ARDENT | CONSULTING ENGINEERS

HOMES FOR LAMBETH

PROPOSED REDEVELOPMENT: WOOTTON STREET, LONDON, SE1 8AZ

FLOOD RISK ASSESSMENT & DRAINAGE STRATEGY

Ardent Consulting Engineers
3rd Floor, The Hallmark Building
52-56 Leadenhall Street
LONDON
EC3M 5JE
Tel: 020 7680 4088
Fax: 020 7488 3736
enquiries@ardent-ce.co.uk

REPORT REF NO. 193860-04A
PROJECT NO. 193860
DECEMBER 2020

HOMES FOR LAMBETH

WOOTTON STREET,
LONDON, SE1 8AZ

FLOOD RISK ASSESSMENT & DRAINAGE STRATEGY

REPORT REF NO. 193860-04A
PROJECT NO. 193860
DECEMBER 2020

WOOTTON STREET
LONDON, SE1 8AZ

FLOOD RISK ASSESSMENT & DRAINAGE STRATEGY

Ardent Consulting Engineers
3rd Floor, The Hallmark Building
52-56 Leadenhall Street
LONDON
EC3M 5JE
Tel: 020 7680 4088
Fax: 020 7488 3736
enquiries@ardent-ce.co.uk

REPORT REF NO. 193860-04A
PROJECT NO. 193860
DECEMBER 2020

CONTENTS

LIST OF FIGURES

LIST OF TABLES

APPENDICES

DOCUMENT CONTROL SHEET

REV	ISSUE PURPOSE	AUTHOR	CHECKED	APPROVED	DATE
-	DRAFT	BW/CJC	CD/CC	DRAFT	NOV 20
A	FINAL	EF/CJC	EF	BC	DEC 20

DISTRIBUTION

This report has been prepared for the exclusive use of Homes for Lambeth. It should not be reproduced in whole or in part, or relied upon by third parties, without the express written authority of Ardent Consulting Engineers.

1. INTRODUCTION

1.1. Ardent Consulting Engineers (hereafter referred to as Ardent) has been appointed by Homes for Lambeth to undertake a Flood Risk Assessment & Drainage Strategy (FRA) for the proposed residential development Site located south of Wootton Street, London, SE1 8AZ (hereafter referred to as 'the Site'). The Lead Local Flood Authority (LLFA) and the Local Planning Authority (LPA) are London Borough of Lambeth.

1.2. The Site is approximately 0.18ha in area and the Environment Agency (EA) Flood Map shows that the Site is located within Flood Zone 3. This FRA has been prepared to support the full planning application for the proposed development which is to comprise the demolition of the existing single storey building and the construction of a new part 5, 8 & 10 storey building to provide a new community centre at the ground floor level and 36 residential units above. The development also includes landscaping, car parking and associated infrastructure works. The developable area considered in this report is 0.137ha associated with the redevelopment, works associated with Windmill House have not been included for the purposes of this report and it is assumed that the existing drainage regime will remain.

1.3. This FRA has been prepared with specific reference to the requirements of the National Planning Policy Framework (NPPF) released in February 2019 and the Planning Practice Guidance (PPG), which superseded the Technical Guidance to the NPPF, in March 2014. This report also takes into consideration the requirements within the Non-statutory technical standards for sustainable drainage systems (March 2015) and the LASOO Best Practice Guidance (July 2015).

Site Location

1.4. The Site is located south of Wootton Street, Waterloo, London. The Site is bounded by Wootton Street to the north, Greet Street to the east, a private road to the South and Windmill House (high rise residential bock of flats) to the west.

1.5. The area surrounding the site is predominantly residential use; Waterloo East Railway Station is located approximately 25m to the north of the Site. Waterloo Bus Garage is situation approximately 45m to the south-west of the Site. There is a variety of commercial offices shops, pubs and supermarkets in the vicinity of the Site.

1.6. The Site is currently occupied by the former "Coral Day Nursery", a single storey building adjacent to a 9-storey block of flats, Windmill House. There is hardstanding area covered with artificial turf for the children's playground located in the middle of the Site. There are approximately 8 parking bays located on the southern boundary off the private road frontage, and an open grass area located in the eastern extent of the Site.

1.7. The Site has a drop kerb vehicular access (crossover) from the gated private access road adjacent to the southern boundary of the Site which connects to Greet Street and Windmill Walk. There is a pedestrian footway along the north, east and southern boundaries of the Site.

1.8. The overall Site occupies an area of approximately 0.18ha and is centred on National grid reference 531423mE, 180019mN as shown in **Figure 1-1** below.

Figure 1-1: Site Location Plan

1.9. The Site approximately square in plan with ground levels generally sloping towards the south-west (**Figure 1-1**).

1.10. The topographical survey drawing (**Appendix A**), prepared by Laser Surveys in December 2019, shows that the Site slopes gently from the centre outwards, the highest level recorded (excluding the building and surface features) is 2.98m AOD at the north-east corner of the Site. The lowest ground level within the Site is 2.64m AOD and is shown in the south-western extent of the Site.

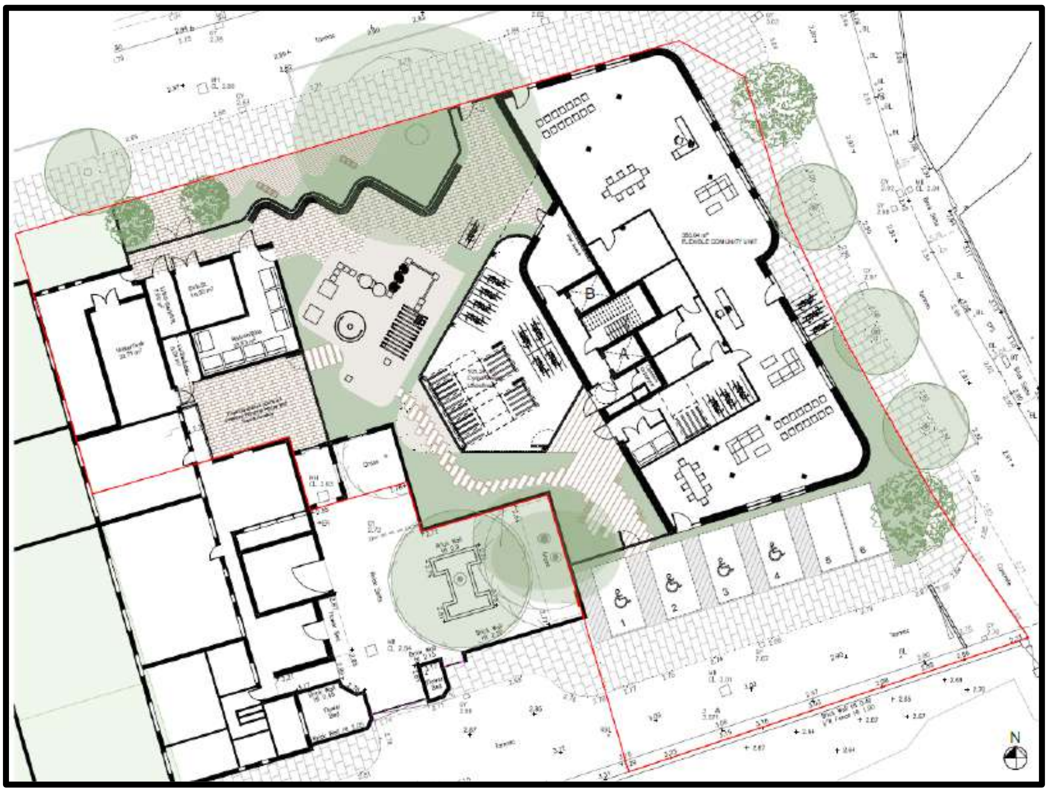
1.11. The topographic survey shows the existing building (Coral Day Nursery) has a floor threshold level of circa. 3.02m AOD. The survey shows trees located along the eastern; south-western and northern boundaries of the Site. There is also an open grass area in the eastern and northern extents of the Site.

Development Proposals

1.12. The proposed development comprises the demolition of the existing single storey building and the construction of a new 5, 8 & 10 storey building to provide a new community centre at the ground floor level and 36 residential units above. The development also includes landscaping, car parking and associated infrastructure works (**Figure 1-2**).

1.13. The proposed development layout is included in **Appendix B** and an excerpt of the ground floor plan is shown in **Figure 1-2** below.

Figure 1-2: Extract of Proposed Site Layout (ground floor)



2. POLICY CONTEXT

National Planning Policy Framework (February 2019)

2.1. The current version of the *NPPF* was published on 19 February 2019; paragraphs 155 to 165 inclusive establish the Planning Policy relating to flood risk management. The *Technical Guide to the NPPF* has been superseded by the *Planning Practice Guidance* (PPG) *Flood Risk and Coastal Change* in March 2014.

2.2. The main focus of the policy is to direct development towards areas of the lowest practicable flood risk and to ensure that all development is safe, without increasing flood risk elsewhere. The main considerations are:

- Applying the Sequential Test, and if necessary, apply the Exception Test;
- Safeguarding land from development that is required for current and future flood management;
- Using opportunities offered by new development to reduce the causes and impacts of flooding; and,
- Where climate change is expected to increase flood risk so that some existing development may not be sustainable in the long-term, seeking opportunities to facilitate the relocation of development, including housing, to more sustainable locations.

2.3. The *NPPF* states that a Flood Risk Assessment is required for all development in Flood Zones 2 and 3. In Flood Zone 1, an assessment should accompany all proposals involving:

- Sites of 1 hectare or more;
- Land which has been identified by the Environment Agency (EA) as having critical drainage problems;
- Land identified in a strategic flood risk assessment as being at increased flood risk in future; or

- Land that may be subject to other sources of flooding, where its development would introduce a more vulnerable use.

2.4. The Environment Agency's (EA) flood map for planning shows the Site is located in Flood Zone 3. Furthermore, the proposed development will include the introduction of impermeable areas (roofs and hardstanding) resulting in a runoff which will need to be managed to an acceptable level of risk to the Site and adjacent land. Hence a site-specific flood risk assessment is required for the proposed development.

Planning Practice Guidance Flood Risk and Coastal Change

2.5. The accompanying planning practice guidance to the NPPF provides additional guidance to local planning authorities to ensure the effective implementation of the planning policy set out in the National Planning Policy Framework on development in areas at risk of flooding.

2.6. The PPG provides supporting information on:

- The application of the sequential approach and Sequential and Exception Tests;
- Measures to reduce flood risk to acceptable levels;
- How to manage residual risks;
- Guidance on how to take climate change into account; and
- Guidance relating to SuDS drainage principles.

Sustainable Drainage Systems - Non-statutory technical standards for sustainable drainage systems March 2015

2.7. The Non-statutory technical standards for sustainable drainage systems were published in March 2015. This document sets out non-statutory technical standards for sustainable drainage systems. They should be used in conjunction with the Planning Practice Guidance. In addition, the LASOO Best Practice Guidance was issued in July 2015).

2.8. The Local Planning Authority (LPA) may set local requirements for planning permission that have the effect of more stringent requirements than these non-statutory technical standards.

2.9. In addition, SuDS should be designed in accordance with CIRIA 753 SuDS Manual, which represents current best practice.

The London Plan, The Spatial Development Strategy for London, Consolidated with Alterations Since 2011, March 2016

2.10. The London Plan is the overall strategic plan for London, setting out an integrated economic, environmental, transport and social framework for the development of London.

2.11. Policies within the London Plan which are relevant to flood risk and surface water management are as follows:

- Policy 5.3 – Sustainable design and construction;
- Policy 5.10 – Urban greening;
- Policy 5.12 – Flood risk management; and
- Policy 5.13 – Sustainable drainage

2.12. Policies 5.12 and 5.13 are the most relevant and applicable provisions.

2.13. A revised version of The London Plan 'Intend to Publish London Plan 2019' is currently being finalised and is available in draft form. The key policies in the intend to publish version of the London Plan relating to Flood Risk Management and Sustainable Drainage are Policies SI 12 and Policy SI 13 respectively. Although rewritten these policies cover very similar requirements. One notable point raised within the new Sustainable Drainage Policy is the statement that "development proposals for impermeable surfacing should normally be resisted unless they can be shown to be unavoidable, including on small surfaces such as front gardens and driveways".

Local Planning Policy

2.14. In the preparation of this report, specific reference is made to the following regional and local planning policy pertinent to flood risk:

- Emerging Lambeth Local Plan (2020);
- London Borough of Lambeth Preliminary Flood Risk Assessment (PFRA) (June 2011);
- London Borough of Lambeth Strategic Flood Risk Assessment (SFRA) (March 2013);
- London Borough of Lambeth Surface Water Management Plan (March 2011).

2.15. The Emerging Lambeth Local Plan sets out the vision, objectives, strategy and policies that will guide public and private sector investment to manage development and regeneration in the Borough over 15 years. The Emerging Local Plan is about shaping the future of the borough as a better place to live and sets out planning policies to guide the growth in housing up to 2035.

2.16. Within the Lambeth Local Plan Policy EN5 Flood Risk sets out the local policy on flood risk. This policy generally mirrors the requirements of the NPPF and the London plan. Likewise, policy EN6 covers local policy in relation to Sustainable Drainage Systems and Water Management and confirms that the national standards must be applied within Lambeth.

2.17. The Preliminary Flood Risk Assessment (PFRA) for the London Borough of Lambeth, prepared by URS / Scott Wilson in 2011, is a high-level screening exercise that compiles information on significant local flood risk from past and future floods. According to the PFRA, the study has not identified any past floods in the vicinity of the site that are considered to have had significant harmful consequences, but future flood risk is estimated to be high in the Borough.

2.18. The Lambeth Strategic Flood Risk Assessment (SFRA), prepared by URS in 2013, provides an overview of flood risk in the Borough from all potential sources and to inform flooding policies including the allocation of land for development. The report provides an assessment of the level of flooding geographically and outlines the constraints of flooding on future development proposals.

2.19. Appendix A of the SFRA includes a set of flood risk plans which provide a spatial indication of recorded flooding incidents and areas considered to be at risk of flooding from various sources. Relevant maps from the SFRA include;

• Figure 8 – Thames Water DG5 Register Sewer Flooding Incidents; and

• Figure 9 – Susceptibility to Groundwater Flooding.

2.20. These maps are referenced within section 4 of this site-specific flood risk assessment which considers the different sources of flooding in turn.

2.21. The Level 2 aspect of the SFRA focuses on the Vauxhall and Waterloo areas within the north of Lambeth where tidal flood risk in the event of a flood defence breach is significant. The methodology for application of the sequential test and advice in relation to flood risk management set out in the SFRA is discussed within the relevant sections of this report.

2.22. An SFRA Addendum has also been prepared to incorporate updated Environment Agency Thames Tidal Breach Modelling (2017). The Addendum provides flood hazard mapping for the current day and 2100 epoch flood defence breach scenarios.

2.23. The Lambeth Surface Water Management Plan (SWMP) prepared by URS / Scott Wilson in 2011, was produced to outline the preferred surface water management strategy at a local level. The report also establishes a long-term action plan to manage surface water and how any capital works will be financed and maintained.

2.24. The approach adopted by the SWMP involves identifying, defining and prioritising Critical Drainage Areas, including further definition of existing local flood risk zones and mapping new areas of potential flood risk. A Critical Drainage Area (CDA) is defined as a discrete geographic area and usually a hydrological catchment, where multiple and interlinked sources of flood risk (surface water, groundwater, sewer, main river and/or tidal) cause flooding in one or more Local Flood Risk Zones. Local Flood Risk Zones (LFRZs) are discrete areas/extents of predicted surface water flooding.

2.25. The Site is located within a Critical Drainage Area 'Group7_034' – Waterloo Station in the northern extent of the Lambeth Borough Administrative boundary.

Sequential Test Requirements

2.26. The purpose of the sequential test is to "steer new development to areas with the lowest risk of flooding. Development should not be allocated or permitted if there are reasonably available sites appropriate for the proposed development in areas with a lower risk of flooding… The sequential approach should be used in areas known to be at risk now or in the future from any form of flooding."

2.27. The NPPF states that, should it not be feasible for development to be located within an area of lower flood risk, the exception test may have to be applied depending upon the flood zone and development vulnerability as per Table 2 of the Planning Practice Guidance.

Exception Test Requirements

2.28. The NPPF states that a Flood Risk Assessment is required "for proposals of 1 hectare or greater in Flood Zone 1; all proposals for new development (including minor development and change of use) in Flood Zones 2 and 3, or in an area within Flood Zone 1 where proposed development or a change of use to a more vulnerable class may be subject to other sources of flooding."

2.29. For the NPPF Exception Test to be passed:

- *"the development would provide wider sustainability benefits to the community that outweigh the flood risk; and*

- *the development will be safe for its lifetime taking account of the vulnerability of its users, without increasing flood risk elsewhere, and, where possible, will reduce flood risk overall. "*

2.30. Both elements of the exception test should be satisfied for development to be allocated or permitted.

2.31. According to Table 3 (refer to **Table 2-1** below) of the Planning Practice Guidance, the proposed residential development for the Site is classified as 'More Vulnerable'. The Site, which is located in Flood Zone 3, is therefore required to undergo the Sequential and Exception Tests. It is understood that this has been undertaken by others. This Flood Risk Assessment will act as evidence to satisfy the second part of the Exception Test.

Table 2-1: Extract from the PPG - Table 3: Flood Risk Vulnerability

Flood risk vulnerability classification (see table 2)		Essential infrastructure	Water compatible	Highly vulnerable	More vulnerable	Less vulnerable
Flood zone (see table 1)	Zone 1	✓	✓	✓	✓	✓
	Zone 2	✓	✓	Exception Test required	✓	✓
	Zone 3a	Exception Test required	✓	×	Exception Test required	✓
	Zone 3b functional floodplain	Exception Test required	✓	×	×	×

Key: ✓ Development is appropriate.
× Development should not be permitted.

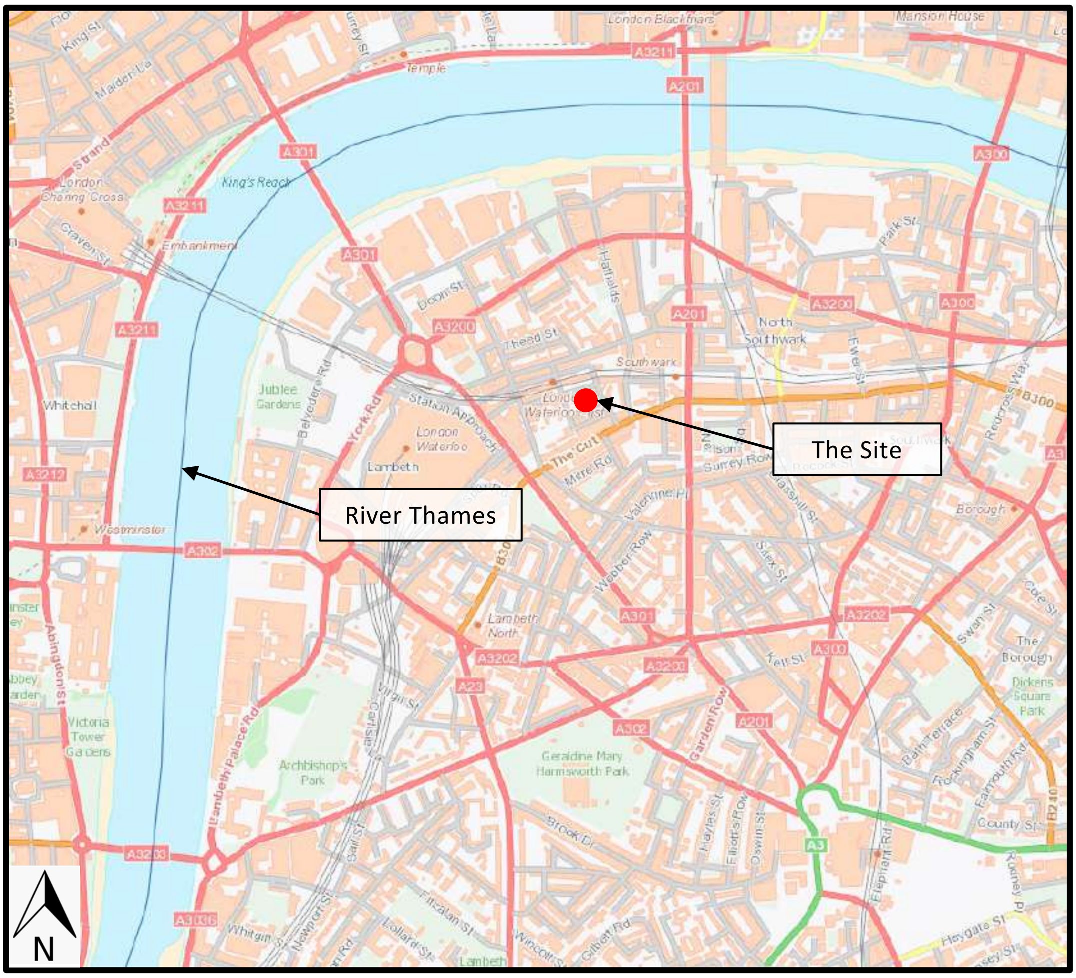
3. BASELINE

Hydrology

3.1. The EA online main river mapping shows there are no main rivers within or near to the Site (**Figure 3-1**). The nearest watercourse is the River Thames located approximately 0.5km to the north of the Site. The online mapping shows no surface water features (e.g. ordinary watercourses, canals, ponds, lakes or reservoirs) located within or near to the Site.

3.2. The lack of open watercourses within land surrounding the Site indicates the high likelihood of culverted watercourses and large diameter sewers in the area.

Figure 3-1: Hydrology



Contains OS data © Crown Copyright and database right 2020

Ground Conditions

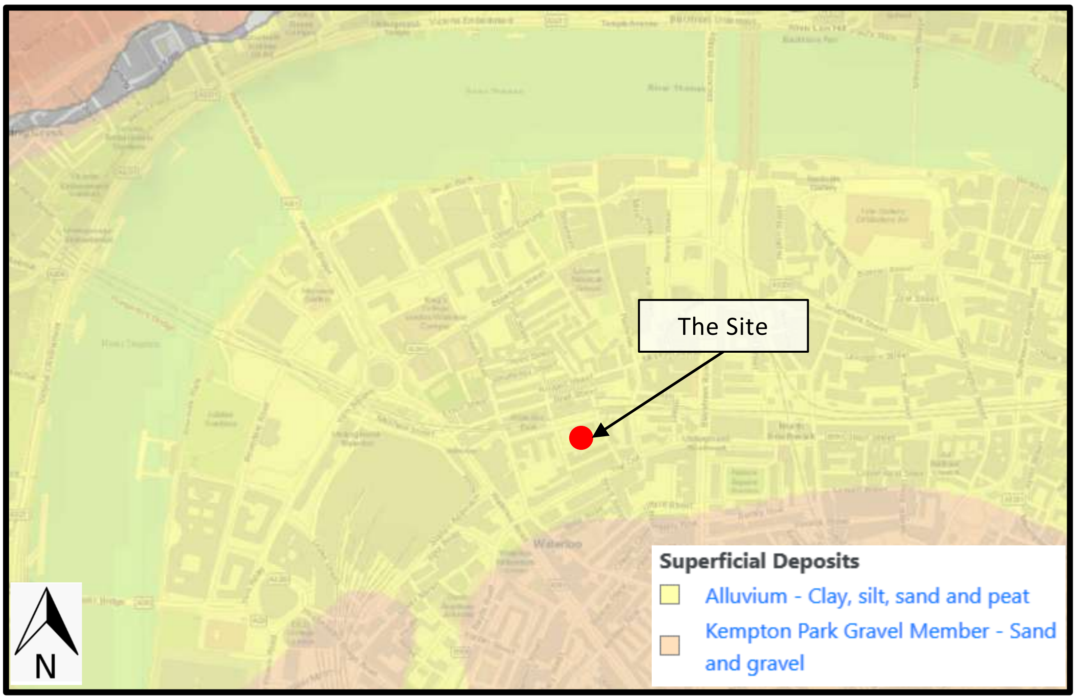
3.3. Soil mapping provided on the Cranfield Soil and AgriFood Institute website 'Soilscapes viewer', shows the Site and adjacent land is underlain with 'loamy and clayey soils of coastal flats with naturally high groundwater' (**Figure 3-2**).

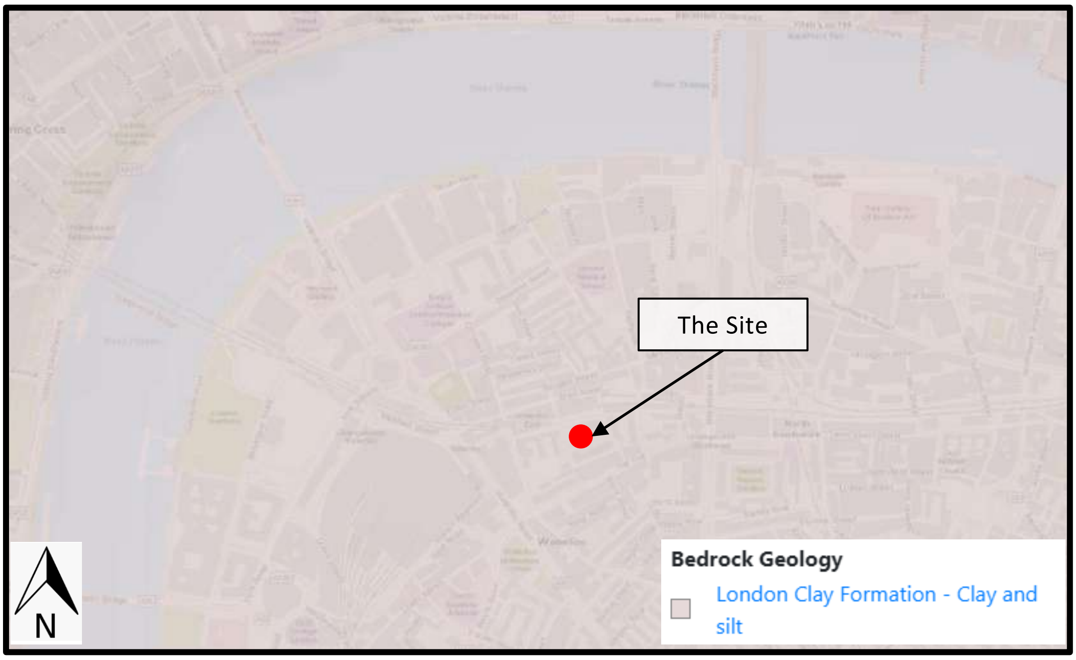
Figure 3-2: Soil Type

Soils Data © Cranfield University (NSRI) and for the Controller of HMSO [2020]

3.4. The British Geological Survey (BGS) online mapping (**Figure 3-3**) shows the Site resides on 'Alluvium – Clay, silt, sand and peat' superficial deposits. The underlying bedrock is the 'London Clay Formation - Clay and silt'.

Figure 3-3: BGS Online Superficial and Bedrock Mapping





Top: Superficial Deposits; **Bottom**: Bedrock. Contains British Geological Survey materials © UKRI [2020]. Contains Ordnance Survey data © Crown copyright and database right 2017

3.5. The BGS online borehole mapping (**Figure 3-4**) shows numerous boreholes located nearby the Site. One of the nearest available historic borehole logs (TQ38SW2168) is situated near the junction between Windmill Walk and Wootton Street, approximately 35m to the west of the Site and is approximately 19m deep. The soil and geological profile description of the borehole comprises 8.2m thick Sand and Gravel superficial deposits overlain on >11.3m depth of clay (**Table 3-1**). The borehole logs have been included in **Appendix C** for reference.

Figure 3-4: BGS Online Borehole Mapping

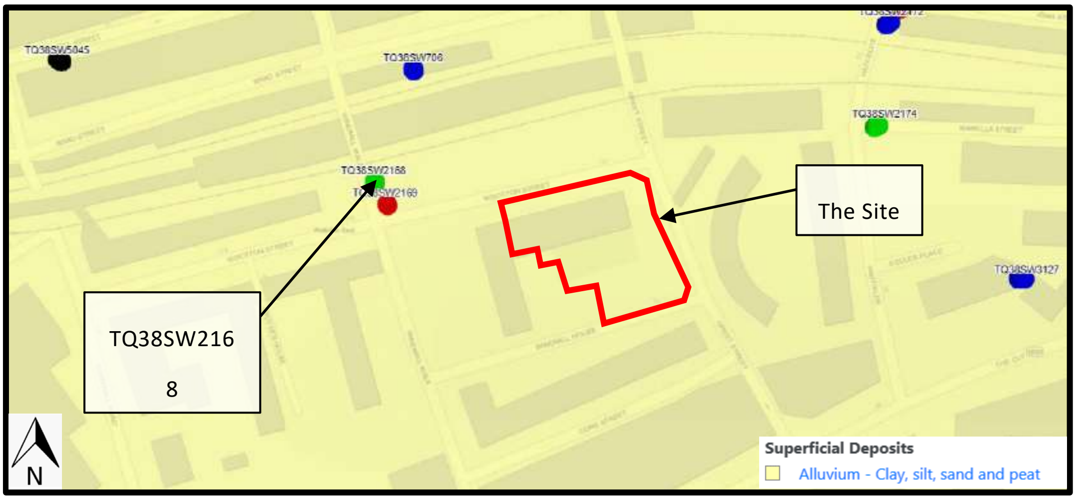


Table 3-1: BGS Borehole Log Summary

Borehole log id	Profile description (meters below ground level (mbgl))	Groundwater encountered
TQ38SW2168	0.00 – 0.05: Paving Slabs 0.05 – 0.16: yellow-brown coarse sand (made ground) 0.16 – 2.00: grey brown clayey fine to coarse sand, fine to coarse gravel, brick and concrete fragments (made ground). 2.00 – 3.80: grey brown mottled clay with wood fragments, coarse sand and coarse gravel sized brick fragments (made ground). 3.80 – 5.20: Brown fine to coarse sand with flint gravel and occasional pockets of grey-brown clay (Terrace gravels and made ground). 5.20 – 9.60: grey brown medium and coarse sand and coarse flint gravel (Terrace Gravells). 9.60 - 19.50: London Clay	Yes, groundwater seepage at 4.00mbgl

3.6. The Site is not located within a Groundwater Source Protection Zone. These zones help to monitor risk of contamination from any activities that might cause pollution to the groundwater source.

Existing Sewer Infrastructure

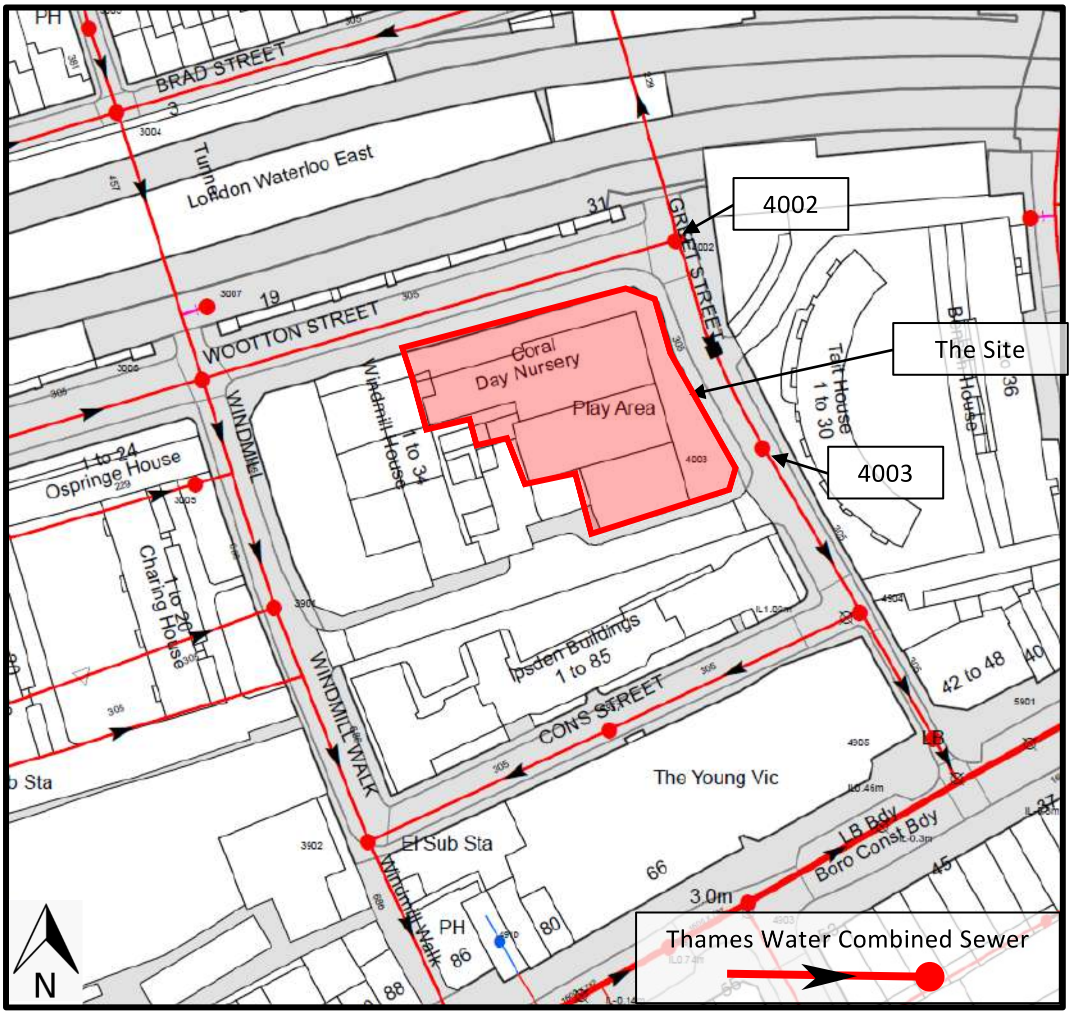
3.7. An extract from Thames Water sewer asset plans show there are no public sewers located within the Site (**Figure 3-5**). To the north of the Site there is a 305mmØ combined sewer flowing east to west within the carriageway of Wootton Street. To the east of the Site there is a 305mmØ combined sewer flowing north east to south west which is located within the carriageway of Greet Street.

3.8. The nearest downstream manhole east of the Site is 4003 located adjacent to the south east corner of the Site within the carriageway of Greet Street.

3.9. The topographical survey shows 3 manholes along the western boundary and 5 in the north-east corner of the Site. The survey also shows 2 surface water gullies in the hardstanding area in the south and south-west extent of the Site and 5 along the northern boundary of the Coral Day Nursery. These on site surface water drainage features do not appear on public sewer asset plans and are likely to be private drainage serving the Site.

3.10. Refer to **Appendix D** for Thames Water asset plan and correspondence from Thames Water and **Appendix A** for Topographical Survey.

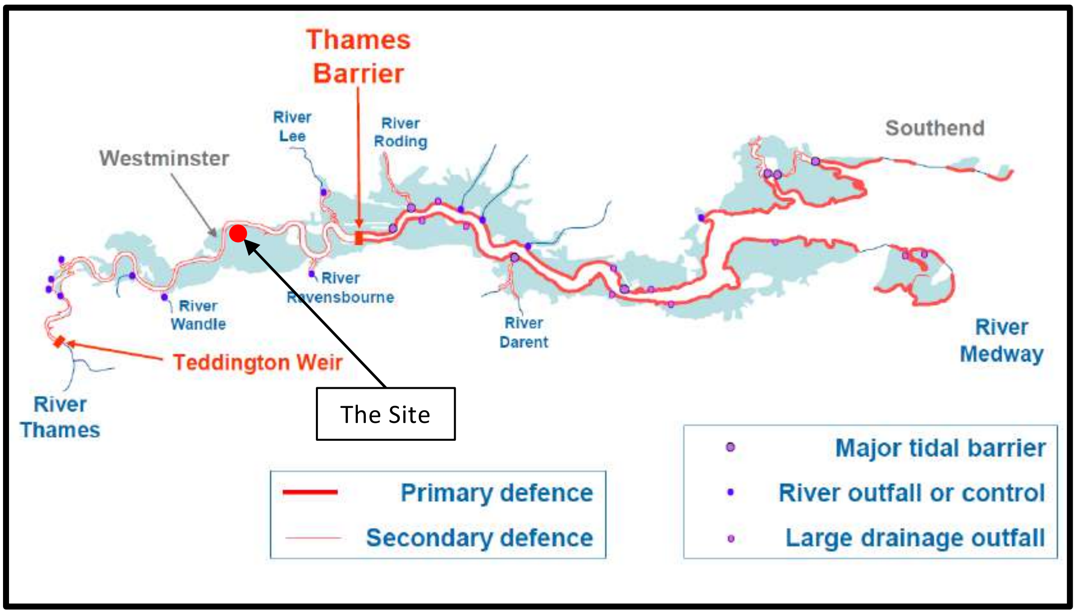
Figure 3-5: Extract of Thames Water Sewer Asset Plan



Flood Defences

3.11. As indicated in **Figure 3-6** the Site benefits from tidal and fluvial flood defences (wall) along both banks of the River Thames up to the Thames Barrier situated approximately 14.8km downstream from the Site. The SFRA states these defences are designed to defend against the 1 in 1,000-year event to the year 2030. However, these defences continue to provide a 1 in 1,000-year event standard of protection for tidal surge until about 2070 based on sea level rise projections used in the Thames Estuary 2100 Project (TE2100 report).

