Old Kent Road Integrated Water Management Strategy

FINAL REPORT

London Borough of Southwark, Greater London Authority and Thames Water

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Quality information

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List of Acronyms

AAP	Area Action Plan
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 contribute to areas of specific locations of high or very high flood risk
DEFRA	Department for Environment, Food and Rural Affairs
EA	Environment Agency
GI	Green Infrastructure
GLA	Greater London Authority
IWMS	Integrated Water Management Strategy
l/p/d	Litres/person/day (a water consumption measurement)
LBS	London Borough of Southwark
LDS	Local Development Study
NPPF	National Planning Policy Framework
OFWAT	The Water Services Regulation Authority (formerly the Office of Water Services)
OKR	Old Kent Road (Opportunity Area)
S106	Section 106 (Town and Country Planning Act 1990)
SPG	Supplementary Planning Guidance
SPD	Supplementary Planning Document
SuDS	Sustainable Drainage Systems (or Sustainable urban Drainage Systems)
TWUL	Thames Water Utilities Limited
UKCP09	United Kingdom Climate Projections 2009
WFD	Water Framework Directive
WwTW	Wastewater Treatment Works

Glossary

Term	Definition[1]
Attenuation	Reduction of peak flow and increased duration of a flow event.
Attenuation storage	Volume used to store runoff during extreme rainfall events. Comes into use once the inflow is greater than the controlled outflow.
Bio-retention area	A depressed landscaping area that is allowed to collect runoff so it percolates through the soil below the area into an underdrain, thereby promoting pollutant removal.
Blackwater	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.
Combined Sewer	A sewer designed to carry foul sewage and surface runoff in the same pipe.
Critical Drainage Area	A discrete geographic area where multiple and interlinked sources of flood risk (surface water, groundwater, sewer, main river and/or tidal) cause flooding during severe weather, affecting people, property or local infrastructure
Detention Basin	A vegetated depression that is normally dry except following storm events. Constructed to store water temporarily to attenuate flows. May allow infiltration of water to the ground.
Evapotranspiration	Water which is returned to the atmosphere through the processes of evaporation and transpiration of vegetation.
Extensive Green Roof	A green roof with thin growing medium and little or no irrigation. This creates stressful conditions for plants and low plant diversity.
Green Roof	A roof with plants growing on its surface, which contributes to local biodiversity. The vegetated surface provides a degree of retention, attenuation and treatment of rainwater, and promotes evapotranspiration.
Greenfield Runoff	The surface water runoff regime from a site before development
Greywater	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.
Infiltration	The proportion of rainwater which infiltrates through the soil.
Inset Appointee	A third party organisation that would take responsibility for a bulk supply from an incumbent water and sewerage provider for the construction, operation and maintenance water or sewerage infrastructure.
Intensive Green Roof	A green roof designed with deep soil and irrigation system. This creates more favourable conditions for plants and high plant diversity. Such roofs are also often designed for access.
Open Space	A sub-set of public realm which is publicly accessible for use by the community. This may comprise wither green space or civic space.
Permeable pavement	A permeable surface that is paved and drains through voids between solid parts of the pavement.
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. In some circumstances, water for use in the laundry may also be supplied by non-potable sources.
Potable water	High quality water supplied for uses within the home, including water used for drinking and used in the kitchen and bathroom.
Public Ream	Publicly accessible land, relating to areas both within and external to development plots.
Average annual 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 is defined separately from storm water due to the differing water quality characteristics.

[1] Key definitions as taken from the CIRIA SuDS Manual

Term	Definition[1]
SuDS	Sustainable drainage systems are an approach to surface water management that combines a sequence of management practices and control structures designed to drain surface water in a more sustainable fashion than some conventional techniques.
Streetscape	A subset of public realm including all land along and adjoining the highway (including street, footway and cycle-way).
Storm Water	Storm water runoff from the urban environment generated during rainfall events. This consists predominately of runoff from impervious areas. In the IWMS context, the flow has been split from roof water; these flows are typically combined and discharged to the drainage system.
Surface Water	Water, which flows over the ground surface to the drainage system. This includes both roof water and storm water.
Swale	A shallow vegetated channel designed to conduct and retain water, but may also permit infiltration. The vegetation filters particulate matter.

Non-Technical Summary

The Old Kent Road Integrated Water Management Strategy has identified that, without the adoption of new, integrated water management measures, the regeneration of the Old Kent Road Opportunity Area will result in a significant increase in potable demand and wastewater discharge putting significant stress on already constrained water supply and sewerage infrastructure serving the areas of proposed redevelopment.

In particular, the increase in wastewater discharge has significant implications with respect to the limited capacity in the wider combined sewer system and the resultant increase in risk of sewer and surface water flooding. In addition, there is the risk that significant investment in network upgrades would be required without measures to both reduce discharge and manage demand as far as possible.

To mitigate these risks, this study has considered ways in which water management measures could be delivered in an integrated way across the Opportunity Area to allow appropriate measures to be planned within forthcoming development masterplan proposals and to provide a robust evidence base for the development of planning policy relating to water management. To guide the process, water management objectives were developed centred around three core aims and reflected in the draft Area Action Plan policies currently in development:

- Minimise the volume and rate of water discharging to the combined sewer;
- Minimise the demand for additional potable supplies; and
- Achieve the above objectives in a way that maximises wider sustainability benefits.

To determine a preferred strategy of measures to implement that meet these aims, a constraints and opportunities assessment has been completed, considering the existing infrastructure limitations of the Opportunity Area, alongside the hydrological and hydrogeological context, the potential for provision of open space and the topographical baseline. The constraints and opportunities assessment was then used in parallel with a calculation of current and future water and wastewater flows using a water balance calculation to identify a range of feasible measures to implement.

Each feasible measure has been assessed and scored for preference against a range of criteria covering deliverability and sustainability requirements via a high level Multi Criteria Analysis. This process identified a preferential set of measures that could be implemented to form a preferred option scenario for delivery. The preferred option scenario combines measures in three main categories: delivering water efficiency, managing surface water runoff, and providing alternative water supplies.

The study highlights limited potential for the implementation of Opportunity Area wide measures for a range of limiting factors. The preferred option scenario therefore focuses on localised measures delivered on a plot by plot scale, utilising the opportunity for shared or communal infrastructure within areas of core regeneration throughout the Opportunity Area. The following summary of measures forms the preferred option scenario strategy for the Old Kent Road Opportunity Area:

- Water efficiency measures maximised in new build and retrofitted to existing property alongside accelerated implementation of Thames Water's progressive metering programme and incentive programmes for retrofitting;
- Maximisation of source control based Sustainable Drainage Systems on a plot by plot basis, focusing on green roofs, localised bio-retention and permeable surfaces;
- Installation of Sustainable Drainage Systems, for conveyance of surface water runoff and above ground attenuation features for areas of public realm and streetscape. Seek to provide communal above ground features within areas of planned open space within the public realm and develop an offset approach to delivering these;
- Provide underground storage in addition to communal features to ensure residual runoff is limited to greenfield rates; and
- Implementation of localised greywater recycling, supplemented by rainwater harvesting where possible to supply a source of water for non-potable uses.

The feasibility of delivery of the preferred option scenario has been tested within two key areas of regeneration proposed within the Opportunity Area where Supplementary Planning Documents are being prepared. Conceptual design of potential measures was developed based on indicative proposed layout plans for the two areas to demonstrate how the proposed measures within the option scenario could be delivered. The testing process provided costed conceptual designs to deliver measures solely on plot and by providing shared communal infrastructure. This process demonstrated that the measures can be feasibly and practically delivered for the tested areas, but crucially, has also identified a cost saving as well as a more likely attainment of all of study's water management objectives through preferential delivery of communal off-plot measures as part of the strategy delivery. A potential cost per unit of water managed has been estimated for the communal measures which could be developed into an offset cost which could be charged via a range of mechanisms in order to fund and deliver the communal features proposed.

