered necessary in this development. SUDS will be achieved by the continued use of soft-landscaped areas for infiltration.