Figure 3-6: The Thames River Tidal Flood Risk Management System



Environment Agency Flood Model Data

3.12. Ardent have written to the Environment Agency (EA) in order to request detailed flood extent and level data. This information provides the most up to date modelled flooding information for tidal flooding from the Thames Estuary and includes breach modelling. A full copy of the information provided by the EA is included within **Appendix E**, and a summary is provided below.

3.13. Tidal flood risk information has been taken from the TE2100 Extreme Water Levels data (provided by the EA) based on the Thames Estuary 2100 study completed by HR Wallingford in 2015. Current day in-channel extreme flood levels at the nearest node to the Site (2.33 – modelled) are 4.83m AOD. As the Site is located upriver of the Thames Barrier the extreme flood level relates to the level at which the river is maintained by operation of the barrier and does not therefore relate to a given return period. It is anticipated that the effects of climate change will require the Thames Barrier to be closed on an increasingly frequent basis and therefore it will be necessary to increase the maximum allowable water level upstream of the barrier to limit the frequency of closures. By 2100 the extreme flood level at the same location in the Thames is predicted to increase to 5.79m AOD.

3.14. The Site currently benefits from tidal flood defences along the River Thames which provide a level of protection up to the 0.1% AEP level and therefore the Site is currently only at residual risk of tidal flooding as a result of a breach of the flood defences or overtopping of the defences by a storm event which exceeds the crest level (for example a storm less likely than the 0.1% AEP event).

3.15. Site specific flood levels have been provided by the EA which have been taken from the Thames Tidal Upriver Breach Inundation Modelling Study 2017 which was completed by Atkins Ltd. The EA has identified ten node points within and around the Site (**Figure 3-7**) and have provided predicted flood levels during current day and climate change events for each node (**Table 3-2**).

Figure 3-7: Extract of EA Node Points Location

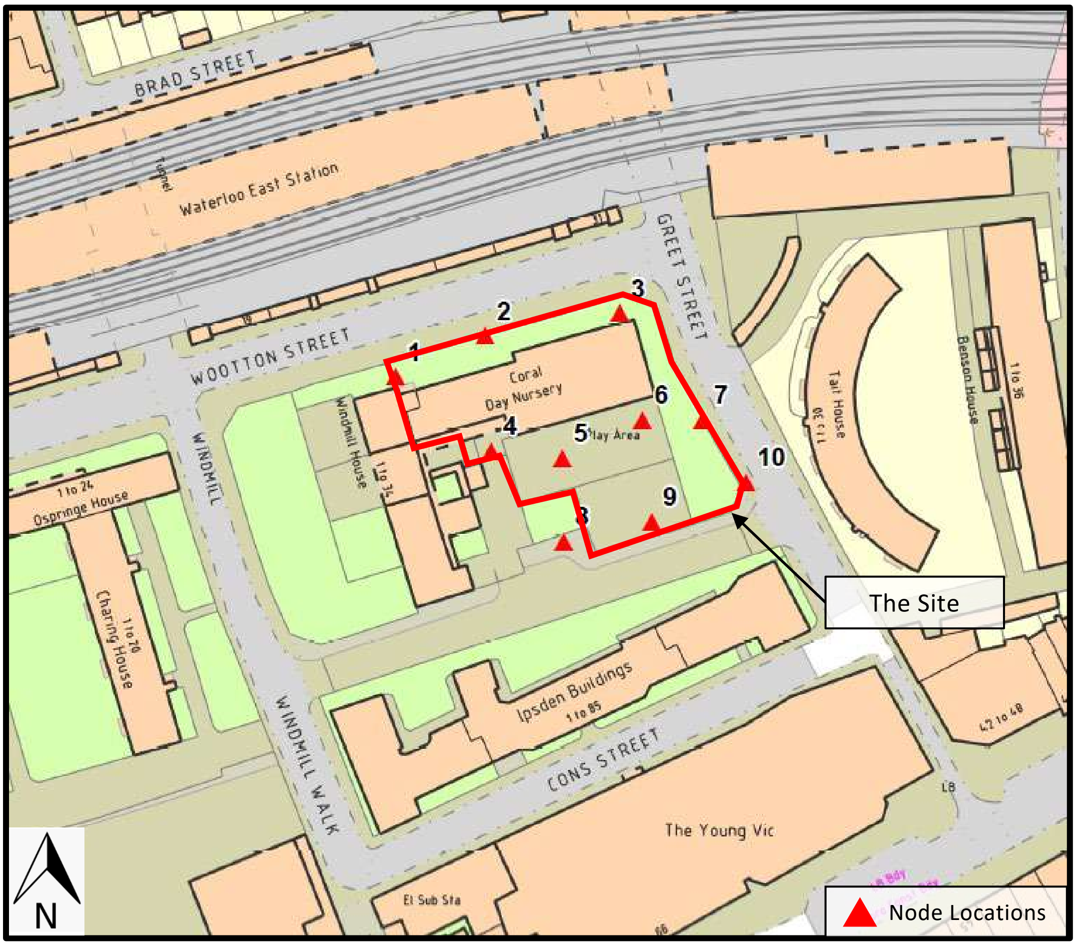


Table 3-2: Tidal Defence Breach Levels

Node ID	Modelled Levels in for Max likely Water Level (m AOD)	
	2014	2100
1	2.81	4.31
2	2.81	4.31
3	2.81	4.31
4	No value	4.31
5	No value	4.31
6	No value	4.31
7	No value	4.31
8	No value	4.31
9	No value	4.31
10	No value	4.30

3.16. The data in **Table 3-2** indicates that the northern edge of the Site could flood to a maximum depth of approximately 0.17m as a consequence of flood defences being breached in the current day extreme scenario. This is based on a predicted maximum flood water level of 2.81m AOD and the lowest current a ground level within the Site (2.64m AOD). Most of the Site however is above the current day predicted breach water level.

3.17. When the anticipated rise in tidal water levels up to the year 2100 are taken into account, the flood water resulting from a breach is expected to reach the Site with a maximum water level of 4.31m AOD. Comparing the breach levels above against the lowest current a ground level within the Site (2.64m AOD) it can be seen that the 2100 breach represents a flood depth of up to approximately 1.67m deep.

3.18. Mapping showing flood depth, velocity and hazard rating at the Site in the event of a defence breach has been provided by the EA. The Flood Hazard mapping relates to the 2100 (climate change) scenario and is shown in **Figure 3-8** below. A full-size copy of the mapping is also included in **Appendix E**. The flood hazard mapping confirms flood depths up to 1.5 – 2.0m; flood velocity up to 0.3 – 1.0m/s and a flood hazard rating of "Danger for Most" at the Site location. Land to the east of the Site is shown at similar hazard rating whereas land to the west and south indicates a higher hazard.

3.19. However, the flood hazard rating within the Site (post development) will depend upon the ground level designed as part of the scheme.

Figure 3-8: Extract of Breach scenario 2100 – Flood Depth, Velocity and Hazard Mapping

4. SOURCES OF FLOODING

4.1. The NPPF requires flood risk from the following sources to be assessed, each of which are assessed separately below:

- Tidal sources (flooding from the sea);
- Fluvial sources (river flooding);
- Pluvial sources (flooding resulting from overland flows);
- Groundwater sources;
- Sewer surcharge;
- Artificial sources, canals, reservoirs etc; and
- It also requires the risk from increases in surface water discharge to be assessed (surface water management).

Tidal/Fluvial Flooding

4.2. Tidal flooding can occur in low lying land from the sea and tidal estuaries, caused by storm surges and high tides. Where tidal defences exist, they can be overtopped or breached during severe storms, which may become more likely with climate change.

4.3. Fluvial flooding occurs when the capacity for a watercourse is exceeded typically during times of heavy rainfall. The Environment Agency (EA) distinguish between 3 different flood zones as described below:

- Flood Zone 1 is land assessed as having a less than 1 in 1,000 annual probability of river or sea flooding (<0.1%);
- Flood Zone 2 is land assessed as having between a 1 in 100 and 1 in 1,000 annual probability of river flooding (1% – 0.1%), or between a 1 in 200 and 1 in 1,000 annual probability of sea flooding (0.5% – 0.1%) in any year; and
- Flood Zone 3 is land assessed as having a 1 in 100 or greater annual probability of river flooding (>1%), or a 1 in 200 or greater annual probability of flooding from the sea (>0.5%) in any year.

4.4. The EA flood map for planning shows the Site is located within Flood Risk Zone 3 (**Figure 4-1**). The Site is therefore considered to have a high annual probability of sea/tidal flooding (greater than 0.5%).

Figure 4-1: Extract of EA Flood Risk from Rivers or Tidal Maps

4.5. The EA flood Risk map for planning shows the extent of the flood zones assuming that there are no flood defences in place. However, the EA flood map confirms that the Site benefits from flood defences along the banks of the River Thames and the Thames Barrier.

4.6. Existing flood defences protect the Site against tidal flooding up to the 0.1% AEP event. There remains a residual risk of flooding at the Site from tidal sources. The residual risk relates to the possibility of flood defences failing as a consequence of a breach or an extreme event leading to overtopping. It should be noted that a failure of flood defences does not lead to flooding as extensive as that which would occur if flood defences were not present at all as shown on the EA flood risk map for planning.

4.7. As discussed in **Section 3** of this report, breach model data provided by the EA shows that the northern edge of the Site is predicted to flood to a maximum level of 2.81m AOD should the defences be breached during the current day extreme event scenario. The 2100 epoch (climate change) breach scenario flood level increases to a maximum of 4.31m AOD. The flood hazard rating for the 2100 epoch is "Danger for Most".

4.8. Whilst it is considered unlikely that the site will flood from tidal sources, since the existing defences provide protection up to the 1 in 1,000-year event under normal circumstances, the potential impact of a failure of the defences is significant. Mitigation measures are therefore necessary in order to manage the residual risk of tidal flooding.

4.9. As part of the development of the Site, the Fluvial and Tidal flood risk can be mitigated through the following approaches:

- Adoption of a sequential approach to set more vulnerable uses, such as residential dwellings at first floor level and above.
- Set finished floor levels for the residential units above the 2100 breach flood level at a minimum level of 4.31m AOD.
- Preparation of a Flood Response Plan.
- Sign up to EA flood warnings and establish a flood management protocol so that residents know what to do in the event of a flood warning.
- Use flood resilient construction at ground floor level.

4.10. Subject to the implementation of these mitigation measures the Site is considered to be at an acceptable level of risk from tidal flooding.

Pluvial Flooding

4.11. Pluvial (or Surface water) flooding is caused when the volume of rainwater falling to the surface does not drain away through the existing drainage systems or soak into the ground. Instead this water flows over the ground surface pooling in low lying areas. This is exacerbated by highly impermeable urban development or low permeability soils and geology (such as clayey soils).

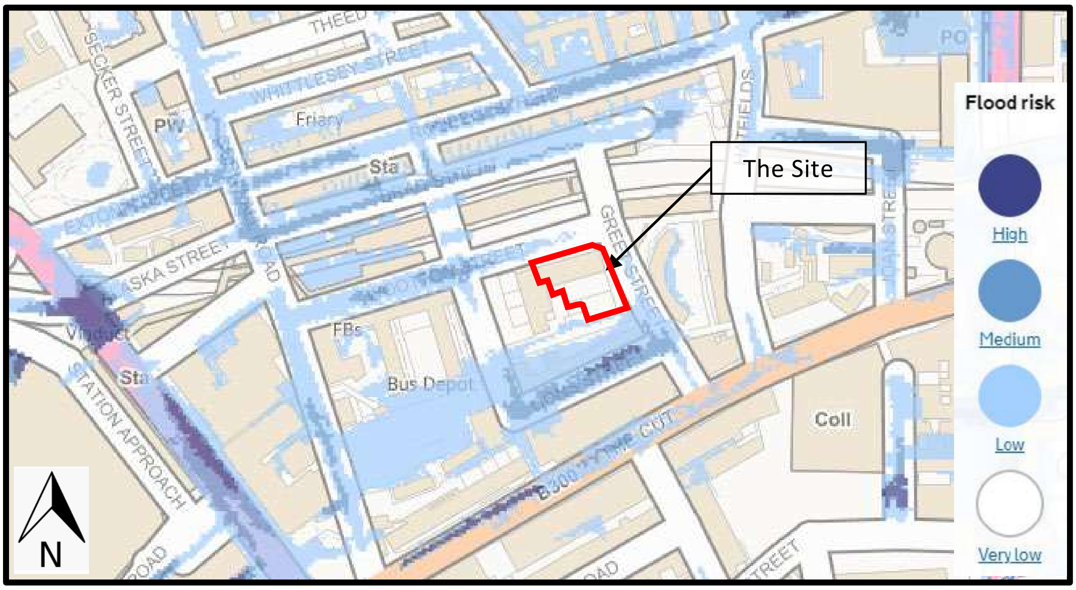
4.12. The SFRA surface water flood risk maps are too coarse and the scale is too small to define the surface water flood risk at the Site. As such, the Environment Agency's flood risk from surface water mapping will be used to assess the Site.

4.13. The EA distinguishes between four levels surface water flood risk as defined below:

- Very low risk is defined as an area of land which has an annual chance of flooding or Annual Exceedance Probability (AEP) of less than 0.1%;
- Low risk is defined as an area of land which has an AEP between 0.1% and 1%;
- Medium risk is defined as an area of land which has an AEP between 1% and 3.3%; and
- High risk is defined as an area of land which has an AEP greater than 3.3%.

4.14. The EA flood risk from surface water online mapping shows that the Site is at very low risk of surface water flooding. As shown in **Figure 4-2** below, there is a low risk surface water flow pathway adjacent to the Site's southern boundary within the carriageway of the adjacent Private Road. Similarly, there is low and medium risk, surface water flow pathway within Greet Street and Wootton Street, adjacent to the eastern and northern boundaries of the Site. The EA online flood mapping shows the surface water depth at this location is between 300 and 900mm.

Figure 4-2: Extract of Surface Water Flood Maps for Planning



4.15. Historic surface water flood events are provided in figure 1 in the PFRA and figure D-2 in the SWMP. These figures show no surface water flooding incidents within or near to the Site; the nearest incident is located circa. 750m south-west of the Site.

4.16. As indicated in **Figure 4-2** safe access and egress to the Site, away from potential surface water flooding can be achieved from Greet Street (very low risk, low risk and medium risk).

4.17. As part of the development of the Site, the surface water flood risk can be further reduced through the following approaches:

- Ensure the surface level of the Site adjacent to the private road, Greet Street and Wootton Street is a minimum of 150mm, or kerb height above the road surface level to prevent the ingress of surface water runoff into the Site.
- Managing runoff from the built development through an appropriately designed and maintained surface water drainage scheme.
- Setting finished floor levels for the ground floor at least 150mm above the external ground levels.

4.18. Subject to the implementation of the mitigation measures above the Site is at very low risk of surface water flooding.

Groundwater Flooding

4.19. The BGS defines groundwater flood risk as the emergence of groundwater at the ground surface (ignoring perennial river channels), or into man-made ground above the 'normal' groundwater level. Typically, areas affected by groundwater flooding may take weeks or months to dissipate.

4.20. The susceptibility of an area to groundwater flooding is largely dependent on the presence of permeable ground conditions. In the local context this is generally where perched groundwater is present in permeable superficial deposits. Nearby borehole logs confirm sand and gravel in the superficial deposits, which are in turn underlain by clay and the London Clay Formation bedrock (impermeable strata) with low permeability. Groundwater seepage was encounter in the nearby borehole log at a depth of 4 meters below ground level.

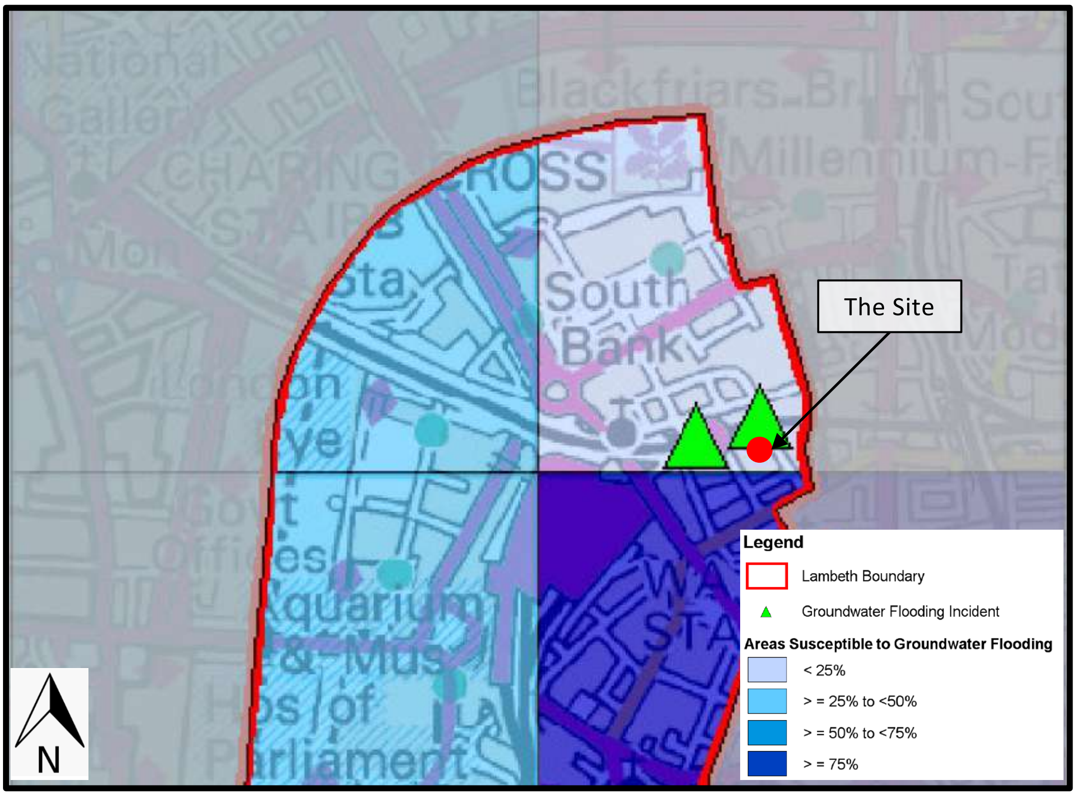
4.21. The SFRA states that there is limited information regarding historical instances of groundwater flooding within the Borough and information available is anecdotal. Figure 9 appended to the SFRA shows the level of susceptibility of land to groundwater flooding across the Borough (**Figure 4-3**). An extract from the SFRA mapping shows the Site resides in a 1 km grid square area in which '<25% of land is susceptible to groundwater flooding', although the Site is near to the boundary of the adjacent area in which >75% of land is susceptible to groundwater flooding.

4.22. The groundwater susceptibility flood mapping is coarse and the scale is too small to define the groundwater flood risk for the Site. In order to better understand any localised groundwater in the Site a Site-specific investigation would be advised.

4.23. As indicated in **Figure 4-3** and in the 'Lambeth Surface Water Management Plan: Intermediate Assessment of Groundwater Flooding Susceptibility' (March 2011) there are two historic groundwater flooding incidences near to the Site; both of these incidences refer to flooded basements in private homes on the north side of the Waterloo East Station (TQ3130180072 and TQ3142080110) on the 30 March 2001 and 23 January 2003.

4.24. EA long term monitoring of boreholes records within Lambeth between 1985 and 2009 show no measured groundwater levels within the first 5m meters.

Figure 4-3: SFRA Extract Areas Susceptible to Groundwater Flooding



4.25. As part of the development of the Site, the groundwater flood risk will be reduced through the following approaches:

- Setting of finished floor levels for the ground floor at least 150mm above the external ground levels.
- Limiting construction of the residential units to above-ground (i.e. no basements).

4.26. With the inclusion of these mitigation measures the Site is at very low risk of groundwater flooding.

Sewer Flooding

4.27. In urban areas, rainwater is frequently drained into surface water sewers or sewers containing both surface and wastewater known as 'combined sewers'. Flooding can occur if the sewer has inadequate capacity, becomes blocked, or as a result of structural failure.

4.28. The SFRA provides historic sewer flooding information which has been taken from Thames Water's DG5 flood register. Historic sewer flooding is presented on Figure 8 appended to the SFRA which shows the number of properties affected internally by sewer flooding per postcode area over the 10-year period running up the publication of the SFRA in 2013. The records show that there were 0 to 5 records of sewer related flooding in the post code area of the Site, during the period.

4.29. Modern sewer systems are typically designed to accommodate rainfall events with a 1 in 30-year return period. Older sewer systems were often constructed without consideration of a design standard therefore some areas of The London Borough of Lambeth may be served by Victorian sewers with an effective design standard of less than 1 in 30 years.

4.30. Thames Water sewer asset plans show there are no public sewers located within the Site (**Figure 3-5**). To the north of the Site there is a 305mmØ combined sewer flowing west along Wootton Street. To the east of the Site, a 305mmØ combined sewer flows in a south-easterly direction within the carriageway of Greet Street.

4.31. A combined sewer network generally poses a higher risk of flooding than a system comprising of separate foul and surface water networks.

4.32. In the event of a sewer surcharging, the resulting flood flow route would be similar to that of surface water flooding. It is therefore likely that sewer flooding could be contained within the highway of Greet Street and Wootton Street and flow away from the Site, provided that suitable raised ground levels are set as part of the development.

4.33. As part of the development of the Site, the sewer flood risk will be mitigated through the following approaches:

- Ensuring the surface level of the Site, adjacent to the private road, Greet Street and Wootton Street, is a minimum of 150mm or kerb height above the road surface level to prevent the ingress of flows from surcharging sewers.
- Managing runoff from the built development through an appropriately designed and maintained surface water drainage scheme.
- Setting finished floor levels for the ground floor at least 150mm above the external ground levels.

4.34. Subject to the inclusion of the above mitigation measures the Site is at very low risk of flooding from sewers.

Finished Floor Levels

4.35. Finished floor levels for the residential units (more vulnerable) to be set above the 2100 breach flood level at a minimum level of 4.31m AOD.

4.36. Setting finished floor levels for commercial development (less Vulnerable use) at ground floor to be at least 150mm above the external ground levels.

4.37. It is proposed that all less vulnerable development will be located at ground level and more vulnerable at first floor and above.

4.38. The above approach ensures that all residential development is well above the 2100 breach flood level of 4.31m AOD.

Safe Access and Egress

4.39. Whilst safe refuge will be provided above the maximum breach level, maximum likely water level (MLWL) it is considered necessary to provide safe access and egress from the site where excavation is considered possible and time allows. However, the advice of the emergency services to be taken on the day.

4.40. Safe access and egress are required to enable the excavation of people from the development, provide the emergency services with access to the development during times of flood.

4.41. Safe access and egress must be provided for the development in order of preference as follows;

i) Safe dry route for people and vehicles,

ii) Safe dry route for people.

iii) If a dry route for people is not possible, a route for people where the flood hazard (in terms of depth and velocity of flooding) is low and should not cause risk to people.

iv) If a dry route for vehicles is not possible, a route for vehicles where the flood hazard (in terms of depth and velocity of flooding) is low to permit access for emergency vehicles. However, the public should not drive vehicles in floodwater.

4.42. Pedestrian access and egress is afforded via Greet Street, The Cut, Baylis Road, Kennington Road and Kennington Park Road to the South(if time permits and if advised by the emergency services). Refer to **Appendix K** for more information.

Flood Response Plan (FRP)

4.43. In the event of a breach, it is important to ensure the warning systems are in place and responsibility is assigned to be able to quickly deal with a flood event. The flood response plan outlines the flood warnings, responsibilities and safe access and egress routes from the site. However, the advice of the emergency services should be taken on the day. Refer to **Appendix K** for the Response Plan.

Artificial Sources

4.44. Artificial sources include any water bodies not covered by the previous categories. This typically includes canals, lakes, reservoirs etc.

4.45. The EA Flood Risk from reservoirs map indicates that the Site is not within a location where land could be affected as a result of a reservoir breach. No other significant artificial sources of flooding within the Site vicinity have been identified.

Current Flood Risk and Residual Flood Risk

4.46. The potential sources of flood risk to the Site have been identified and discussed in the preceding paragraphs in Section 5 of this report, along with potential mitigation measures to reduce the flood risk to an acceptable level. **Table 4-1** below summaries the potential sources of flood risk to the Site and the residual flood risks after the implementation of these flood risk management and mitigation measures.

Table 4-1: Flood Risk Summary

Flood Risk	Potential Source	Flood Risk Before Management and Mitigation Measures	Residual Flood Risk After Management and Mitigation Measures
Tidal (Sea)	River Thames Estuary	High	Low
Fluvial	River Thames Estuary	Low	Very Low
Pluvial (Surface Water)	Surface water flow pathway in the private road, Greet Street and Wootton Street. Surface water runoff from proposed development	Low	Very Low
Groundwater	Perched groundwater in superficial deposits.	Low	Very Low
Sewer	Thames Water public combined sewers in carriageway of Jonathan Street and Vauxhall Walk.	Low	Very Low
Artificial	None Identified	Not Significant	Not Significant

5. SURFACE WATER MANAGEMENT

Existing Surface Water Drainage Discharge

5.1. The Site is a brownfield site with an approximate developable area of 0.137ha. The Site is currently occupied by the former "Coral Day Nursery", a single storey building adjacent to a 9-storey block of flats, Windmill House. The topographical survey indicates 5 inspection chamber covers located throughout the Site, which suggests the Site is currently served by private sewer assets, which it is assumed to discharge into the public combined sewers adjacent to the Site.

5.2. The current hardstanding area of the Site includes the roof area of the existing nursery, a hard-surfaced play area and parking bays which amounts to a combined area of 0.095ha.

5.3. The Modified Rational Method has been used to estimate the current surface water discharge rate from the hardstanding area considered in the drainage strategy (0.095ha) as shown below.

$Q = 2.78 \times C \times i \times A$, where

Q = Peak Discharge (l/s)

i = Rainfall intensity (mm/hr) (FEH 60-minute duration storm)

A = Impermeable Area (ha)

C = Run-off coefficient

5.4. Therefore, based on the Modified Rational Method, peak run-off rates generated from the developable area for the 1 in 1 year, 1 in 2 year, 1 in 30 year and 1 in 100-year, 60 minute duration storm are as presented in **Table 5-1**. A copy of the calculation is provided in **Appendix F**.

Table 5-1: Existing Brownfield Surface Water run-off rates

Area (ha)	Surface Water Run-off (l/s)			
	1 in 1-year	1 in 2-year	1 in 30-year	1 in 100-year
0.095	2.4	3.13	9.76	13.09

5.5. The greenfield run-off values for the Site (0.137ha) were calculated using MicroDrainage ICP-Suds method (recommended for drainage areas <50ha); **Table 5-2** summaries the greenfield run-off rate for the Site and a copy of the MicroDrainage results can be found in (**Appendix F**).

Table 5-2: Greenfield Surface Water run-off rates

Area (ha)	Surface Water Run-off (l/s)				
	Qbar	1 in 1-year	1 in 2-year	1 in 30-year	1 in 100-year
0.137	0.2	0.2	0.2	0.5	0.7

Potential Sustainable Drainage Systems (SuDS)

5.6. **Table 5-3** appraises the constraints and opportunities for the use of SuDS techniques within the Site and it adopts the management train approach outlined in CIRIA C753 'The SuDS Manual'.

Table 5-3: CIRIA C753 SuDS Management Train Approach

Type:	**Rainwater Harvesting** (Source Control)
Constraints:	The benefits of rainwater harvesting on a specific design storm event cannot be quantified, due to the seasonal availability of storage within the structure.
Opportunities:	None. Not considered as part of the surface water management strategy.
Type:	**Living Roofs / Green Roofs** (Source Control)
Constraints:	Green roofs require a level roof and easy access for regular maintenance.
Opportunities:	Green roofs are being proposed within the proposed development.
Type:	**Infiltration Devices** (Source Control)
Constraints:	Infiltration devices would not be feasible due to adverse ground conditions. The Site is underlain by made ground loamy soil with natural high groundwater over London Clay solid geology. Historic boreholes indicate that localised pockets of more permeable material may be affected by shallow ground water perched above the London Clay.

Opportunities:	None. Poor infiltration potential and potential contaminants in the made ground.
Type:	**Lined Permeable Paving** (Source Control)
Constraints:	Opportunities for permeable paving are limited by the relatively small extent of external hard surfaces included within the proposed layout and existing tree root protection areas.
Opportunities:	There will be some opportunity to provide water treatment benefits through utilising permeable paving for external spaces within the development.
Type:	**Bioretention System / Rain Gardens** (Source Control)
Constraints:	Rain gardens are ineffective to drain large catchments that discharge into the system at a single location. These systems provide little attenuation benefit where an infiltration solution is not available.
Opportunities:	Rain gardens could be incorporated into the green landscape areas for the Site.
Type:	**Swales, etc.** (Permeable Conveyance)
Constraints:	In order to provide practicable attenuation benefits 1:3 side-slope swales tend to require a significant land requirement.
Opportunities:	None. Not enough space available to utilise swales.
Type:	**Detention Basins**
Constraints:	Constrained Site, limited open space for basin with 1:3 (or 1:4) side-slopes.
Opportunities:	None. Not enough space available to utilise basin.
Type:	**Attenuation Tanks** (end of pipe treatment)
Constraints:	Constrained to open space (required minimum distance from proposed or existing structures). Shallow groundwater needs to be considered; tanks can be lined but will need to account for buoyancy or up-lift if immersed below groundwater level.
Opportunities:	Should attenuation be required this could be achieved by use of oversized sewers/pipes or cellular attenuation storage.

5.7. After consideration of the CIRIA C753 approach, the most viable SuDS options for the Site include a combination of green roofing, permeable paving and an attenuation tank. Therefore, it is proposed to utilise part of the flat roof as a living roof, permeable paving materials for external hard surfaces and an attenuation tank to temporarily store surface water from the developed areas before leaving the Site. A summary of the simple index approach as outlined in CIRIA 753 can be found in **Appendix J**.

5.8. The NPPF states that major developments should incorporate sustainable drainage systems unless there is clear evidence that this would be inappropriate. The systems used should take account of advice from the Lead Local Flood Authority (LLFA), have appropriate operational and maintenance arrangements together with providing multifunctional benefits where possible.

5.9. The Sustainable Design and Construction SPG (Supplementary Planning Guidance) (April 2014) references London Plan policy 5.13 which states that developers should aim for a greenfield run-off rate from their developments. The SPG recognises that "there may be situations where it is not appropriate to discharge at greenfield run-off rates. These include, for example, sites where the calculated greenfield run-off rate is extremely low and the final outfall of a piped system required to achieve this would be prone to blockage.

5.10. DEFRA issued the non-statutory technical guidance for Sustainable Drainage Systems in March 2015. This document and the CIRIA Guidance C753 (The SuDS Manual) have been used to determine the appropriate SuDS Strategy, which considers the spatial and environmental constraints of the Site.

5.11. In February 2016, climate change requirements were updated. Section 6 of the NPPF requires that to allow for predicted impacts of climate change on surface water run-off, the following increases to rainfall intensity should be allowed for:

- 2015 to 2039: +5% (10% Upper end);
- 2040 to 2069: +10% (20% Upper end); and
- 2070 to 2115: +20% (40% Upper end).

5.12. Therefore, under the NPPF an allowance of 40% for the effects of climate change will achieve the policy requirements for the proposed residential development.

5.13. National and local policy and guidance stipulate that the discharge of surface water runoff should follows the hierarchy of drainage options list below, as reasonably practicable:

1) into the ground (infiltration);
2) to a surface water body (watercourse);
3) to a surface water sewer, highway drain, or another drainage system; or

4) to a combined sewer.

5.14. Given the low permeability of the Site's underlying soil and geological material, discharge to infiltration has been excluded. Similarly, there are no nearby open surface water bodies (watercourses) located adjacent to the Site to receive the surface water runoff. The Thames Water sewer asset plans show public combined gravity sewers located in the carriageway of Wootton Street and Greet Street adjacent to the northern and eastern boundaries of the Site (**Appendix D**). A pre-planning enquiry capacity check with Thames Water confirmed sufficient surface water capacity for the aforementioned public sewers assets, at a maximum discharge rate of 2.0l/s for all storm events up to and including 1 in 100yr+40%CC (**Appendix F**).

5.15. It is proposed that the controlled runoff leaving the Site is discharged into combined sewer manhole 4003 located within Greet Street, adjacent to the south-east corner of the Site. The surface water runoff from the developable area of the Site for all storm events (up to and including the 100 years plus a 40% allowance for climate change) will be restricted to a 2.0l/s. This is considered to be in line with local policy to aim for greenfield run-off rates whilst making practical allowance to avoid blockage risk as outlined in the SPG (see 6.7 above).

Pre and Post Development Impermeable Area

5.16. The proposed development plans (**Appendix B**) show the planning redline boundary equates to approximately 0.137ha, enclosing a residential block, landscaping and parking areas. Approximately 0.113ha of the Site is regarded as 'impermeable' area; this includes roofs, play areas, external hard landscaping and car parking spaces. **Table 5-4** describes pre and post developable areas for the Site, indicating an approximate increase of 19% post development impermeable area.

Table 5-4: Pre and Post Development Areas

Development Stage	Site	Area (Ha)		Percentage (%)	
		Green Space	Development impermeable area	Green Space	Development impermeable area
Pre-development	0.137	0.042	0.095	30	70
Post-development	0.137	0.024	0.113	17	83

Proposed Surface Water Drainage Strategy

5.17. **Drawing 193860-003** illustrates the Proposed Drainage Strategy, indicating how the Site will be drained.

5.18. The proposed surface water drainage strategy considers the runoff from the impermeable area of the developable part of the Site (0.113ha), which includes the roofs, play areas, external hard landscaping and car parking spaces. The surface water drainage will incorporate source control measures (such as living roofs and permeable paving) where feasible.

5.19. The runoff generated from the Site is from 'clean' surfaces and catch-pits upstream of the tank are deemed adequate to minimise the volume of silt and debris entering the tank, which reduces the maintenance requirements for the system and improving the end of system water quality leaving the Site. The runoff from permeable paved surfaces will pass through a catch-pit before entering the surface water drainage network downstream of the tank.

5.20. The surface water flow within the proposed sewer network is controlled through a hydro-brakes flow control device installed downstream of the attenuation tank, limiting the off-site discharge rate to 2l/s all storm events up to and including the 1 in 100-year return period and including a 40% allowance for climate change. The surface water joins the foul water flow from the Site (this is discussed in more detailed in the proceeding section) at a proposed adoptable combined sewer which will tie into the existing 305mm dia. Thames Water combined sewer network at manhole 4003 in Greet Street.

5.21. The proposed surface water drainage network within the Site will be designed to contain the critical duration of 1 in 30-year return period storm. Any flooding for up to the critical 1 in 100-year return period storm with a 40% allowance for climate change shall be contained within the Site without increasing the risk to person or property both on and off site. The drainage calculations included in **Appendix F** demonstrate storm events up to the 1 in 100 year plus an allowance for climate change can be attenuated within the attenuation tanks for the Site.

5.22. In line with the London Plan and local guidance; SuDS drainage principles will need to be applied and the rate of discharge should aim to mimic greenfield run-off rates. As discussed in the previous section, the maximum surface water discharge rate will be restricted to 2l/s for the 1 in 100-year storm event +40% climate change. While this rate is marginally higher than the corresponding greenfield runoff rate, its less than the brownfield values (which is more representative of the current site condition). Furthermore, a higher rate (2l/s) reduces the risk of blockage in the sewer network. Drainage principles will need to be agreed with the Lead Local Flood Authority. Should local policy be followed, Thames Water would envisage no capacity concerns with regards to expected flows for the Site.

Surface Water Drainage Calculation

5.23. The surface water drainage strategy has been developed in MicroDrainage, the industry leading software tool for drainage design. A Source Control model has been built to calculate the potential storage requirement for the impermeable area of the Site (0.113ha). The model results are presented in (**Appendix F**).

5.24. **Table 5-5** outlines the existing and proposed surface water run-off rates under various storm scenarios, as well as the attenuation requirements up to the 1 in 100-year storm, with 40% climate change allowance. Post development rates and storage volumes stated within **Table 5-5** represent the drainage catchment area for the impermeable area of the development pre and post development;

refer to the **MicroDrainage** calculations provided in **Appendix F** for further details.

Table 5-5: Existing and Proposed Surface Water Run-off Rates

Site	Rainfall events			
	1 in 2 year	1 in 30 year	1 in 100 year	1:100 year + 40% CC
Greenfield	0.2	0.5	0.7	n/a
Pre-Development (0.095ha)	3.1	9.8	13.1	n/a
Post Development (0.113ha)	2.0	2.0	2.0	2.0
Percentage reduction	35%	79%	84%	n/a
Storage Requirements (m^3) Post development	9.1	33.2	50.7	78.6

Storage Requirements

5.25. The attenuation has been sized to accommodate runoff for all storms up to and including the 1 in 100-year event, with 40% climate change allowance. Refer to the MicroDrainage calculations included in **Appendix F**.