The study concludes with a range of delivery mechanisms for the preferred option scenario, including the offset proposals and identifies the most likely providers and owners of the measures required to deliver the preferred option scenario for the strategy.

1. Introduction

1.1 Background

AECOM was appointed by the London Borough of Southwark (LBS), supported by the Greater London Authority (GLA), Thames Water and the Environment Agency (the study group) to deliver an Integrated Water Management Strategy (IWMS) for the Old Kent Road (OKR) Opportunity Area. The IWMS will set a framework for understanding, planning and delivering water services and flood risk management infrastructure to support the proposed development within the OKR Opportunity Area.

Located between Bermondsey and Camberwell in the north of the Borough, the OKR Opportunity Area extends over 114ha and has been identified as having the potential to deliver 20,000 new homes and 5,000 new jobs. Without a coherent water management strategy, this aspirational growth target will place considerable pressure on the already strained water supply and drainage infrastructure serving these areas. An Area Action Plan (AAP) is being developed to guide and steer the redevelopment of the Opportunity Area.

Whilst the growth target poses significant challenge for water management in the area, re-development proposals of this scale also present a rare opportunity to utilise the early planning stages to deliver a water sensitive urban design, which makes water an integral part of the fabric of the new development.

Water management objectives for the Opportunity Area have been set via draft AAP policies. The IWMS must now demonstrate how the objectives and requirements of the draft AAP policies can be met.

1.2 Key Drivers

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

London's population is growing, with current projections estimating an increase of 37% to reach 11.3 million people by 2050[2]. Much of this growth will occur in a limited number of areas with capacity to accommodate more significant growth, identified in the London Plan (2015)[3] as Opportunity Areas. This planned population growth will significantly increase demand on the existing water supply and wastewater systems. In relation to wastewater network capacity, Thames Water have already identified drainage capacity issues within the OKR Opportunity Area which could lead to increases in flood risk, as well as treatment capacity issues within the wider wastewater network if mitigation measures are not put in place.

More generally, 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 and hence challenges to water supply, sewerage and flood risk.

1.3 Strategy Governance and Stakeholder Engagement

The IWMS has been developed in collaboration with key partners integral to the delivery and management of water infrastructure in the OKR Opportunity Area. LBS, GLA and Thames Water have financed and led the study group which also included the Environment Agency in an advisory capacity.

In addition to the steering group governance, a wider range of stakeholders were engaged through a workshop held in March 2017. The aim of this workshop was to ensure that the IWMS captured and

[2] Mayor of London (updated 2015) London Infrastructure Plan 2050

[3] Greater London Authority, March 2015. The London Plan, the spatial development strategy for London consolidated with alterations since 2011.

considered all potential water management options, and that the approach to assessing these options was appropriate.

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 OKR Opportunity Area in an integrated way, and to provide guidance on how the required infrastructure should be planned, provided and managed.

A series of water management objectives have been developed based on the draft AAP policies, and from these, performance criteria have been developed to measure the relative success of the options proposed in meeting the strategy outcomes and water management objectives. This process is outlined in Figure 1-2 and the priority objectives are identified in bold lettering.

Figure 1-2 IWMS Objectives

Strategy Outcomes

- Create an integrated, sustainable vision for how water should be managed in the OKR Opportunity Area;
- Ensure flexibility and adaptability in the strategy to support the varied phasing and delivery programmes across the Opportunity Area; and
- Provide a clear framework for developers and stakeholders in order to meet requirements of the strategy.

Water Management Objectives

- Minimise the volume of water that is discharged to the combined sewer network to avoid the need for expensive and highly disruptive upgrades;
- Manage surface water runoff in a manner that would match runoff from the site if it were undeveloped;
- Reduce the demand for centralised water supply; and
- Deliver these objectives in a way that maximises wider sustainability benefits while having direct regard to the need to ensure the viability of development and the deliverability of the preferred strategy.

Performance Criteria

- Follow the London Plan drainage hierarchy in selecting measures that make up option scenarios;
- Seek to discharge surface water to ground, or surface water features as preferential to discharge to sewer;
- 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;
- Seek to provide resilience to change factors affecting water availability and flood risk such as climate change; and
- Select options based on a cost-benefit assessment which sufficiently balances wider sustainability and environmental benefits with cost/viability and deliverability/complexity.

1.5 Legislative and Policy Considerations

The growth within the OKR Opportunity Area will need to comply with EU Directives, UK legislation, planning policy and guidance on water, which have framed the IWMS development. A full list is provided in Appendix A, with an overview of the key local policy context in relation to water and flood risk for the Opportunity Area discussed below.

1.5.1 The London Plan

The London Plan (2016) includes a number of key policies aimed to protect water resources within London, minimise flood risk and assist in the protection of the water environment during redevelopment and construction.

In particular, Policy 5.13 (Sustainable Drainage) sets out the requirement for development to “aim to achieve greenfield runoff rates” and identifies the drainage hierarchy that all development should follow to manage surface water runoff. The drainage hierarchy set out in this policy has formed a key water management objective for the IWMS and is set out below:

- Store rainwater for later use;
- Use infiltration techniques, such as porous surfaces in non-clay areas;
- Attenuate rainwater in ponds or open water features for gradual release;
- Attenuate rainwater by storing in tanks or sealed water features for gradual release;
- Discharge rainwater direct to a watercourse;
- Discharge rainwater to a surface water sewer/drain;
- Discharge rainwater to the combined sewer.

With regards to minimising water demand, Policy 5:15 (Water Use and Supplies) sets out that new development should incorporate water saving measures and be designed such that water mains consumption would meet a target of 105 litres or less per head per day.

The IWMS provides an opportunity to demonstrate how achievable the water based policies are in the context of strategic planning.

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 policies. In relation to managing surface water runoff and reducing flood risk, it sets out minimum expectations from developers in relation to London Plan Policy 5.13, including the following key points:

- 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 (with noted exceptions);
- Achieving a greenfield runoff rate is of particular importance where the development is located in a catchment that contributes to combined sewers with known and/or modelled capacity or flooding issues (as is the case in the Old Kent Road Opportunity Area).

The SPG sets out that 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.

[4] Mayor of London, 2014, Sustainable Design and Construction SPG, London Plan 2011 Implementation Framework.

1.5.3 LBS Local Planning Policies

The extant development plan for LBS is the Core Strategy (2011) and saved policies of the Southwark Plan (2007). Water and flood risk policies within these documents, as well as draft policies from the emerging New Southwark Plan and the draft AAP which are of relevance to the OKR Opportunity Area[5] (and which have shaped the IWMS) have been included in full in Appendix A.

The policy of most relevance is the draft AAP policy which has been aligned to the water management objectives of the IWMS. In summary, this draft policy requires new development to:

- Include SuDS and the use of the SuDS management train within drainage design;
- Be designed to reduce surface water runoff to greenfield rates (where feasible);
- Maximise amenity and biodiversity through drainage design; and
- Evaluate the feasibility of providing greywater re-use systems to supply non-potable demand.

1.5.4 Thames Estuary 2100

The Opportunity Area has a significant area falling within the defended flood extent of the Tidal River Thames. 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 OKR Opportunity Area is protected from tidal flooding by the Thames Tidal Defences, which consist of a combination of flood walls or embankments and the Thames Barrier, which is located approximately 8 km downstream on the River from Tower Bridge.

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 2 (Central London), and is covered by flood risk management policy P5; "to take further action to reduce flood risk beyond that required to keep pace with climate change".

