AECOM

Charlton to Bexley Riverside Integrated Water Management Strategy

Greater London Authority

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Quality information

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Revision History

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List of Acronyms

BGS	British Geological Society
CIRIA	Construction Industry Research and Information Association
CDA	Critical Drainage Area – an area of land described as a catchment where surface water flows and drainage coontibute to areas of specific locaitons of high or very high flood risk
DEFRA	Department for Environment, Food and Rural Affairs
EA	Environment Agency
FWMA	Flood and Water Management Acr
GI	Green Infrastructure
GLA	Greater London Authority
GWR	Grey Water Recyling
IWMS	Integrated Water Management Strategy
l/p/d	Litres/person/day (a water consumption measurement)
LBB	London Borough of Bexley
LDS	Local Development Study
Ml	Megalitre (Million litres)
NPPF	National Planning Policy Framework
OA	Opportunity Area
OFWAT	The Water Services Regulation Authority (formerly the Office of Water Services)
RBG	Royal Borough of Greenwich
RWH	Rainwater Harvesting
S106	Section 106 (Town and Country Planning Act 1990)
SFRA	Strategic Flood Risk Assessment
SPG	Supplementary Planning Guidance
SPD	Supplementary Planning Document
SuDS	Sustainable Drainage Systems (or Sustainable urban Drainage Systems)
SINC	Site of Importance for Nature Conservation
SSSI	Site of Special Scientific Interest
SWMP	Surface Water Management Plan
TWUL	Thames Water Utilities Limited
WFD	Water Framework Directive
WwTW	Wastewater Treatment Works

1. Introduction

1.1 Background

AECOM was appointed by the Greater London Authority (GLA), alongside partners the London Borough of Bexley (LBB) and the Royal Borough of Greenwich (RBG) and Thames Water, to deliver an Integrated Water Management Strategy (IWMS) for Opportunity Areas (OAs) in south east London. The IWMS covers the four OAs of Charlton Riverside, Woolwich, Thamesmead and Abbey Wood, and Bexley Riverside spanning land from north Greenwich to east Bexley.

The total area for the four OAs is 24.11 km^2. However, Bexley Riverside OA, which covers the largest area (13.19 km^2), has been split into four growth areas as identified in the LBB Growth Strategy; An Emerging Vision; Belvedere, Erith, Slade Green and Crayford (see Section 2 – Proposed Development). It should also be noted that the growth within the specific area of Thamesmead spans both the Thamesmead & Abbey Wood OA and the Bexley Riverside OA and this has been shown as a specific growth area in Figure 1-1.

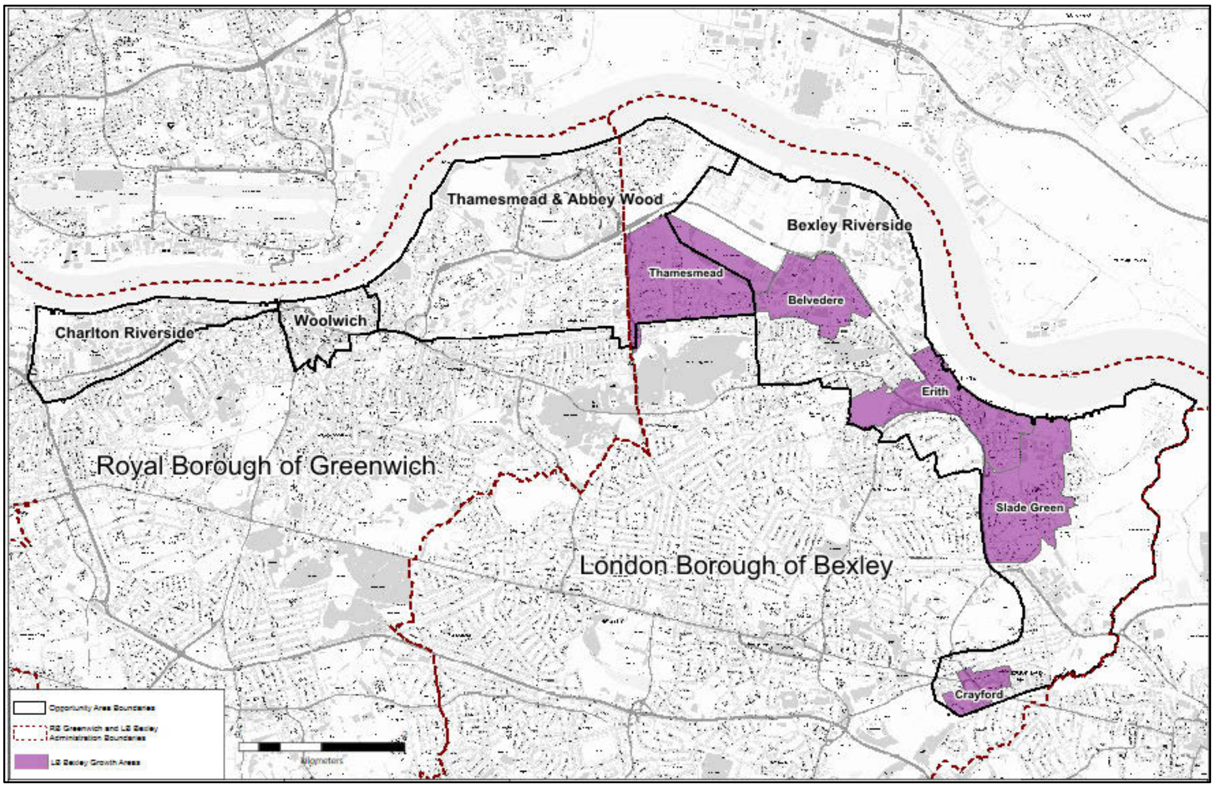


Figure 1-1 Location map of the Study Area, identifying the Opportunity Areas and growth areas.

A significant amount of development and regeneration is proposed within the four OAs, and the scale of regeneration poses a number of significant challenges around provision of water supply, wastewater services and management of flood risk.

It is therefore essential to understand, plan and implement new fully integrated water services infrastructure to support the proposed development to avoid sewer and surface water flooding and increase water supply security in a more sustainable way. A coordinated and collaborative approach to investment and maintenance of infrastructure solutions between the relevant stakeholders will be required to meet this aim. The IWMS will set the framework for achieving this.

1.2 Key Drivers

Future population growth, climate change and infrastructure capacity constraints are the key drivers behind the need for an integrated approach to strategic water management.

London's population is growing, with current projections estimating that London's population will increase by 37% to reach 11.3million people by 2050[1]. Much of this growth will occur in a limited number of areas with capacity to accommodate more significant growth, termed Opportunity Areas and identified in the London Plan (2015)[2]. The former Major of London's 'City in the East' (2016)[3] sets out a vision for more expansive growth in OAs within the east of London. The planned population growth within the Charlton to Bexley Riverside OAs would result in significantly increased demand on the existing water supply and wastewater systems, which Thames Water identify as already stressed and nearing capacity.

The current UKCP09 climate change projections suggest that the UK is likely to experience warmer wetter winters and hotter drier summers, potentially resulting in an increased frequency of drought and flood events. This may lead to water availability issues and increasing need for resilience in storm water and flood risk management.

Further, the OAs are located at the downstream end of the wider wastewater drainage network for two Wastewater Treatment Works (WwTW) and other OAs are proposed upstream of the study area which will all have potential impact on the capacity of the drainage infrastructure serving the OAs.

These drivers have the potential to impact future water availability, quality and distribution within the study area, resulting in challenges to water supply, sewerage and flood risk. Therefore, a strategic and sustainable approach is required to manage the potential risk to the water systems in the future.

The four OAs within this study area are located adjacent to each other along the River Thames water frontage and share common elements of the water supply and wastewater network. Therefore they are considered to have similar water cycle challenges as well as opportunities for shared infrastructure solutions, and would benefit from a strategic approach to water management.

1.3 Strategy Governance and Stakeholder Engagement

This IWMS has been developed in collaboration and consultation with key partners, integral to the delivery and management of water infrastructure for the Charlton to Bexley Riverside OAs. The steering group that has overseen the development of this IWMS consists of:

- Greater London Authority;
- Royal Borough of Greenwich;
- London Borough of Bexley;
- Peabody group;
- Thames Water Utilities Ltd; and
- Environment Agency.

In addition to the steering group governance, wider stakeholder engagement has been undertaken for the study via a workshop which was held during the IWMS development. The aim of this workshop was to ensure the IWMS captured and considered all potential water management options and that the approach to assessing those options was appropriate. A list of the wider stakeholders involved in the workshop is provided within the Stakeholder Engagement Strategy in Appendix B.

1.4 Strategy aims and objectives

The purpose of the IWMS is to develop a framework to sustainably manage water supply, wastewater and flood risk in the four Charlton to Bexley Riverside OAs and to provide guidance on how the required infrastructure should be planned, provided and managed.

[1] Mayor of London (updated 2015), London Infrastructure Plan 2050
[2] Greater London Authority, March 2015, The London Plan The spatial development strategy for London consolidated with alterations since 2011.

[3] Mayor of London, 2016, City in the East.

To deliver this aim, a series of water management and sustainability objectives have been set and agreed based on a detailed list of essential and desirable outcomes provided by each of the Steering Group members for the study. These objectives, shown in Figure 1-2 , have guided the development of the Strategy, and include core water management aspirations which must be met, as well as key outcome objectives for the Strategy to deliver.

The IWMS considers a range of water management 'measures' and how these can be combined into 'option scenarios' to provide an integrated strategy solution for each OA. Building on the objectives, key performance criteria have been developed to measure how successful each of the developed option scenarios is in meeting the water management objectives of the Strategy.

Figure 1-2: IWMS Objectives:

Strategy Outcomes

- Create a sustainable vision for how water should be managed in the OAs;
- Provide a clear and defensible evidence base for the development of water and flood risk management policy for site specific policies and Supplementary Planning Guidance (SPG) for the OAs (where required);
- Ensure flexibility and adaptability in the option scenarios to support the varied phasing and delivery programmes of different growth locations within the OAs; and
- Provide a clear framework for what developers and other stakeholders are expected to do in order to meet the strategy recommendations.

Water Management Objectives

- Minimise water demand, and aim for re-use of water for non-potable demands;
- Minimise discharge to the sewer system by managing surface water; and
- Integrate water management and flood risk management from all sources where feasible to aim to reduce flood risk.

Performance Criteria

- Follow the London Plan hierarchy in selecting measures that make up the option scenarios;
- Aim to achieve zero discharge of surface water flows to combined sewers by maximising discharge to ground or surface water bodies;
- Irrespective of the discharge type, aim to achieve greenfield runoff rate from new development for all storms up to the 1 in 100 year AEP event with an allowance for climate change;
- Deliver demand reduction measures to minimise demand for potable water; and
- Demonstrate a reduction in flood risk from all potential sources, where possible.

1.5 Legislative and Policy Considerations

The growth within the OAs will need to comply with EU Directives, UK legislation, planning policy and guidance on water, which are listed in Appendix A.

Of the legislation, the requirements of the Flood and Water Management Act (FWMA) are a key driver for this study. As designated Risk Management Authorities (RMAs), the FWMA requires Thames Water (sewer flooding) and the Boroughs (Lead Local Flood Authorities covering local flood risk) to manage flood risk from the sources for which they are responsible and requires RMAs to work together and share information to achieve this aim. It also requires all RMAs to aim to contribute towards the achievement of sustainable development when exercising their flood management functions. An IWMS is a key tool to helping both Thames Water and Boroughs meet the requirements of the FWMA through contribution to sustainable development via water and flood risk management considerations, and developing integrated solutions to the provision of water services and drainage in growth areas.

As set out in Section 4, various information sources which have been developed from related water and flood risk legislative and policy requirements have been used to inform this IWMS, including:

- The Borough's Strategic Flood Risk Assessments (published and developing);
- The London Sustainable Drainage Action Plan;
- Drain London: The Borough's Surface Water Management Plans; and
- The Thames District River Basin Management Plan.

An overview of the key regional (London wide) and local planning policy context for these areas is provided in the following sub-sections.

1.5.1 The London Plan (March 2015)

Development growth within London is driven by the London Plan March 2015[1], which sets out an integrated economic, environmental, transport and social framework for the development of London over a 20-25 year period.

The Plan includes a number of key policies aimed to assist protection of the water environment during redevelopment and construction. In particular, Policy 5.13 (Sustainable Drainage) identifies the drainage hierarchy that all development should follow to manage surface water runoff. Table 1-1 provides a summary of the London Plan policies that are key drivers to the IWMS. The IWMS provides an opportunity to demonstrate how achievable the water based policies are in the context of strategic planning.

Table 1-1: Key London Plan Policy

Policy	Description
Policy 5.3 **Sustainable Design and Construction**	Development proposals should demonstrate that sustainable design standards are integral to the proposal, including its construction and operation, and ensure that they are considered at the beginning of the design process. **Major development proposals should meet the minimum standards outlined in the Mayor's supplementary planning guidance (SPG)** and this should be clearly demonstrated within a design and access statement.
Policy 5.12 **Flood Risk Management**	Development proposals must comply with the flood risk assessment and management requirements set out in the NPPF and the associated technical Guidance on flood risk over the lifetime of the development and have regard to measures proposed in Thames Estuary 2100 (TE2100) and Catchment Flood Management Plans. Developments which are required to pass the Exceptions Test set out in the NPPF and the Planning Practice Guidance will need to address flood resilient design and emergency planning by demonstrating that: • the development will remain safe and operational under flood conditions • a strategy of either safe evacuation and/or safely remaining in the building is followed under flood conditions • key services including electricity, water etc. will continue to be provided under flood conditions • buildings are designed for quick recovery following a flood. Development adjacent to flood defences will be required to protect the integrity of existing flood defences and wherever possible should aim to be set back from the banks of watercourses and those defences to allow their management, maintenance and upgrading to be undertaken in a sustainable and cost effective way.
Policy 5.13 **Sustainable Drainage**	Development should utilise sustainable urban drainage systems (SuDS) unless there are practical reasons for not doing so, and should aim to achieve greenfield run-off rates and ensure that surface water run-off is managed as close to its source as possible in line with the following drainage hierarchy: **a) Store rainwater for later use;** **b) Use infiltration techniques, such as porous surfaces in non-clay areas;** **c) Attenuate rainwater in ponds or open water features for gradual release;** **d) Attenuate rainwater by storing in tanks or sealed water features for gradual release;** **e) Discharge rainwater direct to a watercourse;** **f) Discharge rainwater to a surface water sewer/drain;** **g) Discharge rainwater to the combined sewer.** Drainage should be designed and implemented in ways that deliver other policy objectives of this Plan, including water use efficiency and quality, biodiversity, amenity and recreation.

Policy	Description
Policy 5.14 **Water Quality and Wastewater Infrastructure**	Development proposals must ensure that adequate wastewater infrastructure capacity is available in tandem with development. Proposals that would benefit water quality, the delivery of the policies in this Plan and of the Thames River Basin Management Plan should be supported while those with adverse impacts should be refused. Development proposals to upgrade London's sewage (including sludge) treatment capacity should be supported provided they utilise best available techniques and energy capture. The development of the Thames Tideway Sewer Tunnels to address London's combined sewer overflows should be supported in principle.
Policy 5.15 **Water Use and Supplies**	The Mayor will work in partnership with appropriate agencies within London and adjoining regional and local planning authorities to protect and conserve water supplies and resources in order to secure London's needs in a sustainable manner by: a) minimising use of mains water; b) reaching cost-effective minimum leakage levels; c) in conjunction with demand side measures, promoting the provision of additional sustainable water resources in a timely and efficient manner, reducing the water supply deficit and achieving security of supply in London; d) minimising the amount of energy consumed in water supply; e) promoting the use of rainwater harvesting and using dual potable and grey water recycling systems, where they are energy and cost-effective; f) maintaining and upgrading water supply infrastructure; g) ensuring the water supplied will not give rise to likely significant adverse effects to the environment particularly designated sites of European importance for nature conservation; Development should minimise the use of mains water by: a) incorporating water saving measures and equipment; b) designing residential development so that **mains water consumption would meet a target of 105 litres or less per head per day.**

1.5.2 Sustainable Design and Construction SPG (April 2014)

The GLA's Sustainable Design and Construction SPG[4] provides guidance on the implementation of London Plan policy 5.3 - Sustainable Design and Construction, as well as a range of policies relating to environmental sustainability. It is a key supporting document for the management of flood risk in London and the implementation of SuDS.

With regards to Greenfield runoff rates, the SPG states the following preferred standards:

" all developments on greenfield sites must maintain greenfield runoff rates. On previously developed sites, runoff rates should not be more than three times the calculated greenfield rate. The only exceptions to this, where greater discharge rates may be acceptable, are where a pumped discharge would be required to meet the standards or where surface water drainage is to tidal waters and therefore would be able to discharge at unrestricted rates provided unacceptable scour would not result".

However, if it is not practical to achieve greenfield runoff rates, the essential standards for runoff requires a minimum of 50% attenuation of the site's (prior to re-development) surface water runoff at peak times. Developers are required to demonstrate and justify why greenfield runoff rates cannot be achieved, and identify which methods/opportunities have been used to minimise final site runoff, as close to greenfield rate as practical. This should be done using calculations and drawings appropriate to the scale of the application.

1.5.3 Local Planning Policies

1.5.3.1 RBG Local Planning Policy

The current RBG Local Plan[5] was adopted in July 2014. The plan sets out the current development policies for the Borough and includes the following policies relevant to the IWMS:

- Policy DH1: Design;
- Policy EA2: Charlton Riverside;
- Policy TC2: Woolwich Town Centre;

[4] Mayor of London, 2014, Sustainable Design and Construction SPG, London Plan 2011 Implementation Framework.
[5] Royal Borough of Greenwich, July 2014, Royal Greenwich Local Plan: Core Strategy with Detailed Policies

- Policy OS(g): Green and River Corridors;
- Policy E2: Flood Risk;
- Policy E3: Residual Flood Risk;
- Policy E(e): Contaminated Land; and
- Policy E(f): Living Roofs and Walls.

1.5.3.2 LBB Local Planning Policy

The LBB are currently in production of the Bexley Growth Strategy, which has a planned adoption date of 2017. Relevant policies related to water and flood risk are therefore drawn from the current LBB Core Strategy[6] which was adopted in February 2012 as part of the LBB Local Development Framework (LDF), and saved policies from the UDP.

The Core Strategy sets out the current development policies for the Borough and includes the following policies relevant to the IWMS:

- Policy CS01: Achieving Sustainable Development;
- Policy CS03: Belvedere Geographic Region;
- Policy CS04: Erith Geographic Region;
- Policy CS05: Crayford Geographic Region;
- Policy CS08: Adapting to and mitigating the effects of climate change, including flood risk management;
- Policy CS09: Using Bexley's resources sustainably;
- Policy CS17: Green Infrastructure;
- Policy CS18: Biodiversity and Geology;
- Policy CS20: Sustainable waste Management; and
- Policy CS21: Providing for Infrastructure.

Relevant saved UDP policies include:

- S13 & TS14 (Thames-side environment);
- TS15 (Thames-side biodiversity); and,
- TS19 (Crayford Marshes)

1.5.3.3 Other Policy and Guidance

Other relevant local policy and guidance include:

- The Greener Greenwich SPD[7];
- The Greener Greenwich Strategy[8], including:
  - Strategic Objective 10 – To foster sustainable water management.

1.5.4 Thames Estuary 2100

The Environment Agency's Thames Estuary 2100 (TE2100) plan sets out the strategic direction for managing flood risk in the Thames estuary to the end of the century and beyond. The study area is protected from tidal flooding from the River Thames by the Thames Tidal Defences, which consist of a flood wall or embankment. The Thames Barrier is located half way along the river bank of the Charlton Riverside OA, therefore the majority of the study area is outside of its influence.

6 London Borough of Bexley, February 2012, Local Development Framework, Development Plan Document, Bexley Core Strategy
7 http://www.royalgreenwich.gov.uk/downloads/file/2464/greener_greenwich_supplementary_planning_document_-_adopted_17_sep_2014
8 http://www.royalgreenwich.gov.uk/downloads/file/537/greener_greenwich_strategy

The TE2100 action plan splits the tidal River Thames and estuary into 23 policy units, which have been grouped into action zones where the policy units have similar characteristics and require a similar type and range of actions. There are eight action zones and the TE2100 plan sets out recommendations for each.

The study area is covered by Action Zone 3 (East London), Action Zone 4 (East London downstream of Thames Barrier) and Action Zone 5 (Middle Estuary). The Charlton Riverside OA is located within Policy Unit Greenwich, and is covered by flood risk management policy P5; “to take further action to reduce flood risk”. The Woolwich, Thamesmead and Abbey Wood and the north of Bexley Riverside OAs are located within Policy Unit Thamesmead. The southern part of the Bexley Riverside OA is located within the Dartford and Erith Policy Unit. Both of these policy units are covered by flood risk management policy P4; “to take further action to keep up with climate and land use change so that flood risk does not increase”. Full details are provided in Appendix F (Strategic-level flood risk assessment).

It should be noted that the TE2100 Plan is an adaptable plan and so it is important to consider that actions for the plan may be brought forward/pushed back or changed based on how London and the River Thames respond in the future.

2. Proposed Development

2.1 Introduction

Understanding the scale and distribution of future development, and the likely population that this development generates is central for understanding the likely water demands and discharges that need to be met. Furthermore, the character of the development will affect the characteristics of storm and surface water flows. This section sets out the assumptions for future growth and the nature of the development to feed into the water balance (see next section), from which the IWMS has been developed.

2.2 Planning Context

Strategic planning in London is shared between the GLA and the London Boroughs. As part of the legislation setting up the GLA, the Mayor has to produce a spatial development strategy, better known as the London Plan. This plan sets out the planning policy framework for strategic issues across London. As Local Planning Authorities, the London Boroughs are required to produce Local Development Documents, including their Local Plans and associated evidence to plan for their locality. The Local Plans should be in general conformity to the London Plan.

Growth is a strategic challenge for London, and as such the London Plan (2016) identifies 38 broad OAs that should be the focus for concentrating housing and economic development. These are areas of London that have a high concentration of brownfield land and significant capacity for redevelopment and the London Plan sets out broad housing and employment growth aspirations to 2036 for the areas. This IWMS focuses on four Opportunity Areas that fall within two London Boroughs.

The Charlton Riverside, Woolwich and Thamesmead and Abbey Wood OAs are quite discrete, however, the Bexley Riverside OA is much larger and has been split into a number of smaller growth areas. As such, this report refers to growth areas as the spatial extent of expected strategic growth within each OA as set out in Table 2-1.

Table 2-1: Opportunity Areas

Borough	Opportunity Area	Growth Area
Royal Borough of Greenwich	Charlton Riverside	Charlton Riverside
	Woolwich	Woolwich Town Centre
Royal Borough of Greenwich / London Borough of Bexley	Thamesmead and Abbey Wood	Thamesmead and Abbey Wood
London Borough of Bexley	Bexley Riverside	Belvedere
		Crayford
		Erith
		Slade Green

Although both Boroughs have existing Local Plans, the LBB Core Strategy (2012) and the RBG Local Plan (2014) -that acknowledge the Opportunity Areas-, neither extend to 2036 and in the case of LBB the growth aspirations were considerably lower. Both Boroughs are now in the process of collecting evidence and testing growth options in accordance with the London Plan to support the development of new Local Plans. The RBG is also in the process of producing supplementary planning guidance for Charlton Riverside to accommodate growth to 2036 and beyond.

Furthermore, although not a statutory planning document, the City in the East prospectus developed by the previous Mayor further advocates growth in the OAs identified.

Finally, Peabody Housing Association is the largest land owner in Thamesmead and Abbey Wood and as steering group members for this study, they have confidentially provided their long term growth aspirations for this area.

2.3 Growth Scenarios for Testing

There are a range of sources from which various growth assumptions for the growth areas could be developed. Neither the emerging Local Plan projections, the London Plan or City in the East document present assumptions that are consistently lower or higher than the others for all of the growth areas. As such, a composite set of low, medium and high growth assumptions has been developed and tested for each growth area based on whichever source was deemed the most relevant as illustrated in Table 2-2. Furthermore, for Thamesmead and Abbey Wood as well as Charlton Riverside, the study benefitted from added insight from Peabody and the emerging Supplementary Planning Document (SPD) respectively.

Table 2-2: Source of Growth Projections for each Growth Scenario

Growth Area	Low	Medium	High
Charlton Riverside	London Plan	Local Plan	Additional Option from SDP
Woolwich Town Centre	Local Plan	London Plan	City in the East
Thamesmead and Abbey Wood	London Plan	Local Plan	Additional Option from Peabody
Belvedere	London Plan	Emerging Local Plan update	City in the East
Crayford	London Plan	City in the East	Emerging Local Plan update
Erith	London Plan	City in the East	Emerging Local Plan update
Slade Green	City in the East	London Plan	Emerging Local Plan update

However, as the emerging local plan projections and the Charlton Riverside SPD are still in development, it is too premature to present these publically. Similarly, although Peabody growth aspirations are useful to build into the modelling, they are commercially sensitive and have been provided on the condition of confidentiality. As such, specific details of the growth assumptions used in the high, medium and low scenarios are provided in confidential Appendix C for use by the Steering Group until such a time that they can be made public.

It is however important to be able to consult publically on the development of the IWMS for each of the growth areas. As such, the IWMS presents and assesses a blended average of each of the potential growth projections as shown in Table 2-3. This is of a sufficient scale to illustrate the potential for more integrated water management in each of the growth areas. Estimates of population generated from new residential units have been provided by each of the Boroughs based on census analysis of changing household size at 2.3 people per household in LBB and 2.4 people per household in RBG.

Table 2-3: Average growth assumptions for each growth area to 2036

	Gross Area (ha)	Resi Unit	Population	Jobs	Open Space (ha)
Charlton Riverside	76	4,600	11,100	5,300	14
Woolwich Town Centre	37	7,400	17,700	3,700	1
Thamesmead and Abbey Wood	187	6,000	14,100	4,200	32
Bexley Riverside	309	14,900	35,200	5,100	14
Belvedere	*76*	*6,800*	*15,500*	*2,300*	*2*
Crayford	*23*	*850*	*2,000*	*400*	*0*
Erith	*96*	*3,400*	*7,800*	*950*	*4*
Slade Green	*113*	*3,800*	*8,800*	*1,300*	*8*

2.4 Spatial distribution of growth

For RBG, the Royal Greenwich Local Plan: Site Allocations Issues and Options Consultation (Feb 2016) identifies potential development sites with preferred proposed uses. For the purposes of this study, these sites have been used to inform the spatial distribution of development. Allocation Sites within each of the OA boundaries identified as either residential led or mixed use have been allocated a proportion of the growth projection for that OA relative to the site gross area.

The spatial context for growth in LBB is currently less well defined. As such, it has been assumed that residential growth will be distributed evenly across each of the growth areas, each with a town centre core where the majority of new employment will be located. As the London Plan only provides growth projections at the Opportunity Area scale, the split of development within each growth area has been guided by the split used in the emerging Local Plan projections. Figure 2-1 illustrates the potential spatial extent of growth in each of the growth areas.

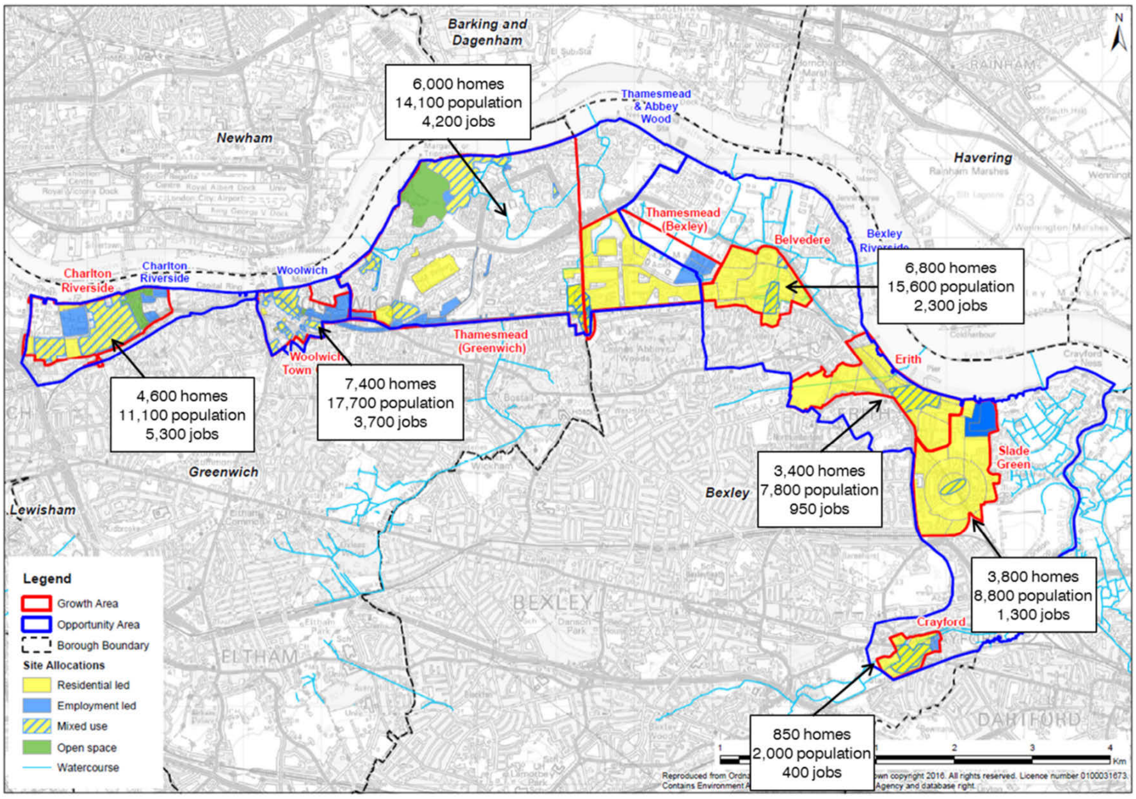


Figure 2-1: Potential areas for development in the growth areas

2.4.1 Other development assumptions

In addition to the level of growth a number of universal assumptions have been made as to the land use within each site including:

- Unless otherwise indicated, phasing has been applied linearly across the period to 2036. If there is phasing within one of the projections, this has been used as the basis for growth across each of the scenarios.
- Housing and employment developable area constitutes 80% of the gross site area.
- 60% of the developable area will be buildings.
- Transport infrastructure accounts for 4% of the site area.
- Public realm outside developable areas accounts for 4% of the site area.
- The 12% of space remaining is for other social and hard infrastructure[9].

[9] Note that these assumptions are broadly consistent with and have been tested against the draft Charlton Riverside SPD and the Bexley PH5 assumptions.

3. IWMS Approach and Method

3.1 Stages of the IWMS

There are four main study components of the Charlton to Bexley Riverside IWMS that follow sequentially in the development of the Strategy. These study components, and the methods used in completing each component are summarised here. The detailed output from each study component is presented later in this report.

- Step 1: Defining the baseline conditions, including constraints and opportunities for water and flood risk management measures within each growth area;
- Step 2: Determining the water balance within the study area as a whole and within each growth area, defining the available water and wastewater flows feeding into and leaving the study area;
- Step 2: Option Appraisal and Strategy Development; identifying and assessing the range of water management and flood risk measures that could be implemented and assessing these against the study objectives and key performance criteria to define a range of option scenarios for an integrated strategy for each growth area;
- Step 4: Strategy delivery; setting out how the option scenarios could be delivered within the growth areas including infrastructure costs, potential infrastructure owners and contributors, stakeholder engagement requirements, phasing implications and different models for overall infrastructure delivery.

3.2 Step 1: Defining the baseline conditions

Constraint and opportunity mapping is key to shaping decisions on which water management measures are feasible and most appropriate across the growth areas when developing option scenarios for the IWMS. High level constraints maps have been produced covering the four OAs to provide a high level overview of water cycle constraints and opportunities for water management. The maps have been developed through stakeholder engagement and a review of existing GIS information for the Study Area.

An overview of the constraints and opportunities for the study area as a whole are presented in Section 4 of this IWMS report. Detailed maps for the study area are provided in Appendix E for the following:

- Thames Water supply network infrastructure locations and constraints;
- Thames Water sewer network infrastructure locations and constraints;
- Surface water catchments and topography constraints;
- Geological constraints;
- Environmental designation constraints;
- Contaminated land constraints; and
- Infrastructure (transport and flood defence) constraints.

3.2.1 Flood Risk Summary

The assessment of opportunities and constraints has included a strategic-level assessment of flood risk across all four OAs and the growth areas within the OAs. This included: a detailed review of the Strategic Flood Risk Assessments (SFRA), Local Flood Risk Management Strategies (LFRMS), and Surface Water Management Plans (SWMP) for RBG and LBB; a review of the Thames Estuary 2100 (TE2100) plan; and a review of the Medium Term Plan (MTP) for planned Flood and Coastal Erosion Management (FCERM) schemes within, and in close proximity to the study area.

A summary is provided within Section 4.7 of this IWMS report and detail provided within Appendix F.

3.2.2 Asset and infrastructure register

GIS layers of the existing water, sewer and flood risk management infrastructure within the OAs have been provided by key stakeholders, including Thames Water, the Environment Agency, RBG and LBB. These datasets have been consolidated and a GIS infrastructure register developed. This is provided to the steering group as confidential Appendix G. An excel version of the register has also been developed and separately delivered as a part of this study.

3.3 Stage 2: The Water Balance

The conceptual water balance approach enables the preferred strategy to be derived based on estimations of both existing and future water demand, wastewater generation and rainfall runoff estimate set against the hydrological water inputs into the system. This is includes an annual balance based on average rainfall, and also includes additional calcualtions of peak runoff estimates including the influence of climate change[10]. A summary of the water balance method and water balance outputs for the study area as a whole is presented in Section 5, with a growth area specific output provided in Sections 7 to 10.

Full detail of the water balance for each OA is presented as a confidential appendix for use by the steering group only at this stage. This reflects that the detailed water balance has been calculated for the high, medium and low planning scenarios which cannot be made public at the time of writing this IWMS.

3.4 Step 3: Options Appraisal and Strategy Development

This component of the IWMS integrates the outputs of the opportunity and constraints baseline definition with the calculated water balance to develop a range of effective solutions that can be applied at different scales across the OAs.

Using the constraints, opportunities and assessment of water balance, a long-list of potential individual water management measures have been considered (presented in Section 6) for the study area as a whole. An appraisal process has then been completed based on how these measures could be combined into option scenarios for each growth area in order to meet the performance criteria and overall study objectives as set out in Section 1.4.

There are several influencing factors which determine whether a measure is able to meet the study performance criteria, or how much it could contribute to meeting it for each Growth Area, based on the site specific opportunities and constraints and water balance calculations. These influencing factors are grouped according to the themes of sustainability, feasibility and deliverability, as shown in Figure 3-1. The influencing factors have been used to determine the most suitable measures for each growth area and further detail is provided in the following subsections.

[10] Climate change allowances based on updated Environment Agency guidance (Feb 2016)

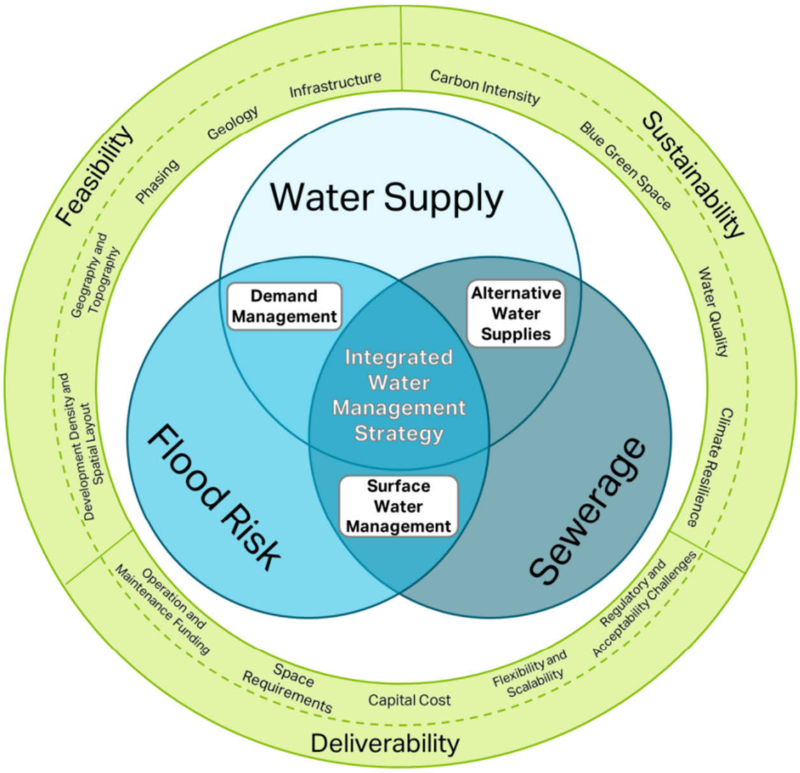


Figure 3-1: Key drivers, influencing factors and considerations required in the process of developing the preferred strategy.

3.4.1 Deliverability Factors

The feasibility of each measure relates the overall spatial and financial viability, and the anticipated ease of delivery. This has been considered in term of the below aspects:

- *Capital cost* - feasibility considerations associated with infrastructure requirements, construction cost and buildability constraints associated with installation in new build and retrofit environments. Ideally, the sum of derived benefits should also be considered for different interventions.
- *Operational and maintenance requirements* - Many of the measures presented will have continuing operational, maintenance or monitoring requirements, with an associated ongoing cost implication, and potential challenges in determining relevant responsibility and ownership.
- *Effective spatial requirements* – The outlined measures have varying spatial requirements. As such, available space may present a constraint to the feasibility of delivery of certain measures within some growth areas; however, this may also promote the use of multi-functional features and spaces.
- *Regulatory challenges and public acceptance* - Existing regulation and legislation in the water management area is complex and fragmented, with a lack of a comprehensive regulatory framework, which may present operational and commercial risks for some measures. Additionally, the social effects of innovative solutions to sustainable water management need to be carefully considered. This may include constraints, such as issues of public acceptability and update, as well positive outcomes, such as to the potential for certain measures to promote community engagement with sustainable water management.
- *Flexibility and scalability of delivery* - The flexibility and scalability of measures relates to the ability to react to the phasing of development delivery and the extent to which significant upfront costs are incurred, or whether these may be spread over the re-development delivery, and how these can be clearly distributed amongst delivery partners.

3.4.2 Sustainability Factors

Sustainability considerations are those related to broader long term sustainability and climate resilience of the presented measures, as well as the extent to which they will deliver added benefits to the local community. This has been considered in terms of the following aspects:

- *Carbon intensity* - Each of the measures has an impact in terms of embedded carbon and ongoing operational energy, associated with water supply, pumping and wastewater treatment. In some cases, green infrastructure can also make contributions to removing greenhouse gases from the atmosphere and sequestering them over the long term. Shading can also result in reduced need for mechanical cooling in the summertime and reduction in demand for water cooling.
- *Blue-green space provided* - Through high design and maintenance standards, the delivery of blue and green infrastructure can enhance the urban environment for the benefit of communities and biodiversity. Particular benefit may be related to the following indicators:
  - *Provision of habitat and biodiversity* - when sufficiently planned, the delivery of diverse, high quality green spaces can provide valuable habitat to a range of flora and fauna, including birds and invertebrates, while contributing to green corridors, allowing the movement of species through urbanised spaces.
  - *Recreation and community* - provision of space for recreation and contribution to community health, wellbeing and social cohesion. Water features can create a sense of place.
  - *Microclimate adaptation* - Reducing the impact of the urban heat island effect by reducing local temperatures through evapotranspiration and reducing heat absorbed and then released by surfaces.
  - *Public realm* - street greening and the delivery of effectively landscaped open spaces can substantially improve the attractiveness and amenity of neighbourhoods and aid the mitigation of car emissions.
- *Climate Resilience* - Different measures have differing levels of resilience to the effects of climate change. Measures which are dependent on rainfall to meet water supply needs have a potentially lower resilience to climate change. More generally, increasing the diversity of available water supply options can also contribute to increasing the overall resilience of the system to climate change and other future disturbance, through increased flexibility and adaptability of supply options. Options also provide resilience to other climate change factors such as increased risk of flood extent or frequency, or urban cooling.
- *Surface water quality* - Many SuDS components, particularly those incorporating natural, vegetative or bio-retention processes, provide opportunities to improve water quality (helping to meet the Water Framework Directive targets) and by treating diffuse water pollution through mechanisms including sedimentation, filtration and biological degradation. These components can also reduce the amount of surface water reaching end watercourses (reducing erosion and pollution), and entering sewers, adding to subsequent treatment requirements and possible Combined Sewer Overflow (CSO) spills

3.4.3 Strategy Development

For each growth area, measures have been assessed and combined to develop a preferred option scenario that meet the performance criteria and study objectives. Sections 7 to 12 of this IWMS set out the option appraisal process for each growth area within the four OAs and in developing a preferred option scenario for each growth area. These sections also set out a summary and recommendations for each growth area strategy.

3.5 Step 4: Strategy Delivery

The delivery plan sets out how the strategy can be implemented effectively. For each growth area, the delivery component sets out a broad estimate of delivery costs, recommendations on delivery responsibility, and phasing implications for the option scenarios. The recommendations identified in the delivery plan will set out the pathway for how the concepts of water and flood risk management as set out in this IWMS can be delivered. This could include local plan policies to be developed in the emerging Borough Local Plans or supplimentary planning guidance for the Opportunty Areas.

One of the roles of the IWMS is to establish a key stakeholder engagement strategy that provides a framework for engaging the relevant parties at a strategic level and maintains their continued input and support as the planning and delivery process advances for the growth areas.

The Strategy delivery plan and stakeholder engagement strategy for the IWMS is presented in Section 13.

4. Study Area Constraints and Opportunities

High level constraints maps have been produced covering the four OAs to provide an overview of the water service and flood risk infrastructure assets, other influencing infrastructure and high level environmental constraints (Appendix E). The constraint and opportunity mapping will inform decisions on which water management measures are feasible and most appropriate across the OAs when developing option scenarios for the IWMS. An overview of the study area constraints and opportunities is summarised in the following sections.

4.1 Topography, Land Use and Infrastructure

The local relief peaks at approximately 60 mAOD to the south and west of the study area boundary, and steeply drops northwards and eastwards toward the River Thames. The topography within the study area is dominated by flat low lying floodplain located directly behind the River Thames Tidal defences (Figure 4-1). The low lying land is historically reclaimed marshland and is significantly below high tide levels. The majority of the study area ranges between -1 mAOD and 10 mAOD.

The study area is urban with a mixture of industrial and commercial, and residential land uses. The River Thames frontage is dominated by industrial and commercial uses, many of which require direct access to the river. The study area has transport links via the River Thames, a network of main roads, the railway and the future Crossrail in Woolwich and Abbey Wood.

The local topography is also impacted by local transport and industry infrastructure within the OAs. Figure E.8 in Appendix E shows the transport infrastructure and Environment Agency flood assets within the study area. Railways and road networks, as well as local utilities (e.g. the Southern Outfall Sewer) and industry along the River Thames frontage, create areas of raised ground or depressions which cut though the landscape. This infrastructure influences the surface water drainage catchment areas as identified in Figure 4-1.

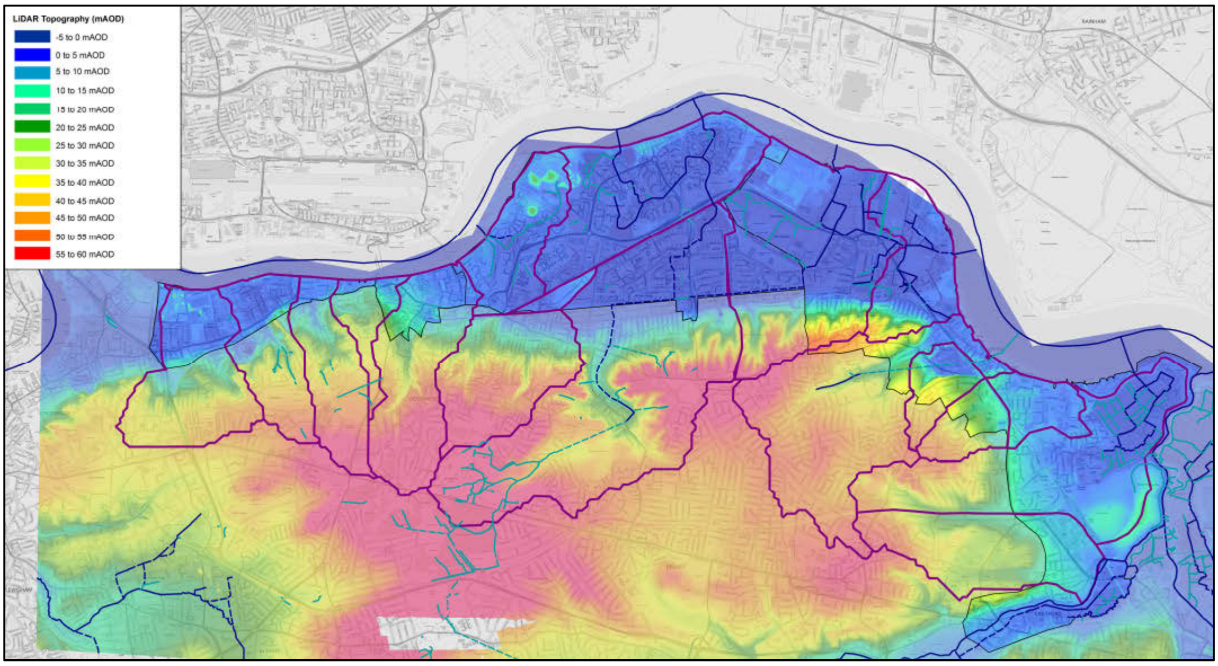


Figure 4-1: Topography and surface water catchments within the Study Area

Table 4-1 summaries the strategic opportunities and constraints associated with the topography, land use and infrastructure and their impact on the surface water drainage catchments across the study area (Appendix E Figure E.3).

Table 4-1: Study Area Overview - Surface Water Catchments Opportunities and Constraints

Opportunities	• The surface water catchments can be used to identify areas that influence surface water flooding hotspots and mitigation measures (such as attenuation) could be targeted in specific areas to help alleviate flooding problems.
Constraints	• Low lying land behind the Thames Tidal flood defences cannot naturally drain surface water by gravity into the River Thames when the tide level is higher than the ground. Pumping stations are required to continue discharging surface water into the River Thames during high tide. • Railways and other transport infrastructure could be a constraint due to changes in the local topography preventing surface water naturally draining to the River Thames.

4.2 Geology and Groundwater

The study area is underlain by three aquifers: the Chalk, Thanet Sands, and Harwich Formation. The Chalk is present at the lowest elevations nearest the River Thames. Thanet Sands overlie the Chalk and are situated near the River Thames and also on slightly higher ground to the south. Much of the study area away from the river margins, on the higher ground, is underlain by the Chalk, Thanet Sands and the lower permeability Lambeth Formation, overlain by the Harwich Formation at outcrop. On the highest elevations (above 55 mAOD) to the south of the study area, London Clay outcrops and overlies the Harwich Formation.

Superficial deposits within the study area consist of Alluvium (clay, silt and sand) in the Charlton Riverside OA, Thamesmead and Abbey Wood OA and the Belvedere and Crayford growth areas. Terrace River Deposits (clay, silt, sand and gravel) are located in the Woolwich OA, and the Erith and Slade Green growth areas.

Table 4-2 summarises the strategic opportunities and constraints associated with the geology and groundwater across the study area, shown in Appendix E Figure E.4. The groundwater injection opportunities within the study area are further described in the Groundwater Injection Technical Note provided in Appendix H.

Table 4-2: Study Area Overview - Geology and Groundwater Opportunities and Constraints

Opportunities	• The permeable nature of the Chalk, Thanet Sands and Harwich Formation in the study area means that groundwater injection is a potential option to mitigate surface water flooding by allowing it to infiltrate into the unconfined chalk. This option is further discussed in detail in Appendix H. • Groundwater injection could potentially benefit water resource availability to the north of London, due to the direction of the groundwater flow.
Constraints	• Due to the confined nature of the majority of the study area, only certain areas can potentially benefit from the groundwater injection option. • There are Source Protection Zones (SPZs) in the south eastern part of the study area, covering Crayford and part of Slade Green which need to be protected from pollution associated with development. • The study area is heavily developed and there are varying depths of made ground and areas of contamination due to historical land uses. This may impact on the feasibility of the groundwater injection option.

4.3 Watercourses

The study area is dominated by the River Thames, which creates the northern/eastern boundary for the OAs. There are also a number of watercourses and systems within the OAs that influence flood risk and surface water drainage; these are shown in Figure 4-2.

The River Cray flows west to east along the northern boundary of the Crayford growth area, and the culverted River Wantsunt runs west to east through the centre of the growth area. These rivers both discharge into the lower catchment of the River Darent.

The Thamesmead Lakes and Canal system is an engineered surface water drainage system for the Thamesmead and Abbey Wood area developed in the 1960s. The Wickham Valley watercourse (Butts Canal) originates near Woolwich Cemetery in East Wickham and flows northwards before entering a culvert, which eventually drains into the Southmere Lake. The lake feeds into the Thamesmead canal system and the water levels are maintained by pumping stations and sluices, which discharge into the River Thames.

The Erith Marshes system drains the eastern part of the Thamesmead growth area in the LBB and the Belvedere growth area. The Yarton Way culverted surface water drain collects water from the Abbey Wood and Belvedere growth areas and discharges into open ditches in Erith Marshes. The water levels in the Marshes are maintained by a weir and two pumping stations; Great Breach and Green Level.

Within the Charlton Riverside OA there is a small open section of an ordinary watercourse, located to the north of the Charlton Gate Business Park. This is a highly industrial area and due to issues with access, it is currently unknown where the source is for the ordinary watercourse, or where it discharges to. Development in this area could use this ordinary watercourse for surface water drainage and provide further understanding of the catchment for this watercourse.

There is an open drain that flows eastwards located outside the study area and to the west of the Erith Growth Area, in Lessness Heath. The drain enters a culvert at Brook Street, which continues eastwards below Erith and discharges into the Thames.

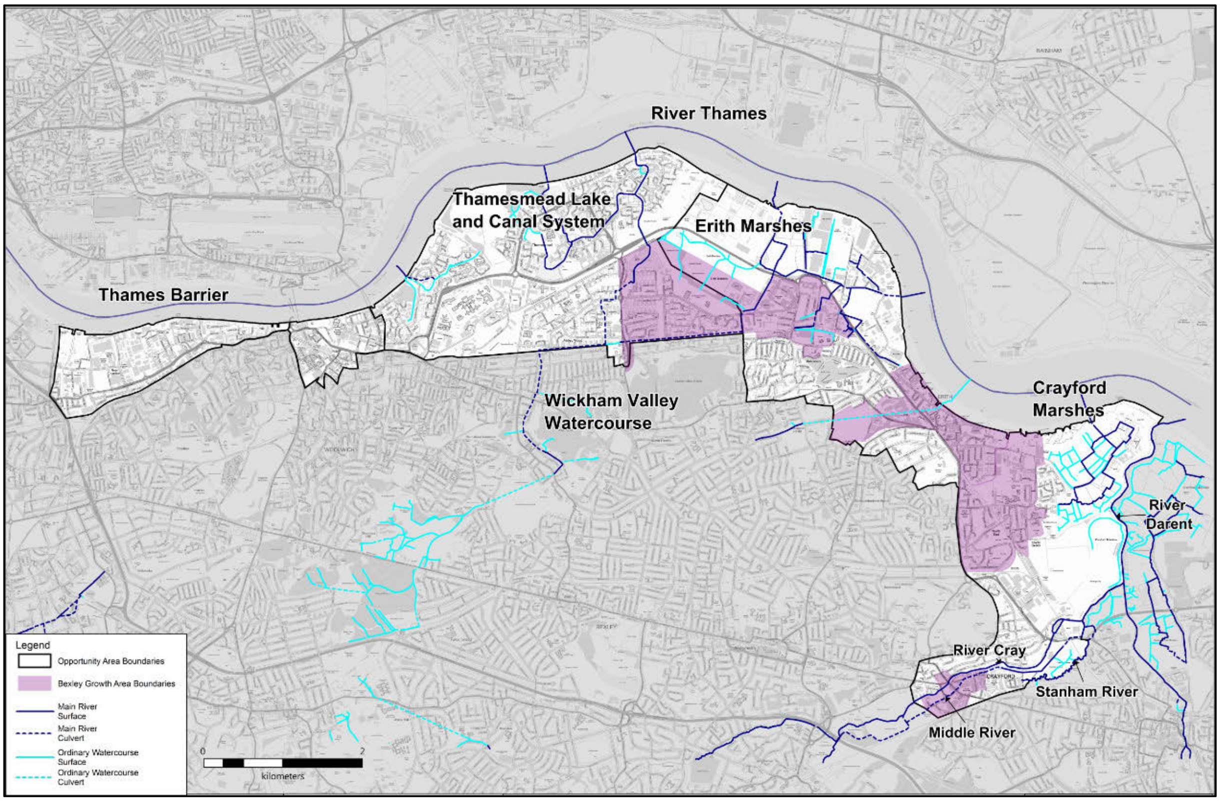


Figure 4-2: Main Rivers and Ordinary Watercourses within the Study Area

Table 4-3 summaries the strategic opportunities and constraints associated with the watercourses across the study area. The watercourses and drainage systems are further described in the Flood Risk Technical Note in Appendix F.