5.26. The proposed attenuation tank will occupy an area of $104m^2$ and a depth of 0.8m. The proposed geocellular tank has a void ratio of 95% and therefore provides a combined storage volume of approximately $79m^3$. Therefore, the proposed attenuation tank is capable of balancing surface water flows up to the 1 in 100-year storm event plus a 40% allowance for climate change.

Urbanisation and Long Term Storage

5.27. As the proposed development comprises of residential apartments, no consideration urban creep through the construction of conservatories or extended hard surfaces via permitted development have been considered in the drainage design. No allowance for urban creep for flatted developments is considered necessary in accordance with the LASOO guidance.

5.28. Whilst there is an increase the amount of impermeable area at the site and subsequent increase in runoff volume, as the discharge rate is being restricted to the lowest practical rate it is not necessary to provide Long Term Storage.

Exceedance Routes

5.29. As a result of heavy or extreme storm events it is sometimes unavoidable for the capacities of sewers and other drainage systems to be exceeded.

5.30. Drainage exceedance will occur when the rate of surface water run-off exceeds the inlet capacity of the drainage system. Typically, this is when the receiving water body or pipe system becomes overloaded, blocked or when the outfall becomes restricted due to flood levels in the receiving sewer. Within the development, this has been mitigated against by raising the finished floor levels to a minimum level of 150mm above proposed external ground levels. Any surface water exceedance flows will be channelled by Site levels into the access road and parking bays and towards the southern boundary of the Site.

LLFA Proforma

5.31. It is a requirement of the London Borough of Lambeth to submit their London Sustainable Drainage Proforma with any major planning application. Therefore, a completed version of the proforma is included in **Appendix I** of this report.

Future Maintenance

5.32. It is intended that the SuDS components employed throughout the drainage strategy will be maintained by a private management company.

5.33. The maintenance of all SuDS components will be in accord with the best practices and the CIRIA Manual C753. An excerpt of the recommended operation and maintenance requirements for the proposed permeable paving and attenuation tank (from CIRIA Manual C753) is provided in **Appendix H**.

Water Quality

5.34. In terms of surface water treatment, the integration of the SuDS features outlined in the above sections would make sure that surface water run-off would be of sufficient quality, so as not to cause pollutant-based detriment to the ground below or the receiving watercourse.

5.35. In line with CIRIA 753 it can be seen that the mitigation indices associated with green roofs and permeable paving exceed the pollution hazard indices associated with suspended solids, metals and hydrocarbons. It is therefore considered that the integration of permeable paving and green roofs would satisfy the requirements of CIRIA C753.

5.36. A summary of the simple index approach as outlined in CIRIA 753 can be found in **Appendix J**.

6. FOUL WATER MANAGEMENT

Proposed Foul Water Strategy

6.1. Thames Water sewer asset plans show there are no public sewers located within the Site (**Figure 3-5**). To the north of the Site there is a 305mmØ combined sewer flowing west within carriageway of Wootton Street which serves the adjacent residential area. To the east of the Site there is a 305mmØ combined sewer flowing south into a 1600×762 combined sewer which is located within The Cut and serves the wider area to the south of the Site.

6.2. The nearest downstream manhole east of the Site is MH4003 located at the junction of Greet Street and the private access road to the south of the Site. The nearest downstream manhole north of the Site is MH4002 which is located at the junction of Wootton Street and Greet Street.

6.3. It is proposed that the flow water sewerage for the Site will drain via gravity to the proposed combined sewer at the south-east corner of the Site and outfall into Thames Water public combined sewer at manhole 4003.

6.4. British Flows and Loads and sewers for adoption 7^{th} Edition assign a daily flow rate of 4000 litres per dwelling. The proposed development is for 36 apartments, which equates to a foul water discharge rate of 1.67 l/s. An additional 0.80 l/s is calculated to be generated by the community space within the development totalling 2.47 l/s for the site overall. The proposed combined flows are less than the existing flows due to the proposed surface water discharge rate of 2.0 l/s which is considerably less than the existing scenario. Capacity within the Thames Water combined sewer will not be an issue.

6.5. The pre-development enquiry response from Thames Water confirms in their correspondence that that existing sewer in Greet Street has capacity to accept the foul water flows.

6.6. Refer to **Appendix D** for copies of Thames Water record plans and correspondence. The proposed Foul Water Drainage Strategy is shown on Drawing No. **193860-003**.

7. CONCLUSIONS

7.1. This Flood Risk Assessment has been prepared by Ardent to accompany the planning application for the demolition of the existing single storey building and the construction of a new 5, 8 & 10 storey building to provide a new community centre at the ground floor level and 36 residential units including landscaping, car parking and associated infrastructure works. The Site of the proposed development encloses an area of approximately 0.137 ha of which 0.137 ha is considered developable and is located off Wootton Street, London, SE1 8LX.

7.2. According to the EA flood maps, the Site is located in Flood Zone 3a. Under the NPPF the proposed development is classified as 'more vulnerable' and will be subject to the sequential and exception test. The Sequential Test and first part of the Exception Test have been undertaken by others and this FRA forms the second part.

7.3. In terms of development layout a sequential approach has been taken where no residential living or sleeping accommodation will be located on the ground floor within Flood Zone 3a.

7.4. Potential flood risk from sources other than fluvial and tidal at the Site include surface water, groundwater and sewers are 'very low risk' following the implementation of mitigation measures proposed in this report. The flood risk from artificial sources is not considered significant for the Site.

7.5. There is a residual risk in the event of a breach in the defences. Non-residential units are to be located at the ground floor. Residential development and safe refuge during an extreme flood event is provided at the first floor of all the buildings. The first floor is located above the maximum 2100 tidal breach level of 4.31m AOD. The occupants of the ground floor non-residential units can access the first floor via general use or fire escape stairs.

7.6. In the event of a breach, if times allows and following the advice of the emergency services, site occupiers can evacuate the site to the

South away from the flow routes. Residents of the proposed development should familiarise themselves with the Flood Response Plan outlined in this report and register with the EA's 'Flood Warning Direct' service.

7.7. The surface water drainage strategy will reduce flood risk by restricting surface water flows to 2l/s, for all return period events up to and including the 1 in 100-year critical event (including a 40% allowance for climate change). Surface water run-off from the Site will be drained under gravity. The surface water from the Site will be attenuated and temporarily stored on Site within a geocellular attenuation tank providing a storage volume of $79m^3$. Additionally, source control measures including a greenroofs, permeable paving and catch pit's are proposed to provide water quality amenity and biodiversity benefits as part of a SuDS drainage scheme.

7.8. The proposed foul discharge from the developed Site is anticipated to be 2.47 l/s. The proposed combined flows are less than the existing flows.

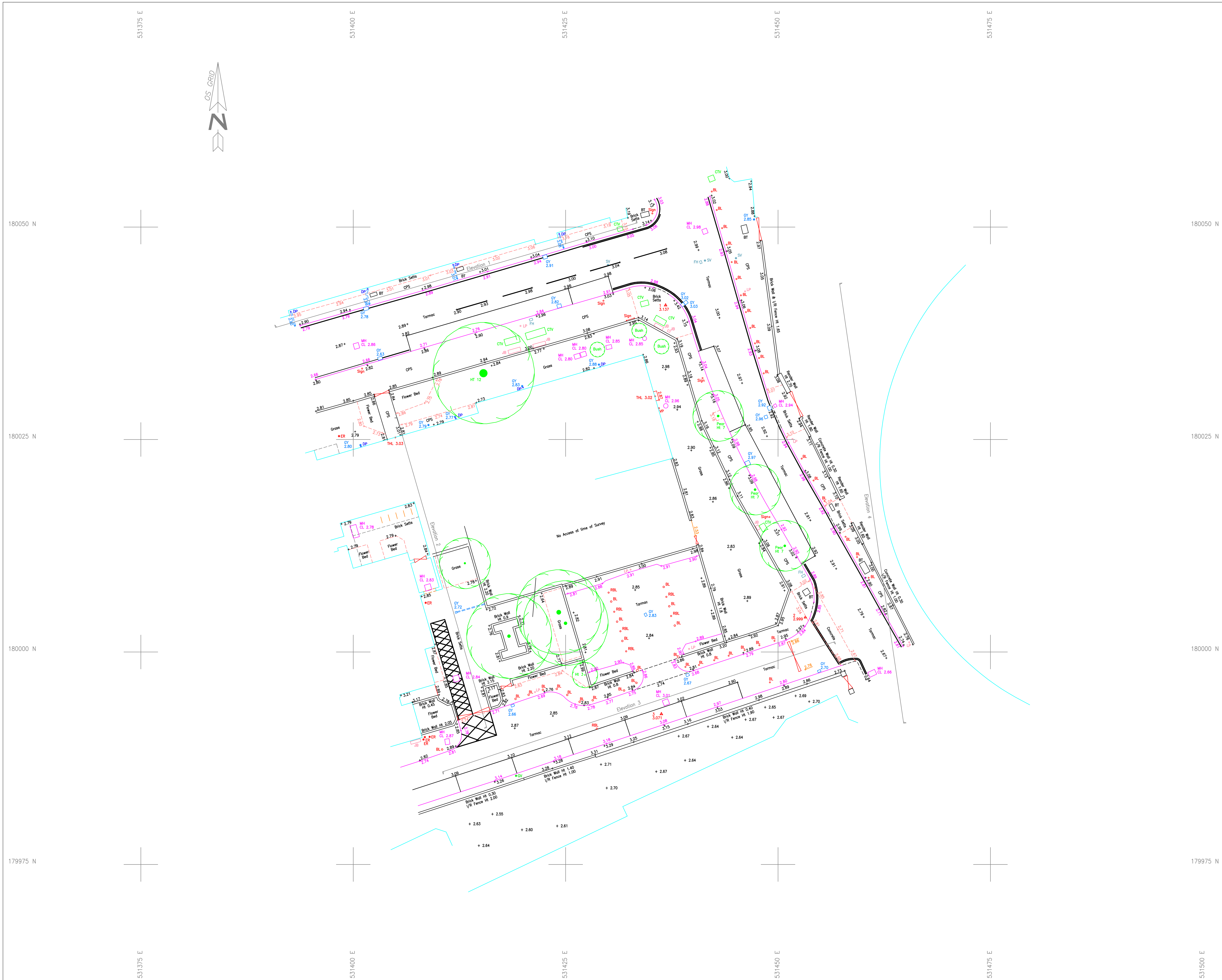
7.9. A pre-development enquiry to Thames Water has confirmed the combined sewer assets in Greet Street can accommodate the surface and foul water flows.

7.10. Both the restricted surface water and the foul flows from the development are proposed discharge by gravity to the existing Thames Water combined sewer in Greet Street at manhole 4003.

7.11. A management company will be appointed to maintain the landscaping and shared SuDS within the development. Funding of the maintenance regime will likely to be via the yearly maintenance fees from the development. All maintenance will be in accord with the best practices and the CIRIA Manual C753.

7.12. In conclusion, this Flood Risk Assessment demonstrates that the proposals are consistent with the aims of the NPPF. The Site will not be at significant risk of flooding or increase the flood risk to others.

Appendix A
Topographical Survey



© LASER SURVEYS

LAND AND BUILDING SURVEYS, UNDERGROUND SERVICES LOCATION, CCTV DRAINAGE SURVEYS.

Established 1975. Member of The Survey Association.

LASER SURVEYS LTD, OPEN SPACE UPPER INTERFIELDS, MALVERN WR14 1UT
TEL 01886 833173 FAX 01886 833485 email: worcester@lasersurveys.com

OLD DAIRY. STUBBERS FARM. MOUNTNESSING ROAD, BLACKMORE. CM4 0NX
TEL 01708 438408 FAX 01708 438405 email: london@lasersurveys.com

DATUM NOTES

CO-ORDINATES USED ARE BASED ON O/S NATIONAL GRID, OBTAINED USING THE ACTIVE GPS NETWORK AND ADJUSTED TO A LOCAL GRID WITH A SCALE FACTOR OF 1.0000.

LEVELS ARE RELATED TO :- ORDNANCE SURVEY ACTIVE GPS NETWORK.

SURVEY CONTROL STATIONS SHOWN

ABBREVIATIONS (where applicable)

AV	Air Valve	MK	Marker
BK	Brick	MS	Milestone
BL	Bollard	MT	Meter
BS	Bus Stop	MY	Mercury
BT	British Telecom	OH	Overhead
C/B	Close Boarded	PAV	Paving
CL	Cover Level	PB	Post Box
CLK	Chainlink	PE	Pipe
CO	Column	PM	Parking Meter
Conc	Concrete	P/R	Post and Rail
CP	Catch Pit	PT	Post
CPS	Concrete Paving Slabs	P/W	Post and Wire
CTV	Cable Television	RE	Rodding Eye
CW	Combined Water	RET	Retaining
DC	Drainage Channel	RS	Road Sign
DP	Drain Pipe	RSJ	Rolled Steel Joist
EP	Electricity Pole	SC	Stop Cock
ER	Earthing Rod	SK	Soakaway
FB	Flower Bed	SPT	Septic Tank
FE	Fence	ST	Silt Trap
FH	Fire Hydrant	SV	Stop Valve
FL	Floor Level	SVC	Security Video Camera
FP	Flag Pole	SW	Storm Water
FW	Foul Water	TCB	Telephone Call Box
GP	Gate Post	THL	Threshold Level
GV	Gas Valve	TL	Traffic Light
GY,G	Gully	TK	Tank
HT	Height	TP	Telegraph Pole
IC	Inspection Cover	UG	Underground
IL	Invert Level	UTF	Unable to trace Further
IN	Interceptor	UTR	Unable To Raise
I/R	Iron Railings	VP	Vent Pipe
JB	Junction Box	WL	Water Level
KO	Kerb Outlet	WM	Water Meter
LB	Litter Bin	WO	Wash Out
LP	Lamp Post		
MH	Manhole Cover		

NOTES

* Drainage pipe sizes (where shown) have been gauged from the surface for safety reasons and should be regarded as approximate only.
* Tree species (where shown) should be treated with caution and expert identification is advised.
* Although this is a digital survey the accuracy and amount of detail shown is only commensurate with the graphical scale of mapping as specified. Care should be exercised when working to larger scales.
* Visible features in the vicinity of the boundaries as shown above, may not represent the extent of legally conveyed ownership.
* Whilst every effort has been made to achieve accuracy on this plan, CRUCIAL clearance dimensions, levels and invert levels should be checked prior to design and construction.
* Kerb levels have been taken in the bottom of the channel.

SHEET LAYOUT
NOT TO SCALE

Wootton Street
Lambeth
SE1 8TG

TOPOGRAPHICAL SURVEY

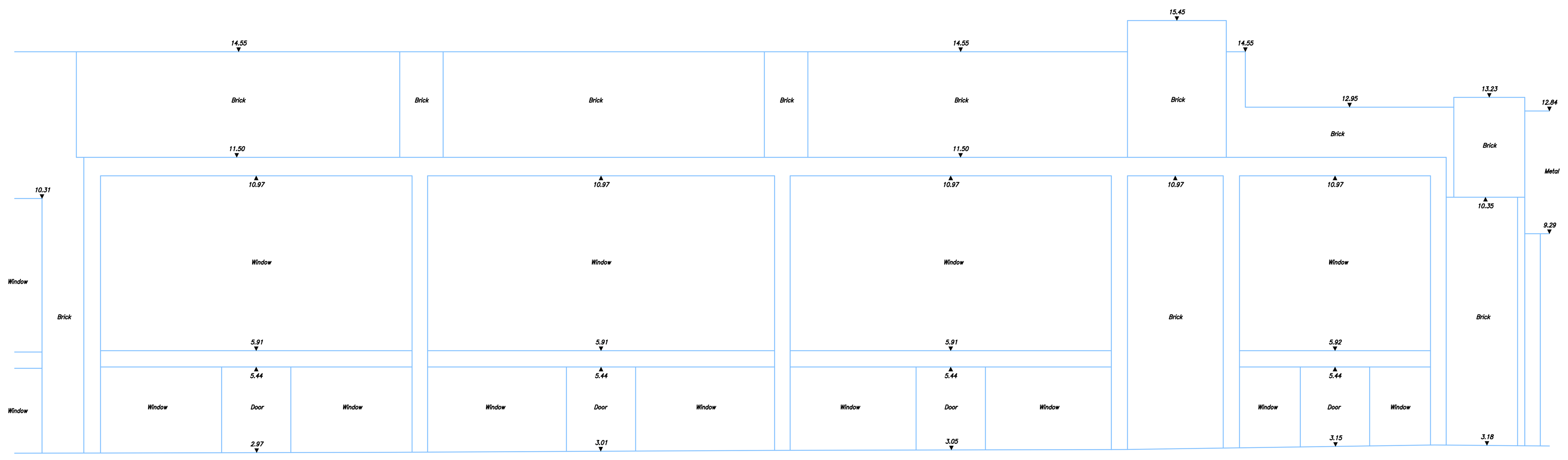
SURVEYED FOR Homes for Lambeth
8 Hambridge Way
Cresington Gardens
London. SW2 2NJ

SURVEYOR S Grimes

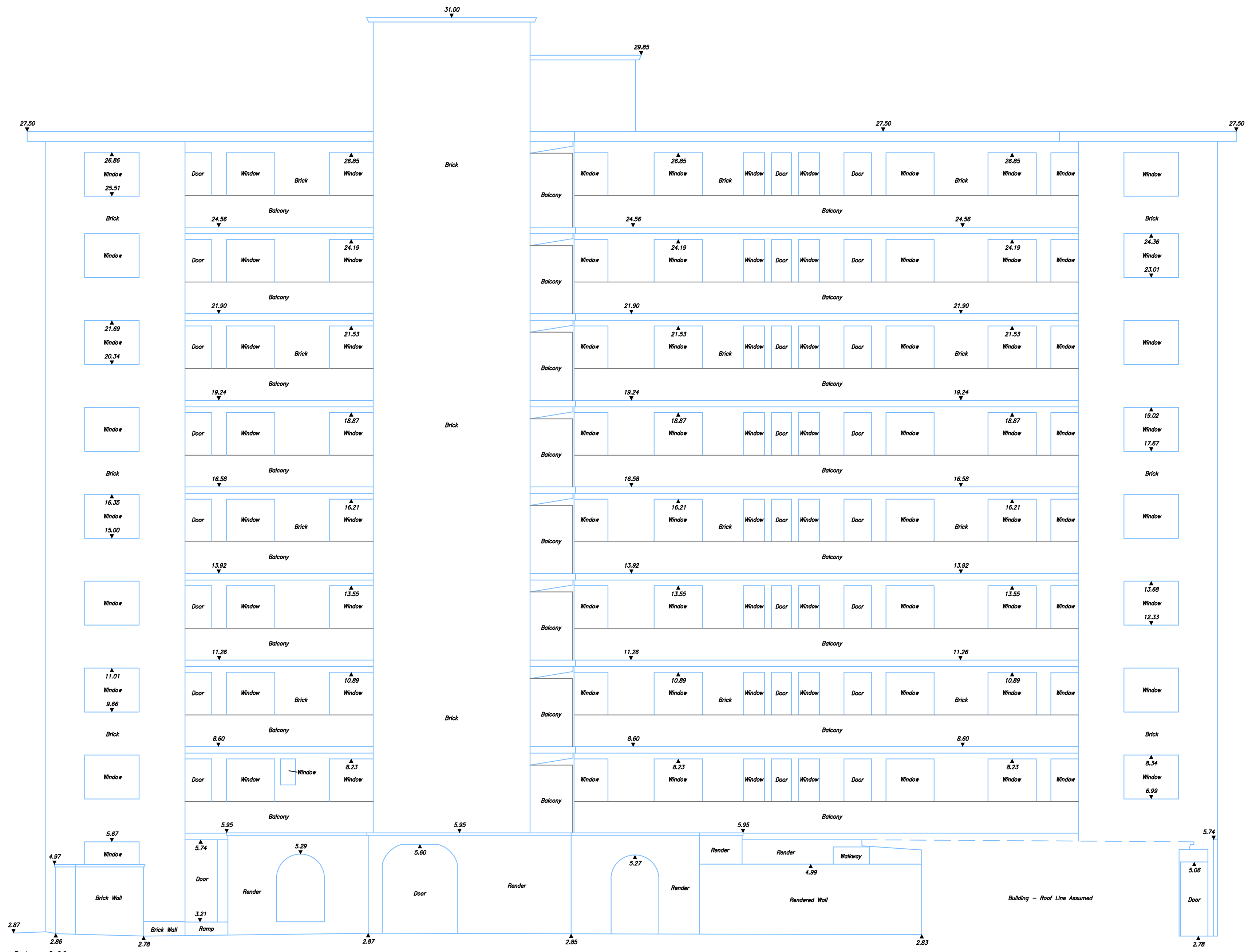
DATE December 2019

NO	DATE	REVISION

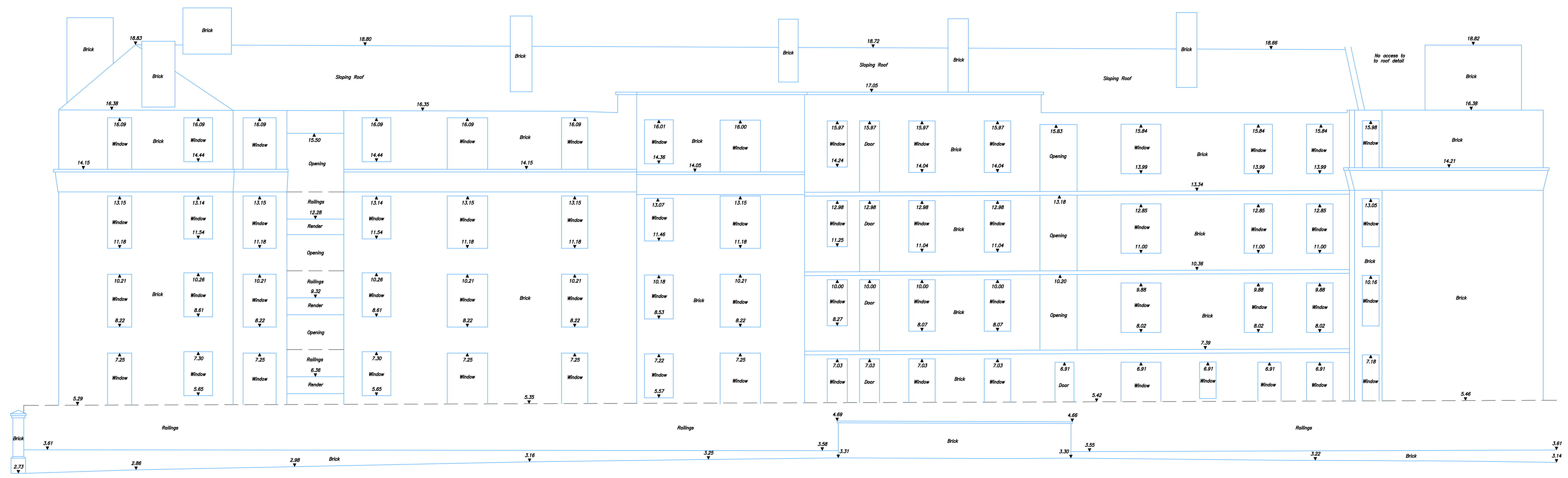
DRAWING NO	N 9576/1	REV	0
DRAWING TITLE	TOPOGRAPHICAL		
SCALE	1 : 200 (A1)		
SEE ALSO DWG NOS			
SHEET	1 of 2		
REF NO	N 9576		



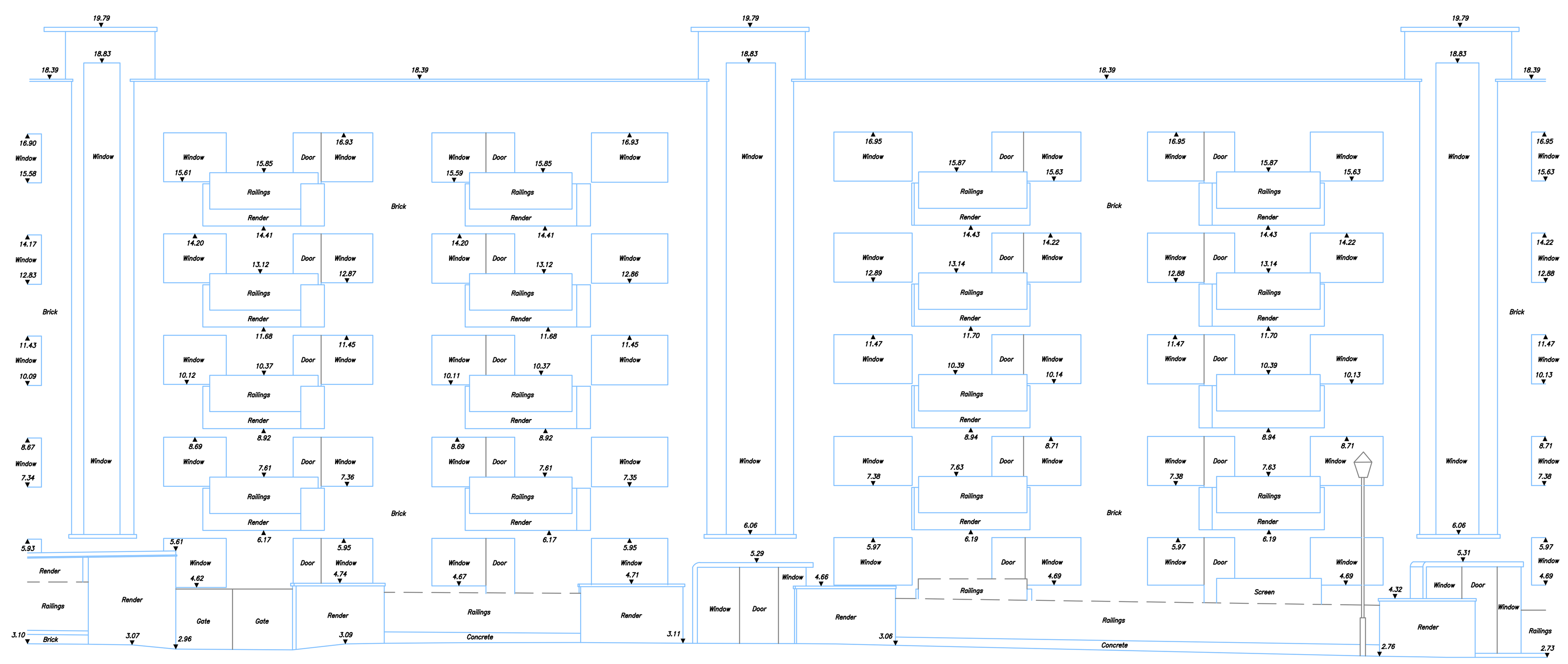
Datum 2.00m
Elevation 1



Datum 2.00m
Elevation 2



Datum 2.00m
Elevation 3



Datum 2.00m
Elevation 4

LAND AND BUILDING SURVEYS, UNDERGROUND SERVICES LOCATION, CCTV DRAINAGE SURVEYS.
Established 1975. Member of The Survey Association.
LASER SURVEYS LTD, OPEN SPACE UPPER INTERFIELDS, MALVERN WR14 1UT
TEL 01886 833173 FAX 01886 833485 email: worcester@lasersurveys.com
OLD DAIRY. STUBBERS FARM. MOUNTNESSING ROAD, BLACKMORE. CM4 0NX
TEL 01708 438408 FAX 01708 438405 email: london@lasersurveys.com

DATUM NOTES

CO–ORDINATES USED ARE BASED ON O/S NATIONAL GRID, OBTAINED USING THE ACTIVE GPS NETWORK AND ADJUSTED TO A LOCAL GRID WITH A SCALE FACTOR OF 1.0000.

LEVELS ARE RELATED TO :– ORDNANCE SURVEY ACTIVE GPS NETWORK.

SURVEY CONTROL STATIONS SHOWN △

ABBREVIATIONS (where applicable)

AV	Air Valve	MK	Marker
BK	Brick	MS	Milestone
BL	Bollard	MT	Meter
BS	Bus Stop	MY	Mercury
BT	British Telecom	OH	Overhead
C/B	Close Boarded	PAV	Paving
CL	Cover Level	PB	Post Box
CLK	Chainlink	PE	Pipe
CO	Column	PM	Parking Meter
Conc	Concrete	P/R	Post and Rail
CP	Catch Pit	PT	Post
CPS	Concrete Paving Slabs	P/W	Post and Wire
CTV	Cable Television	RE	Rodding Eye
CW	Combined Water	RET	Retaining
DC	Drainage Channel	RS	Road Sign
DP	Drain Pipe	RSJ	Rolled Steel Joist
EP	Electricity Pole	SC	Stop Cock
ER	Earthing Rod	SK	Soakaway
FB	Flower Bed	SPT	Septic Tank
FE	Fence	ST	Silt Trap
FH	Fire Hydrant	SV	Stop Valve
FL	Floor Level	SVC	Security Video Camera
FP	Flag Pole	SW	Storm Water
FW	Foul Water	TCB	Telephone Call Box
GP	Gate Post	THL	Threshold Level
GV	Gas Valve	TL	Traffic Light
GY,G	Gully	TK	Tank
HT	Height	TP	Telegraph Pole
IC	Inspection Cover	UG	Underground
IL	Invert Level	UTF	Unable to trace Further
IN	Interceptor	UTR	Unable To Raise
I/R	Iron Railings	VP	Vent Pipe
JB	Junction Box	WL	Water Level
KO	Kerb Outlet	WM	Water Meter
LB	Litter Bin	WO	Wash Out
LP	Lamp Post		
MH	Manhole Cover		

A	Arch Ht (cm)
B	Beam Ht (cm)
C	Ceiling Ht (cm)
D	Door Ht (cm)
FC	False Ceiling Ht (cm)
H	Head Ht (cm)
S	Sill Ht (cm)
SP	Spring Ht (cm)
BSU	Beam Slopes Up
CSU	Ceiling Slopes Up

NOTES

* Drainage pipe sizes (where shown) have been gauged from the surface for safety reasons and should be regarded as approximate only.
* Tree species (where shown) should be treated with caution and expert identification is advised.
* Although this is a digital survey the accuracy and amount of detail shown is only commensurate with the graphical scale of mapping as specified. Care should be exercised when working to larger scales.
* Visible features in the vicinity of the boundaries as shown above, may not represent the extent of legally conveyed ownership.
* Whilst every effort has been made to achieve accuracy on this plan, CRUCIAL clearance dimensions, levels and invert levels should be checked prior to design and construction.
* Kerb levels have been taken in the bottom of the channel.

SHEET LAYOUT
NOT TO SCALE

Wootton Street
Lambeth
London
SE1 8TG

Elevations

SURVEYED FOR Homes for Lambeth
8 Hambridge Way
Cressingham Gardens
London
SW2 2NJ

SURVEYOR S Grimes
DATE December 2019

NO	DATE	REVISION

DRAWING NO	N 9576/2	REV	0
DRAWING TITLE	Elevations		
SCALE	1 : 100 (A0)		
SEE ALSO DWG NOS	N XXXX/X – X		
SHEET	2 of 2		
REF NO	N 9576		

Appendix B
Proposed Layout Plans

rev	date	description
P1 - WIP	Work in Progress	P1

0 2 4 6m

HFL HOMES FOR LAMBETH

stockwool

The Pump House 19 Hooper Street
London E1 8BU 020 7264 8600
info@stockwool.co.uk

Client
HOMES FOR LAMBETH

Project
WOOTTON STREET

Drawing
GROUND FLOOR PLAN

Status
PLANNING

Scale	1:200@A3
CAD File	3496W-Wootton-MainModel
Date	14/12/2020
Drawn	AB/DF
Checked	PM

Project no_Drawing no_Revision
3496W_PL(20)100_P1 - WIP

Appendix C

BGS Borehole Logs

Version 2.0.6

British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

BGS ID: 1066341 : BGS Reference: TQ38SW2168
British National Grid (27700) : 531359,180035
Report an issue with this borehole

Soil Mechanics

BOREHOLE No. 207

Sheet 1 of 3

Equipment & Methods
Hand dug inspection pit to 1.00m then cable percussive boring in 200mm diameter to 19.50m. Casing installed to 10.00m.

Location No. 7658

Location JUBILEE LINE EXTENSION TQ 38 SW 2168

Carried out for London Underground Limited (JLE008)

Ground Level 2.71 m O.D.

Coordinates 531359.10m E 180035.18m N

Date 30.08.90 to 31.08.90

Description	Reduced Level	Depth (Thick)	Sample Depth	Sample Type	Sample No.	Test	Field Records
PAVING SLABS	2.71	(0.05) 0.05					
Light yellow-brown medium and coarse sand. (MADE GROUND)	2.66 2.55	(0.11) 0.16					
Dark grey brown clayey fine to coarse sand with some fine to coarse gravel and cobble sized brick and concrete fragments. (MADE GROUND)	0.71	(1.84) 2.00	1.50	D	1		
Soft dark grey brown mottled brown clay with many partially decomposed wood fragments and fine fibres and with a little coarse sand to coarse gravel sized brick fragments. (MADE GROUND)	-1.09	(1.80) 3.80	2.00 - 2.50	B	2	C N-2	1,-/1,-,-,1
			3.10	W	18		
Light brown fine to coarse sand with some subangular to subrounded fine to medium flint gravel and occasional pockets of grey-brown clay (<60mm). (TERRACE GRAVELS / MADE GROUND ?)	-2.49	(1.40) 5.20	4.50	D	3		
Medium dense grey and grey-brown very sandy (fine to coarse) subangular to rounded fine to coarse flint GRAVEL. (TERRACE GRAVELS)	-5.49	(3.00) 8.20	5.90 - 6.40	B	4	C N-19	2,3/5,4,5,5
			7.50	D	5		
Medium dense grey brown generally medium and coarse SAND and subangular to subrounded fine to coarse flint GRAVEL. (TERRACE GRAVELS)	-6.89	(1.40) 9.60	8.80 - 9.30	B	6	C N-21	3,4/5,5,6,5
(LONDON CLAY) (As sheet 2)		(9.90)					

Remarks

Logged by AWSF

Scale 1:50

Notes:
Materials are described in accordance with Appendices. For explanation of symbols and abbreviations see Fig. 1.
All depths and reduced levels in metres. Thicknesses given in brackets in depth column. 09.12.90/18.57 (Ver 4.1.28)

Fig. 26

Version 2.0.6

British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

BGS ID: 1066341 : BGS Reference: TQ38SW2168
British National Grid (27700) : 531359,180035
Report an issue with this borehole

Soil Mechanics

BOREHOLE No. 207

Sheet 2 of 3

Equipment & Methods	Location No. 7658	
As sheet 1	Location: JUBILEE LINE EXTENSION TQ38SW 2168	
Carried out for: London Underground Limited (JLE008)	Ground Level	Coordinates: As sheet 1	Date

Description	Reduced Level	Legend	Depth (Thick)	Samples/Tests Depth	Sample Type	Sample No.	Test	Field Records
rare pockets (<7mm) of light brown fine sand				10.50	D	7		
				11.80 - 12.25	U	8		40 blows 260mm recovery
				12.11	D	9		
				12.11 - 12.56	D	10	S N=27	3,4/5,7,7,8
Stiff becoming very stiff below about 13.50m thinly laminated extremely to very closely fissured grey- brown CLAY with occasional partings (<2mm) of light brown silt and silty fine sand. Fissures randomly orientated planar smooth and mottled dark grey. (LONDON CLAY) Below 15.50m generally very closely fissured with rare lenses (<5mm) of light brown silt and fine sand				13.50	D	10a		
			(9.90 pen)					
				15.00 - 15.45	U	11		50 blows 280mm recovery
				15.33	D	12		
				15.33 - 15.78	D	13	S N=27	2,3/5,7,8,7
				17.50	D	14		
fissures slightly polished				18.00 - 18.45	U	15		50 blows 320mm recovery
				18.37	D	16		
				18.37 - 18.82	D	17	S N=33	3,5/7,7,9,10
				19.00 - 19.45	U	19		70 blows 220mm recovery
				19.27	D	20		
BOREHOLE ENDS AT 19.50 m.	-16.79		19.50					

Remarks

1. Borehole terminated and grouted (1:1 bentonite/cement mix) following complaint by British Rail. Cable percussive rig moved 8.15m in a SSE direction to borehole 207A and drilling recommenced.