5 Not all water or flood risk related policies are included unless they have a direct bearing on the OKR study area – for example Thames Policy Area related policies which does not cover the OKR Opportunity Area

2. Proposed Development

2.1 Introduction

Understanding the scale and distribution of future development within the OKR Opportunity Area, and the likely population that this development generates is central to understanding the potential 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 nature of the development to feed into the calculations required to develop the IWMS.

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, known as the London Plan. The Plan sets out the planning policy framework for strategic issues across London. As local planning authorities, London boroughs are required to produce local development documents and evidence documents which underpin the amount of development proposed within each borough. These documents should be in general conformity with the London Plan, which is also legally part of the development plan.

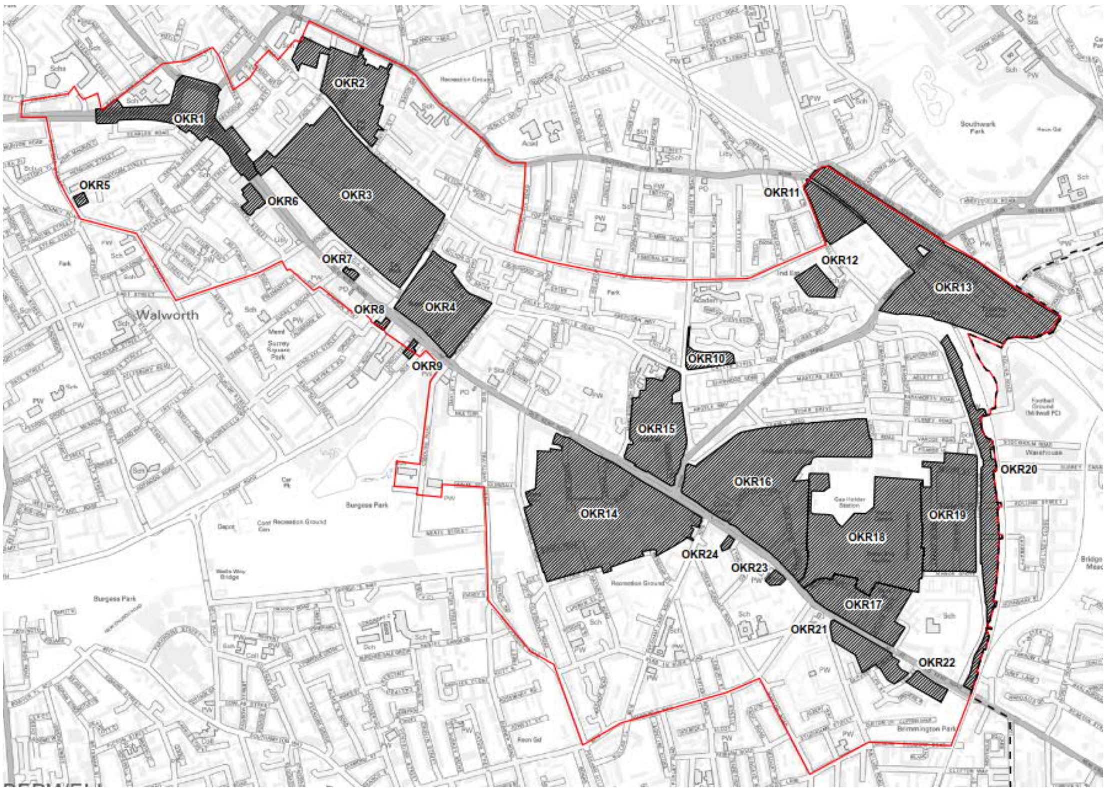
Growth is a strategic challenge for London, and as such, the London Plan identifies 38 broad Opportunity Areas that should be the focus for concentrating housing and economic development. These areas of London have a high concentration of brownfield land and significant capacity for redevelopment and the London Plan sets out broad housing and employment growth aspirations for these areas up to 2036.

This IWMS is for the OKR Opportunity Area within the London Borough of Southwark. LBS are currently preparing the New Southwark Plan (NSP); however, until adoption of the NSP, the extant development plan for LBS is the Core Strategy (2011) and saved policies of the Southwark Plan (2007). The Council are also preparing a detailed vision and planning policy framework for the OKR Opportunity Area in the form of the OKR AAP. Southwark consulted on the draft AAP from June to November 2016 and it sets out the vision for the Opportunity Area up to 2036. Once adopted the AAP will form part of the development plan for Southwark and will also be endorsed by the GLA as the Opportunity Area Planning Framework for the OKR Opportunity Area.

2.3 Spatial Distribution of Growth

The OKR Opportunity Area is expected to be transformed and become an integral part of Central London, providing at least 20,000 new homes and 5,000 new jobs. To help achieve this Southwark has identified 24 sites within the Opportunity Area that will be redeveloped up to 2036. Figure 2-1 shows the location of these sites.

Figure 2-1: Sites Allocated for Redevelopment in the Draft Old Kent Road AAP



Capacity studies for each of the sites have been undertaken by LBS to determine the potential for residential, commercial, retail and social infrastructure (e.g. schools) to be provided within each site relative to the sites' gross area. For the purposes of this IWMS, these sites and their potential capacity have been used to inform the spatial distribution of development within the Old Kent Road Opportunity Area.

3. IWMS Approach and Method

3.1 Stages of the IWMS

There are four main study components of the OKR IWMS that follow sequentially in the development of the Strategy as outlined below:

Stage 1 Baseline

- Define the water and flood risk related baseline conditions, including constraints and opportunities for water and flood risk management measures across the Opportunity Area. This will include constraints of the exising water and wastewater infrastructure, flood risk limitations, and opportunities created by regeneration. It also includes a review of proposed housing and employment numbers.

Stage 2 Water Balance

- Based on planning growth numbers, determine the water balance for the current baseline and future conditions (post development) within the Opportunity Area to define how water flows in and out of the area will change with time and how different inflows and outflows of water can be used and managed efficiently within the development.

Stage 3 Options Appraisal

- Option appraisal and strategy development including a review of a range of water management and flood risk measures that could be implemented in combination to meet the study objectives set out in Section 1.
- Set out a preferred strategy for water and flood risk management through analysis of a range of option scenarios or combination of measures (further explanation provided in the main text below).

Stage 4 Strategy Delivery & Testing

- Set out how option scenarios can be delivered, the stakeholders involved and next steps to inform planning and infrastructure delivery.
- For the OKR IWMS, this includes testing the preferred strategy at two key growth areas within the Opportunity Area.(further explanation provided in the main text below).

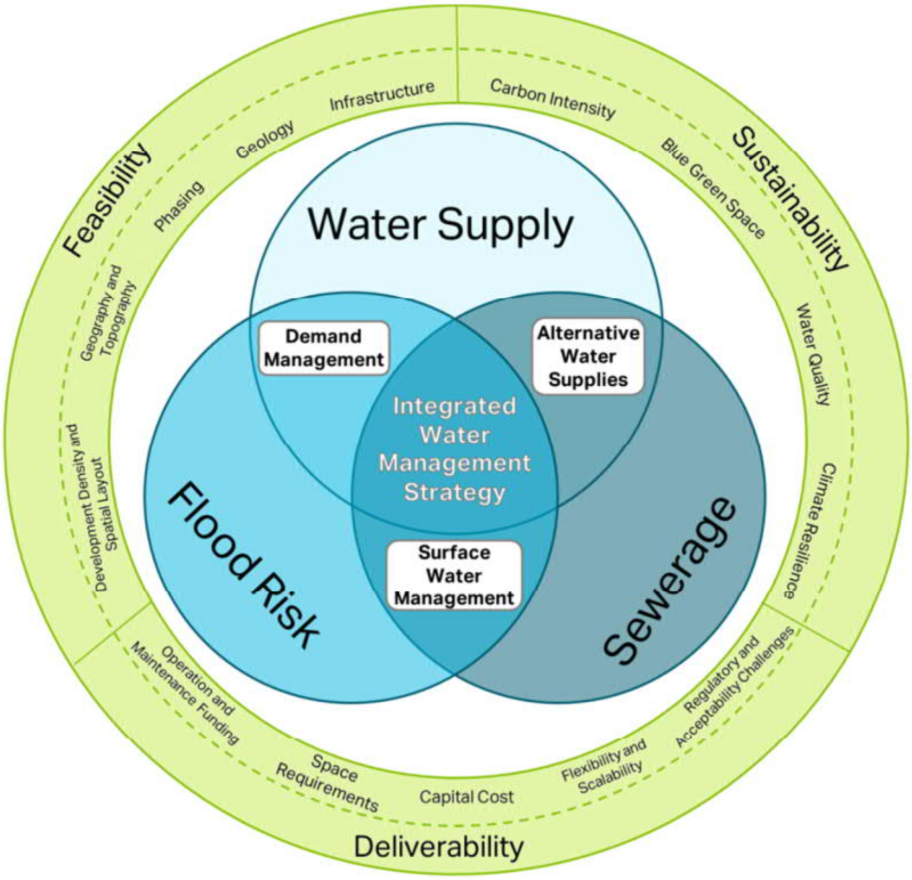
3.2 Stage 3: Options Appraisal and Strategy Development