Table 4-3: Study Area Overview - Watercourses Opportunities and Constraints

Opportunities	• The Thamesmead Lake and Canal system and Erith Marshes drainage system networks are already in place, therefore there is potential for new development in the Thamesmead and Abbey Wood OA and Belvedere growth to connect their surface water discharge into these systems. • The small section of open ordinary watercourse within the Charlton Riverside OA could be used for surface water drainage. • The proximity of the study area to the River Thames would make discharging surface water to the river an obvious option. However, as mentioned previously, the low lying land behind the Thames Tidal flood defences cannot naturally drain surface water by gravity into the River Thames when the tide level is higher than the ground. Pumping stations are required to continue discharging surface water into the River Thames during high tide.
Constraints	• The watercourses present flood risk to the area which may limit the type and nature of development in some areas. The Thames frontage is protected by flood defences meaning the risk is residual but needs to be considered in the event of a breach. Flooding from ordinary watercourses needs to be considered as does undefended flood risk from the River Cray.

4.4 Drainage and Wastewater Network

There are two sewer networks and associated Wastewater Treatment Works (WwTW) that cover the study area; Crossness WwTW to the west and Longreach WwTW to the east (Appendix E Figure E.2):

Crossness WwTW:

- Large sewer catchment on the south side of the River Thames, extending as far west as Wimbledon to Crossness WwTW in north Bexley.
- Crossness WwTW is located within the study area, within the north eastern area of the Thamesmead and Abbey Wood OA. Charlton Riverside, Woolwich, and Thamesmead and Abbey Wood OAs drain to Crossness WwTW. These areas are within the lower sewer catchment, close to the WwTW.
- The Crossness sewer network catchment is pumped into the Southern Outfall Sewer via three trunk main combined sewers. The Southern Outfall Sewer cuts across the Thamesmead and Abbey Wood OA.
- The Crossness WwTW network is largely a combined system with some areas of seperated sewer in the study area, particularly within the Thamesmead and Abbey Wood OA.
- During storm events where the capacity of the network is exceeded, the Charlton Storm Overflow spills excess storm flows from both Southern Outfall Sewers and the High Level Sewer No. 2 directly into the River Thames.

Longreach WwTW:

- Large sewer catchment on the south side of the River Thames, extending as far south as Sevenoaks and as far east to Longreach WwTW in Dartford. Longreach WwTW is located outside of the study area.
- Eastern Belvedere, Erith, Slade Green and Crayford growth areas drain to Longreach WwTW.
- Appendix E Figure E.2 identifies that the majority of sewers in the Longreach network covering the study area are separated into surface water and foul sewers, with a combined trunk main feeding into the STW.

Based on the Thames Water Flow Utilisation Map (2015) the sewer network capacity during the dry weather flow for each OA is as follows:

- Charlton Riverside OA (western half) - approximately 50% (Crossness)
- Charlton Riverside OA (eastern half) - approximately 30% (Crossness)
- Woolwich OA – approximately 95% (Crossness)
- Thamesmead and Abbey Wood OA - approximately 50% (Crossness)
- Bexley Riverside OA - approximately 30% (Longreach)

This highlights the limited capacity of the sewers within the Crossness catchment to accept additional foul flows and surface water runoff from new development. In the Woolwich OA there is no capacity for any increase in combined flow volumes during rainfall events without resulting in an unacceptable risk of flooding downstream and adjacent development. A wastewater network investigation study has recently been undertaken for the Greenwich Peninsula OA development, adjacent to the west of the study area. Interim results suggest that there will be an increase in sewer flooding in the local area by 2030s.

Table 4-4 summaries the strategic opportunities and constraints associated with the drainage and wastewater network across the study area.

Table 4-4: Study Area Overview - Drainage and Wastewater network Opportunities and Constraints

Opportunities	• Thames Water expect all development to reduce peak combined flow off their site as part of development so that it is no greater than pre-development discharges as a minimum. This is a significant driver to ensure that the volume and rate of wastewater discharge (both foul and surface water) is minimised as far as possible within the development. – Reduced input into the combined sewer further upstream of the network to allow capacity – Separate out surface water from the combined sewer network – Discharge surface water into the River Thames (also a constraint as the low lying land requires pumping when tide locked).
Constraints	• The main constraint for this network is the Southern Outfall Sewer. There are three trunk main sewers that discharge to the Southern Outfall Sewer. These are combined sewers and are anecdotally understood to already be at full capacity most of the time. • The capacity at Crossness WwTW is a restriction. When flows to the works exceed ~12.9 m^3/s Greenwich pumping station diverts all the flow to an outfall discharging directly to the River Thames.

4.5 Water Resources and Water Supply

Water resources within London are currently subject to significant levels of stress and will continue to be in the future. This arises from several pressures including effects of climate change on raw resources, leakage, environmental protection and finite capacity within raw resources. Thames Water manages the water supply in London as a single 'resource zone'; that is, all customers in this zone share the same water resources and hence share the balance of supply and demand. Under the current assessment of water resource availability for the next 25 years[11], the supply demand deficit in the London Water Resource Zone (WRZ) is predicted to increase from a deficit of 59.4 million litres a day currently to 415.9 million litres a day by 2040. This highlights the significant pressure that London's water resource base is under in order to continue to supply water to meet the growth that is planned across the City.

The study area is located within the Thames Water Riverside Water Demand Zone, which consists of a mixture of urban and commercial areas. There are approximately 81,150 properties in the zone with an average daily demand of approximately 49 Ml/d. The study area is located too far east to utilise the London Ring Main, which enables water to be supplied to the London WRZ. Therefore the Riverside Zone is supplied by Honor Oak Pumping Station and Nunhead Upper Reservoirs located to the west. The eastern side is supplied by the Crayford Road infusion from the Eltham Zone. Treated water storage within the zone is provided by Northumberland Heath Reservoir. There are 28 District Metering Areas (DMAs) within the zone, of which 21 are pressure managed.

Thames Water has developed a plan for addressing the forecast deficit in the London Water Resource Zone through a combination of measures to tackle leakage, manage and reduce water demand, and install new water supply schemes. The plan is reliant on significant demand reduction measures from existing property and highlights the need for new developments to minimise water use and help identify innovative solutions to delivering alternative supplies.

Table 4-5 summaries the strategic opportunities and constraints associated with the water resources and water supply network across the study area, shown in Appendix E Figure E.1.

Table 4-5: Study Area Overview - Water Resources and Water Supply Opportunities and Constraints

Opportunities	• Thamesmead has been identified by Thames Water as a key location to trial universal retrofitting of smart meters in order to reduce water demand within the area. • To expand the Thames Water ring main eastwards, to create a figure of 8 shape, allowing a wider distribution of resources within the London Resource Zone. Thames Water have identified this as a potential option in the future, however it is not expect to be developed within the timeframe of this IWMS. • Proposed upgrades in the Nunhead region may present opportunities to consider system upgrade/expansion to service regional growth requirements.
Constraints	• The capacity of the existing infrastructure in the study area is unlikely to be sufficient to meet the demands of the projected growth. • The study area is outside Thames Water's ring main and local resource options are expected to be insufficient to meet future population growth and demand. Potable water demands need to be managed and extensive water supply infrastructure upgrades may be required. • There are ongoing issues with the reliability of the 1000 mm main from Nunhead Reservoir to Greenwich, which would impact the supply network to some of the growth areas identified in the study area. There are ongoing works to resolve this.

4.6 Contaminated Land and Environmental Designations

The River Thames frontage in the study area has a long history of industrial land use, which has left many areas contaminated. A high level desk study was undertaken for this IWMS to collate information regarding contaminated land within the study area. This study concluded the following:

- The Charlton Riverside Masterplan PERA (2016)[12] has identified elevated concentrations of metals Made Ground within the area. The concentrations are a low risk to human health in a commercial land use scenario but mitigation measures would likely be required for a residential land use scenario. However, the intrusive investigation has only been performed on less than 15% of Charlton Riverside OA; therefore, further investigations are recommended to evaluate soil and groundwater quality related hazards in this area.

[11] Thames Water Utilities Limited (2015), Water Resources Management Plan (2015-40)
[12] AECOM (2016), Charlton Riverside Masterplan Preliminary Environmental Risk Assessment.

- The Crossrail 1 Assessment of Contaminated Land (2005)[13] identified the whole of the Royal Arsenal West site in the Woolwich OA as an area of potential hazardous contaminated land. Smaller areas of potential contamination have been identified based on land use in the north of the Woolwich OA.
- The Erith Area Action Plan DPD[14] states that Erith's industrial heritage has left a number of vacant contaminated sites and ongoing pollution issues. Many of these sites are adjacent to sensitive areas of importance for nature conservation.
- There are also a number of areas within Thamesmead and Abbey Wood OA and the Bexley Riverside OA (especially the Slade Green growth area) that are designated as current or historic landfill sites. Although these areas may appear to be areas of open land, there is a risk of contamination and pollution associated with these sites which would need to be discussed with the Environment Agency before any options can be developed.

Appendix E Figure E.5 shows areas within the study area that have been designated as Sites of Special Scientific Interest (SSSIs), a Local Nature Reserve or Sites of Importance for Nature Conservation (SINCs 2016, LBB). There is one SSSI designation within the study area at Gilbert's Pitt, which is only partially within the Charlton Riverside OA, and a Local Nature Reserve at Erith Marshes. There are a number of SINC's identified within the Bexley Riverside OA, the majority of which follow the Erith and Crayford Marshes. These areas provide potential opportunities to promote green and blue corridors within the growth areas in Bexley.

Table 4-6 summaries the strategic opportunities and constraints associated with the contaminated land and environmental designations across the study area, shown in Appendix E Figures E.5 and E.6.

Table 4-6: Study Area Overview - Contaminated Land and Environmental designations Opportunities and Constraints

Opportunities	• Improved water management could assist in improving the condition of the local nature reserves within the Bexley Riverside OA.
Constraints	• There are areas of current and historic landfill sites along the northern boundary of the Thamesmead and Abbey Wood OA, the western parts of the Erith and Crayford growth areas and across large extents of the southern half of the Slade Green growth area. • The eastern half of the Woolwich OA, covering the Royal Arsenal West site, is identified as potentially hazardous contaminated land.

4.7 Flood Risk

The Study Area Flood Risk technical note is provded in Appendix F. Table 4-7 provides a summary of the risk of flooding from all sources across the study area.

Table 4-7: Summary of flood risk within the Study Area

Source of Flooding	Summary of flood risk
Tidal	The whole study area is defended from tidal flooding by the Thames tidal defences, designed to a standard of protection of 0.1% AEP flood event. Therefore the risk of tidal flooding is residual in the event of a breach in the defences. The Environment Agency Thames Tidal Breach Modelling Study illustrates that if a breach were to occur between the Greenwich Peninsula and Dartford, there would be large flood extents due to the low lying land and large areas within the extreme or significant flood hazard categories.
Fluvial	The Crayford growth area is located within undefended Flood Zone 3 (1% annual event propobability [AEP]) extent for the River Cray.
Surface Water	The risk of surface water flooding is wide spread across the study due to the low lying nature of the land.
Groundwater	The risk of groundwater flooding varies across the study area due to geology and topography. There are two historic incidents of groundwater flooding recorded along the railway line to the south east of the Charlton Riverside OA (RBG records). There are eight historic incidents of groundwater flooding along the southern Thamesmead and Abbey Wood OA boundary (RBG records). The majority of the Abbey Wood area is considered to have potential for groundwater flooding of property below ground level.

[13] Mott McDonald Ltd (2005), Crossrail 1, Assessment of Contaminated Land, Technical Report, 1E0322-C1E00-00013
[14] London Borough of Bexley, Erith Area Action Plan DPD Issues and Options

Source of Flooding	Summary of flood risk
Sewer	At postcode level, records of sewer flooding within the last 10 years range from 2 – 3 records in the western part of the Charlton OA to 21 – 50 records near Abbey Wood.
Artificial	The Marsh Dykes is the term used to describe the area of reclaimed marshland, which includes the Thamesmead lakes and canals system, the Erith Marshes system and the Crayford Marshes. These areas were developed with commercial and residential uses in the 1960s and surface water runoff in is managed through artificial networks. The water levels in the Thamesmead lakes and canals system and Erith Marshes system are controlled by sluices and pumps into the River Thames. The culverted part of the Butts Canal poses an increased flood risk as a result of blockage and siltation. The current managed water level in the Erith Marshes ditches and dykes system is very close to the soffit (roof of the culvert), and this results in there being little surplus capacity in the Yarton Way culvert to respond to storm flows. Therefore, the performance of much of the network that drains into the Yarnton Way culvert is dictated, under storm conditions, by the water level in ditches and dykes.

The Flood Risk technical note identifies flood risk hotpots within each OA in the Study Area. Flood risk hotspots are locations that locally have a higher risk of flooding compared to the rest of the study area due to one or more sources of flood risk. They have been identified based on land which is located within, or subject to one or more of the following:

- Fluvial Flood Zones 2 or 3;
- Close proximity to waterbodies (rivers, canals, ponds or water features) with either historical flood records and or susceptibility to surface water flooding;
- Significant area of land with a modelled surface water flood risk of 'High' (1 in 30 year), or 'Medium' (1 in 100 year);
- More than one historical record of flooding from any source.

These locations, and specific mitigation, should be considered carefully when assessing individual planning applications in these locations. Proposals for additional development should preferentially be steered away from these higher risk areas and consideration should be given at masterplanning stage to plot layout and provision of green space, allowing space for flood waters specifically associated with surface water and or storage for tidal or fluvial flood water.

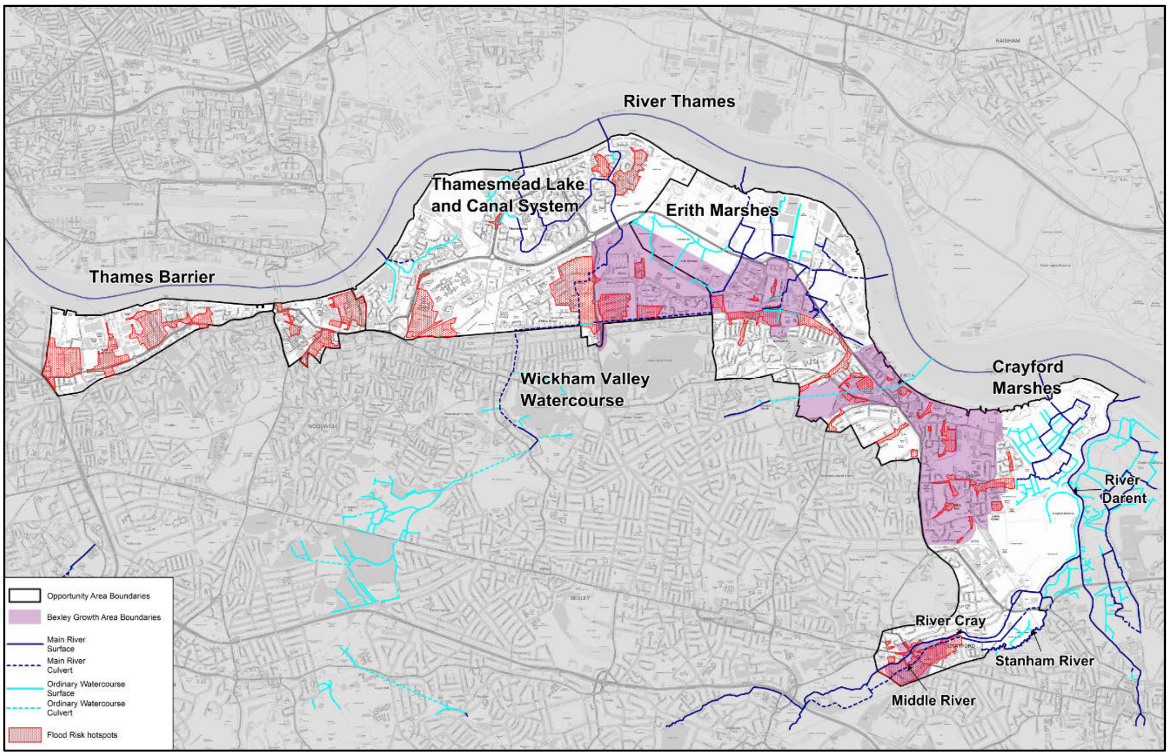


Figure 4-3 Flooding hotspots within the Study Area

5. Opportunity Area Water Cycle

5.1 Annual Water Balance

The objective of the water balance is to broadly characterise and quantify the water cycle flows anticipated from the proposed development. In order to undertake this, each growth area was taken as a separate system boundary and changes to the water cycle built up from anticipated development within each site allocation.

Flows were estimated on an annual scale to consider the area–wide balance between input and output of water. The two predominant inflows to the urban cycle are:

- The natural hydrological flows, which originate as rainfall and exit the system through groundwater infiltration, evapotranspiration and urban runoff.
- The centralised water supply, which is imported from outside the area boundary and consumed or discharged through the wastewater system.

Each of the flows included within the water balance is briefly described in Table 5-1.

Table 5-1: Urban Water Cycle Flows

Flow	Definition
Rainfall	The volume of natural precipitation falling over the Opportunity Areas over an average year.
Roof water	The quantity of rainwater which falls directly on rooftops within the Opportunity Areas. This has been split from storm water due to the differing water quality characteristics.
Surface Water	Runoff from the urban environment generated during rainfall events. This consists predominately of runoff from impervious areas. This flow has been split from roof water above; however, within the current system, both roof water and storm water are combined and enter the drainage system.
Evapotranspiration	Water which is returned to the atmosphere through the processes of evaporation and transpiration of vegetation
Infiltration	The proportion of rainwater which infiltrates through the soil.
Potable water	High quality water supplied for uses within the home, including water used for drinking and used in the kitchen and bathroom. Within this analysis, potable water has been assumed as necessary for all household uses except toilet flushing.
Non-Potable Water	Water which is utilised for low-contact uses including irrigation and toilet flushing. In general, this water is not required to be of the same quality as that used for potable uses. Under the current (baseline) scenario in the Opportunity Areas, water for all uses is supplied from the centralised, potable system. In some circumstances, water for use in the laundry may also be supplied by non-potable sources; however, this has not been included in the analysis at this stage.
Grey Water	Wastewater generated from use in hand basins, baths and showers. Grey water generally excludes water used in toilets, the kitchen or for cleaning use, which has a greater concentration of contaminants.
Black Water	Wastewater generated from toilets, kitchen and laundry use. This has a higher concentration of contaminants than grey water. Under the current scenario both black water and grey water are combined and disposed to the drainage system.

Each of these flows has been estimated for the growth areas, in the pre-development and post-development state. These estimates have been developed based on the best information available; however, it should be noted that they are based on assumptions and should not be regarded as assured. An overview of the key assumptions and overall calculation methodology for the water balance is provided in Appendix D.

In considering these calculations, it should be noted that the master-planning for this growth areas is still at an early stage and therefore only limited resolution is currently available regarding the anticipated residential and commercial development. Additionally, only limited information on the current land use is available. Therefore, whilst the model calculations provide a good indication of the relative magnitude of various flows, they are based on several assumptions and simplifications in order to facilitate strategic-level analysis and planning, and should not be regarded as assured volumes. More detailed analysis will be required at a later stage in each growth area in order to determine the exact volumes, and detailed design of the required infrastructure undertaken.

5.1.1 Results

A combined pre-development annual water balance for the growth areas is shown in Figure 5-1. The post-development water balance for the average growth scenario is shown in Figure 5-2.

It should be noted that these calculations represent bulk annual flows, and therefore do not capture the spatial and temporal variation of flows across this annual time period, and the associated impact on the availability of harvestable volumes. This is further discussed in Section 5.2 below.

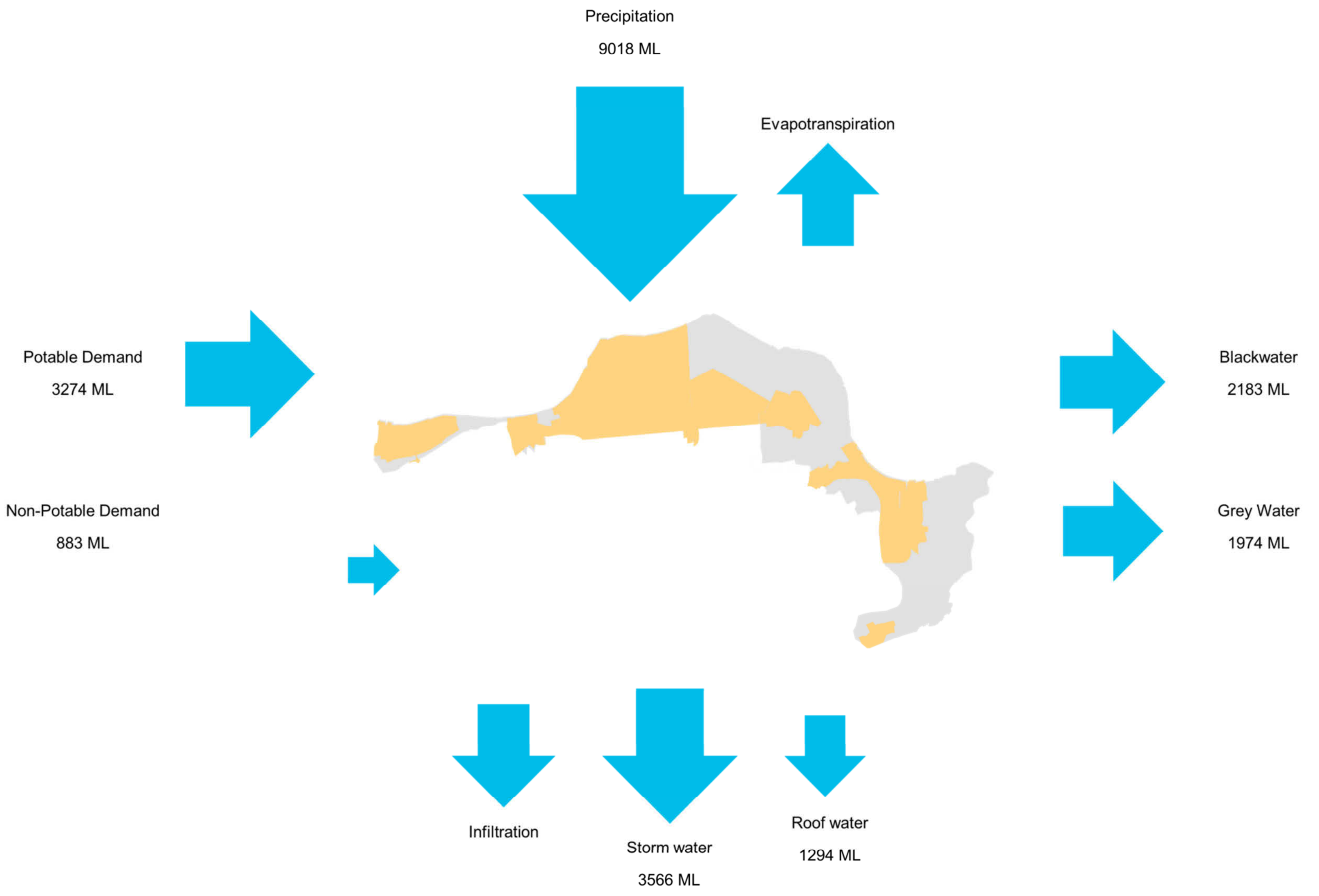


Figure 5-1: Pre-development water balance for the growth areas

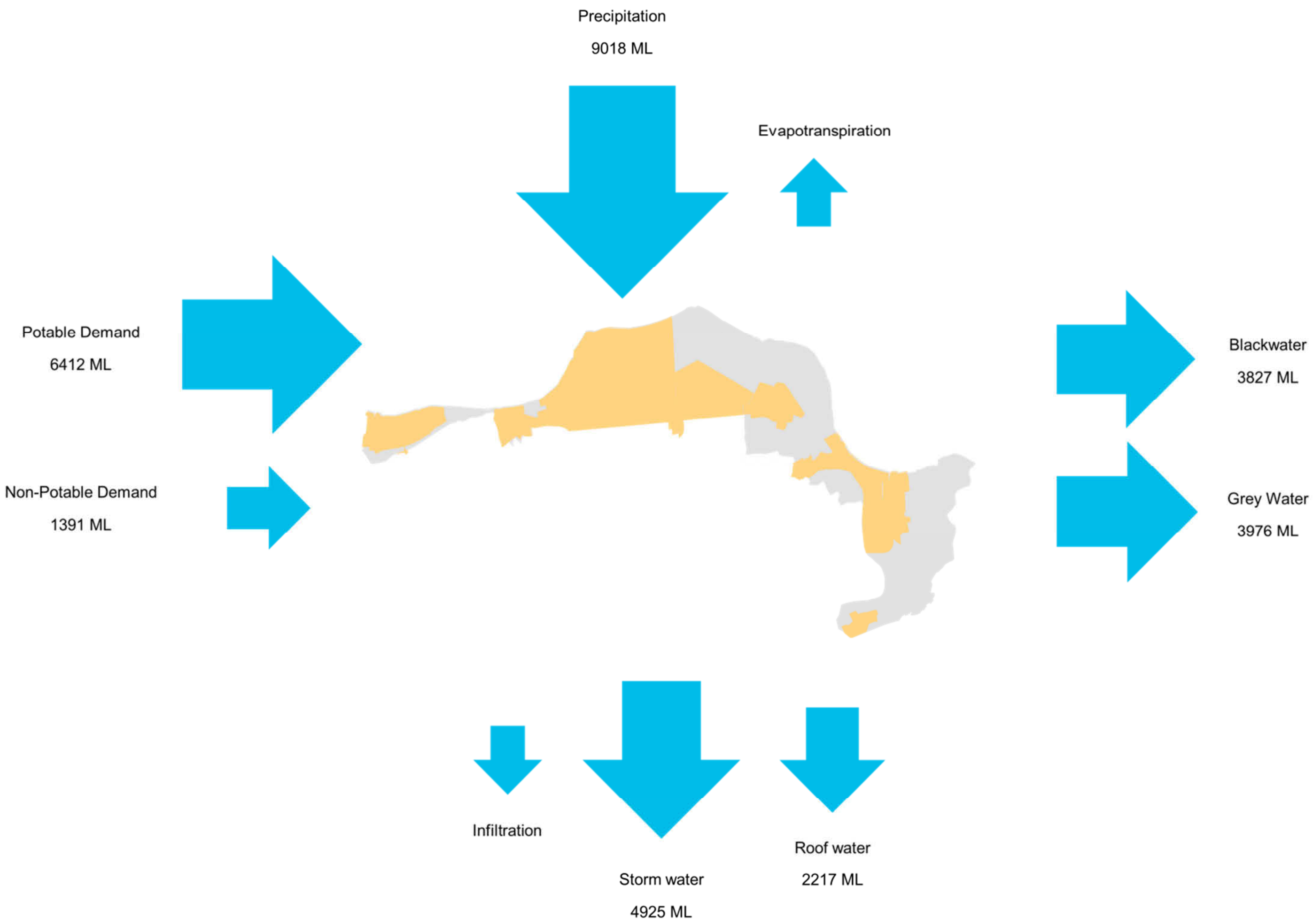


Figure 5-2: Post-development water balance for the growth areas

Comparing the results, it can be seen that the proposed development across the growth areas will lead to a substantial increase in the demand for water and subsequent generation of wastewater. There is also an increase in the proportion of rainfall falling on rooftops and contributing to urban stormwater, through an increase in anticipated impervious surfaces.

The magnitude of the anticipated increase in water demand and wastewater generation estimated from the proposed development is further illustrated in Figure 5-3.

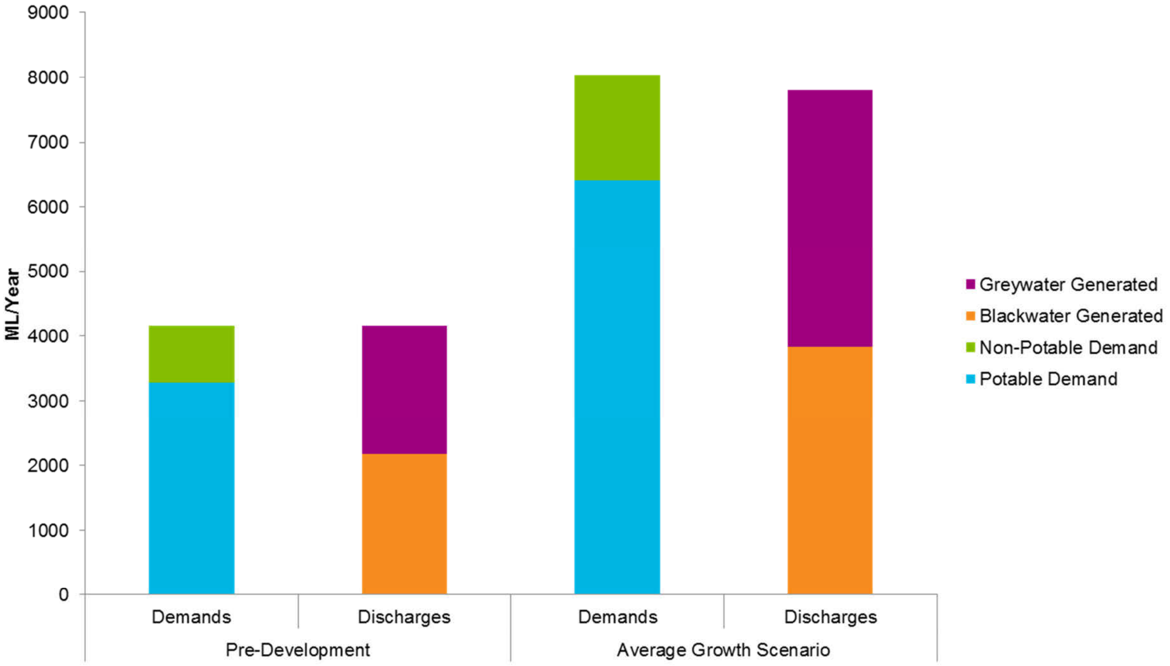


Figure 5-3: Overall anticipated increase in flow over the growth areas

The split of these flows across each growth area is shown in Chapters 7 to 12.

As these figures illustrate, without intervention, the proposed development across the Charlton to Bexley Opportunity Areas will significantly increase demand on the regional water supply and wastewater assets. The capacity of these systems to cope with increased demand of this magnitude is likely to be limited, unless provisions are made to mitigate this impact.

5.2 Temporal Variation and Peak Instantaneous Water Flows

The distribution of the flows as described in the water balance are, in reality not uniform, fluctuating significantly across different days and seasons. Variability in rainfall intensity and subsequent runoff rates of surface water during heavy rainfall events is a key feature determining both capacity in the sewer system and the required storage and harvestable volumes provided through any water reuse systems. Additionally, the peak wastewater flows arising from site occupation is also a key factor in considering sewer capacity in dry weather conditions.

5.2.1 Water Supply and Wastewater Generation

Demand for water varies seasonally with the weather. In hot, dry weather, customer usage may increase; while in cold weather leakage may rise due to an increased number of burst pipes.

Water demand also varies diurnally, with the greatest demands occurring in the morning and evening, before and after standard office hours. Thames Water modelling standards indicate that a peak factor of 2.12 times the average flow should be used to represent peak residential sewage flows, and 3 used for commercial flows (excluding infiltration). Considering the water balance presented above, the estimated pre and post-development peak sewage flow for each area is indicated in Table 5-2.

Table 5-2: Estimated Increase in peak instantaneous sewer discharge (excluding infiltration)

Growth Area	Estimated Peak Sewer Discharge (l/s)	
	Pre-Development	Post-Development
Charlton Riverside	37.3	65.1
Woolwich Town Centre	34.7	82.2
Thamesmead and Abbey Wood	199.3	221.4
Belvedere	34.3	70.2
Crayford	4.1	9.6
Erith	16.7	37.3
Slade Green	22.1	45.8

Temporal variability in water demand and wastewater discharge also needs to be considered when planning or designing greywater or wastewater recycling systems. Sufficient volumes of storage must be provided in order to store water during higher discharge periods, so that this is available to service demand during hours of peak water use.

5.2.2 Rainfall and Runoff

Rainfall varies seasonally across the year. On average, the majority falls in the autumn months of October and November and the driest month is February, as shown in Figure 5-4. Although, there is a large variance in the annual rainfall totals in London as well as in the distribution of that rainfall across the year. The rainfall occurring within a week or day also varies significantly, depending on the number and intensity of storm events.

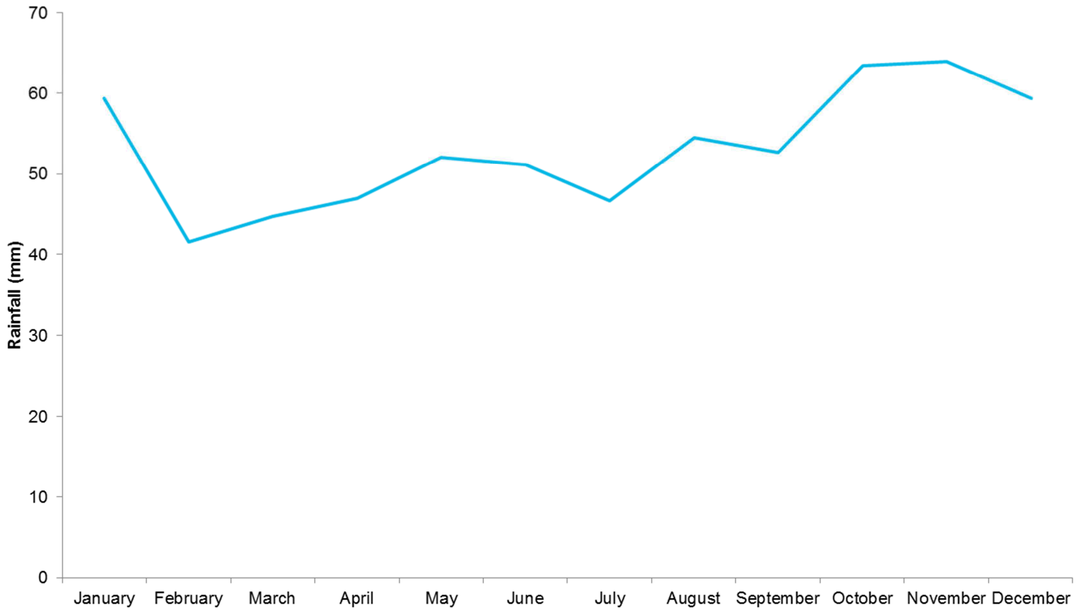


Figure 5-4: London average monthly rainfall recorded between 1961 and 2016

The annual, weekly and daily variability in rainfall is a key consideration in determining the actual harvestable volumes of rainfall and stormwater which might be harnessed as an alternative water supply. Substantial water storage volumes are often required in order to capture rainfall during periods of high in order to ensure supply during drier weather. As such, the volume of water available for reuse may be primarily dependent on spatial and feasibility constraints in supplying large storage volumes.

The volume of rainfall that falls in a short space of time, during significant storm events additionally has a significant impact on local drainage systems.

Catchment urbanisation increases the impact of high intensity storm events, through removal of the natural processes of infiltration, interception and evapotranspiration on naturally vegetated surfaces. The resultant increase in the volume and speed of runoff causes significant and rapid loading to be imposed on drainage systems during storm events. Current Thames Water standards provide for a design drainage capacity of 1 in 30 years. However, drainage systems across London are of varying age, with capacity for a highly variable range of storm events. In events exceeding the design capacity, the system may be susceptible to surcharge and localised flooding might occur.

As such, a key aspect of the water management strategy for the OAs will be in reducing the surface water flows entering the drainage system, and providing attenuation to reduce the peak flow rate at which this discharges. This is of particular importance for the Charlton Riverside and Woolwich OAs, which are served by combined sewage infrastructure. In these areas, reduction of surface water runoff can be used to offset increased peak foul flows arising from new development. As the Thamesmead and Abbey Wood Opportunity Areas is located downstream in the same sewer catchment, this will also contribute to sewer capacity in this area.

It should be noted that, where infiltration opportunities are limited, attenuation is used to achieve delayed discharge of runoff at a restricted rate. The overall effect of delayed flows should therefore be considered from a catchment-wide perspective. In particular, the central Southern Outfall Sewer conveys flows over a large catchment, from Merton across South London, ultimately discharging at the Crossness WwTW. Therefore, when considering attenuation approaches, the impact of ongoing delayed flows should be considered in terms of potential influence on the peak storm flow hydrographs in downstream areas. The minimum anticipated requirement is for all new development within the OAs to reduce site runoff to Greenfield rates. This is the rate at which runoff would naturally discharge from an undeveloped, highly permeable catchment. Currently, the OAs are predominately urbanised, which means that this will be a significant challenge. Increasing green, permeable areas within the catchment, and providing attenuation storage and SuDS features will assist in achieving this.

In order to establish the attenuation volume required across the OAs, anticipated runoff rates for the existing site under the 1 in 100 year plus 40% climate change event have been calculated. The greenfield runoff rate has also been calculated for each growth area and the associated volume of attenuation required to restrict discharge estimated. This is summarised in Table 5-3 below.

It should be noted that these runoff rates and attenuation volumes have been estimated at a high level across a very large area. Greenfield runoff rates have been estimated at a central location within each growth area; however, these were observed to vary significantly across the extent of each area (due to variation in local parameters including rainfall and winter rainfall acceptance potential). Additionally, areas with particularly low greenfield runoff rates may be able to accommodate greater localised infiltration, which may reduce required attenuation volumes. As the input parameters are highly dependent on local conditions and drainage system design, it is particularly important that runoff rates and attenuation requirements are confirmed at a site-specific scale during subsequent planning and development stages.

Table 5-3: Estimated pre-development and Greenfield Runoff Rates for the 1 in 100 year rainfall event (plus climate change) and estimated attenuation storage volumes required to achieve Greenfield rates

Growth Area	Estimated 1 in 100 year Runoff Rates (with climate change) (l/s)		Approximate Attenuation Storage Required (m^3)
	Pre-Development	Greenfield	
Charlton Riverside	23,055	1,388	36,500
Woolwich Town Centre	14,707	827	318,500
Thamesmead and Abbey Wood	75,598	5751	42,000
Belvedere	16,428	846	39,500
Crayford	9,430	57	131,500
Erith	30,538	156	24,500
Slade Green	30,200	158	58,000

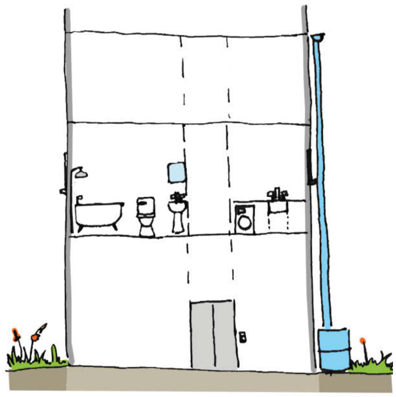
Considering these flows in comparison to the peak sewage flows described in Table 5-2, it may be observed that the reduction in instantaneous surface water flow entering the combined drainage system during storm events (through achieving Greenfield runoff rates), will more than compensate for the anticipated increase in peak sewage flows. Therefore, effectively managing the surface water discharge to achieve as close to greenfield rates as possible will be an important part of to creating capacity within the sewer system.

6. Water Management Measures

This section highlights a number of water management measures that may be implemented to mitigate the impact of the development anticipated within the OAs. The delivery and performance of these measures will vary across the growth areas, due to the different opportunities, constraints and water use characteristics of each area.

6.1 Demand Management

Demand management strategies are generally the first priority for sustainable water management and should be considered wherever possible. Demand management conserves potable water supplies and reduces the generation of wastewater. It is assumed in new build areas that development will be delivered to the latest guidance issued in the London Plan, promoting the highest current industry standards with respect to water efficiency, through the incorporation of water saving measures and equipment.

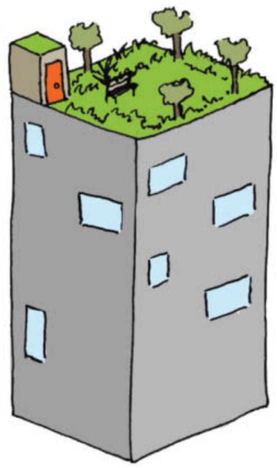


The London Boroughs of Greenwich and Bexley are both a part of Thames Water's progressive metering programme and it is anticipated that all growth areas will be metered. Additionally, the installation of new water supply infrastructure may provide an opportunity for further installation of smart network technologies embedded within the metering program, to optimise water network operation. Such systems and technologies enable remote, real time monitoring of water usage, allowing rapid targeting of leakage, operation issues and system inefficiencies. Additionally, customers can be provided with the information and tools they need to make informed choices about their behaviours and water usage patterns. Detailed monitoring of water quality parameters will also be invaluable in assessing the performance and future potential of water recycling systems.

Community education, engagement and incentive schemes can also be utilised to improve consumer behaviours and encourage the uptake of water conservation practices and technologies. A downside of specifying water efficient fixtures and fittings is that they can be replaced for less efficient versions once the development is sold on and as such is not a guaranteed reduction in potable water demand.

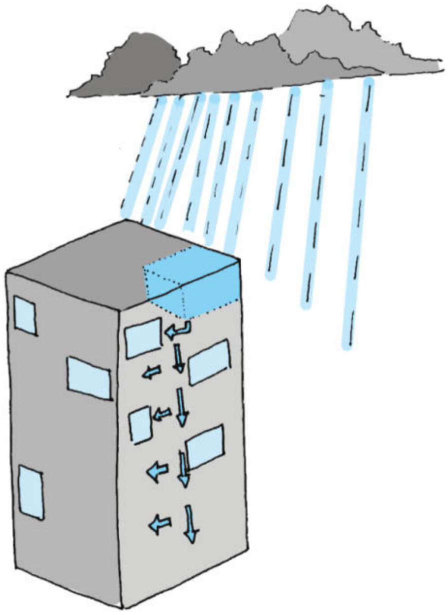
6.2 Blue and Green Roofs

Green roofs consist of a planted soil layer, constructed on the roof of a building to create a living surface. The vegetated substrate is generally built on top of a drainage layer. Following rainfall, water is stored in the soil layer and absorbed by vegetation. Green roofs may be designed and constructed to be accessible, and landscaped to provide biodiversity and community benefit. In many cases, it may be beneficial to combine vegetated roofs with roof water collection storages, known as blue roofs, where the stored water can be used to provide an additional balancing irrigation supply for vegetation. Green and blue roofs may be constructed on new buildings, or retrofitted onto existing surfaces, although, in some cases there will be restrictions on the ability to retrofit due to inadequate structural capacity or overly sloping surfaces, and are likely to be more expensive.



The construction of green roofs will result in a reduction of runoff occurring from roof surfaces, through adsorption, and evapotranspiration by the rooftop vegetation. The reduction in impervious surface will also provide benefits in reducing the speed of runoff and providing water quality benefits through filtration and bio-retention. Green roofs will only perform attenuation functions until they reach saturation. Living walls and green facades may also be suitable for installation and provide similar functions and benefits as green roofs.

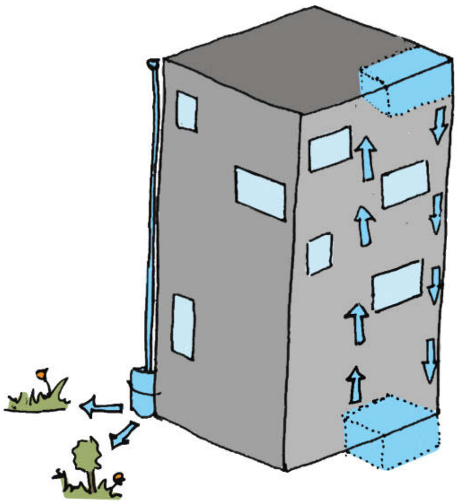
6.3 Roof Water Recycling



Rainwater can be collected from the roof of buildings and stored in underground or over ground tanks for reuse locally. The collected water may be used for garden watering or indoor non-potable uses, such as toilet flushing or hot water and laundry uses. As such, roof water collection contributes to a reduced discharge of urban runoff to the combined and surface water sewer systems and a reduction in potable water supply volume. Due to the reduced exposure to contaminants, treatment infrastructure is often lower than for other types of water; however, disinfection is likely to be required if the water is to be used for higher contact uses including hot water systems, laundry uses or spray applications, and particularly if water is likely to be mixed with centralised potable supplies.

Due to the variable nature of the rainfall supply, significant storage volumes are likely to be required, which may present spatial and feasibility challenges. However, many buildings are already required to provide water storage for surface water attenuation, which may be harnessed for this purpose. Rainwater harvesting is less suitable for high rise development due to higher demands and less rooftop catchment availability. However, this is likely to be beneficial for lower rise residential development, or industrial or commercial uses with large rooftops and non-potable process, irrigation or sanitary demands.

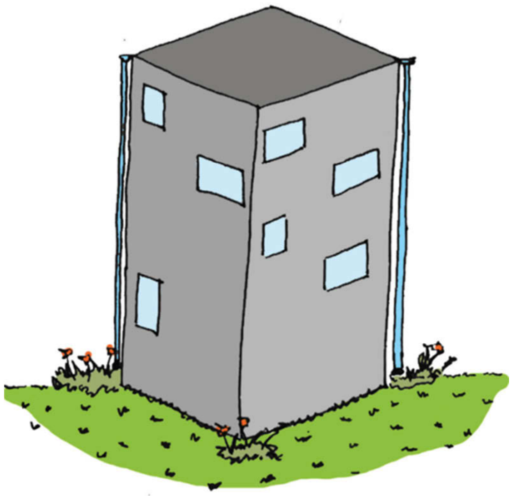
6.4 Grey Water Recycling



Grey water is wastewater that excludes toilet waste and is therefore a higher quality than sewage. It includes waste from uses such as hand washing and showering. Water is collected using separate plumbing (to the standard sewage system), stored, treated and redistributed for non-potable use. Due to the potential for contaminants and pathogens to be present in grey water, it requires a higher level of treatment than rain water. This will include some form of filtration, biological treatment and disinfection, generally undertaken within a package treatment unit. A significant advantage of grey water as a supply option is that it is largely climate independent, so is more reliable and therefore requires reduced storage volumes. It should be noted that combined storage and reuse of rainwater greywater and storm water is possible, and can result in increased consistency of water supply and reduced capital costs. In order to facilitate cost savings these features use the same storage volume for recycled greywater and storm attenuation, discharging recycled volumes in anticipation of storm events, using intelligent control systems.

Recycling of greywater is a localised solution to significantly reduce booth foul water flows, and potable demands. As such, this is scalable and avoids many of the feasibility challenges associated with area-scale recycling. However, there are likely to be cost savings and energy efficiencies in installing localised systems within all buildings across the development areas.

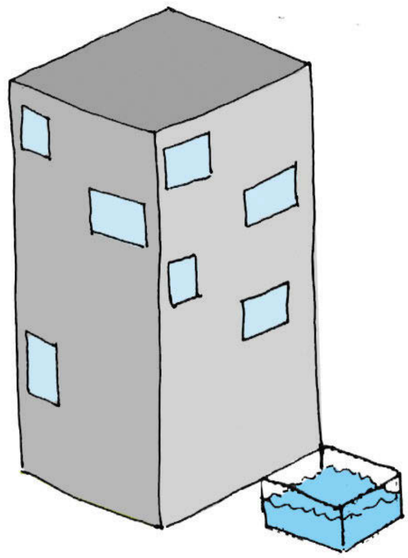
6.5 Green Source Control Measures



At the plot or development (sub-area) scale, source control measures look to maximise permeable surfaces within the site in an effort to increase the amount of water that is attenuated, treated and processed within the natural hydrological cycle. These features celebrate the presence of water, enriching the urban environment, while providing valuable function for flood alleviation and biodiversity enhancement. As such, incorporating features such as raingardens, filter strips, swales and tree pits will assist in absorbing runoff generated within the development, reducing flooding, improving water quality, providing irrigation for vegetation and enhancing amenity value. Incorporation of these measures will contribute towards providing the required attenuation storage, required. Managing surface water quality and quantity on site will be also be essential to the successes of any downstream measures, preventing inundation of surface water conveyance networks and effectively managing water quality throughout the development.

These measures are designed to promote infiltration of runoff into the ground beneath, promoting recharge of the water table and reducing runoff. This is highly beneficial where possible; however, contaminated land or soils with poor infiltration characteristics may present constrains in certain locations.

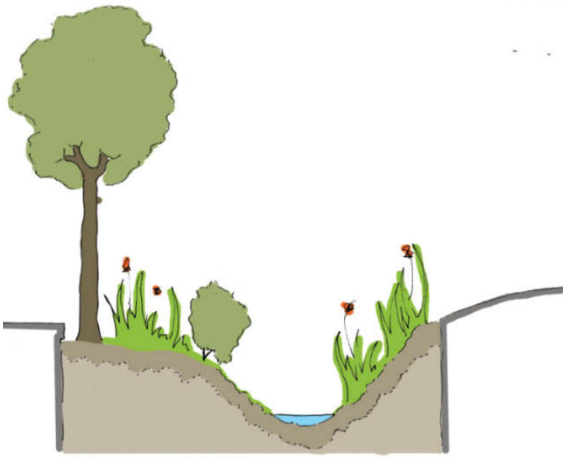
6.6 Below Ground Storage



Underground geo-cellular storage can be implemented within site drainage systems to control and manage runoff generated on the site. These systems can be designed to withstand traffic loads, meaning that they can be installed under roads and car parks as well as recreational areas and other public open space. During high intensity rainfall events, these facilities provide on-site attenuation, restricting outflow to avoid overloading the drainage system. Installed in isolation, these structures will not have any benefit in reducing total discharge to the sewer system; however, by restricting the peak instantaneous discharge rates during storm events, they contribute to preventing flooding issues. Stormwater attenuation tanks may be combined with storage for greywater or rainwater recycling systems, resulting in cost efficiencies and, if appropriate treatment measures are in place, reused for non-potable supply.

Underground storage does not deliver the additional benefit associated with green infrastructure; however, may provide a practical means of achieving the required attenuation volumes, particularly within development plots, which are likely to be spatially constrained.

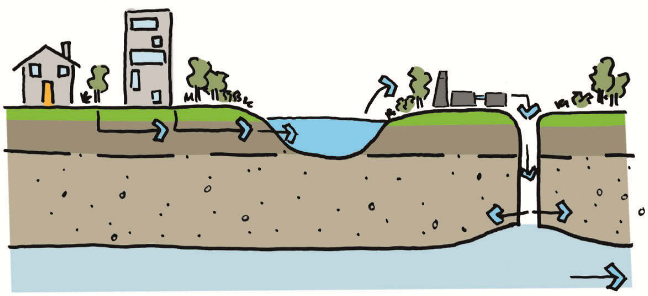
6.7 Strategic SuDS Networks



A strategic surface water network may be implemented within the Opportunity Areas to manage and convey surface water, while providing attenuation and water quality treatment. As an alternative to traditional underground piped systems, this may be delivered using a connected sequential train of SuDS features, such as swales, filter strips and flow spreaders. Providing several SuDS features in a series will enhance treatment as the slowed water passes the different features and treatment mechanisms. The infrastructure will also have a range of positive benefits to the urban environment, through improved aesthetics, air and water quality, microclimate management and biodiversity benefit. The capacity of the network must be sufficient to drain roads and public space, while conveying water collected from plots, to downstream locations for storage, harvesting or discharge. As such, the required configuration will be strongly influenced by the selected option for stormwater discharge, and the balance of on-plot to downstream attenuation.