Notes:
Materials are described in accordance with Appendices. For explanation of symbols and abbreviations see Fig. 1. (c) Soil Mechanics
All depths and reduced levels in metres. Thicknesses given in brackets in depth column. 06.12.90/10.56 (Ver 4.1.28)

Logged by: AWSF
Scale: 1:50
Fig. 26

Version 2.0.6

British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

BGS ID: 1066341 : BGS Reference: TQ38SW2168
British National Grid (27700) : 531359,180035
Report an issue with this borehole

Soil Mechanics

BOREHOLE No.207

Sheet 3 of 3

Equipment & Methods

As sheet 1

Location No. 7658

Location

JUBILEE LINE EXTENSION TQ38SW 2168

Carried out for

London Underground Limited (JLE008)

Ground Level

Coordinates

As sheet 1

Date

Description	Reduced Level	Legend	Depth (Thick)	Samples/Tests Depth	Sample Type	Sample No.	Test	Field Records

Water Level Observations During Boring

Date	Time	Depth of Hole (m)	Depth of Casing (m)	Depth to Water (m)	Remarks
1990 30.08	-	4.00	4.00	4.00	Slight seepage
30.08	-	4.00	4.00	-	Water added from 4.00m to 8.00m.
30.08	-	16.00	10.00	16.00	Slight seepage
30.08	-	19.00	10.00	19.00	Slight seepage at end of shift
31.08	-	19.00	10.00	3.10	Start of shift
31.08	-	19.50	10.00	19.00	End of borehole

Remarks

Logged by AWSF

Scale 1:50

Notes:
Materials are described in accordance with Appendices. For explanation of symbols and abbreviations see Fig. 1. (c) Soil Mechanics
All depths and reduced levels in metres. Thicknesses given in brackets in depth column. 06.12.90/10.56 (Ver 4.1.28)

Fig. 26

Appendix D

Thames Water Correspondence

Christopher Cant

Ardent Consulting Engineers
Office 3, The Garage Studios
41-43 St Marys Gate
Lace Market
Nottingham
NG1 1PU

Wastewater pre-planning
Our ref DS6069664

4th February 2020

Pre-planning enquiry: Confirmation of sufficient capacity

Site Address: Windmill House, Wootton Street, Lambeth, SE1 8LX

Dear Mr Cant,

Thank you for providing information on your development for 36 flats and a 347.3m^2 community centre.

We have completed the assessment of the foul water flows and surface water run-off based on the information submitted in your application with the purpose of assessing sewer capacity within the existing Thames Water sewer network.

Foul Water

If your proposals progress in line with the details you've provided, we're pleased to confirm that there will be sufficient sewerage capacity in the adjacent combined sewer network to serve your development.

This confirmation is valid for 12 months or for the life of any planning approval that this information is used to support, to a maximum of three years.

Please note that you must keep us informed of any changes to your design – for example, an increase in the number or density of homes. Such changes could mean there is no longer sufficient sewerage capacity.

Surface Water

Please note that discharging surface water to the public sewer network should only be considered after all other methods of disposal have been investigated and proven to not be viable. In accordance with the Building Act 2000 Clause H3.3, positive connection to a public sewer will only be consented when it can be demonstrated that the hierarchy of disposal methods have been examined and proven to be impracticable. The disposal hierarchy being: 1st Soakaways; 2nd Watercourses; 3rd Sewers.

Only when it can be proven that soakage into the ground or a connection into an adjacent watercourse is not possible would we consider a restricted discharge into the public combined sewer network.

If the peak surface water run-off discharge is then restricted to a maximum of 2l/s as your drainage strategy indicates, then we would have no objections to the proposals.

We would encourage techniques such as green roofs and/or permeable paving that restricts surface water discharge from your site.

Please note that the Local Planning authority may comment on surface water discharge under the planning process.

Please Note

All connection requests are subject to a full Section 106 (Water Industry Act 1991) application before the Company can confirm approval to the connection itself. Please also note that capacity in the public sewerage system cannot be reserved. Please make sure you submit your connection application giving us at least 21 days' notice of the date you wish to make your new connection/s.

The discharge of non-domestic effluent is not permitted until a valid trade effluent consent has been issued by Thames Water. If anything other than domestic sewage is discharged into the public sewers without the above agreement an offence is committed and the applicant will be liable to the penalties contained in Section 109(1) (WIA 1991).

Applicants should contact Trade Effluent prior to seeking a connection approval, to discuss trade effluent consent and conditions of discharge. A Trade Effluent reference number should be obtained and included in the relevant box of the attached application form. The address for Trade Effluent is - Thames Water Utilities Limited, Waste Water Quality, Crossness Sewage Treatment Works, Belvedere Road, Abbeywood, London. SE2 9AQ. Alternatively you can telephone them on 020 8507 4321.

The views expressed by Thames Water in this letter are in response to this pre-planning enquiry at this time and do not represent our final views on any future planning applications made in relation to this site.

Yours sincerely,

Jonathan Shildrick BSc
Development Engineer
Developer Services

Asset location search

Thames Water Property Searches

Apogee
Hall Park CourtHall Park Way
TELFORD
TELFORD
TF1 3PT

Search address supplied	1 Wootton Street London SE1 8TG
Your reference	420792
Our reference	ALS/ALS Standard/2019_4105120
Search date	5 November 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

Asset location search

Thames Water Property Searches

Search address supplied: 1, Wootton Street, London, SE1 8TG

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

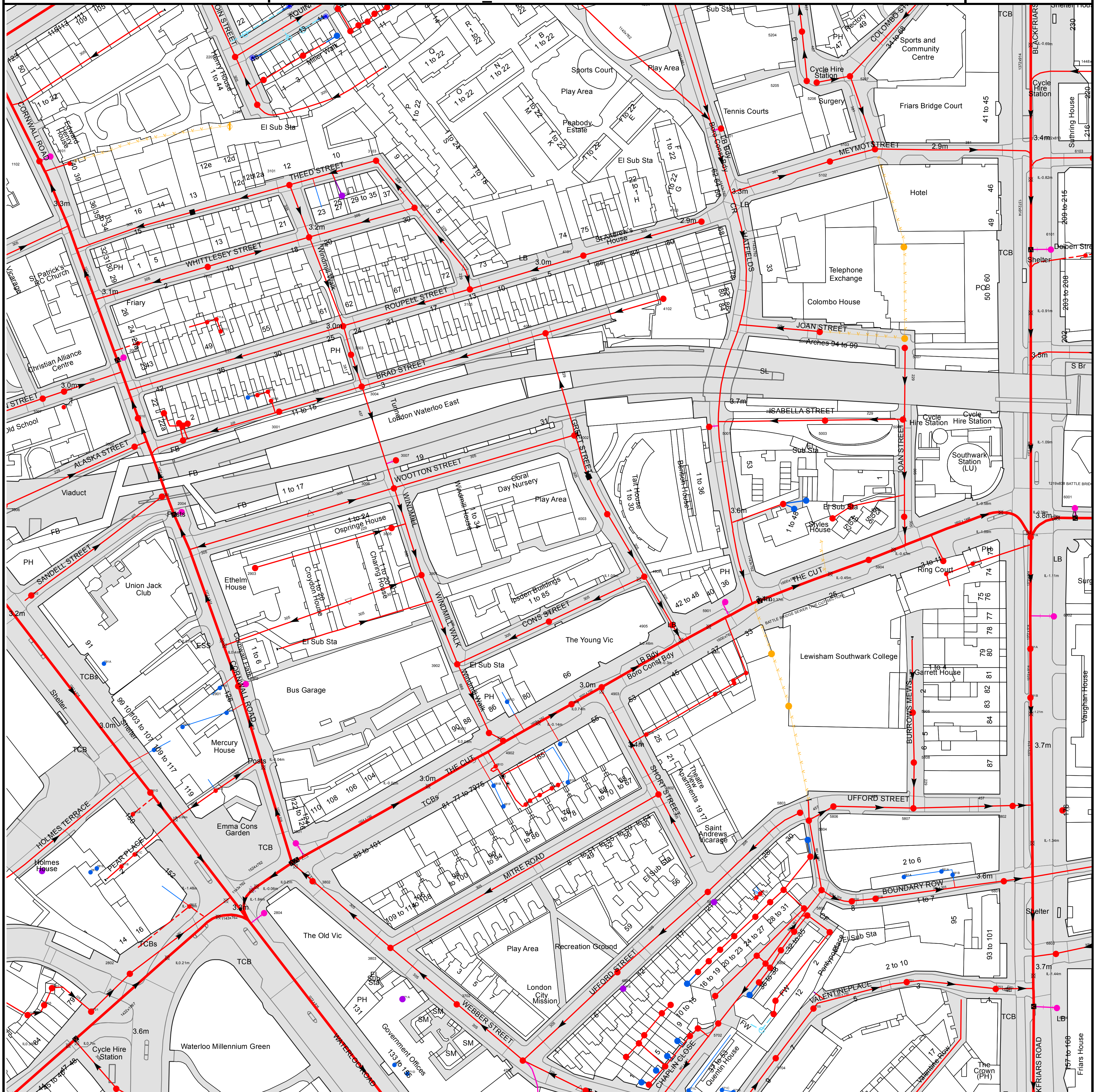
Clean Water queries

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_4105120



The width of the displayed area is 500 m and the centre of the map is located at OS coordinates 531431,179996

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
571B	n/a	n/a
471C	n/a	n/a
571C	n/a	n/a
47YV	n/a	n/a
47XV	n/a	n/a
47YY	n/a	n/a
5704	2.86	.08
47XT	n/a	n/a
47XR	n/a	n/a
5204	4.12	n/a
5007	n/a	n/a
5002	n/a	n/a
611K	n/a	n/a
6101	n/a	n/a
4103	3.29	1.36
5102	n/a	n/a
6103	3.82	n/a
5103	n/a	n/a
5101	3.81	n/a
5206	3.83	n/a
5205	3.77	n/a
5207	3.44	n/a
20BF	n/a	n/a
20BJ	n/a	n/a
3001	3.3	1.06
301B	n/a	n/a
201B	n/a	n/a
201F	n/a	n/a
301A	n/a	n/a
3004	2.99	.37
3003	n/a	.41
4001	3.28	.96
201C	n/a	n/a
3002	3.21	.55
201D	n/a	n/a
211A	n/a	n/a
4102	3.4	1.26
3105	3.11	.56
2102	3.33	1.3
4101	3.05	1.05
3102	3.39	.75
3104	3.26	1.06
311A	n/a	n/a
3101	3.53	.88
3103	n/a	n/a
2103	n/a	.64
22AH	n/a	n/a
2203	3.85	n/a
32EG	n/a	n/a
491A	n/a	n/a
4902	3.04	-.13
491C	n/a	n/a
4901	n/a	.06
291D	n/a	n/a
291E	n/a	n/a
491B	n/a	n/a
491D	n/a	n/a
291B	n/a	n/a
4903	3.04	-.2
2901	2.58	-.03
2902	n/a	n/a
3902	2.33	.18
4957	n/a	n/a
4904	2.46	.67
3901	3.11	.21
2903	n/a	1.17
3005	n/a	n/a
4003	3.08	1.18
2004	n/a	n/a
2003	n/a	.55
3006	2.69	.24
3007	n/a	n/a
201I	n/a	n/a
4002	3.06	1.51
20CA	n/a	n/a
20BE	n/a	n/a
5808	n/a	n/a
5905	n/a	n/a
691B	n/a	n/a
591A	n/a	n/a
59YT	n/a	n/a
59YS	n/a	n/a
59YR	n/a	n/a
691A	n/a	n/a
4905	3.23	.5
6902	3.77	n/a
5901	n/a	n/a
6901	n/a	n/a
691C	n/a	n/a
69ZU	n/a	n/a
5904	n/a	n/a

Manhole Reference	Manhole Cover Level	Manhole Invert Level
601A	n/a	n/a
50YS	n/a	n/a
5005	n/a	n/a
50YT	n/a	n/a
6001	n/a	n/a
50YR	n/a	n/a
50YV	n/a	n/a
50YW	n/a	n/a
5001	n/a	n/a
5003	n/a	n/a
5004	n/a	n/a
58YW	n/a	n/a
58XV	n/a	n/a
5803	3.96	.96
58YQ	n/a	n/a
58XW	n/a	n/a
58YY	n/a	n/a
5804	3.91	.1
58YX	n/a	n/a
5705	2.85	.05
5805	3.63	n/a
58XX	n/a	n/a
5806	3.77	-.01
581E	n/a	n/a
581B	n/a	n/a
581A	n/a	n/a
6701	3.57	-.32
5807	3.51	-.22
681A	n/a	n/a
681B	n/a	n/a
6703	n/a	n/a
6801	n/a	n/a
6802	n/a	n/a
6803	n/a	n/a
6704	3.73	n/a
681C	n/a	n/a
4802	3.44	.89
47ZS	n/a	n/a
47ZT	n/a	n/a
47ZU	n/a	n/a
47YX	n/a	n/a
47YW	n/a	n/a
48ZV	n/a	n/a
5801	3.09	.82
58YR	n/a	n/a
581F	n/a	n/a
57ZS	n/a	n/a
5702	2.78	.65
58YS	n/a	n/a
58YT	n/a	n/a
57YV	n/a	n/a
58YU	n/a	n/a
581C	n/a	n/a
58XZ	n/a	n/a
57YW	n/a	n/a
581D	n/a	n/a
57YZ	n/a	n/a
5802	2.74	.36
58XT	n/a	n/a
58YV	n/a	n/a
57YY	n/a	n/a
57YX	n/a	n/a
58XU	n/a	n/a
4702	2.75	.13
47YT	n/a	n/a
371D	n/a	n/a
371E	n/a	n/a
4701	2.61	.48
47YZ	n/a	n/a
47ZQ	n/a	n/a
47ZR	n/a	n/a
3702	n/a	.42
371A	n/a	n/a
471B	n/a	n/a
4801	3.02	.74
3803	n/a	.33
2804	3.51	n/a
281F	n/a	n/a
3802	n/a	.23
3801	n/a	n/a
481F	n/a	n/a
481A	n/a	n/a
4805	n/a	n/a
4806	n/a	n/a
2803	n/a	.29
481C	n/a	n/a
481B	n/a	n/a
4804	n/a	n/a
481E	n/a	n/a
481D	n/a	n/a
32FB	n/a	n/a
32EE	n/a	n/a
22CB	n/a	n/a

Manhole Reference	Manhole Cover Level	Manhole Invert Level
32CJ	n/a	n/a
32EJ	n/a	n/a
32CI	n/a	n/a
32CH	n/a	n/a
32CG	n/a	n/a
32DA	n/a	n/a
32CF	n/a	n/a
32CE	n/a	n/a
1703	n/a	n/a
1705	n/a	n/a
2801	n/a	n/a
2701	n/a	n/a
2702	3.9	1.08
2802	n/a	n/a
281D	n/a	n/a
181A	n/a	n/a
281E	n/a	n/a
281B	n/a	n/a
281C	n/a	n/a
281A	n/a	n/a
281G	n/a	n/a
291C	n/a	n/a
291A	n/a	n/a
1902	3.66	.92
2002	n/a	.22
201E	n/a	n/a
201G	n/a	n/a
1007	n/a	1.02
201H	n/a	n/a
2001	n/a	n/a
201A	n/a	n/a
211B	n/a	n/a
1102	3.47	-.27
2101	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

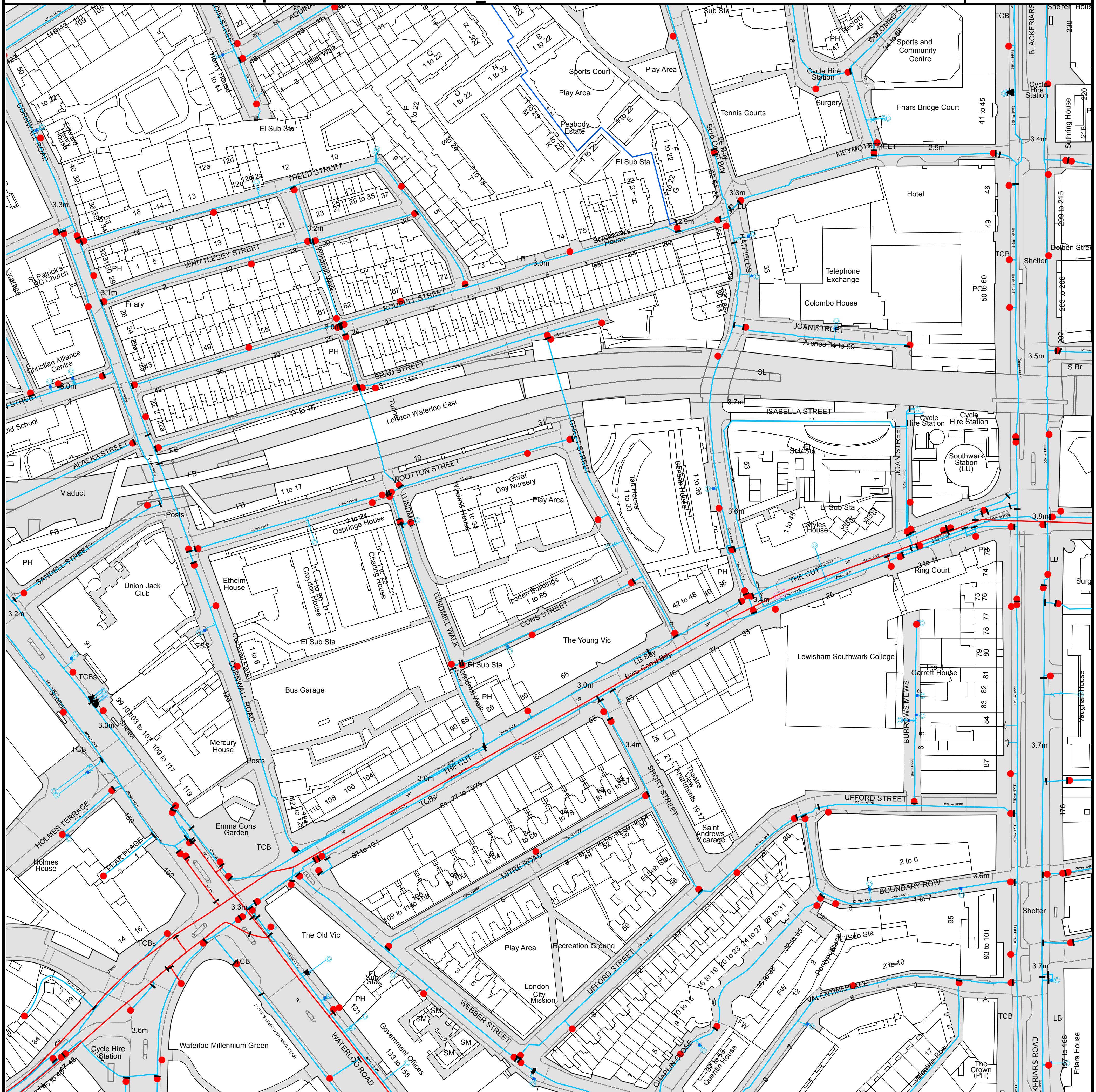
Proposed

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_4105120



The width of the displayed area is 500 m and the centre of the map is located at OS coordinates 531431, 179996.

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 Purpose Valve
- Air Valve
- Pressure Control Valve
- 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

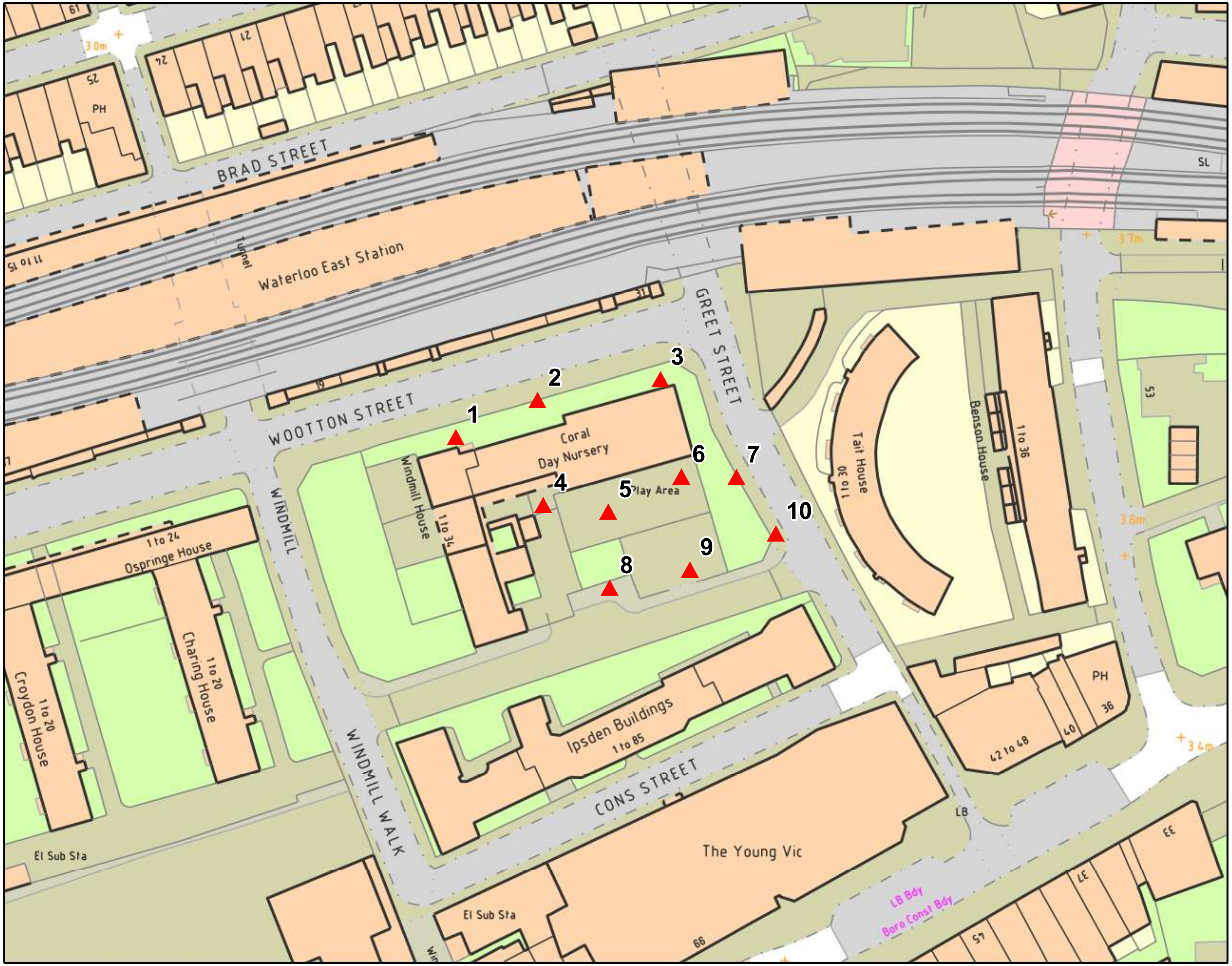
You can get more information about the PCCB from www.propertycodes.org.uk

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

Appendix E

Environment Agency Correspondence

Node Location Map centred on SE1 8AZ created 14 November 2019 [Ref: KSL 146986 KB]



Environment Agency

Scale 1: 1,000

Legend

▲ Node Point Locations

Contact Us: National Customer Contact Centre, PO Box 544, Rotherham, S60 1BY. Tel: 03708 506 506 (Mon-Fri 8-6). Email: enquiries@environment-agency.gov.uk

Thames Tidal Upriver Breach Inundation Modelling - 2017

The table below displays site-specific modelled flood levels at your site. These have been taken from the Thames Tidal Upriver Breach Inundation Modelling Study 2017 completed by Atkins Ltd. in May 2017.

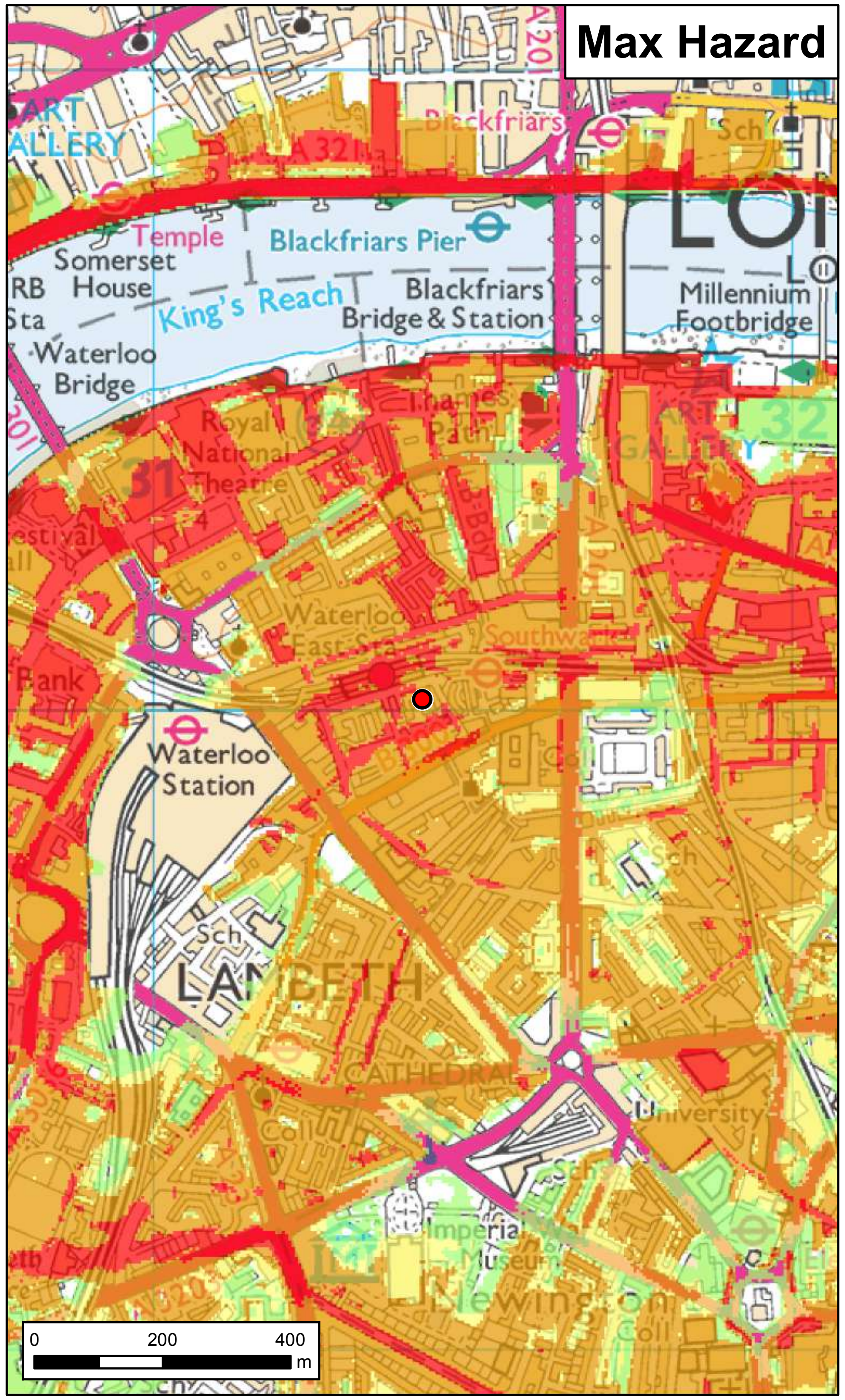
We have developed a modelling approach where all upriver breach locations along the Thames are equitably modelled, to ensure a consistent approach across London. This modelling simulates 5679 continuous tidal breaches along the entire extent of the Thames from Teddington to the Thames Barrier. For hard and composite defences breaches are set at 20 m wide; for soft defences, breaches are 50 m wide. In both cases, the defence breach scour distance was assumed to extend into the floodplain by the same distance as the breach width.

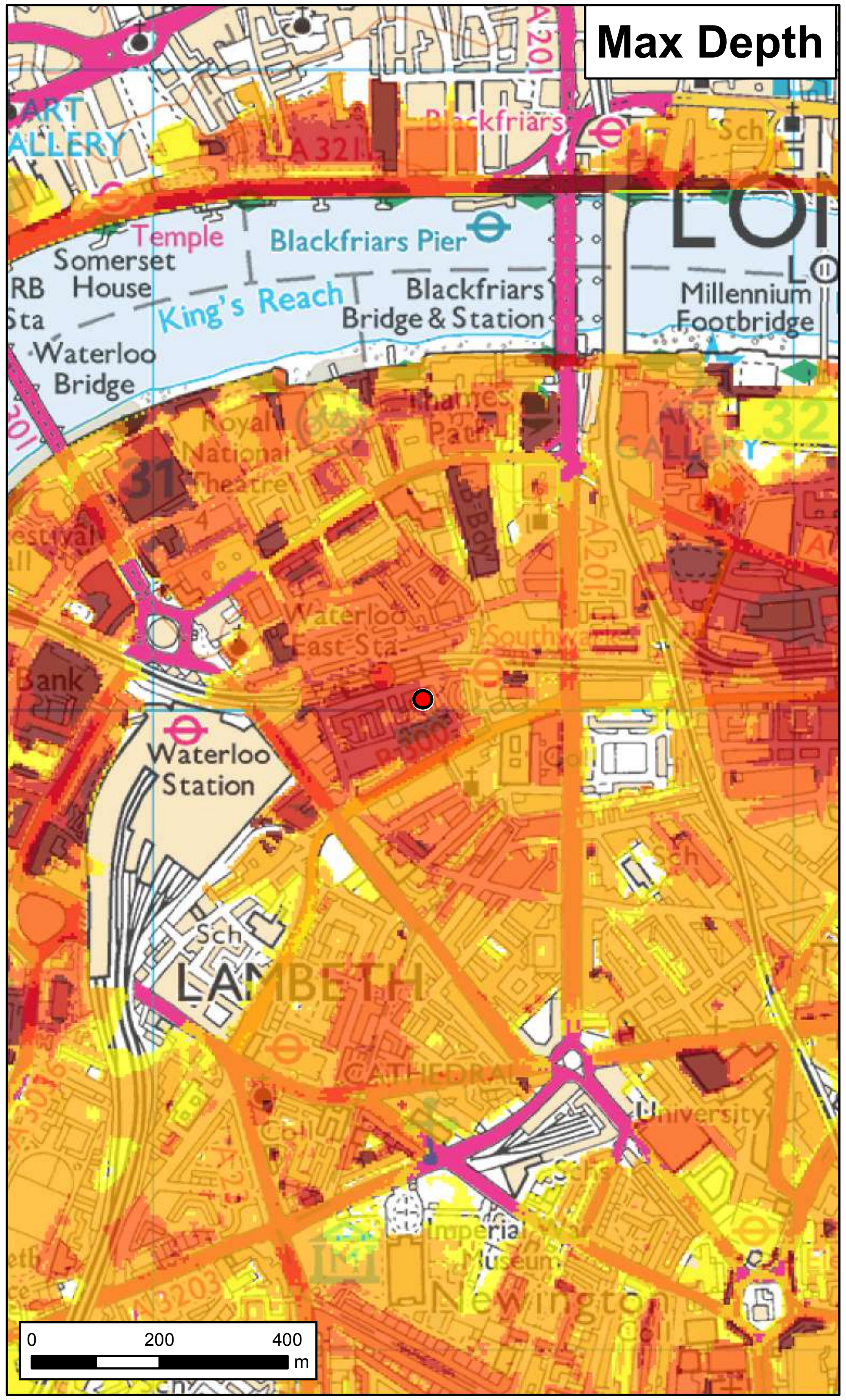
For breaches upriver of the Thames Barrier, there is no return period for modelled levels as the levels are controlled by barrier closures. The levels used are referred to as Maximum Likely Water Levels (MLWLs). Therefore 2014 and 2100 epochs were modelled on that basis.

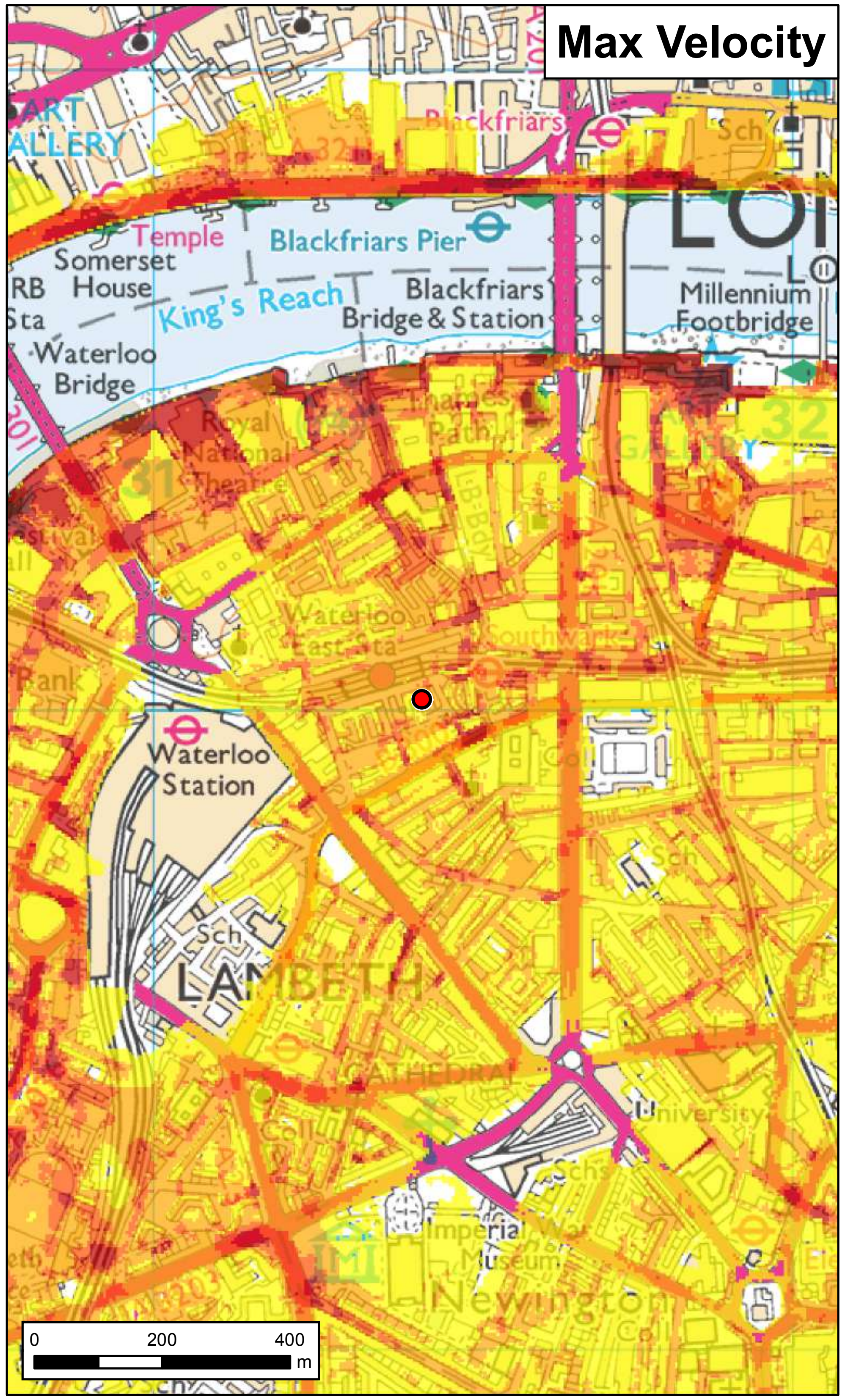
This model has been designed for catchment wide flood risk mapping. It should be noted that it was not created to produce flood levels for specific development sites within London.

	National Grid Reference		Modelled levels in mAODN for Max Likely Water Level	
Node	**Easting**	**Northing**	**2014**	**2100**
1	531395	180026	2.81	4.31
2	531410	180032	2.81	4.31
3	531432	180036	2.81	4.31
4	531411	180013	Nil return	4.31
5	531422	180012	Nil return	4.31
6	531436	180019	Nil return	4.31
7	531445	180018	Nil return	4.31
8	531423	179999	Nil return	4.31
9	531437	180002	Nil return	4.31
10	531452	180008	Nil return	4.30

Orchard House, Endeavour Park, London Road, Addington, West Malling, Kent, ME19 5SH.
Customer services line: 020 8474 6848
Email: kslenquiries@environment-agency.gov.uk
Website: https://www.gov.uk/government/organisations/environment-agency







● Site Location

Max Hazard	Max Depth (m)	Max Velocity (m/s)
Less than 0.75 (Low Hazard)	0 - 0.25	0 - 0.3
Between 0.75 and 1.25 (Danger for Some)	0.25 - 1.00	0.3 - 1.0
Between 1.25 and 2.00 (Danger for Most)	1.00 - 1.50	1.0 - 1.5
Greater than 2.00 (Danger for All)	1.50 - 2.00	1.5 - 2.5
	> 2.00	> 2.5

Date Printed	14/11/2019	Scenario year	2100	Scenario Annual Chance	MLWL

This map shows the combined flood hazard to people (called a hazard rating) if our flood defences are breached at any given single location, for a range of scenarios. The hazard rating depends on the depth and velocity of floodwater, and maximum values of these are also mapped.

The map is based on computer modelling of simulated breaches covering the entire extent between Teddington Weir and the Thames Barrier. Each breach has been modelled individually and the results combined to create this map. Multiple breaches, other combinations of breaches, different sized tidal surges or flood flows may all give different results.

The map only considers the consequences of a breach, it does not make any assumption about the likelihood of a breach occurring. The likelihood of a breach occurring will depend on a number of different factors, including the construction and condition of the defences in the area. A breach is less likely where defences are of a good standard, but a risk of breaching remains.