This stage of the IWMS integrates the outputs of the baseline opportunity and constraints assessment with the calculated water balance to develop a range of effective solutions (measures) that can be applied across the Opportunity Area.

A long list of potential water management measures have been considered for the Opportunity Area as a whole (Section 6). An appraisal process has then been completed based on how these measures could be combined to meet the overall study objectives and performance criteria 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. Influencing factors are grouped according to the themes of feasibility, sustainability and deliverability as described in Figure 3.1 below.

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



Feasibility Factors

Feasibility considerations cover limitations and constraints imposed by the natural and man-made environments in terms of whether individual measures could reasonably be implemented given those constraints. These factors dictate which measures are feasible and hence considered for combining into option scenarios.

The limitations and constraints have been derived by determining the baseline conditions and mapping key constraints related to:

- *Geology and hydrogeology* – which affects the rate at which water can infiltrate to the ground;
- *Topography* - which affects how water can be drained without the need for pumping and affects how water flows can be moved between areas of development;
- *Surface infrastructure* - such as major transport routes which affects how surface water can be moved and drained and can present barriers to the movement of different water flows and piped systems between development areas and water resources; and
- *Development phasing* – which influences how effectively shared infrastructure can be delivered in relation to funding and contributions to the infrastructure.

Sustainability Factors

Sustainability considerations are those related to broader long term sustainability and climate resilience of the identified feasible measures, as well as the extent to which they will deliver added benefits to the local community. These factors contribute to the selection of feasible measures into combinations of measures or option scenarios via a high level Multi Criterion Analysis (MCA). The MCA scores these factors for each measure in a qualitative way.

The following factors have been considered:

- *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. Green infrastructure can also contribute 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.
  - *Public realm* - street greening and the delivery of effectively landscaped open spaces can substantially improve the attractiveness and amenity of neighbourhoods.
- *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.
- *Surface water quality* - Many SuDS components, particularly those incorporating natural, vegetative or bio-retention processes, provide opportunities to improve water quality, in turn helping to meet Water Framework Directive (WFD) targets, 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, thereby reducing subsequent treatment requirements and possible Combined Sewer Overflow (CSO) spills.

Deliverability Factors

Deliverability considerations are those related to cost, viability, and the anticipated ease of delivery. Measures will be more preferential in relation to some of these factors than others, and these factors need to be considered in combination with sustainability factors via the qualitative MCA process.

The following factors have been considered:

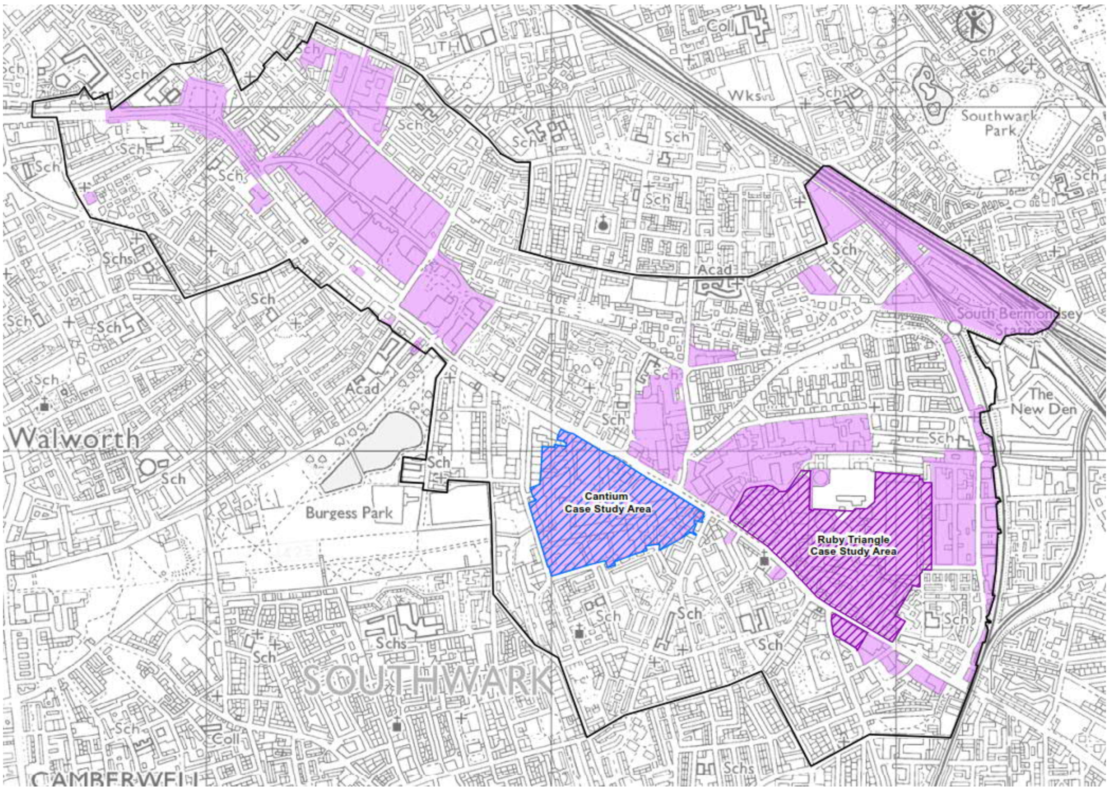
- *Capital cost* - feasibility considerations associated with infrastructure requirements, construction cost and buildability constraints associated with installation in new build and retrofit environments.
- *Operational and maintenance requirements* - Many of the measures presented will have continuing operational, maintenance or monitoring requirements, with an associated ongoing cost implication, and potential challenges in determining relevant responsibility and ownership.
- *Effective spatial requirements* – Available space for many of the proposed measures will present a particular constraint to the feasibility of delivery in some growth areas.
- *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.
- *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.

3.3 Stage 4: Strategy Delivery and Testing

The final stage of the strategy sets out a high level plan and approach for delivering the preferred option scenario. It provides recommendations on infrastructure delivery, funding mechanisms, and roles and responsibilities of key stakeholders in implementing the strategy.

A key component of the OKR IWMS is to test deliverability of the preferred strategy for meeting the water management objectives by assessing measures at two specific locations in more detail. The two areas are Ruby Triangle and Cantium Park as shown in Figure 3-2 and are referred to within this IWMS collectively as Case Study areas.

Figure 3-2: Location of Ruby Triangle and Cantium Park Case Study areas.