The design and configuration of streetscape networks will require detailed consideration of spatial availability and constraints, topography, water quality and discharge. Desirably, new street networks and green spaces should be flexibly designed around the natural hydrology of the area, with overall site levels rationalised in order to facilitate natural drainage pathways over as much of the area as possible. Spatial availability, topographical fragmentation and existing infrastructure should all be considered with respect to constraints on the delivery of strategic networks.

6.8 Groundwater Recharge



Managed aquifer recharge is the artificial injection of collected water to recharge the level of groundwater within an underlying aquifer.

A detailed analysis has been completed on the potential for groundwater recharge to inform this IWMS based on the three aquifers present beneath the OAs (Chalk, Thanet Sands, and Harwich Formation). The analysis considered the depth of aquifers, the depth of saturated zone, the regional groundwater movement, and contamination constraints to assess the outline feasibility of recharge as an option. The analysis is reported in detail in Appendix H – Groundwater Injection Technical Note.

The analysis identified that of the three aquifers present, the Chalk aquifer is indicated to have capacity to accept discharged surface water in certain OAs. This is a regional aquifer, from which water is extracted for potable supply purposes in other areas of Greater London. Therefore, in addition to effectively removing water from the sewer system, recharge of the groundwater supply in this area would contribute to regional water resource availability. This could also provide environmental benefit by assisting to raise water levels above that of the adjacent River Thames to prevent saline intrusion to the local water table.

Collected water would need to be of an appropriate water quality, so treatment prior to injection is likely to be a requirement. Treatment technologies may include passive, biological treatment processes (such as wetlands), with additional tertiary stages (such as UV disinfection) a potential requirement depending on source water quality and discharge quality requirements.

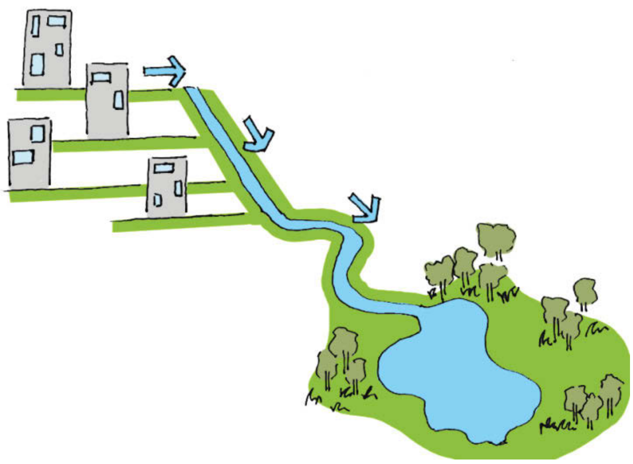
6.9 Tidal and Fluvial Discharge

As the OAs are located immediately adjacent to the River Thames, collected surface water runoff from the growth areas could potentially be discharged directly into the watercourse. Due to the low topography of the riverside areas, and the variable tidal nature of water levels within the River Thames, water would be required to be pumped at the point of outfall.

There are additionally a number of smaller watercourses and systems within or near to the OAs, which may provide localised opportunities for discharge. These include the engineered Thamesmead Lakes and Canal system, the Erith Mashes, the River Cray, the culverted River Wantsunt and an unidentified ordinary watercourse in the Erith growth area.

The ability to discharge into these watercourses will be dependent on the local topography and drainage. Appropriate attenuation and water quality management measures would be required to ensure no adverse impacts on the watercourse hydrology and quality. Detailed hydrological analysis would also be necessary to ensure that these measures do not cause any additional flood risk to other areas of the catchments or contribute to pollution or ecological deterioration. Particular consideration would be required to manage surface water discharge from industrial areas, which may contain contaminants

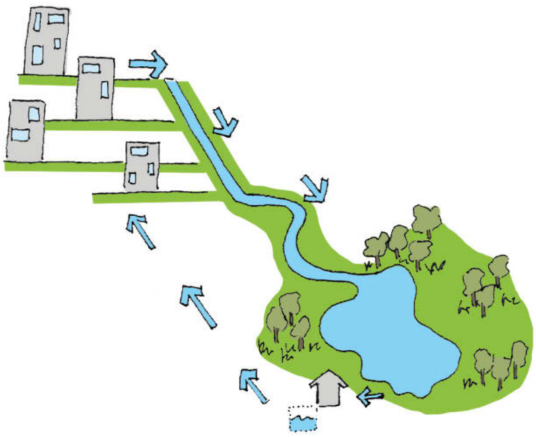
6.10 Downstream Stormwater Retention Ponds or Wetlands



As an alternative or complementary measure to providing localised, on-plot storage of storm water runoff, downstream detention may also be provided. This could be in the form of a dry detention basin or a pond or wetland system, with the potential to provide additional quality and biodiversity benefits. These systems provide attenuation and treatment of storm water runoff, and are designed to support emergent and submerged aquatic vegetation along the shoreline. The retention time promotes pollutant removal through sedimentation and the opportunity for biological uptake mechanisms further reduces concentrations of pollutants. These features also have the potential to provide significant ecological and amenity benefits.

Volumes of water storage could be provided as a single volume, a series of dispersed volumes, or used in conjunction with other means of providing attenuation. The natural topography of the OAs and the presence of existing drainage systems will impact the required location and contributing catchment of the retention storage. These systems would be most effective if installed in conjunction with upstream SuDS networks, to treat and convey incoming storm flows. The availability of space will be the major constraint in the delivery of surface storages, with further challenges presented by topographical and infrastructure constraints, fragmenting catchment connectivity.

6.11 Stormwater Recycling

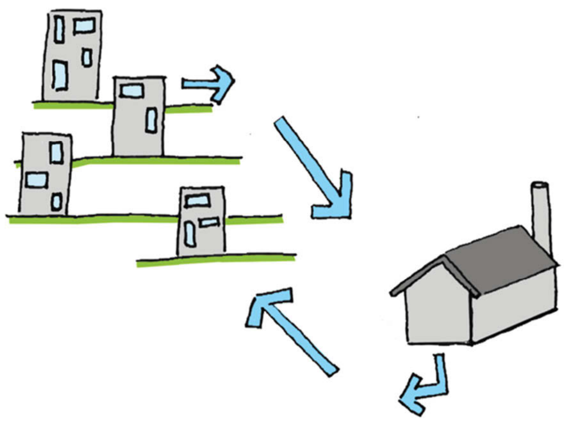


Stormwater treatment and harvesting from urban catchment areas can provide an alternative water source to offset centralised potable demands, while reducing storm flow in the sewer system. Stormwater picks up a wide range of pollutants from the surfaces it flows off and its quality is highly variable over time. Typical storm water treatment generally involves some form of filtration to capture the suspended solids and pollutants attached to the sediments followed by disinfection. This is often provided using vegetated systems, designed to use natural, passive processes for filtering pollutants. Supply is variable due to the dependence on rainfall patterns, with significant storage infrastructure likely to be required to manage this, and a back-up water supply connection may additionally be required for particularly dry periods. Water could be supplied for outdoor irrigation use, for specific industrial process or for non-potable uses within residences and businesses.

This infrastructure would need to be carefully planned in conjunction with the proposed surface water drainage network and masterplan layout with spatial constraints likely to impact upon feasibility of infrastructure delivery in high density development areas. Detailed feasibility investigation would additionally be required to determine the exact extent of the hydrological catchment able to contribute, given spatial fragmentation due to dividing infrastructure and topography.

A non-potable distribution network would be required in order to maximise use of the alternative supply; however, smaller scale localised solutions for irrigation or outdoor use may be feasible, in conjunction with delivery of surface water attenuation infrastructure.

6.12 Wastewater Recycling



Wastewater recycling comprises collection of wastewater flows (including both blackwater and greywater), treatment to a high standard, and distribution for non-potable re-use. Wastewater contains a high concentration of contaminants that can present risks to human health. As such, significant processing is required to treat flows to a high quality in order to adequately manage this risk. These treatment processes can be costly and energy intensive, including advanced water treatment technologies, such as microfiltration, reverse osmosis or advanced oxidation, although new processes such as electrocoagulation and food chain reaction may provide more cost and space effective solutions.

The Crossness Sewer Treatment Works, located adjacent to the OAs, produces significant quantities of treated effluent which are currently discharged into the River Thames. These treated flows could be harnessed to provide a non-potable water supply to the new areas. Additional processing of the effluent would be required in order to treat flows to a high quality, in order to adequately manage any risk to human health. This is likely to involve an additional tertiary treatment stage (such as UV disinfection) in addition to advanced water treatment technologies, such as those referenced above.

Treated wastewater is available in significant quantities, and has the potential to provide a highly consistent and reliable supply stream to reduce demands on mains water and waste water discharge. The reclaimed water could be used to supply non-potable uses with homes and businesses, as well as for irrigation and process uses. Given the substantial availability of supply, such a scheme could additionally be expanded, to feed the growth anticipated in surrounding areas.

7. Charlton Riverside – Option Appraisal and Strategy Development

7.1 Post-Development Conditions

Charlton Riverside is anticipated to experience significant growth, with averaged projections of approximately 11,110 additional residents and 5,300 new jobs over the next 20 years. The development is anticipated to be largely wholesale and comprise a mixture of housing and commercial. Considering the predicted growth in this area, the anticipated post-development annual water balance for Charlton Riverside is shown in Figure 7-1.

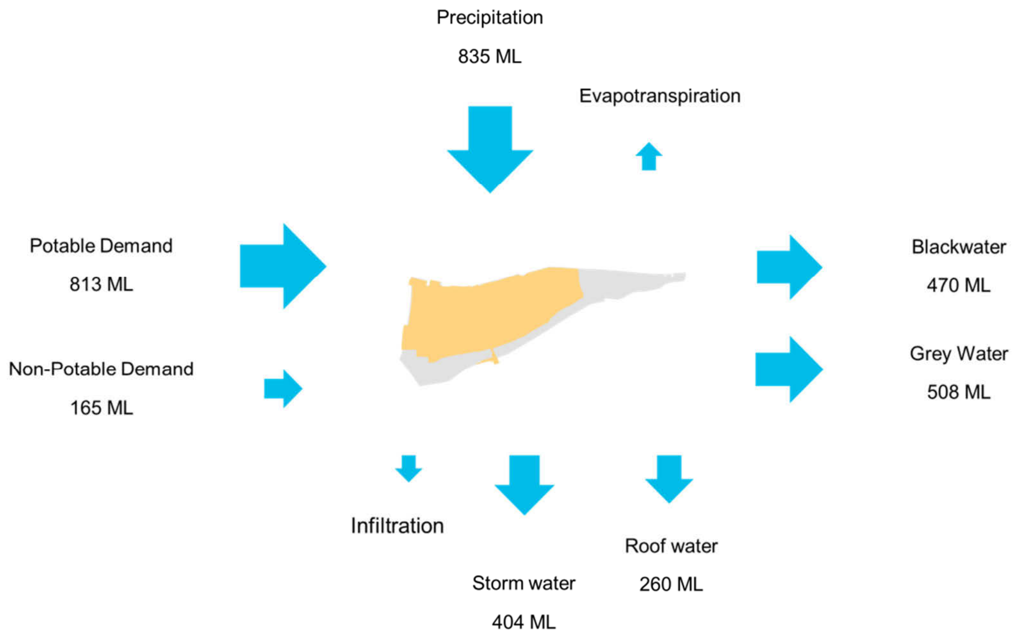


Figure 7-1: Charlton Riverside growth area annual post-development water balance

The magnitude of the anticipated increase in water demand and wastewater generation anticipated from the proposed development is illustrated in Figure 7-2.

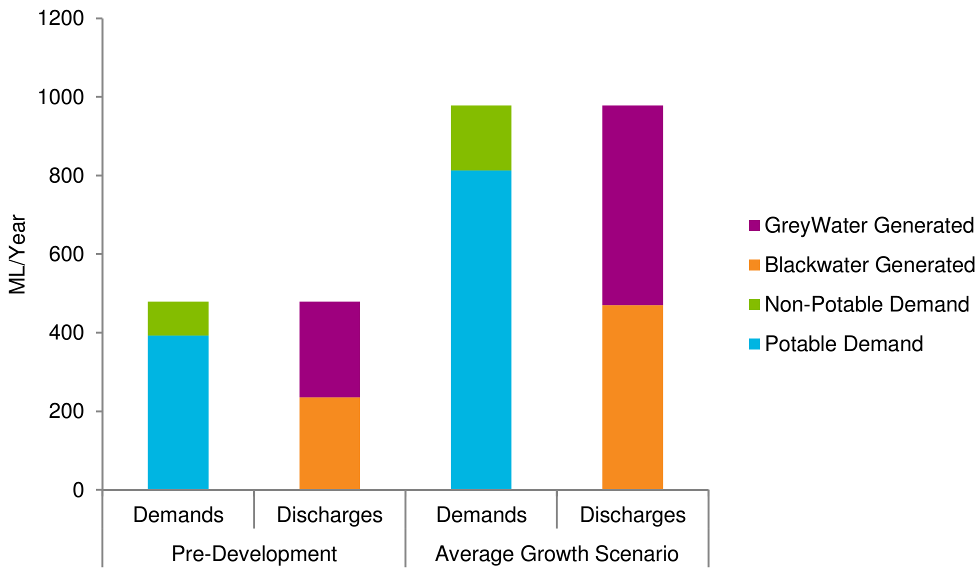


Figure 7-2: Charlton Riverside growth area - anticipated increase in demand and discharge (ML/year)

The anticipated unmitigated peak sewer and surface water flows are shown in Table 7-1. The estimated greenfield runoff rate and volume of attenuation provided is also summarised.

Table 7-1: Key drainage characteristics

Parameter	Value
1 in 100 year Peak Runoff Rate (l/s)	23,055
Peak Sewage Flow Rate (l/s)	65.1
Greenfield Runoff Rate(l/s)	1,388
Attenuation Required (m^3)	58,088

7.2 Summary of key local constraints and opportunities

7.2.1 Topography and Geography

The development is located adjacent to the tidal River Thames, which will present a potential opportunity for tidal discharge of surface water. There is additionally a small open section of an ordinary watercourse, located to the north of the Charlton Gate Business Park; however, both the source and discharge location for the watercourse are unconfirmed. A significant area of open space is expected to be allocated during re-development, which may also present opportunities for surface water management infrastructure.

The majority of the area is located within defended Flood Zone 3, as associated with the tidal River Thames. Widespread areas have been identified as susceptible to surface water flooding, due to low lying land.

The area is topographically fragmented, which may present constraints for gravitational conveyance of surface water. The expected density of development may also create spatial challenges for locating surface water conveyance, attenuation and treatment systems. However, there are allocated areas of strategic open space within the area, which may be harnessed for these systems.

7.2.2 Geology and Hydrogeology

Charlton Riverside is underlain by a chalk aquifer, which is dewatered and likely to have sufficient capacity to accept the estimated rate of 10 Megalitres a day (Ml/d) surface water runoff from the local area via injection. Injection of water to the aquifer in this region would be beneficial to groundwater resources within London, which are ultimately extracted for potable water supply (thereby contributing to indirect regional recycling), and also assist in locally raising the water table to minimise saline intrusion, due to ingress of water from the Thames estuary.

The ground conditions are understood to be permeable, suggesting opportunities for local source control infiltration techniques. However, this will be limited in several areas by potential contaminated land and made ground, which is anecdotally understood to be of substantial thickness in several areas.

7.2.3 Infrastructure

The sewer system serving this growth area is currently combined and pumped into the Southern Outfall Sewer, ultimately feeding into the Crossness sewage catchment. The capacity of the pumping stations is understood to restrict flow, creating a bottleneck in the system and leading to capacity issues during storm events. Overflows from this system discharge to the River Thames during storm events.

As such, there is an opportunity to reduce peak inflows and remove surface water flow from the combined system. This will offset increased foul flows within the catchment, and additionally contribute towards water neutrality across the other opportunity areas in the Crossness catchment.

Within the Charlton Riverside growth area, the wholesale nature of the development proposals may present opportunities for the implementation of new surface water networks, including interconnected SuDS treatment trains.

7.3 Preferred Water Management Strategy

7.3.1 Demand Management

Demand management should be maximised within the growth area. All development areas should be constructed to the maximum achievable standards in water efficiency and smart network technologies. The area is understood to be part of an existing metering programme, with the new development proposed to be incorporated into this system. Consideration may also be given to the installation of local water storages within the network, to minimise the impact of demand spikes on water supply. Community engagement and educational opportunities should be harnessed within the development area, to promote water efficient behaviours.

7.3.2 Surface Water Management

In order to enable sustainable development of the growth area, it is essential that a cohesive, integrated approach to manging surface water quality and quantity is implemented. A critical aspect of water management within Charlton Riverside will be in the provision of attenuation storage. A total attenuation requirement of 58,088 m^3 has been estimated across the extent of the growth area, in order to achieve greenfield runoff rates.

The surface water management strategy will need to incorporate the following elements:

- Maximised provision of source control features within each development plot, to control the quality and quantity of surface water runoff generated on site and maximise infiltration, in line with the SuDS hierarchy.
- Streetscape SuDS features to provide conveyance of runoff from development plots and public realm areas to the ultimate discharge location. Strategic storage features may also be required in conjunction with conveyance features to provide for streetscape attenuation requirements.
- Ultimate discharge of the collected and treated runoff.

7.3.2.1 Source Control

Permeable surfacing should be maximised on all development plots, along with the installation of SuDS systems. An emphasis should be placed on green, surface SuDS systems, in order to optimise water quality and wider sustainability benefits. A number of approaches are available to developers, including bio-retention systems, retention ponds, swales, green walls and facades. Underground attenuation systems should only be used as a last resort.

The exact configuration of source control measures will be dependent on development-specific spatial and geological constraints. However, all developers should aim to provide attenuation volumes necessary to achieve greenfield runoff rates from their own plot. This will prevent inundation of strategic surface water conveyance networks and facilitate the management of water quality throughout the surface water treatment train.

Due to the likely spatial constraints across the area, green or blue roofs are likely to present a particularly advantageous opportunity for surface water management, while also providing amenity and biodiversity benefit. It is generally recommended that accessible, intensive green or blue-green roofs should be installed on all new buildings, across the development. Where appropriate, these systems may be combined with rainwater harvesting or infiltration systems. Living walls and bio-retention systems are additionally likely to be spatially favourable approaches.

7.3.2.2 Streetscape Conveyance and Attenuation

To facilitate strategic management of runoff across the growth area, a conveyance network for surface water will be required. Ideally, this should be delivered as a strategic interconnected network of streetscape swales and green infrastructure to drain roads and public spaces; conveying, attenuating and filtering storm water flows along the natural catchment hydrology. Supporting underground drainage infrastructure will be necessary to convey flows across the area and manage areas of spatial and topographical fragmentation. There may be opportunity to open up sections of previously open watercourse which are now culverted and part of the sewer system. These opportunities should be explored.

As the current drainage infrastructure is combined, the implementation of a dedicated surface water network to remove inflows from the combined sewer system is likely to be of significant benefit to sewer capacity in the region particularly for the Thamesmead and Abbey Wood OA located downstream in the catchment where additional foul flows cannot be offset by removing surface water due to the separated nature of the catchment.

As highlighted above, source control systems should be maximised within development areas to provide greenfield discharge rates from each development and a further degree of attenuation will be provided by the described conveyance systems. However, additional strategic storages are likely to be necessary to provide attenuation for streetscape and other public realm areas, as well as meeting residual attenuation needs for any more constrained development plots.

The design of the streetscape drainage network and location of attenuation features will be strongly influenced by the natural catchment hydrology, masterplan layout and ultimate discharge location. Priority should be given to the strategic location of attenuation storages in locations where this will be of greatest benefit to surface water flood risk. Consideration should be given as to whether there are opportunities for watercourse de-culverting and ecological enhancement as a part of the development master planning and surface water management. Due to the spatial requirements for surface water management elements, this should be considered at an early stage in the master planning process, through the positioning of open green space or public realm.

It should be noted that development phasing will potentially have a significant impact on the delivery and feasibility of surface water management approaches. Key strategic conveyance and attenuation infrastructure would need to be in place prior to the connection of individual development plots.

7.3.2.3 Discharge

Within Charlton Riverside, there is an opportunity to discharge collected and treated stormwater to the underlying chalk aquifer. This would have numerous benefits, including removing surface water from the combined sewer system, while contributing to regional water resource availability, and helping to prevent saline intrusion to the water table.

Injected water would need to be of an appropriate water quality, so pre-treatment will be a requirement. Effective implementation of source control and SuDS treatment stages along the conveyance pathways would assist in managing water quality and minimising end treatment requirements.

Utilisation of passive, biological treatment processes (such as wetlands) would be preferential, provided these are able to be spatially accommodated within the proposal. Further treatment stages, such as UV disinfection or the use of advanced treatment technologies may also be required, depending on the source water quality and discharge requirements although it is understood that water treatment to potable standards is likely to be required. Consultation with the Environment Agency and other key stakeholders would be required to confirm the required water quality parameters and acceptable treatment stages for discharged water in specific locations.

Collected stormwater could be discharged using one or more boreholes, depending on conveyance networks, spatial availability and treatment requirements. It should be noted that site investigation and local proving would be required in order to confirm the feasibility and rates of groundwater recharge.

While there are numerous benefits associated with the implementation of a strategic groundwater recharge scheme, it is acknowledged that there are numerous potential associated spatial, geological and feasibility constraints. In particular, the requirement for achieving potable water quality is likely to have significant cost and energy implications which will influence feasibility.

As an alternative preferred option, collected surface water could be discharged to the tidal River Thames, which would also achieve the key objective to remove surface water from the combined sewer system.

Due to the tidal nature of the River Thames, there would still be a requirement for surface water storage and/or a pumped outfall; this is in order to manage the impact of tide-locking, which restricts discharge during high tides, meaning water will either need to be stored or pumped until the tide is low enough for natural discharge. Early consideration should be given to the spatial requirements for surface water storage in development master-planning and drainage system design. It should be noted that pumping presents an ongoing operational and maintenance requirement, which will additionally be influenced by changing water levels associated with climate change. However, the master planning in the Growth Area may present opportunities for minimising pump reliance, by harnessing green space areas to manage surface water flows.

7.3.3 Alternative Water Supplies

The installation of a non-potable water recycling solution within the development area would substantially offset potable demand and reduce drainage discharges. It is anticipated that this could reduce demand on potable supplies by approximately 17%.

The aquifer recharge solution, as described above, would contribute to indirect regional water recycling, through recharging the groundwater supply, which is ultimately extracted for water supply within Greater London. The water balance indicates that up to 664 Ml of water could be available annually (although only a proportion of this is likely to be able to be effectively collected, conveyed and discharged).

In addition, the development area could reach a greater level of sustainability through implementing localised water recycling solutions. Greywater, rainwater or combined recycling systems at a plot-scale or development-scale are likely to be particularly beneficial. Whilst this is suitable for all properties, it would be of particular benefit in commercial properties, where relative non-potable demand is greater and system maintenance is centrally managed. The preferred recycling option for each development plot should be assessed based on the individual roof area, plot layout and water demand characteristics.

As it is proposed that storm water is conveyed and treated through a strategic approach across the development, this infrastructure could further be harnessed to provide localised green space irrigation, further reducing the demand on centralised potable supplies.

7.4 Key Recommendations and Next Steps

It is recommended that the key components of the outlined water management strategy are incorporated into planning policy for the growth area. In particular:

- All new properties should achieve water efficiency targets of 105 L/day, in line with the optional efficiency targets of the Building Regulations, and the recommendations of the London Plan.
- All properties should achieve greenfield runoff rates. Attenuation should be provided in line with the SuDS hierarchy, prioritising infiltration and water management through multi-functional green infrastructure.
- Wherever possible, new properties should be constructed with Green/Blue Roofs.
- Wherever possible, properties should be constructed with an alternative water supply, provided through either rainwater or greywater harvesting.

High level cost estimates and outcomes for the Growth Area, as associated with these measures, are provided in Appendix I.

It is additionally recommended that further scoping, investigation and design is undertaken to support the following aspects of the strategy:

- Further investigation should be undertaken into the opportunities and feasibility for strategic groundwater recharge.
- Feasibility and concept level design should be undertaken for a streetscape surface water conveyance network, discharging surface water to the River Thames.

8. Woolwich Town Centre - Option Appraisal and Strategy Development

8.1 Post-Development Conditions

Woolwich Town Centre is anticipated to experience significant growth, with averaged projections of approximately 17,660 additional residents and 3,670 new jobs over the next 20 years. The development is anticipated to be of high-density town centre typography, including high rise retail and commercial. Considering the predicted growth in this area, the anticipated post-development annual water balance for the Woolwich Town Centre is shown in Figure 8-1 below.

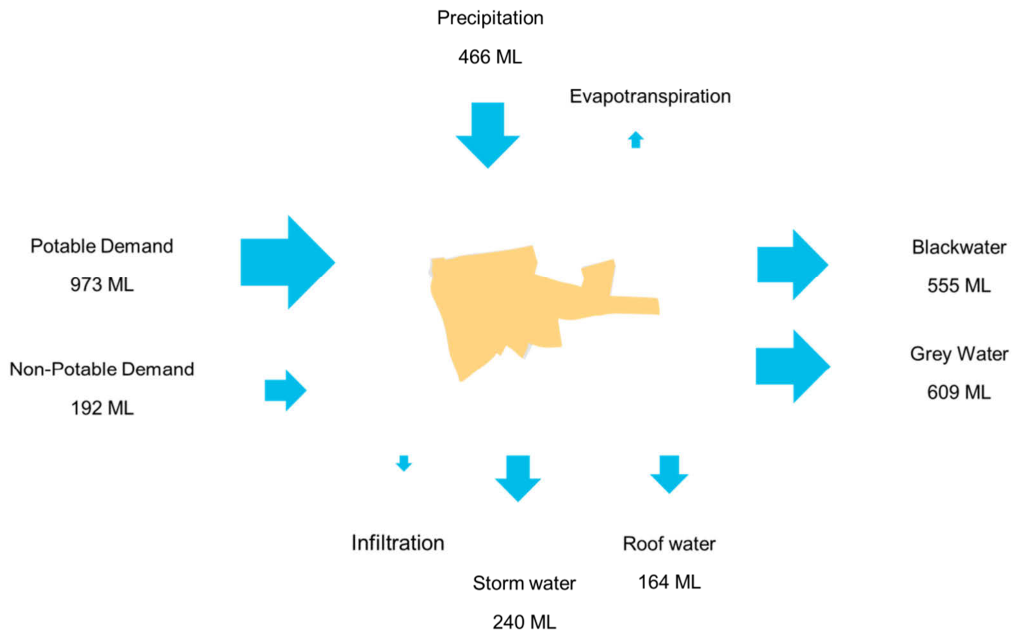


Figure 8-1: Woolwich Town Centre growth area post-development annual water balance

The magnitude of the anticipated increase in water demand and wastewater generation anticipated from the proposed development is illustrated in Figure 8-2.

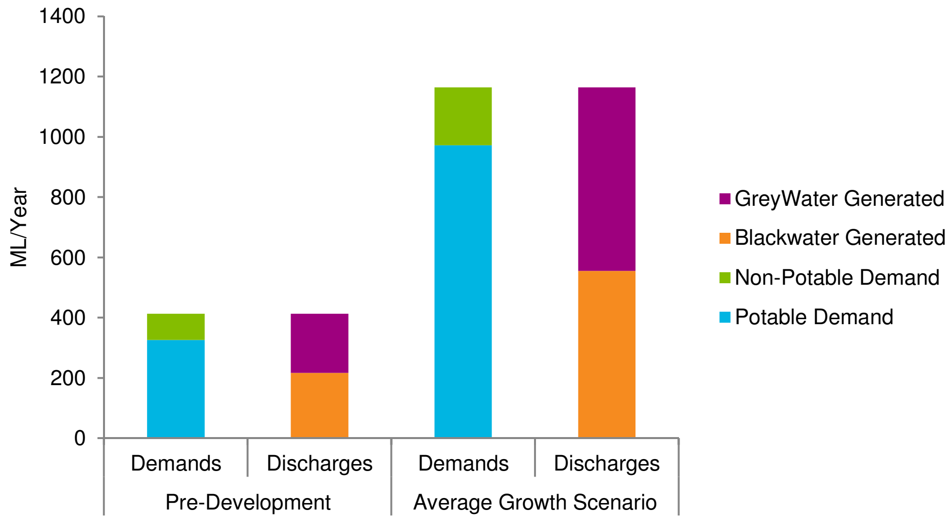


Figure 8-2: Woolwich growth area - anticipated increase in demand and discharge (ML/year)

The anticipated unmitigated peak sewer and surface water flows are shown in Table 8-1 below. The estimated greenfield runoff rate and volume of attenuation provided is also summarised.

Table 8-1: Key drainage characteristics

Parameter	Value
1 in 100 year Peak Runoff Rate (l/s)	14,707
Peak Sewage Flow Rate (l/s)	82.2
Greenfield Runoff Rate (l/s)	827
Attenuation Required (m^3)	36,463

8.2 Summary of Local Constraints and Opportunities

8.2.1 Topography and Geography

Woolwich Town centre is located adjacent to the tidal River Thames, which will present a potential opportunity for tidal discharge of surface water. Spatially, the development is fragmented by a railway line and split topographic catchments, which may impose a constraint on conveyance of surface water across the development area. There is additionally likely to be relatively little available space for attenuation within the high density redevelopment.

A substantial area of the site, particularly to the east, is located within defended Flood Zone 3, as associated with the tidal River Thames. Large areas have also been identified as susceptible to surface water flooding.

8.2.2 Geology and Hydrogeology

The underlying ground conditions in Woolwich are generally understood to be permeable, suggesting opportunities for local source control infiltration technique. However, potential areas of contaminated land may impose constraints in certain areas, particularly around the eastern half of the OA.

The western extent of the OA is also situated on the edge of a chalk aquifer, which is dewatered and likely to have significant capacity to accept discharge of collected surface water to groundwater in this location. Injection of water to the aquifer in this region would be beneficial to groundwater resources within London, which are ultimately extracted for potable water supply (thereby contributing to indirect regional recycling), and also assist in locally raising the water table to minimise saline intrusion, due to ingress of water from the Thames estuary.

8.2.3 Infrastructure

The drainage infrastructure within Woolwich is currently combined and feeds into the Crossness sewage catchment. This is known to have capacity issues during storm events. As such, there is an opportunity to reduce peak inflows and remove surface water flow from the combined system to offset increased foul flows within the catchment, and contribute towards water neutrality across the OA.

There is a limited area within the OA, around Woolwich Arsenal, which is served by separate surface water system, with a pumped outfall to the River Thames. This existing outfall could be harnessed to discharge collected water from the majority of the new development.

8.3 Preferred Water Management Strategy

8.3.1 Demand Management

Demand management should be maximised within the growth area. All development areas should be constructed to the maximum achievable standards in water efficiency and smart network technologies. Water metering is proposed across the development area. Consideration may also be given to the installation of local water storages within the network, to minimise the impact of demand spikes on water supply. Community engagement and educational opportunities should be harnessed within the development area, to promote water efficient behaviours.

8.3.2 Surface Water Management

In order to enable sustainable development of the growth area, it is essential that a cohesive, integrated approach to manging surface water quality and quantity is implemented, including attenuation, conveyance and discharge of runoff. A critical aspect of water management within Woolwich will be the provisions of attenuation storage. A total attenuation requirement of 36,463 m^3 has been estimated across the extent of the growth area, in order to achieve greenfield runoff rates.

The surface water management strategy will need to incorporate the following elements:

- Maximised provision of source control features within each development plot, to control the quality and quantity of surface water runoff generated on site and maximise infiltration, in line with the SuDS hierarchy.
- Streetscape SuDS features to provide conveyance of runoff from development plots and public realm areas to the ultimate discharge location. Strategic storage features may also be required in conjunction with conveyance features to provide for streetscape attenuation requirements.
- Ultimate discharge of the collected and treated runoff.

8.3.2.1 Source Control

Permeable surfacing should be maximised on all development plots, along with the installation of SuDS systems. An emphasis should be placed on green, surface SuDS systems, in order to optimise water quality and wider sustainability benefits. A number of approaches are available to developers, including bio-retention systems, retention ponds, swales, green walls and facades. Underground attenuation systems should only be used as a last resort, where sufficient volume cannot be provided by above ground measures.

The exact configuration of source control measures will be dependent on development-specific spatial and geological constraints. However, all developers should aim to provide attenuation volumes necessary to achieve greenfield runoff rates. This will prevent inundation of strategic surface water conveyance networks and facilitate the management of water quality throughout the surface water treatment train.

Due to the likely spatial constraints across the area, green or blue roofs are likely to present a particularly advantageous opportunity for surface water management, while also providing amenity and biodiversity benefit. It is generally recommended that accessible, intensive green or blue-green roofs should be installed on all new buildings, across the development. Where appropriate, these systems may be combined with rainwater harvesting or infiltration systems. Living walls and bio-retention systems are additionally likely to be spatially favourable approaches.

8.3.2.2 Streetscape Conveyance and Attenuation

To facilitate strategic management of runoff across the growth area, a conveyance network for surface water will be required. Ideally, this should be delivered as a strategic interconnected network of streetscape swales and green infrastructure to drain roads and public spaces; conveying, attenuating and filtering storm water flows along the natural catchment hydrology. Supporting underground drainage infrastructure will be necessary to convey flows across the area and manage areas of spatial and topographical fragmentation.

As the current drainage infrastructure is combined, the implementation of a dedicated surface water network to remove inflows from the combined sewer system is likely to be of significant benefit to sewer capacity in the region particularly for the Thamesmead and Abbey Wood OA located downstream in the catchment where additional foul flows cannot be offset by removing surface water due to the separated nature of the catchment.

As highlighted above, source control systems should be maximised within development areas to provide greenfield discharge rates from each development plot and a further degree of attenuation will be provided by the described conveyance systems. However, additional strategic storages are likely to be necessary to provide attenuation for streetscape and other public realm areas, as well as meeting residual attenuation needs for any more constrained development plots.

The design of the streetscape drainage network and location of attenuation features will be strongly influenced by the natural catchment hydrology, masterplan layout and ultimate discharge location. Priority should be given to the strategic location of attenuation storages in locations where this will be of greatest benefit to surface water flood risk. Due to the spatial requirements for surface water management elements, this should be considered at an early stage in the master planning process, through the positioning of open green space or public realm.

In particular, early consideration should be given to the impact of the central railway line, in fragmenting the natural drainage catchments across the area. Opportunities to manage flows through streetscape conveyance could be limited in this area, emphasising the importance of early consideration of conveyance routes and maximising on-plot attenuation in the fragmented area.

While the redevelopment areas are anticipated to be relatively fragmented across the extent of the Opportunity Areas, it is likely that the scale and density of the proposed development within Woolwich will present opportunities for SuDS features to be incorporated within and delivered as part of the streetscape redevelopment in certain areas.

It should be noted that development phasing will likely have a significant impact on the delivery and feasibility of surface water management approaches. Key strategic conveyance and attenuation infrastructure would need to be in place prior to the connection of individual development plots.

8.3.2.3 Discharge

As the eastern extent of the Woolwich Opportunity Area is located within the extent of the chalk aquifer, there may be an opportunity to discharge treated surface water to the aquifer. If feasible, the groundwater injection infrastructure servicing the Woolwich and Charlton OAs could be combined, providing a regional discharge solution. Pumping of collected surface water to discharge would be required, based on the location of favourable geology and catchment typology.

If feasible, groundwater discharge is considered the preferential option for surface water management, due to the numerous inherent benefits, including complete removal of surface water from the combined sewer system, contribution to regional water resource availability, and helping to prevent saline intrusion to the local water table.

Injected water would need to be of an appropriate water quality, so pre-treatment will be a requirement. Effective implementation of source control and SuDS treatment stages along the conveyance pathways would assist in managing water quality and minimising end treatment requirements.

Utilisation of passive, biological treatment processes (such as wetlands) would be preferential, provided these are able to be spatially accommodated within the proposal. Further treatment stages, such as UV disinfection may also be required depending on source water quality and discharge requirements. It is understood that water treatment to potable standards is likely to be required. Consultation with the Environment Agency and other key stakeholders would be required to confirm the required water quality parameters and acceptable treatment stages for discharged water. Due to the significance of the land and infrastructure requirements to facilitate groundwater injection, it is recommended that any proposed systems for Charlton Riverside and Woolwich Town Centre be combined, if possible.

Collected stormwater could be discharged using one or more boreholes, depending on conveyance networks, spatial availability and treatment requirements. It should be noted that site investigation and local proving would be required in order to confirm the feasibility and rates of groundwater recharge.

While there are numerous benefits associated with the implementation of a strategic groundwater recharge scheme, it is acknowledged that there are numerous potential associated spatial, geological and feasibility constraints. In particular, the requirement for achieving potable water quality is likely to have significant cost and energy implications which will influence feasibility.

As an alternative preferred option, collected surface water could be discharged to the tidal River Thames, which would also achieve the key objective to remove surface water from the combined sewer system.

If spatial, geological or feasibility constraints prevent this from being a preferential option, collected surface water could alternatively be discharged to the River Thames. This could utilise the existing pumped outfall, located near Woolwich Arsenal. Consideration would need additionally to be given to the requirement for additional surface water storage, to manage the impacts of tide-locking, considering additional surface water inflows and current pump capacity. Early consideration should be given to the spatial requirements for surface water storage in development master-planning and drainage system design.

8.3.3 Alternative Water Supplies

The installation of a non-potable water recycling solution within the development area would substantially offset potable demand and reduce drainage discharges. It is anticipated that this could reduce demand on potable supplies by approximately 16%.

The aquifer recharge solution, as described above, will contribute to indirect regional water recycling, through recharging the groundwater supply, which is ultimately extracted for water supply within Greater London. The water balances indicate that up to 404 ML of water could be available annually (although only a proportion of this is likely to be able to be effectively collected, conveyed and discharged).

In addition, the development area could reach a greater level of sustainability through implementing localised water recycling solutions. Greywater, rainwater or combined recycling systems at a plot-scale or development-scale are likely to be particularly beneficial. Whilst this is suitable for all properties, it would be of particular benefit in commercial properties, where relative non-potable demand is greater and system maintenance is centrally managed. The preferred recycling option for each development plot should be assessed based the individual roof area, plot layout and water demand characteristics.

As it is proposed that storm water is conveyed and treated through a strategic approach across the development, this infrastructure could additionally be harnessed to provide localised green space irrigation, further reducing the demand on centralised potable supplies.

8.4 Key Recommendations and Next Steps

It is recommended that the key components of the outlined water management strategy are incorporated into planning policy for the growth area. In particular:

- All new properties should achieve water efficiency targets of 105 L/day, in line with the optional efficiency targets of the Building Regulations, and the recommendations of the London Plan.
- All properties should achieve greenfield runoff rates. Attenuation should be provided in line with the SuDS hierarchy, prioritising infiltration and water management through multi-functional green infrastructure.
- Wherever possible, new properties should be constructed with Green/Blue Roofs.
- Wherever possible, properties should be constructed with an alternative water supply, provided through either rainwater or greywater harvesting.

High level cost estimates and outcomes for the Growth Area, as associated with these measures, are provided in Appendix I.

It is additionally recommended that further scoping, investigation and design is undertaken to support the following aspects of the strategy:

- Further investigation should be undertaken into the opportunities and feasibility for strategic groundwater recharge.
- Feasibility and concept level design should be undertaken for a streetscape surface water conveyance network, discharging surface water to the River Thames.

9. Thamesmead and Abbey Wood – Option Appraisal and Strategy Development

9.1 Post-Development Conditions

The Thamesmead and Abbey Wood OA is anticipated to experience significant growth, with averaged projections of 14,140 additional residents and 4,850 new jobs over the next 20 years. A substantial proportion of the OA is owned by a single landowner and it is understood that much of the development will be rented housing. Considering the anticipated growth in this area, the anticipated post-development annual water balance for Thamesmead and Abbey Wood is shown in Table 9-1 below.

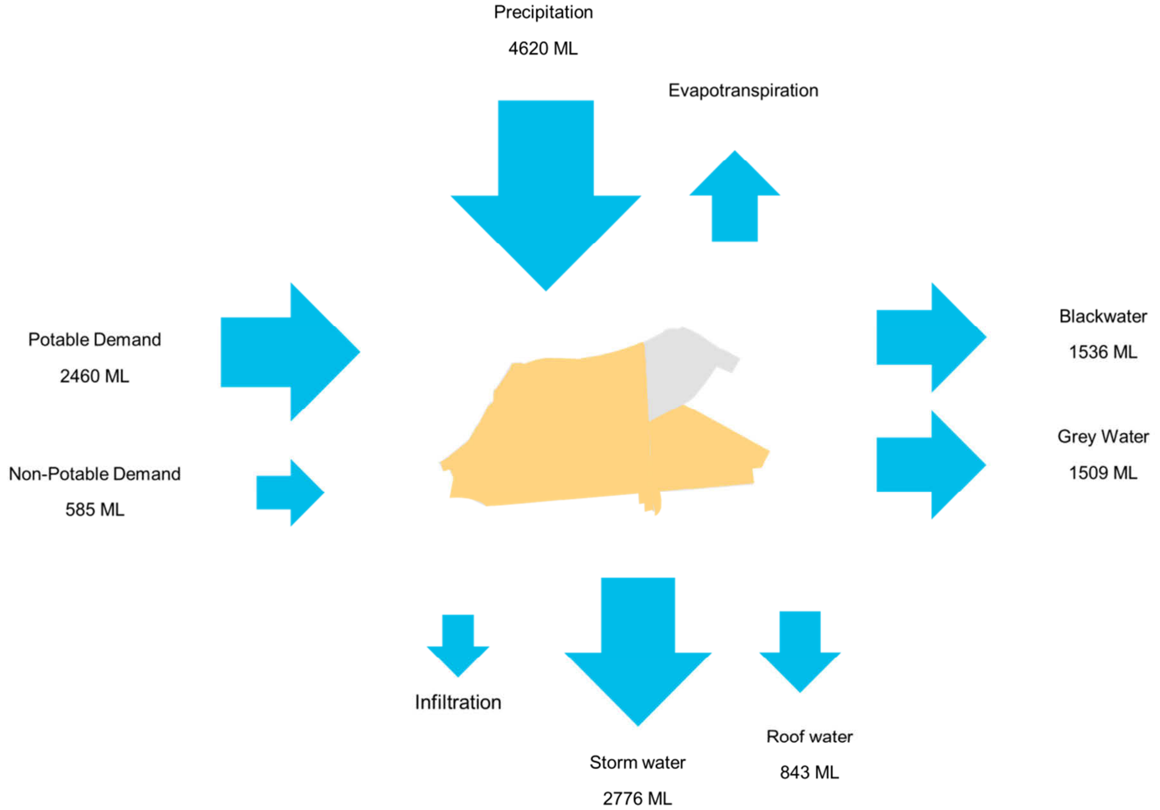


Figure 9-1: Thamesmead and Abbey Wood growth area post-development water balance

The magnitude of the anticipated increase in water demand and wastewater generation anticipated from the proposed development is illustrated in Figure 9-2.

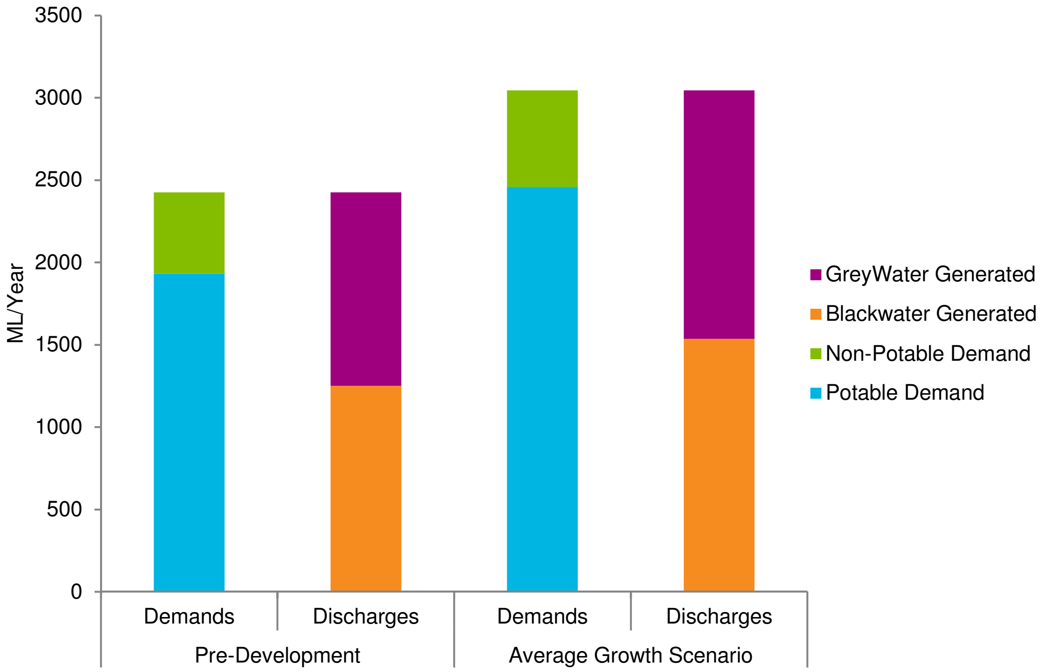


Figure 9-2: Thamesmead and Abbey Wood growth area - anticipated increase in demand and discharge (ML/year)

The anticipated unmitigated peak sewer and surface water flows are shown in Table 9-1 below. The estimated greenfield runoff rate and volume of attenuation provided is also summarised.

Table 9-1: Key drainage characteristics

Parameter	Value
1 in 100 year Peak Runoff Rate (l/s)	75,598
Peak Sewage Flow Rate (l/s)	221.4
Greenfield Runoff Rate (l/s)	5,751
Attenuation Required (m^3)	318,505

9.2 Summary of Local Constraints and Opportunities

9.2.1 Topography and Geography

Spatially, the areas of development are likely to be fragmented across the OA, which may limit the delivery of strategic infrastructure. However, the development is anticipated to be of a relatively low to medium density, so there is likely to be more space available for the incorporation of SuDS and surface water management features. There is additionally a large area of green space planned for the OA.

The area is topographically fragmented, which may present constraints for gravitational conveyance of surface water.

The vast majority of the OA is located within defended Flood Zone 3, as associated with the tidal River Thames. Several surface water flood risk hotspots have additionally been identified across the area.

The Erith Marshes system drains the eastern part of the Thamesmead growth area (within LBB). The Yarton Way culverted surface water drain collects water from Abbey Wood, discharging into open ditches in Erith Marshes. The water levels in the Marshes are maintained by a weir and two pumping stations; Great Breach and Green Level. Erith Marshes are designated as a SINC, as one of few remaining areas of Thames-side grazing marsh in London, supporting scarce birds, plants and insects. However, the watercourses within this system are understood to have capacity constraints so it may not be feasible to expand the area currently discharging to this system.

Further opportunities may be present through strategic green space associated with additional SINC's falling within the area. These include the Ridgeway, a vegetated linear footpath on the bank of the Southern Outfall Sewer, Southmere Park and Yarnton Way, comprising a large lake with surrounding parkland, poplar woodland and an accessible corridor of greenspace.

9.2.2 Geology and Hydrogeology

The ground conditions in Thamesmead and Abbey Wood are generally understood to be permeable, suggesting opportunities for implementation of local source control infiltration technique. However, contaminated land and historic landfill sites are present across the area, particularly along the northern boundary. There is some potential for discharge of collected water into the underlying confined chalk aquifer; however this will be at a low injection rate.

The Thamesmead area consists primarily of reclaimed marshland and therefore has a high water table. Any proposed SuDS installations will need to carefully consider the risk of high ground water levels, in conjunction with the overall Lake and Canal System operation.

9.2.3 Infrastructure

The Opportunity Area is spatially divided by several pieces of significant infrastructure, including the Southern Outfall Sewer and strategic road networks, which will limit surface connectivity.

The drainage infrastructure servicing the area is split into foul and surface water sewers, with the latter discharging into the Lake and Canal System. This is an engineered surface water drainage system servicing the local area. Water levels within the system are maintained by pumping stations and sluices, which ultimately discharge into the River Thames.

The sewerage system in the Thamesmead and Abbey Wood area feeds into the Southern Outfall Sewer, which discharges into the Crossness WwTW, situated immediately to the east of the OA. The system is understood to be at approximately 50% capacity during dry weather flow events; however the main trunk sewer is anecdotally understood to experience capacity issues during storm events. As the system is already separated, there is limited opportunity to offset the anticipated increase in foul flows, excepting through wastewater recycling and upstream interventions in Charlton Riverside and Woolwich.

It is understood that Thames Water are retrofitting a water metering programme across the whole of the Thamesmead and Abbey Wood area.

9.3 Preferred Water Management Strategy

9.3.1 Demand Management

Demand management should be maximised within the growth area. All development areas should be constructed to the maximum achievable standards in water efficiency and smart network technologies. Water metering is proposed across the development area. Consideration may also be given to the installation of local water storages within the network, to minimise the impact of demand spikes on water supply. Community engagement and educational opportunities should be harnessed within the development area, to promote water efficient behaviours.

9.3.2 Surface Water Management

In order to enable sustainable development of the growth area, it is essential that a cohesive, integrated approach to manging surface water quality and quantity is implemented. A critical aspect of water management within Thamesmead and Abbey Wood will be in the provision of attenuation storage, through a combination of existing and new surface water management infrastructure. A total attenuation requirement of 318,505 m^3 has been estimated across the extent of the growth area, in order to achieve greenfield runoff rates. It should be noted that this does not account for existing storage volumes (provided through the existing lake and canal system).

The surface water management strategy will need to incorporate the following elements:

- Maximised provision of source control features within each development plot, to control the quality and quantity of surface water runoff generated on site and maximise infiltration, in line with the SuDS hierarchy.
- Streetscape SuDS features to provide conveyance of runoff from development plots and public realm areas to the ultimate discharge location. Strategic storage features may also be required in conjunction with conveyance features to provide for streetscape attenuation requirements.
- Ultimate discharge of the collected and treated runoff.

9.3.2.1 Source Control

Permeable surfacing should be maximised on all development plots, along with the installation of SuDS systems. An emphasis should be placed on green, surface SuDS systems, in order to optimise water quality and wider sustainability benefits. A number of approaches are available to developers, including bio-retention systems, retention ponds, swales, green walls and facades. Underground attenuation systems should only be used as a last resort.

The exact configuration of source control measures will be dependent on development-specific spatial and geological constraint and it is also acknowledged that the strategic water attenuation and conveyance network has capacity to accommodate additional runoff to cater for new growth. However, all developers should aim to provide on-site attenuation where possible to minimise runoff rates. This is because it represents best practice water management and will assist in maintaining as much capacity as possible within the regional surface water attenuation system and facilitate the management of water quality throughout the surface water treatment train.

Due to low spatial requirements, green or blue roofs are likely to present a particularly advantageous opportunity for surface water management, while also providing amenity and biodiversity benefits. It is generally recommended that accessible, intensive green or blue-green roofs should be installed on all new buildings, across the development. Where appropriate, these systems may be combined with rainwater harvesting or infiltration systems. Living walls and bio-retention systems are additionally likely to be spatially favourable approaches.

9.3.2.2 Streetscape Conveyance and Attenuation

The development area already benefits from a strategic surface water attenuation and conveyance network, through the Lake and Canal System. However, localised conveyance elements will still be required to connect and incorporate the new development areas. This system should harness green infrastructure and streetscape SuDS elements, wherever possible, to convey and treat flows from development plots and public realm areas. Underground drainage elements should be minimised in order to manage water quality and runoff rates and maximise the multiple benefits to the urban landscape.

Given the relatively lower density of the development areas, more space is likely to be available for the incorporation of surface SuDS features. The incorporation of blue-green infrastructure, such as bio-retention system, swales and ponds could be used to enhance the local streetscape and environment and provide biodiversity and amenity benefits in public realm areas.

The location and provision of any additional SuDS features will need to be carefully designed in conjunction with the strategic conveyance network, and will be strongly influenced by the natural hydrological catchments and connection to the canal system. Priority should be given to the strategic location of new infrastructure in locations where this will be of greatest benefit to surface water flood risk. This should be considered at an early stage in the master planning process, through the positioning of open green space or public realm

Opportunities should be taken to expand the blue-green corridors provided by the Lake and Canal System and enhance its ecological and amenity characteristics wherever possible.