Please contact the Environment Agency for further information on emergency planning associated with flood risk in this area.

General Enquiries No: 03708 506 506. Weekday Daytime calls cost 5p plus up to 6p per minute from BT Weekend Unlimited. Mobile and other providers' charges may vary

Environment Agency

Thames Tidal Breach Hazard Mapping

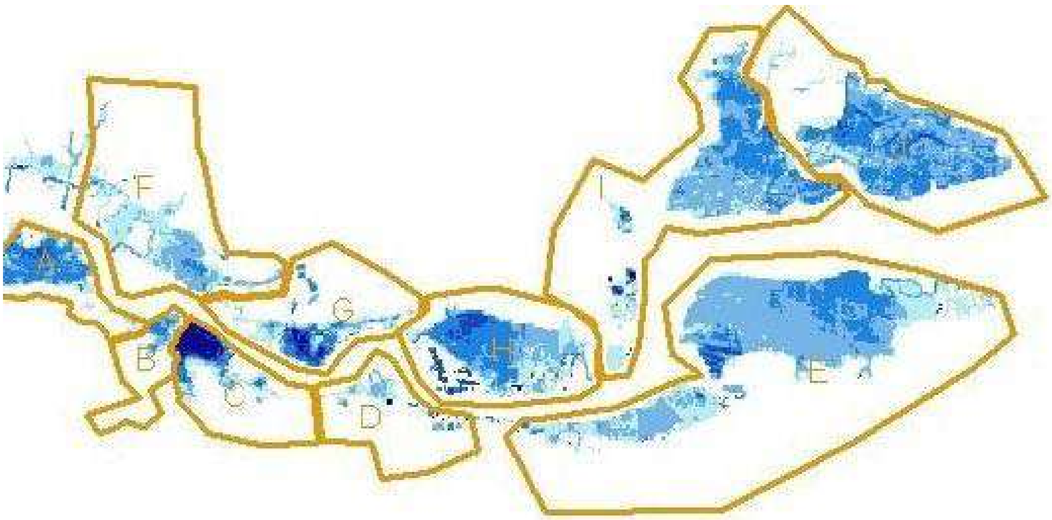
Map Centred on SE1 8AZ
KSL 146986 KB

Environment Agency
creating a better place

Thames Estuary 2100

Phase 3 Studies, Topic 1.5

Phase 3 Set 2 Estuary Wide Options Hydraulic modelling



Modelling the 1953 flood

EA Study Lead:	David Ramsbottom
Consultants:	HR Wallingford

Thames Estuary 2100

Status: Final

Date: December 2008

We are the Environment Agency. It's our job to look after your environment and make it **a better place** - for you, and for future generations.

Your environment is the air you breathe, the water you drink and the ground you walk on. Working with business, Government and society as a whole, we are making your environment cleaner and healthier.

The Environment Agency. Out there, making your environment a better place.

Produced by:

HR Wallingford on behalf of the Environment Agency
HR Wallingford Report Number EX 5944

Environment Agency
TE2100 Project Thames Barrier
Eastmoor Street Charlton
London SE7 7PN
Tel: 0208 3054160
Email: enquiries@environment-agency.gov.uk
www.environment-agency.gov.uk

Contents

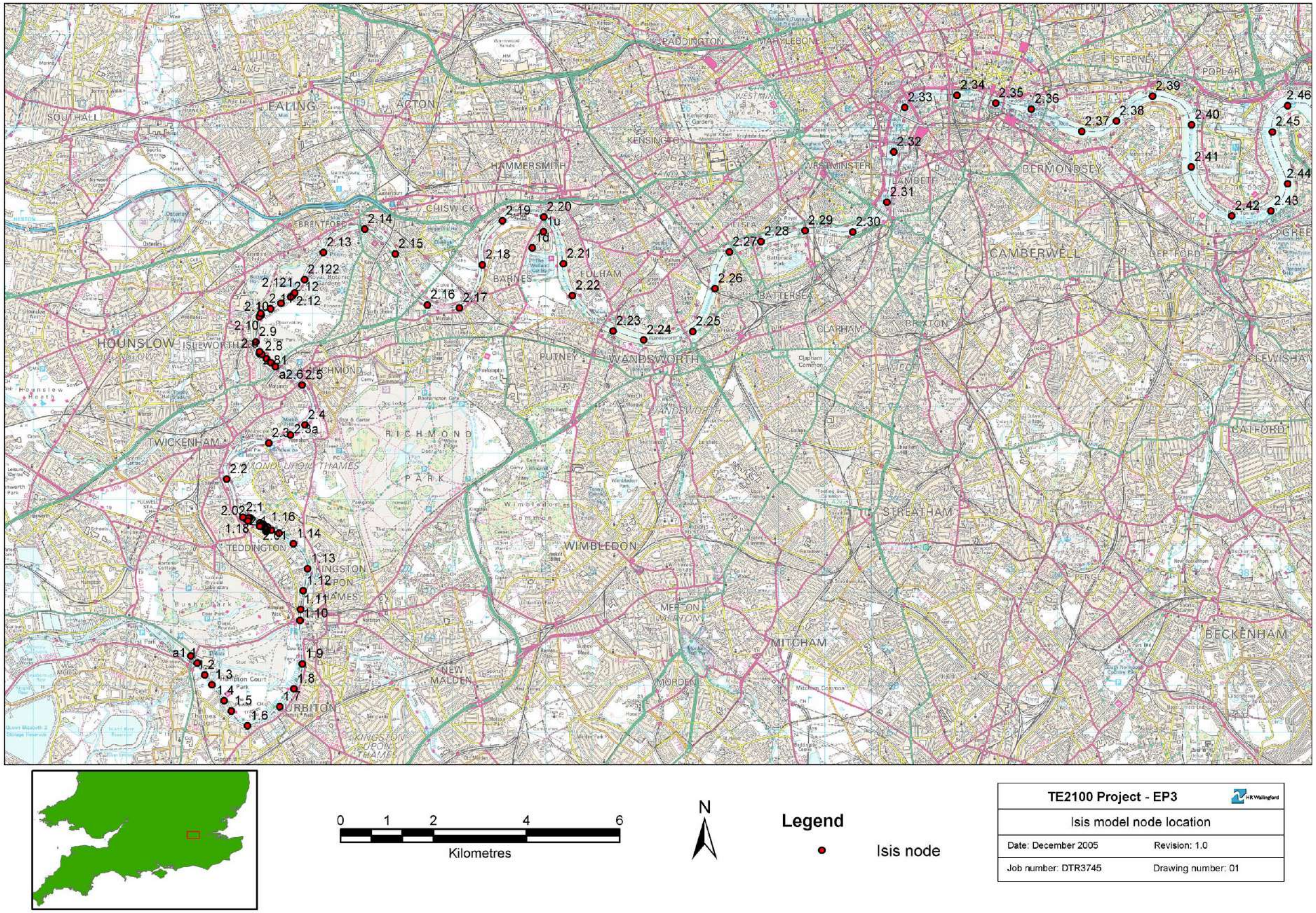


Figure A.3 Model estuary node locations: Molesey to Greenwich

Annex D Base water levels

D.1 Assumptions

Design water levels have been produced for 3 conditions:

- Basecase 0 – The model of the estuary is 'glass walled' so that there is no overtopping and water levels in the channel are higher than with the floodplains (conservative).
- Base case 1 – The model of the estuary includes the floodplains and uses the present day defence levels.
- Basecase 2 – The model of the estuary includes the floodplains and uses the present day defence levels with the freeboard removed.

The design water levels for the case where the Thames Barrier is operational are based on the following assumptions:

- Downriver of the barrier water levels are produced for tides of given return periods. The design tides are the 1,000 year and 10,000 year tides.
- Upriver of Hammersmith the water levels are determined by interactions between tide and flow, but at high flows are dominated by the fluvial flow.
- In present day conditions the water levels between the Thames Barrier and Hammersmith are controlled by the operational rules of the barrier. The maximum water levels are determined by the range of tides that can pass through the Thames Barrier (Figure D.1).

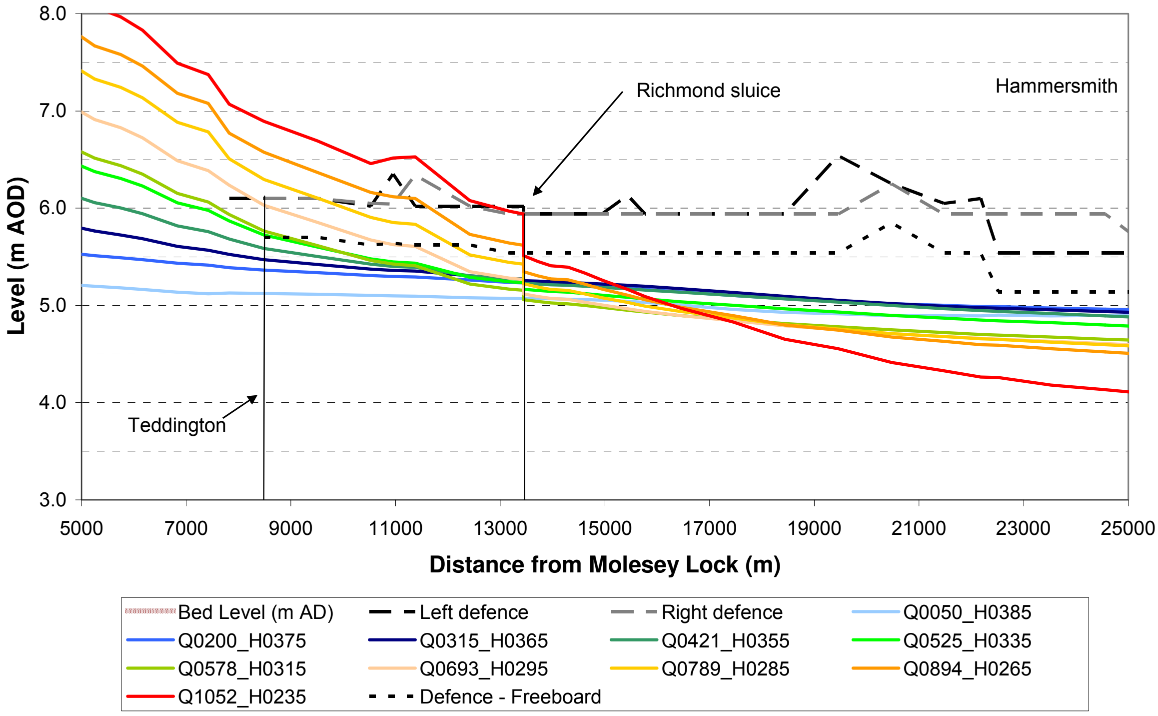


Figure D.1 Water level profiles for combinations of flow and tide for which the Thames Barrier is not closed

D.2 Barrier Closed According to Rule 1

D.2.1 Present Day

Long profiles of water level have been plotted for tides of 1,000 year and 10,000 year return periods under present day conditions with the barrier closed. This is for the ‘glass wall’ model, actual defences model, and defences without freeboard model.

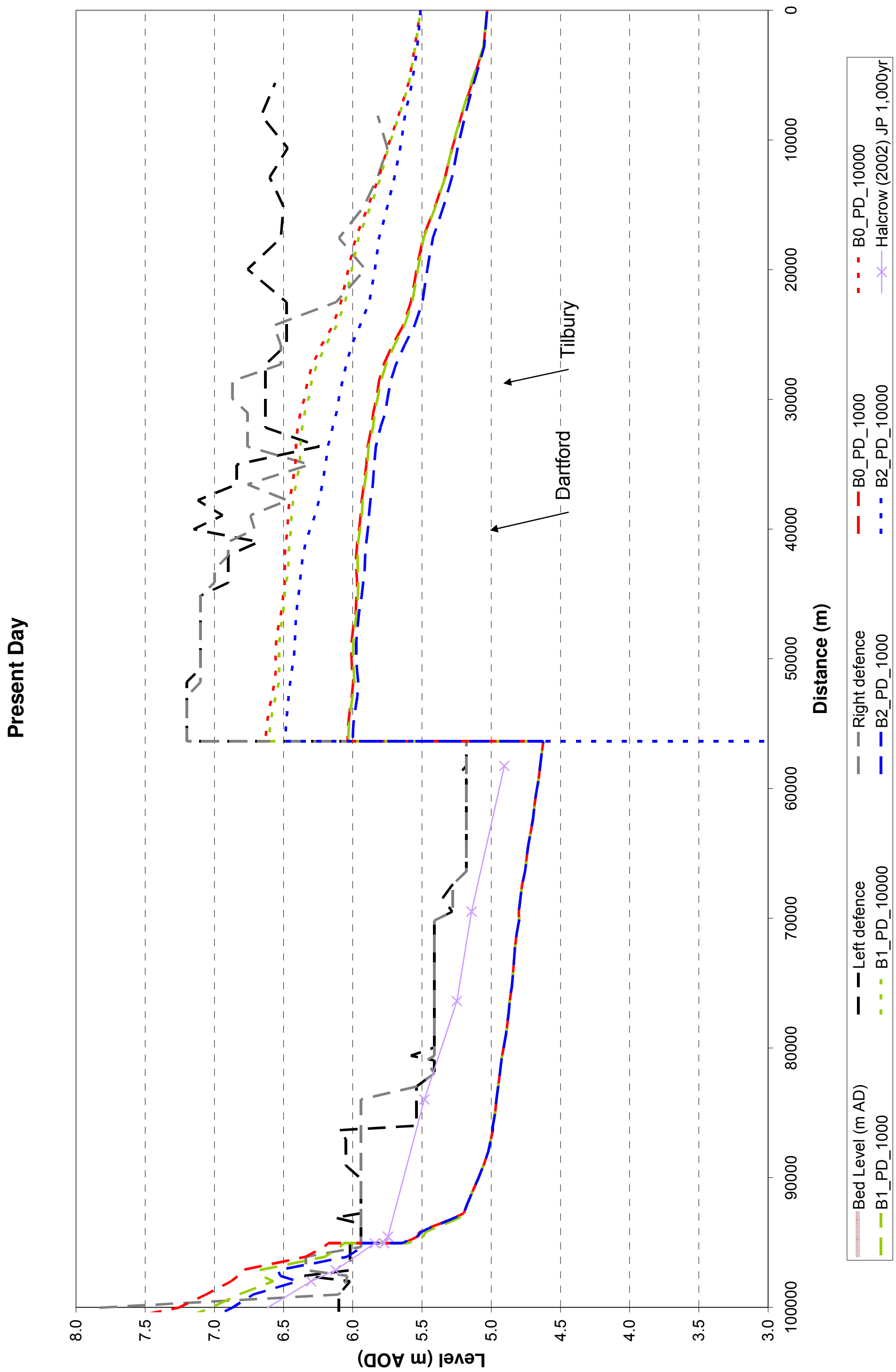


Figure D.2 Peak water levels: barrier closed; present day

River water levels are approximately 0.1 m lower for the model without freeboard in the 1,000 year tide and approximately 0.2 m lower with the 10,000 year tide. Water levels with the actual defences are similar to the glass wall model in all present day events because there is very little overtopping of the actual defences.

Upstream of the Thames Barrier the water levels between the barrier and Richmond are from the barrier closure rule. Upstream of Richmond the water levels are from the 1,000 year fluvial flow. These water levels are lower than the Halcrow (2002) joint probability 1,000 year water levels, which included uncertainty in closure of the barrier. In West London the water levels are greater than the Halcrow (2002) joint probability water levels because Halcrow used lower flows.

Table D.1 Peak water levels: barrier closed; present day

Location	Node	100 year			1,000 year			10,000 year		
		B0	B1	B2	B0	B1	B2	B0	B1	B2
Teddington	2.1	6.05	6.04	6.05	7.26	7.02	6.87	-	-	-
	2.3	5.56	5.54	5.55	6.88	6.57	6.40	-	-	-
	2.4	5.46	5.44	5.45	6.80	6.68	6.54	-	-	-
Richmond	a2.6	5.27	5.27	5.27	6.18	6.07	5.94	-	-	-
	a2.7	5.26	5.26	5.26	5.64	5.61	5.65	-	-	-
	2.9d	5.24	5.24	5.24	5.54	5.49	5.53	-	-	-
	2.21	4.96	4.96	4.96	4.96	4.96	4.96	-	-	-
	2.29	4.87	4.87	4.87	4.87	4.87	4.87	-	-	-
	2.36	4.80	4.80	4.80	4.80	4.80	4.80	-	-	-
	2.47	4.65	4.65	4.65	4.65	4.65	4.65	-	-	-
Barrier	a3.1	5.53	5.52	5.52	6.04	6.03	6.00	6.63	6.60	6.49
	3.2	5.52	5.52	5.52	6.03	6.03	6.00	6.62	6.60	6.48
	3.3	5.50	5.50	5.50	6.02	6.02	5.99	6.61	6.58	6.47
	3.4	5.49	5.49	5.48	6.01	6.00	5.97	6.59	6.56	6.46
Roding	a3.5u	5.48	5.47	5.47	6.00	5.99	5.96	6.57	6.53	6.45
	a3.5d	5.48	5.47	5.47	6.00	5.99	5.96	6.57	6.53	6.45
	3.6	5.48	5.47	5.46	6.01	5.99	5.97	6.56	6.53	6.44
	3.7	5.48	5.47	5.46	6.01	6.00	5.98	6.56	6.53	6.42
Beam	3.8	5.48	5.47	5.47	6.01	6.00	5.98	6.56	6.53	6.42
	3.9	5.47	5.47	5.46	6.00	5.99	5.97	6.54	6.52	6.42
	3.10	5.45	5.45	5.45	5.98	5.97	5.95	6.52	6.50	6.41
	3.11	5.44	5.44	5.44	5.97	5.96	5.94	6.50	6.49	6.39
	3.12	5.43	5.43	5.43	5.97	5.96	5.93	6.49	6.48	6.38
	3.13	5.43	5.43	5.42	5.97	5.97	5.91	6.49	6.47	6.37
	3.14	5.43	5.43	5.42	5.98	5.97	5.91	6.49	6.47	6.36
Darent	3.15u	5.43	5.43	5.42	5.97	5.96	5.90	6.48	6.46	6.34
	3.15d	5.43	5.43	5.42	5.97	5.96	5.90	6.48	6.46	6.34
	3.16	5.43	5.43	5.42	5.95	5.95	5.89	6.47	6.45	6.31
	3.17	5.41	5.42	5.41	5.94	5.94	5.88	6.47	6.44	6.27
	3.18	5.41	5.41	5.40	5.94	5.93	5.87	6.46	6.43	6.24
	3.19	5.40	5.40	5.39	5.92	5.91	5.86	6.44	6.41	6.22
	3.20	5.38	5.39	5.38	5.90	5.90	5.85	6.42	6.38	6.20
	3.21	5.37	5.37	5.36	5.89	5.89	5.83	6.41	6.38	6.18
	3.22	5.35	5.34	5.33	5.86	5.85	5.80	6.40	6.37	6.15
	3.23	5.34	5.34	5.32	5.85	5.84	5.77	6.38	6.35	6.12
	3.24	5.32	5.32	5.31	5.83	5.82	5.75	6.35	6.32	6.10
	3.25	5.28	5.29	5.28	5.81	5.80	5.73	6.33	6.30	6.08
Tilbury	3.26	5.25	5.25	5.24	5.78	5.76	5.69	6.29	6.26	6.05
	3.27	5.19	5.19	5.18	5.71	5.70	5.62	6.22	6.19	6.01
	3.28	5.13	5.13	5.12	5.64	5.63	5.55	6.14	6.12	5.95
	3.29	5.09	5.09	5.08	5.58	5.57	5.50	6.09	6.06	5.88
Mucking	3.30	5.05	5.05	5.04	5.54	5.53	5.46	6.03	6.01	5.84
	3.31	5.01	5.01	5.00	5.49	5.49	5.42	5.98	5.96	5.81
	3.32	4.93	4.93	4.93	5.41	5.40	5.34	5.89	5.87	5.75
	3.33	4.86	4.87	4.86	5.33	5.33	5.28	5.81	5.80	5.70
	3.34	4.82	4.82	4.82	5.28	5.29	5.24	5.75	5.74	5.66
Canvey	3.35	4.75	4.76	4.76	5.22	5.22	5.19	5.67	5.67	5.62
	3.36	4.68	4.69	4.69	5.14	5.14	5.13	5.60	5.59	5.57
	3.37	4.61	4.61	4.61	5.06	5.06	5.05	5.55	5.55	5.54
Southend	3.38	4.57	4.57	4.57	5.03	5.03	5.03	5.51	5.51	5.51

D.2.2 Defra '06 climate change scenario: 2050

Long profiles of water level have been plotted for tides of 1,000 year and 10,000 year return periods under Defra '06 2050 scenario with the barrier closed. This is for the 'glass wall' model, actual defences model, and defences without freeboard model.

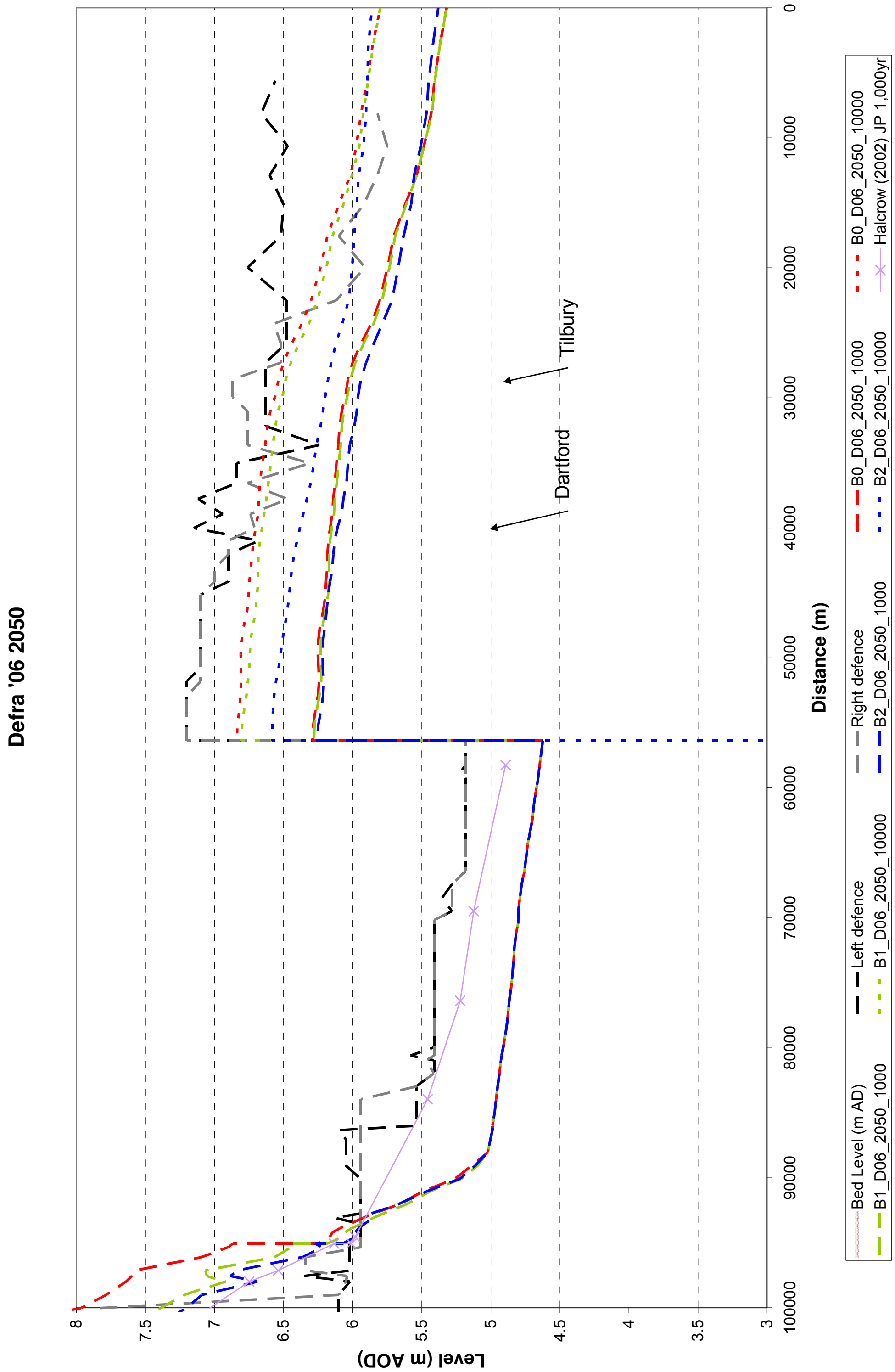


Figure D.3 Peak water levels: barrier closed; 2050 (Defra climate change)

The water levels for the B2 case are from older model runs using a tide that is 0.06m too high at Southend. This is because 10 years of climate change between 1990 and 2000 have been double counted. This was corrected for the Phase 3 Set 1 Options, and the base conditions for the B0 and B1 cases were re-run. For Defra'06 in 2050 this has an influence on water levels in the 100 and 1,000 year tides. In the 10,000 year tide in 2050 (and for 1,000 and 10,000 year tides after 2050) the impact of this error is constrained to Southend and North Kent because of overtopping. In the 1,000 year tide the model with the actual defence levels gives water levels approximately the same as the glass wall model, and the model without freeboard are approximately 0.1 m lower than the glass wall model. In the 10,000 year tide these differences are approximately 0.05 m and 0.3 m, upstream of Tilbury.

Upstream of the Thames Barrier the water levels between the barrier and Richmond are from the barrier closure rule. Upstream of Richmond the water levels are from the 1,000 year fluvial flow plus 20% due to climate change. These water levels are lower than the Halcrow (2002) joint probability 1,000 year water levels for 2050, which included uncertainty in closure of the barrier. In West London the water levels are greater than the Halcrow (2002) joint probability water levels for 2050 because Halcrow used lower flows.

Table D.2 Peak water levels: barrier closed; 2050 (Defra climate change)

Location	Node	100 year			1,000 year			10,000 year		
		B0	B1	B2	B0	B1	B2	B0	B1	B2
Teddington	2.1	6.63	6.60	6.50	7.97	7.39	7.21	-	-	-
	2.3	6.19	6.15	6.03	7.64	6.92	6.69	-	-	-
	2.4	6.11	6.07	6.11	7.57	7.07	6.84	-	-	-
Richmond	a2.6	5.54	5.50	5.52	6.87	6.46	6.27	-	-	-
	a2.7	5.26	5.26	5.26	6.26	6.18	6.07	-	-	-
	2.9d	5.24	5.24	5.24	6.17	6.07	5.97	-	-	-
	2.21	4.96	4.96	4.96	4.96	4.96	4.96	-	-	-
	2.29	4.87	4.87	4.87	4.87	4.87	4.87	-	-	-
	2.36	4.80	4.80	4.80	4.80	4.80	4.80	-	-	-
	2.47	4.65	4.65	4.65	4.65	4.65	4.65	-	-	-
Barrier	a3.1	5.74	5.74	5.76	6.29	6.28	6.26	6.84	6.81	6.58
	3.2	5.73	5.74	5.76	6.29	6.28	6.25	6.83	6.80	6.58
	3.3	5.73	5.73	5.74	6.27	6.26	6.23	6.82	6.79	6.58
	3.4	5.72	5.72	5.74	6.25	6.24	6.21	6.81	6.77	6.57
Roding	a3.5u	5.73	5.72	5.73	6.24	6.23	6.21	6.81	6.76	6.55
	a3.5d	5.73	5.72	5.73	6.24	6.23	6.21	6.81	6.76	6.55
	3.6	5.73	5.73	5.74	6.25	6.23	6.22	6.81	6.75	6.54
	3.7	5.73	5.73	5.74	6.25	6.23	6.22	6.81	6.75	6.52
Beam	3.8	5.73	5.73	5.74	6.25	6.23	6.21	6.81	6.74	6.51
	3.9	5.72	5.72	5.73	6.24	6.22	6.20	6.79	6.72	6.49
	3.10	5.70	5.70	5.72	6.21	6.20	6.19	6.76	6.70	6.47
	3.11	5.68	5.68	5.69	6.20	6.18	6.18	6.75	6.69	6.46
	3.12	5.68	5.68	5.69	6.19	6.17	6.16	6.75	6.68	6.45
	3.13	5.67	5.67	5.68	6.18	6.17	6.15	6.74	6.69	6.44
	3.14	5.67	5.67	5.68	6.18	6.17	6.14	6.73	6.68	6.42
Darent	3.15u	5.67	5.67	5.68	6.18	6.16	6.13	6.72	6.67	6.40
	3.15d	5.67	5.67	5.68	6.18	6.16	6.13	6.72	6.67	6.40
	3.16	5.66	5.66	5.67	6.16	6.15	6.11	6.70	6.66	6.38
	3.17	5.65	5.65	5.66	6.15	6.14	6.08	6.68	6.64	6.36
	3.18	5.64	5.64	5.64	6.14	6.13	6.07	6.68	6.63	6.33
	3.19	5.63	5.63	5.63	6.13	6.12	6.05	6.67	6.61	6.30
	3.20	5.61	5.61	5.62	6.12	6.10	6.04	6.65	6.59	6.28
	3.21	5.60	5.60	5.61	6.10	6.09	6.02	6.63	6.58	6.26
	3.22	5.59	5.59	5.59	6.10	6.08	5.99	6.62	6.56	6.23
	3.23	5.58	5.58	5.58	6.08	6.06	5.97	6.60	6.54	6.22
	3.24	5.56	5.56	5.56	6.05	6.04	5.96	6.56	6.51	6.20
	3.25	5.53	5.53	5.53	6.04	6.02	5.94	6.54	6.48	6.18
Tilbury	3.26	5.50	5.50	5.50	6.00	5.98	5.90	6.50	6.45	6.16
	3.27	5.45	5.45	5.45	5.94	5.92	5.85	6.44	6.39	6.12
	3.28	5.39	5.38	5.38	5.87	5.85	5.78	6.37	6.32	6.08
	3.29	5.33	5.33	5.32	5.80	5.79	5.72	6.30	6.26	6.03

Location	Node	100 year			1,000 year			10,000 year		
		B0	**B1**	**B2**	**B0**	**B1**	**B2**	**B0**	**B1**	**B2**
Mucking	3.30	5.29	5.28	5.27	5.75	5.73	5.67	6.23	6.19	6.00
	3.31	5.25	5.25	5.24	5.70	5.69	5.63	6.18	6.15	5.99
	3.32	5.16	5.16	5.16	5.62	5.61	5.58	6.10	6.07	5.97
	3.33	5.09	5.09	5.10	5.54	5.53	5.56	6.02	6.00	5.96
	3.34	5.04	5.05	5.05	5.48	5.49	5.51	5.97	5.95	5.92
Canvey	3.35	4.98	4.98	5.02	5.43	5.42	5.47	5.94	5.92	5.90
	3.36	4.95	4.94	5.00	5.41	5.40	5.45	5.90	5.89	5.90
	3.37	4.91	4.91	4.96	5.37	5.37	5.42	5.86	5.85	5.89
Southend	3.38	4.86	4.86	4.92	5.32	5.32	5.38	5.80	5.80	5.86

D.2.3 Defra '06 climate change scenario: 2100

Long profiles of water level have been plotted for tides of 1,000 year and 10,000 year return periods under Defra '06 2100 scenario with the barrier closed. This is for the 'glass wall' model, actual defences model, and defences without freeboard model.

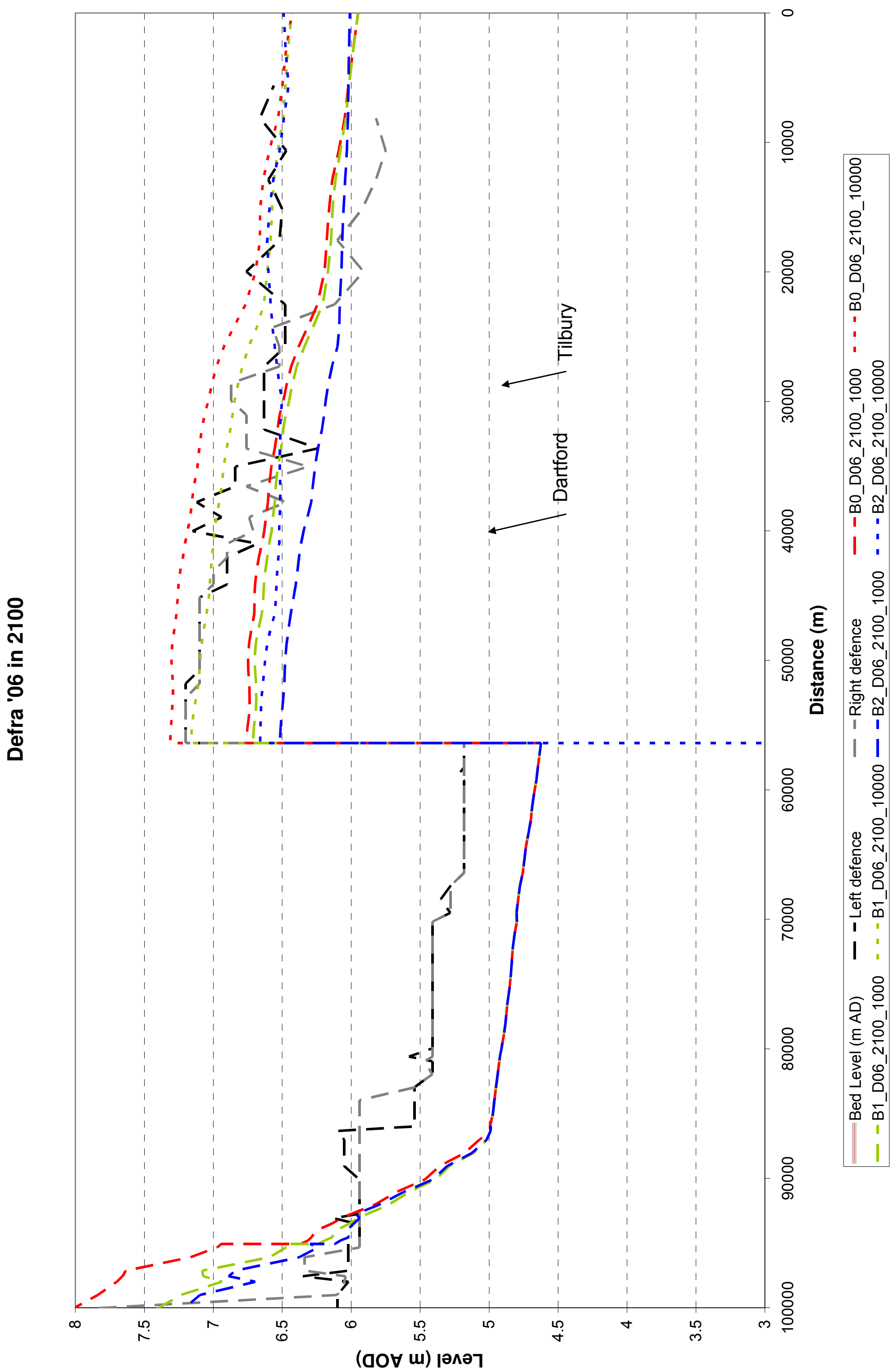


Figure D.4 Peak water levels: barrier closed; 2100 (Defra climate change)

Table D.3 Peak water levels: barrier closed; 2100 (Defra climate change)

Location	Node	100 year			1,000 year			10,000 year		
		B0	B1	B2	B0	B1	B2	B0	B1	B2
Teddington	2.1	6.68	6.63	6.52	8.01	7.40	7.21	-	-	-
	2.3	6.27	6.20	6.07	7.70	6.94	6.70	-	-	-
	2.4	6.18	6.15	6.16	7.64	7.08	6.84	-	-	-
Richmond	a2.6	5.64	5.60	5.60	6.94	6.49	6.30	-	-	-
	a2.7	5.28	5.26	5.27	6.37	6.24	6.12	-	-	-
	2.9d	5.24	5.24	5.24	6.29	6.14	6.02	-	-	-
	2.21	4.96	4.96	4.96	4.96	4.96	4.96	-	-	-
	2.29	4.87	4.87	4.87	4.87	4.87	4.87	-	-	-
	2.36	4.80	4.80	4.80	4.80	4.80	4.80	-	-	-
	2.47	4.65	4.65	4.65	4.65	4.65	4.65	-	-	-
Barrier	a3.1	6.22	6.20	6.21	6.76	6.71	6.52	7.31	7.16	6.66
	3.2	6.22	6.20	6.20	6.75	6.71	6.51	7.31	7.16	6.66
	3.3	6.20	6.19	6.18	6.74	6.69	6.50	7.30	7.14	6.65
	3.4	6.20	6.18	6.17	6.74	6.69	6.49	7.29	7.13	6.65
Roding	a3.5u	6.20	6.19	6.15	6.74	6.69	6.48	7.29	7.11	6.64
	a3.5d	6.20	6.19	6.15	6.74	6.69	6.48	7.29	7.11	6.64
	3.6	6.20	6.19	6.14	6.75	6.70	6.48	7.30	7.10	6.63
	3.7	6.21	6.19	6.14	6.75	6.70	6.48	7.30	7.09	6.62
Beam	3.8	6.20	6.19	6.13	6.74	6.69	6.47	7.30	7.08	6.61
	3.9	6.18	6.17	6.11	6.72	6.67	6.46	7.28	7.07	6.59
	3.10	6.19	6.17	6.08	6.70	6.65	6.44	7.27	7.05	6.55
	3.11	6.19	6.17	6.06	6.70	6.64	6.42	7.26	7.03	6.55
	3.12	6.18	6.17	6.06	6.70	6.63	6.40	7.25	7.03	6.54
	3.13	6.17	6.15	6.06	6.69	6.62	6.39	7.24	7.02	6.54
	3.14	6.15	6.13	6.05	6.67	6.61	6.38	7.22	7.01	6.53
Darent	3.15u	6.13	6.11	6.04	6.65	6.60	6.36	7.21	7.00	6.52
	3.15d	6.13	6.11	6.04	6.65	6.60	6.36	7.21	7.00	6.52
	3.16	6.11	6.09	6.03	6.63	6.58	6.35	7.19	6.99	6.52
	3.17	6.10	6.08	6.01	6.62	6.57	6.32	7.17	6.98	6.52
	3.18	6.09	6.08	5.99	6.60	6.56	6.29	7.16	6.96	6.51
	3.19	6.08	6.06	5.98	6.60	6.55	6.28	7.14	6.94	6.51
	3.20	6.06	6.04	5.97	6.58	6.53	6.26	7.11	6.93	6.52
	3.21	6.04	6.03	5.95	6.55	6.51	6.24	7.10	6.90	6.52
	3.22	6.02	6.01	5.93	6.54	6.49	6.21	7.08	6.88	6.51
	3.23	5.99	5.99	5.91	6.52	6.48	6.20	7.06	6.86	6.51
	3.24	5.97	5.96	5.89	6.49	6.45	6.19	7.04	6.85	6.50
	3.25	5.94	5.94	5.86	6.47	6.43	6.17	7.01	6.82	6.52
Tilbury	3.26	5.91	5.91	5.83	6.44	6.40	6.14	6.98	6.79	6.54
	3.27	5.87	5.86	5.79	6.38	6.34	6.10	6.92	6.74	6.55
	3.28	5.82	5.80	5.74	6.32	6.28	6.09	6.85	6.68	6.57
	3.29	5.76	5.75	5.73	6.25	6.21	6.08	6.77	6.63	6.58
Mucking	3.30	5.73	5.72	5.72	6.19	6.17	6.07	6.69	6.61	6.60
	3.31	5.70	5.69	5.69	6.18	6.15	6.07	6.66	6.58	6.61
	3.32	5.69	5.68	5.67	6.16	6.14	6.06	6.66	6.57	6.59
	3.33	5.67	5.66	5.66	6.14	6.11	6.04	6.64	6.56	6.57
	3.34	5.63	5.63	5.64	6.09	6.08	6.03	6.59	6.53	6.52
Canvey	3.35	5.60	5.60	5.62	6.05	6.04	6.02	6.53	6.49	6.49
	3.36	5.56	5.56	5.60	6.02	6.02	6.02	6.50	6.48	6.45
	3.37	5.53	5.53	5.58	5.99	5.99	6.02	6.47	6.46	6.48
Southend	3.38	5.49	5.49	5.55	5.95	5.95	6.01	6.43	6.43	6.49

Water level profiles for the 100 year tide in 2100 under Defra '06 are similar to the 1,000 year tide in 2050 under Defra '06. In the 1,000 year tide the model with the actual defence levels gives water levels approximately 0.05 m lower than the glass wall model, and the model without freeboard are approximately 0.3 m lower than the glass wall model, upstream of Tilbury. In the 10,000 year tide these differences upstream of Tilbury are approximately 0.35 m and 0.7 m. Downstream of Tilbury the water levels are 0.1 m lower than the glass wall model in the other models. In the B2 model the water levels are above the defence (with freeboard removed) levels in the 10,000 year event. With the actual defence levels (B1 model) the 10,000 year tide levels around the crest level of the defences between the Thames Barrier and Tilbury.