Planning for these two Case Study areas is significantly advanced in comparison to much of the wider Opportunity Area in terms of building massing and spatial delineation of individual plots. Local Development Study (LDS) documents have been produced setting out the planning aspirations of these two key regeneration areas and have been used to determine phasing, development and other localised constraints to implementing the preferred strategy.

The purpose of the testing is to demonstrate that the strategy proposed can be delivered, including the water management objectives set by this study, and to provide examples to developers as to how the specific (and ambitious) requirements can be met. The delivery testing process has also considered where the development of an offset policy could aid the delivery of the water management objectives, specifically in relation to the management of surface water runoff as set out in the following subsection.

3.3.1 Delivery Mechanisms and Offset Policy

Key to delivering the water management objectives related to surface water management will be the development of an appropriate delivery mechanism. One such approach may be to allow developers to meet their drainage requirement through off site measures. As such, this IWMS also explores the potential to develop an 'offset' policy that enables development that would otherwise be unacceptable from a policy perspective by putting in place water management improvement offsite. The principle of the offset policy and potential delivery mechanisms is set out in section 9.

4. Stage 1 - Study Area Constraints and Opportunities

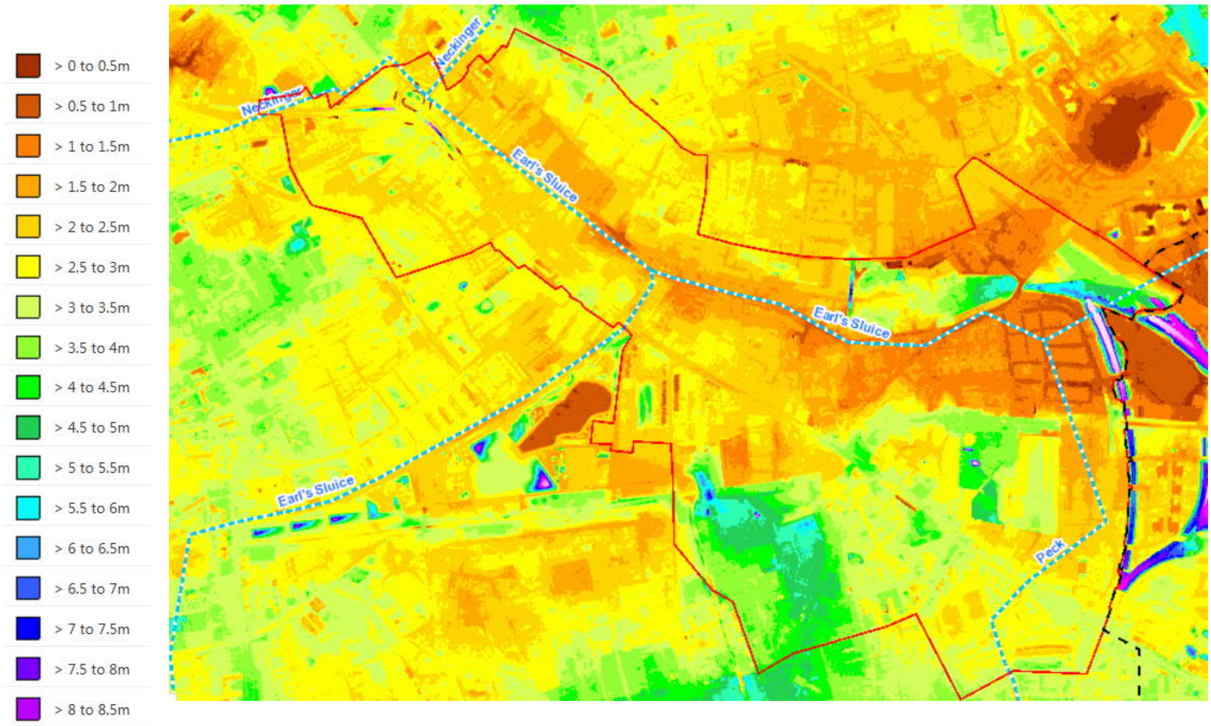
High level constraints maps have been produced covering the OKR Opportunity Area. These provide an overview of the water service and flood risk infrastructure assets, other influencing infrastructure and high level environmental constraints. Their purpose is to inform the feasibility assessment of water management measures.

An overview of the study area constraints and opportunities is summarised in the following sections with detailed maps provided in Appendix G.

4.1 Topography & Land use

The topography of the Opportunity Area is dominated by flat, low lying floodplain located within an area protected by the River Thames Tidal defences. The low lying land is historically reclaimed marshland and is located below high tide levels associated with the River Thames. There is a topographical valley running north-west to south-east across the northern part of the Opportunity Area associated with the location of the lost river 'Earls Sluice' (now part of the Thames Water combined sewer system) as shown in Figure 4-1. To the south of the route of the Earl's Sluice, the relief rises from an average elevation of 1mAOD to between 4 and 7mAOD.

Figure 4-1: Local Topography (m AOD)



Surface water catchments have been developed to indicate how surface water flows move across the Opportunity Area taking the topography into account. This helps inform how proposed surface water management features could be aligned to use gravity as the means by which to provide attenuation and manage flows to discharge (see Appendix G)

As the study area is urban with a mixture of industrial, commercial and residential land uses with a network of main roads and railway lines crossing the Opportunity Area surface features are likely to further impede flows. Historical features including the Grand Surrey Canal (now largely turned to roads and linear parks) also still influence local topography.

Table 4-1: Topography and land use Opportunities and Constraints

Opportunities	• Surface water catchments can be used to identify areas of regeneration which could be linked by surface water management features using gravity drainage.
Constraints	• Railways, highways and the historic location of the Grand Surrey Canal result in changes to the local topography preventing surface water from draining naturally to the River Thames. • The large number of surface water catchments, defined by the topography, will limit interconnectivity of strategic SuDS systems across the Opportunity Area without the requirement for pumping.

4.2 Geology and Groundwater

The geology of the Opportunity Area is shown in Appendix G and is underlain by two aquifers: the Lewes Nodular Chalk and Thanet Sand Formations. The Chalk is present at outcrops in the northern part of the study area while Thanet Sands are present in outcrops covering the majority of the remaining Opportunity Area.

Thanet Sand overlies Chalk and is situated on the higher ground with Chalk on the lower elevations. The western part of the study area is underlain by lower permeability Lambeth Formation, and in the far western part of the study area this is overlain by London Clay. In these areas the elevation of the Chalk and Thanet Sand units falls toward the north, underlying the Lambeth Group and London Clay.

These aquifers are overlain by superficial deposits. The Kempton Park Gravel formation overlies the Chalk and Thanet Sand outcrop across the study area and is likely to be in hydraulic continuity with the underlying aquifers. In the south of the Opportunity Area, the Langley Silt overlies the gravels while in the north east alluvium overlies the gravel.

Table 4-2: Geology and Groundwater Opportunities and Constraints

Opportunities	• The permeability of the superficial deposits could provide significant potential for disposal of surface water by infiltration to ground, particularly for the southern sections. The study area is not located within a Source Protection Zone and hence is opportunities for infiltration are less restricted. • The permeable nature of the bedrock (Chalk and Thanet Sands) means that groundwater injection is a potential option to manage surface water. This option is further discussed in detail in Section 6.3.7. Groundwater injection could potentially be beneficial to water resource availability to the north of London due to the direction of groundwater flow.
Constraints	• The legislation governing the discharge of pollutants to groundwater, namely the Environmental Permitting Regulations 2016, creates a potential constraint with regards to the high quality required for discharges directly to aquifers. Discharge direct to aquifers has to meet the criteria to exclude it from the regulations (such as water company discharges of potable water not containing hazardous substances), or it must be permitted and thus subject to the usual application and risk assessment process. • 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 groundwater injection or infiltration.