9.3.2.3 Discharge

The hydrogeology in this region indicates that it might be possible to discharge a small amount of collected surface water into the underlying aquifer. However, given the substantial infrastructure requirement, the high water table and low anticipated rate of discharge, this has not been deemed a preferential option.

The area is situated adjacent to the Erith Marshes, which already accepts discharge from the eastern portion of the OA. However, it is understood that there are capacity constraints within this system which will limit the ability to incorporate additional development areas into this system.

The area additionally benefits from the established Lake and Canal surface water management system. This system incorporates surface conveyance and storage elements, and tidal discharge. It is understood that sufficient capacity is available within this system to accommodate the additional discharge from the new development areas. Therefore, it is recommended that the new development areas are incorporated within this system.

9.3.3 Alternative Water Supplies

The installation of a non-potable water recycling solution within the development area would substantially offset potable demand and reduce drainage discharges. It is anticipated that this could lead to a reduction of approximately 19% on potable supplies.

The Thamesmead and Abbey Wood OA is positioned adjacent to the Crossness WwTW, which provides a unique potential opportunity in terms of an alternative water supply. Significant quantities of treated effluent, currently discharged into the River Thames, are produced by the plant.

Additional processing of the effluent would be required in order to treat flows to a high quality, in order to adequately manage any risk to human health. This is likely to involve an additional tertiary treatment stage (such as UV disinfection) in addition to advanced water treatment technologies, such as such as microfiltration, reverse osmosis or advanced oxidation.

Treated wastewater is available in significant quantities, and has the potential to provide a highly consistent and reliable supply stream to reduce demands on mains water and waste water discharge. The reclaimed water could be used to supply non-potable uses within homes and businesses, as well as for irrigation and process uses. Given the substantial availability of supply, such a scheme could additionally be expanded, to feed the growth anticipated in surrounding areas.

While the cost for such a system may be substantial, this would be partially offset by reducing the need for reinforcement of the water supply network required to accommodate additional demand within the Growth Area.

If a strategic scale wastewater recycling solution is not deemed to be feasible in this location, localised water recycling provides an alternative approach. Greywater, rainwater or combined recycling systems at a plot-scale or development-scale are likely to be particularly beneficial in this location. The type of solution used for each plot should be determined based on plot layout, building typology and demand characteristics. Whilst recycling is generally recommended for all properties, this would be of particular benefit in commercial properties, where relative non-potable demand is greater and system maintenance is centrally managed.

9.4 Key Recommendations and Next Steps

It is recommended that the key components of the outlined water management strategy are incorporated into planning policy for the growth area. In particular:

- All new properties should achieve water efficiency targets of 105 L/day, in line with the optional efficiency targets of the Building Regulations, and the recommendations of the London Plan.
- All developers should aim to provide on-site attenuation to minimise runoff rates as feasible before connecting to the existing surface water attenuation system.
- Wherever possible, new properties should be constructed with Green/Blue Roofs.

- Wherever possible, properties should be constructed with an alternative water supply, provided through rainwater, greywater or wastewater recycling (depending on the outcomes of the Crossness recycling feasibility study, as recommended below).

High level cost estimates and outcomes for the Growth Area, as associated with these measures, are provided in Appendix I.

It is additionally recommended that further scoping, investigation and design is undertaken to support the following aspects of the strategy:

- Further investigation should be undertaken into the opportunities and feasibility for a strategic wastewater recycling plant, utilising treated effluent from the Crossness WwTW.

10. Belvedere – Option Appraisal and Strategy Development

10.1 Post-Development Conditions

The Belvedere growth area is situated within the Bexley Riverside OA and is also located adjacent to the Thamesmead and Abbey Wood OA. Within Belvedere, the anticipated net growth comprises of 15,570 new residents and 2,310 new jobs over the next 20 years. The development is anticipated to be largely wholesale and comprise a mixture of housing and commercial uses.

Considering the predicted growth in this area, the anticipated post-development annual water balance for the Belvedere OA is shown in Figure 10-1 below.

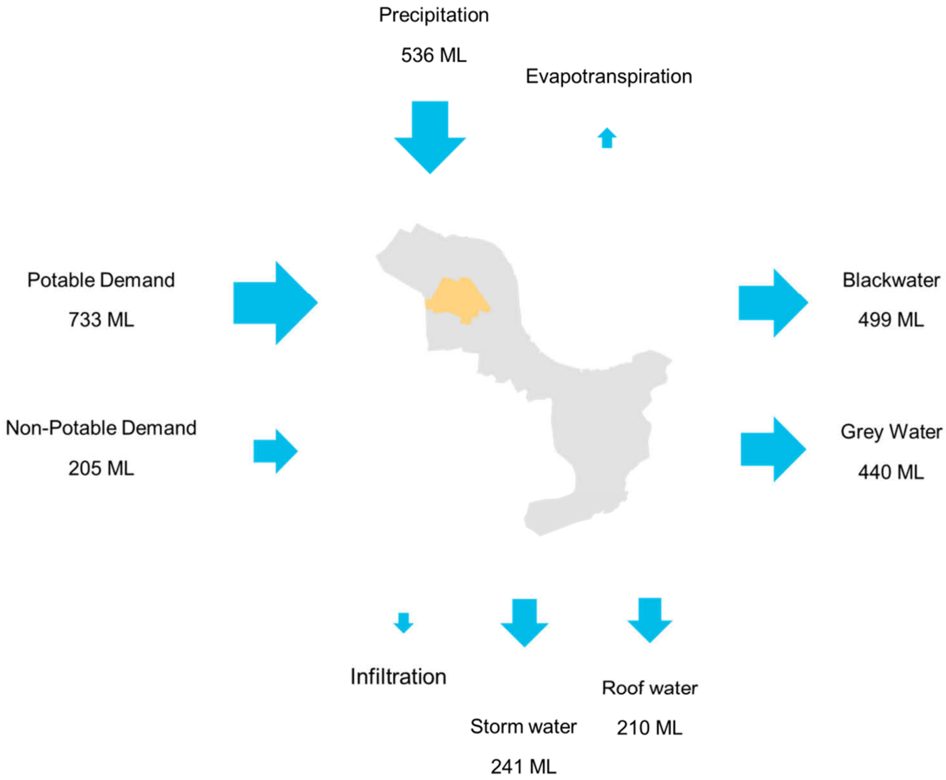


Figure 10-1: Belvedere growth area post-development water balance

The magnitude of the anticipated increase in water demand and wastewater generation anticipated from the proposed development is illustrated in Figure 10-2.

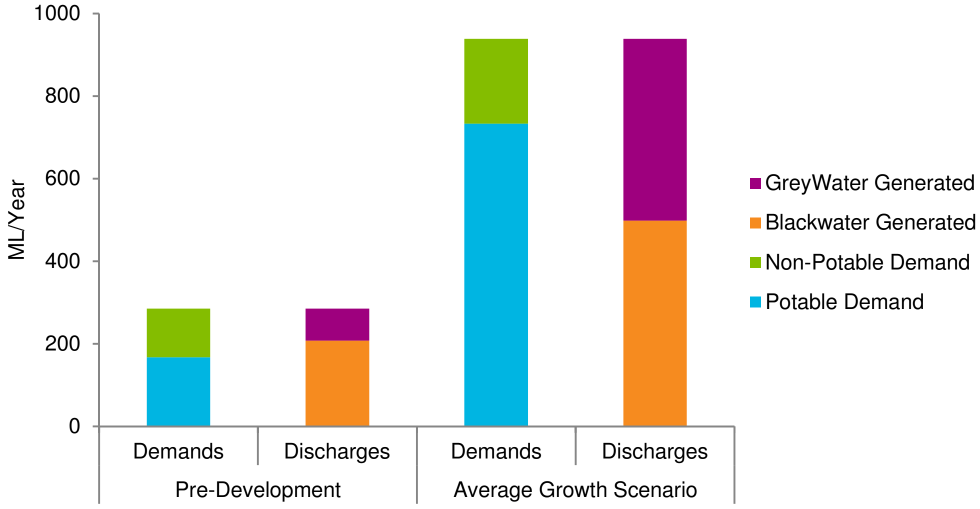


Figure 10-2: Belvedere growth area - anticipated increase in demand and discharge (ML/year)

The anticipated unmitigated peak sewer and surface water flows are shown in Table 10-1 below. The estimated greenfield runoff rate and volume of attenuation provided is also summarised.

Table 10-1: Key drainage characteristics

Parameter	
1 in 100 year Peak Runoff Rate (l/s)	16,428 l
Peak Sewage Flow Rate (l/s)	70.2
Greenfield Runoff Rate (l/s)	846
Attenuation Required (m^3)	41,909

10.2 Summary of Local Constraints and Opportunities

10.2.1 Topography and Geography

There are surface watercourses running through Belvedere, discharging towards the adjacent Erith Marshes. The marshes are understood to be a valuable ecological asset and the upstream waterbodies may present potential discharge options, and may also offer potential opportunities for ecological improvement. However, the fluvial capacity constraints of these watercourses are currently not well understood.

Belvedere is almost entirely located within defended Flood Zone 3, as associated with the Tidal Thames. Several areas of surface water flood risk are present, particularly to the south of the railway line.

The development within Belvedere is anticipated to be largely wholesale, which will present opportunities for delivery of strategic solutions across the area. The growth area is also located immediately adjacent to the Thamesmead and Abbey Wood opportunity area, which may present opportunities for combined infrastructure solutions.

There are no currently allocated new areas of strategic green space within the Belvedere development, which may limit available space for surface attenuation options. However, there are several SINCs within the Growth Area, including the Belvedere Dykes, which are a number of vegetated drainage dykes, providing a home to some rare flora and fauna. The site also contains part of the Erith Marshes SINC, a rare area of grazing Marsh. There will also be areas of greenspace which have not been considered 'strategic' in the context of this study owing to their limited capacity to provide strategic SuDS options.

10.2.2 Geology and Hydrogeology

The underlying ground conditions in Belvedere are generally understood to be permeable, suggesting opportunities for use of local source control infiltration techniques. However, there has been a long industrial history within Bexley, which has left many areas of contaminated land. Several of these sites are additionally understood to be adjacent to sensitive areas of importance for nature conservation.

The Erith Marshes system drains the Belvedere growth area. The Yarton Way culverted surface water drain collects water from this area and discharges into open ditches in Erith Marshes. The water levels in the Marshes are maintained by a weir and two pumping stations; Great Breach and Green Level.

Within Belvedere, there additionally potential for some discharge of collected water into the underlying confined chalk aquiver; however, volumes would be limited.

10.2.3 Infrastructure

Belvedere is situated within the Longreach sewer catchment, and also located adjacent to the Crossness sewage treatment works. The area is served by a separate surface water drainage system, discharging into local surface water systems. The area is spatially fragmented by strategic rail infrastructure, and topographical catchments.

10.3 Preferred Water Management Strategy

10.3.1 Demand Management

Demand management should be maximised within the growth area. All development areas should be constructed to the maximum achievable standards in water efficiency and smart network technologies. Water metering is proposed across the development area. Community engagement and educational opportunities should be harnessed within the development area, to promote water efficient behaviours.

10.3.2 Surface Water Management

In order to enable sustainable development of the growth areas, it is essential that a cohesive, integrated approach to manging surface water quality and quantity is implemented. A critical aspect of water management within Belvedere will be in the provision of attenuation storage. A total attenuation requirement of 41,909 m^3 has been estimated across the extent of the growth area, in order to achieve greenfield runoff rates.

The surface water management strategy will need to incorporate the following elements:

- Maximised provision of source control features within each development plot, to control the quality and quantity of surface water runoff generated on site and maximise infiltration, in line with the SuDS hierarchy.
- Streetscape SuDS features to provide conveyance of runoff from development plots and public realm areas to the ultimate discharge location. Strategic storage features may also be required in conjunction with conveyance features to provide for streetscape attenuation requirements.
- Ultimate discharge of the collected and treated runoff.

10.3.2.1 Source Control

Permeable surfacing should be maximised on all development plots, along with the installation of SuDS systems. An emphasis should be placed on green, surface SuDS systems, in order to optimise water quality and wider sustainability benefits. A number of approaches are available to developers, including bio-retention systems, retention ponds, swales, green walls and facades. Underground attenuation systems should only be used as a last resort.

The exact configuration of source control measures will be dependent on development-specific spatial and geological constraint. However, all developers should aim to provide on-plot attenuation volumes necessary to achieve greenfield runoff rates. This will prevent inundation of strategic surface water conveyance networks and facilitate the management of water quality throughout the surface water treatment train.

Due to the likely spatial constraints across the area, green or blue roofs are likely to present a particularly advantageous opportunity for surface water management, while also providing amenity and biodiversity benefit. It is generally recommended that accessible, intensive green or blue-green roofs should be installed on all new buildings, across the development. Where appropriate, these systems may be combined with rainwater harvesting or infiltration systems.

10.3.2.2 Streetscape Conveyance, Attenuation and Discharge

Belvedere benefits from a separate surface water discharge system, which discharges into surface water bodies and is ultimately pumped into the River Thames. However, it is understood that the Erith Marshes are limited in capacity to accept additional discharge; therefore reduction of existing discharge rates to Greenfield rates through the incorporation of additional attenuation will be critical for this area.

It is recommend that the new development feeds into this existing system, while incorporating additional attenuation and treatment elements and expanding the network where necessary. Any expanded or new surface water conveyance and management systems should be maintained at surface level wherever possible, and opportunities taken to bring existing drainage elements to surface water where possible. SuDS features such as swales and green infrastructure should be harnessed to drain new roads and public spaces; providing conveyance, attenuation and treatment benefits.

As highlighted above, source control systems should be maximised within development areas to provide greenfield discharge rates from each development. However, additional strategic storages are likely to be necessary to provide attenuation for streetscape and other public realm areas, as well as meeting residual attenuation needs for any more constrained development plots. Water should be attenuated using above ground features, such as ponds, wherever possible.

The design and location of streetscape features will be strongly influenced by the natural catchment hydrology, masterplan layout and existing drainage network. Priority should be given to the strategic location of attenuation storages in locations where this will be of greatest benefit to reduce surface water flood risk. Due to the spatial requirements for surface water management elements, this should be considered at an early stage in the master planning process, through the positioning of open green space or public realm.

It should be noted that development phasing will potentially have a significant impact on the delivery and feasibility of surface water management approaches. Key strategic conveyance and attenuation infrastructure would need to be in place prior to the connection of individual development plots.

10.3.3 Alternative Water Supplies

The installation of a non-potable water recycling solution within each of the growth areas would substantially offset potable demand and reduce drainage discharges. It is anticipated that this could lead to a reduction of approximately 22% on potable supplies.

The Belvedere growth area is positioned adjacent to the Crossness WwTW, which provides a unique potential opportunity in terms of an alternative water supply. Significant quantities of treated effluent are produced by the WwTW, which are currently discharged into the River Thames.

Additional processing of the effluent would be required in order to treat flows to a high quality, in order to adequately manage any risk to human health. This is likely to involve and additional tertiary treatment stage (such as UV disinfection) in addition to advanced water treatment technologies, such as such as microfiltration, reverse osmosis or advanced oxidation.

Treated wastewater is available in significant quantities, and has the potential to provide a highly consistent and reliable supply stream to reduce demands on mains water and waste water discharge. The reclaimed water could be used to supply non-potable uses within homes and businesses, as well as for irrigation and process uses. Given the substantial availability of supply, such a scheme could additionally be expanded, to feed the growth anticipated in surrounding areas.

While the cost for such a system may be substantial, this would be partially offset by reducing the need for reinforcement of the water supply network to accommodate additional demand within the Growth Area.

If a strategic scale wastewater recycling solution is not deemed to be feasible for this area, localised water recycling provides and alternative approach. Greywater, rainwater or combined recycling systems at a plot-scale or development-scale are likely to be particularly beneficial. The type of solution used for each plot should be determined based on individual plot layout, building typology and demand characteristics. Whilst recycling is generally recommended for all properties, this would be of particular benefit in commercial properties, where relative non-potable demand is greater and system maintenance is centrally managed.

10.4 Key Recommendations and Next Steps

It is recommended that the key components of the outlined water management strategy are incorporated into planning policy for the growth area. In particular:

- All new properties should achieve water efficiency targets of 105 L/day, in line with the optional efficiency targets of the Building Regulations, and the recommendations of the London Plan.
- All properties should achieve greenfield runoff rates. Attenuation should be provided in line with the SuDS hierarchy, prioritising infiltration and water management through multi-functional green infrastructure.
- Wherever possible, new properties should be constructed with Green/Blue Roofs.
- Wherever possible, properties should be constructed with an alternative water supply, provided through rainwater, greywater or wastewater recycling (depending on the outcomes of the Crossness recycling feasibility study, as recommended below).

High level cost estimates and outcomes for the Growth Area, as associated with these measures, are provided in Appendix I.

It is additionally recommended that further scoping, investigation and design is undertaken to support the following aspects of the strategy:

- Feasibility and concept level design should be undertaken for a streetscape surface water conveyance network to connect the new development area into existing surface water system.
- Further investigation should be undertaken into the opportunities and feasibility for a strategic wastewater recycling plant, utilising treated effluent from the Crossness WwTW.

11. Erith and Slade Green – Option Appraisal and Strategy Development

11.1 Post-Development Conditions

The growth areas of Erith and Slade Green are positioned directly adjacent within the Bexley Riverside OA. Over the next 20 years approximately 7,780 new residents and 1,250 new jobs are expected within Erith, while 8,840 new residents and approximately 980 new jobs are anticipated within Slade Green.

The development across these areas is anticipated to be largely wholesale and comprise a mixture of housing and commercial uses. Considering the predicted growth in this area, the anticipated post-development annual water balance for the two growth areas is shown in Figure 11-1 below.

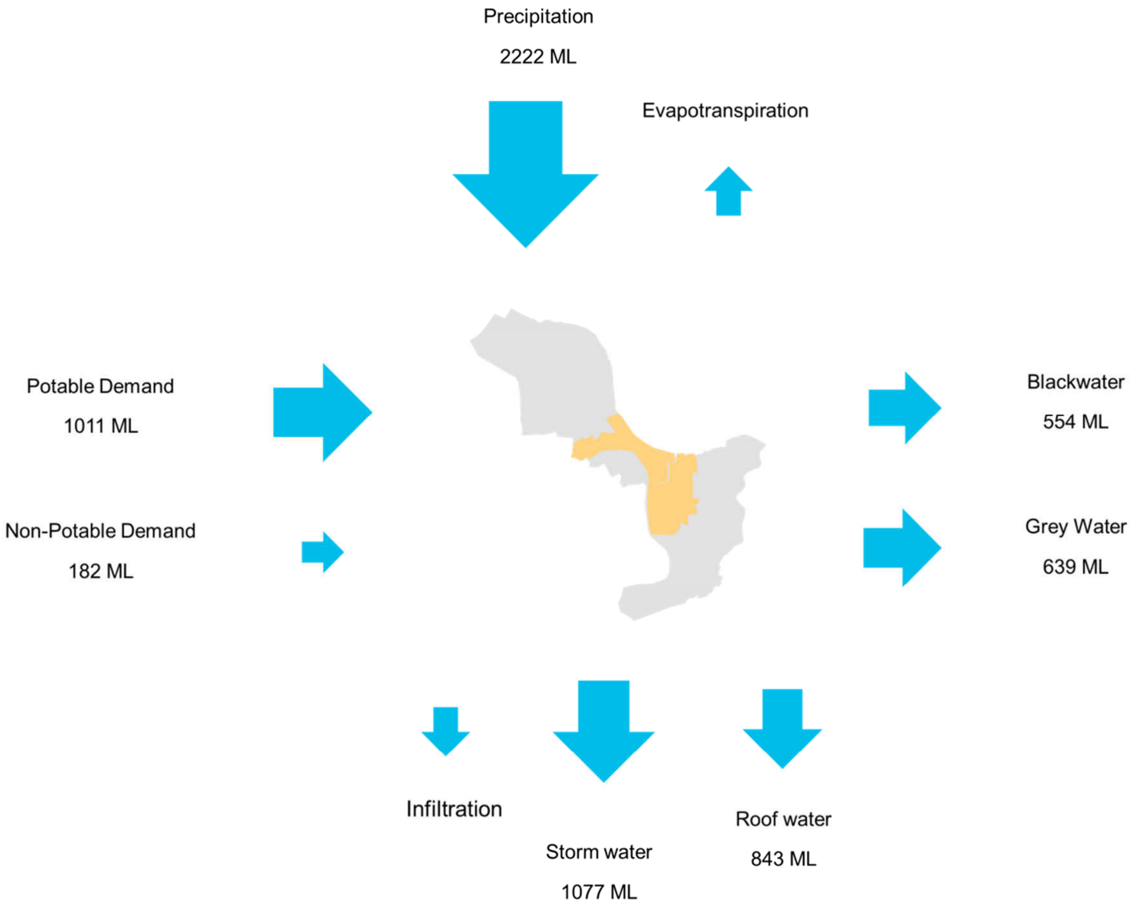


Figure 11-1: Erith and Slade Green growth area post-development water balance

The magnitude of the anticipated increase in water demand and wastewater generation anticipated from the proposed development is illustrated in Figure 11-2.

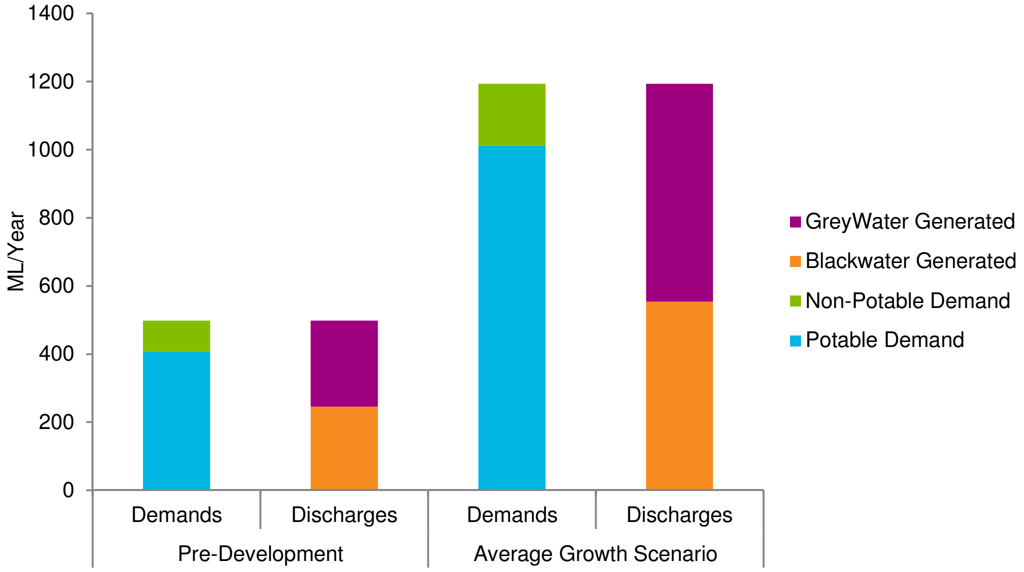


Figure 11-2: Erith and Slade Green growth area - anticipated increase in demand and discharge (ML/year)

The anticipated unmitigated peak sewer and surface water flows are shown in Table 11-1 below. The estimated greenfield runoff rate and volume of attenuation provided is also summarised.

Table 11-1: Key drainage characteristics

Parameter	Erith	Slade Green
1 in 100 year Peak Runoff Rate (l/s)	30,538	30,200
Peak Sewage Flow Rate (l/s)	37.3	45.8
Greenfield Runoff Rate (l/s)	156	156
Attenuation Required (m^3)	131,610	24,562

11.2 Summary of Local Constraints and Opportunities

11.2.1 Topography and Geography

Slade Green and Erith are positioned adjacent to the River Thames, which may present opportunities for tidal discharge of surface water. Slade Green is additionally positioned immediately adjacent to the Crayford Marshes.

Substantial areas of defended Flood Zone 2 and 3 are present within Erith and Slade Green, as associated with the tidal River Thames. Surface water flooding hotspots have been identified across both growth areas.

The connected nature of the two areas and the wholesale nature of the development may present opportunities for delivery of strategic infrastructure solutions within each area. Both areas are also understood to have an allocation of green space, which may present opportunities for the incorporation of surface water management systems. There are additionally existing designated SINCs within the Growth Areas. These are Erith Quarry and Fraser Road, comprising a mixture of woodland, scrub and grassland of value to a range of important birds, invertebrates and plants, and the Slade Green Recreation Ground, a grassland site with a hedgerow and large colony of common lizards. Several other SINCs are located immediately adjacent to the area, notably including the Crayford Marshes and Crayford landfill and Howbury Grange.

11.2.2 Geology and Hydrogeology

The underlying ground conditions in both growth areas are generally understood to be permeable, suggesting opportunities for use of local source control infiltration techniques. However, there has been a long industrial history within Bexley, which has left many areas of contaminated land. Current and historic landfill sites and present within the western parts of Erith and large extents of the southern half of the Slade Green growth area. Several of these sites are additionally understood to be adjacent to sensitive areas of importance for nature conservation.

Aquifer discharge is not suitable in the areas of Erith and Slade Green, due to a shallow water table, which could create a groundwater flooding risk downgradient of the discharge site.

11.2.3 Infrastructure

Erith and Slade Green are both located within the Longreach sewage catchment. The areas are served by separate surface and foul water drainage systems.

The growth areas are spatially fragmented by several strategic road and rail networks, and topographically fragmented by separate surface water catchments.

11.3 Preferred Water Management Strategy

11.3.1 Demand Management

Demand management should be maximised within the growth areas. All development areas should be constructed to the maximum achievable standards in water efficiency and smart network technologies. Water metering is proposed across the development areas. Community engagement and educational opportunities should be harnessed within the development areas, to promote water efficient behaviours.

11.3.2 Surface Water Management

In order to enable sustainable development of the growth areas, it is essential that cohesive, integrated approach to manging surface water quality and quantity is implemented. A critical aspect of water management within Erith and Slade Green will be in the provision of attenuation storage. A total attenuation requirement of 156,172 m^3 has been estimated across the extent of the growth area, in order to achieve greenfield runoff rates.

The surface water management strategy will need to incorporate the following elements:

- Maximised provision of source control features within each development plot, to control the quality and quantity of surface water runoff generated on site and maximise infiltration, in line with the SuDS hierarchy.
- Streetscape SuDS features to provide conveyance of runoff from development plots and public realm areas to the ultimate discharge location. Strategic storage features may also be required in conjunction with conveyance features to provide for streetscape attenuation requirements.
- Ultimate discharge of the collected and treated runoff.

11.3.2.1 Source Control

Permeable surfacing should be maximised on all development plots, along with the installation of SuDS systems. An emphasis should be placed on green, surface SuDS systems, in order to optimise water quality and wider sustainability benefits. A number of approaches are available to developers, including bio-retention systems, retention ponds, swales, green walls and facades. Underground attenuation systems should only be used as a last resort.

The exact configuration of source control measures will be dependent on development-specific spatial and geological constraint. However, all developers should aim to provide attenuation volumes necessary to achieve greenfield runoff rates. This will prevent inundation of strategic surface water conveyance networks and facilitate the management of water quality throughout the surface water treatment train.

Due to the likely spatial constraints across the area, green or blue roofs are likely to present a particularly advantageous opportunity for surface water management, while also providing amenity and biodiversity benefit. It is generally recommended that accessible, intensive green or blue-green roofs should be installed on all new buildings, across the development. Where appropriate, these systems may be combined with rainwater harvesting or infiltration systems.

11.3.2.2 Streetscape Conveyance, Attenuation and Discharge

Both Erith and Slade Green benefit from a separate surface water system, which ultimately discharges into the River Thames. It is recommended that the new development feeds into this existing system, while incorporating additional attenuation and treatment elements and expanding the network where necessary. Any expanded or new surface water conveyance and management systems should be maintained at surface level wherever possible, and opportunities taken to bring existing drainage elements to surface water where possible. SuDS features such as swales and green infrastructure should be harnessed to drain new roads and public spaces; providing conveyance, attenuation and treatment benefits.

As highlighted above, source control systems should be maximised within development areas to provide greenfield discharge rates from each development. However, additional strategic storages are likely to be necessary to provide attenuation for streetscape and other public realm areas, as well as meeting residual attenuation needs for any more constrained development plots. Water should be attenuated using above ground features, such as ponds, wherever possible.

The design and location of streetscape features will be strongly influenced by the natural catchment hydrology, masterplan layout and existing drainage network. Priority should be given to the strategic location of attenuation storages in locations where this will be of greatest benefit to reduce surface water flood risk. Due to the spatial requirements for surface water management elements, this should be considered at an early stage in the master planning process, through the positioning of open green space or public realm.

It should be noted that development phasing will potentially have a significant impact on the delivery and feasibility of surface water management approaches. Key strategic conveyance and attenuation infrastructure would need to be in place prior to the connection of individual development plots.

11.3.3 Alternative Water Supplies

The installation of a non-potable water recycling solution within the Erith and Slade Green growth areas would substantially offset potable demand and reduce drainage discharges. It is anticipated that this could lead to a reduction of approximately 15% on potable supplies.

There are limited opportunities for strategic scale water recycling schemes in this area; therefore, localised water recycling is recommended. Greywater, rainwater or combined recycling systems at a plot-scale or development-scale are likely to be particularly beneficial in this location. The type of solution used for each plot should be determined based on individual plot layout, building typology and demand characteristics. Whilst recycling is generally recommended for all properties, this would be of particular benefit in commercial properties, where relative non-potable demand is greater and system maintenance is centrally managed.

11.4 Key Recommendations and Next Steps

It is recommended that the key components of the outlined water management strategy are incorporated into planning policy for the growth area. In particular:

- All new properties should achieve water efficiency targets of 105 L/day, in line with the optional efficiency targets of the Building Regulations, and the recommendations of the London Plan.
- All properties should achieve greenfield runoff rates. Attenuation should be provided in line with the SuDS hierarchy, prioritising infiltration and water management through multi-functional green infrastructure.
- Wherever possible, new properties should be constructed with Green/Blue Roofs.
- Wherever possible, properties should be constructed with an alternative water supply, provided through either rainwater or greywater harvesting.

High level cost estimates and outcomes for the Growth Area, as associated with these measures, are provided in Appendix I.

It is additionally recommended that further scoping, investigation and design is undertaken to support the following aspects of the strategy:

- Feasibility and concept level design should be undertaken for a streetscape surface water conveyance network, connecting the new development area into the existing drainage system.

12. Crayford – Option Appraisal and Strategy Development

12.1 Post-Development Conditions

The growth area of Crayford is anticipated to experience significant growth over the next 20 years, with average projections for 1,970 new residents and 420 new jobs. The development within this area is anticipated to be largely wholesale and comprise a mixture of housing and commercial uses.

Considering the predicted growth in this area, the anticipated post-development annual water balance for the Crayford growth area is shown in Figure 12-1 below.

Figure 12-1: Crayford growth area post-development water balance

The magnitude of the anticipated increase in water demand and wastewater generation anticipated from the proposed development is illustrated in Figure 12-2.

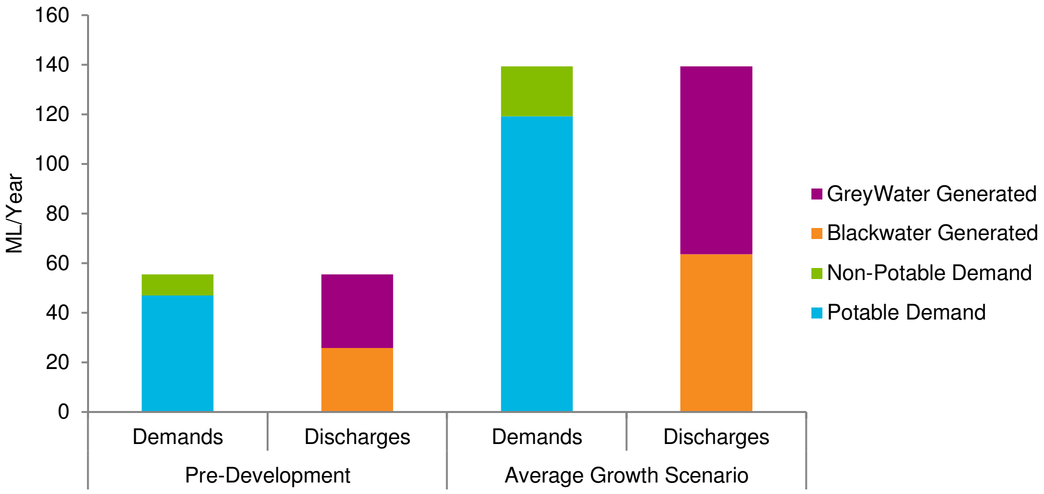


Figure 12-2 : Crayford growth area - anticipated increase in demand and discharge (ML/year)

The anticipated unmitigated peak sewer and surface water flows are shown in Table 12-1 below. The estimated greenfield runoff rate and volume of attenuation provided is also summarised.

Table 12-1: Key drainage characteristics

Parameter	Value
1 in 100 year Peak Runoff Rate (l/s)	9,430
Peak Sewage Flow Rate (l/s)	9.6
Greenfield Runoff Rate (l/s)	57.4
Attenuation Required (m^3)	39,425

12.2 Summary of Local Constraints and Opportunities

12.2.1 Topography and Geography

The River Cray flows west to east along the northern boundary of the Crayford Growth area, and the culverted River Wantsunt runs west to east through the centre of the growth area. These rivers both discharge into the lower catchment of the River Darent. Crayford Marshes are located upstream of Crayford and are a valuable ecological asset and a designated SINC. Crayford is also located adjacent to the SINC of Crayford Rough, a former rail yard, and contains part of the SINC covering tidal estuaries of the River Thames.

Crayford is located within undefended Flood Zone 3 and therefore at actual risk of flooding from the River Cray. Areas within the Crayford have also been identified as susceptible to surface water flooding. This will need to be considered in any subsequent development proposals.

The central watercourse could potentially benefit from de-culverting as part of wider surface water management and urban greening approaches. However, capacity constraints and flood risk will need to be carefully considered.

The development within Crayford is anticipated to be of a high density, with no allocated areas of strategic green space, which may limit available space for surface attenuation options. However, the wholesale nature of the development may present opportunities for the delivery of coordinated and spatially planned strategic solutions.

12.2.2 Geology and Hydrogeology

The underlying ground conditions within Crayford are generally understood to be permeable, suggesting opportunities for use of local source control infiltration techniques. However, there has been a long industrial history within Bexley, which has left many areas of contaminated land and the western extent of Crayford is known to have accommodated historic landfill sites.

Aquifer discharge is not suitable in Crayford, due to a shallow water table, which could create a groundwater flooding risk downgradient of the discharge site.

12.2.3 Infrastructure

Crayford is located within the Longreach sewer catchment and is served by separate surface water and foul drainage systems. Strategic road networks run throughout the growth area.

12.3 Preferred Water Management Strategy

12.3.1 Demand Management

Demand management should be maximised within the growth area. All development areas should be constructed to the maximum achievable standards in water efficiency and smart network technologies. Water metering is proposed across the development area. Community engagement and educational opportunities should be harnessed within the development area, to promote water efficient behaviours.

12.3.2 Surface Water Management

In order to enable sustainable development of the growth areas, it is essential that cohesive, integrated approach to manging surface water quality and quantity is implemented. A critical aspect of water management within Crayford will be in the provision of attenuation storage. A total attenuation requirement of 39,425m^3 has been estimated across the extent of the growth area, in order to achieve greenfield runoff rates

The surface water management strategy will need to incorporate the following elements:

- Maximised provision of source control features within each development plot, to control the quality and quantity of surface water runoff generated on site and maximise infiltration, in line with the SuDS hierarchy.
- Streetscape SuDS features to provide conveyance of runoff from development plots and public realm areas to the ultimate discharge location. Strategic storage features may also be required in conjunction with conveyance features to provide for streetscape attenuation requirements.
- Ultimate discharge of the collected and treated runoff.

12.3.2.1 Source Control

Permeable surfacing should be maximised on all development plots, along with the installation of SuDS systems. An emphasis should be placed on green, surface SuDS systems, in order to optimise water quality and wider sustainability benefits. A number of approaches are available to developers, including bio-retention systems, retention ponds, swales, green walls and facades. Underground attenuation systems should only be used as a last resort.

The exact configuration of source control measures will be dependent on development-specific spatial and geological constraint. However, all developers should aim to provide attenuation volumes necessary to achieve greenfield runoff rates. This will prevent inundation of strategic surface water conveyance networks and facilitate the management of water quality throughout the surface water treatment train.

Due to the likely spatial constraints across the area, green or blue roofs are likely to present a particularly advantageous opportunity for surface water management, while also providing amenity and biodiversity benefit. It is generally recommended that accessible, intensive green or blue-green roofs should be installed on all new buildings, across the development. Where appropriate, these systems may be combined with rainwater harvesting or infiltration systems.

12.3.2.2 Streetscape Conveyance, Attenuation and Discharge

Crayford benefits from a separate surface water system, which ultimately discharges into local waterways and/or the River Thames.

It is recommend that the new development feeds into this existing system, while incorporating additional attenuation and treatment elements and expanding the network where necessary. Any expanded or new surface water conveyance and management systems should be maintained at surface level wherever possible, and opportunities taken to bring existing drainage elements to surface water where possible. SuDS features such as swales and green infrastructure should be harnessed to drain new roads and public spaces; providing conveyance, attenuation and treatment benefits.

Consideration should be given as to whether there are opportunities for watercourse de-culverting and ecological enhancement as a part of the development master planning and surface water management.

As highlighted above, source control systems should be maximised within development areas to provide greenfield discharge rates from each development. However, additional strategic storages are likely to be necessary to provide attenuation for streetscape and other public realm areas, as well as meeting residual attenuation needs for any more constrained development plots.

The design and location of streetscape features will be strongly influenced by the natural catchment hydrology, masterplan layout and existing drainage network. Priority should be given to the strategic location of attenuation storages in locations where this will be of greatest benefit to surface water flood risk. Due to the spatial requirements for surface water management elements, this should be considered at an early stage in the master planning process, through the positioning of open green space or public realm.

It should be noted that development phasing will potentially have a significant impact on the delivery and feasibility of surface water management approaches. Key strategic conveyance and attenuation infrastructure would need to be in place prior to the connection of individual development plots.

12.3.3 Alternative Water Supplies

The installation of a non-potable water recycling solution within Crayford would substantially offset potable demand and reduce drainage discharge. It is anticipated that this could lead to a reduction of approximately 14% on potable supplies.

There are limited opportunities for strategic scale water recycling schemes in this area; therefore, localised water recycling is recommended. Greywater, rainwater or combined recycling at a plot-scale or development-scale is likely to be particularly beneficial. Whilst this is suitable for all properties, this would be of particular benefit in commercial properties, where relative non-potable demand is greater and system maintenance is centrally managed. The preferred recycling option for each development plot should be assessed based on the plot layout, typology and water demand characteristics.

12.4 Key Recommendations and Next Steps

It is recommended that the key components of the outlined water management strategy are incorporated into planning policy for the growth area. In particular:

- All new properties should achieve water efficiency targets of 105 L/day, in line with the optional efficiency targets of the Building Regulations, and the recommendations of the London Plan.
- All properties should achieve greenfield runoff rates. Attenuation should be provided in line with the SuDS hierarchy, prioritising infiltration and water management through multi-functional green infrastructure.
- Wherever possible, new properties should be constructed with Green/Blue Roofs.
- Wherever possible, properties should be constructed with an alternative water supply, provided through either rainwater or greywater harvesting.

High level cost estimates and outcomes for the Growth Area, as associated with these measures, are provided in Appendix I.

It is additionally recommended that further scoping, investigation and design is undertaken to support the following aspects of the strategy:

- Feasibility and concept level design should be undertaken for a streetscape surface water conveyance network, connecting the new development area into the existing drainage system.

13. Strategy Delivery

13.1 Introduction

This section of the report considers how the various options identified within the described strategy could be effectively procured, constructed and maintained, and which parties might be best placed to deliver these. In general, this should be arranged such that benefits are derived for the OAs in terms of:

- Satisfying planning and regulatory requirements;
- Optimising cost for the works;
- Certainty of delivery of required works to meet the overall programme; and
- Placing risk and associated responsibility with the party that is best placed to manage this effectively.

It is anticipated that the works will be carried out across a variety of scales, from plot, to sub-area (development scale) to area scale and that therefore the solutions for each of these will vary.

Additionally, there a variety of mechanisms whereby costs on a strategic scale for the entire development could be cross-charged to individual plot developers. However, this will be highly dependent on a large number of factors; particularly, the means by which infrastructure works of this nature are recovered from the private sector.

It is considered that ongoing discussions with the key regional stakeholders and individual developers is required in order to further confirm the most appropriate of these potential mechanisms and the detail. A stakeholder engagement plan is detailed in section 13.4, but in particular, these discussions should involve:

- Community Infrastructure Levy (CIL) and whether the works could be recovered through this in part;
- S106 / S278 etc. and how costs could be allocated to the plot developers;
- The charging mechanisms between Thames Water and the plot developers; and
- The use or otherwise of an Inset Appointee.

The following sections summarise the key considerations which will need to be taken into account during the delivery of the works, and how delivery of the key components of the strategy might be approached.

13.2 Key Delivery Considerations

There are a number of criteria that will need to be considered in the delivery of various aspects of the strategy, recognising that this may be impacted on by the specific requirements of those organisations that will both carry out the works and be responsible for the ongoing operation and maintenance. The major factors that have been considered are described below.

13.2.1 Location

There are a number of proposed measures that involve works directly to or adjacent to proposed buildings, and which are self-contained within the various development plots. As such, these works would be carried out by the particular plot developers. There are, however, a number of solutions at both sub-area and area scale, which involve works outside of the plot boundaries. Therefore, these measures could conceivably be carried out by a number of parties.

13.2.2 Scale of the works

The proposed solutions cover some very significant works and, as such, are likely to yield benefits to the wider Charlton to Bexley OA (and potentially beyond), rather than being specific to an individual plot or development parcel. In this circumstance, it is likely that these works would be carried out by Thames Water or others, rather than by individual plot developers, as the need for them is strategic and could also require the use of statutory powers in terms of land acquisition, which they are best placed to deliver.

13.2.3 Timing of the works

Following on from the above, it is clear that there will be some works for which timing will be critical to serve the development, especially in the early phases. Where this is the case, a balance will be required between those works which are purely for the benefit of a single development, and therefore could be the responsibility of that plot developer, and those works which are required for the wider development, but again which need to be procured and delivered at an early stage. In particular, this is a critical consideration for the delivery of strategic SuDS conveyance systems, surface water discharge systems or strategic water reuse approaches. In order for these approaches to be feasible, they need to be delivered at an early stage, in order to enable connection of individual development plots as the overall growth area phasing develops. This may also result in cost efficiencies (as opposed to piece-wise development of connecting infrastructure).

For many developments, this will be a critical factor in achieving the key objective of removing surface water from the combined sewer system. This could therefore represent a significant opportunity for Thames Water / others to deliver these works and then for the individual plot developers to connect to these systems.

13.2.4 Cash flow for the works

It is recognised that certain solutions will involve significant cost, and that these costs will have to be incurred at an early stage in the overall development. In these circumstances, consideration will be required as to which party is best placed to be responsible for these works. Given the level of cost, it is very unlikely that one or more of the plot developers would be in a position to fund this, in part or as a whole, as the impact on their cash flow and hence the viability of their developments would be significant. In these circumstances, it would be preferable if Thames Water or a third party procured and funded these works, while recognising that there may be cross-charging mechanisms to the plot developer(s).

13.2.5 Potential for integrated infrastructure delivery

Development of the Charlton to Bexley OAs will involve extensive infrastructure delivery, to support the proposed development. As such, there are likely to be efficiencies which may be realised through adopting a cohesive strategy for integrated delivery of new water infrastructure in conjunction with other utilities, public realm or transport infrastructure.

13.2.6 Overall duration of the works

There is recognition that the delivery of the planned growth within the Charlton to Bexley OA could take place over 30 years and therefore this timescale needs to be considered when identifying an optimal delivery strategy. Given these timescales, there is a need to maintain flexibility in the solutions that are developed, so that they may be able to respond to new regulations, advancements in technology and changing market conditions over this period. As such, this long term approach and need to maintain flexibility could be more suited to Thames Water or other third parties, who are considered to be better placed to assess how this could impact on their approach to providing long-term solutions in the context of the wider network, rather than the plot Developers, who will be primarily concerned with solutions which meet the needs of their developments at the time when these are being delivered.

13.2.7 Appetite for taking on risk and responsibility for delivery of the works

This will have an impact on the delivery strategy; with a desire to place risk and responsibility with those parties who are best placed to manage this, but without this negatively impacting on the wider strategy for the delivery of the Charlton to Bexley Opportunity Area. As such, it is considered that the plot developers will be best placed to take on the risk and responsibility for those items which are critical to the delivery of their schemes and for which they have the ability to control the outcome. However, where there is a strategic solution which is for the benefit of the wider development and which requires a significant degree of control over the final outcome, then it's more likely that this will be best placed to be managed by Thames Water / others.

13.2.8 Nature of companies that can deliver the works

This will be a key aspect of the delivery strategy; recognising that the market is developing in terms of companies that have the ability to carry out strategic works of this nature, and that there are changing regulations affecting the delivery of such works in the water market. The impact of this is that there will be significant interest from the market in respect of delivery and long-term management of assets for development of this scale and importance, driven by the substantial revenue streams that will be available from a variety of end occupiers. There are a number of examples of major schemes that are being delivered currently through Energy Saving Companies (ESCOs) and Multi Utility Services Companies (MUSCOs) including Kings Cross in London. The potential for a scheme of this scale to attract interest from the market, allied with the changes in regulations of the water market is anticipated to be substantial.

13.3 Potential Delivery Approaches

Taking in to account all of the above factors, consideration has been given to the proposed solutions and how their delivery could be approached. This has been broadly divided between the foul and surface water management aspects of the strategy and the water recycling solutions, whilst recognising that some solutions will be applicable across more than one of these options.

13.3.1 Foul Water

Delivery of planned growth within the OAs will generally involve increasing development density and the water balance calculations indicate that foul flows will increase. It will therefore be necessary to install new foul sewers and to upgrade sections of the existing network. The following section defines the design standards, procurement options and adopting authority for foul sewers that are proposed to accommodate the additional foul flows.

13.3.1.1 New Foul Sewers

New foul sewers, pumping stations and rising mains that enable foul flows to be conveyed from development parcels to strategic sewers or wastewater treatment plant may be procured using one of the following options:-

- New foul sewers that extend through land controlled by the developer or the local authority may be designed and constructed by the developer before being offered to Thames Water for adoption under Section 104 of the Water Industry Act, providing that the new sewers are designed and constructed in accordance with the requirements of Sewers for Adoption and other mandatory build standards.
- New foul sewers that extend through third party land may be requisitioned from Thames Water under Section 98 of the Water Industry Act.

Developers are required to provide local foul drainage network to convey foul flows from new buildings to adopted foul sewers. These networks should be designed in accordance with the requirements of Building Regulations Part H. New foul drainage networks should be designed to restrict the extent of foul drainage that is privately maintained by ensuring that foul sewers that accommodate flows from more than a single curtilage or dwelling are offered for adoption to Thames Water.

13.3.1.2 Network Reinforcements

Additional foul flows that are discharged to combined sewers may be offset through the introduction of SuDS that will provide an equivalent, or greater reduction in surface water discharge to remove the requirement for the combined sewer network to be reinforced.

However, there is potential for network reinforcement works to be required for areas of the site that are currently served by foul sewer networks, where development density is to be increased. For sites of this nature, it will be necessary for development promoters to procure Sewer Impact Assessments from Thames Water and for these parties to pay for reinforcement works that are required to ensure that additional foul flows will not cause detriment to the performance of the existing foul sewer network.

13.3.2 Surface Water

A cascading system of SuDS is proposed to be installed as an integral part of the development to allow the peak discharge from rainfall events with a return period of 1 in 100 years (plus climate change) to be restricted to permissible rates, whilst ensuring that urban pollutants are removed and removing surface water from the combed sewer system. The following section defines the design standards, procurement options and adopting authority for each component of the SuDS treatment train.

13.3.2.1 Source Control Features within Development Plots

A range of SuDS have been proposed to be installed on plot in order to function as source control features that will attenuate and improve the quality of surface water where it is collected. Suitable systems include green roofs, permeable surfacing, bio-retention systems and below ground attenuation measures. These systems should ideally be designed to enable rainfall generated during events with a return period of up to 1 in 100 years plus 40% climate change to be restricted to the equivalent discharge for a rainfall event with a return period of 1 in 30 years, where the development parcels will discharge surface water to site control features situated within areas of public open space.

In constrained areas of the opportunity area, where it is not practical to provide site control features, it will be necessary to increase the size of SuDS systems to enable rainfall generated during events with a return period of up to 1 in 100 years plus 40% climate change to be restricted to permissible runoff rates.

SuDS systems that are installed on plot should generally be designed and installed by individual developers, in line with regional planning policy and guidance given by the LLFAs. On plot systems will generally be situated within unadopted areas of the site and it is therefore likely to be necessary for developers to engage management companies to maintain SuDS features in order to remove the requirement for individual residents to take this responsibility.

13.3.2.2 Site Control Features within areas of Public Open Space

Site control features will generally be required to provide secondary attenuation and contaminant removal. As strategic SuDS systems also provide a distributed attenuation capacity (assisting to alleviate the requirement for site specific capacity), the delivery of such features may additionally be a highly cost-effective means of delivering attenuation for the new development areas.

Suitable forms of site control features have been identified as bio-retention systems, swales and ponds. These systems should be designed to enable the peak discharge from the surrounding catchment to be restricted to permissible rates.

Site control features should generally be positioned within areas of public open space and they should be designed in accordance with the requirements of the LLFA with clear ongoing management and maintenance plans. Close consideration should be given to maintenance requirements and wherever possible, opportunities should be harnessed to provide innovative and low-maintenance SuDS systems. Emerging masterplans for the opportunity area should ideally be designed to incorporate areas of public open space at low points within the catchment to facilitate the provision of site control features. Green spaces should also be provided adjacent to receiving watercourses to accommodate site control features in order to allow overflows to be provided to convey excess flows generated by exceedance events from the site control feature to the receiving watercourse.

Where SuDS features are installed in areas of TfL road network, they should be designed with reference to the recently released TfL guidance on SuDS within the streetscape.

13.3.2.3 Surface Water Sewers

New surface water sewers that discharge directly to public surface water sewers should be designed and constructed in accordance with Sewers for Adoption to accommodate surface water generated during rainfall events with a return period of 1 in 30 years to allow them to be offered to Thames Water for adoption.

Proposed surface water sewers that convey attenuated flows from individual development plots to SuDS or watercourses should be designed in accordance with the requirements of the LLFA to allow them to be adopted.

13.3.2.4 Highway Drainage

Highways generate significantly higher risks of contamination than residential dwellings and highway runoff does not generate revenue. Thames Water is therefore likely to refuse applications for surface water runoff from new highways to be discharged to existing surface water sewers.

New highway drainage systems are therefore likely to be required to enable surface water runoff from adopted roads to be collected, attenuated and discharged directly to watercourses, wherever possible. New highway drainage systems and associated SuDS should be designed in accordance with the Design Manual for Roads and Bridges to allow them to be offered to the Highway Authority under a Section 278 Agreement. Where SuDS features are installed in areas of TfL road network, they should additionally be designed with reference to the recently released TfL guidance on SuDS within the streetscape[15].

13.3.2.5 Surface Water Discharge

A number of potential surface water discharge options have been considered within the strategy, including strategic groundwater recharge and surface water discharge to the River Thames. In cases where it is not immediately possible to drain to a watercourse, Thames Water may be willing to explore the option of adopting strategic infrastructure, such as surface water networks or pumping stations, to facilitate the ultimate removal of surface water from the combined sewer networks. While such options may result in ongoing operational costs, there may still be ultimate cost efficiencies over the current water treatment and management process associated with the combined sewer system.

13.3.3 Thames Water Sewer Diversions

Networks of adopted foul, surface water and combined sewers extend through the proposed development. These sewers have easements to enable Thames Water to maintain the existing assets in order to ensure that their hydraulic performance is maintained and that flood risk is reduced.

Masterplans for new developments should ideally be designed to enable existing easements for strategic sewer assets to be maintained by treating trunk sewers as a constraint to the development. In the event that this approach is not possible and proposed development block conflict with existing sewers, then it is likely to be necessary to obtain consent from Thames Water to divert existing assets under Section 185 of the Water Industry Act. Diversions of this form will need to be carefully planned to ensure that potential increases in sewer length will not adversely affect hydraulic capacity or self-cleansing velocities.