D.2.4 Defra '06 climate change scenario: 2170

Long profiles of water level have been plotted for tides of 100 year, 1,000 year and 10,000 year return periods under Defra '06 2170 scenario with the barrier closed. This is for the 'glass wall' model, actual defences model, and defences without freeboard model.

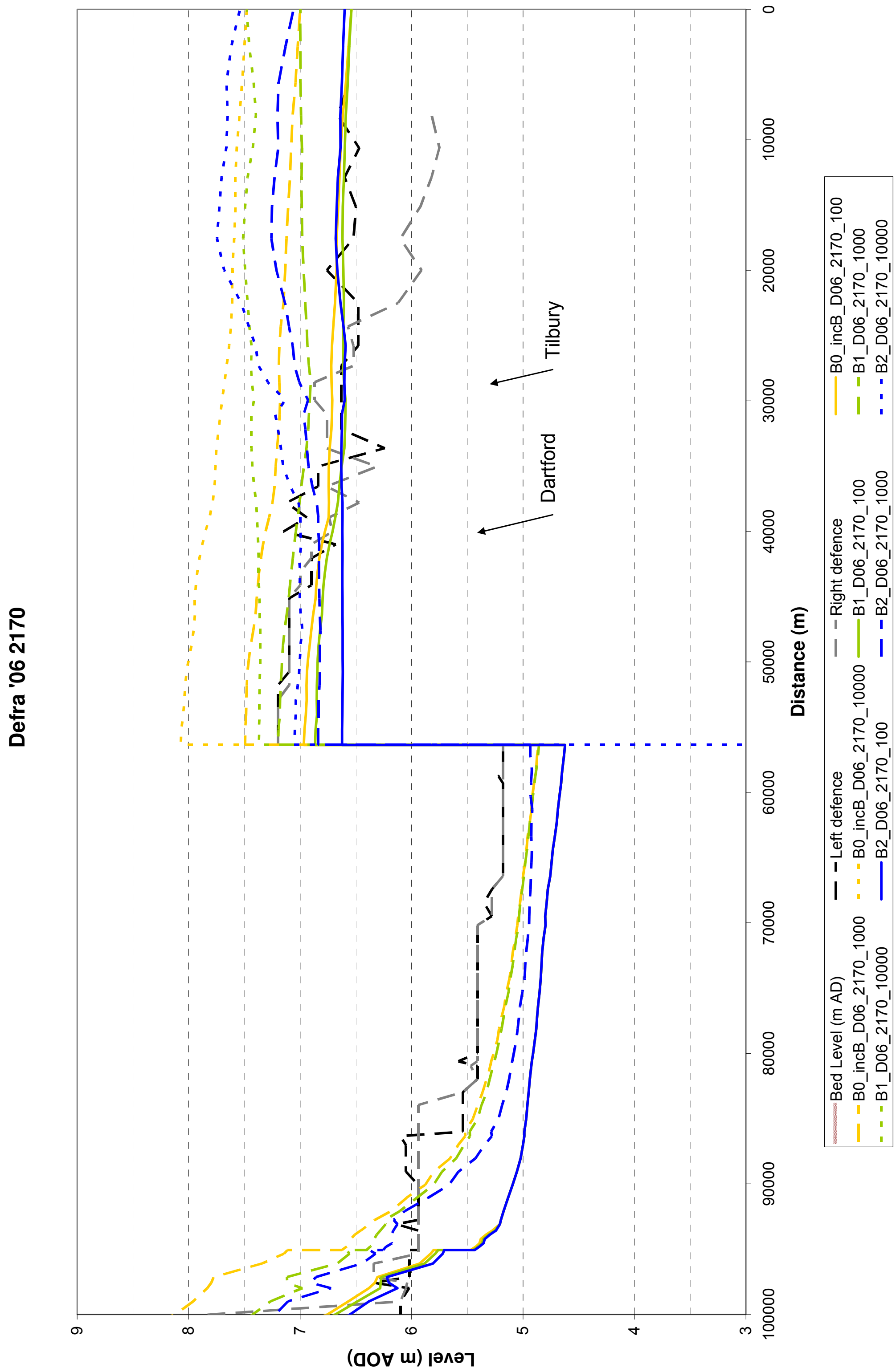


Figure D.5 Peak water levels: barrier closed; 2170 (Defra climate change)

Table D.4 Peak water levels: barrier closed; 2170 (Defra climate change)

Location	Node	100 year			1,000 year			10,000 year		
		B0	B1	B2	B0	B1	B2	B0	B1	B2
Teddington	2.1	6.76	6.69	6.56	8.12	7.43	7.23	-	-	-
	2.3	6.38	6.28	6.13	7.83	6.98	6.72	-	-	-
	2.4	6.31	6.27	6.22	7.78	7.12	6.86	-	-	-
Richmond	a2.6	5.80	5.76	5.71	7.12	6.58	6.38	-	-	-
	a2.7	5.47	5.45	5.44	6.63	6.40	6.26	-	-	-
	2.9d	5.39	5.37	5.36	6.57	6.33	6.18	-	-	-
	2.21	4.96	4.96	4.96	5.41	5.37	5.19	-	-	-
	2.29	4.87	4.87	4.87	5.17	5.16	5.03	-	-	-
	2.36	4.80	4.80	4.80	5.04	5.04	4.94	-	-	-
	2.47	4.65	4.65	4.65	4.88	4.88	4.92	-	-	-
Barrier	a3.1	6.97	6.87	6.62	7.49	7.20	6.84	8.07	7.37	7.05
	3.2	6.96	6.86	6.62	7.49	7.19	6.84	8.07	7.37	7.05
	3.3	6.95	6.85	6.62	7.49	7.18	6.84	8.05	7.37	7.04
	3.4	6.94	6.85	6.62	7.48	7.18	6.83	8.04	7.37	7.04
Roding	a3.5u	6.94	6.85	6.62	7.48	7.18	6.83	8.03	7.36	7.02
	a3.5d	6.94	6.85	6.62	7.48	7.18	6.83	8.03	7.36	7.02
	3.6	6.94	6.85	6.62	7.47	7.17	6.82	8.02	7.36	7.01
	3.7	6.93	6.84	6.62	7.46	7.16	6.82	8.00	7.36	7.00
Beam	3.8	6.91	6.83	6.62	7.44	7.15	6.82	7.98	7.36	7.00
	3.9	6.90	6.82	6.62	7.42	7.14	6.82	7.96	7.36	6.98
	3.10	6.88	6.81	6.62	7.40	7.12	6.82	7.95	7.36	7.00
	3.11	6.86	6.80	6.62	7.39	7.10	6.83	7.94	7.37	7.00
	3.12	6.86	6.79	6.62	7.38	7.09	6.83	7.94	7.37	7.01
	3.13	6.84	6.78	6.62	7.37	7.08	6.83	7.92	7.37	7.00
	3.14	6.83	6.76	6.62	7.35	7.07	6.83	7.90	7.37	7.01
Darent	3.15u	6.80	6.74	6.62	7.33	7.05	6.83	7.88	7.38	6.99
	3.15d	6.80	6.74	6.62	7.33	7.05	6.83	7.88	7.38	6.99
	3.16	6.78	6.71	6.62	7.31	7.04	6.84	7.85	7.38	7.00
	3.17	6.74	6.69	6.62	7.28	7.02	6.84	7.81	7.39	7.00
	3.18	6.74	6.66	6.62	7.25	7.01	6.85	7.78	7.40	7.01
	3.19	6.75	6.65	6.63	7.23	6.99	6.89	7.77	7.41	7.09
	3.20	6.74	6.63	6.63	7.22	6.97	6.93	7.76	7.43	7.15
	3.21	6.73	6.60	6.63	7.21	6.94	6.94	7.75	7.44	7.17
	3.22	6.72	6.60	6.63	7.19	6.93	6.95	7.73	7.44	7.20
	3.23	6.72	6.60	6.63	7.18	6.92	6.97	7.71	7.44	7.22
	3.24	6.71	6.59	6.60	7.18	6.91	6.93	7.70	7.41	7.13
	3.25	6.72	6.61	6.60	7.19	6.91	7.01	7.68	7.43	7.29
Tilbury	3.26	6.72	6.61	6.60	7.19	6.92	7.05	7.66	7.44	7.37
	3.27	6.71	6.61	6.59	7.19	6.93	7.07	7.64	7.44	7.40
	3.28	6.70	6.61	6.61	7.17	6.94	7.10	7.62	7.46	7.46
	3.29	6.69	6.61	6.64	7.15	6.96	7.14	7.61	7.47	7.53
Mucking	3.30	6.67	6.61	6.67	7.13	6.97	7.21	7.61	7.49	7.68
	3.31	6.67	6.62	6.68	7.12	6.98	7.26	7.59	7.51	7.75
	3.32	6.66	6.62	6.67	7.11	6.99	7.25	7.58	7.49	7.73
	3.33	6.65	6.61	6.66	7.09	6.99	7.23	7.58	7.47	7.71
	3.34	6.64	6.60	6.64	7.08	6.99	7.20	7.57	7.43	7.66
Canvey	3.35	6.62	6.59	6.64	7.07	6.99	7.20	7.54	7.40	7.65
	3.36	6.59	6.57	6.63	7.04	7.00	7.19	7.52	7.42	7.66
	3.37	6.57	6.56	6.62	7.02	7.00	7.13	7.50	7.46	7.62
Southend	3.38	6.54	6.54	6.60	7.00	7.00	7.06	7.48	7.48	7.54

The 1,000 and 10,000 year water levels are above the defence levels in the B1 and B2 models.

D.3 Barrier Open

The events for the basecase water level profiles when the Thames Barrier is open are as follows:

- 100 year tide and 100 year fluvial flow
- 1,000 year tide and 1,000 year fluvial flow
- 10,000 year tide and 10,000 year fluvial flow

While these events are not the joint probability 100, 1,000 or 10,000 year return periods they give a high level appreciation of the water level profiles under extreme tides and flows if the Thames Barrier is not closed.

The water levels for the Thames Barrier open case are from older model runs using a tide that is 0.06m too high at Southend. This is because 10 years of climate change between 1990 and 2000 have been double counted. For the B0 case this has an influence on water levels in the 100, 1,000 and 10,000 year tides. In the B1 and B2 case the impact of this error is constrained to downstream of Dartford until 2050 because of overtopping upstream of the Thames Barrier. In 2100 the influence of the error in the B1 and B2 cases is downstream of Tilbury due to the impact of overtopping in the outer estuary as well as upstream of the Thames Barrier. For the B1 and B2 runs in 2170 the error is only in the water levels at Southend because of overtopping along the majority of the estuary.

D.3.1 Present Day

Long profiles of water level have been plotted for tides of 100 year, 1,000 year and 10,000 year return periods under present day conditions with the barrier open. This is for the 'glass wall' model, actual defences model, and defences without freeboard model.

In all return periods overtopping upstream of the barrier has a significant impact on water levels in the model with actual defences and the model without freeboard relative to the glass wall model. The reduction is approximately 0.7 m in the 10,000 year tide, 0.5 m in the 1,000 year tide and 0.2 m in the 100 year tide for the model with actual defence levels. For the model without freeboard the water levels are further reduced by approximately 0.2 m. Downstream of Dartford river water levels are approximately 0.1 m lower for the model without freeboard in the 1,000 year tide and approximately 0.2 m lower with the 10,000 year tide compared to the glass wall model.

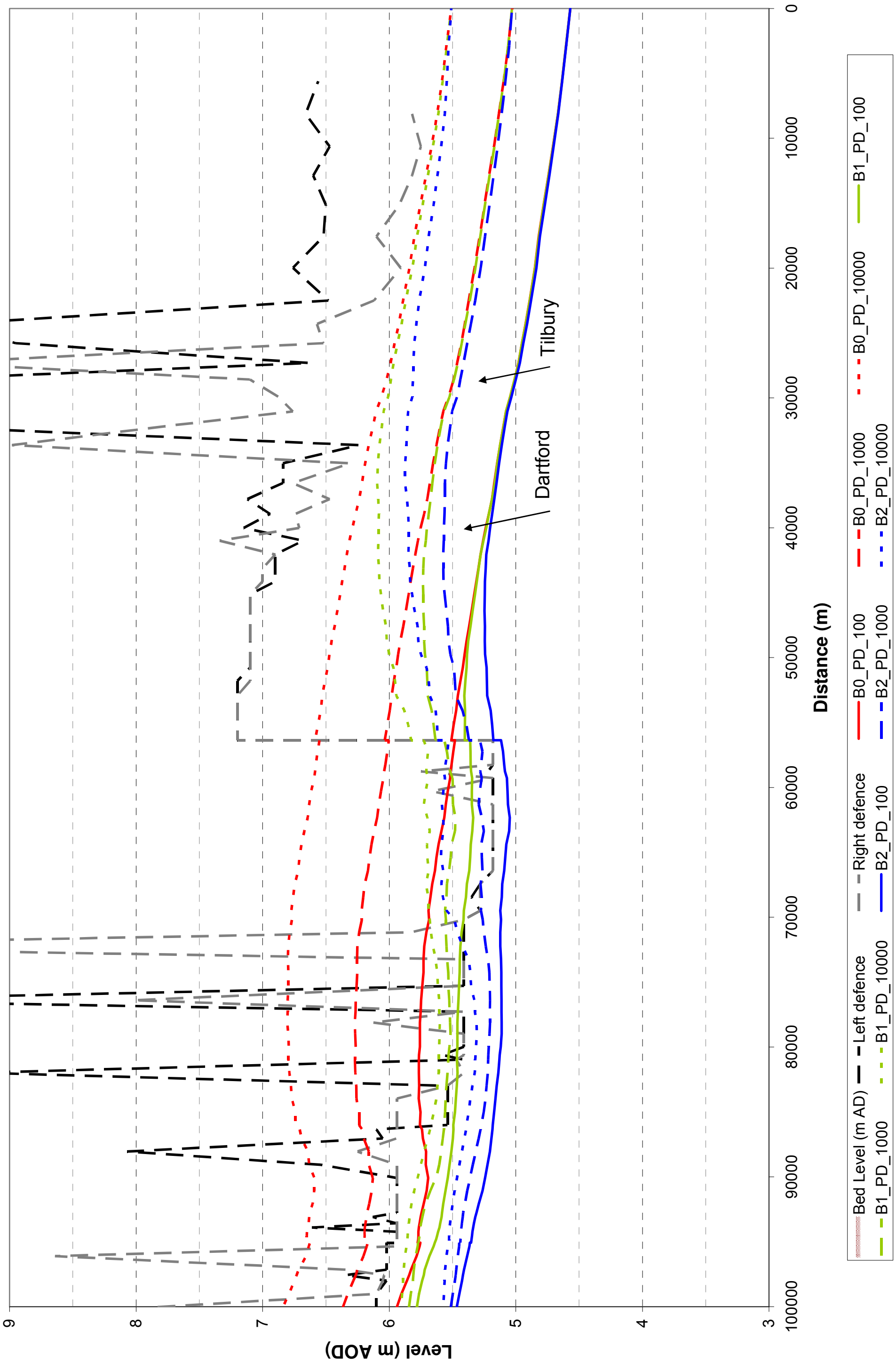


Figure D.6 Peak water levels: barrier open; present day

Table D.5 Peak water levels: barrier open; present day

Location	Node	100 year			1,000 year			10,000 year		
		B0	B1	B2	B0	B1	B2	B0	B1	B2
Teddington	2.1	5.94	5.78	5.47	6.37	5.85	5.51	6.84	5.91	5.57
	2.3	5.86	5.74	5.43	6.28	5.81	5.48	6.75	5.89	5.56
	2.4	5.83	5.72	5.41	6.25	5.81	5.47	6.72	5.89	5.56
Richmond	a2.6	5.75	5.64	5.36	6.17	5.77	5.45	6.63	5.86	5.54
	a2.7	5.78	5.64	5.35	6.20	5.77	5.44	6.66	5.86	5.53
	2.9d	5.77	5.62	5.35	6.19	5.76	5.43	6.65	5.85	5.53
	2.21	5.77	5.47	5.16	6.26	5.56	5.24	6.77	5.63	5.36
	2.29	5.75	5.45	5.11	6.27	5.53	5.20	6.80	5.61	5.33
	2.36	5.69	5.41	5.12	6.22	5.56	5.28	6.77	5.69	5.55
	2.47	5.51	5.36	5.09	6.03	5.53	5.28	6.58	5.70	5.56
Barrier	a3.1	5.51	5.40	5.18	6.04	5.64	5.37	6.59	5.83	5.62
	3.2	5.49	5.40	5.19	6.02	5.65	5.39	6.56	5.85	5.62
	3.3	5.47	5.40	5.20	6.00	5.67	5.42	6.54	5.88	5.63
	3.4	5.46	5.41	5.23	5.98	5.70	5.48	6.53	5.95	5.68
Roding	a3.5u	5.44	5.40	5.23	5.96	5.70	5.48	6.51	5.95	5.69
	a3.5d	5.44	5.40	5.23	5.96	5.70	5.48	6.51	5.95	5.69
	3.6	5.42	5.39	5.23	5.94	5.70	5.49	6.49	5.97	5.70
	3.7	5.41	5.39	5.24	5.93	5.72	5.52	6.47	6.00	5.75
Beam	3.8	5.39	5.38	5.25	5.91	5.72	5.53	6.46	6.02	5.77
	3.9	5.37	5.36	5.24	5.89	5.73	5.54	6.43	6.03	5.78
	3.10	5.35	5.34	5.25	5.87	5.73	5.55	6.41	6.05	5.80
	3.11	5.33	5.32	5.25	5.85	5.73	5.56	6.39	6.07	5.82
	3.12	5.31	5.31	5.24	5.83	5.74	5.57	6.37	6.08	5.84
	3.13	5.30	5.29	5.24	5.81	5.73	5.57	6.35	6.08	5.84
	3.14	5.28	5.28	5.23	5.80	5.73	5.58	6.34	6.09	5.85
Darent	3.15u	5.26	5.26	5.22	5.77	5.71	5.57	6.31	6.09	5.85
	3.15d	5.26	5.26	5.22	5.77	5.71	5.57	6.31	6.09	5.85
	3.16	5.24	5.23	5.20	5.75	5.70	5.57	6.29	6.09	5.85
	3.17	5.21	5.21	5.19	5.73	5.69	5.56	6.27	6.08	5.85
	3.18	5.19	5.19	5.17	5.70	5.67	5.56	6.24	6.09	5.86
	3.19	5.17	5.17	5.15	5.68	5.66	5.56	6.22	6.10	5.87
	3.20	5.15	5.15	5.13	5.65	5.64	5.55	6.19	6.09	5.88
	3.21	5.12	5.12	5.11	5.63	5.62	5.54	6.16	6.08	5.87
	3.22	5.10	5.10	5.09	5.60	5.59	5.52	6.13	6.06	5.86
	3.23	5.08	5.08	5.07	5.57	5.57	5.50	6.10	6.04	5.85
	3.24	5.05	5.05	5.04	5.53	5.53	5.47	6.06	6.01	5.82
	3.25	5.01	5.01	5.00	5.49	5.49	5.44	6.02	5.99	5.81
Tilbury	3.26	4.98	4.98	4.97	5.46	5.46	5.41	5.99	5.97	5.81
	3.27	4.95	4.95	4.94	5.43	5.43	5.38	5.96	5.94	5.80
	3.28	4.92	4.92	4.91	5.40	5.40	5.36	5.93	5.90	5.79
	3.29	4.89	4.89	4.88	5.37	5.36	5.32	5.89	5.87	5.76
Mucking	3.30	4.85	4.85	4.84	5.33	5.32	5.28	5.84	5.82	5.72
	3.31	4.82	4.82	4.81	5.29	5.28	5.24	5.80	5.78	5.69
	3.32	4.78	4.78	4.77	5.25	5.24	5.21	5.75	5.74	5.65
	3.33	4.74	4.74	4.74	5.21	5.21	5.18	5.71	5.70	5.62
	3.34	4.71	4.71	4.70	5.17	5.17	5.14	5.67	5.65	5.59
Canvey	3.35	4.67	4.67	4.67	5.13	5.13	5.11	5.62	5.61	5.56
	3.36	4.64	4.64	4.63	5.10	5.10	5.08	5.58	5.58	5.55
	3.37	4.60	4.60	4.60	5.06	5.06	5.05	5.55	5.55	5.53
Southend	3.38	4.57	4.57	4.57	5.03	5.03	5.03	5.51	5.51	5.51

D.3.2 Defra '06 2050

Long profiles of water level have been plotted for tides of 100 year, 1,000 year and 10,000 year return periods under Defra 2050 scenario with the barrier open. This is for the 'glass wall' model, actual defences model, and defences without freeboard model.

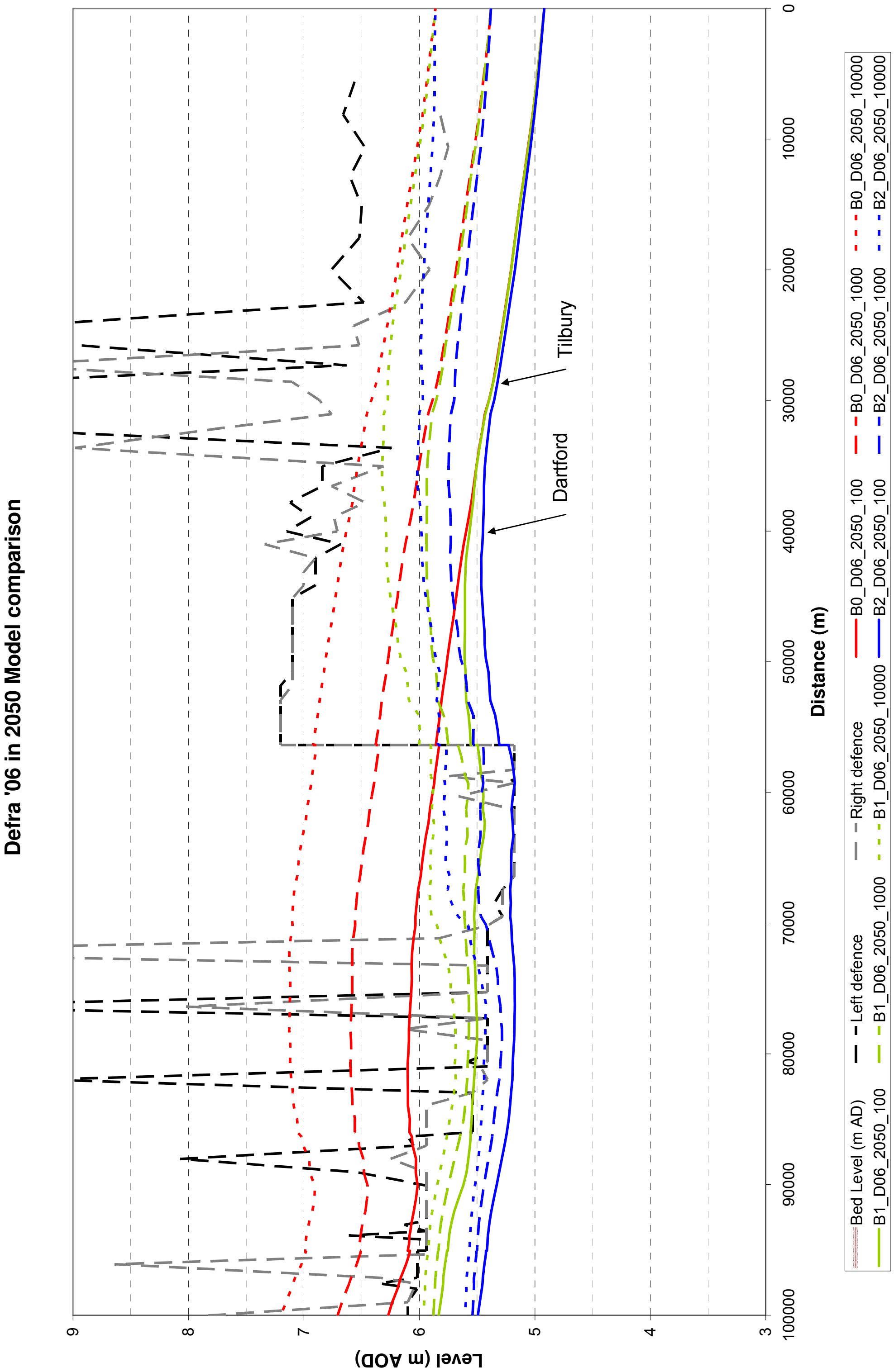


Figure D.7 Peak water levels: barrier open; 2050 (Defra climate change)

Table D.6 Peak water levels: barrier open; 2050 (Defra climate change)

Location	Node	100 year			1,000 year			10,000 year		
		B0	B1	B2	B0	B1	B2	B0	B1	B2
Teddington	2.1	6.27	5.83	5.49	6.71	5.88	5.54	7.20	5.96	5.61
	2.3	6.19	5.80	5.46	6.63	5.87	5.53	7.11	5.95	5.59
	2.4	6.16	5.79	5.45	6.59	5.86	5.53	7.08	5.95	5.59
	a2.6	6.08	5.76	5.42	6.51	5.84	5.51	6.98	5.93	5.57
	a2.7	6.10	5.75	5.42	6.53	5.83	5.50	7.00	5.92	5.57
	2.9d	6.09	5.75	5.41	6.52	5.83	5.50	6.99	5.92	5.56
	2.21	6.10	5.54	5.22	6.58	5.60	5.34	7.09	5.72	5.46
	2.29	6.08	5.51	5.17	6.59	5.57	5.30	7.12	5.70	5.42
	2.36	6.04	5.53	5.21	6.56	5.61	5.47	7.10	5.90	5.66
	2.47	5.86	5.47	5.19	6.38	5.62	5.44	6.92	5.90	5.78
Barrier	a3.1	5.86	5.56	5.31	6.38	5.75	5.53	6.92	6.00	5.84
	3.2	5.84	5.56	5.32	6.36	5.77	5.53	6.90	6.00	5.83
	3.3	5.82	5.57	5.35	6.34	5.79	5.53	6.88	6.01	5.83
	3.4	5.81	5.60	5.39	6.33	5.84	5.58	6.86	6.09	5.85
Roding	a3.5u	5.79	5.60	5.39	6.31	5.85	5.59	6.85	6.10	5.84
	a3.5d	5.79	5.60	5.39	6.31	5.85	5.59	6.85	6.10	5.84
	3.6	5.77	5.60	5.40	6.29	5.86	5.61	6.83	6.12	5.82
	3.7	5.76	5.61	5.42	6.27	5.88	5.64	6.81	6.16	5.86
Beam	3.8	5.74	5.61	5.43	6.26	5.90	5.66	6.79	6.19	5.88
	3.9	5.72	5.61	5.44	6.24	5.90	5.67	6.77	6.19	5.89
	3.10	5.70	5.61	5.45	6.21	5.91	5.69	6.75	6.22	5.92
	3.11	5.68	5.61	5.46	6.19	5.93	5.71	6.73	6.25	5.94
	3.12	5.67	5.61	5.46	6.18	5.94	5.72	6.71	6.27	5.96
	3.13	5.65	5.60	5.46	6.16	5.94	5.73	6.69	6.27	5.97
	3.14	5.64	5.60	5.46	6.14	5.94	5.74	6.68	6.29	5.98
Darent	3.15u	5.62	5.58	5.46	6.12	5.94	5.73	6.66	6.28	5.98
	3.15d	5.62	5.58	5.46	6.12	5.94	5.73	6.66	6.28	5.98
	3.16	5.60	5.57	5.45	6.10	5.94	5.73	6.63	6.29	5.98
	3.17	5.57	5.55	5.45	6.07	5.94	5.73	6.61	6.29	5.99
	3.18	5.55	5.54	5.44	6.05	5.93	5.74	6.58	6.30	6.00
	3.19	5.53	5.52	5.44	6.03	5.94	5.75	6.56	6.32	6.02
	3.20	5.51	5.50	5.43	6.00	5.93	5.75	6.54	6.32	6.02
	3.21	5.48	5.48	5.42	5.98	5.92	5.74	6.51	6.31	6.01
	3.22	5.45	5.45	5.40	5.95	5.90	5.74	6.48	6.31	6.00
	3.23	5.43	5.43	5.38	5.92	5.89	5.73	6.46	6.31	6.00
	3.24	5.40	5.40	5.35	5.88	5.85	5.70	6.41	6.27	5.97
	3.25	5.36	5.36	5.32	5.85	5.82	5.69	6.37	6.27	5.97
Tilbury	3.26	5.34	5.33	5.30	5.82	5.80	5.69	6.34	6.27	5.98
	3.27	5.31	5.31	5.27	5.79	5.77	5.67	6.31	6.25	5.99
	3.28	5.28	5.28	5.25	5.76	5.74	5.65	6.28	6.23	5.98
	3.29	5.25	5.25	5.22	5.73	5.71	5.63	6.25	6.21	5.98
Mucking	3.30	5.21	5.21	5.17	5.68	5.67	5.59	6.19	6.16	5.96
	3.31	5.17	5.17	5.14	5.64	5.63	5.57	6.15	6.12	5.95
	3.32	5.13	5.13	5.10	5.60	5.59	5.53	6.11	6.08	5.92
	3.33	5.10	5.09	5.07	5.56	5.55	5.50	6.06	6.04	5.91
	3.34	5.06	5.06	5.04	5.52	5.52	5.47	6.02	6.00	5.89
Canvey	3.35	5.02	5.02	5.00	5.48	5.48	5.44	5.97	5.96	5.87
	3.36	4.98	4.98	4.98	5.45	5.45	5.42	5.94	5.93	5.87
	3.37	4.95	4.95	4.95	5.41	5.41	5.40	5.90	5.89	5.87
Southend	3.38	4.92	4.92	4.92	5.38	5.38	5.38	5.86	5.86	5.86

In the B1 and B2 models the peak water level is in the reach between Erith and Dartford. The river water level falls in the reach between Erith and the Thames Barrier because of overtopping upstream of the Thames Barrier, where defence levels are lower. In the 100 year event water levels downstream of Dartford are similar in the three models, because of no local overtopping and little influence from upstream. In the 1,000 year tide the overtopping upstream of the barrier has an influence on water levels to downstream of Tilbury.

D.3.3 Defra '06 2100

Long profiles of water level have been plotted for tides of 100 year, 1,000 year and 10,000 year return periods under Defra 2100 scenario with the barrier open. This is for the 'glass wall' model, actual defences model, and defences without freeboard model.