4.3 Watercourses and Flood Risk

The Opportunity Area is dominated by the River Thames which forms the northern boundary of the LB Southwark and is approximately 1km to the north at its closest point. Appendix G includes a flood risk map and shows that the majority of the Opportunity Area is in Flood Zone 3, but is defended by the Thames Tidal Defence system. Tidal flooding is therefore a residual risk that will only materialise in the unlikely event that the River Thames flood defences fail. The Strategic Flood Risk Assessment (SFRA) for the LBS states that flood defences in this location provide a standard of protection for a 0.1% AEP (1 in 1000 year) flood event.

There are no open sections of main rivers or ordinary watercourses within the study area. There are, however, three 'lost rivers' (including the aforementioned Earl's Sluice), each of which are now contained within the combined sewer network. While these watercourses are no longer located at the surface, it is useful to understand their location as they are often located in topographical lows and indicate direction of surface water movement. The Earls Sluice traverses the centre of the Opportunity Area in an easterly direction to its outfall to the River Thames at St Georges Wharf. The Peck flows in a northerly direction across the south of the Opportunity Area before joining the Earl's sluice, and the Neckinger traverses the north western tip of the Opportunity Area in the vicinity of the New Kent Road and OKR interchange flowing in a north easterly direction to its outfall with the River Thames downstream of Tower Bridge.

The now infilled Grand Surrey Canal also flowed through this part of Southwark . Whilst the canal is no longer operational (or visible in most locations) there are aspirations across the Boroughs through which it flowed to re-instate its route as a series of linear parkways with the design of new development used to mimic the historical canal side setting. This represents a significant opportunity for the incorporation of water management features into proposed areas of open space located in proximity to the old canal route.

There are significant areas of surface water flood risk through the study area as shown in Appendix G. Surface water flow routes are shown along some of the routes of the lost rivers. The south east portion of the Opportunity Area is shown to be located within the East Southwark Critical Drainage Area (CDA). This CDA delineates where surface water runoff contributes to areas of significant localised flood risk, and significant areas of high risk are shown within the southern boundary of the Opportunity Area.

Table 4-3: Summary of flood risks

Source of Flooding	Summary of Flood Risk
Tidal	Where the Opportunity Area is shown to be within a Flood Zone, it is defended from tidal flooding by the Thames Tidal Defences which offer a level of protection up to the 0.1% AEP (1 in 1000 year). Therefore, the risk of tidal flooding is residual in the unlikely event of a breach in flood defences.
Fluvial	There are no main rivers or ordinary watercourses within the study area; therefore the Opportunity Area is not at risk from fluvial sources. (The River Thames is considered under Tidal sources as noted above).
Surface Water	The risk of surface water flooding is widespread across the study area and is heavily influenced by local infrastructure including highways and railway embankments. The LB Southwark Surface Water Management Plan has identified surface water flood risk hotspots across the Borough. The south eastern portion of the Opportunity Area falls into a CDA.
Groundwater	The risk of groundwater flooding varies across the study area due to geology and topography but is generally low as the opportunity area lies within a zone that has limited potential for groundwater flooding to occur. There have been 5 records of groundwater flooding incidents within the borough that have occurred within the last 10 years. However, groundwater flooding is often associated with

	Chalk catchments which allow groundwater levels to rise to the near surface through permeable subsoil following long periods of wet weather and / or reductions in water abstraction. In addition, groundwater flooding may occur where the ground has been modified to a significant degree. If this artificial ground is of substantial thickness and permeability then a shallow perched water table may exist which could potentially result in groundwater flooding.
Sewer	At post code level, records of sewer flooding within the last 10 years range from 1 to 5 records within that period across the Opportunity Area[6] indicating a medium risk of sewer flooding.

4.4 Water Resource and Water Supply Network

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 the effects of climate change on raw resources, leakage and environmental protection. Thames Water manages the water supply in London as a single 'resource zone'; that is, all consumers 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[7], 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.

Thames Water has developed a plan for removing the forecast deficit in the London WRZ through a combination of measures to tackle leakage, manage and reduce water demand and implement new water supply schemes. The plan is reliant on significant demand reduction measures from existing properties and highlights the need for new development to minimise water use and help identify innovative solutions to delivering alternative supplies. This creates a clear driver to consider whether some of the demand for water can be met by alternative means.

An OKR utilities strategy[8] developed for the OKR Opportunity Area has identified that there are no major constraints within the supply network in the study area; however this also indicates that localised reinforcements will be required to supply the scale of proposed new development.

4.5 Surface Water and Foul Water Infrastructure

The majority of the Opportunity Area is served by combined sewers (containing both foul and surface water) which are owned and maintained by Thames Water. Wastewater from the Opportunity Area flows to the Crossness Wastewater Treatment Works (WwTW). The network layout is shown in Appendix G.

As part of the OKR Utilities Study, Thames Water undertook high level hydraulic modelling of the planned growth at OKR Opportunity Area. Findings indicate that the trunk sewer located along the Old Kent Road currently surcharges during wet weather as there is no capacity within the sewer during key events; modelling indicates that up to 22 manholes would surcharge during a 1 in 20 year storm event. Increases in foul discharge would increase this risk of flooding and therefore, there is an increased risk of combined sewer flooding without a reduction in surface water runoff. Capacity modelling also indicates that pipe full capacity is lower at the northern section of the Opportunity Area where a significant proportion of the study area growth would be located.

As well as the localised constraints, the Crossness WwTW catchment has limited capacity to accept increases in foul discharge expected from the significant growth proposed within Opportunity Areas

[6] Thames Water sewer flooding records (DG5) may underestimate the number of actual events if these have not been notified by the property owners.
[7] Thames Water Utilities Limited (2015), Water Resources Management Plan (2015-40)
[8] Old Kent Road Utilities Study: An assessment of existing utilities capacity and the need for reinforcement, LB Southwark, June 2016

such as OKR. Similar Opportunity Areas are identified by the GLA both upstream and downstream in the Crossness catchment, including significant proposals across the London Boroughs of Greenwich and Bexley. It is therefore essential that measures are taken across these development proposals to offset the significant combined increase in foul discharge by managing surface water disposal to this combined system.

4.6 Open Space Provision

In order to identify spatial opportunities for provision of water management measures, a review of existing and proposed open spaces was undertaken and key locations mapped. This mapping exercise is shown in Appendix G and has been used to inform a strategy for connecting development areas with locations for water management measure provision.

The open space mapping in Appendix G demonstrates that opportunities are apparent across many of the areas of redevelopment across the study area providing the potential to create mixed use open space that provides water management benefits.

5. Water Cycle Analysis

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 of the OKR Opportunity Area. In order to undertake this, the Opportunity Area as a whole was taken as a separate system boundary and changes to the water cycle built up from anticipated development within each site allocation.

In order to inform the delivery testing approach for the two Case Study areas, the same process was then repeated for Cantium and Ruby Triangle.

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.
Storm 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 B.

In considering these calculations, it should be noted that as masterplans are only being developed for part of the Opportunity Area, the level of detail available on the anticipated level of development varies across the area. 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 planning in order to determine the exact volumes, and detailed design of the required infrastructure.

5.1.1 Results

A combined pre-development annual water balance for the OKR Opportunity Area is shown in Figure 5-1. The post-development water balance area is shown in Figure 5-2. The same water balance comparison is shown for the two Case Study areas in Figure 5-3 to Figure 5-6.