Building Over or Close to Agreements may be discussed with Thames Water for development parcels and structures that are proposed within 3m of a Thames Water asset. However, these agreements frequently impose restrictions on piling and introduce a requirement for pre and post construction surveys of sewers to be undertaken and it is therefore generally more desirable to divert sewers in the manner described within the preceding paragraph unless diversions would adversely affect hydraulic performance of the existing asset.

13.3.4 Water Supply

The water balance calculations indicate that the opportunity area will generate a significant additional demand for potable water and that opportunities exist to enable this demand to be reduced through the introduction of water recycling measures. The following section defines the procurement options and adopting authority for each element of the water supply network.

13.3.4.1 Traditional Approach

Thames Water would normally be responsible for supplying water to the proposed development. Systematic upgrades to the strategic water supply network may be delivered in one of the following ways, depending on timing:-

- Thames Water seeks to identify growth that will occur during the each five year Asset Management Plan period (AMP) so that they may apply to OFWAT for funding to enable strategic water mains to be installed.

[15] https://consultations.tfl.gov.uk/policy/suds-guidance/user_uploads/suds-in-london---a-design-guide_full-document.pdf

With sufficient notice, Thames Water may therefore seek funding to offset the construction costs of new potable water supply infrastructure against income that is predicted to be generated from the new water main. The offset will be provided in the form of an asset payments, where the new water main is installed under a self-lay agreement, or alternatively in the form of a commuted sum if the new water main is installed by Thames Water;

- A cost sharing agreement may be established between Thames Water and another party, such as the developer or Local Authority, in order to enable the delivery of potable water infrastructure to be accelerated to enable development.

Individual developers will be responsible for requisitioning new water mains that extend from the local water supply network to the proposed development. New water mains are traditionally requisitioned through Section 41 of the Water Industry Act 1991 and the party that is responsible for the requisition is responsible for paying the cost that Thames Water will incur when they install the water main.

13.3.4.2 Inset Agreement

An Inset Agreement could be considered as an alternative route to procure the water supply for the proposed development. This alternative arrangement would involve a third party organisation arranging the bulk supply of potable water including the construction, operation and maintenance of the water supply network that would extend through the new development.

Inset agreements may be granted when the following three criteria are satisfied:-

1. Where the premises of one or more customers is supplied with at least 50 Ml of water per year;
2. Where no premises within the area are already served by an appointed company and the site is classified as being unserved.
3. If the existing appointed company consents to the transfer of that area.

The Inset Appointee must have access to adequate water resources and recycling facilities in order to service the customers on the site. In the event that the Inset Appointee does not have access to these resources, then they must be purchased from Thames Water.

13.3.4.3 Water Recycling

Rainwater harvesting and greywater recycling have been identified as potential methods of reducing potable water demand. Rainwater harvesting systems are generally more appropriate for low density areas of development as they generally generate a lower maintenance burden. Greywater recycling systems are more effective for higher density developments, as the supply is more closely aligned to the demand; however, these systems are more onerous to maintain.

The requirement for water recycling measures to be provided within the OAs may be verified by commissioning Thames Water to undertake a Strategic Potable Water Supply Assessment. This study may be used to identify the extent and timing of network reinforcement works and to establish the effect that water recycling measures may have in delaying the timing of these works. Once the optimal extent of water recycling measures has been identified, the requirement for these features to be constructed as an integral part of the development may be enforced through planning policy.

The following two methods of delivering water recycling features may be considered:-

- Plot scale rainwater harvesting or greywater recycling options enable water to be captured at source and locally recycled for toilet flushing and irrigation purposes in order to enable the potable water demand of the development to be reduced. On plot water recycling solutions are traditionally installed by developers and maintained by management companies, or product manufacturers operating under a maintenance agreement.
- Area wide rainwater harvesting or greywater recycling systems would need to be procured, operated and maintained from Thames Water or an Inset Appointee. Area wide systems have not previously been deployed extensively within the UK, predominantly due to restrictions in the ability of water companies to charge for non-potable water. However, a site wide rainwater recycling system has recently been

successfully installed as part of the North West Cambridge development and the Cambridge Water company have successfully negotiated charging arrangements with OFWAT and there is therefore potential for area wide solutions to be considered by Thames Water.

13.4 Stakeholder Engagement

There are a large number and wide variety of stakeholders who will need to be engaged to facilitate the delivery of water management measures set out in this IWMS. Details of key stakeholders across the Opportunity Areas are provided in confidential Appendix B for use by the steering group, and this appendix also includes an initial plan for engaging the various stakeholders with an interest in and influence on the strategy.

Appendix A EU Directives, National Legislation and Guidance on Water

The growth within the Opportunity Areas will need to comply with EU Directives, UK legislation and guidance on water, as shown in Table A-1 below.

Table A-1: EU Directives & UK Legislation & Guidance on Water

Directive/Legislation/Guidance	Description
Birds Directive 2009/147/EC	Provides for the designation of Special Protection Areas.
Environmental Protection Act 1990	Integrated Pollution Control (IPC) system for emissions to air, land and water.
Flood & Water Management Act 2010	The Flood and Water Management Act 2010 is the outcome of a thorough review of the responsibilities of regulators, local authorities, water companies and other stakeholders in the management of flood risk and the water industry in the UK. The Pitt Review of the 2007 flood was a major driver in the forming of the legislation. Its key features relevant to this study are: • To give the Environment Agency an overview of all flood and coastal erosion risk management and unitary and county councils the lead in managing the risk of all local floods. • To encourage the uptake of sustainable drainage systems by removing the automatic right to connect to sewers. • To widen the list of uses of water that water companies can control during periods of water shortage, and enable Government to add to and remove uses from the list. • To enable water and sewerage companies to operate concessionary schemes for community groups on surface water drainage charges. • To make it easier for water and sewerage companies to develop and implement social tariffs where companies consider there is a good cause to do so, and in light of guidance issued by the Secretary of State.
Future Water, February 2008	Sets the Government's vision for water in England to 2030. The strategy sets out an integrated approach to the sustainable management of all aspects of the water cycle, from rainfall and drainage, through to treatment and discharge, focusing on practical ways to achieve the vision to ensure sustainable use of water. The aim is to ensure sustainable delivery of water supplies, and help improve the water environment for future generations.
Groundwater Directive 80/68/EEC	To protect groundwater against pollution by 'List 1 and 2' Dangerous Substances.
Habitats Directive 92/44/EEC and Conservation of Habitats & Species Regulations 2010	To conserve the natural habitats and to conserve wild fauna and flora with the main aim to promote the maintenance of biodiversity taking account of social, economic, cultural and regional requirements. In relation to abstractions and discharges, can require changes to these through the Review of Consents (RoC) process if they are impacting on designated European Sites. Also the legislation that provides for the designation of Special Areas of Conservation provides special protection to certain non-avian species and sets out the requirement for Appropriate Assessment of projects and plans likely to have a significant effect on an internationally designated wildlife site.
Land Drainage Act 1991	Sets out the statutory roles and responsibilities of key organisations such as Internal Drainage Boards, local authorities, the Environment Agency and Riparian owners with jurisdiction over watercourses and land drainage infrastructure.
Making Space for Water, 2004	Outlines the Government's strategy for the next 20 years to implement a more holistic approach to managing flood and coastal erosion risks in England. The policy aims to reduce the threat of flooding to people and property, and to deliver the greatest environmental, social and economic benefit.
National Planning Policy Framework (NPPF)	Planning policy in the UK is set by the National Planning Policy Framework (NPPF). Supported by the online Planning Practise Guidance (PPG) NPPF advises local authorities and others on planning policy and operation of the planning system.

Directive/Legislation/Guidance	Description
NPPF Guidance SuDS Policy (April 2015)	Sustainable Drainage Systems (SuDS) are an approach to managing rainwater and surface water that replicates natural drainage, the key objectives being to manage the flow rate and volume of runoff at source, in order to reduce risk of flooding and to improve water quality. From 6th April 2015, the Planning Practice Guidance for Flood Risk and Coastal Change (PPG) was amended to provide a stronger emphasis on the implementation of SuDS. LPAs (such as Royal Borough of Greenwich and London Borough of Bexley) are required to ensure that SuDS are incorporated in all major development plans where appropriate, and through the use of planning conditions or planning obligations, make sure that there are clear arrangements in place for ongoing maintenance over the lifetime of the development. LLFAs are statutory consultees for surface water drainage. As LLFAs, each local authority will need to be consulted on the drainage elements of planning applications for major development to ensure they take account of the Government's 'Sustainable Drainage Systems: Non-Statutory Technical Guidance' .
Ramsar Convention	Provides for the designation of wetlands of international importance
National Strategy for Flood and Coastal Erosion Risk Management	In accordance with the FWMA, the Environment Agency has developed a National Strategy for Flood and Coastal Erosion Risk Management (FCERM) in England . This Strategy provides a framework for the work of all flood and coastal erosion risk management authorities. The National FCERM Strategy sets out the long-term objectives for managing flood and coastal erosion risks and the measures proposed to achieve them. It sets the context for, and informs the production of local flood risk management strategies by LLFAs, which will in turn provide the framework to deliver local improvements needed to help communities manage local flood risk. It also aims to encourage more effective risk management by enabling people, communities, business and the public sector to work together to: • ensure a clear understanding of the risks of flooding and coastal erosion, nationally and locally, so that investment in risk management can be prioritised more effectively; • set out clear and consistent plans for risk management so that communities and businesses can make informed decisions about the management of the remaining risks; • encourage innovative management of risks taking account of the needs of communities and the environment; • ensure that emergency responses to flood incidents are effective and that communities are able to respond properly to flood warnings; and, • ensure informed decisions are made on land use planning. The Environment Agency's 'Adapting to Climate Change: Advice for Flood and Coastal Erosion Risk Management Authorities' guidance is a supporting note for the National FCERM Strategy. It provides the UK Climate Projections (UKCP09) climate change factors for river flood flows and extreme rainfall for each river basin district, and provides advice on applying climate change projections in the FCERM. It is essential that land use planning decisions consider the impact of a changing climate where appropriate.
Urban Waste Water Treatment Directive (UWWTD) 91/271/EEC	This Directive concerns the collection, treatment and discharge of urban waste water and the treatment and discharge of waste water from certain industrial sectors. Its aim is to protect the environment from any adverse effects caused by the discharge of such waters.
Water Act 2003	Implements changes to the water abstraction management system and to regulatory arrangements to make water use more sustainable.
Water Framework Directive (WFD) 2000/60/EC	The WFD is the most significant piece of water legislation since the creation of the EU. The overall requirement of the directive is that all waterbodies in the UK must achieve "Good Status". The current review cycle has established this target for 2027. The definition of a waterbody's 'status' is a complex assessment that combines standards for water quality with standards for hydromorphology (i.e. habitat and flow quality) with ecological requirements. The Environment Agency is the body responsible for the implementation of the WFD in the UK. The Environment Agency have been supported by UKTAG[16], an advisory body which has proposed water quality, ecology, water abstraction and river flow standards to be adopted in order to ensure that water bodies in the UK (including groundwater) meet the required status[17]. The two key aspects of the WFD relevant to the wastewater assessment in this study are the policy requirements that: • development must not cause a deterioration in status of a waterbody[18]; and • development must not prevent future attainment of 'good status', hence it is not acceptable to allow an impact to occur just because other impacts are causing the status of a water body to already be less than good.

[16] The UKTAG (UK Technical Advisory Group) is a working group of experts drawn from environment and conservation agencies. It was formed to provide technical advice to the UK's government administrations and its own member agencies. The UKTAG also includes representatives from the Republic of Ireland.

Directive/Legislation/Guidance	Description
Natural Environment & Rural Communities Act 2006	Covering Duties of public bodies – recognises that biodiversity is core to sustainable communities and that Public bodies have a statutory duty that states that "every public authority must, in exercising its functions, have regard, so far as is consistent with the proper exercise of those functions, to the purpose of conserving biodiversity
Water Resources Act 1991	Protection of the quantity and quality of water resources and aquatic habitats. Parts have been amended by the Water Act 2003. Also sets out flood defence responsibilities of the Environment Agency for main rivers
Wildlife & Countryside Act 1981 (as amended)	Legislation that provides for the protection and designation of SSSIs and specific protection for certain species of animal and plant among other provisions.

[17] UK Environmental Standards and Conditions (Phase I) Final Report, April 2008, UK Technical Advisory Group on the Water Framework Directive.
[18] i.e. a reduction High Status to Good Status as a result of a discharge would not be acceptable, even though the overall target of good status as required under the WFD is still maintained

Appendix B Stakeholder Engagement

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Appendix C Proposed Growth Assumptions Technical Note

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Appendix D Water Balance Methodology and Key Assumptions

Baseline Site Conditions

Limited information has been sourced on the current site conditions for each growth area. As such, master-map OS data has been analysed to determine proportional land coverage and surface permeability within the following categories:

- Buildings;
- Land (assumed to comprise 50% permeable space and 50% impermeable space);
- Water;
- Land for rail (assumed to comprise 50% permeable space and 50% impermeable space);
- Roads, tracks and paths (assumed to be wholly impermeable).

Baseline water consumption has been estimated by considering the modelled demand information supplied by Thames Water. The data provided included daily demands for each sub-area (District Metered Area [DMA]) within the Thames Water network supply zone (Riverside Demand Zone). This information is based on a calibration day (Thursday) in January 2015.

The annual demand in each growth area was estimated proportionally by assuming an even spatial distribution of demand across the area occupied by each DMA within the opportunity areas.

Household demands were assumed to apply every day of the year, while non-household demands were assumed to apply over 253 days within each year. The split between potable and non-potable use has been assumed based on standard fittings consumption.

Overall wastewater discharge was estimated using the water demands, and split of grey water to black water assumed based on equivalent fittings consumption. No system loss or leakage has been included in the model at this stage.

Growth Assumptions

The post-development water balance has been developed based on the growth scenario assumptions detailed in Chapter 4. Across each known site allocation, assumptions have been made about the development layout and land cover, which are summarised below:

- Developable housing and employment area has been assumed to cover 80% of the total site area. Of this developable area:
  - 60% is assumed to be covered by built footprint,
  - The remaining 40% covered by landscaping, hardstanding and parking with an assumption of 50% permeable and 50% impermeable.
- Transport infrastructure is assumed to account for 4% of overall site area and is assumed to be totally impermeable.
- Social and hard infrastructure accounts for 12% of overall area and is also assumed to be totally impermeable.
- Public realm (outside the developable area) is assumed to account for 4% of overall area, comprised of 50% permeable and 50% impermeable surfaces.

Post Development Conditions

The post development site conditions have assumed a net increase of population and employment, and associated water demand and wastewater discharge, based on the planning data analysis. Land coverage for the site allocations has been taken as detailed above, assuming residual (undeveloped) land across each growth area maintains the same proportional coverage split as in the pre-development state.

Precipitation, Runoff and Evapotranspiration

Long term precipitation data for the local area has been provided by the Environment Agency. This was used to generate an average annual rainfall of 632 mm, applied over the area to estimate total annual precipitation.

Estimates for stormwater and roofwater were obtained using the land use (and permeability) assumptions detailed above, with the following assumed annual volumetric runoff coefficients:

- Rooftop areas - 0.9.
- Grass / Pervious Surface – 0.2.
- Hardstanding / impervious surfaces - 0.7.

Balancing estimates for evapotranspiration and infiltration were used to complete the mass balance.

Water Demand

Domestic water demands were estimated using the Building Regulations 2010 (BR 2010) Part G (2015 Edition) Water Efficiency Calculator for New Dwellings. Non-domestic demand was calculated using BS8524:2001 Calculating domestic water consumption in non-domestic buildings. For both these methodologies, the total water demand is based on assumptions on the use of sanitary fittings.

It is assumed that all new buildings will be constructed to the high efficiency Optional Performance criteria specified in BR2010, corresponding to end use water efficiency targets specified in the London Plan. No allowance for outdoor water use or normalisation factor was applied to the water demand estimates. The resultant water use assumptions for domestic and non-domestic properties are summarised in Table D-1 and D-2 below.

Table D-1: Domestic Water Use

Domestic Sanitary Ware	Water Demand (L/person/day)
Potable	97.80
Bathroom taps	9.48
Bath	18.70
Shower	34.96
Kitchen taps	13.00
Dishwasher	4.50
Washing machine	17.16
Non-Potable	13.54
WC full flush	5.84
WC part flush	7.696
Total domestic water demand	111.33

Table D-2: Non- Domestic Water Use

Non-Domestic Sanitary Ware	Water Demand (L/person/day)
Potable	17.65
Hand basins	5.00
Showers	1.34
Kitchenette	3.58
Dishwasher	0.60
Kitchen Canteen	7.13
Non-Potable	*18.00*
WC male (4.5 litre)	9.00
WC female (4.5 litre)	9.00
Total non-domestic water demand	*35.65*

Wastewater Generation

Wastewater generation was calculated using the same fittings consumption values. Grey water was taken to be water generated from bath, shower and hand basin. Black water was taken as water generated from the kitchen, toilets and laundry. No system loss has been applied to the wastewater estimates at this stage.

The resultant wastewater assumptions are summarised in Table D-3 and D-4 below.

Table D-3: Domestic Wastewater Generation

Domestic Sanitary Ware	Wastewater Generation (L/person/day)
Grey	63.14
Bathroom taps	9.48
Bath	18.70
Shower	34.96
Black	48.19
Kitchen taps	13.00
Dishwasher	4.50
Washing machine	17.16
WC full flush	5.84
WC part flush	7.70
Total domestic water demand	111.33

Table D-4: Non-Domestic Wastewater Generation

Non-Domestic Sanitary Ware	Wastewater Generation (L/person/day)
Grey	6.34
Hand basins	5.00
Showers	1.34
Black	*29.31*
Dishwasher	0.60
Kitchenette	3.58
Kitchen Canteen	7.13
WC male	9.00
WC female	9.00
Total domestic water demand	*111.33*

Methodology Limitations

In considering these calculations, it should be noted that the master-planning for this growth areas is still at an early stage, and therefore only limited resolution is currently available regarding the anticipated residential and commercial development. Additionally, only limited information on the current land use is available. Therefore, whilst the model calculations provide a good indication of the relative magnitude of various flows, they are based on several assumptions and simplifications in order to facilitate strategic-level analysis and planning, and should not be regarded as assured volumes. More detailed analysis will be required at a later stage in each growth area in order to determine the exact volumes, and detailed design of the required infrastructure undertaken.

Appendix E Constraints and Opportunities Mapping

Purpose

The purpose of the constraints mapping is to provide a high level overview of water cycle constraints and opportunities for water management linked to the Opportunity Areas (OAs). Constraint and opportunity mapping is key to shaping decisions on which water management measures are feasible and most appropriate across the OAs when developing option scenarios for the IWMS.

The maps present a visual register of the key water service and flood risk infrastructure assets, other influencing infrastructure and high level environmental constraints.

The maps have been developed through stakeholder engagement and a review of existing GIS information covering the four OAs within the Study Area. The knowledge of Thames Water's water supply and wastewater network teams has been utilised to provide a high level spatial assessment of the capacity constraints in both the sewer network and the water supply network. The mapping has also included a review of:

- sensitive receptors;
- potential land contamination;
- infiltration potential of soils and geology;
- natural drainage catchments, and
- surface water management.

The Constraints Maps

The following draft maps covering the whole study area have been produced for information and to aid steering group/stakeholder discussion of options:

Figure E.1 Thames Water supply Network Infrastructure Locations and Constraints;

Figure E.2 Thames Water Sewer Network Infrastructure Locations and Constraints;

Figure E.3 Surface Water Catchments and Topography Constraints;

Figure E.4 Geological Constraints;

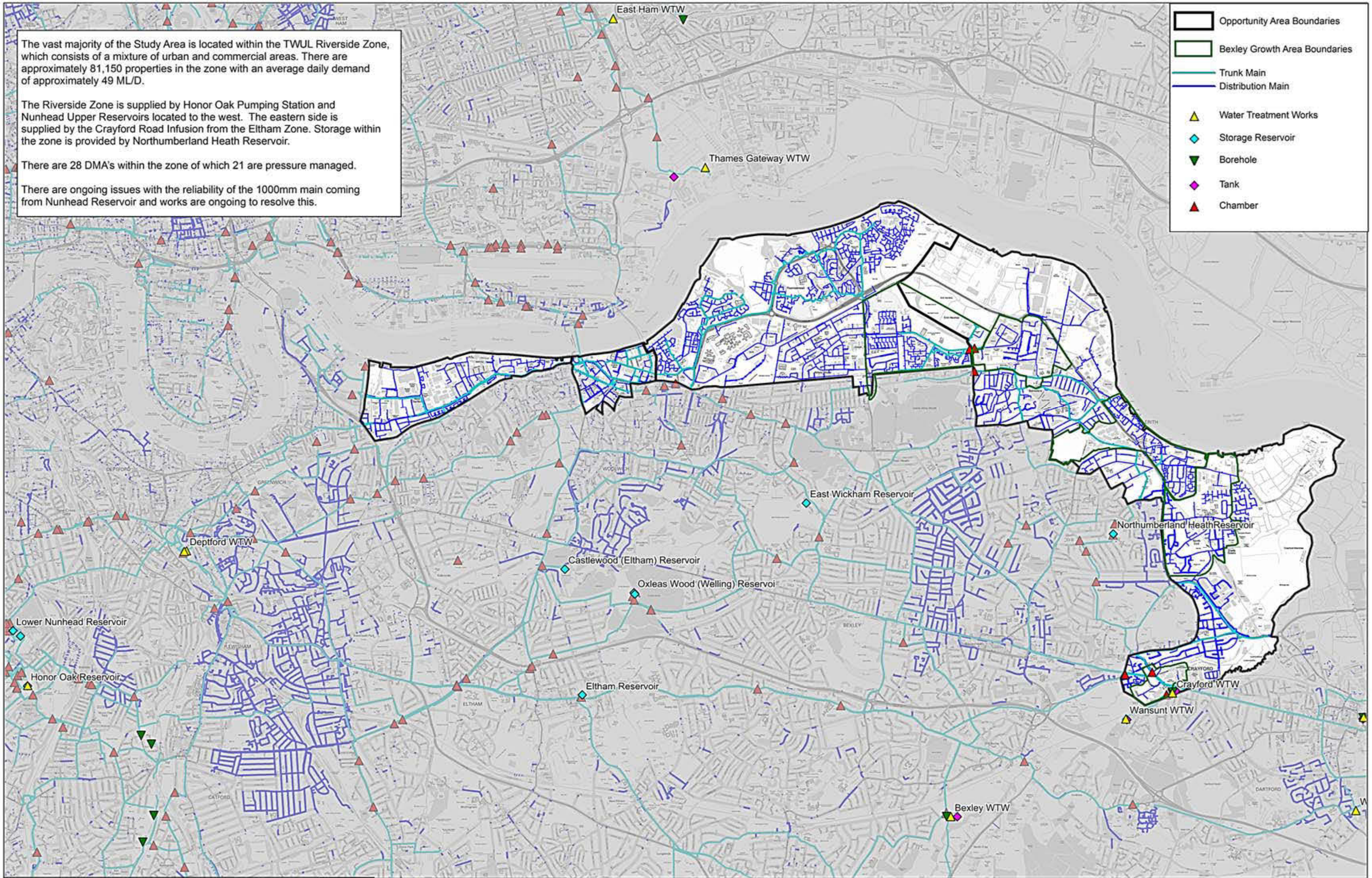
Figure E.5 Environmental Designation Constraints;

Figure E.6 Contaminated Land Constraints;

Figure E.7 Infrastructure Constraints; and

Figure E.8 Tidal and Fluvial Flood Risk.

Figure E.9 Flood Risk Hotspots



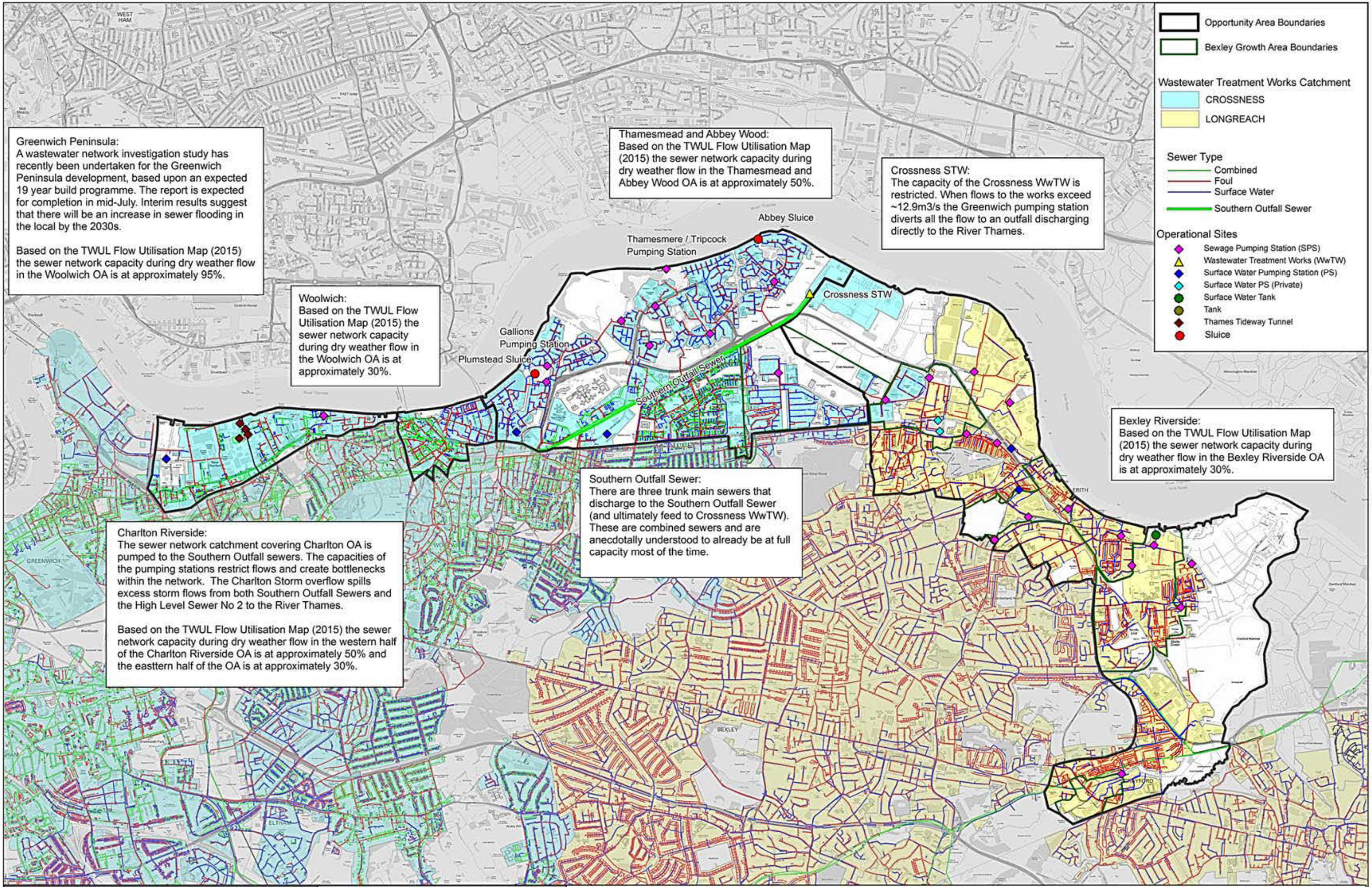
Charlton to Bexley Riverside IWMS

Thames Water Water Supply Network Constraints STUDY AREA

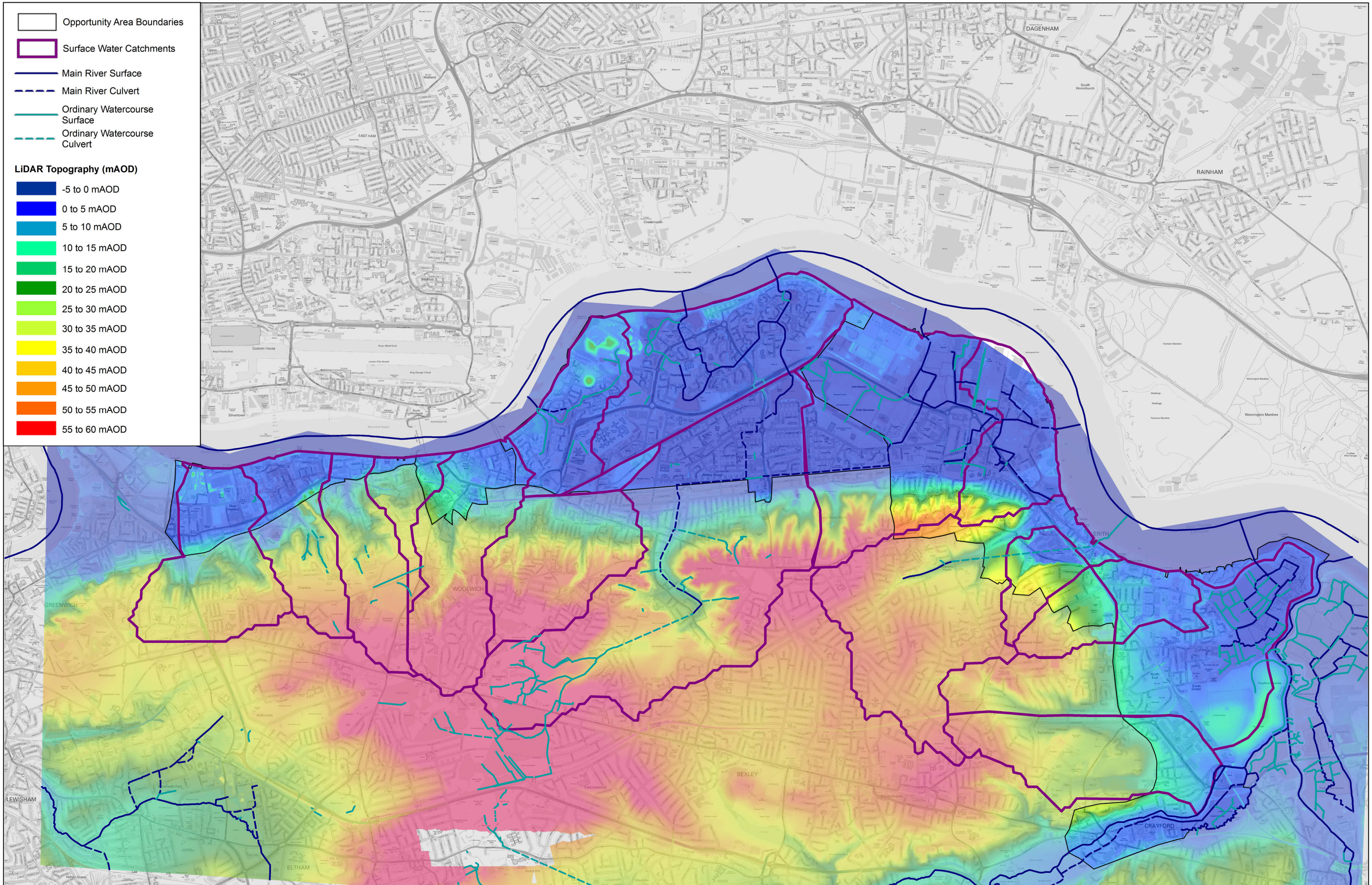
Scale 1: 47,000

FINAL

AECOM



Charlton to Bexley Riverside IWMS **Thames Water Sewer Network Constraints STUDY AREA**	Scale 1: 40,000 Copyright: Contains Ordnance Survey data © Crown copyright and database right 2017	**FINAL**	AECOM



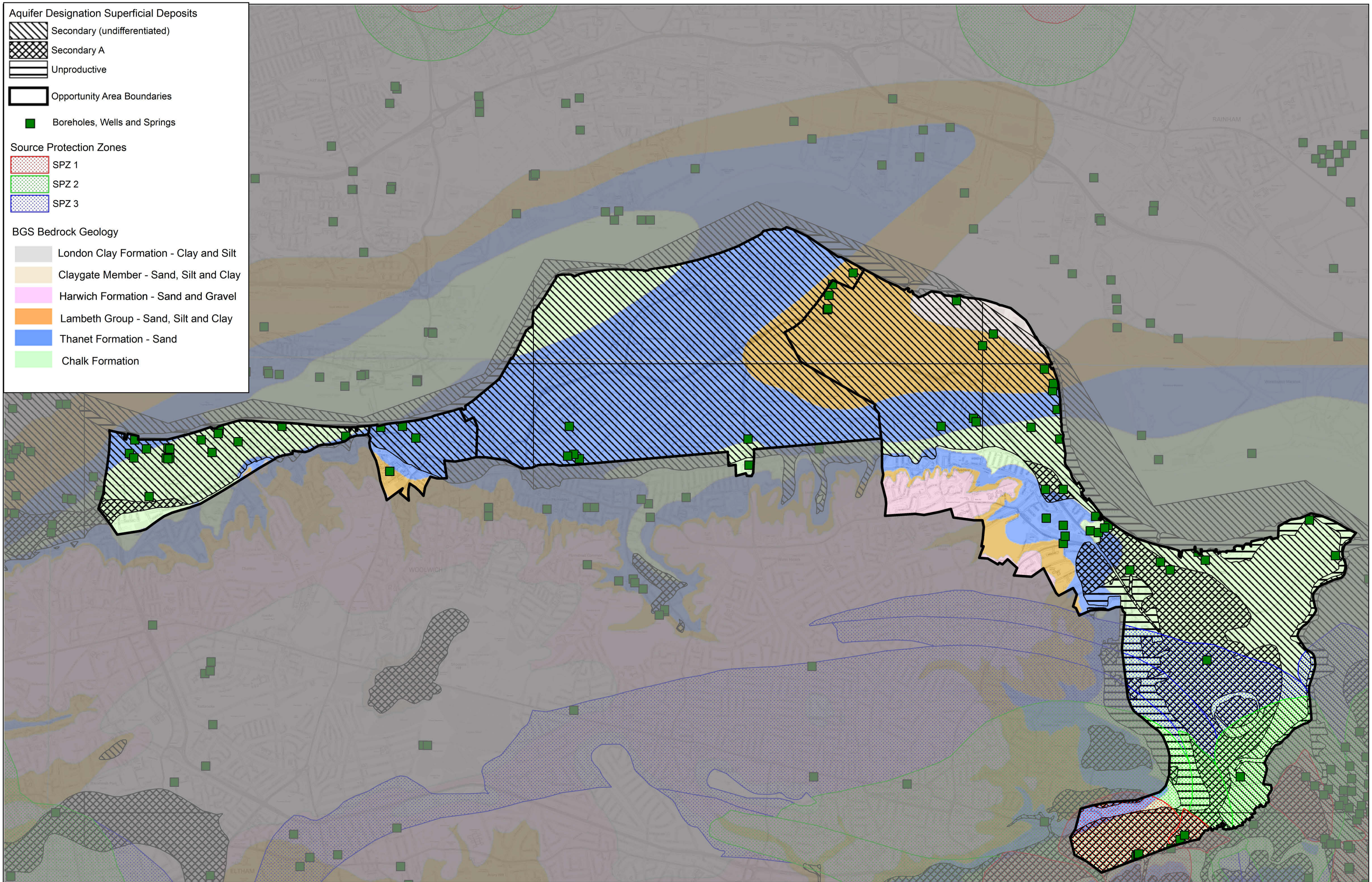
Charlton to Bexley Riverside IWMS

Topography and Surface Water Catchment Constraints
STUDY AREA

Scale 1: 40,000

FINAL

AECOM

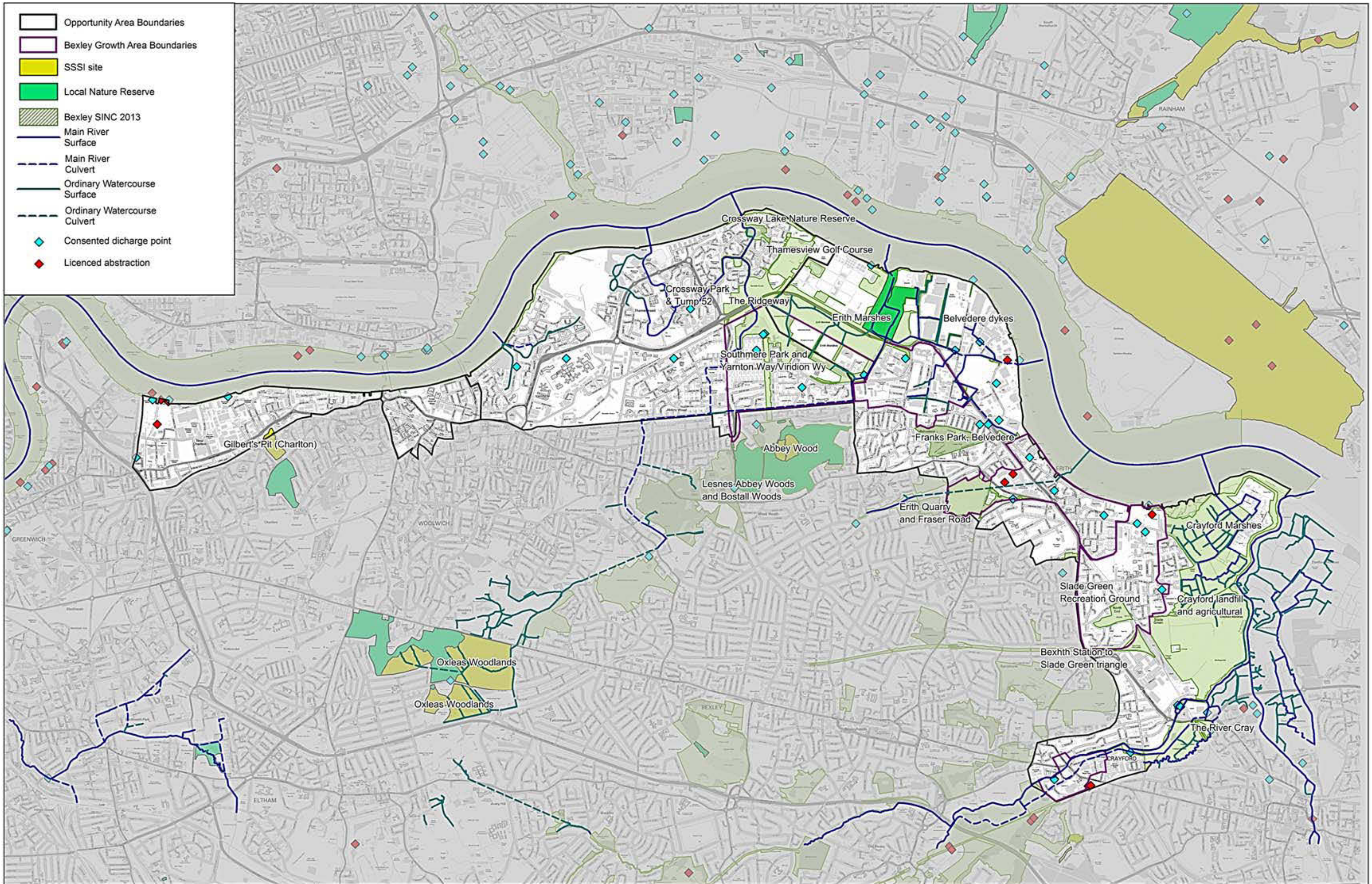


Charlton to Bexley Riverside IWMS

Geological Constraints
STUDY AREA

Scale 1: 40,000

FINAL



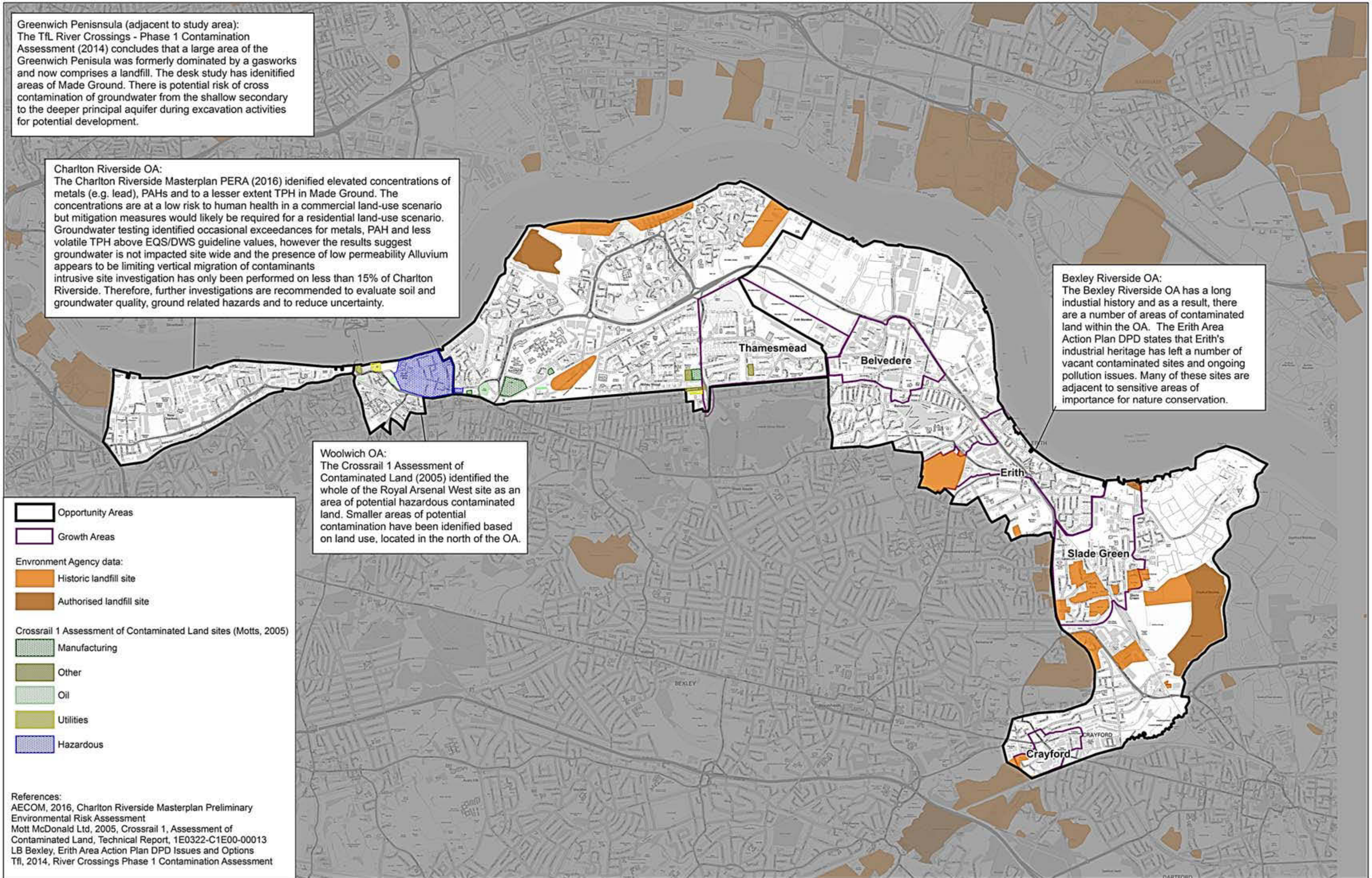
Charlton to Bexley Riverside IWMS

Environmental Constraints STUDY AREA

Scale 1: 40,000

FINAL

AECOM



Charlton to Bexley Riverside IWMS

Contaminated Land Constraints
STUDY AREA

Scale 1: 40,000

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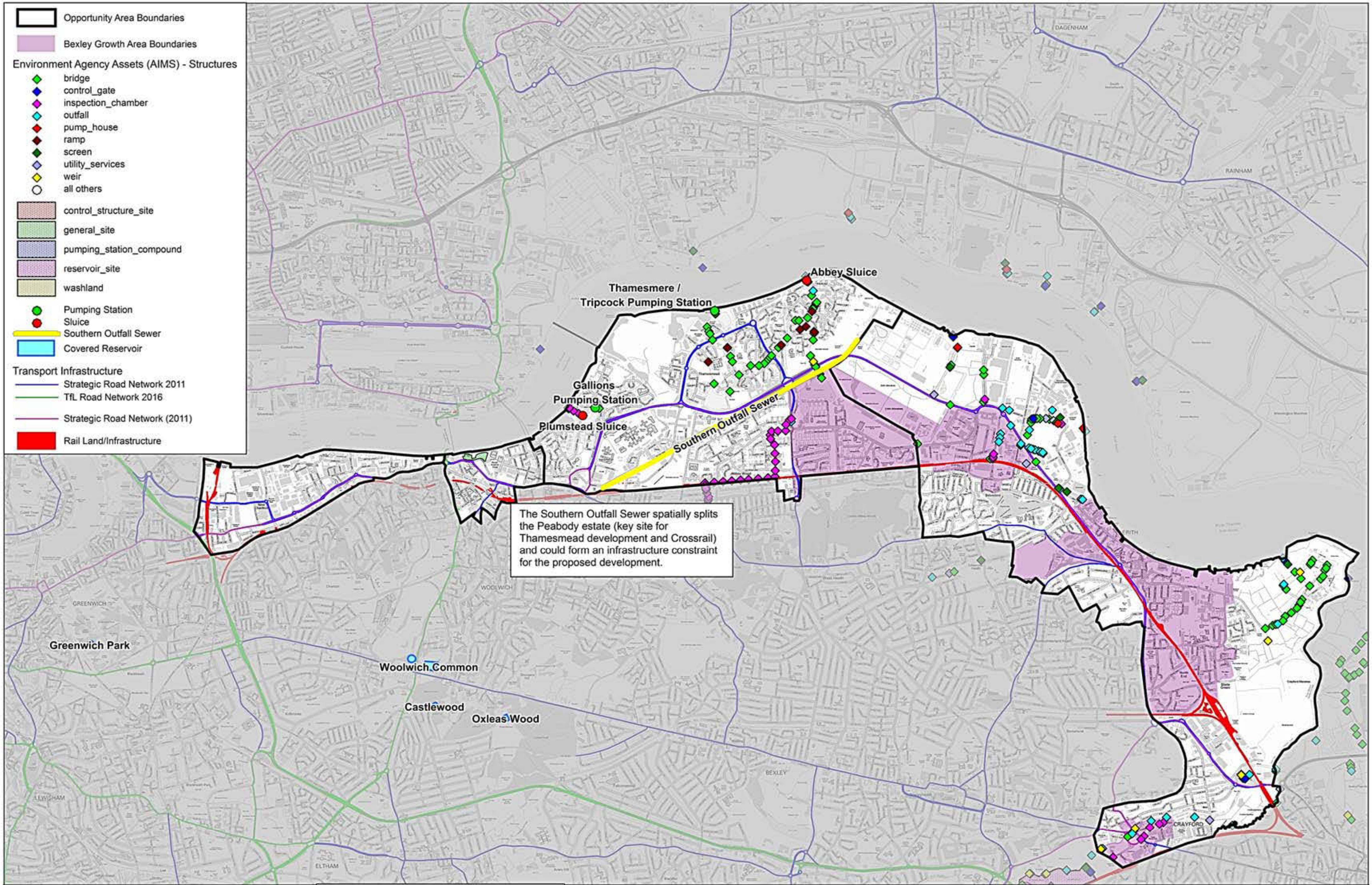


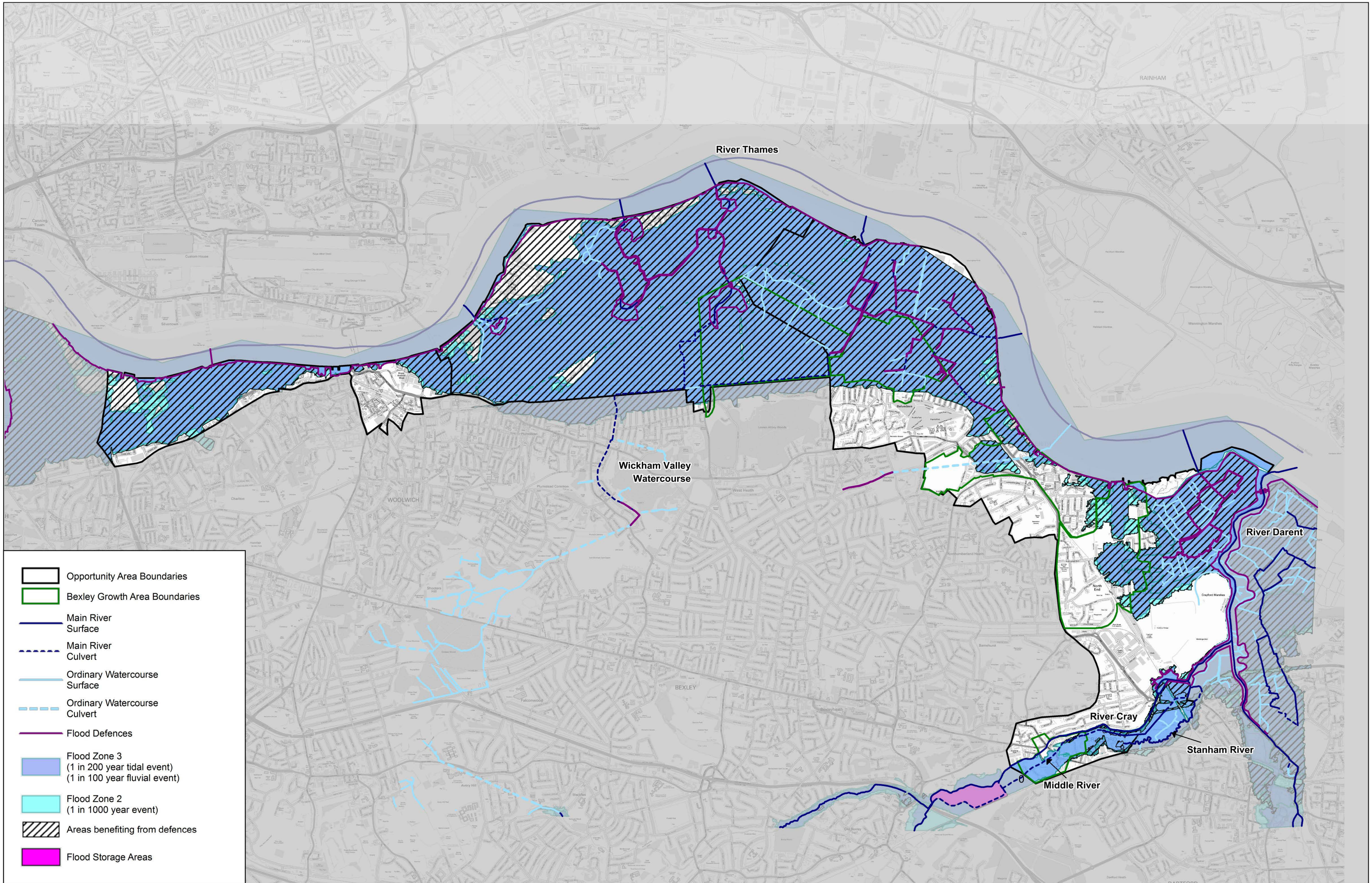
Charlton to Bexley Riverside IWMS

Infrastructure Constraints
STUDY AREA

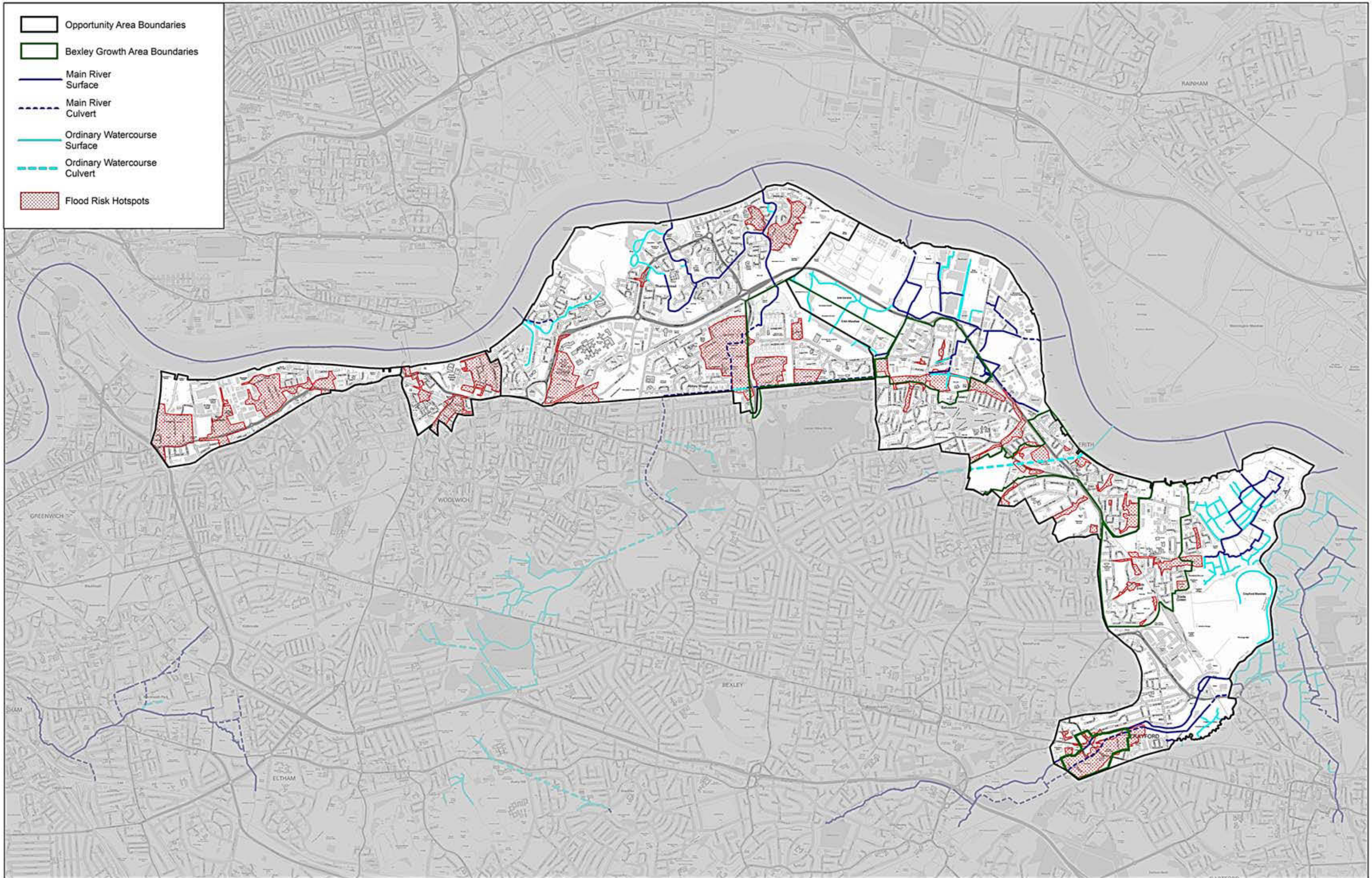
Scale 1: 40,000

FINAL

AECOM



Charlton to Bexley Riverside IWMS Fluvial and Tidal (Residual) Flood Risk Constraints - STUDY AREA	Scale 1: 37,000 Copyright: Contains Ordnance Survey data © Crown copyright and database right 2017	FINAL	AECOM



Charlton to Bexley Riverside IWMS

Food Risk Hotspots (Other Sources)
STUDY AREA

Scale 1: 40,000

FINAL

AECOM

Appendix F Strategic-level Flood Risk Assessment

Introduction

The purpose of this technical note is to provide a summary of the risks from all sources of flooding to the Study Area, highlighting where the key flood risk hotspots are within each of the four Opportunity Areas (OAs), and identify any management opportunities available to mitigate these risks. The outcomes of this technical note will inform the Charlton to Bexley IWMS with regards to local flooding constraints to development and help to determine which management options within the London Plan SuDS heirarchy are feasible within the OAs.