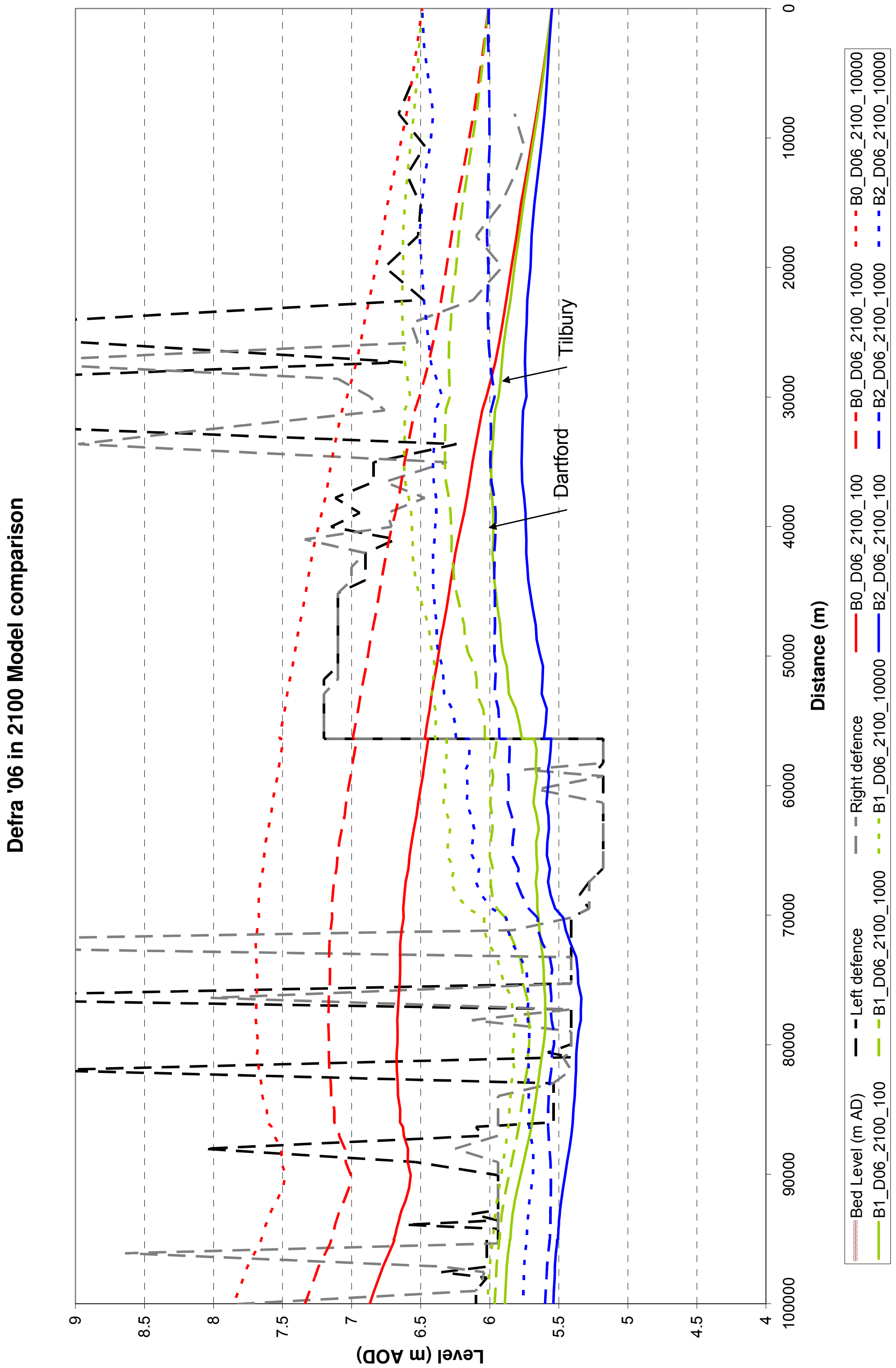


Figure D.8 Peak water levels: barrier open; 2100 (Defra climate change)

Table D.7 Peak water levels: barrier open; 2100 (Defra climate change)

Location	Node	100 year			1,000 year			10,000 year		
		B0	**B1**	**B2**	**B0**	**B1**	**B2**	**B0**	**B1**	**B2**
Teddington	2.1	6.87	5.89	5.54	7.34	5.97	5.60	7.86	6.02	5.76
	2.3	6.80	5.88	5.53	7.27	5.96	5.59	7.78	6.01	5.75
	2.4	6.77	5.88	5.53	7.24	5.95	5.59	7.76	6.00	5.75
	a2.6	6.69	5.86	5.51	7.15	5.93	5.57	7.66	5.98	5.73
	a2.7	6.70	5.85	5.51	7.15	5.93	5.57	7.66	5.98	5.73
	2.9d	6.68	5.85	5.50	7.13	5.93	5.56	7.64	5.97	5.73
	2.21	6.67	5.66	5.39	7.15	5.76	5.57	7.65	5.85	5.72
	2.29	6.66	5.60	5.34	7.17	5.73	5.55	7.69	5.84	5.72
	2.36	6.63	5.66	5.53	7.15	5.95	5.72	7.68	6.16	5.98
	2.47	6.47	5.67	5.57	6.99	5.97	5.86	7.52	6.32	6.15
Barrier	a3.1	6.47	5.77	5.61	6.99	6.04	5.93	7.52	6.40	6.25
	3.2	6.45	5.79	5.60	6.97	6.04	5.93	7.50	6.39	6.25
	3.3	6.44	5.81	5.59	6.95	6.05	5.94	7.48	6.39	6.27
	3.4	6.42	5.86	5.62	6.94	6.09	5.97	7.47	6.42	6.33
Roding	a3.5u	6.40	5.87	5.62	6.91	6.10	5.96	7.45	6.41	6.34
	a3.5d	6.40	5.87	5.62	6.91	6.10	5.96	7.45	6.41	6.34
	3.6	6.38	5.88	5.62	6.90	6.11	5.96	7.43	6.40	6.34
	3.7	6.37	5.91	5.64	6.88	6.16	5.97	7.41	6.42	6.37
Beam	3.8	6.36	5.92	5.66	6.86	6.18	5.97	7.40	6.43	6.39
	3.9	6.34	5.92	5.67	6.84	6.19	5.96	7.38	6.44	6.38
	3.10	6.31	5.94	5.69	6.82	6.21	5.96	7.35	6.48	6.40
	3.11	6.30	5.96	5.71	6.80	6.24	5.96	7.33	6.51	6.41
	3.12	6.28	5.97	5.72	6.78	6.26	5.97	7.32	6.54	6.41
	3.13	6.27	5.97	5.73	6.77	6.26	5.97	7.30	6.55	6.41
	3.14	6.25	5.98	5.74	6.75	6.28	5.97	7.28	6.56	6.41
Darent	3.15u	6.23	5.98	5.74	6.73	6.28	5.96	7.26	6.56	6.40
	3.15d	6.23	5.98	5.74	6.73	6.28	5.96	7.26	6.56	6.40
	3.16	6.21	5.98	5.74	6.71	6.28	5.96	7.24	6.56	6.40
	3.17	6.19	5.98	5.74	6.68	6.28	5.96	7.22	6.57	6.39
	3.18	6.17	5.98	5.75	6.66	6.30	5.97	7.19	6.59	6.39
	3.19	6.15	5.99	5.77	6.64	6.32	5.99	7.17	6.61	6.41
	3.20	6.13	5.99	5.77	6.62	6.33	6.00	7.15	6.62	6.41
	3.21	6.10	5.98	5.77	6.59	6.32	5.99	7.12	6.62	6.40
	3.22	6.08	5.97	5.76	6.56	6.32	5.99	7.09	6.62	6.40
	3.23	6.06	5.96	5.76	6.54	6.32	5.99	7.07	6.62	6.40
	3.24	6.02	5.94	5.73	6.51	6.29	5.96	7.03	6.58	6.35
	3.25	5.99	5.92	5.74	6.47	6.29	5.98	7.00	6.60	6.39
Tilbury	3.26	5.96	5.91	5.75	6.44	6.30	6.00	6.97	6.62	6.43
	3.27	5.93	5.90	5.74	6.41	6.29	6.01	6.94	6.63	6.44
	3.28	5.91	5.88	5.73	6.38	6.28	6.01	6.91	6.63	6.46
	3.29	5.88	5.85	5.73	6.35	6.27	6.02	6.87	6.64	6.48
Mucking	3.30	5.84	5.82	5.70	6.31	6.24	6.01	6.82	6.63	6.49
	3.31	5.81	5.79	5.70	6.28	6.23	6.02	6.78	6.63	6.51
	3.32	5.77	5.76	5.68	6.24	6.20	6.02	6.74	6.62	6.49
	3.33	5.74	5.72	5.65	6.20	6.16	6.01	6.70	6.60	6.47
	3.34	5.70	5.69	5.63	6.16	6.13	6.00	6.65	6.58	6.43
Canvey	3.35	5.66	5.65	5.60	6.12	6.10	6.00	6.60	6.55	6.41
	3.36	5.62	5.62	5.59	6.08	6.07	6.01	6.56	6.53	6.44
	3.37	5.59	5.59	5.57	6.04	6.04	6.01	6.53	6.51	6.48
Southend	3.38	5.55	5.55	5.55	6.01	6.01	6.01	6.49	6.49	6.49

With the Thames Barrier open overtopping upstream of the barrier has a large influence on river water levels downstream of the barrier in the B1 and B2 models. In the 1,000 and 10,000 year tides there is some overtopping of the downstream defences in the B1 and B2 models.

D.3.4 Defra '06 2170

Long profiles of water level have been plotted for tides of 100 year, 1,000 year and 10,000 year return periods under Defra 2170 scenario with the barrier open. This is for the 'glass wall' model, actual defences model, and defences without freeboard model.

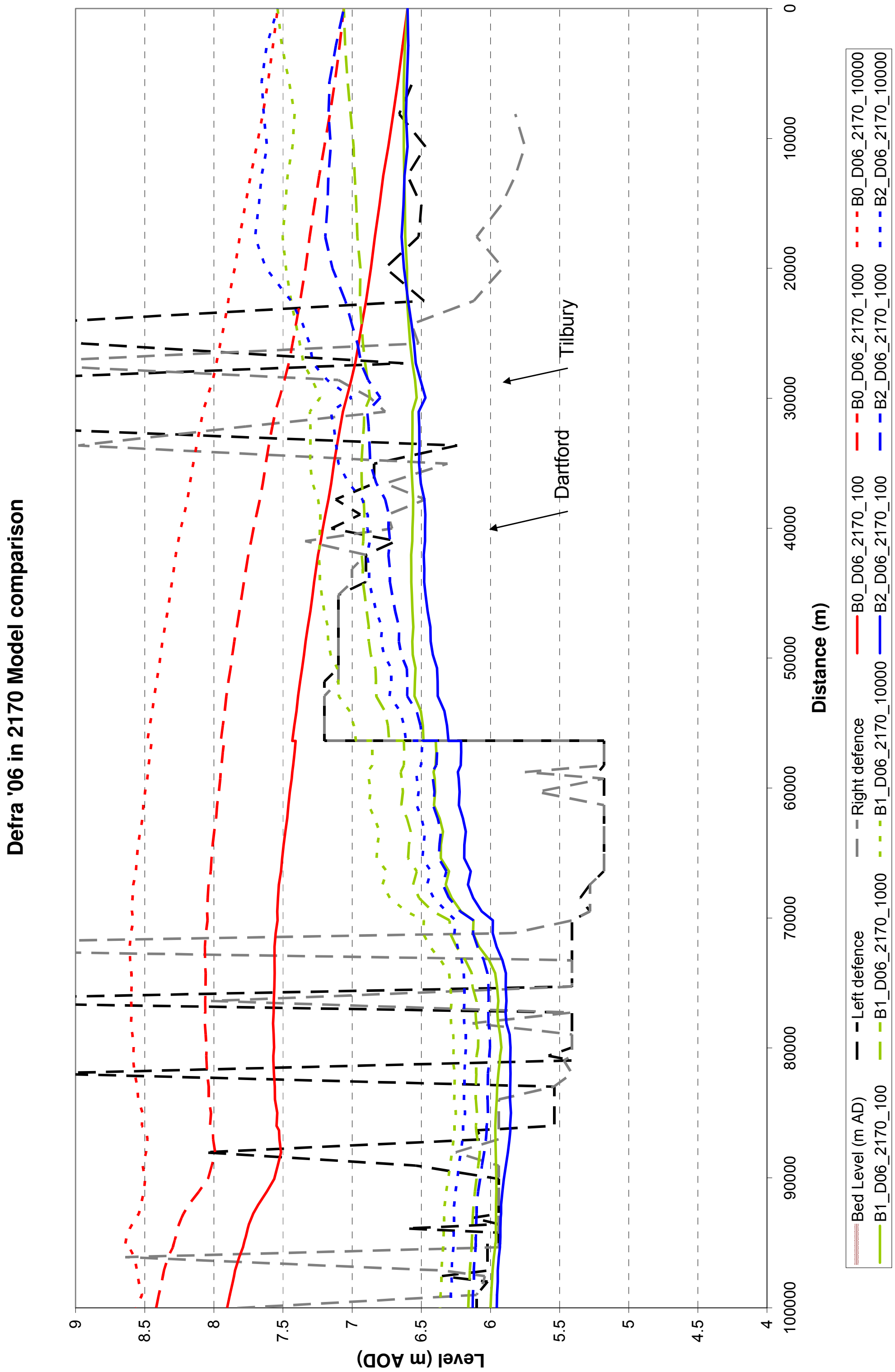


Figure D.9 Peak water levels: barrier open; 2170 (Defra climate change)

Table D.8 Peak water levels: barrier open; 2170 (Defra climate change)

Location	Node	100 year			1,000 year			10,000 year		
		B0	B1	B2	B0	B1	B2	B0	B1	B2
Teddington	2.1	7.90	6.00	5.96	8.42	6.16	6.13	8.56	6.36	6.29
	2.3	7.86	5.99	5.95	8.38	6.15	6.12	8.54	6.36	6.28
	2.4	7.85	5.99	5.95	8.36	6.15	6.12	8.56	6.36	6.28
	a2.6	7.78	5.97	5.93	8.29	6.14	6.11	8.61	6.34	6.27
	a2.7	7.78	5.96	5.93	8.29	6.14	6.11	8.64	6.34	6.27
	2.9d	7.77	5.96	5.93	8.28	6.13	6.11	8.63	6.34	6.27
	2.21	7.56	5.96	5.86	8.04	6.11	6.02	8.55	6.26	6.19
	2.29	7.57	5.94	5.89	8.06	6.10	6.01	8.60	6.28	6.19
	2.36	7.54	6.21	6.06	8.05	6.42	6.22	8.59	6.61	6.32
	2.47	7.43	6.40	6.22	7.95	6.63	6.39	8.47	6.85	6.50
Barrier	a3.1	7.43	6.49	6.30	7.95	6.73	6.49	8.48	6.97	6.61
	3.2	7.42	6.49	6.31	7.94	6.74	6.51	8.46	6.99	6.63
	3.3	7.40	6.50	6.33	7.92	6.77	6.53	8.45	7.02	6.65
	3.4	7.39	6.55	6.38	7.91	6.83	6.60	8.43	7.10	6.73
Roding	a3.5u	7.38	6.55	6.38	7.90	6.83	6.60	8.42	7.10	6.72
	a3.5d	7.38	6.55	6.38	7.90	6.83	6.60	8.42	7.10	6.72
	3.6	7.36	6.54	6.39	7.88	6.83	6.61	8.40	7.11	6.72
	3.7	7.35	6.56	6.42	7.87	6.87	6.65	8.39	7.16	6.77
Beam	3.8	7.34	6.57	6.43	7.85	6.88	6.66	8.37	7.17	6.79
	3.9	7.32	6.56	6.44	7.83	6.88	6.66	8.35	7.18	6.78
	3.10	7.30	6.56	6.45	7.82	6.90	6.69	8.34	7.20	6.83
	3.11	7.29	6.57	6.47	7.80	6.91	6.71	8.32	7.22	6.86
	3.12	7.28	6.57	6.48	7.78	6.92	6.73	8.30	7.23	6.88
	3.13	7.26	6.57	6.48	7.77	6.92	6.73	8.29	7.23	6.88
	3.14	7.25	6.57	6.48	7.75	6.93	6.74	8.28	7.24	6.89
Darent	3.15u	7.23	6.57	6.47	7.73	6.92	6.73	8.26	7.23	6.87
	3.15d	7.23	6.57	6.47	7.73	6.92	6.73	8.26	7.23	6.87
	3.16	7.21	6.56	6.47	7.71	6.92	6.74	8.24	7.23	6.89
	3.17	7.19	6.56	6.47	7.69	6.91	6.74	8.22	7.23	6.89
	3.18	7.17	6.56	6.48	7.67	6.92	6.76	8.19	7.25	6.93
	3.19	7.15	6.57	6.50	7.65	6.93	6.82	8.17	7.29	7.02
	3.20	7.13	6.57	6.52	7.63	6.93	6.87	8.15	7.31	7.10
	3.21	7.11	6.57	6.51	7.60	6.93	6.88	8.13	7.30	7.12
	3.22	7.09	6.56	6.52	7.58	6.92	6.88	8.10	7.30	7.13
	3.23	7.07	6.56	6.52	7.56	6.91	6.89	8.08	7.31	7.15
	3.24	7.04	6.53	6.47	7.53	6.87	6.80	8.05	7.23	7.00
	3.25	7.01	6.55	6.51	7.49	6.89	6.88	8.01	7.29	7.18
Tilbury	3.26	6.98	6.56	6.54	7.46	6.91	6.94	7.98	7.35	7.28
	3.27	6.95	6.58	6.55	7.43	6.92	6.96	7.95	7.38	7.31
	3.28	6.93	6.59	6.57	7.41	6.93	7.00	7.93	7.41	7.36
	3.29	6.90	6.60	6.60	7.38	6.95	7.05	7.90	7.44	7.44
Mucking	3.30	6.86	6.60	6.63	7.34	6.94	7.14	7.85	7.48	7.62
	3.31	6.84	6.62	6.64	7.31	6.96	7.19	7.81	7.50	7.70
	3.32	6.80	6.62	6.63	7.27	6.97	7.18	7.77	7.48	7.68
	3.33	6.78	6.62	6.62	7.24	6.98	7.17	7.73	7.47	7.66
	3.34	6.74	6.63	6.60	7.20	6.99	7.15	7.69	7.43	7.62
Canvey	3.35	6.70	6.63	6.61	7.16	7.01	7.17	7.65	7.42	7.64
	3.36	6.67	6.63	6.60	7.13	7.03	7.16	7.61	7.46	7.66
	3.37	6.64	6.62	6.59	7.09	7.05	7.12	7.57	7.51	7.62
Southend	3.38	6.60	6.60	6.60	7.06	7.06	7.06	7.54	7.54	7.54

For the Defra ’06 climate change scenario in 2170 there is overtopping of the majority of defences in the B1 and B2 models in the 1,000 year tide and above. There is overtopping of the lower defences (North Kent and upstream of the Thames Barrier) in the 100 year tide.

Appendix F

Drainage Calculations

Summary of Results for 2 year Return Period

Half Drain Time : 43 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	1.562	0.062	0.0	1.8	1.8	6.1	O K
30 min Summer	1.568	0.068	0.0	1.8	1.8	6.7	O K
60 min Summer	1.566	0.066	0.0	1.8	1.8	6.5	O K
120 min Summer	1.579	0.079	0.0	1.8	1.8	7.8	O K
180 min Summer	1.579	0.079	0.0	1.8	1.8	7.8	O K
240 min Summer	1.575	0.075	0.0	1.8	1.8	7.4	O K
360 min Summer	1.560	0.060	0.0	1.8	1.8	6.0	O K
480 min Summer	1.545	0.045	0.0	1.8	1.8	4.4	O K
600 min Summer	1.531	0.031	0.0	1.8	1.8	3.1	O K
720 min Summer	1.520	0.020	0.0	1.8	1.8	2.0	O K
960 min Summer	1.505	0.005	0.0	1.8	1.8	0.5	O K
1440 min Summer	1.500	0.000	0.0	1.5	1.5	0.0	O K
2160 min Summer	1.500	0.000	0.0	1.1	1.1	0.0	O K
2880 min Summer	1.500	0.000	0.0	0.9	0.9	0.0	O K
4320 min Summer	1.500	0.000	0.0	0.6	0.6	0.0	O K
5760 min Summer	1.500	0.000	0.0	0.5	0.5	0.0	O K
15 min Winter	1.572	0.072	0.0	1.8	1.8	7.1	O K
30 min Winter	1.581	0.081	0.0	1.8	1.8	8.0	O K
60 min Winter	1.578	0.078	0.0	1.8	1.8	7.7	O K
120 min Winter	1.592	0.092	0.0	1.8	1.8	9.1	O K
180 min Winter	1.590	0.090	0.0	1.8	1.8	8.9	O K
240 min Winter	1.581	0.081	0.0	1.8	1.8	8.0	O K
360 min Winter	1.558	0.058	0.0	1.8	1.8	5.7	O K
480 min Winter	1.535	0.035	0.0	1.8	1.8	3.4	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	37.329	0.0	7.9	17
30 min Summer	23.452	0.0	9.9	30
60 min Summer	14.283	0.0	12.0	48
120 min Summer	10.229	0.0	17.3	84
180 min Summer	8.026	0.0	20.3	120
240 min Summer	6.636	0.0	22.5	154
360 min Summer	4.949	0.0	25.1	220
480 min Summer	3.963	0.0	26.8	282
600 min Summer	3.318	0.0	28.0	342
720 min Summer	2.862	0.0	29.2	398
960 min Summer	2.260	0.0	30.6	504
1440 min Summer	1.620	0.0	33.0	0
2160 min Summer	1.169	0.0	35.7	0
2880 min Summer	0.933	0.0	38.0	0
4320 min Summer	0.691	0.0	42.2	0
5760 min Summer	0.566	0.0	46.1	0
15 min Winter	37.329	0.0	8.8	17
30 min Winter	23.452	0.0	11.0	30
60 min Winter	14.283	0.0	13.6	52
120 min Winter	10.229	0.0	19.4	92
180 min Winter	8.026	0.0	22.7	130
240 min Winter	6.636	0.0	25.2	168
360 min Winter	4.949	0.0	28.1	236
480 min Winter	3.963	0.0	30.0	296

Summary of Results for 2 year Return Period

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
600 min Winter	1.516	0.016	0.0	1.8	1.8	1.6	O K
720 min Winter	1.503	0.003	0.0	1.8	1.8	0.3	O K
960 min Winter	1.500	0.000	0.0	1.5	1.5	0.0	O K
1440 min Winter	1.500	0.000	0.0	1.1	1.1	0.0	O K
2160 min Winter	1.500	0.000	0.0	0.8	0.8	0.0	O K
2880 min Winter	1.500	0.000	0.0	0.6	0.6	0.0	O K
4320 min Winter	1.500	0.000	0.0	0.5	0.5	0.0	O K
5760 min Winter	1.500	0.000	0.0	0.4	0.4	0.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
600 min Winter	3.318	0.0	31.4	350
720 min Winter	2.862	0.0	32.6	392
960 min Winter	2.260	0.0	34.3	0
1440 min Winter	1.620	0.0	36.9	0
2160 min Winter	1.169	0.0	39.9	0
2880 min Winter	0.933	0.0	42.5	0
4320 min Winter	0.691	0.0	47.2	0
5760 min Winter	0.566	0.0	51.6	0

Summary of Results for 30 year Return Period

Half Drain Time : 165 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	1.685	0.185	0.0	1.8	1.8	18.3	O K
30 min Summer	1.727	0.227	0.0	1.8	1.8	22.4	O K
60 min Summer	1.754	0.254	0.0	1.8	1.8	25.0	O K
120 min Summer	1.780	0.280	0.0	1.8	1.8	27.7	O K
180 min Summer	1.775	0.275	0.0	1.8	1.8	27.2	O K
240 min Summer	1.765	0.265	0.0	1.8	1.8	26.2	O K
360 min Summer	1.741	0.241	0.0	1.8	1.8	23.8	O K
480 min Summer	1.715	0.215	0.0	1.8	1.8	21.3	O K
600 min Summer	1.690	0.190	0.0	1.8	1.8	18.8	O K
720 min Summer	1.666	0.166	0.0	1.8	1.8	16.4	O K
960 min Summer	1.623	0.123	0.0	1.8	1.8	12.1	O K
1440 min Summer	1.558	0.058	0.0	1.8	1.8	5.7	O K
2160 min Summer	1.508	0.008	0.0	1.8	1.8	0.8	O K
2880 min Summer	1.500	0.000	0.0	1.6	1.6	0.0	O K
4320 min Summer	1.500	0.000	0.0	1.1	1.1	0.0	O K
5760 min Summer	1.500	0.000	0.0	0.9	0.9	0.0	O K
15 min Winter	1.710	0.210	0.0	1.8	1.8	20.8	O K
30 min Winter	1.759	0.259	0.0	1.8	1.8	25.6	O K
60 min Winter	1.794	0.294	0.0	1.8	1.8	29.0	O K
120 min Winter	1.836	0.336	0.0	1.8	1.8	33.2	O K
180 min Winter	1.836	0.336	0.0	1.8	1.8	33.2	O K
240 min Winter	1.821	0.321	0.0	1.8	1.8	31.7	O K
360 min Winter	1.785	0.285	0.0	1.8	1.8	28.1	O K
480 min Winter	1.746	0.246	0.0	1.8	1.8	24.3	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	95.280	0.0	20.1	18
30 min Summer	60.800	0.0	25.7	33
60 min Summer	36.970	0.0	31.3	62
120 min Summer	23.495	0.0	39.8	120
180 min Summer	17.593	0.0	44.7	162
240 min Summer	14.155	0.0	48.0	190
360 min Summer	10.228	0.0	51.9	252
480 min Summer	8.046	0.0	54.6	318
600 min Summer	6.654	0.0	56.4	384
720 min Summer	5.686	0.0	57.8	448
960 min Summer	4.423	0.0	59.9	576
1440 min Summer	3.103	0.0	63.0	808
2160 min Summer	2.181	0.0	66.4	1124
2880 min Summer	1.705	0.0	69.4	0
4320 min Summer	1.220	0.0	74.4	0
5760 min Summer	0.972	0.0	79.1	0
15 min Winter	95.280	0.0	22.6	18
30 min Winter	60.800	0.0	28.9	32
60 min Winter	36.970	0.0	35.0	60
120 min Winter	23.495	0.0	44.6	118
180 min Winter	17.593	0.0	50.0	174
240 min Winter	14.155	0.0	53.7	226
360 min Winter	10.228	0.0	58.3	276
480 min Winter	8.046	0.0	61.1	350

Summary of Results for 30 year Return Period

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
600 min Winter	1.708	0.208	0.0	1.8	1.8	20.6	O K
720 min Winter	1.672	0.172	0.0	1.8	1.8	17.0	O K
960 min Winter	1.608	0.108	0.0	1.8	1.8	10.7	O K
1440 min Winter	1.522	0.022	0.0	1.8	1.8	2.1	O K
2160 min Winter	1.500	0.000	0.0	1.5	1.5	0.0	O K
2880 min Winter	1.500	0.000	0.0	1.1	1.1	0.0	O K
4320 min Winter	1.500	0.000	0.0	0.8	0.8	0.0	O K
5760 min Winter	1.500	0.000	0.0	0.6	0.6	0.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
600 min Winter	6.654	0.0	63.1	418
720 min Winter	5.686	0.0	64.7	486
960 min Winter	4.423	0.0	67.1	608
1440 min Winter	3.103	0.0	70.6	820
2160 min Winter	2.181	0.0	74.5	0
2880 min Winter	1.705	0.0	77.7	0
4320 min Winter	1.220	0.0	83.4	0
5760 min Winter	0.972	0.0	88.5	0

Summary of Results for 100 year Return Period

Half Drain Time : 255 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	1.751	0.251	0.0	1.8	1.8	24.8	O K
30 min Summer	1.815	0.315	0.0	1.8	1.8	31.1	O K
60 min Summer	1.863	0.363	0.0	1.8	1.8	35.9	O K
120 min Summer	1.922	0.422	0.0	1.8	1.8	41.7	O K
180 min Summer	1.935	0.435	0.0	1.8	1.8	43.0	O K
240 min Summer	1.929	0.429	0.0	1.8	1.8	42.4	O K
360 min Summer	1.907	0.407	0.0	1.8	1.8	40.2	O K
480 min Summer	1.882	0.382	0.0	1.8	1.8	37.7	O K
600 min Summer	1.856	0.356	0.0	1.8	1.8	35.2	O K
720 min Summer	1.829	0.329	0.0	1.8	1.8	32.5	O K
960 min Summer	1.771	0.271	0.0	1.8	1.8	26.8	O K
1440 min Summer	1.675	0.175	0.0	1.8	1.8	17.3	O K
2160 min Summer	1.575	0.075	0.0	1.8	1.8	7.4	O K
2880 min Summer	1.520	0.020	0.0	1.8	1.8	2.0	O K
4320 min Summer	1.500	0.000	0.0	1.5	1.5	0.0	O K
5760 min Summer	1.500	0.000	0.0	1.2	1.2	0.0	O K
15 min Winter	1.784	0.284	0.0	1.8	1.8	28.1	O K
30 min Winter	1.857	0.357	0.0	1.8	1.8	35.3	O K
60 min Winter	1.916	0.416	0.0	1.8	1.8	41.1	O K
120 min Winter	1.989	0.489	0.0	1.8	1.8	48.3	O K
180 min Winter	2.013	0.513	0.0	1.8	1.8	50.7	O K
240 min Winter	2.013	0.513	0.0	1.8	1.8	50.7	O K
360 min Winter	1.981	0.481	0.0	1.8	1.8	47.5	O K
480 min Winter	1.949	0.449	0.0	1.8	1.8	44.4	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	126.120	0.0	26.6	18
30 min Summer	81.060	0.0	34.3	33
60 min Summer	49.550	0.0	42.0	62
120 min Summer	31.615	0.0	53.5	122
180 min Summer	23.900	0.0	60.7	180
240 min Summer	19.393	0.0	65.8	234
360 min Summer	14.185	0.0	72.2	290
480 min Summer	11.230	0.0	76.1	354
600 min Summer	9.316	0.0	78.9	422
720 min Summer	7.971	0.0	81.1	490
960 min Summer	6.198	0.0	83.9	614
1440 min Summer	4.322	0.0	87.9	864
2160 min Summer	2.996	0.0	91.4	1208
2880 min Summer	2.310	0.0	94.0	1524
4320 min Summer	1.609	0.0	98.2	0
5760 min Summer	1.252	0.0	101.8	0
15 min Winter	126.120	0.0	29.9	18
30 min Winter	81.060	0.0	38.4	33
60 min Winter	49.550	0.0	47.0	62
120 min Winter	31.615	0.0	60.0	120
180 min Winter	23.900	0.0	68.0	176
240 min Winter	19.393	0.0	73.6	232
360 min Winter	14.185	0.0	80.6	332
480 min Winter	11.230	0.0	85.2	376

Summary of Results for 100 year Return Period

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
600 min Winter	1.914	0.414	0.0	1.8	1.8	41.0	O K
720 min Winter	1.878	0.378	0.0	1.8	1.8	37.3	O K
960 min Winter	1.795	0.295	0.0	1.8	1.8	29.1	O K
1440 min Winter	1.651	0.151	0.0	1.8	1.8	14.9	O K
2160 min Winter	1.522	0.022	0.0	1.8	1.8	2.1	O K
2880 min Winter	1.500	0.000	0.0	1.5	1.5	0.0	O K
4320 min Winter	1.500	0.000	0.0	1.1	1.1	0.0	O K
5760 min Winter	1.500	0.000	0.0	0.8	0.8	0.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
600 min Winter	9.316	0.0	88.3	452
720 min Winter	7.971	0.0	90.7	528
960 min Winter	6.198	0.0	94.1	674
1440 min Winter	4.322	0.0	98.5	910
2160 min Winter	2.996	0.0	102.3	1208
2880 min Winter	2.310	0.0	105.2	0
4320 min Winter	1.609	0.0	110.0	0
5760 min Winter	1.252	0.0	114.1	0

Summary of Results for 100 year Return Period (+40%)

Half Drain Time : 406 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	1.860	0.360	0.0	1.8	1.8	35.6	O K
30 min Summer	1.953	0.453	0.0	1.8	1.8	44.8	O K
60 min Summer	2.031	0.531	0.0	1.8	1.8	52.5	O K
120 min Summer	2.133	0.633	0.0	1.8	1.8	62.5	O K
180 min Summer	2.171	0.671	0.0	1.8	1.8	66.3	O K
240 min Summer	2.179	0.679	0.0	1.8	1.8	67.1	O K
360 min Summer	2.151	0.651	0.0	1.8	1.8	64.3	O K
480 min Summer	2.119	0.619	0.0	1.8	1.8	61.2	O K
600 min Summer	2.089	0.589	0.0	1.8	1.8	58.2	O K
720 min Summer	2.060	0.560	0.0	1.8	1.8	55.3	O K
960 min Summer	2.004	0.504	0.0	1.8	1.8	49.8	O K
1440 min Summer	1.902	0.402	0.0	1.8	1.8	39.7	O K
2160 min Summer	1.750	0.250	0.0	1.8	1.8	24.7	O K
2880 min Summer	1.639	0.139	0.0	1.8	1.8	13.7	O K
4320 min Summer	1.524	0.024	0.0	1.8	1.8	2.3	O K
5760 min Summer	1.500	0.000	0.0	1.6	1.6	0.0	O K
15 min Winter	1.906	0.406	0.0	1.8	1.8	40.1	O K
30 min Winter	2.013	0.513	0.0	1.8	1.8	50.6	O K
60 min Winter	2.104	0.604	0.0	1.8	1.8	59.7	O K
120 min Winter	2.226	0.726	0.0	1.8	1.8	71.7	O K
180 min Winter	2.278	0.778	0.0	1.9	1.9	76.9	O K
240 min Winter	2.295	0.795	0.0	1.9	1.9	78.6	O K
360 min Winter	2.278	0.778	0.0	1.9	1.9	76.9	O K
480 min Winter	2.232	0.732	0.0	1.8	1.8	72.3	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	176.568	0.0	37.3	19
30 min Summer	113.484	0.0	48.0	33
60 min Summer	69.370	0.0	58.7	62
120 min Summer	44.261	0.0	74.9	122
180 min Summer	33.460	0.0	85.0	182
240 min Summer	27.150	0.0	92.1	240
360 min Summer	19.859	0.0	100.9	322
480 min Summer	15.722	0.0	106.5	382
600 min Summer	13.042	0.0	110.4	446
720 min Summer	11.159	0.0	113.5	512
960 min Summer	8.677	0.0	117.6	646
1440 min Summer	6.051	0.0	123.0	922
2160 min Summer	4.194	0.0	127.8	1296
2880 min Summer	3.234	0.0	131.4	1640
4320 min Summer	2.252	0.0	137.4	2252
5760 min Summer	1.752	0.0	142.6	0
15 min Winter	176.568	0.0	41.9	18
30 min Winter	113.484	0.0	53.8	33
60 min Winter	69.370	0.0	65.7	62
120 min Winter	44.261	0.0	84.0	120
180 min Winter	33.460	0.0	95.2	178
240 min Winter	27.150	0.0	103.0	234
360 min Winter	19.859	0.0	113.0	342
480 min Winter	15.722	0.0	119.4	434

Summary of Results for 100 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Σ Max Outflow (l/s)	Max Volume (m³)	Status
600 min Winter	2.192	0.692	0.0	1.8	1.8	68.4	O K
720 min Winter	2.155	0.655	0.0	1.8	1.8	64.7	O K
960 min Winter	2.078	0.578	0.0	1.8	1.8	57.2	O K
1440 min Winter	1.933	0.433	0.0	1.8	1.8	42.8	O K
2160 min Winter	1.708	0.208	0.0	1.8	1.8	20.5	O K
2880 min Winter	1.563	0.063	0.0	1.8	1.8	6.3	O K
4320 min Winter	1.500	0.000	0.0	1.5	1.5	0.0	O K
5760 min Winter	1.500	0.000	0.0	1.2	1.2	0.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
600 min Winter	13.042	0.0	123.8	470
720 min Winter	11.159	0.0	127.0	548
960 min Winter	8.677	0.0	131.8	702
1440 min Winter	6.051	0.0	137.7	996
2160 min Winter	4.194	0.0	143.4	1364
2880 min Winter	3.234	0.0	147.2	1668
4320 min Winter	2.252	0.0	153.9	0
5760 min Winter	1.752	0.0	159.7	0

Rainfall Details

Rainfall Model	FEH
Return Period (years)	100
FEH Rainfall Version	2013
Site Location	GB 531431 180023 TQ 31431 80023
Data Type	Point
Summer Storms	Yes
Winter Storms	Yes
Cv (Summer)	0.750
Cv (Winter)	0.840
Shortest Storm (mins)	15
Longest Storm (mins)	5760
Climate Change %	+40

Time Area Diagram

Total Area (ha) 0.113

Time From:	(mins) To:	Area (ha)
0	4	0.113

Model Details

Storage is Online Cover Level (m) 3.000

Cellular Storage Structure

Invert Level (m) 1.500 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	104.0	104.0	0.800	104.0	136.6	0.801	0.0	136.7

Hydro-Brake® Optimum Outflow Control

Unit Reference	MD-SHE-0064-2000-1200-2000
Design Head (m)	1.200
Design Flow (l/s)	2.0
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	64
Invert Level (m)	1.250
Minimum Outlet Pipe Diameter (mm)	100
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)	Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.200	2.0	Kick-Flo®	0.573	1.4
Flush-Flo™	0.282	1.8	Mean Flow over Head Range	-	1.6

The hydrological calculations have been based on the Head/Discharge relationship for the Hydro-Brake® Optimum as specified. Should another type of control device other than a Hydro-Brake Optimum® be utilised then these storage routing calculations will be invalidated

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	1.5	0.800	1.7	2.000	2.5	4.000	3.5	7.000	4.5
0.200	1.7	1.000	1.8	2.200	2.6	4.500	3.7	7.500	4.7
0.300	1.8	1.200	2.0	2.400	2.7	5.000	3.9	8.000	4.8
0.400	1.7	1.400	2.1	2.600	2.8	5.500	4.0	8.500	5.0
0.500	1.6	1.600	2.3	3.000	3.0	6.000	4.2	9.000	5.1
0.600	1.5	1.800	2.4	3.500	3.3	6.500	4.4	9.500	5.2

ICP SUDS Mean Annual Flood

Input

Return Period (years)	2	SAAR (mm)	600	Urban	0.000
Area (ha)	0.137	Soil	0.300	Region Number	Region 6

Results	**l/s**
QBAR Rural	0.2
QBAR Urban	0.2
Q2 years	0.2
Q1 year	0.2
Q30 years	0.5
Q100 years	0.7

PRELIMINARY DRAINAGE CALCULATIONS

23/12/2020

ARDENT CONSULTING ENGINEERS

EXISTING SURFACE WATER

Existing site information:

Site Boundary Area	1373	m2
Developable Area	0.137	ha
Impermeable Area	0.0950	ha

Modified Rational Method Equation:

$$Q_n = 2.78\ CiA$$

where:

C	*Runoff Coefficients =* 1 (in this case 1 as using impermeable area)
i_n	*Rainfall Intensity for n return period (mm/hr)*
A	*Impermeable Area (Ha)*
Q_n	*Runoff for n return period (l/s)*

Rainfall Intensity:

The rainfall intensities for various return periods were extracted from the FEH website.
The rainfall intensities for each return period relate to the 60 minute duration.