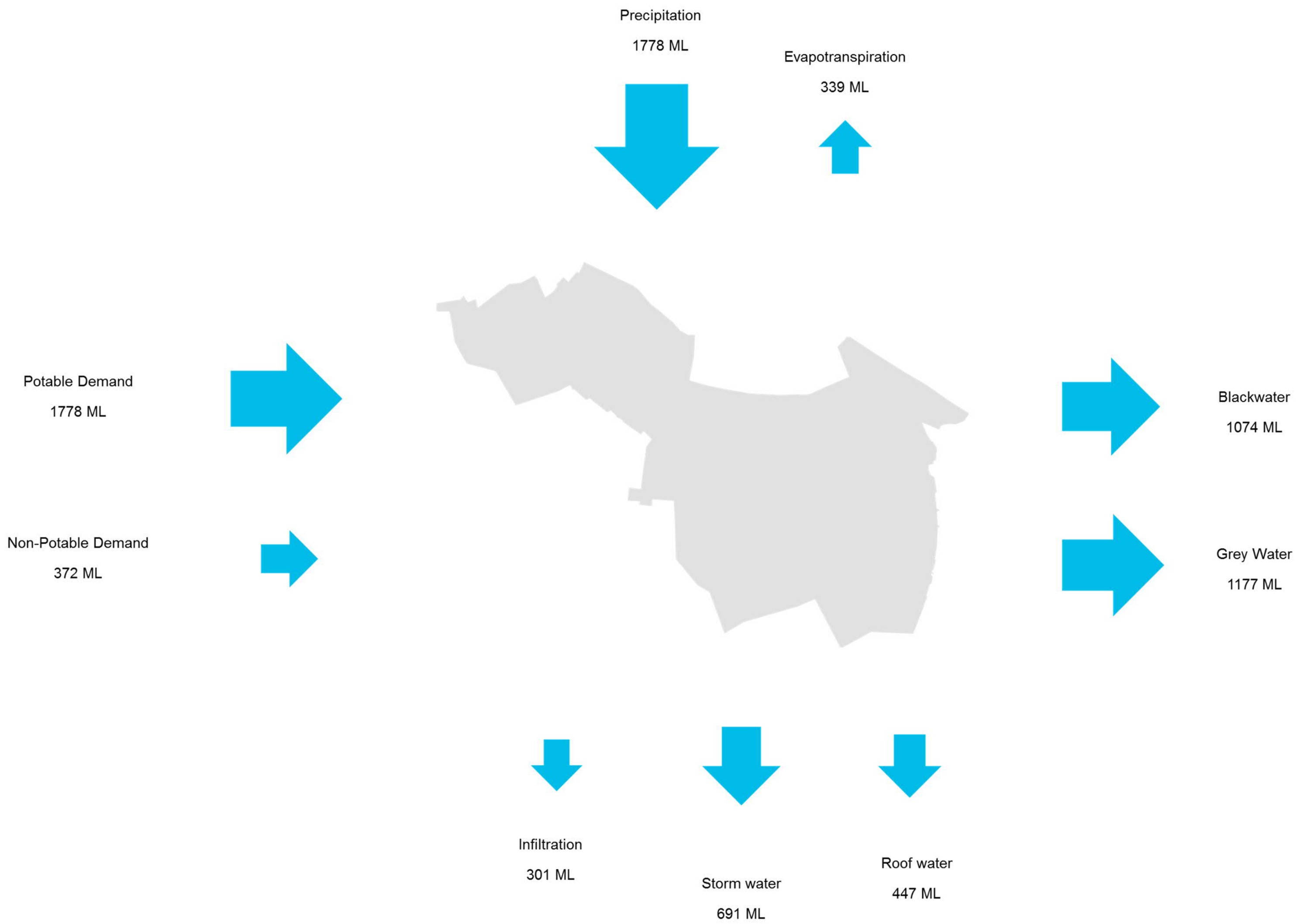


Figure 5-1: Pre-development water balance for the opportunity area

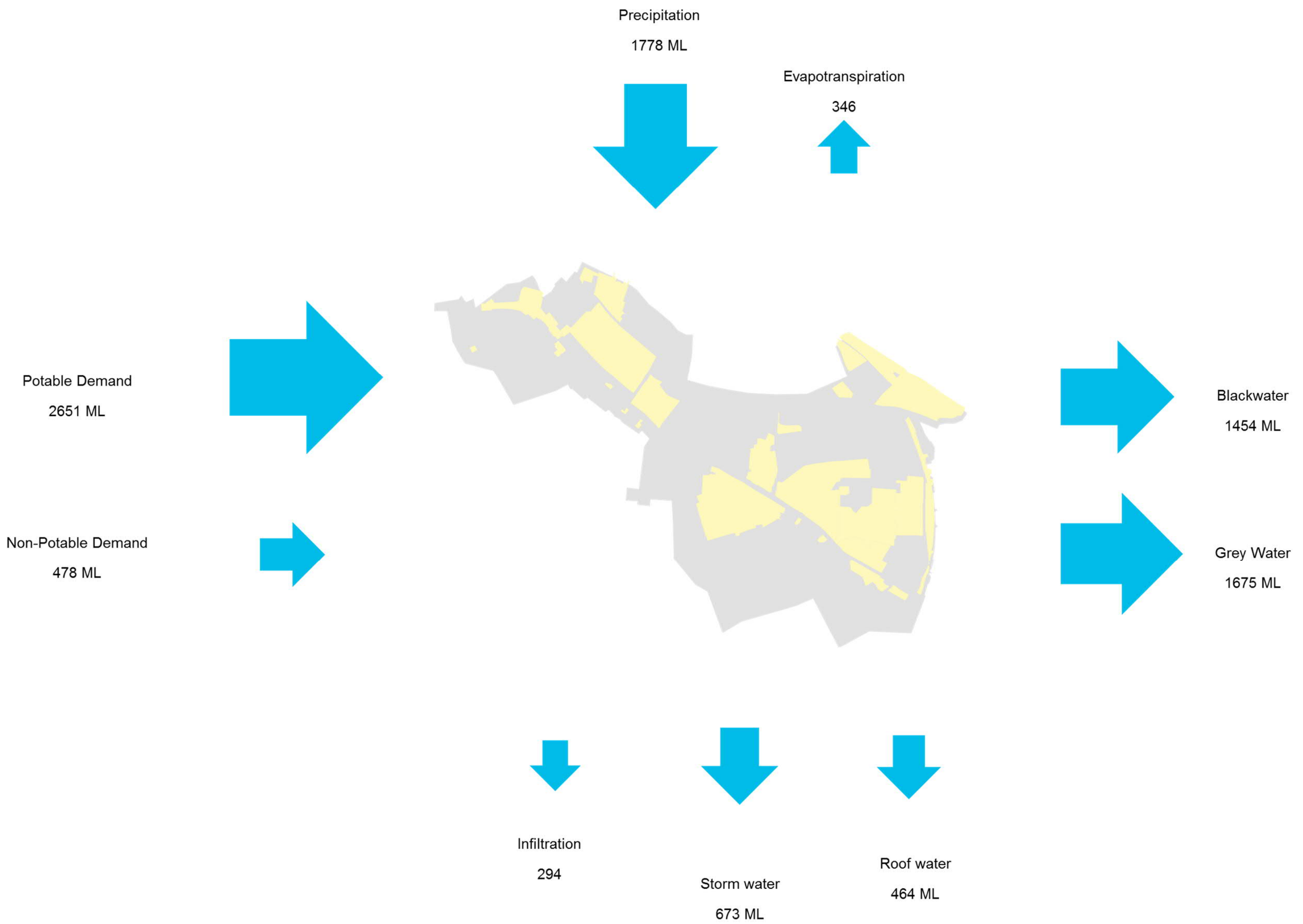


Figure 5-2: Post-development water balance for the opportunity area

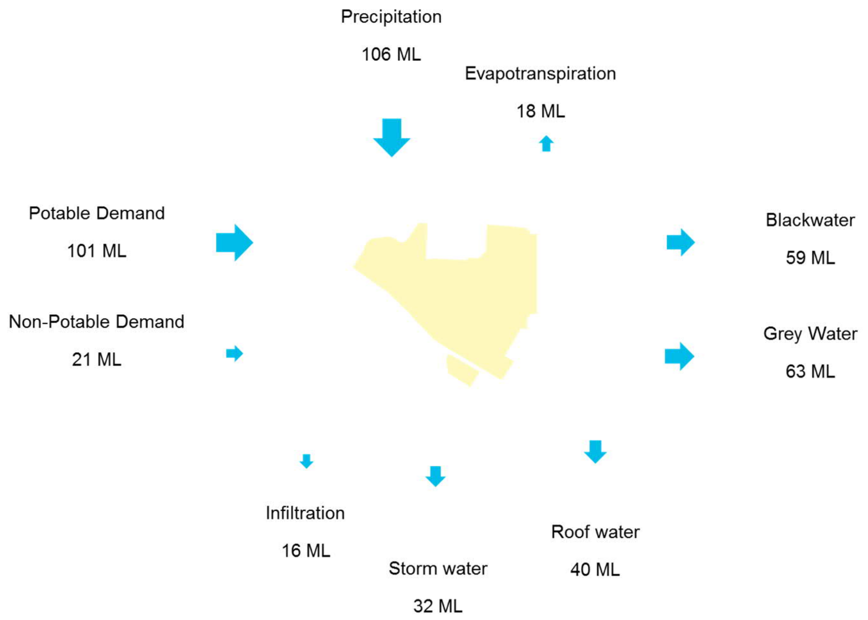


Figure 5-3: Pre-Development Water Balance for Ruby Triangle

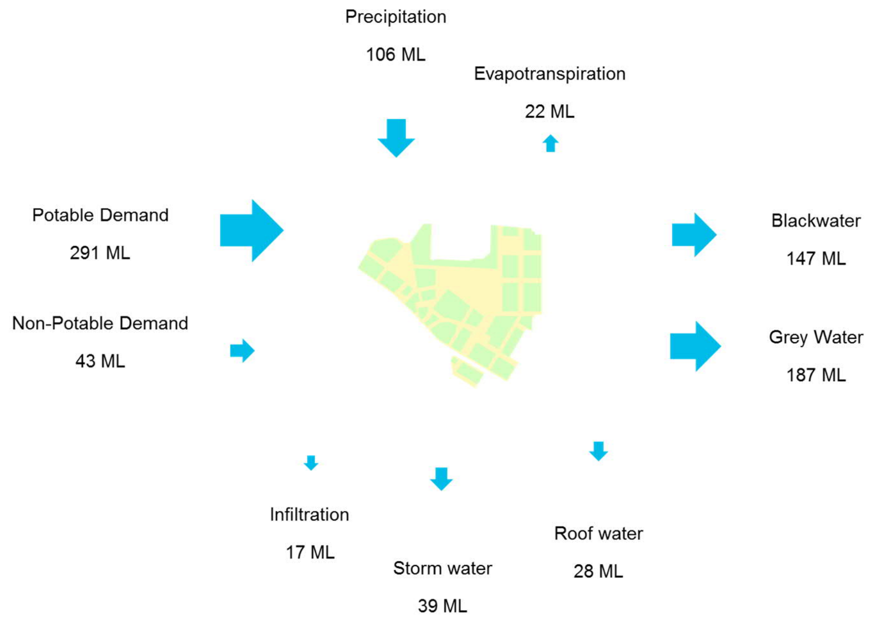


Figure 5-4: Post-Development Water Balance for Ruby Triangle

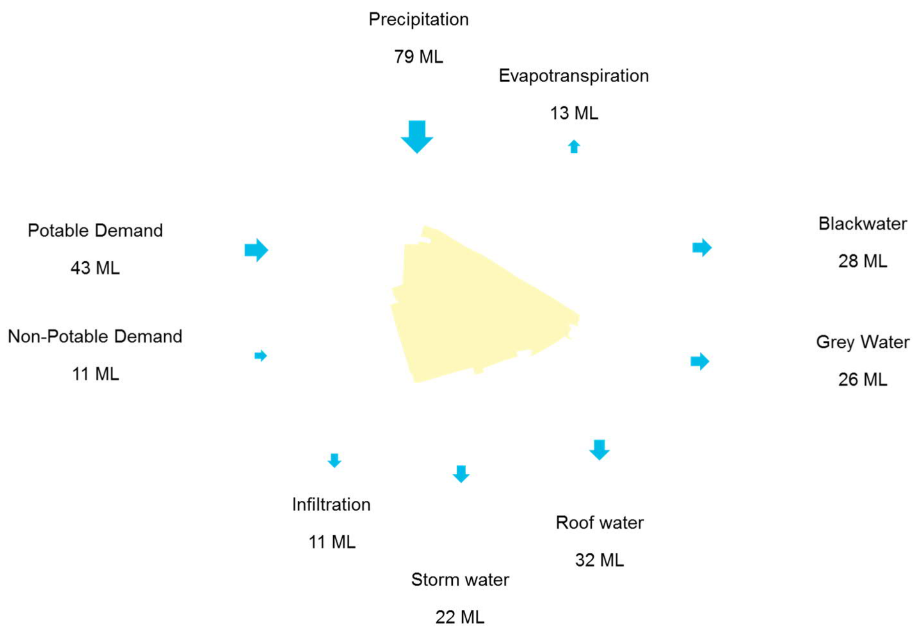