The assessment has involved a review of the existing flood risk evidence documents covering the four OAs within the Study Area, including the existing borough-wide Strategic Flood Risk Assessments (SFRAs) and Local Flood Risk Manangment Strategies (LFRMS), to identify whether there is sufficient information to support the Charlton to Bexley IWMS.

Please note - This document provides a strateguc level summary of the risks of flooding from all sources to the Study Area for the specific purposed of the IWMS objectives. It should be used for planning purposes. It does not replace Strategic Flood Risk Assessments will be required as part of the Local Plan process.

Objectives

The key objectives of the flood risk summary for the study area are:

- to determine flood risk from all sources across the study area, particularly with regard to residual risk in the event of breach or overtopping of the tidal defences.
- identify flood risk hotspots by combining risk from a range of sources.
- identify existing and proposed mitigation options required to manage that risk.
- identifying where significant risks (flood risk hotspots) need to be managed, and where options to manage risk can be combined with potential water attenuation and re-use at a strategic scale.

Existing Evidence Base

Table 1: Existing Evidence Base for the Study Area

<table>
<tr><th>Evidence</th><th>Link</th><th>Description</th></tr>
<tr><td>RB Greenwich Level 1 Strategic Flood Risk Assessment (AECOM, 2016)</td><td>http://www.royalgreenwich.gov.uk/downloads/download/783/strategic_flood_risk_assessment_greenwich</td><td rowspan="2">A strategic assessment of the risk of flooding across the Borough from the tidal Thames, fluvial watercourses, ordinary watercourses, surface water, groundwater, reservoirs and drainage infrastructure.</td></tr>
<tr><td>LB Bexley Level 1 and Level 2 Strategic Flood Risk Assessment (Entec, 2010 & 2014)</td><td></td></tr>
<tr><td>RB Greenwich Local Flood Risk Management Strategy (2015)</td><td></td><td rowspan="2">The LFRMS is a document which sets out how the Lead Local Flood Authority (LLFA) is responding to identified local flood risk across the Borough and specifies:
• the RMAs in the Borough;
• the flood and coastal erosion risk management functions that may be exercised by the RMAs in relation to the Borough;
• the objectives for managing local flood risk;
• the measures proposed to achieve those objectives;
• how and when the measures are expected to be implemented;
• the costs and benefits of those measures, and how they are to be paid for;
• the assessment of local flood risk for the purpose of the Local Strategy;
• how and when the LFRMS is to be reviewed; and,
• how the Local Strategy contributes to the achievement of wider environmental objectives.</td></tr>
<tr><td>LB Bexley Local Flood Risk Management Strategy Action Plan (2015)</td><td></td></tr>
</table>

Evidence	Link	Description
RB Greenwich Surface Water Management Plan (Halcrow, 2011)		A SWMP is a plan which outlines the preferred surface water management strategy in a given location. In this context surface water flooding describes flooding from sewers, drains, groundwater, and runoff from land, small water courses and ditches that occurs as a result of heavy rainfall.
RB Greenwich Ordinary Watercourse Database (URS & JBA, 2016)		
Thamesmead Lakes and Canals study (URS, 2011)		Update of the hydraulic model for the two lake and canal systems in Thamesmead – the Western Catchment, and the Central and Eastern Catchment.
Regional Flood Risk appraisal for Greater London – First Review (August 2014)		Outlines current flood risk characteristics and potential future flood risk mitigation measures for each major development opportunity area in Greater London, including those within this study area.
Thames River Basin District Flood Risk Management Plan 2015 – 2021 (Environment Agency, 2014)		Thames River Basin District FRMP has been published by the Environment Agency and sets out the proposed measures to manage flood risk in the Thames River Basin District from 2015 to 2021 and beyond.
Thames Estuary 2100 plan (TE2100), (Environment Agency, 2012)		The TE2100 Plan, established by the Environment Agency in 2002, set out recommendations for flood risk management for London and the Thames estuary through to the end of century and beyond. The Plan primarily looks at tidal flooding, though other sources of flooding including high river flows as a result of heavy rainfall and surface water flooding are considered. The key driver for the project was to consider how tidal flood risk was likely to change in response to future changes in climate and people and property in the floodplain. Additional to this there was an understanding that many of the existing flood walls, embankments and barriers were getting older and would need to be raised or replaced to manage rising water levels.
Managing the Marshes Vision and Strategy (LB Bexley, 2006)		The marshes contribute to the East London and Kent Thameside Green Grids. The Crayford/Dartford Marshes and Rainham Marshes (jointly referred to as the "Inner Thames Marshes") are identified as one of three strategically important open space opportunities in the London Thames Gateway.
• Charlton riverside Draft Masterplan SPD (2012); • Woolwich Town Centre Draft Masterplan SPD (2012); • Thamesmead and Abbeywood SPD (2009).		

Sources of Flood Risk and Responsibilities

There are a number of Risk Management Authorities (RMAs) that have responsibilities and powers for managing flood risk within the study area, including the Environment Agency, the LLFAs and Thames Water Utilities Limited. In order to achieve strategic flood risk management it is important that the RMAs co-operate, share information, and contribute towards the achievement of sustainable development. Table 2 summaries the RMAs that are responsible for different sources of flooding within the study area.

Table 2. Sources of flood risk and RMAs responsible within the study area.

Flood Source	Responsible RMA	Description
Tidal	Environment Agency	Can occur due to tidal storm surges or high tides overtopping banks. Where there are tidal Thames defences, there is a risk of tidal flooding if the defences fail.
Main River	Environment Agency	Can occur when a river cannot cope with the volume of water draining into it or becomes blocked by debris and overflows its banks onto surrounding land.

Flood Source	Responsible RMA	Description
Ordinary Watercourses	LLFA (RB Greenwich and LB Bexley)	Can occur when other watercourses, such as streams, ditches, drains, cuts, dykes and sluices cannot hold the volume of water flowing through them and overflow onto surrounding land.
Surface Water	LLFA (RB Greenwich and LB Bexley)	Can occur when heavy rainfall cannot be absorbed into the ground or enter the drainage systems.
Groundwater	LLFA	Can occur when water levels in the ground rise above surface levels, which is most likely to occur in areas underlain by permeable rocks and after long periods of rainfall.
Sewers	Thames Water	Can occur when surface water or combined (surface water and foul) sewers are overwhelmed by heavy rainfall, which exceeds the capacity of the sewer network, the system becomes blocked by debris or sediment, and/or the system surcharges due to high water levels in the receiving watercourse.
Reservoir	Environment Agency	Can occur when reservoirs, which hold large volumes of water above ground, overtop or breach, resulting in a fast release of water.

Flood risk by Opportunity Area

Tables 3 to 6 present a summary of the flood risk from all sources to each of the four OAs within the study area, based on the datasets outlined in Table 2 as well as historical flood risk incident data received from various Risk Management Authorities.

Flood Risk Hotspots

As part of Drain London studies, rainfall runoff modelling was undertaken to identify Local Flood Risk Zones (LFRZs) for each Borough as areas where flooding affects houses, businesses and/or infrastructure. Critical Drainage Areas (CDAs) were then delineated to cover the wider drainage catchment areas where mitigation measures may be implemented to reduce flooding experienced in the flood risk zone. The catchment may cover more than one LFRZ.

As part of this IWMS, the baseline and historical flooding incident information from all flood risk sources, including the LFRZs and CDAs, have been used to identify Flood Risk Hotspots within each OA. Flood Risk Hotspots are locations that locally have a higher risk of flooding compared to the study area due to one or more sources of flood risk. They have been identified based on land which is located within, or subject to one or more of the following:

- Fluvial Flood Zones 2 or 3;
- Close proximity to waterbodies (rivers, canals, ponds or water features) with either historical flood records and or susceptibility to flooding;
- Significant area of land with a modelled surface water flood risk of ‘High’ (1 in 30 year), or ‘Medium’ (1 in 100 year); and
- More than one historical record of flooding from any source.

Developers are encouraged to provide flood mitigation solutions where the development falls within or close to a Flood Risk Hotspot and is at risk from multiple flood sources. These solutions should be identified in the early stages of planning.

Climate Change Allowances

In February 2016 the Environment Agency published revised guidance on climate change allowances in an update to the document ‘Adapting to Climate Change: Advice to Flood and Coastal Erosion Risk Management Authorities’[1]. This document reflects an assessment completed by the Environment Agency between 2013 and 2015 using UKCP09 data, to produce more representative climate change allowances for river basin districts across England.

The new guidance determines the climate change allowances that should be considered for net sea level rises, peak river flow and peak rainfall intensity across England and Wales and are significantly different to the previous values. Therefore the new guidance should be used as the standard for tidal, fluvial and surface water flood risk.

[1] Environment Agency, February 2016, Adapting to Climate Change: Advice to Flood and Coastal Erosion Risk Management Authorities. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/516116/LIT_5707.pdf

At the time of publishing this IWMS, the updated climate change allowances have not been incorporated into the fluvial flood models or the Environment Agency's Flood Map for Surface Water for this study area. Therefore the flood risk identified for each OA and growth area in Tables 3 to 6 have followed the previous climate change allowances set out in each Council's SFRAs.

It is important to note that any future site specific FRAs would be required to consider the updated climate change allowances. Further details of the new climate change guidance can be found on the Environment Agency website: https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances

Table 3. Summary of flood risk for all sources of flooding in Charlton Riverside OA

Charlton Riverside OA:

Topography/Infrastructure/Characteristics:

The Charlton Riverside OA is relatively flat, with areas of higher land along the southern boundary and in the north east corner. The majority of the OA is between 3 mOAD and 6 mOAD, however the Thames Barrier Industrial Park is approximately 1-2 mAOD and the depression on Bugsbys Way under the rail bridge is at -0.425 mAOD. These areas are susceptible to surface water flooding. The highest point with the OA is approximately 26 mAOD along the southern boundary near Mayron Park, with a steep gradient north westwards to the Woolwich Road (A206).

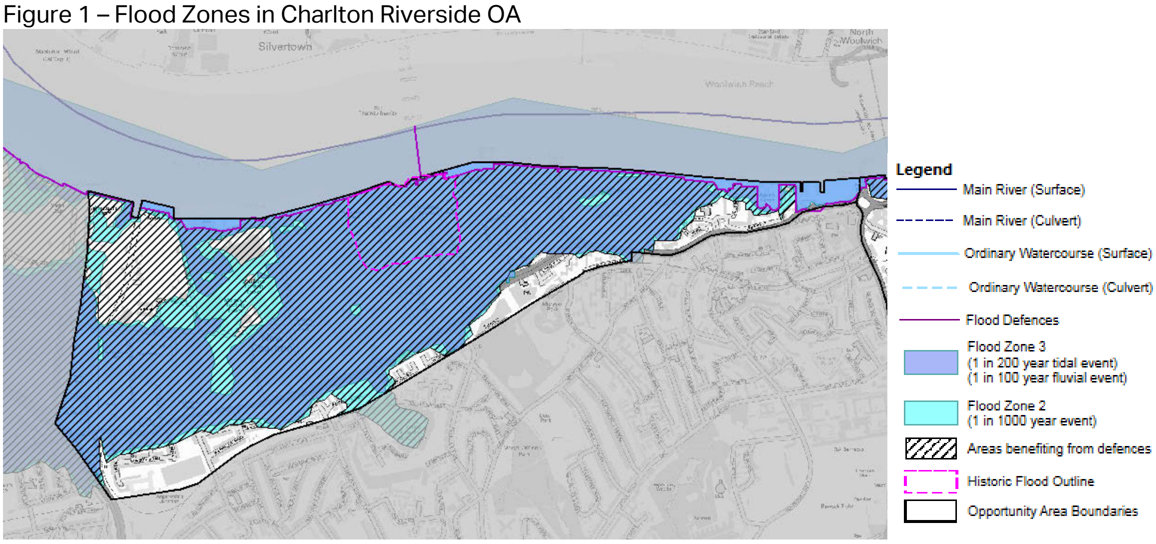
Flood Risk Summary:

Tidal Flood Risk:

The majority of the OA is located within Flood Zone 3 associated with the tidal River Thames, with a small area in the north western corner in Flood Zones 1 and 2. However the areas of Flood Zone 3 are also shown to be 'Areas Benefiting from Defences' from the Thames Tidal Defences, which include the Thames Barrier and the raised flood defence walls along the River Thames frontage. The Thames Barrier is located approximately halfway along the OA's Thames frontage. The Environment Agency Asset Information Management System (AIMS) data shows the OA is defended by River Wall and two sections of embankment; one section from Christie's Wharf to the jetties north of the Lombard Trading Estate, and the other just downstream of the Thames Barrier. The SFRA states that the defences have a design standard of protection for 0.1% AEP flood event.

During periods of extreme tide levels and/or storm events, water levels upstream of the Barrier may be controlled by the operation of the Thames Barrier. Therefore the risk of tidal flooding is residual, in the event of a breach or overtopping of the local defences.

Figure 1 – Flood Zones in Charlton Riverside OA



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<u>Breach modelling hazard rating:</u>

The Thames Tidal Breach Modelling Study (March 2015)[2] is described fully in the RB Greenwich SFRA and breach modelling hazard mapping covering the Charlton Riverside OA Hs been identified from the RB Greenwich SFRA.

The Charlton OA is impacted by four breach locations from the Thames Tidal Breach Modelling Study (March 2015): Green01 to Green03 are located upstream of the Thames Barrier; Green04 is located downstream of the Barrier. Flood hazard mapping from the results of these breach locations are presented in the figures below.

At the time of publishing, the Environment Agency in the process of updating the Thames Tidal breach modelling. It is recommended that developers contact the Environment Agency for the most up to date breach modelling data.

[2] The Thames Tidal Breach Modelling Study (March 2015) was completed for the Environment Agency to simulate a series of breach scenarios along the Thames frontage, to quantify the residual risk of tidal flooding.

Charlton Riverside OA:

Note:
For breach locations downstream of the Barrier (Green04), the 0.5% AEP flood event under climate change conditions for the year 2100 scenario results have been presented.
For breach locations upstream of the Barrier (Green01 to Green03), return periods cannot be applied to water levels, as water levels are a function of the maximum tide level allowed through the Barrier, as defined by the barrier closure rule / matrix. As a result, a Maximum Likely Water Level (MLWL) is applied. Hazard mapping for the MLWL under climate change conditions for the year 2100 have been presented for breach locations Green01 to Green03.

Flood Hazard categories:

Flood Hazard	Description
Low	**Caution** – Flood zone with shallow flowing water or deep standing water
Moderate	**Dangerous for some** (i.e. children) – Danger: flood zone with deep or fast flowing water
Significant	**Dangerous for most people** – Danger: flood zone with deep fast flowing water
Extreme	**Dangerous for all** – Extreme danger: flood zone with deep fast flowing water

Summary of breach results

The breach modelling shows that the western part of the OA is at 'Significant' risk under the 2100 climate change scenario, with danger for most people from breach locations to the west, along the Greenwich Peninsula. However the greatest risk (Extreme) to the OA occurs when there is a breach to the north (Greenwich04), downstream of the Thames Barrier. Under this 2100 climate change scenario, the majority of the OA would be classified as danger for all. Although the risk of tidal flood is residual, the consequence of a breach would be significant.

Figure 1a - Breach Location: Green01 (upstream of barrier) - MLWL for the year 2100.

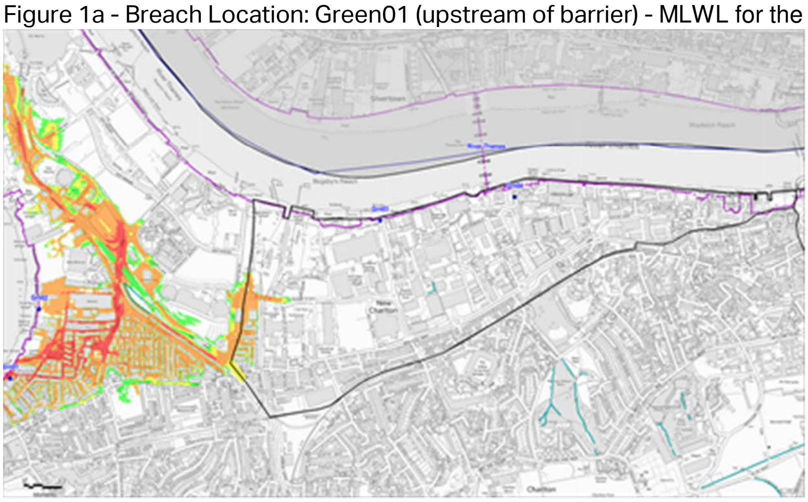

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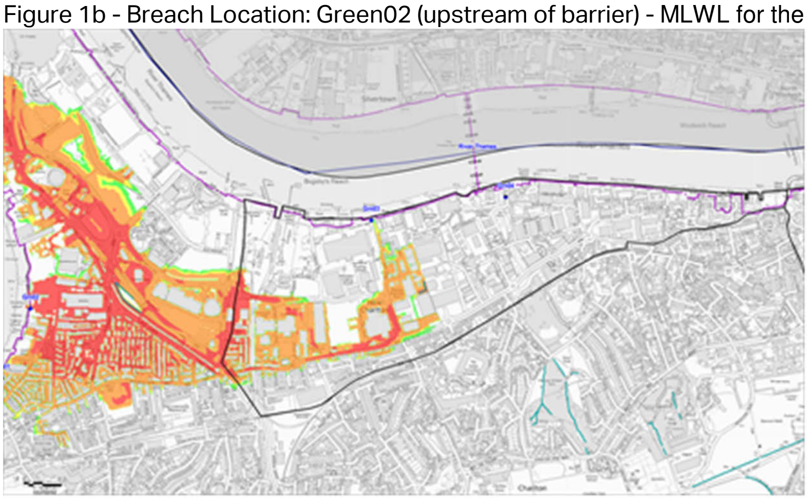
Figure 1b - Breach Location: Green02 (upstream of barrier) - MLWL for the year 2100



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Charlton Riverside OA:

Figure 1c - Breach Location: Green03 (upstream of barrier) - MLWL for the year 2100

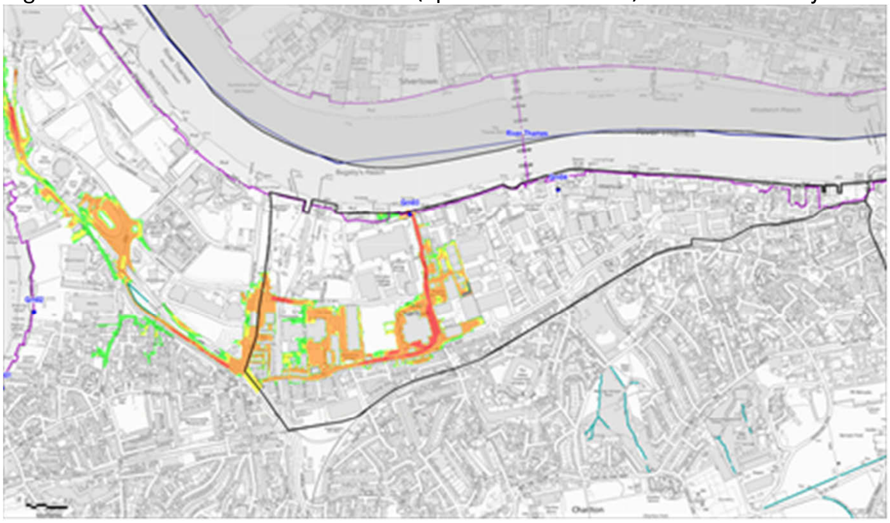
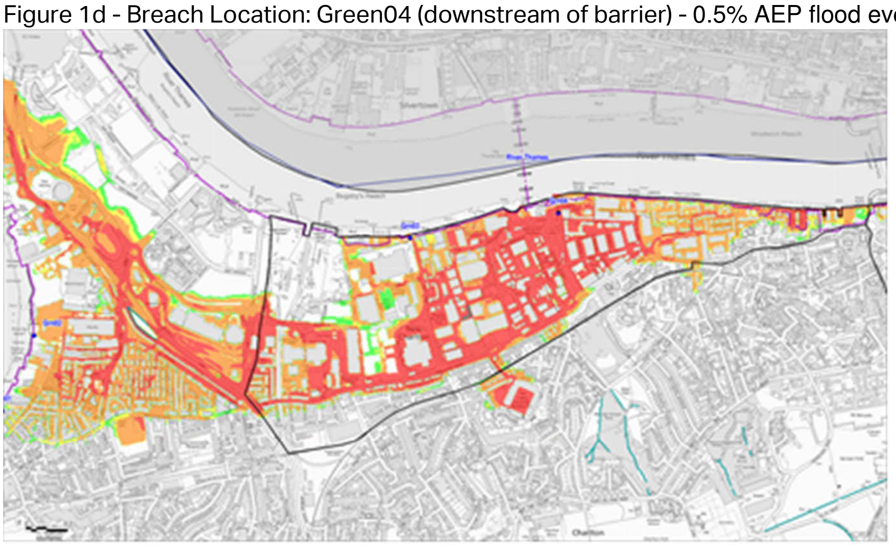


Figure 1d - Breach Location: Green04 (downstream of barrier) - 0.5% AEP flood event for the year 2100



Fluvial Flood Risk:

There are no main rivers located in the Charlton Riverside OA, other than the tidal Thames, and no fluvial flood zones from other main rivers extend as far as the OA.. The Greenwich Ordinary Watercourse Survey identifies a small unnamed ordinary watercourse to the east of Ropery Business Park. The flood risk from this ordinary watercourse is unknown.

Surface Water Flood Risk:

The uFMfSW identifies widespread areas susceptible to surface water flooding within the Charlton Riverside OA due to low lying land, which would impact roads, properties and commercial buildings. Notable areas of high risk of surface water ponding include:

- The Angerstein Business Centre (including Horn Lane),
- Bugsbys Way (under the rail bridge),
- Anchor and Hope Lane,
- the Thames Barrier Industrial Park (including Westmoor Street and Eastmoor Street), and
- Woolwich Church Road.

The historic surface water flood outlines of the Thames Barrier Industrial Park and Charlton Prospect Vale are located within or partially within the Charlton OA (as identified in the SFRA and SWMP).

Charlton Riverside OA:

Figure 2 – uFMfSW in Charlton Riverside OA

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The Charlton Riverside OA is located with Critical Drainage Area (CDA) Group6_014, as identified in the RB Greenwich SFRA. Local Flood Risk Zones within this CDA are:

- Thames Barrier Industrial Estate
- Ruston Road
- Prentiss Court
- Floyd Road/Delafield Road
- Bugsby Way

Groundwater Flood Risk:

The Groundwater Flood Risk in The Charlton Riverside OA is considered to occur from within the superficial deposits of alluvium and river terrace deposits in areas adjoining the River Thames. MWH Consulting's Groundwater Flooding Study for the RB Greenwich has mapped the Groundwater Flood Risk in the RB Greenwich SFRA along with historic records of groundwater flooding.

The majority of the Charlton Riverside OA is considered to be within MWH's Zone A - Limited potential for groundwater flooding to occur. However, the area to the south west of the OA and Thames Barrier Industrial Park are considered to be within MWH's Zone 2 – Potential for groundwater flooding of property situated below ground level.

There are two historic incidents of groundwater flooding recorded along the railway line to the south east of the OA.

Sewer Flood Risk

The RB Greenwich SFRA shows that, using the TWUL DG5 Flood Register, the SE7 7 postcode area which incorporates the westerner side of the Charlton Riverside OA has experienced 2 – 3 records of sewer flooding within the last 10 years. The SE7 8 postcode area, which incorporates New Charlton to the east of the OA has experienced slightly more with 3 – 7 records of sewer flooding within the last 10 years.

It should be noted that records only appear on the DG5 register where they have been reported to TWUL, and as such they may not include all instances of sewer flooding. Furthermore given that TWUL target these areas for maintenance and improvements, areas that experienced flooding in the past may no longer be at greatest risk of flooding in the future.

Artificial Flood Risk

There are no artificial sources of flood risk in the Charlton Riverside OA.

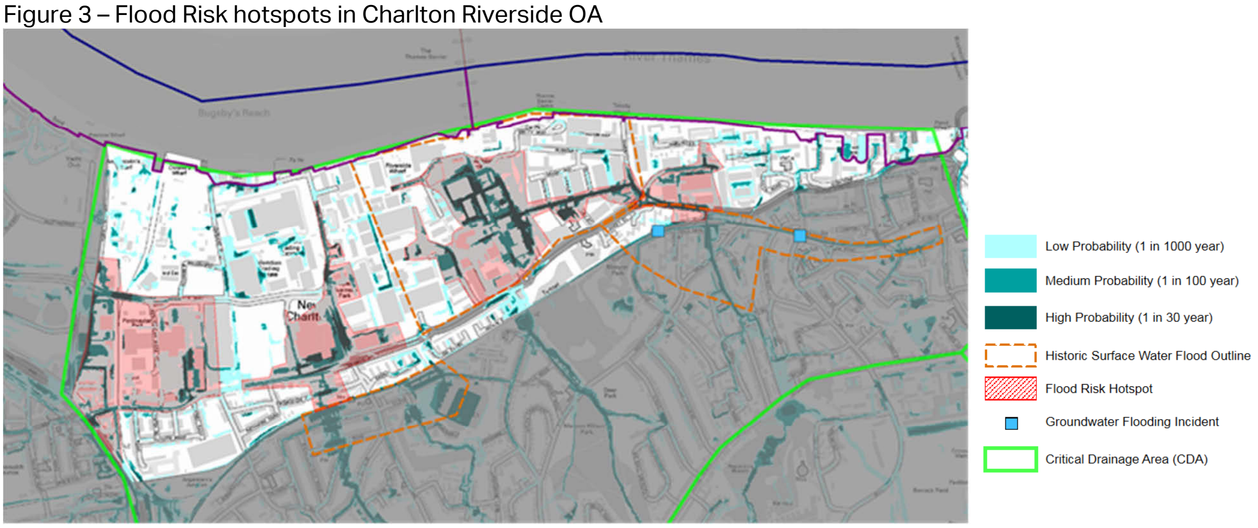
Charlton Riverside OA:

Flood Risk Hotspots

The baseline and historical flooding incident information from all flood risk sources has been used to identify Flood Risk Hotspots within the Charlton Riverside OA; these areas are shown in Figure 3.

Flood Risk Hotspots are locations that locally have a higher risk of flooding compared to the rest of the study area due to one or more sources of flood risk being present. These locations, and specific mitigation, should be considered carefully when assessing individual planning applications in these locations. With respect to the Charlton Riverside OA, proposals for additional development should preferentially be steered away from these higher risk areas and consideration should be given at masterplanning stage to plot layout and provision of green space, allowing space for flood waters specifically associated with surface water.

Figure 3 – Flood Risk hotspots in Charlton Riverside OA



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Local Management Opportunities Summary

The Regional Flood Risk appraisal for Greater London identifies the following potential flood risk mitigation measures for the Charlton Riverside OA:

- Located in the Greenwich TE2100 policy unit.
- Raising river walls and embankments required by 2065 for normal tides and tidal surges.
- Open spaces to be retained for potential flood storage and work to flood defences in future.
- New development is a good opportunity to introduce more sustainable rainwater management and should readily be able to achieve Greenfield run-off rates and reduce the current risks.
- Development close to the Thames can discharge directly to the river.

A summary of mitigation measures that should be considered at the detailed design stage for developments where the flood depths are expected to exceed 0.6 m are:

- Accept water passage through building at higher water depths;
- Attempt to keep water out for low depths of flooding;
- Use materials with a low permeability at lower levels;
- Provide key services including electricity, water, etc. to continue under flood conditions;
- Site electrical controls, cables and appliances above the predicted maximum flood levels;
- Design to drain water away after flooding;
- Ensure access to all spaces to permit drying and cleaning.

The impact the flood waters will have on the structural integrity of the buildings must be considered at the detailed design stage. It must be demonstrated that the buildings will remain safe in the event of a breach in the flood defences during a high tidal event.

Table 4. Summary of flood risk for all sources of flooding in Woolwich OA

Woolwich OA:

Topography/Infrastructure/Characteristics:

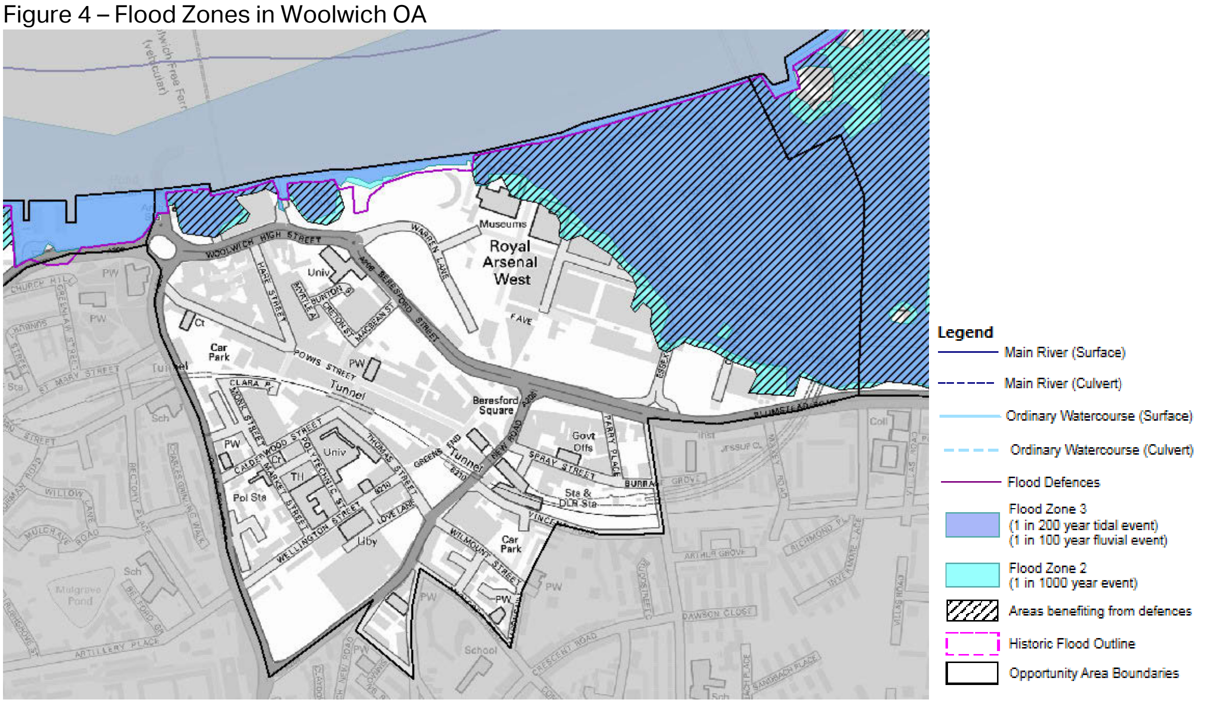
The Woolwich OA is located adjacent to the Charlton Riverside OA, bounded to the north by the tidal River Thames. The topography within the OA generally slopes north eastwards, from approximately 30 mAOD in the southwest to approximately 4 mAOD in the northeast. There is a rail line that intersects the south western part of the OA and creates a depression in the areas where it is not tunneled. The Woolwich Arsenal railway station is located to the central south of the OA. The land adjacent to the River Thames is significantly below high tide levels.

Flood Risk Summary:

Tidal Flood Risk:

The majority of the OA is located within Flood Zone 1, with the Royal Arsenal area to the north east of the site in Flood Zone 3, as well as two areas along the north west River Thames frontage. The Flood Zones are associated with the tidal River Thames, however the areas of Flood Zones 2 and 3 are also shown to be 'Areas Benefiting from Defences' from the Thames Tidal Defences (TTD). At this location the TTD consist of raised flood defence walls along the River Thames frontage. The SFRA states that the defences have a design standard of protection for 0.1% AEP flood event. The OA is located downstream of the Thames Barrier; therefore, the risk of tidal flooding is residual, in the event of a breach or overtopping of the local defences.

Figure 4 – Flood Zones in Woolwich OA



Breach hazard modelling:

The Thames Tidal Breach Modelling Study (March 2015)[3] is described fully in the RB Greenwich SFRA and breach modelling hazard mapping covering the Charlton Riverside OA. The Woolwich OA is impacted by two breach locations from the Thames Tidal Breach Modelling Study (March 2015): Green04 and Thames01, both of which are located downstream of the Thames Barrier. Flood hazard mapping from the results of these breach locations are presented below.

At the time of publishing, the Environment Agency in the process of updating the Thames Tidal breach modelling. It is recommended that developers contact the Environment Agency for the most up to date breach modelling data.

Note:
For breach locations downstream of the Barrier, the 0.5% AEP flood event under climate change conditions for the year 2100 scenario results have been presented.

[3] The Thames Tidal Breach Modelling Study (March 2015) was completed for the Environment Agency to simulate a series of breach scenarios along the Thames frontage, to quantify the residual risk of tidal flooding.

Woolwich OA:

Flood Hazard categories:

Flood Hazard	Description
Low	**Caution** – Flood zone with shallow flowing water or deep standing water
Moderate	**Dangerous for some** (i.e. children) – Danger: flood zone with deep or fast flowing water
Significant	**Dangerous for most people** – Danger: flood zone with deep fast flowing water
Extreme	**Dangerous for all** – Extreme danger: flood zone with deep fast flowing water

<u>Summary of breach results</u>
The breach modelling shows that only the western part of the OA is at 'Significant' risk under the 2100 climate change scenario, with danger for most people from breach location Greenwich04. However the greatest risk (Extreme) to the OA occurs when there is a breach to the northeast corner (Thames01). Under this 2100 climate change scenario, the whole eastern part of the OA, including Royal Arsenal West, would be classified as "danger for all" and "danger for most". Although the risk of tidal flood is residual, the consequence of a breach would be significant.

Figure 4a – Breach Location: Green04 (downstream of barrier) - 0.5% AEP flood event for the year 2100.

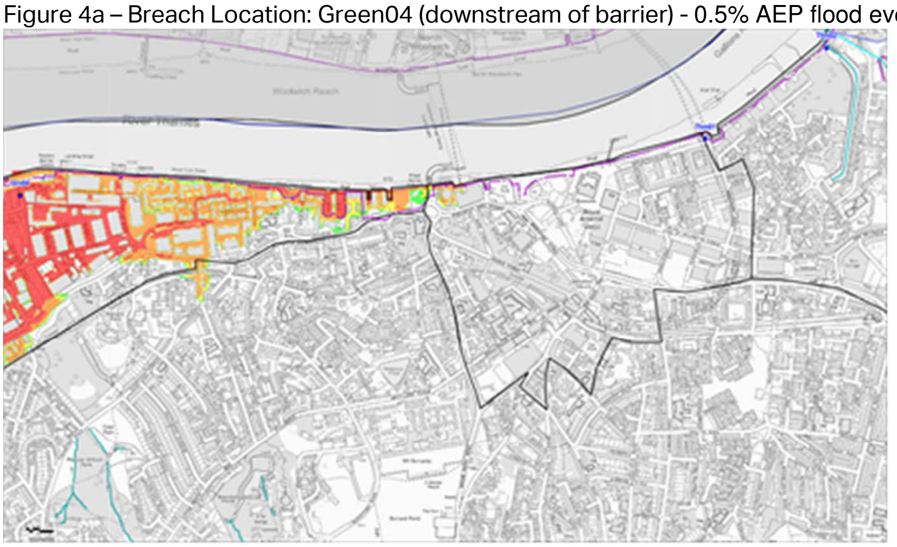
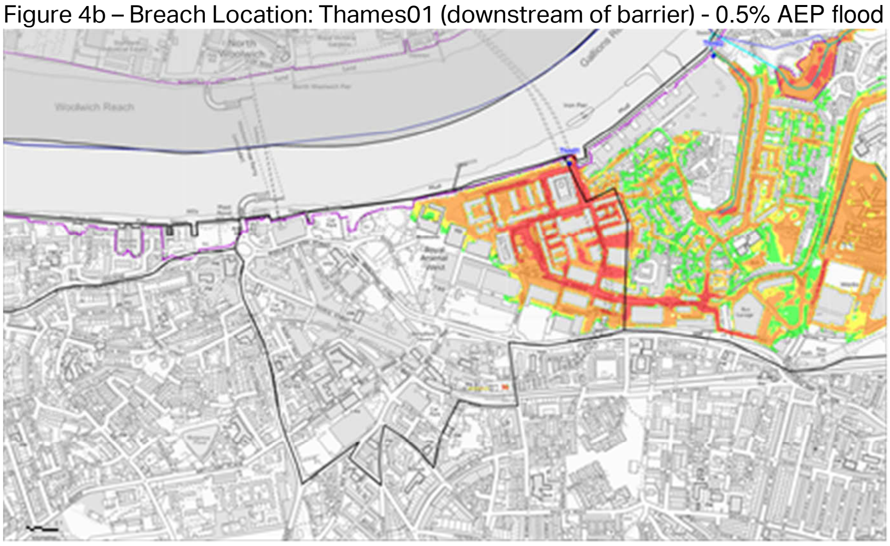


Figure 4b – Breach Location: Thames01 (downstream of barrier) - 0.5% AEP flood event for the year 2100



Woolwich OA:
Fluvial Flood Risk:
There are no main rivers or ordinary watercourses located in the Woolwich OA, other than the tidal Thames, and no fluvial flood zones from other main rivers extend as far as the OA..
Surface Water Flood Risk:

Woolwich OA:

The uFMfSW identifies areas susceptible to surface water flooding within the Woolwich OA. Notable areas of high risk of surface water ponding include:

- Brookhill Road,
- Woolwich Arsenal Station and surrounding area, including the rail lines, and
- Royal Arsenal West.

There are no historic surface water flood outlines from the RB Greenwich SFRA within the Woolwich OA.

Figure 5 – uFMfSW in Woolwich OA

The Woolwich OA is located with CDA Group6_001. The Woolwich Town Centre Local Flood Risk Zone is located within the Woolwich OA.

Groundwater Flood Risk:

The Groundwater Flood Risk in the Woolwich OA is considered to occur from with the superficial deposits of alluvium and river terrace deposits in areas adjoining the River Thames. MWH Consulting's Groundwater Flooding Study for the RB Greenwich has mapped Groundwater Flood Risk in the RB Greenwich SFRA along with historic records of groundwater flooding.

The majority of the Woolwich OA is considered to be within MWH's Zone A - Limited potential for groundwater flooding to occur. There is a small area to the south west of the OA that has not been modelled by MWH.

There are no historic incidents of groundwater flooding recorded within the OA.

Sewer Flood Risk

There is no TWUL DG5 Flood Register information covering the Woolwich OA within the RB Greenwich SFRA. There are no historic records of sewer flooding held by RB Greenwich Council.

Artificial Flood Risk

There are no artificial sources of flood risk in the Woolwich OA.

Flood Risk Hotspots

Woolwich OA:

The baseline and historical flooding incident information from all flood risk sources has been used to identify Flood Risk Hotspots within the Woolwich OA; these areas are shown in Figure 6.

Flood Risk Hotspots are locations that locally have a higher risk of flooding compared to the rest of the study area due to one or more sources of flood risk being present. These locations, and specific mitigation, should be considered carefully when assessing individual planning applications in these areas. With respect to the Woolwich OA, proposals for additional development should preferentially be steered away from these higher risk areas and consideration should be given at masterplanning stage to plot layout and provision of green space, allowing space for flood waters specifically associated with surface water.

Figure 6 – Flood Risk hotspots in Woolwich OA

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Local Management Opportunities Summary

The Regional Flood Risk appraisal for Greater London identifies the following potential flood risk mitigation measures for the Woolwich OA:

- Located in Thamesmead TE2100 policy unit.
- Raising river walls and embankments required by 2040 for normal tides and tidal surges.
- Open spaces to be retained for potential flood storage.
- Set development back from rivers edge to enable a range of flood risk management options.
- New development is a good opportunity to introduce more sustainable rainwater management and should readily be able to achieve a substantial reduction on current runoff rates.

A summary of mitigation measures that should be considered at the detailed design stage for developments where the flood depths are expected to exceed 0.6 m are:

- Accept water passage through building at higher water depths;
- Attempt to keep water out for low depths of flooding;
- Use materials with a low permeability at lower levels;
- Provide key services including electricity, water, etc. to continue under flood conditions;
- Site electrical controls, cables and appliances above the predicted maximum flood levels;
- Design to drain water away after flooding;
- Ensure access to all spaces to permit drying and cleaning.

The impact the flood waters will have on the structural integrity of the buildings must be considered at the detailed design stage. It must be demonstrated that the buildings will remain safe in the event of a breach in the flood defences

Woolwich OA:
during a high tidal event.

Table 5. Summary of flood risk for all sources of flooding in Thamesmead and Abbey Wood OA

Thamesmead and Abbey Wood OA:

Topography/Infrastructure/Characteristics:

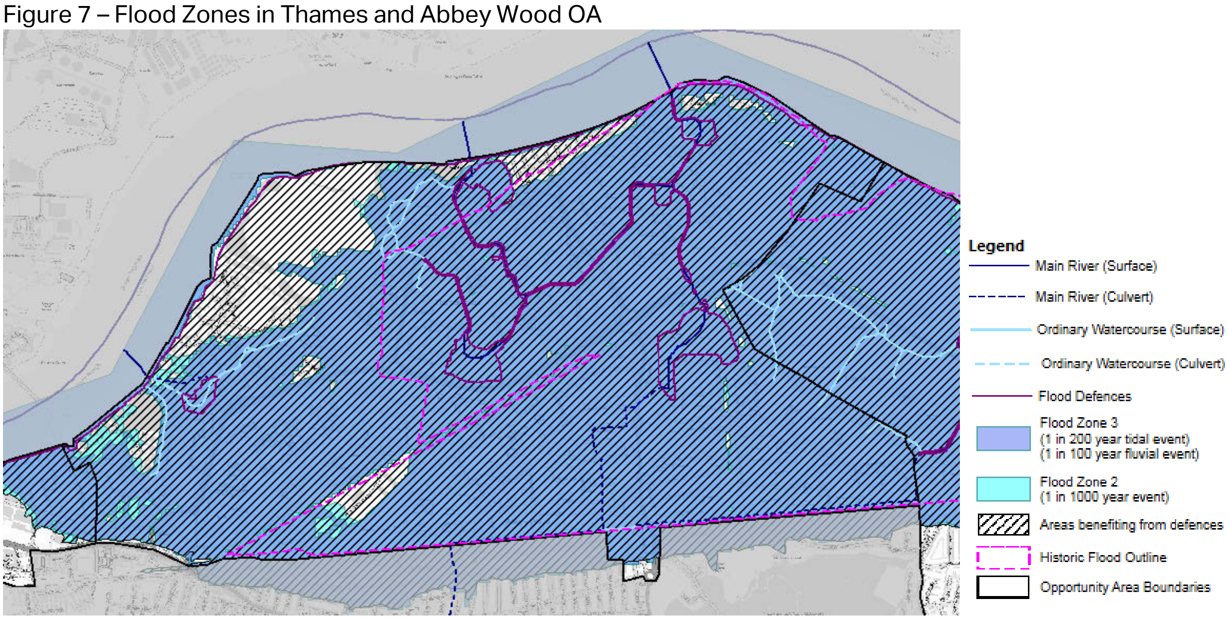
The Thamesmead and Abbey Wood OA is located between the Woolwich OA to the west and the Bexley Riverside OA to the east, bounded to the north by the tidal River Thames. The topography of the majority the OA is significantly below high tide levels. The raised Thames Water Southern Outfall Sewer runs southwest to northeast through the centre of the OA, creating a ridge of higher land. There are areas of higher ground levels to the north west of the OA associated with an authorised landfill site. The drainage system in this area is dominated by the Thamesmead lakes and canals system and the Erith Marshes system.

Flood Risk Summary:

Tidal Flood Risk:

The majority of the OA is located within Flood Zone 3 associated with the tidal River Thames. However the areas of Flood Zone 3 are also shown to be 'Areas Benefiting from Defences' from the Thames Tidal Defences, which include the Thames Barrier and the raised flood defence walls along the River Thames frontage. The Thames Barrier is located approximately halfway along the OA's Thames frontage. The Environment Agency Asset Information Management System (AIMS) data shows the OA is defended by River Wall and two sections of embankment; one section 1.8 km long eastwards from Margret or Tripcock Ness beacon, and the other a 550 m stretch around Cross Ness beacon. The SFRA states that the defences have a design standard of protection for 0.1% AEP flood event. During periods of extreme tide levels and/or storm events, water levels upstream of the Barrier may be controlled by the operation of the Thames Barrier. Therefore the risk of tidal flooding is residual, in the event of a breach or overtopping of the local defences.

Figure 7 – Flood Zones in Thames and Abbey Wood OA



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<u>Breach modelling:</u>

The Thames Tidal Breach Modelling Study (March 2015)[4] is described fully in the RB Greenwich SFRA and breach modelling hazard mapping covering the Thamesmead and Abbey Wood OA has been identified from the RB Greenwich SFRA. The Thamesmead and Abbey Wood OA is impacted by six breach locations from the Thames Tidal Breach Modelling Study (March 2015): Thames01 through to Thames07, with the exception of Thames06. Flood hazard mapping from the results of these breach locations are presented below.

At the time of publishing, the Environment Agency in the process of updating the Thames Tidal breach modelling. It is recommended that developers contact the Environment Agency for the most up to date breach modelling data.

[4] The Thames Tidal Breach Modelling Study (March 2015) was completed for the Environment Agency to simulate a series of breach scenarios along the Thames frontage, to quantify the residual risk of tidal flooding.

Thamesmead and Abbey Wood OA:

Note:
For breach locations downstream of the Barrier, the 0.5% AEP flood event under climate change conditions for the year 2100 scenario results have been presented.