i_1	9.06	mm/hr
i_2	11.86	mm/hr
i_{30}	36.97	mm/hr
i_{100}	49.55	mm/hr

Existing Surface Water Runoff:

Therefore:

			C		i_n		*A*		Q_n	
Q_1	2.78	x	1	x	9.1	x	0.0950	=	**2.39**	**l/s**
Q_2	2.78	x	1	x	11.9	x	0.0950	=	**3.13**	**l/s**
Q_{30}	2.78	x	1	x	37.0	x	0.0950	=	**9.76**	**l/s**
Q_{100}	2.78	x	1	x	49.6	x	0.0950	=	**13.09**	**l/s**

PRELIMINARY DRAINAGE CALCULATIONS

23/12/2020

EXISTING FOUL WATER

ARDENT CONSULTING ENGINEERS

Unit Type	Existing Area/Units	Hours (hrs)	Foul Water Flow Rate l/day	Peak Factor	Peaked Loading l/s	Loading (l/s)
Nursey	425 m2	10	80 per Pupil	6.6	0.0147 per pupil	1.781

*based on 3.5m2 per pupil

TOTAL EXISTING FOUL LOADING = 1.781

PROPOSED FOUL WATER

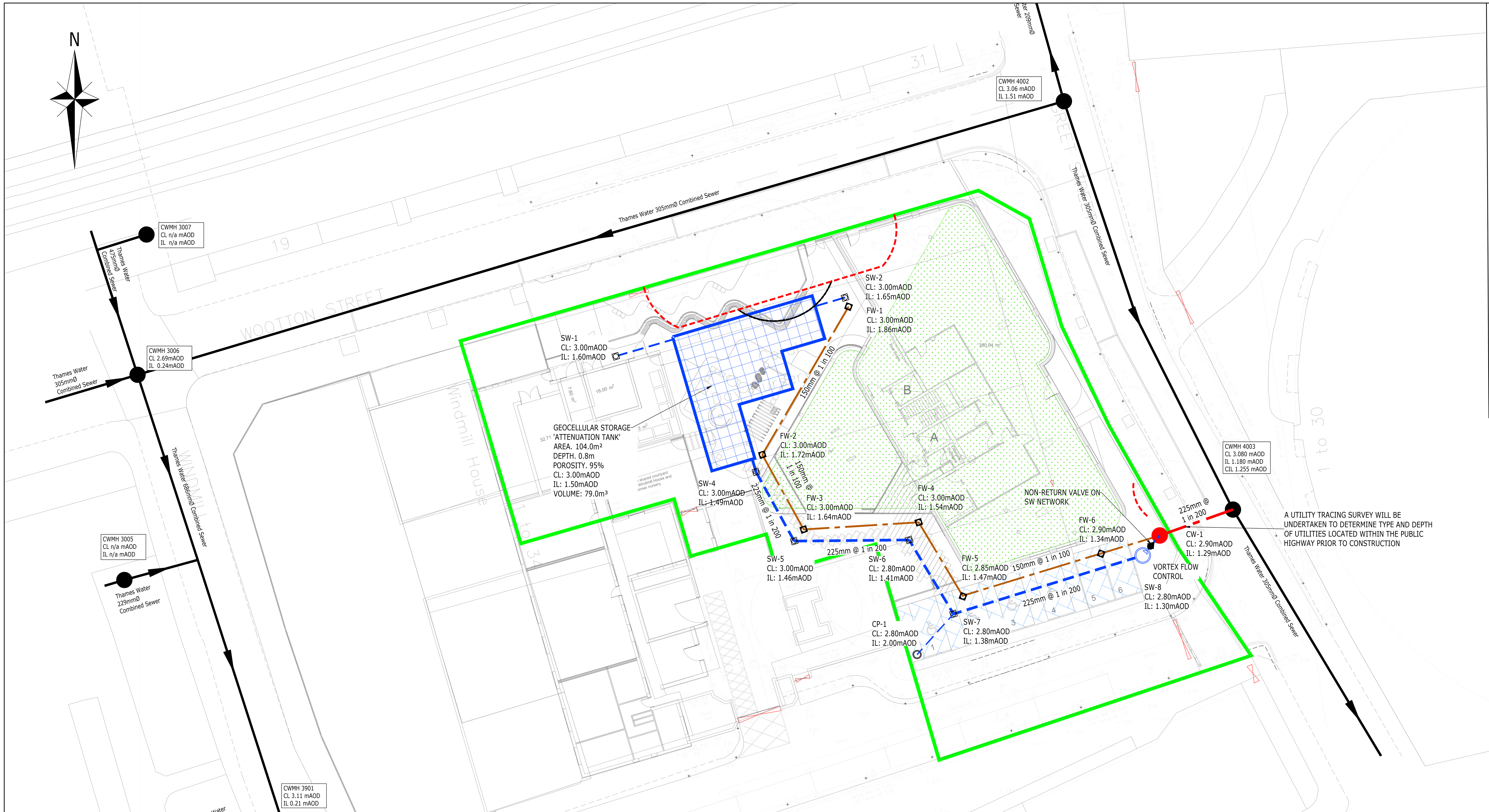
Unit Type	Proposed Area/Units	Hours (hrs)	Foul Water Flow Rate l/day	Peak Factor	Peaked Loading l/s	Loading (l/s)
General Housing	36 property	24	600 per property	6.6	0.0458 per property	1.650
Community Centre	380 m2	10	80 per person	6.6	0.0133 per pupil	0.804

*based on 6.3m2 per person

TOTAL PROPOSED FOUL LOADING = 2.454

Appendix G

Ardent Drawings



THIS SITE IS LOCATED ENTIRELY WITHIN FLOOD RISK ZONE 3.
FINISHED FLOOR LEVELS OF ALL SLEEPING ACCOMMODATION ARE TO SET ABOVE THE MODELLED THAMES TIDAL BREACH LEVEL FOR THE YEAR 2100
THE 2100 THAMES TIDAL BREACH LEVEL FOR THIS SITE IS 4.31mAOD

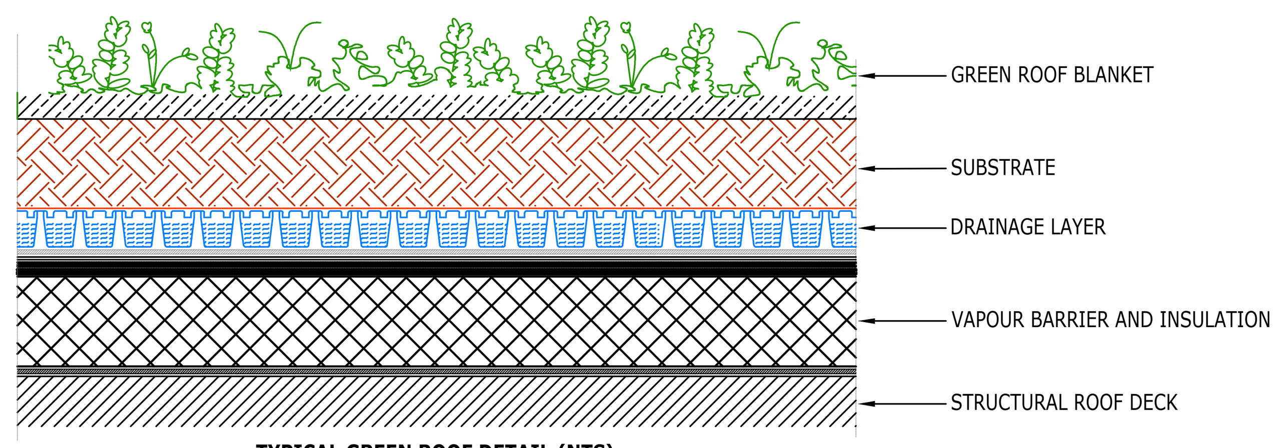
KEY:

- SITE BOUNDARY
- PRIVATE SURFACE WATER DRAIN AND INSPECTION CHAMBER (225mmØ UNLESS NOTED OTHERWISE) (CW-1, CL: 3.00m, IL: 1.60m)
- GEOCELLULAR 'ATTENUATION TANK'
- PROPOSED LINED PERMEABLE PAVING
- PROPOSED INSPECTION CHAMBER WITH SILT TRAP
- PROPOSED SURFACE WATER CONTROL CHAMBER
- PRIVATE FOUL WATER DRAIN AND INSPECTION CHAMBER (150mmØ UNLESS NOTED OTHERWISE) (FW-1, CL: 3.00m, IL: 1.86m)
- PROPOSED ADOPTABLE COMBINED SEWER AND MANHOLE (225mmØ UNLESS NOTED OTHERWISE) (CW-1, CL: 2.90m, IL: 1.29m)
- EXISTING THAMES WATER COMBINED SEWER AND MANHOLE (BASED ON THAMES WATER ASSET PLANS) (CWMH 4003, CL 3.080 mAOD, IL 1.180 mAOD, CIL 1.255 mAOD)
- ROOT PROTECTION ZONE - TAKEN FROM SJA TREE SURVEY
- PROPOSED GREEN ROOF (HATCHING DOES NOT TAKE INTO ACCOUNT FURNITURE AND PV PANELS)
- NON-RETURN VALVE

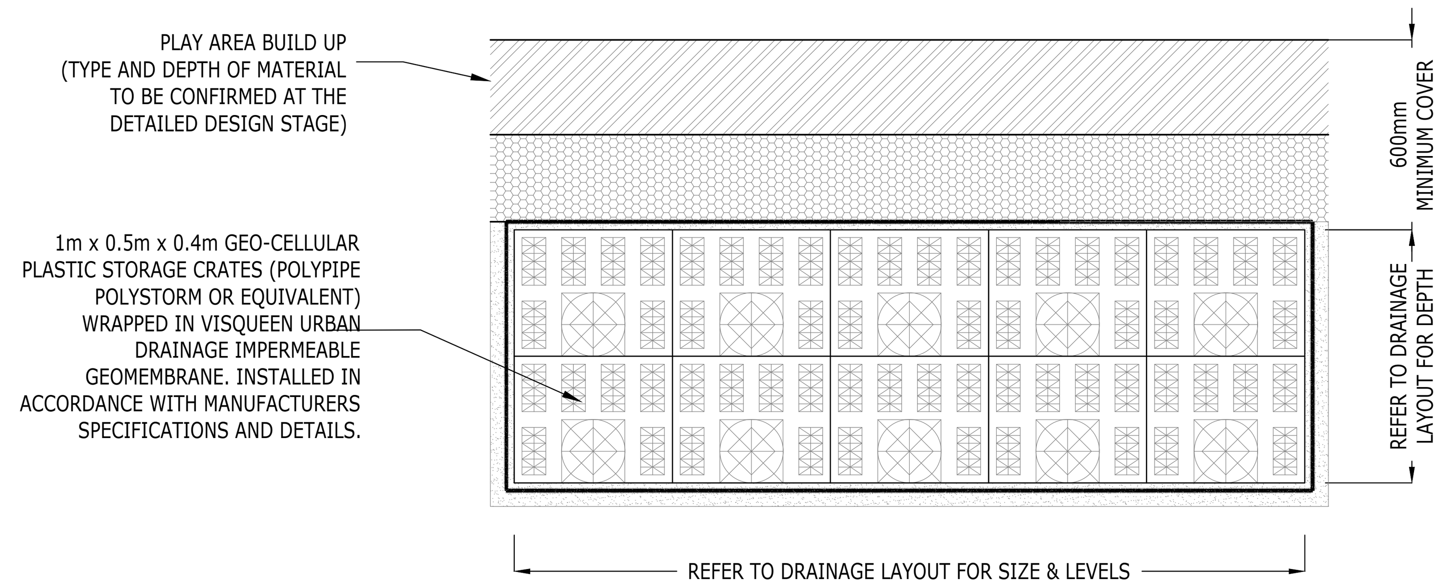
NOTES:

1. THIS DRAWING IS TO BE READ IN CONJUNCTION WITH THE RELEVANT SPECIFICATION AND ALL OTHER RELATED DRAWINGS ISSUED BY THE ENGINEER.
2. DO NOT SCALE FROM THIS DRAWING. WORK FROM FIGURED DIMENSIONS ONLY.
3. ALL DIMENSIONS SHOWN ON THIS DRAWING ARE IN METERS UNLESS OTHERWISE STATED.
4. THIS IS AN OUTLINED DRAINAGE STRATEGY AND IS SUBJECT TO DETAILED DESIGN.
5. ALL COVER LEVELS, INVERT LEVELS, PIPE SIZES AND ATTENUATION VOLUMES ARE INDICATIVE ONLY AND SUBJECT TO DETAILED DESIGN.
6. THIS DRAWING IS BASED ON THE FOLLOWING PLANS:
   -STOCKWOOL SITE LAYOUT DRAWING 3496W_PL(20)100_P1-WP (21.12.20)
   -LASER SURVEYS LTD TOPOGRAPHICAL SURVEY (REF: N9576/1 REV 0
   -THAMES WATER PUBLIC ASSET PLANS (05.11.19)
7. THIS DRAINAGE STRATEGY IS BASED ON THE PRINCIPLES SET OUT IN THE FLOOD RISK ASSESSMENT AND DRAINAGE STRATEGY REPORT (REF. 193860-04) AND IS SUBJECT TO LLFA AND THAMES WATER APPROVAL.
8. ALL DIMENSIONS, LEVELS AND SURVEY GRID CO-ORDINATES ARE TO BE CHECKED ON SITE AND THE ENGINEER NOTIFIED IMMEDIATELY OF ANY DISCREPANCIES PRIOR TO THE COMMENCEMENT OF THE WORKS.
9. NO DEVIATION FROM THE DETAILS SHOWN ON THIS DRAWING IS PERMITTED WITHOUT PRIOR PERMISSION FROM THE ENGINEER.
10. ALL EXISTING SERVICE ROUTES HAVE BEEN TRANSCRIBED FROM THE RESPECTIVE UNDERTAKERS RECORDS AND AS SUCH NO RESPONSIBILITY IS ACCEPTED BY ARDENT CONSULTING ENGINEERS FOR THE ACCURACY OF ROUTES SHOWN.
11. THE AVOIDANCE AND PROTECTION OF SERVICES DURING THE WORKS IS THE RESPONSIBILITY OF THE CONTRACTOR.
12. THE CONTRACTOR IS REMINDED OF HIS OBLIGATION TO VERIFY THE ROUTE OF ALL SERVICES ON SITE PRIOR TO THE COMMENCEMENT OF THE WORKS.
13. THE CONTRACTOR SHOULD ALLOW FOR ANY NECESSARY LIAISON WITH THE STATUTORY UTILITIES DURING THE COURSE OF THE WORKS TO AVOID ANY DISRUPTION TO RETAINED SERVICES.
14. THE CONTRACTOR SHOULD NOTE THAT THE SERVICES SHOWN ARE NOT TO BE CONSIDERED EXHAUSTIVE. PRIVATE SERVICES MAY BE PRESENT WITHIN THE LIMIT OF WORKS AND CARE SHOULD BE TAKEN TO LOCATE AND AVOID THESE DURING CONSTRUCTION.

FOR INFORMATION ONLY



TYPICAL GREEN ROOF DETAIL (NTS)



CELLULAR ATTENUATION TANK CONSTRUCTION DETAILS
(1:20)

DETAILS SHOWN ARE INDICATIVE. REFER TO MANUFACTURER FOR FULL DETAILS AND SPECIFICATIONS. REFER TO MANUFACTURERS DETAILS FOR INLET & OUTLET MANIFOLDS AND INSPECTION ACCESS. (REFER TO LAYOUT FOR LOCATIONS).

Rev	Description	Drn	Chk	App	Date
A	ISSUED FOR PLANNING	CJC	EF	BC	23/12/20

ARDENT CONSULTING ENGINEERS
Third Floor
The Hallmark Building
52-56 Leadenhall Street
London
EC3M 5JE
Tel: 020 7680 4088
Web: www.ardent-ce.co.uk
E-mail: enquiries@ardent-ce.co.uk

Client
HOMES FOR LAMBETH

Project Title:
WOOTTON STREET, LONDON

Drawing Title:
DRAINAGE STRATEGY

A1 Scale	Date	Designed by
1:200	DEC 20	CJC
Drawn by	**Checked by**	**Approved by**
CJC	EF/CC	BC

Drawing Number: 193860/001 Rev A

Appendix H

SuDS Operation and Maintenance Requirements

SUDS Element	Attenuation Tank	
Maintenance Period	**Maintenance Task**	**Frequency**
Maintenance Work	Inspect and identify any areas that are not operating correctly. If required, take remedial action.	Monthly for 3 months, then annually
	Remove debris from the catchment surface (where it may cause risk to performance)	Monthly
	Remove sediment from pre-treatment structures and/or internal forebays.	Annually, or as required
Remedial Work	Repair/rehabilitate inlets, outlets, overflows and vents	As required.
Monitoring	Inspect/check all inlets, outlets, vents, and overflows to ensure that they are in good condition and operating as designed	Annually.
	Survey inside of tank for sediment build-up and remove if necessary	Every 5 years or as required.

Inlets, Outlets, Controls and Inspection Chambers	
Regular Maintenance	**Frequency**
Inlets, outlets and surface control structures Inspect surface structures, removing obstructions and silt as necessary. Check there is no physical damage. Strim vegetation 1m minimum surround to structures and keep hard aprons free from silt and debris.	Monthly Monthly
Inspection chambers and below-ground control chambers Remove cover and inspect, ensuring that water is flowing freely and that the exit route for water is unobstructed. Remove debris and silt. Undertake inspection after leaf fall in autumn.	Annually
Occasional Maintenance	
Check topsoil levels are 20mm above edges of chambers to avoid mower damage.	As necessary
Remedial Work	**Frequency**
Repair physical damage if necessary	As Required

In addition to the above the orifice Plate at the flow control manhole downstream of the surface water drainage system should be inspected after every major storm event and monthly (whichever comes first). Any accumulated silt and debris accumulated in the flow control manhole and those obstructing the flow through the orifice plate should be removed. Any damage to the orifice plate should be recorded and the flow control unit should be repaired or replaced to the original condition in accordance to manufacturing guidance.

Drainage Operation and Maintenance Log

Site Maintenance Supervisor:______________________________ Date:___________

☐ Routine ☐ Response to rainfall event __ in ☐ Other:_______________

BMP	Frequency	Date Performed	Comments
Gullies and Manholes	Monthly Inspections		
	Maintenance Quarterly and as necessary		
Pavement Areas (parking, driveways, service areas)	Quarterly Sweeping		
	Rubbish & Litter Removal as Necessary		
Landscaped & Vegetated Areas	Maintenance as necessary		
Flow Controls	Monthly Inspections and after every major storm event		
	Debris, Rubbish & Litter Removal. Maintenance as necessary		
Attenuation Tanks	Inspect and identify areas not operating property every 3 months (for the first 3 months) and every 6 months after		
	Full bi-annual inspection		

Appendix I

London Sustainable Drainage Proforma

GREATER**LONDON**AUTHORITY

1. Project & Site Details

Project / Site Name (including sub-catchment / stage / phase where appropriate)	193860 - Wootton Street, London
Address & post code	Land south of Wootton Street, London SE1 8AZ
OS Grid ref. (Easting, Northing)	E 531423 N 180019
LPA reference (if applicable)	
Brief description of proposed work	Demolition of the existing single storey building and the construction of a new 6 storey building to provide a new community centrre at the ground floor level and 36 residential units
Total site Area	1370 m^2
Total existing impervious area	950 m^2
Total proposed impervious area	1130 m^2
Is the site in a surface water flood risk catchment (ref. local Surface Water Management Plan)?	No
Existing drainage connection type and location	Assumed into existing Thames Water combined sewers adjacent to the site.
Designer Name	Christopher Cant
Designer Position	Assistant Engineer
Designer Company	Ardent Consulting Engineers

2. Proposed Discharge Arrangements

2a. Infiltration Feasibility

Superficial geology classification	Alluvium - Clay, silt, sand and peat
Bedrock geology classification	London Clay Formation
Site infiltration rate	m/s
Depth to groundwater level	m below ground level
Is infiltration feasible?	No

2b. Drainage Hierarchy

	Feasible (Y/N)	*Proposed (Y/N)*
1 store rainwater for later use	Y	N
2 use infiltration techniques, such as porous surfaces in non-clay areas	N	N
3 attenuate rainwater in ponds or open water features for gradual release	N	N
4 attenuate rainwater by storing in tanks or sealed water features for gradual release	Y	Y
5 discharge rainwater direct to a watercourse	N	N
6 discharge rainwater to a surface water sewer/drain	N	N
7 discharge rainwater to the combined sewer.	Y	Y

2c. Proposed Discharge Details

Proposed discharge location	Combined Sewer in Greet Street
Has the owner/regulator of the discharge location been consulted?	Yes

GREATER LONDON AUTHORITY

3. Drainage Strategy

3a. Discharge Rates & Required Storage

	Greenfield (GF) runoff rate (l/s)	*Existing discharge rate (l/s)*	*Required storage for GF rate (m^3)*	*Proposed discharge rate (l/s)*
Qbar	0.2			
1 in 1	0.2	3.13		2
1 in 30	0.5	9.76		2
1 in 100	0.7	13.09		2
1 in 100 + CC				2
Climate change allowance used		40%		

3b. Principal Method of Flow Control

Vortex Flow Control

3c. Proposed SuDS Measures

	Catchment area (m^2)	*Plan area (m^2)*	*Storage vol. (m^3)*
Rainwater harvesting	0		0
Infiltration systems	0		0
Green roofs	0	0	0
Blue roofs	0	0	0
Filter strips	0	0	0
Filter drains	0	0	0
Bioretention / tree pits	0	0	0
Pervious pavements	0	108	0
Swales	0	0	0
Basins/ponds	0	0	0
Attenuation tanks	1130		79
Total	**1130**	**108**	**79**

4. Supporting Information

4a. Discharge & Drainage Strategy	*Page/section of drainage report*
Infiltration feasibility (2a) – geotechnical factual and interpretive reports, including infiltration results	Pages 13-15, Section 3
Drainage hierarchy (2b)	Page 36-37, Section 5
Proposed discharge details (2c) – utility plans, correspondence / approval from owner/regulator of discharge location	Section 6, Appendix D
Discharge rates & storage (3a) – detailed hydrologic and hydraulic calculations	Page 40, Section 5
Proposed SuDS measures & specifications (3b)	Page 34-35, Section 5

4b. Other Supporting Details	*Page/section of drainage report*
Detailed Development Layout	Appendix B
Detailed drainage design drawings, including exceedance flow routes	Appendix G
Detailed landscaping plans	Appendix B
Maintenance strategy	Page 41, Section 5
Demonstration of how the proposed SuDS measures improve:	
a) water quality of the runoff?	Page 42, Section 5
b) biodiversity?	Page 42, Section 5
c) amenity?	Page 42, Section 5

Appendix J

CIRIA 753 Simple Index

Land use	Pollution hazard level	Total suspended solids (TSS)	Metals	Hydrocarbons
Residential roofs	Very low	0.2	0.2	0.05
Other roofs (typically commercial/industrial roofs)	Low	0.3	0.2	0.05
Individual property driveways, residential car parks, low traffic roads (eg cul de sacs, home zones and general access roads) and non-residential car parking with infrequent change (eg schools, offices) ie < 300 traffic movements/day	**Low**	**0.5**	**0.4**	**0.4**
Commercial yard and delivery areas, non-residential car parking with frequent change (e.g. hospitals, retail), all roads except low traffic roads and trunk roads/motorways	Medium	0.7	0.6	0.7
Sites with heavy pollution (e.g. haulage yards, lorry parks, highly frequented lorry approaches to industrial estates, waste sites), sites where chemicals and fuels (other than domestic fuel oil) are to be delivered, handled, stored, used or manufactured; industrial sites; trunk roads and motorways	High	0.8	0.8	0.9

Table 1: Pollution hazard indices for different land use classifications

(land use in bold applicable for the development).

	Mitigation indices		
Type of SuDS component	**TSS**	**Metals**	**Hydrocarbons**
Filter strip	0.4	0.4	0.5
Filter drain	0.4	0.4	0.4
Swale	0.5	0.6	0.6
Bio retention system	0.8	0.8	0.8
Permeable pavement	**0.7**	**0.6**	**0.7**
Detention basin	0.5	0.5	0.6
Pond	0.7	0.7	0.5
Wetland	0.8	0.8	0.8
Proprietary treatment systems	These must demonstrate that they can address each of the contaminant types to acceptable levels for frequent events up to approximately the 1 in 1 year return period event, for inflow concentrations relevant to the contributing drainage area.		

Table 2: Indicative SuDS mitigation indices for discharges to surface waters

(bold text is applicable to this development).

For surface water discharge from Residential Parking Areas and Low Traffic Roads <300 traffic movements/day			
	Required mitigation indices		
Source	**TSS**	**Metals**	**Hydrocarbons**
Low	**0.5**	**0.4**	**0.4**
Type of SuDS component provided			
Permeable pavement	0.7	0.6	0.7
Downstream Defender	-	-	-
Total	**0.7**	**0.6**	**0.7**
Check	**+0.20**	**+0.20**	**+0.30**

Table 3: SuDS mitigation indices provided

Appendix K
Flood Response Plan

FLOOD RESPONSE PLAN

Wootton Street, London

ARDENT CONSULTING ENGINEERS

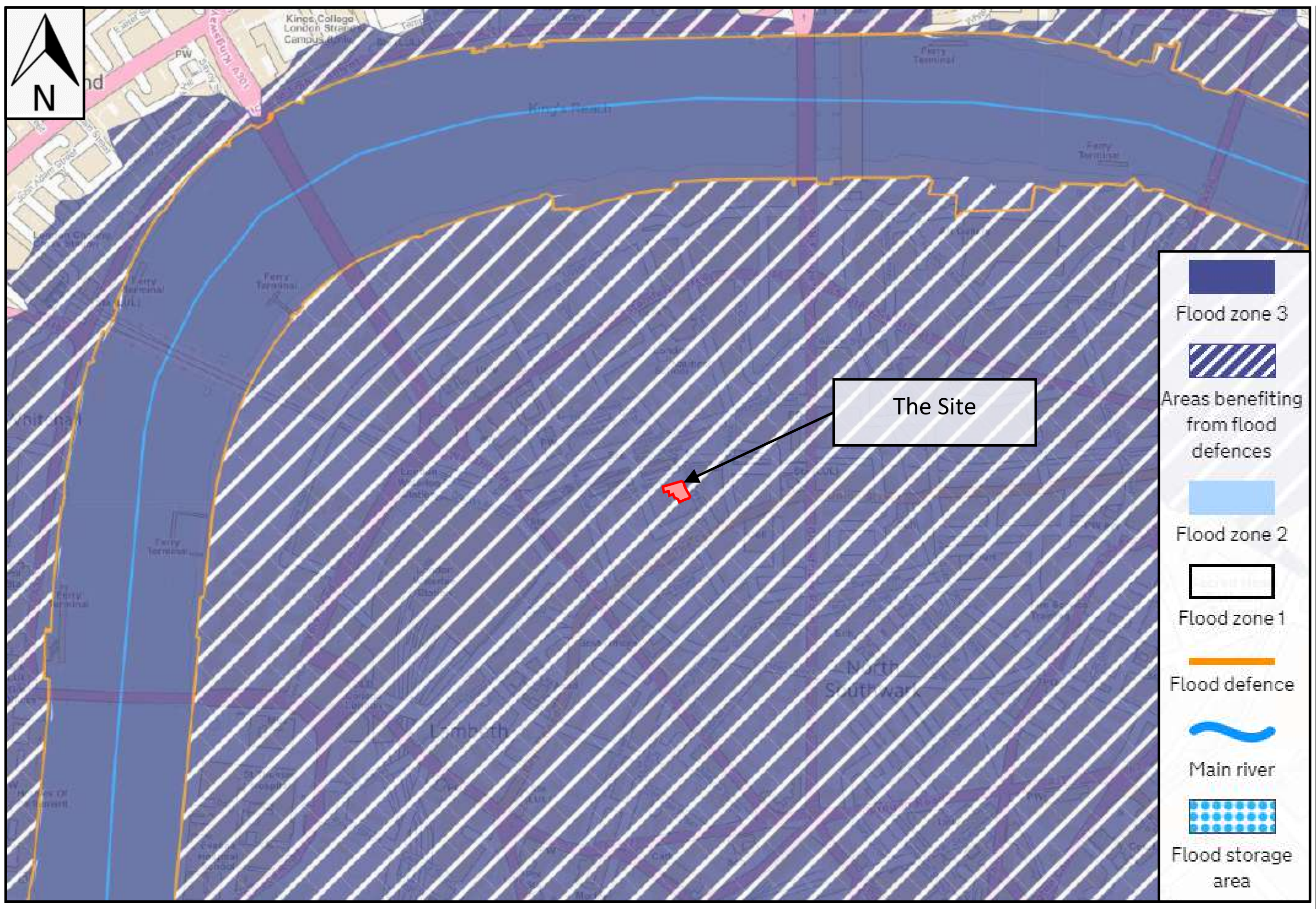
NOVEMBER 2020

FLOODING IS IN PROGRESS

If the reader is referring to this plan because flooding is in progress without a flood warning at or near the site:

- Sound the alarm and prepare to instruct staff and visitors;
- Turn off gas, electricity and water supplies if safe to do so;
- Await further information from the emergency services or via local radio; and,
- Don't walk or drive through flood water, unless directed to by Emergency Services; 150 mm of fast flowing water can knock you over and 600mm of water will float your car.

If instructed by the Emergency Services to evacuate, it is strongly recommended that you evacuate. The area could be inundated with flood water for several days following a breach in the flood defences.



ENVIRONMENT AGENCY FLOOD ZONES

EMERGENCY KIT

This is a useful bag that is packed with essentials in case you need to evacuate your home. It should be stored somewhere you can easily get to. Handy things to keep in your grab bag include:

- A list of useful telephone numbers (local authority, insurance company, family and friends, Corgi registered gas engineer and trained electrician).
- Mobile phone charger.
- Spare home and car keys.
- Toiletries, sanitary supplies.
- First-aid kit.
- Any essential medication
- A wind-up or battery-operated radio.
- Torch with spare batteries.
- Cash and credit cards.
- Spare clothes and blankets.
- Sensible flat shoes.
- Bottled water.
- A stock of non-perishable snack items.
- Essential items for babies or pets.

If asked by the emergency services to leave your home, please do so as quickly and calmly as possible. If you have time, turn off electricity, gas, and water supplies, unplug appliances, and lock all windows and doors. Take your grab bag with you.

Residents should listen to the advice and guidance from the emergency services at the time of an incident for actions to take. A Rest Centre will be announced at the time and widely communicated using all available media.

Refer to London Borough of Lambeth Council's webpage for further details: **https://www.lambeth.gov.uk/parking-transport-and-streets/streets-and-roads/flooding-guide**

ENVIRONMENT AGENCY FLOOD WARNING CODES

The Environment Agency operates three levels of flood warnings as summarised below:

		
FLOOD ALERT	FLOOD WARNING	SEVERE FLOOD WARNING
Flooding is possible. Be prepared.	Flooding is expected. Act Now.	Severe flooding. Danger to life. Action Needed.

EMERGENCY CONTACT NUMBERS:

Agency	Number
Environment Agency Flood Warning Direct	0345 988 1188
Lambeth London Borough Council	020 7926 1000
National Gas Emergency Service	0800 111 999
UK Power Networks (Power Cut)	0800 028 0247
Thames Water	0845 9200 800 / 0800 316 9800
NHS 111 Services	111

IF THERE IS A DANGER TO LIFE ALWAYS DIAL 999 OR 112 AND ASK FOR THE APPROPRIATE EMERGENCY SERVICE.

FLOOD RESPONSE PLAN

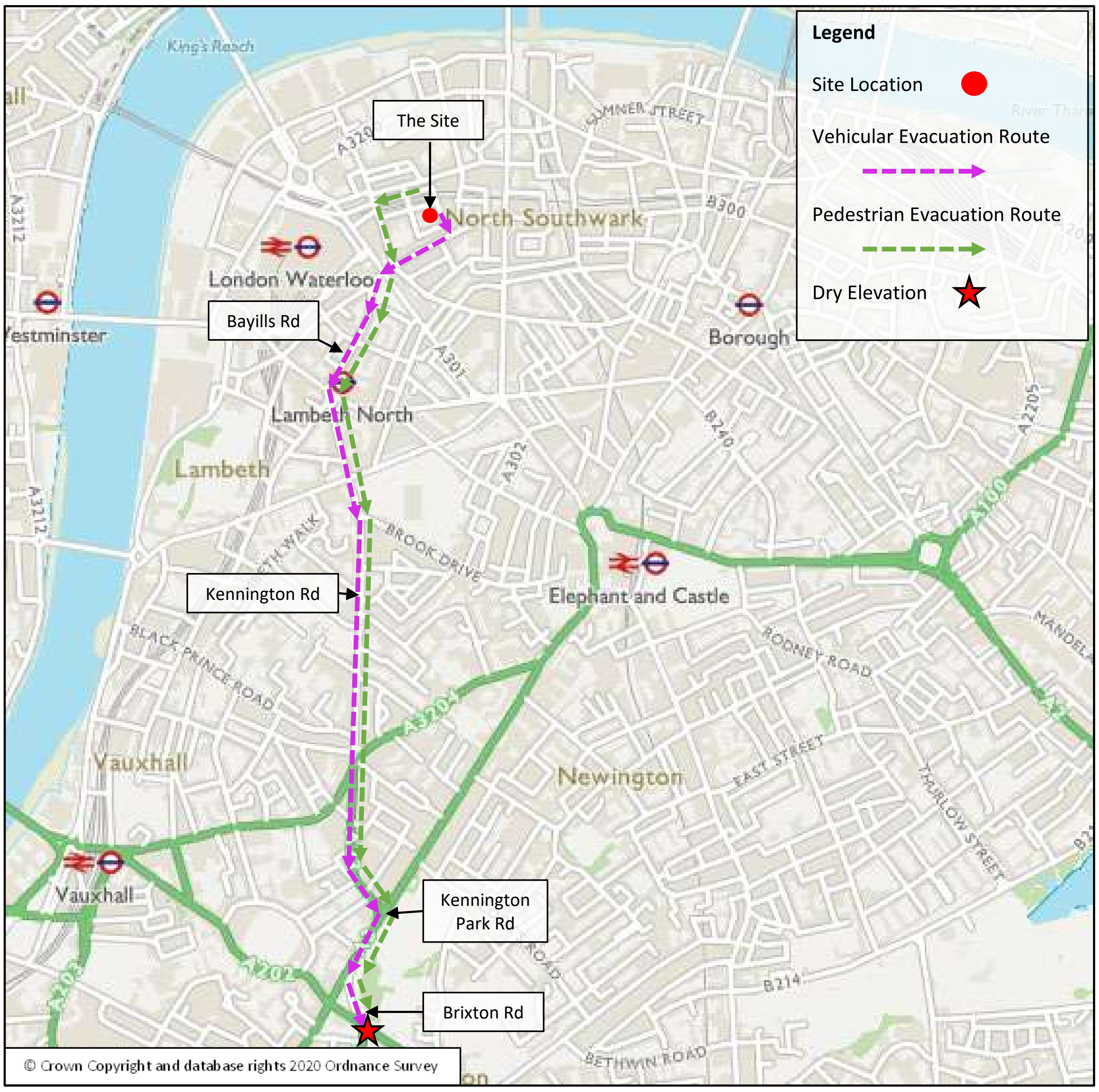
Wootton Street, London

ARDENT CONSULTING ENGINEERS

NOVEMBER 2020

SAFE ACCESS AND EGRESS ROUTES

The below diagrams outline safe access and egress routes in the event of a flood at the Site.



During a flood event, safe access is provided to higher levels off-site.

Safe access and egress on foot is afforded via **Greet Steet, The Cut, Baylis Road, Kennington Road and Kennington Park Road** to the south during the 2100 breach scenario (if time permits and advised by the emergency services).

Vehicular egress is provided via **Wootton Street** and **Cornwall Road** to the north and south along **Baylis Road and Kennington Road** onto **Kennington Park Road**, during the 2100 breach scenario (if time permits and advised by the emergency services).

If asked by the emergency services to leave your premise, please do so as quickly and calmly as possible. If you have time, turn off electricity, gas, and water supplies, unplug appliances, and lock all windows and doors. Take your grab bag with you.

An offsite refuge will be confirmed by Emergency Services during an event

Staff and visitors should listen to the advice and guidance from the emergency services at the time of an incident.

ANNUAL REVIEW OF PLAN

- Check residents and/or the management team and contacts lists and update details if necessary;
- Contact the Environment Agency Floodline Service to check that the flood risk to the Site has not changed;
- Check if the evacuation procedures are still correct;
- Undertake Flood Evacuation exercise;

In accordance with the flood risk assessment and planning requirements for the site the development has been designed and constructed to provide a safe refuge. The structure has been designed to withstand the forces of the floodwater and debris on a breach or a severe storm event that could theoretically occur for the Maximum Likely Water Level (MLWL).

Take your grab bag with you.

Note the flood extents were obtained from the Environment Agency, and the information contained in this notice will be reviewed annually by the developments managing agent.