Flood Hazard categories:

Flood Hazard	Description
Low	**Caution** – Flood zone with shallow flowing water or deep standing water
Moderate	**Dangerous for some** (i.e. children) – Danger: flood zone with deep or fast flowing water
Significant	**Dangerous for most people** – Danger: flood zone with deep fast flowing water
Extreme	**Dangerous for all** – Extreme danger: flood zone with deep fast flowing water

Summary of breach results
The breach modelling shows that the Thamesmead and Abbey Wood OA is at 'Significant' risk under the 2100 climate change scenario, with breach locations Thames04, Thames05, and Thames07 resulting in the most widespread hazard across the area. The previous breach modelling undertaken as part of the Bexley SFRA (2010) indicates that the Thamesmead and Abbey Wood OA would have a likely rate of onset of 3 to 6 hours (for the 0.5% AEP plus climate change scenario). This information is not available for the updated Breach Modelling Study (March 2015) shown in Figures 7a to 7f. Although the risk of tidal flooding is residual, the consequence of a breach would be significant.Figure 7a – Breach Location: Thames01 (downstream of the barrier)

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Figure 7b – Breach Location: Thames02 (downstream of the barrier)

Thamesmead and Abbey Wood OA:

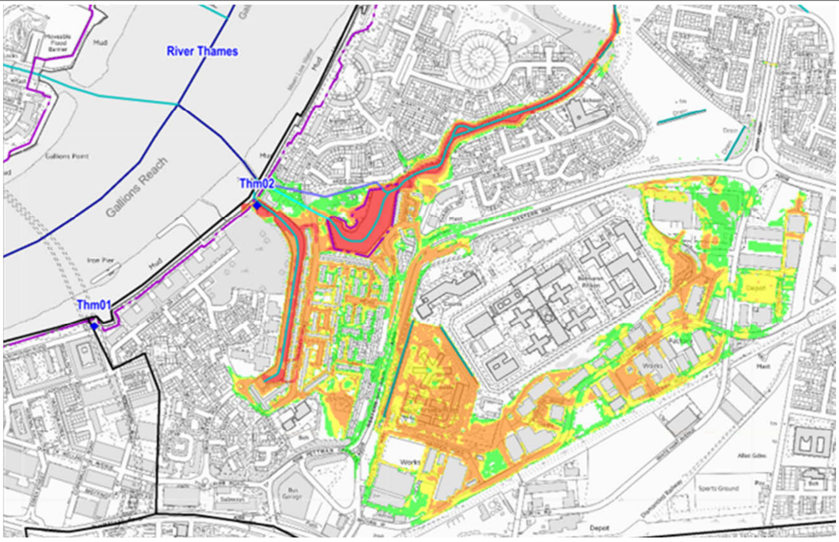

Figure 7c – Breach Location: Thames03 (downstream of the barrier)

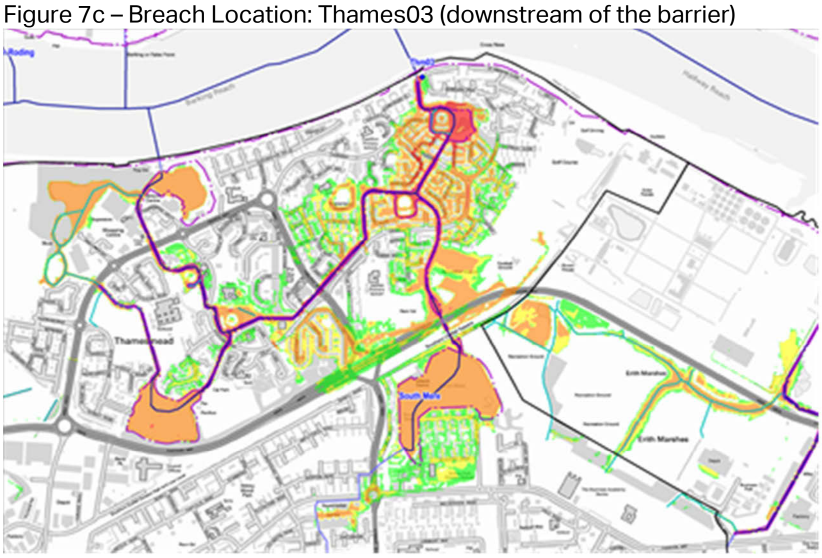

Figure 7d – Breach Location: Thames04 (downstream of the barrier)

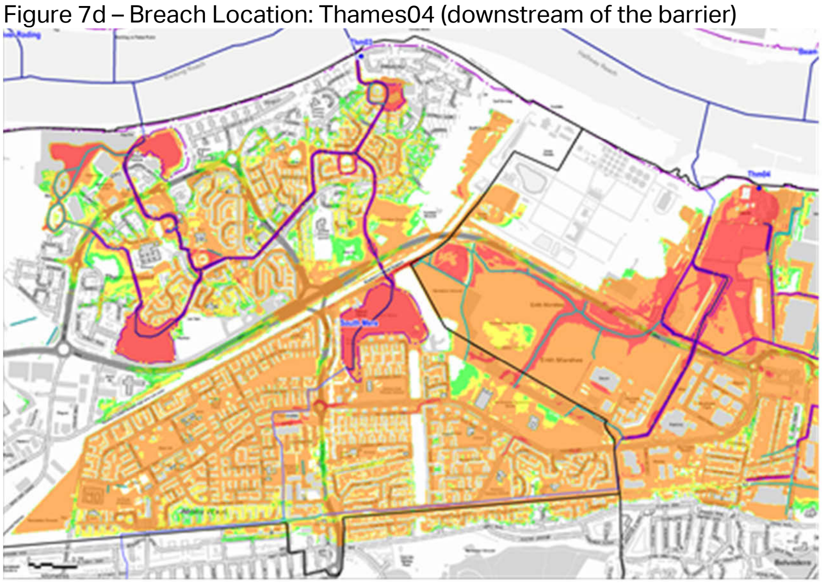

Figure 7e – Breach Location: Thames05 (downstream of the barrier)

Thamesmead and Abbey Wood OA:

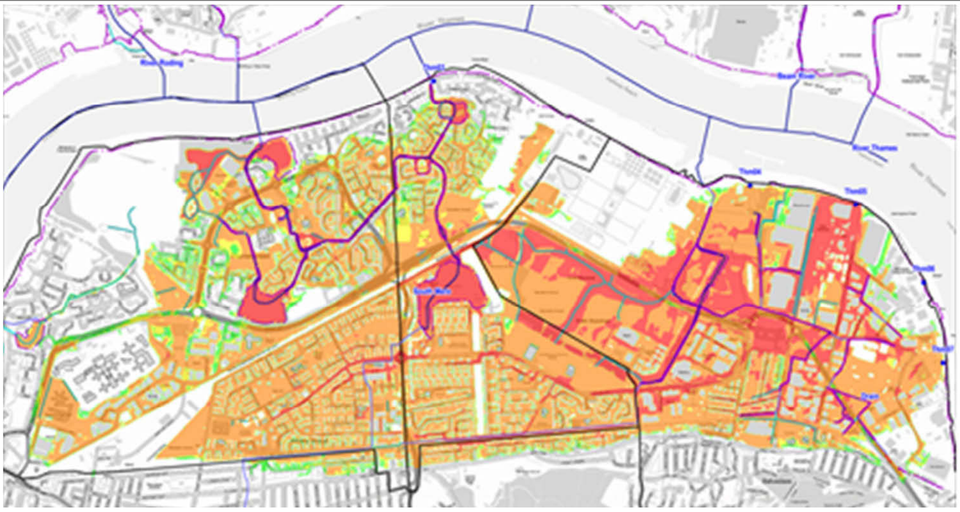

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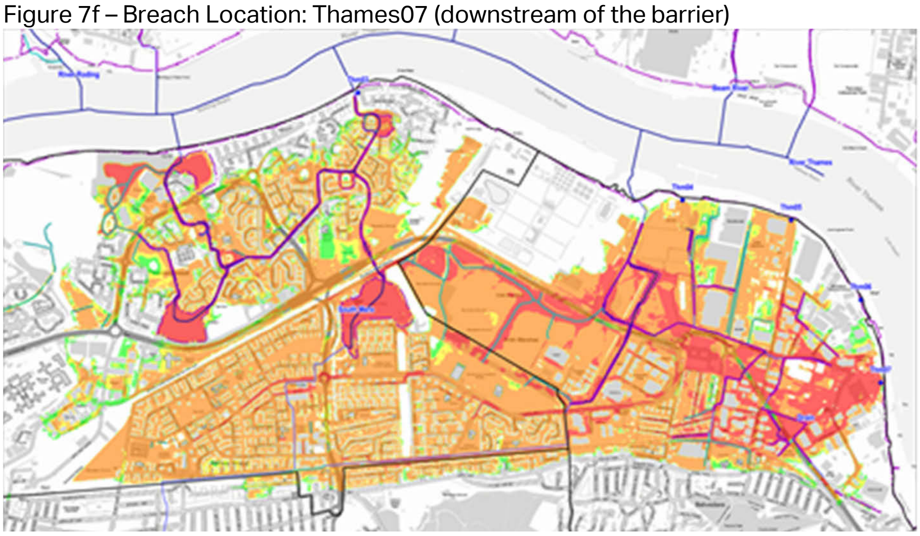
Figure 7f – Breach Location: Thames07 (downstream of the barrier)



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Fluvial Flood Risk:

The Wickham Valley watercourse (also known as the Butts canal) is a main river that flows northwards from near Woolwich Cemetery in East Wickham through RB Greenwich and enters a culvert to the south of the Thamesmead and Abbey Wood OA. The culvert follows the southern boundary of the OA eastwards before turning north and discharging into the Southmere Lake. Southmere Lake is connected to the Thamesmead Lakes and canals surface water drainage network, and eventually discharges into the River Thames. Water levels within the canals are controlled by sluices and pumping stations.

The Erith Marshes system of ditches and dykes is located to the east of the Thamesmead and Abbey Wood OA. It is also a surface water drainage system and water levels are controlled by sluices and pumping stations.

The ordinary watercourses within the Thamesmead and Abbey Wood OA form part of the wider surface water drainage networks in this area, which is further described in the Artificial Flood Risk section below. As the watercourses are managed through the ditches/dykes/canal systems, the fluvial flood risk in the Thamesmead and Abbey Wood OA is considered to be low.

It should be noted that the Environment Agency is undergoing an update of the Wickham Valley Watercourse model (Environment Agency, 2016), which will include the updated climate change allowances. The outputs from this model should be used for all future flood risk assessments within this catchment.

Surface Water Flood Risk:

The Thamesmead lakes and canals system and the Erith Marshes system are used to drain surface water in the Thamesmead and Abbey Wood OA. They are complex surface water drainage networks comprised of piped drains,

Thamesmead and Abbey Wood OA:

open ditches and pumps. The majority of the OA drains to the Thamesmead lakes and canals system (including Butts canal) to the north of the OA, the eastern section of the Thamesmead Growth Area in LB Bexley drains to the Erith Marshes. The drainage networks are further described in the Artificial Flood Risk section below.

The uFMfSW identifies that areas susceptible to surface water flooding within the Thamesmead and Abbey Wood OA tend to follow the road network. Notable areas of high risk of surface water ponding include:

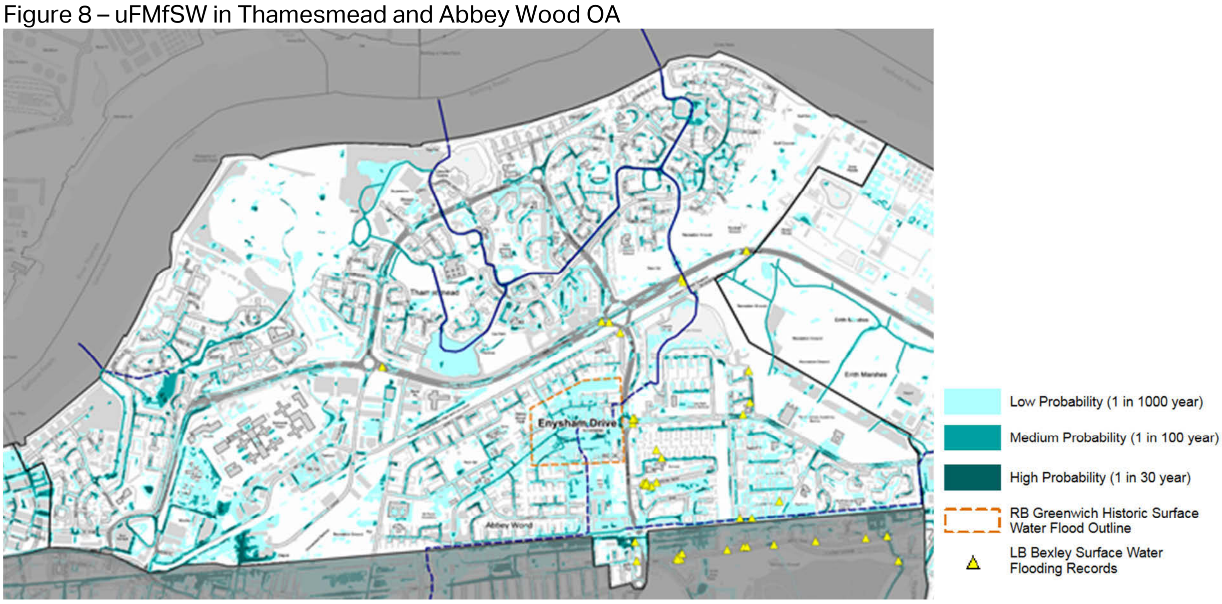
- Eynsham Drive,
- Overton Road,
- Areas close to the rail line along southern boundary,
- Royal Arsenal East/HMP Thameside.

The uFMfSW mapping shows the indicative drainage path and flood extent of the Butts Canal, which is part of the Thamesmead lakes and canals system, in the Thamesmead area. The uFMfSW mapping does not account for the capacity of the culverted section of Butt's Canal, and therefore the flood extents should be considered as indicative of flooding in the event of a total blockage of the culvert. The RB Greenwich SFRA has identified that the surface water flooding experienced in Abbey Wood in 2005 and 2007 were a result of blockages to the culverted section of the Butts Canal.

The Thamesmead and Abbey Wood OA is located with CDA Group6_001.

There are historic surface water flood outlines (RB Greenwich) and surface water flood records (LB Bexley) within the Thamesmead and Abbey Wood OA. These are shown in Figure 8.

Figure 8 – uFMfSW in Thamesmead and Abbey Wood OA



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Groundwater Flood Risk:

The majority of the bedrock in the Thamesmead and Abbey Wood OA is comprised of Thanet Sand Formation. There is an area of Chalk to the northwest and a small area of Chalk to the south. The eastern part of the OA is underlain by Lambeth Group. Therefore the base geology is relatively permeable. The LB Bexley SFRA states the risk of groundwater flooding is considered to be locally variable as the composition and stratigraphy of the overlying superficial deposits will influence how groundwater levels in the chalk aquifer will translated into groundwater levels within the superficial deposits.

MWH Consulting's Groundwater Flooding Study for the RB Greenwich has mapped Groundwater Flood Risk in the RB Greenwich SFRA, covering the Greenwich half of the Thamesmead and Abbey Wood OA. The majority of the Abbey Wood area is considered to be within MWH's Zone B - Potential for groundwater flooding of property situated below ground level. There are small areas to the north and south of the rail line which creates the southern boundary for the OA that are in MWH's Zone C – Potential for groundwater flooding to occur at surface. These areas correspond to 8 historic incidents of groundwater flooding along the OA boundary (RB Greenwich records). The rest of the Greenwich half of the OA is in Zone A – Limited potential for groundwater flooding to occur.

Sewer Flooding

Thamesmead and Abbey Wood OA:

The LB Bexley PFRA shows that, using the TWUL DG5 Flood Register, the SE2 9 postcode area which covers the Abbey Wood area has experienced 21 – 50 records of sewer flooding within the last 10 years. It should be noted that records only appear on the DG5 register where they have been reported to TWUL, and as such they may not include all instances of sewer flooding. Furthermore given that TWUL target these areas for maintenance and improvements, areas that experienced flooding in the past may no longer be at greatest risk of flooding in the future.

The Thamesmead Canal Corridor modelling project (May 2010) predicted that even during extreme rainfall events (1 in 100yr +CC), Southmere Lake was not assessed as presenting a flood risk to the surrounding residential areas. The modelling did however predict surcharging issues from Thames Water surface water sewers in the Wolvercote Road and Lensbury Road areas. The surface water flooding in these areas was identified as being sensitive to the lake levels in Southmere. When lake levels become elevated, the resultant surcharging of the contributing drains exacerbates the surface water flooding predictions.

Artificial Flood Risk

The Marsh Dykes is the term used to describe the area of reclaimed marshland, including the Thamesmead lakes and canals system, the Erith Marshes system and the Crayford Marshes. These areas were developed with commercial and residential uses in the 1960s and surface water runoff in is managed through the artificial networks of lakes, canals, ditches and dykes.

The Thamesmead lakes and canals system falls within the Thamesmead and Abbeywood OA, and crosses both RB Greenwich and LB Bexley. Surface water in this area is managed through a system of five lakes and a canal network (including the Butts Canal) and has a water surface area of approximately 250 hectares. Wickham Valley watercourse (Butts Canal) rises near Woolwich Cemetery in East Wickham and is culverted along much of its length to its outfall into Southmere Lake. The canals drain into the River Thames under gravity at Abbey Sluice or at times of tide lock flow can be pumped at Tripcock and Gallions pumping stations. The system was designed to have a capacity exceeding everyday requirement, thus allowing for storm water. The total storage volume is 189,069 m^3. A study conducted by the Environment Agency states 184,870 m^3 of storage volume is required to absorb a 1% AEP (1 in 100 year flood event).

The culverted part of the Butts Canal poses an increased flood risk as a result of blockage and siltation. The RB Greenwich SFRA has highlighted two areas as at risk of blockage, the Bracondale Road silt trap and the Woodbrook Road trash screens, which are the responsibility of the Environment Agency. The other section of the Butts Canal in the Borough is at Thamesmead, where the watercourse flows through a series of open drainage channels until it joins the River Thames.

The Erith Marshes system drains the eastern part of the Thamesmead growth area in LB Bexley. The Yarton Way culverted surface water drain collects water from the Abbywood and Belvedere growth areas and discharges into open ditches in Erith Marshes. The water levels in the Marshes are maintained by a weir and two pumping stations; Great Breach (to the east of Crossness STW) and Green Level.

The current managed water level in the Erith Marshes ditches and dykes system is -0.76 m AOD, which is very close to the soffit (roof of the culvert), and this results in there being little surplus capacity in the Yarton Way culvert to respond to storm flows. The performance of much of the network that drains into the Yarnton Way culvert is limited, under storm conditions, by the water level in ditches and dykes.

Potential opportunities to deculvert the Butts Canal and Yarton Way culverts in order to reduce local flood risk should be investigated by developers and incorporated into the redevelopment of the OA.

There is no risk of flooding from reservoirs in the Thamesmead and Abbey Wood OA.

Flood Risk Hotspots

Thamesmead and Abbey Wood OA:

The baseline and historical flooding incident information from all flood risk sources has been used to identify Flood Risk Hotspots within the Thamesmead and Abbey Wood OA; these areas are shown in Figure 9. Flood Risk Hotspots are locations that locally have a higher risk of flooding compared to the study area due to one or more sources of flood risk. These locations, and specific mitigation, should be considered carefully when assessing individual planning applications in these areas. With respect to the Thamesmead and Abbey Wood OA, proposals for additional development should preferentially be steered away from these higher risk areas and consideration should be given at masterplanning stage to plot layout and provision of green space, allowing space for flood waters specifically associated with surface water.

Figure 9 – Flood Risk hotspots in Thamesmead and Abbey Wood OA

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Local Management Opportunities Summary

The Regional Flood Risk appraisal for Greater London identifies the following potential flood risk mitigation measures for the Thamesmead and Abbey Wood OA:

- Located in Thamesmead TE2100 policy unit.
- Raising river walls and embankments required by 2040 for normal tides and tidal surges.
- New development needs careful consideration, particularly of residual risks and emergency measures.
- Set development back from rivers edge to enable a range of flood risk management options.
- New development is a good opportunity to introduce more sustainable rainwater management and should readily be able to achieve a substantial reduction on current run-off rates and reduce the current risks.
- Development close to the Thames can discharge directly to the river.

The Thamesmead and Abbey Wood SPD (2009) identifies the following potential flood risk mitigation measures for the Thamesmead and Abbey Wood OA:

- Thamesmead has always been a significant risk of flooding, which requires the incorporation of an efficient drainage system and appropriate flood mitigation.
- TE2100 identifies potential sites where intertidal habitat (saltmarsh and mudflat) could be created to replace habitats that are being lost due to rising sea levels.
- The Bexley side of the study area benefits from a strong strategic green connection from Lesnes Abbey Woods to Crossness Engines Trust Steam Heritage Museum and the Thames Path. These heritage assets are linked by a generous green corridor which runs along Abbey Way via Southmere Park and Crossway Park.
- To the east, Southmere Park meets the Erith Marshes, which alongside Dartford Marshes and Crayford Marshes are a major asset, providing local urban communities with access to nature and the Thames, flood alleviation, recreation and green space.

A summary of mitigation measures that should be considered at the detailed design stage for developments where the flood depths are expected to exceed 0.6 m are:

Thamesmead and Abbey Wood OA:
• Accept water passage through building at higher water depths; • Attempt to keep water out for low depths of flooding; • Use materials with a low permeability at lower levels; • Provide key services including electricity, water, etc. to continue under flood conditions; • Site electrical controls, cables and appliances above the predicted maximum flood levels; • Design to drain water away after flooding; • Ensure access to all spaces to permit drying and cleaning. The impact the flood waters will have on the structural integrity of the buildings must be considered at the detailed design stage. It must be demonstrated that the buildings will remain safe in the event of a breach in the flood defences during a high tidal event.

Table 6. Summary of flood risk for all sources of flooding in Bexley Riverside OA

Bexley Riverside OA:

Topography/Infrastructure/Characteristics:

The Bexley Riverside OA is located adjacent to the Thamesmead and Abbey Wood OA, bounded to the north by the tidal River Thames. The topography within the OA generally slopes north eastwards, from approximately 45 mAOD to approximately 0 mAOD. The OA contains several shipping-related industries that require operational access to the river. The land adjacent to the River Thames is significantly below high tide levels.

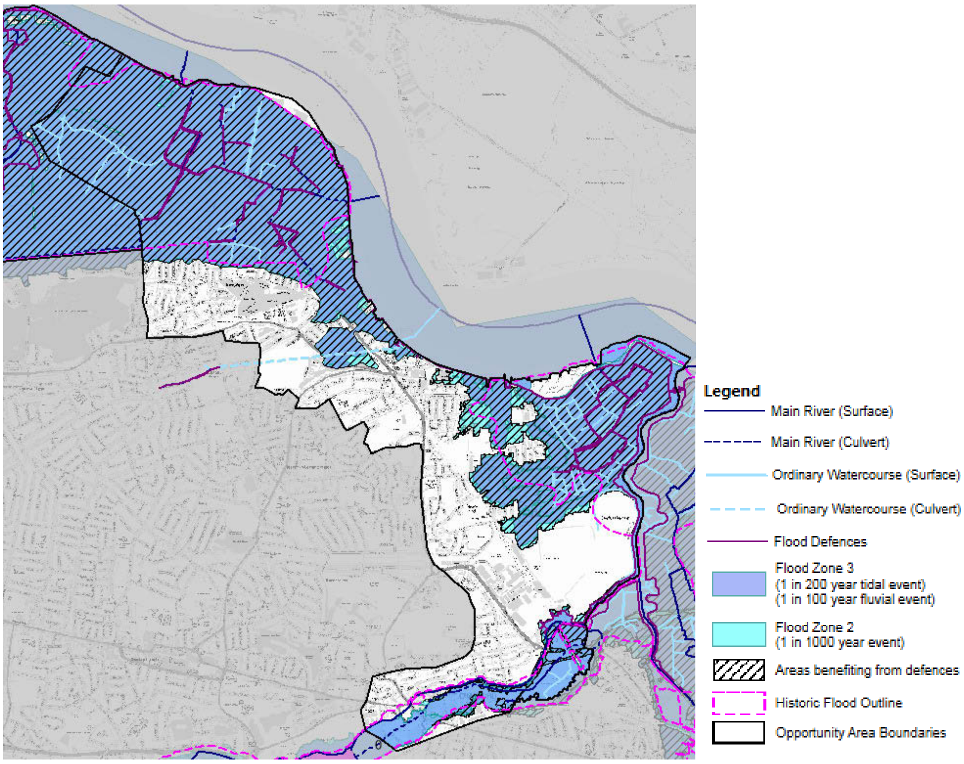
Flood risk in the Bexley Riverside OA has been assessed concentrating on the four main growth areas: Belvedere, Erith, Slade Green and Crayford.

Flood Risk Summary:

Tidal Flood Risk:

The majority of the OA is located within Flood Zone 3 associated with the tidal River Thames. However the areas of Flood Zone 3 are also shown to be 'Areas Benefiting from Defences' from the Thames Tidal Defences, which include raised flood defence walls along the River Thames frontage. The Bexley Riverside OA is located downstream of the Thames Barrier. The Environment Agency AIMS data shows the OA is defended by a River Wall from Crossness WwTW to the Bexley Brewery, and an embankment from the brewery to the River Darent confluence. The Embankment continues upstream along the River Darent and the River Cray. The SFRA states that the defences have a design standard of protection for 0.1% AEP flood event. Therefore the risk of tidal flooding is residual, in the event of a breach or overtopping of the local defences.

Figure 10 – Flood Zones in Bexley Riverside OA



Breach modelling:

The Thames Tidal Breach Modelling Study (March 2015)[5] is described fully in the RB Greenwich SFRA and breach modelling hazard mapping covering the Belvedere Growth area of the Bexley Riverside OA has been identified from the RB Greenwich SFRA. The updated Breach Modelling outputs for the rest of the Bexley Riverside OA were not available as the LB Bexley SFRA uses breaching modelling undertaken in 2010. The Bexley Riverside OA is impacted by four breach locations from the Thames Tidal Breach Modelling Study (March 2015): Thames04 to Thames07. Flood hazard mapping from the results of these breach locations are presented below.

[5] The Thames Tidal Breach Modelling Study (March 2015) was completed for the Environment Agency to simulate a series of breach scenarios along the Thames frontage, to quantify the residual risk of tidal flooding.

At the time of publishing, the Environment Agency in the process of updating the Thames Tidal breach modelling. It is recommended that developers contact the Environment Agency for the most up to date breach modelling data.

Note:
For breach locations downstream of the Barrier, the 0.5% AEP flood event under climate change conditions for the year 2100 scenario results have been presented.

Flood Hazard categories:

Flood Hazard	Description
Low	**Caution** – Flood zone with shallow flowing water or deep standing water
Moderate	**Dangerous for some** (i.e. children) – Danger: flood zone with deep or fast flowing water
Significant	**Dangerous for most people** – Danger: flood zone with deep fast flowing water
Extreme	**Dangerous for all** – Extreme danger: flood zone with deep fast flowing water

Summary of breach results

Belvedere:

The updated breach modelling shows that the Belvedere Growth Area is at 'Significant' risk under the 2100 climate change scenario, with breach locations Thames04, Thames05, and Thames07 resulting in the most widespread hazard across the area. The previous breach modelling undertaken as part of the LB Bexley Level 2 SFRA (2010) indicates that the Thamesmead and Abbey Wood OA would have a likely rate of onset of 3 to 6 hours (for the 0.5% AEP plus climate change scenario). This information is not available for the updated Breach Modelling Study (March 2015) shown in Figures 10a – 10d. Although the risk of tidal flood is residual, the consequence of a breach would be significant.

Erith and Slade Green:

LB Bexley Level 2 SFRA (2010) breach modelling indicates that flood depths are predicted to exceed 3 m to the east of Slade Green, in the Crayford Marsh Embayment. In Erith, flood depths are shown to be generally between 1.5 to 2 m, with small areas of deeper flooding (3-4m) to the north of the growth area. The LB Bexley Level 1 SFRA mapping shows the northern area to have a flood hazard of 'Danger for all' and a likely flooding onset rate of less than 3 hours. West Street is identified as a flood hazard of 'Danger for all' with an onset rate of less than 6 hours. The Europa trading estate is at risk of a breach in flood defences due to a flood pathway under the railway bridge, and has a flood hazard of 'Danger for most', with an onset rate of between 6 and more than 15 hours. In Slade Green, the LB Bexley Level 1 SFRA mapping shows flood depths are greatest to the north adjacent to the River Thames (near the national construction college) and the south east (near Hollywood Way), with deeps up to 4 m. These areas have a flood hazard of 'Danger for all' and an onset rate of less than 6 hours. The Manor Road Trading Estate and areas around the Slade Green Infant School are shown to have flood depths up to 2.5 m, with a hazard rating of 'Danger to most' and an onset rate of less than 15 hours.

Crayford:

LB Bexley Level 2 SFRA (2010) indicates that the residual tidal flooding extends up the River Cray floodplain, almost as far as the A2000 crossing. Flooding in the Tower Retail Park and Crayford Industrial Area is predicted to be in the order of between 0.5 and 1 m deep with peak flood water elevations in the order of 4.4 to 4.89 mAOD. The 2010 breach modelling indicates that the rate of onset for flooding in Crayford would be greater than 15 hours.

Figure 10a – Breach Location: Thm04 (downstream of the barrier)

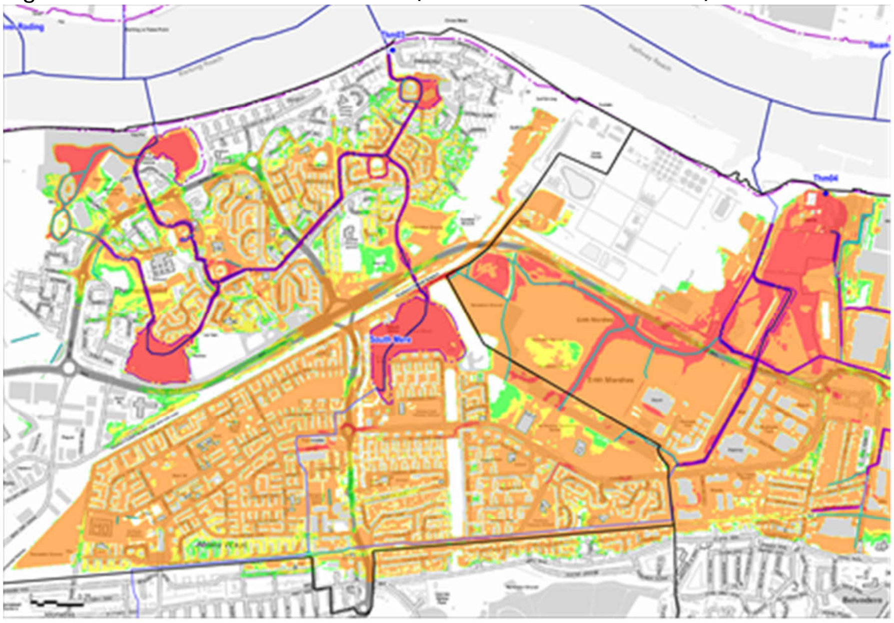


Figure 10b – Breach Location: Thm05 (downstream of the barrier)

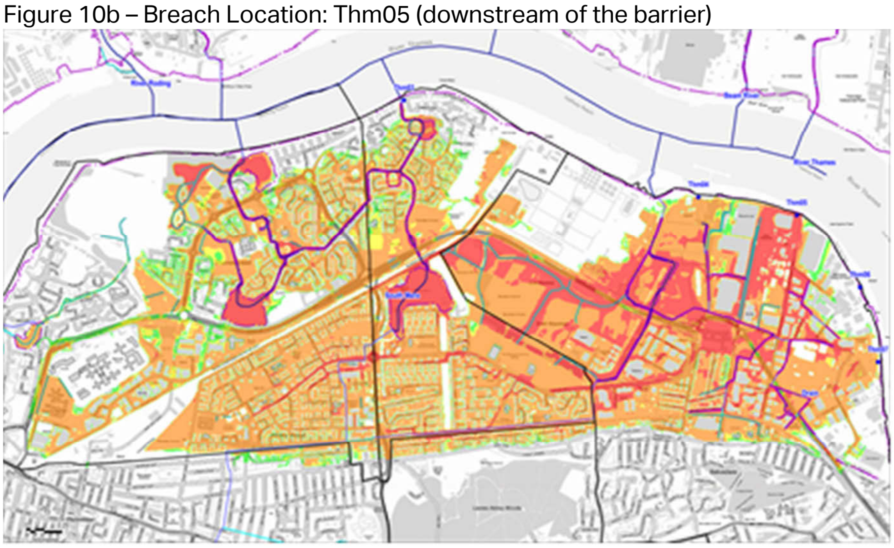


Figure 10c – Breach Location: Thm06 (downstream of the barrier)

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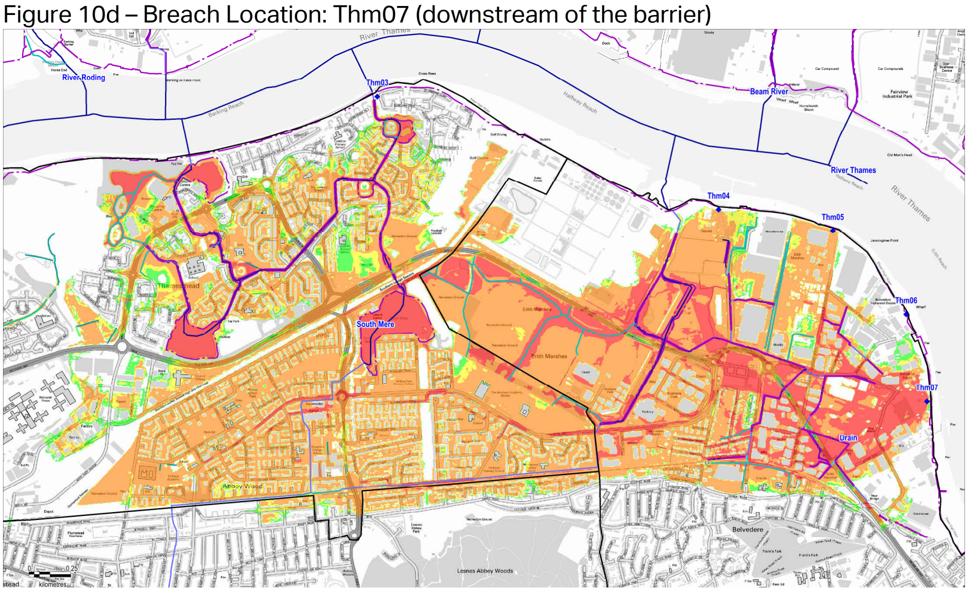
Figure 10d – Breach Location: Thm07 (downstream of the barrier)



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Fluvial Flood Risk:

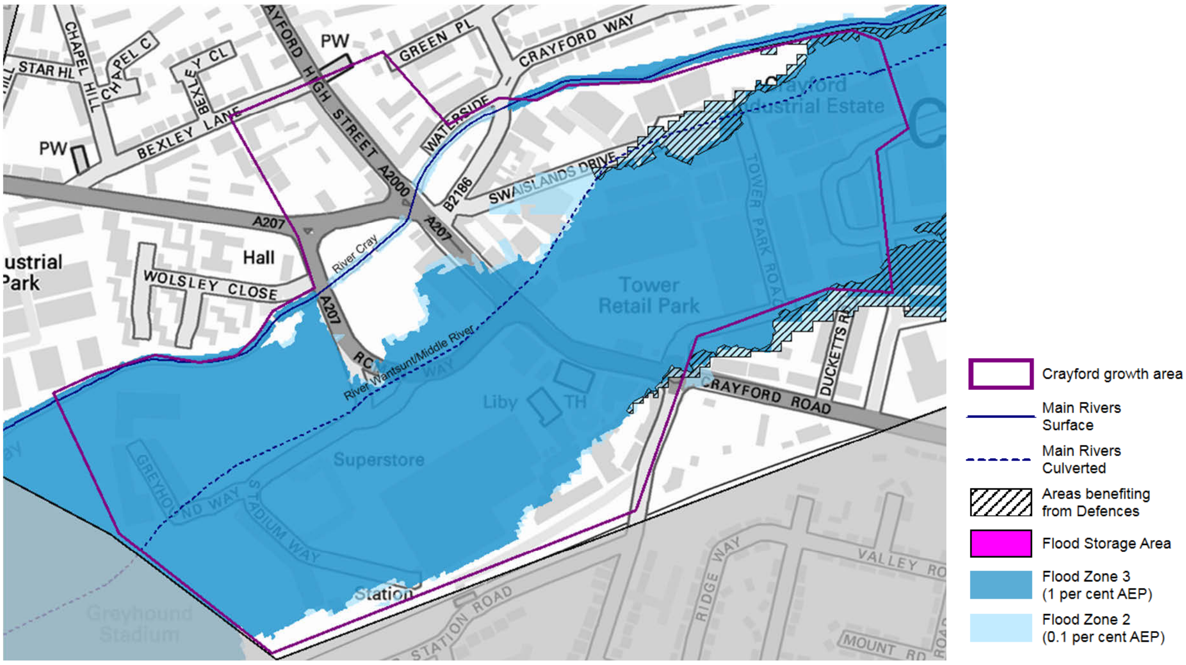
The Belvedere, Erith and Slade Green Growth Area are not at risk of fluvial flooding.

Crayford:

The River Cray flows west to east along the northern boundary of the Crayford Growth area, and the culverted Middle River (River Wantsunt) runs west to east through the center of the growth area. The Environment Agency Flood Map for Planning (Rivers and Sea) shows the majority of the central growth area to be within undefended Flood Zone 3, with small areas of defended Flood Zone 3 and undefended Flood Zone 2. (Figure 11).

The LB Bexley Level 2 SFRA states that for the 1% AEP including the previous climate change allowance, flood depths varying from 0 to 1 m in the north east and south west of the growth area. The majority of the Crayford growth area has a fluvial flood hazard of 'Dangerous for some' for the 1% AEP including the previous climate change allowance scenario.

Figure 11 – Fluvial Flood Risk in the Crayford growth area.



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Surface Water Flood Risk:

Belvedere:

The LB Bexley Level 2 SFRA identifies that surface water flooding hotspots are historically around Belvedere railway station and Mitchell Close. The issues in the area around the railway station are associated with the rapid change in gradient at the bottom of the hill. In Mitchell Close the reported issues are associated with surcharged water flowing from manholes around the junction between Mitchell Close and Lower Road.

The LB Bexley Level 2 SFRA states that all surface water from the Belvedere Employment Area and along Yarnton Way drains into the Erith Marshes surface water drainage network of ditches and dykes.

Erith and Slade Green:

The LB Bexley Level 2 SFRA identifies reported incidents of highway flooding in Slade Green, and the area at the north end of Walnut Tree Road in Erith is known to suffer from surface water flooding.

Crayford:

The LB Bexley Level 2 SFRA states that there have been a significant number of reported surface water flooding incidents around the junctions of London Road, Waterside Road and Crayford High Street. It suggests that it is likely that the reported incidents in the town centre are related to local capacity issues within the drainage network and/or by high water levels restricting discharge from the drains in to the River Cray.

The surface water modelling from the LB Bexley Level 1 SFRA predicts a significant potential surface water flow route located across the north of the sustainable growth area, through Perry Street Farm, down Mayplace Avenue and passing through the Thames Road Industrial Area, before draining into the River Cray.

The Bexley Riverside OA is located with the following Critical Drainage Areas:

- Group6_001
- Group6_002
- Group6_003
- Group6_004

Groundwater Flood Risk:

The BGS 1:50,000 geology mapping suggests that there is a potential route for groundwater to reach the surface. Groundwater flooding is therefore a potential risk along the valley bottom of the River Cray, in the Crayford Marshes, and the Thamesmead and Erith Marshes.

The risk of groundwater flooding is considered to be locally variable as the composition and stratigraphy of the overlying superficial deposits will influence how groundwater levels in the chalk aquifer will translated into groundwater levels within the superficial deposits. LB Bexley SFRA mapping indicates that risk of groundwater levels being near or at the surface during prolonged wet periods is potentially high in the topographically low areas.

Sewer Flood Risk

The LB Bexley PFRA (2011) shows that, using the TWUL DG5 Flood Register, the following sewer flooding incidents were experienced within growth area postcodes in the last 10 years:

- Belvedere (DA17 6) – 1 to 5 records of sewer flooding
- Erith (DA8 1) – 6 to 10 records of sewer flooding
- Slade Green (DA8 2) – N/A
- Crayford (DA1 4) - 6 to 10 records of sewer flooding

It should be noted that records only appear on the DG5 register where they have been reported to TWUL, and as such they may not include all instances of sewer flooding. Furthermore given that TWUL target these areas for maintenance and improvements, areas that experienced flooding in the past may no longer be at greatest risk of flooding in the future.

Artificial Flood Risk

The Belvedere growth area drains to the Erith Marshes system of ditches and dykes. The Yarton Way culverted surface water drain collects water from the Abbywood and Belvedere growth areas and discharges into open ditches in Erith Marshes. The water levels in the Marshes are maintained by a weir and two pumping stations; Great Breach (to the east of Crossness STW) and Green Level.

The current managed water level in the Erith Marshes ditches and dykes system is -0.76 m AOD, which is very close to the soffit (roof of the culvert), and this results in there being little surplus capacity in the Yarton Way culvert to respond to storm flows. The performance of much of the network that drains into the Yarnton Way culvert is limited, under storm conditions, by the water level in ditches and dykes.

The Environment Agency 'Flooding from Reservoirs' mapping available online identifies the following reservoirs that could result in flooding in the Bexley Riverside OA:

- Northumberland Heath Reservoir (Thames Water) – a small area in Northend/Slade Green.
- Hall Place FRR (Environment Agency) – follows the River Cray floodplain through Crayford.
- Danson Park Lake (Bexley Council) – follows the River Cray floodplain through Crayford.

Flood Risk Hotspots

The baseline and historical flooding incident information from all flood risk sources has been used to identify Flood Risk Hotspots within the four growth areas within the Bexley Riverside OA; these areas are shown in Figures 11a – 11d.

Flood Risk Hotspots are locations that locally have a higher risk of flooding compared to the study area due to one or more sources of flood risk. These locations, and specific mitigation, should be considered carefully when considering individual planning applications in these locations. With respect to the Bexley Riverside OA, proposals for additional development should preferentially be steered away from these higher risk areas and consideration should be given at masterplanning stage to plot layout and provision of green space, allowing space for flood waters specifically associated with surface water.

Figure 11a – Flood Risk hotspots in Bevedere Growth Area

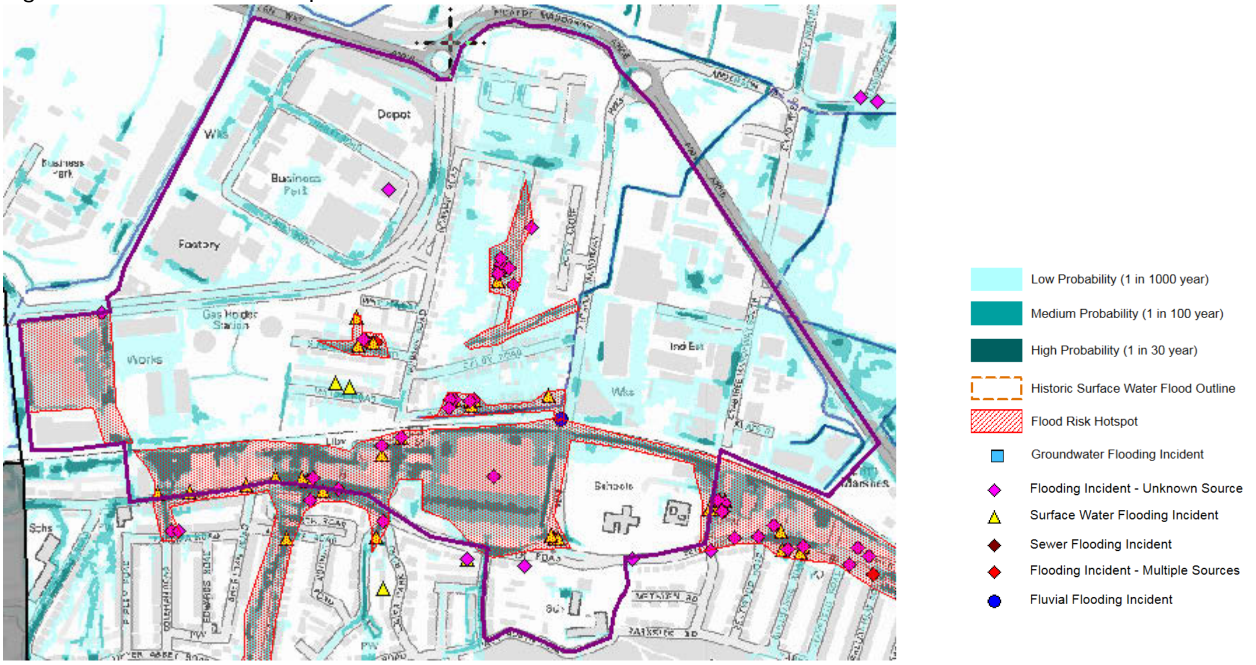

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Figure 11b – Flood Risk hotspots in Erith Growth Area

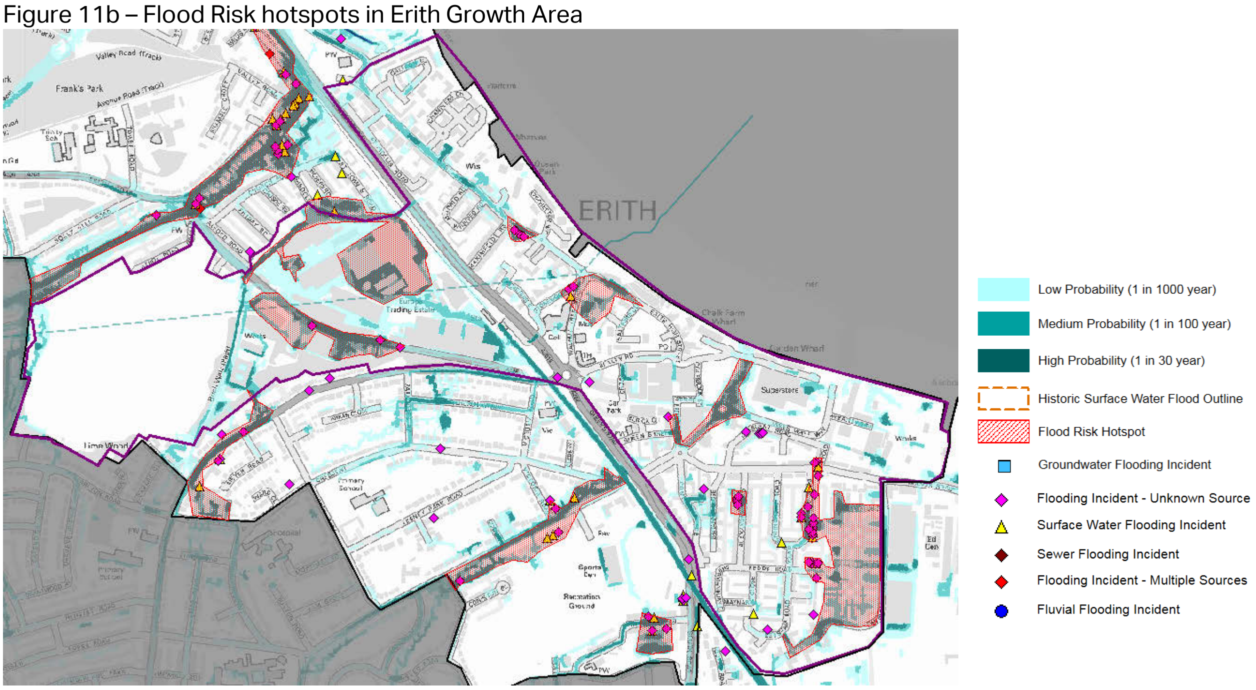

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Figure 11c – Flood Risk hotspots in Slade Green Growth Area

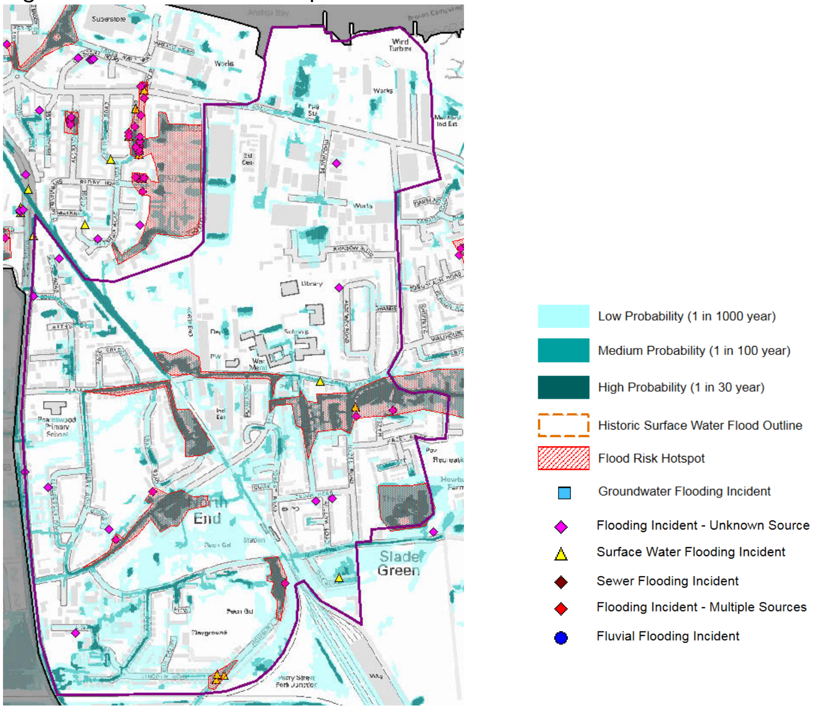

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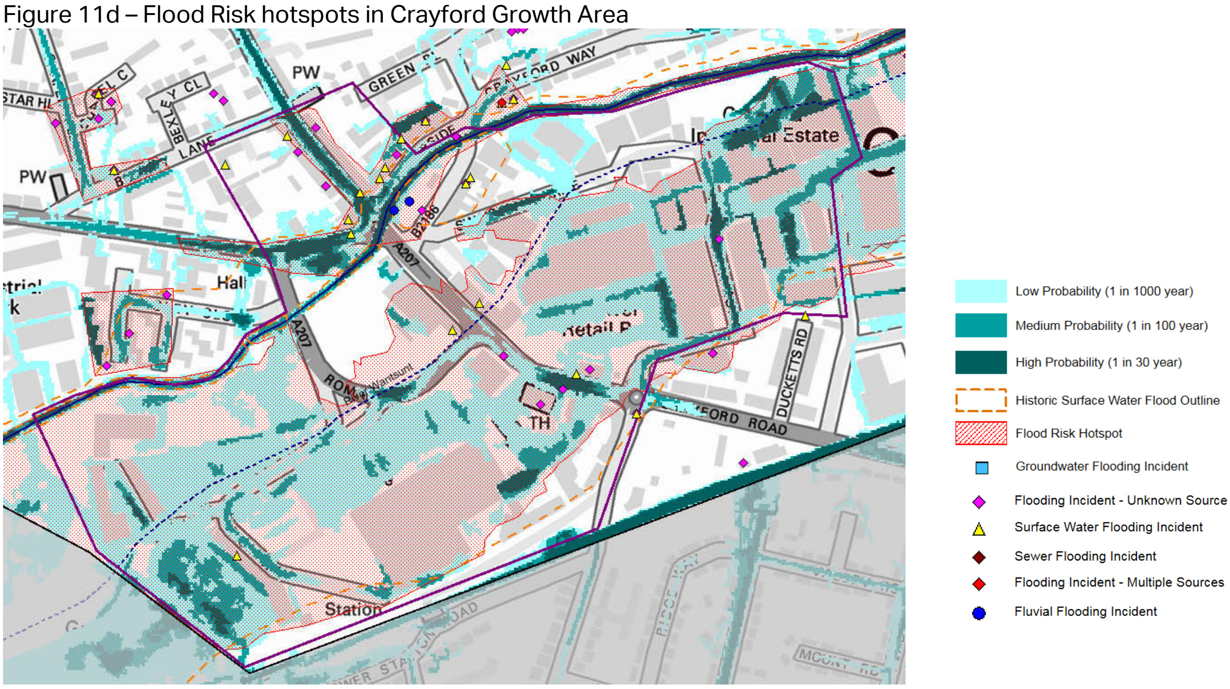
Figure 11d – Flood Risk hotspots in Crayford Growth Area



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Local Management Opportunities Summary

The Regional Flood Risk appraisal for Greater London identifies the following potential flood risk mitigation measures for the Bexley Riverside OA:

- Located in the Thamesmead and Dartford and Erith TE2100 policy units.
- Raising river walls and embankments required by 2040 for normal tides and tidal surges.
- Open spaces to be retained for potential flood storage and work to flood defences in future.
- Need to consider future of Darent Industrial Estate and potential use of Crayford Marshes for tidal storage.
- Outputs from the River Cray flood risk management asset study should be considered.
- Measures to reduce surface water run-off will be important.
- New development is a good opportunity to introduce more sustainable rainwater management and should

readily be able to achieve Greenfield run-off rates and reduce the current risks.

- Development close to the Thames can discharge directly to the river.

A summary of mitigation measures that should be considered at the detailed design stage for developments where the flood depths are expected to exceed 0.6 m are:

- Accept water passage through building at higher water depths;
- Attempt to keep water out for low depths of flooding;
- Use materials with a low permeability at lower levels;
- Provide key services including electricity, water, etc. to continue under flood conditions;
- Site electrical controls, cables and appliances above the predicted maximum flood levels;
- Design to drain water away after flooding;
- Ensure access to all spaces to permit drying and cleaning.

The impact the flood waters will have on the structural integrity of the buildings must be considered at the detailed design stage. It must be demonstrated that the buildings will remain safe in the event of a breach in the flood defences during a high tidal event.

Review of Strategic Management Opportunities

Greenwich LFRMS Action Plan:

The RB Greenwich LFRMS has identified Borough-wide actions and measures to address flood risk management. Although the measures within the action plan are high level and focus at a Borough wide scale, the following actions and measures have been identified as being relevant to the Charlton Riverside and Woolwich OAs:

- Seek opportunities to manage surface water run off locally and individually i.e.
    - Intercepting roof runoff into water butts, back gardens
    - Rainwater harvesting
    - Green roofs
    - Front gardens using permeable paving
    - Replace footways with permeable materials
    - de-pave impervious surfaces.
- Review opportunities linked to proposed development to ensure betterment of flood risk and surface water management. Consider opportunities to reduce risk through re-development.
- Promote de-pave opportunities, water resource management and runoff management (especially from Parks and Open Spaces).
- Promote benefits of green infrastructure such as green roofs to community and developers and promote incorporation and management of green assets within development and redevelopment.
- Highlight links to All London Green Grid, Capital Ring and Greener Greenwich.
- Actively encourage SuDS for development and retrofit. Work in partnership with developers to maximise the uptake and introduction of SuDS.
- Where identified and appropriate introduce residential support schemes to promote benefits and value of green infrastructure to community. Provide green roof training, de-pave workshops, rain garden construction workshops for residents to encourage greater water management increase resilience, skill and knowledge base within Borough and start to build green economy jobs.

Bexley LFRMS Action Plan:

The LB Bexley LFRMS has identified actions and measures to address flood risk management within the Borough. The actions and measures relevant to the Thamesmead and Abbey Wood and Bexley Riverside OAs have been identified below:

- Ensure the incorporation of storage / infiltration or other FRM measures alongside other works where practical.
- Maintain a strategy to ensure SuDS are incorporated in new developments and redevelopments by applying national, regional and local planning policies, supported by a Borough wide education programme. This is particularly relevant in areas likely to derive the most benefit, such as Crayford and Bexley.
- Seek opportunities to intercept roof runoff into gardens and promote the use of green and permeable coverings in gardens. Replace footways with permeable tarmac where practical.
- Extend integrated drainage study in Crayford to provide further options assessment / development required to identify the most effective scheme to reduce flood risk within Crayford. Ideally this scheme will increase the level of protection to at least a 70 year return period. The identified scheme will then be implemented.
- Keep maintenance of Joyden's Wood drainage ditches under review - these are poorly maintained but results in some flood storage potential. Should maintenance be instigated (either in Bexley or Kent) then review opportunities to introduce 'check-weirs' to hold water back and slow response of catchment to rapid response events. Note Hurst Grid Sub Station downstream of wood.
- Look to provide upstream storage capacity to address surface water issues in Riverdale Rd, Church Rd and Pembroke Road.
- Work with TWUL to develop partnership funding scheme to reduce risk of combined surface water flooding and sewer flooding in Pembroke Road and surrounding area.
- Address historical surface water flooding in Fraser Road in developer proposals linked to Erith Quarry development.
- Develop closer partnership working arrangements to secure improved maintenance of the main river / ordinary watercourse network draining upper and lower Belvedere.
- Assist the EA project of evaluation of the Thamesmead ditch and dyke system including optioneering of improvements or changes in maintenance regime.

Environment Agency 6 year Investment Plan

Tables 6 and 7 have been extracted from the Environment Agency Thames Region Flood and Coastal Committee (RFCC) six year investment plan. Table 6 identifies projects in the Study area that are within the current construction programme. Table 7 identifies projects in the Study area that are within future development programme.

The six year investment programme is updated yearly, normally around February. Before any plans are designed in the Study area the Environment Agency recommend being aware of the most up to date programme. Where there are projects identified in the Study area, the developer should work with the Risk Management Authority who is leading on the project.

Table 6. Flood and Coastal Erosion Risk Management (FCERM) Construction Programme (updated February 2015) – Thames Regional Flood and Coastal Committee (RFCC)

Project Name	RMA	Constituency	Location	Estimated Total Project Cost (£k)	Households with a better level of protection from flooding by March 2021	Total households with a better level of protection from flooding when schemes are complete	Economic benefits (Net Present Value, £k)
Thames Barrier Drive Equipment	Environment Agency	Greenwich and Woolwich Boro Const	Thames Barrier, Woolwich	25,880.0	1,450	2,500	1,973,086.1
Thames Barrier Store & Depot	Environment Agency	Greenwich and Woolwich Boro Const	Thames RFCC	3,150.0			

Table 7. Flood and Coastal Erosion Risk Management (FCERM) Development Programme (updated February 2015) – Thames Regional Flood and Coastal Committee (RFCC)

Project Name	RMA	Constituency	Location	Estimated Total Project Cost (£k)	Estimated earliest construction start	Estimated funding for construction by March 2021 dependent on full business case approval and securing required contributions		Households with a better level of protection from flooding by March 2021	Total households with a better level of protection from flooding when schemes are complete	Economic benefits (Net Present Value, £k)
						GiA (£k)	RFCC local levy (£k)			
Crayford Marshes Earth Tidal Flood Embankment	Environment Agency	Dartford Co Const	Darent Industrail Park and Crayford Marshes, Slade Green, Kent - DA8 2AF	5,055.0	Beyond 2021		1,380.0		1,200	11,698.7
Darent Industrial Estate Fluvial Flood Alleviation	Environment Agency	Bexleyheath and Crayford Boro Const	Crayford Marshes, Near Erith, Kent DA8 2LD	540.0	2018 to 2021	500.0		135	135	12,070.7
Clothworkers Wood - Wet Woodland Flood Storage	London Borough of Greenwich	Greenwich and Woolwich Boro Const	Plumstead, Wickham Valley Watercourse	175.0	Beyond 2021	16.4	8.7		30	444.5
Greenwich Groundwater preparation	London Borough of Greenwich	Greenwich and Woolwich Boro Const	Royal Borough of Greenwich	505.0	2018 to 2021	430.0		200	200	3,690.5
Wickham Valley Water Course Flood Storage	London Borough of Greenwich	Greenwich and Woolwich Boro Const	East Wickham, Wickham Valley Watercourse	225.0	Beyond 2021	20.4	24.7		60	956.9

Thames Estuary 2100 (TE2100) Plan:

The TE2100 sets out recommendations and actions to manage tidal flood risk along the River Thames for London and Thames estuary through 2100 and beyond. The TE2100 plan is adaptable and as such is regularly monitored and updated. The TE2100 5-year review has just been published and is available online (https://www.gov.uk/government/publications/thames-estuary-2100-te2100). The whole plan is due to be updated by 2020.

Along the River Thames there are eight Action Zones, i.e. areas with similar characteristics that require a similar type and range of actions. The Charlton to Bexley IWMS study area is covered by Action Zone 3 (East London), Action Zone 4 (East London downstream of Thames Barrier) and Action Zone 5 (Middle Estuary). Each Action Zone is split into Policy Units with a specific TE2100 policy that applies to it. The TE2100 policies that apply to this study area are:

Policy P5: To take further action to reduce flood risk

- Greenwich Policy Unit - Charlton Riverside OA (TE2100 Action Zone 3)

Policy P4: To take further action to keep up with climate change and land use change so that flood risk does not increase.

- Thamesmead Policy Unit - Woolwich, Thamesmead and Abbey Wood, and northern Bexley Riverside OAs – (TE2100 Action Zone 4); and
- Dartford and Erith Policy Unit - Southern Bexley Riverside OA (TE2100 Action Zone 5)

The TE2100 recommendations within each Policy Unit that are relevant to the OAs within this study are identified below:

Greenwich Policy Unit (incorporating Charlton Riverside OA):

- Recommendation 2: To agree a programme of floodplain management including local flood protection, resilience and emergency plans for vulnerable key sites in action zone 3.
- Recommendation 6: To maintain, enhance, improve or replace the river defence walls and active structures through east London over the first 25 years of the plan from 2010 to 2034.
- Recommendation 7: To maintain, enhance and improve or replace the defence walls and active structures through east London during the 15 year period of the Plan from 2035 to 2049.
- Recommendation 8: To implement a programme of defence raising through east London from 2065 to 2070 (with defences upriver of the Thames Barrier being raised by 2065 and downriver in 2070).
- Recommendation 9: To maintain, improve, enhance or replace the river defence walls and active structures through central London post 2070 and into the 22nd century.
- Recommendation 10: To agree a programme of managing flooding from other sources in the defended tidal floodplain in the first 25 years of the TE2100 plan.

Thamesmead Policy Unit (incorporating Woolwich, Thamesmead and Abbey Wood, and northern Bexley Riverside OAs):

- Recommendation 2: To agree a programme of floodplain management including localised flood protection, resilience and local emergency plans for vulnerable key sites in action zone 4.
- Recommendation 6: To maintain, enhance and improve or replace the river defence walls and active structures through the east London downstream of the Thames Barrier zone over the first 25 years of the plan from 2010 to 2034.
- Recommendation 7: To maintain, enhance and improve or replace the defence walls and active structures through east London downstream of the Thames Barrier during the 15 year period of the Plan from 2035 to 2049.
- Recommendation 8: To implement our "end of the century" option between 2050 and 2070.
- Recommendation 9: To maintain, improve and enhance or replace the river defence walls and active structures in east London downstream of the Thames Barrier zone post 2050 and into the 22nd century.
- Recommendation 10: To agree a programme of managing flooding from other sources in the defended tidal floodplain in the first 25 years of the TE2100 plan.
- Recommendation 12: To agree a programme for habitat enhancement and replacement and implement habitat improvement and replacement schemes up to 2050.

Dartford and Erith Policy Unit (incorporating the southern Bexley Riverside OA):

- Recommendation 2: To agree a programme of floodplain management including flood warning, emergency planning, and localized flood protection and resilience for vulnerable key sites in action zone 5.
- Recommendation 6: To maintain, enhance and replace the river defence walls and active structures through action zone 5 over the first 25 years of the plan from 2010 to 2034.
- Recommendation 7: To operate, maintain and enhance the defence walls and active structures through action zone 5 during the 15 year period of the Plan from 2035 to 2049 – this will include defence raising in 2040.
- Recommendation 8: To implement our "end of the century" option in 2070.
- Recommendation 9: To maintain and enhance the river defence walls and active structures in action zone 5 post 2050 and into the 22nd century.
- Recommendation 10: To agree a programme of managing flooding from other sources in the defended tidal floodplain in the first 25 years of the TE2100 plan.
- Recommendation 12: To agree a programme for habitat enhancement and creation.

Appendix G Asset and Infrastructure Register

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Appendix H Groundwater Injection Option Technical Note

The purpose of this technical note is to describe the potential for the capture of storm water and injection into aquifers in the study area for later reuse, as part of the consideration of options for an Integrated Water Management Strategy (IWMS).

Surface and foul waters across the study area are currently collected in a combined sewer network which drains into the Southern Outfall Sewer which delivers waters to Crossness Sewage treatment works. The overall desire is to limit storm water entering the combined sewer network because it has limited additional capacity in many areas. Thames Water would like future developments to make use of surface water collection schemes as much as possible.

Injection described herein is the process whereby surface waters are artificially introduced to an aquifer, as opposed to the natural process of infiltration. This can be achieved by several methods including storm water storage in a permeable lagoon, where the stored water percolates to the water table, or conveying the water into boreholes which are screened at a design depth allowing flow into the aquifer above the water table in the unsaturated zone. As the study area is largely urban the most likely method would be boreholes as they require a much smaller footprint.

The essential requirement for injecting waters into an aquifer is a suitable thickness of unsaturated zone. This limits the risk of direct discharge to groundwater as well as allowing injection of a given volume of water to create a water table mound that does not reach an elevation where it could cause flooding or damage structures. Other considerations are whether the increased water table elevation may liberate any contaminants present and cause pollution.

Reuse involves abstracting groundwater at a future date. This can be done by pumping from a borehole, which could be the same as the injection borehole. Considerations for reuse relate to the water quality of the abstracted groundwater and the intended end use.

1. Geology and Hydrogeology

The study area is underlain by three aquifers, the Chalk, Thanet Sands, and Harwich Formation. The Chalk is present at the lowest elevations nearest the River Thames. Thanet Sands overlie the Chalk and are situated near the River Thames and also on slightly higher ground to the south. Much of the study area away from the river margins, on the higher ground, is underlain by the Chalk, Thanet Sands and the lower permeability Lambeth Formation, overlain by the Harwich Formation at outcrop. On the highest elevations above 55 mAOD at Shooters Hill London Clay outcrops and overlies the Harwich Formation.

Each aquifer presents different properties and therefore different suitability for use as a water resource or for accepting waters injected into the medium. Depth to groundwater and whether the aquifer is confined or unconfined will also influence the capacity for discharging and storing surface water and the ability to abstract it for reuse.

The study area has variable unsaturated zone thicknesses; a shallow water table renders areas unsuitable for significant injection volumes due to limited storage capacity and the consequent risk that a water table mound may lead to groundwater flooding. Some areas have thicker unsaturated zones and a greater depth to groundwater; this includes the Chalk aquifer in the central part of the study area.

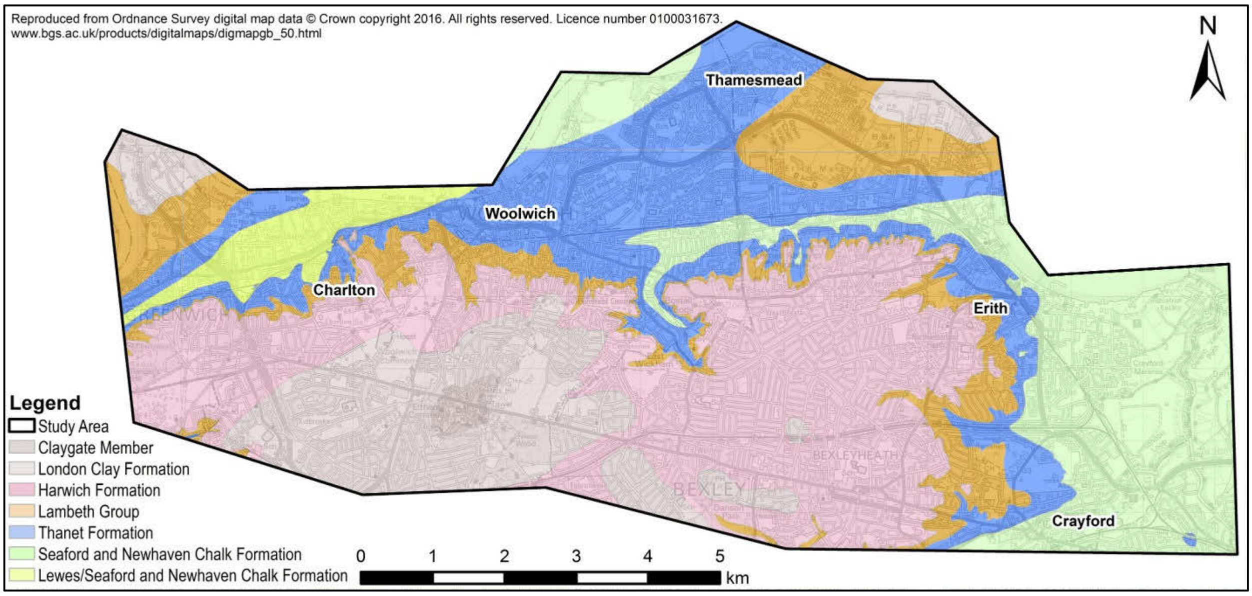

Illustration 1: Geology of Study Area

2. Aquifer Characteristics

Understanding the unsaturated zone and the saturated zone thickness of the aquifers is a first step in assessing their capacity to accept injection of surface water. The data used to define thickness are the 1m Digital Terrain Model (DTM) for surface elevation, the geological layer elevations from the Environment Agency's London Basin Groundwater Model (LBGM), and a Chalk water table contour map from the Environment Agency's Management of the London Basin Chalk Aquifer status report. The water table level used is the most recent available, January 2015. This water table map is updated annually and, although a 2016 version was not available at the time of writing, the water table interpretation does not vary significantly from year to year.

The elevation data used to assess layer thicknesses and unsaturated zone thicknesses were interpolated on a 200m grid. The geology and water table data was taken from boreholes which can be spaced several kilometres apart in places. This data was interpolated to a value every 200m square for the creation of the LBGM and the groundwater model surface used the 50m resolution DTM. The current study used the 1m resolution DTM for the land surface. These data have been input to a GIS layer enabling the surface elevation, geological layer elevations, and the Chalk water table elevation to be compared. The resulting 3D ground model is therefore 'blocky' in nature and elevation changes may not be accurate locally. Nevertheless it allows areas that are suitable or unsuitable for aquifer storage to be identified at a coarse scale. If sites were to be taken forward, ground investigation would be required to confirm these findings.

The following layer calculations provide a spatial representation of where aquifer storage of surface water runoff may be possible.

2.1 Harwich Formation

There is no groundwater monitoring data available for the Harwich Formation aquifer in this area from which to calculate an unsaturated zone thickness, and therefore the first step was to calculate the aquifer thickness. The unsaturated zone thickness will be less than the aquifer thickness.

The thickness calculation was based on the surface elevation minus the top of the geological layer beneath the Harwich Formation, the Lambeth Group. The thickness derived in this way includes the Harwich Formation together with any overlying superficial geology layers and made ground.

The geological map shows very limited superficial cover in the eastern half of the study area, while in the south and west London Clay overlies the Harwich Formation from Kidbrooke to Eltham Common and Shooters Hill, with smaller London Clay outcrops around Bexley.

Therefore with the exception of areas of London Clay outcrop, the Harwich Formation thickness is essentially the surface elevation minus the top of the Lambeth Group surface. In areas where there is London Clay the model thickness may be significantly greater than the Harwich Formation thickness and needs to be corrected for.

Across the centre of the study area from west to east the Harwich Formation outcrops at surface and is generally more than 10 m thick (and up to 25m). It is at its thickest on the highest elevations of the study area around Bostal Woods to West Heath (up to 30 m thick). Around Bexley the thickness reduces to less than 3 m due to the elevation of the Lambeth Group beneath.

Borehole logs from the British Geological Survey (BGS) Geoviewer indicate that the London Clay is in the order of 20 m thick, while in the 3D model top of Lambeth Group beneath the London Clay is approximately 20-30 m below surface. A new top of Harwich Formation has not been interpolated beneath the London Clay for this strategic level study, but the 3D model and borehole evidence indicates that the Harwich Formation is likely to be less than 10 m thick. The outcrop of the Lambeth Group south of Shooters Hill outside the study area suggests that the Harwich Formation may have been eroded away in the area around London Clay deposits.

The depth to the base of the Harwich Formation is shown in Figure 2 including the interpreted thickness around Shooters Hill beneath London Clay in this area.

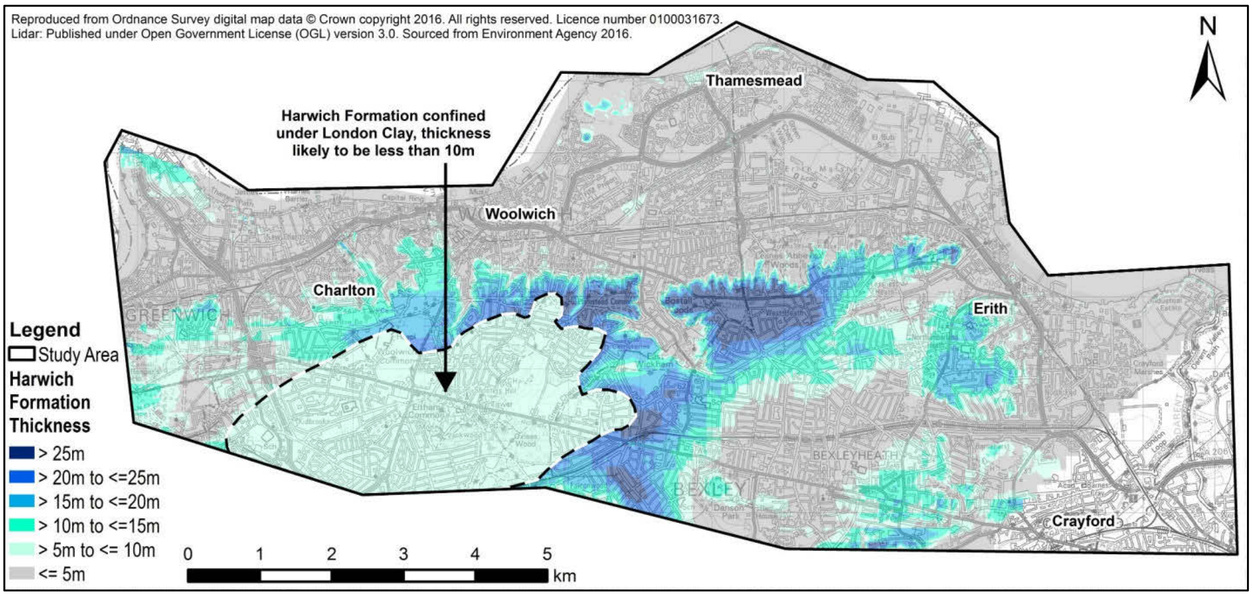

Illustration 2: Thickness of Harwich Formation

No monitoring data is available to estimate a water table elevation but it is reasonable to assume that recharge occurs at outcrop; groundwater discharge is at low points and that the water table is a subdued reflection of topography. The Ordnance Survey (OS) map and DTM have been interrogated for elevations of streams or springs that would indicate a water table control point.

Surface waters on the Harwich Formation are at Lessness Heath rising to 38 mAOD in the east of the study area, below Woolwich Common at 35 mAOD and 30 mAOD in the northern outcrop edges. Streams run off Shooters Hill over the London Clay and then on to Harwich Formation and then the stream sinks into the aquifer to the east of Shooters Hill at 38 m AOD according to the OS map.

Therefore a Harwich Formation water table is not likely to be higher than 38 mAOD in the east and in the north and west between 30 and 35 mAOD.

Based on this general level in the eastern part of the study area there is estimated to be around 10-20 m of unsaturated zone available in the east while in the north and west it may be up to 10 m.

2.2 Thanet Sand

There is no groundwater monitoring data available in the Thanet Sands aquifer from which to calculate an unsaturated zone thickness. The thickness calculation is based on the model elevation of the top of the Thanet Sand minus the top of Chalk. In geological terms everything in between is Thanet Sand. Where the Thanet Sand is at outcrop the top of the layer tends to be above the surface elevation. This relates to the resolution of the geological layering, the DTM and the interpolation. This difference tends to be less than one metre and is found where there is a Thanet Sand unsaturated zone thickness of less than 3 m where it thins out toward the River Thames.

Thanet Sands Formation is found over most of the study area but is entirely absent from the eastern area around Crayford where the Chalk outcrops. Away from the formation edges it is between 7 m and 15 m thick. This thickness does not consider a water table within the formation as there is no discrete groundwater monitoring in this layer. Assumptions need to be made on assuming a thickness that is already saturated either from direct recharge in outcrop areas, and where the Chalk water table rises into the Thanet Sand.

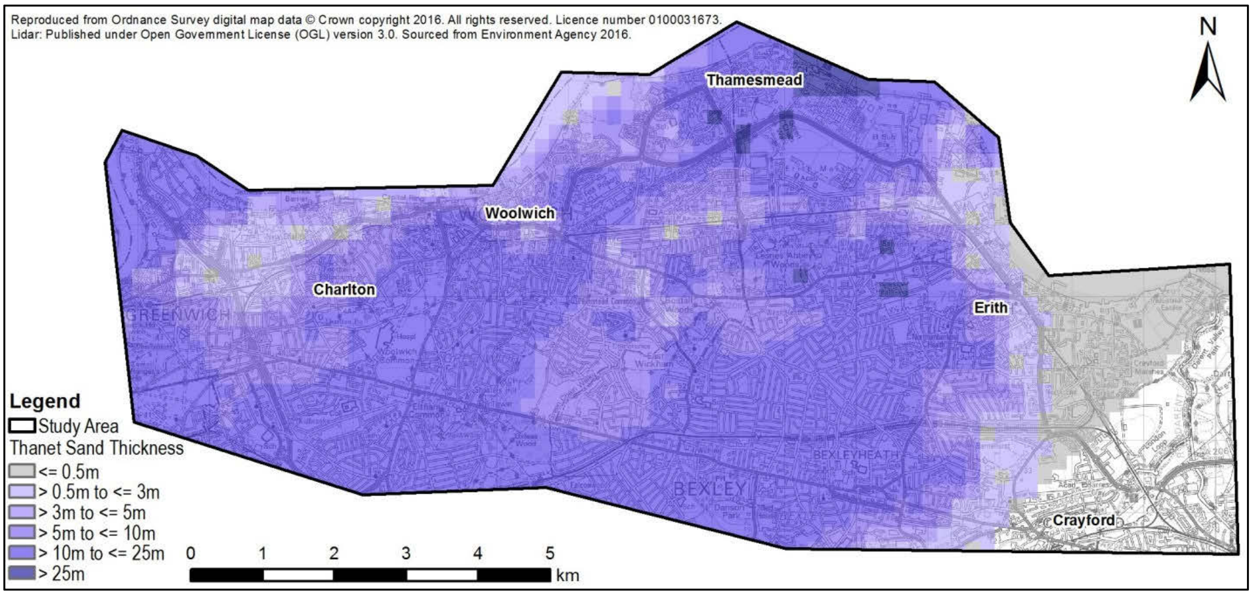

Illustration 3: Thanet Sand Thickness

In some areas the Chalk water table rises above the top of the Chalk into the Thanet Sand leaving an unsaturated zone of less than the full thickness. The 3D model shows that in the north and south of the study area Chalk groundwater is artesian; reducing the available thickness of Thanet Sand in these areas. Across much of the study area the Chalk water table is within the Chalk Formation.

Throughout this area the Thanet Sand is overlain by the low permeability Lambeth Group. Therefore it could be assumed that rainfall recharge occurs to the Harwich Formation overlying the Lambeth Group and flows laterally to local stream and spring discharge points, and little percolation would reach the Thanet Sand. It is possible that there is little groundwater in the Thanet Sand in the central parts of the study area, giving at least a 7m unsaturated zone thickness.

The Thanet Sand is often considered, in combination with the Chalk aquifer beneath, as one aquifer.

2.3 Chalk

The Chalk aquifer underlies the entire study area. It outcrops along the River Thames in the Greenwich to Charlton area, in the east of the study area between Crayford and Erith, a narrow east west strip from Erith to Abbey Wood and a narrow valley near Plumstead Common. Elsewhere it is overlain by Thanet Sand, Lambeth Group and Harwich Formation.

Areas of unsaturated zone thickness have been calculated in the 3D model using the top of Chalk minus the water table elevation from the Environment Agency's Management of the London Basin Chalk Aquifer status report. It is greater than three metres in the north between Charlton and Greenwich as well as through the central and eastern parts of the study area, beneath the overlying formations. Beyond these areas the chalk is fully saturated and the chalk water table rises up into the overlying Thanet Sand.

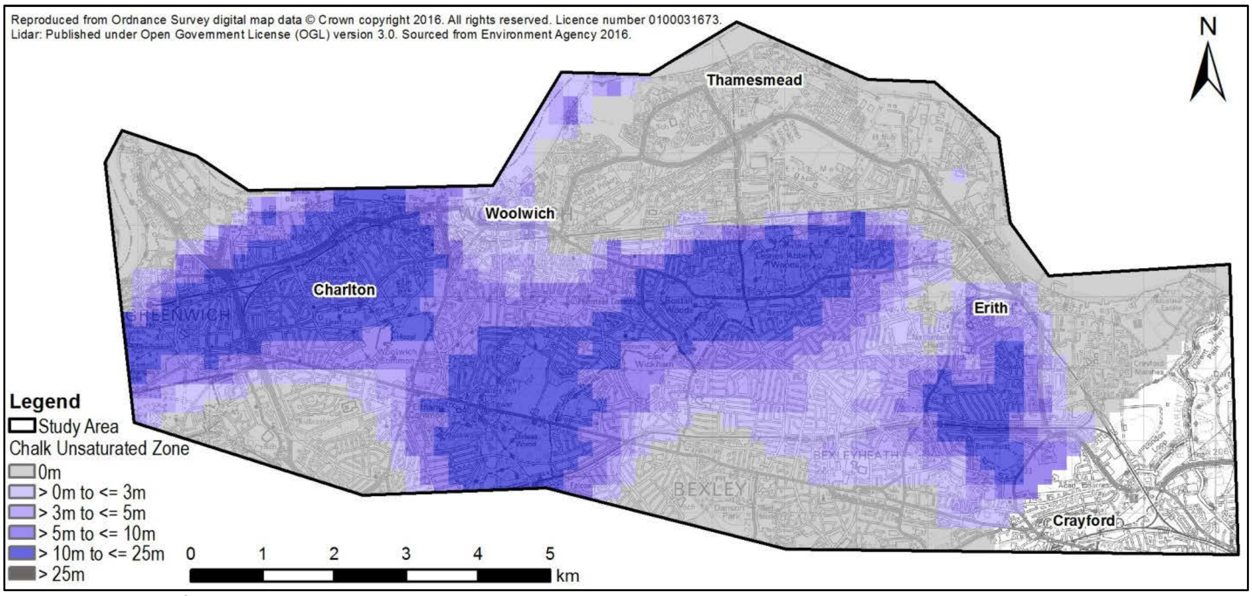

Illustration 4: Chalk Unsaturated Zone Thickness

This unsaturated zone thickness assumes a static water table elevation. The water table varies with season and is also affected by long terms changes in abstraction. In central London abstraction has reduced significantly since the 1960s leading to a rising water table. To stabilise this, the GARDIT (General Aquifer Research, Development and Investigation Team) strategy sought to increase abstraction to the point of stabilising the rising water table. This is reported each year in the Environment Agency's Management of the London Basin Chalk Aquifer status report. It shows that groundwater levels are now generally stable in the study area.

The south eastern corner of the study area is outside the area of the 3D model available from the Environment Agency. This area contains the lower River Darent where it drains to the River Thames and the confluence with the River Cray. This area needs no further consideration because it is likely the Chalk water table is within 3m of surface in this area, and where it is not (e.g north of Crayford), as groundwater may locally flow to Crayford from this area, any water table rise may risk groundwater flooding.

3. Contamination

The study area has an industrial history. Some areas of aquifer may contain contaminated groundwater. This would render these areas unsuitable for injection of surface water because it has the potential to mobilise contaminants and increase their flow rates through the aquifer to natural discharge points, thus causing environmental harm. Injected surface waters in these locations will mix with contaminated groundwater, rendering the injected water unsuitable for reuse.

In general terms the local Environment Agency (KSL Enquiries email 21/06/2016) describes the area:

'In terms of the general 'big picture' view of land contamination in this area I would point out that the North Greenwich Peninsula, Charlton Riverside area and the former MoD land at Woolwich and Thamesmead are the most familiar sites affected by contamination.'

'…..locally groundwater in the Tertiary/Thanet Sand strata is affected by heavy metals in the Woolwich area, the main known area of poor quality groundwater is in the aquifers under the Greenwich Peninsula. This has affected the chalk, Tertiaries and the river terrace gravels.'

3.1 Landfill

The Environment Agency historic landfill data shows discrete sources of contamination. These are located on the Greenwich peninsula and along the River Thames in the Thamesmead area. There are numerous historic landfills in the Erith to Slade Green area, and isolated sites between Abbey Wood and Plumstead Common (see Illustration 5).

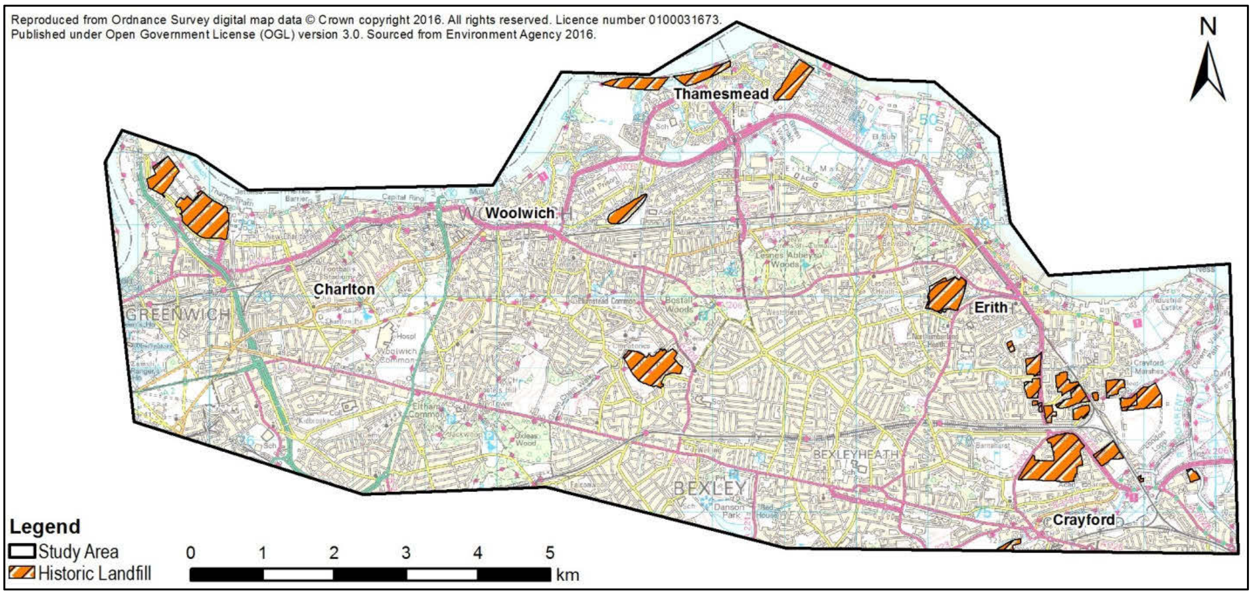

Illustration 5: Location of Historic Landfills

3.2 Saline Intrusion

At the lowest elevations in Chalk near the River Thames, tidal variations in the river level may have led to brackish water entering the aquifer locally where there is an unsaturated zone. It would not be desirable to inject surface waters in these areas as this water would mix with saline groundwater rendering it unsuitable for reuse.

These areas may be suitable as injection sites for the purpose of preventing storm flows to combined sewers; and may be beneficial for London regional water resources in terms of raising the Chalk water table elevation in the vicinity of the River Thames to prevent surface water ingress. These areas are located along the Chalk outcrop from New Charlton to Greenwich.

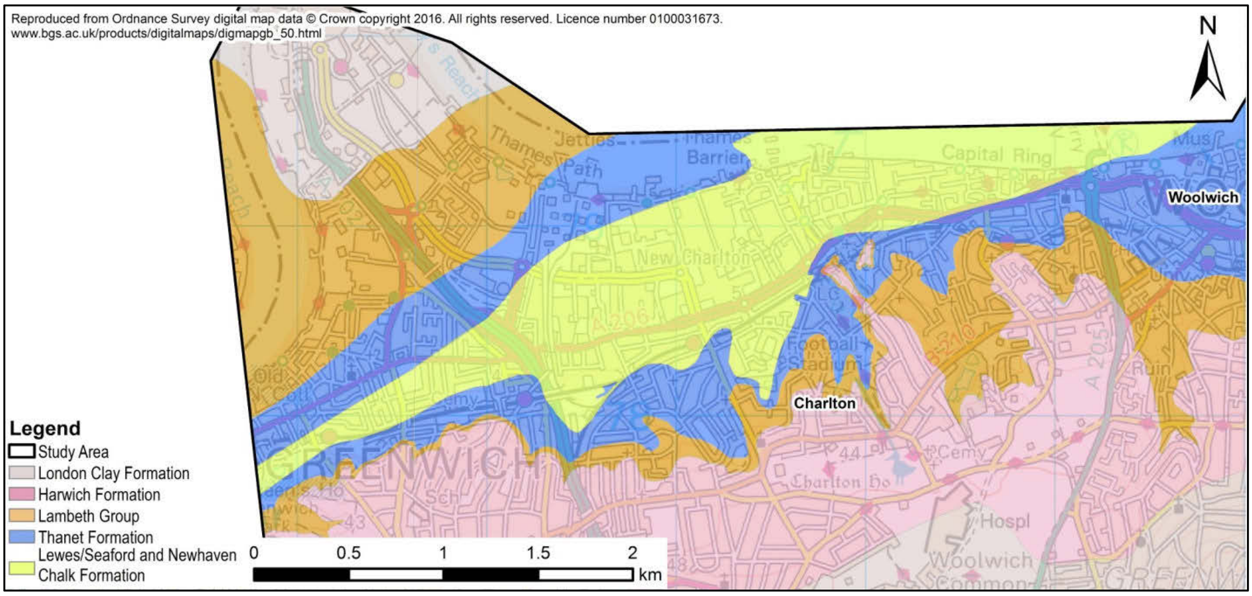

Illustration 6: Chalk and Thanet Sand Outcrop Area with Historic Saline Intrusion

3.3 Source Protection Zones

Injection sites within source protection zones in the study area are unlikely to be allowed by the Environment Agency for the protection of potable water use. In the south east corner of the study area there are public water supply abstractions for Thames Water Crayford PS, the Dartford Creek STW abstraction, and Overy Street abstraction. Injection of storm waters may represent a direct discharge to controlled waters, and required permits may not be allowed in these areas or the storm waters may need a higher level of treatment, thus these areas could be considered as unsuitable.

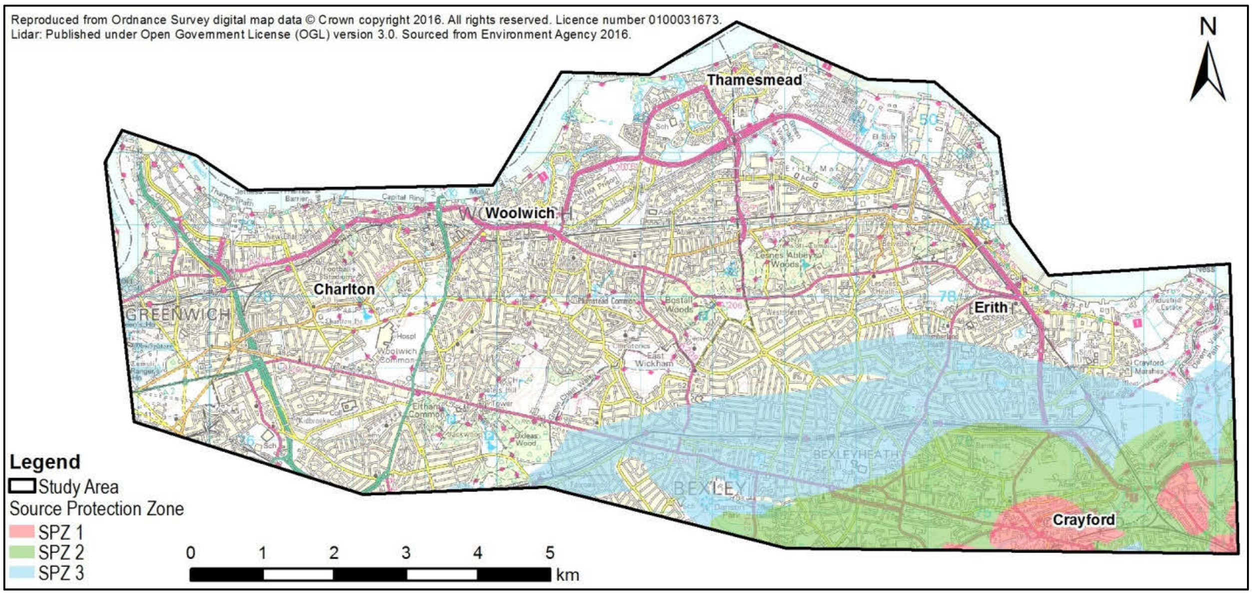

Illustration 7: Location of Source Protection Zones

4. Potential Aquifer Injection Sites

Suitable sites to collect and inject storm waters, thus preventing entry to the combined sewer system, will be areas where there is sufficient unsaturated zone thickness to accommodate a mound of groundwater. Mounding occurs where the volumes injected to the aquifer are greater than the capacity of the aquifer to transmit flow away. This mound causes an increased hydraulic gradient above the ambient groundwater level and will allow flow of sufficient quantities to enable storm waters to drain away where permeability is sufficiently high. The mound created should not be allowed to cause nearby or down gradient groundwater flooding risk. That is, injection would not be recommended where the unsaturated zone thickness becomes shallower down gradient, for example due to a break of slope into a valley.

If the groundwater is to be reused then the injected water should be in an area where existing groundwater quality is suitable for the intended reuse. If the water is not to be reused then consideration should be given to whether the mound of groundwater will cause existing contamination or brackish water to flow to a different receptor.

4.1 Opportunity Areas

The Opportunity Areas are those parcels of land identified for housing and /or commercial development by the local planning authorities and the Greater London Authority, as described in the main body of this report.

The overall themes for aquifer injection and reuse in and around the Opportunity Areas are as follows:

4.1.1 Charlton

This area has aquifer capacity to accept injected surface waters because the Chalk aquifer is dewatered leaving a considerable unsaturated zone. Groundwater flows north north west where the Chalk aquifer becomes confined meaning there is no downgradient flood risk caused by the mound.

The Chalk is in hydraulic continuity with the River Thames so the groundwater may be brackish as abstraction related dewatering has led to periodic saline intrusion. Where the Chalk is unconfined groundwater may be contaminated from local industrial sources.

Therefore there is an opportunity for injecting a volume of water but the water quality may not be suitable for reuse without treatment. The possibility of mobilising contamination and whether this would be acceptable also needs to be considered.

4.1.2 Woolwich

This area has similar capacity to Charlton immediately west of the Opportunity Area boundary. If additional land is available it could be used in the same way as Charlton, or a pipeline could convey the surface water from a collection site to the Charlton site. Similar water quality issues would need to be considered as described for the Charlton Opportunity Area.

4.1.3 Thamesmead and Belvedere

These two Opportunity Areas are underlain by Lambeth Group which acts to confine groundwater in the Chalk and Thanet Sand at depth. Groundwater levels in the Chalk are interpolated to be under pressure and close to ground level, offering limited ability to discharge water to the confined aquifers. Therefore these areas are not considered feasible for storm water injection.

4.1.4 Erith, Slade Green, and Crayford

These Opportunity Areas are not suitable due to the shallow unconfined Chalk water table.

4.2 Other Parts of Study Area

As the Opportunity Areas are all on low ground near the River Thames there are limited suitable injection sites as described above. However other parts of the study area have been found to have thick unsaturated zones, located on higher ground. Use of these areas in the Thanet Sand and Harwich Formation would require pumping from collection sites uphill to the injection sites, and are not considered feasible because although aquifer storage is available in these formations, in some instances mounding near the Opportunity Areas may cause downgradient groundwater flooding risks.

These aquifers could be considered in more detail if existing urban areas across the central parts of the study area (distant from groundwater flood risks) were to be retrofitted to further relieve pressure on the combined sewer system. That is, constraints on development could be reduced if storm flows in the upgradient parts of the catchment can be captured and prevented from entering the combined sewer network, ultimately meaning that less surface water enters the Southern Outfall Sewer.

5. Injection Flow Rates

At the strategic level of this study, estimates of injection rates have been made for the most suitable areas, the unconfined Chalk around Charlton, to give an indication of the potential at the high and low end of aquifer capacity. Injection in these areas may be beneficial to the London Basin water resources situation, and relieve pressure on the combined sewer system. However they are unlikely to be suitable for reuse without additional treatment.

For the unconfined Chalk, the Driscoll Recharge, Cooper Jacob, and Dupuit-Thiem equations have been used with aquifer properties taken from the LBGM, and assuming a mound of 5m, conservatively based on a 10-15m unsaturated zone being available in this area (assuming injection is via boreholes leaving at least 5m below surface). These formulae give results of around 10,000 m^3/d for the injection rate to maintain a 5 m mound (assuming a hydraulic conductivity of 50 m/d and a 50 m saturated thickness). If a lower mound was generated and the hydraulic conductivity was at the low end of the range (10 m/d) in the LBGM then these formulae give results of around 2,000 m^3/d.

6. Further Work

If stakeholders were interested in pursuing the possibilities of utilising the potential injection sites then ground investigations would be required to confirm and refine the data used in this study. These investigations should include drilling boreholes to confirm the elevations and thickness of geological formations, the water table elevation at the site, and hence the unsaturated zone thickness.

Prior to investing in a drilling programme an initial step is recommended to locate the historic boreholes on the British Geological Survey Geoviewer in preferred areas such as Charlton and arrange to visit these sites to measure water levels in the Chalk to confirm depth to water table. Further desk study work is also recommended in the potentially favourable areas as there may be existing investigations and reports prepared by others.

The groundwater chemistry would need to be analysed during investigations at potential injection sites to assess contamination. If groundwater were found to be contaminated then stakeholders would need to consider whether there are any issues about induced mounding causing migration of contaminants to other receptors by carrying out a hydrogeological risk assessment. If the site was still considered desirable then an injection test is recommended to confirm the estimates of injection volumes and mounding.

Appendix I Key Measure Costs and Outcomes

Growth Area	Measure	Key assumptions	Indicative Cost	Estimated Outcomes
Charlton Riverside	***Demand Management***			
	Water Efficient Devices	Installation of water efficient devices to achieve Building Regulations Optional efficiency targets	£5,000,000	Reduced water demand in accordance with London Plan Policy has been incorporated within baseline water balance estimates. This results in an estimated water use reduction of approximately 15% in new domestic properties and 5% in new commercial properties.
	Water Recycling			
	Rainwater Harvesting	Plot based roofwater harvesting systems with collection, treatment and internal non-potable distribution pipework. Storage based on an assumed 20 days of generated rainfall	£22,000,000	Estimated water use reduction of up to 16% in new build developments. This will vary across properties depending on roof area, population and demand characteristics and availability of space for water storage.
	Greywater Recycling	Installation of building scale greywater recycling systems with internal non-potable distribution pipework. Storage based on 3 days of non-potable demand.	£11,000,000	Estimated water use reduction of up to 16% in new build developments. This will vary across properties depending on population and demand characteristics.
	Stormwater Management			
	Green Roofs	Intensive, landscaped green roofs installed on all new buildings, assuming full roof coverage.	£6,000,000	Potential to provide up to 21% of on plot attenuation requirements. However, this volume may not all be available during storm events.
	On-plot underground attenuation	Installation of geo-cellular storage within development plots, providing attenuation volumes to achieve greenfield runoff rates.	£12,000,000	Potential to provide up to 100% of on plot attenuation requirements; however, cost, feasibility and achievable volume will be highly dependent on plot layout, spatial availability and hydro-geological conditions, including infiltration capacity.
Woolwich Town Centre	***Demand Management***			
	Water Efficient Devices	Installation of water efficient devices to achieve Building Regulations Optional efficiency targets	£8,000,000	Reduced water demand in accordance with London Plan Policy has been incorporated within baseline water balance estimates. This results in an estimated water use reduction of approximately 15% in new domestic properties and 5% in new commercial properties.
	Water Recycling			
	Rainwater Harvesting	Plot based roofwater harvesting systems with collection, treatment and internal non-potable distribution pipework. Storage based on an assumed 20 days of generated rainfall	£20,000,000	Estimated water use reduction of up to 13% in new build developments. This will vary across properties depending on roof area, population and demand characteristics and availability of space for water storage.
	Greywater Recycling	Installation of building scale greywater recycling systems with internal non-potable distribution pipework. Storage based on 3 days of non-potable demand.	£15,000,000	Estimated water use reduction of up to 14% in new build developments. This will vary across properties depending on population and demand characteristics.
	Stormwater Management			
	Green Roofs	Intensive, landscaped green roofs installed on all new buildings, assuming full roof coverage.	£3,000,000	Potential to provide up to 21% of on plot attenuation requirements. However, this volume may not all be available during storm events.
	On-plot underground attenuation	Installation of geo-cellular storage within development plots, providing attenuation volumes to achieve greenfield runoff rates.	£6,000,000	Potential to provide up to 100% of on plot attenuation requirements; however, cost, feasibility and achievable volume will be highly dependent on plot layout, spatial availability and hydro-geological conditions, including infiltration capacity.

Growth Area	Measure	Key assumptions	Indicative Cost	Estimated Outcomes
Thamesmead and Abbey Wood	***Demand Management***			
	Water Efficient Devices	Installation of water efficient devices to achieve Building Regulations Optional efficiency targets	£7,000,000	Reduced water demand in accordance with London Plan Policy has been incorporated within baseline water balance estimates. This results in an estimated water use reduction of approximately 15% in new domestic properties and 5% in new commercial properties.
	Water Recycling			
	Rainwater Harvesting	Plot based roofwater harvesting systems with collection, treatment and internal non-potable distribution pipework. Storage based on an assumed 20 days of generated rainfall	£43,000,000	Estimated water use reduction of up to 15% in new build developments. This will vary across properties depending on roof area, population and demand characteristics and availability of space for water storage.
	Greywater Recycling	Installation of building scale greywater recycling systems with internal non-potable distribution pipework. Storage based on 3 days of non-potable demand.	£13,000,000	Estimated water use reduction of up to 15% in new build developments. This will vary across properties depending on population and demand characteristics.
	Stormwater Management			
	Green Roofs	Intensive, landscaped green roofs installed on all new buildings, assuming full roof coverage.	£13,000,000	Potential to provide up to 100% of on plot attenuation requirements. However, this volume may not all be available during storm events.
	On-plot underground attenuation	Installation of geo-cellular storage within development plots, providing attenuation volumes to achieve greenfield runoff rates.	£5,000,000	Potential to provide up to 100% of on plot attenuation requirements; however, cost, feasibility and achievable volume will be highly dependent on plot layout, spatial availability and hydro-geological conditions, including infiltration capacity.
Belvedere	***Demand Management***			
	Water Efficient Devices	Installation of water efficient devices to achieve Building Regulations Optional efficiency targets	£7,000,000	Reduced water demand in accordance with London Plan Policy has been incorporated within baseline water balance estimates. This results in an estimated water use reduction of approximately 15% in new domestic properties and 5% in new commercial properties.
	Water Recycling			
	Rainwater Harvesting	Plot based roofwater harvesting systems with collection, treatment and internal non-potable distribution pipework. Storage based on an assumed 20 days of generated rainfall	£26,000,000	Estimated water use reduction of up to 13% in new build developments. This will vary across properties depending on roof area, population and demand characteristics and availability of space for water storage.
	Greywater Recycling	Installation of building scale greywater recycling systems with internal non-potable distribution pipework. Storage based on 3 days of non-potable demand.	£14,000,000	Estimated water use reduction of up to 13% in new build developments. This will vary across properties depending on population and demand characteristics.
	Stormwater Management			
	Green Roofs	Intensive, landscaped green roofs installed on all new buildings, assuming full roof coverage.	£6,000,000	Potential to provide up to 21% of on plot attenuation requirements. However, this volume may not all be available during storm events.
	On-plot underground attenuation	Installation of geo-cellular storage within development plots, providing attenuation volumes to achieve greenfield runoff rates.	£13,000,000	Potential to provide up to 100% of on plot attenuation requirements; however, cost, feasibility and achievable volume will be highly dependent on plot layout, spatial availability and hydro-geological conditions, including infiltration capacity.

Growth Area	Measure	Key assumptions	Indicative Cost	Estimated Outcomes
Crayford	***Demand Management***			
	Water Efficient Devices	Installation of water efficient devices to achieve Building Regulations Optional efficiency targets	£1,000,000	Reduced water demand in accordance with London Plan Policy has been incorporated within baseline water balance estimates. This results in an estimated water use reduction of approximately 15% in new domestic properties and 5% in new commercial properties.
	Water Recycling			
	Rainwater Harvesting	Plot based roofwater harvesting systems with collection, treatment and internal non-potable distribution pipework. Storage based on an assumed 20 days of generated rainfall	£6,000,000	Estimated water use reduction of up to 14% in new build developments. This will vary across properties depending on roof area, population and demand characteristics and availability of space for water storage.
	Greywater Recycling	Installation of building scale greywater recycling systems with internal non-potable distribution pipework. Storage based on 3 days of non-potable demand.	£2,000,000	Estimated water use reduction of up to 14% in new build developments. This will vary across properties depending on population and demand characteristics.
	Stormwater Management			
	Green Roofs	Intensive, landscaped green roofs installed on all new buildings, assuming full roof coverage.	£2,000,000	Potential to provide up to 14% of on plot attenuation requirements. However, this volume may not all be available during storm events.
	On-plot underground attenuation	Installation of geo-cellular storage within development plots, providing attenuation volumes to achieve greenfield runoff rates.	£6,000,000	Potential to provide up to 100% of on plot attenuation requirements; however, cost, feasibility and achievable volume will be highly dependent on plot layout, spatial availability and hydro-geological conditions, including infiltration capacity.
Erith and Slade Green	***Demand Management***			
	Water Efficient Devices	Installation of water efficient devices to achieve Building Regulations Optional efficiency targets	£8,000,000	Reduced water demand in accordance with London Plan Policy has been incorporated within baseline water balance estimates. This results in an estimated water use reduction of approximately 15% in new domestic properties and 5% in new commercial properties.
	Water Recycling			
	Rainwater Harvesting	Plot based roofwater harvesting systems with collection, treatment and internal non-potable distribution pipework. Storage based on an assumed 20 days of generated rainfall	£55,000,000	Estimated water use reduction of up to 13% in new build developments. This will vary across properties depending on roof area, population and demand characteristics and availability of space for water storage.
	Greywater Recycling	Installation of building scale greywater recycling systems with internal non-potable distribution pipework. Storage based on 3 days of non-potable demand.	£15,000,000	Estimated water use reduction of up to 13% in new build developments. This will vary across properties depending on population and demand characteristics.
	Stormwater Management			
	Green Roofs	Intensive, landscaped green roofs installed on all new buildings, assuming full roof coverage.	£18,000,000	Potential to provide up to 23% of on plot attenuation requirements. However, this volume may not all be available during storm events.
	On-plot underground attenuation	Installation of geo-cellular storage within development plots, providing attenuation volumes to achieve greenfield runoff rates.	£34,000,000	Potential to provide up to 100% of on plot attenuation requirements; however, cost, feasibility and achievable volume will be highly dependent on plot layout, spatial availability and hydro-geological conditions, including infiltration capacity.

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