Figure 5-5: Pre-Development Water Balance for Cantium

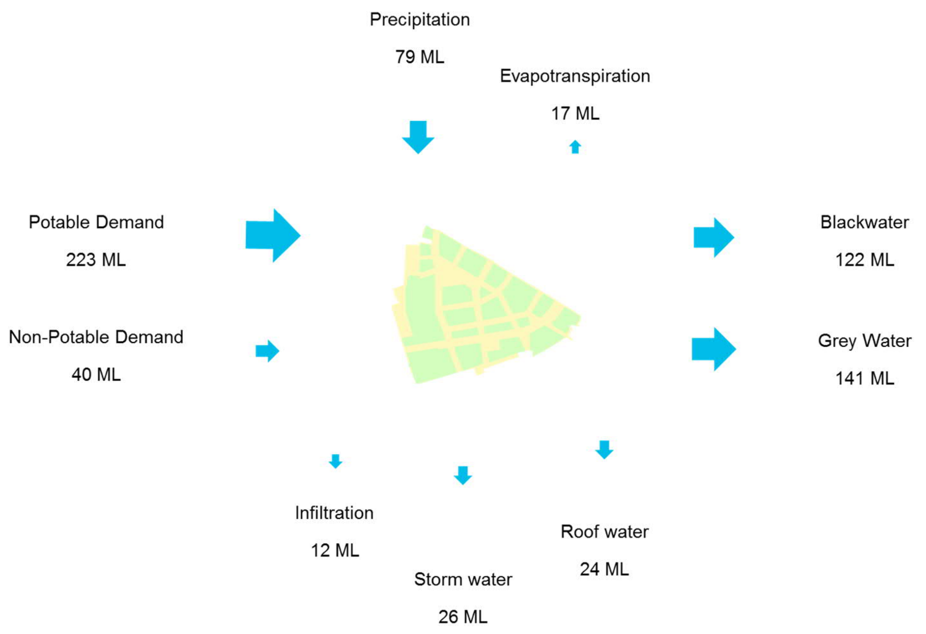


Figure 5-6: Post-Development Water Balance for Cantium

Comparing the results, it can be seen that the proposed development across the Opportunity Area 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 other impervious surfaces contributing to urban stormwater.

The magnitude of the anticipated increase in water demand and wastewater generation estimated from the proposed development is further illustrated in Figure 5-7.

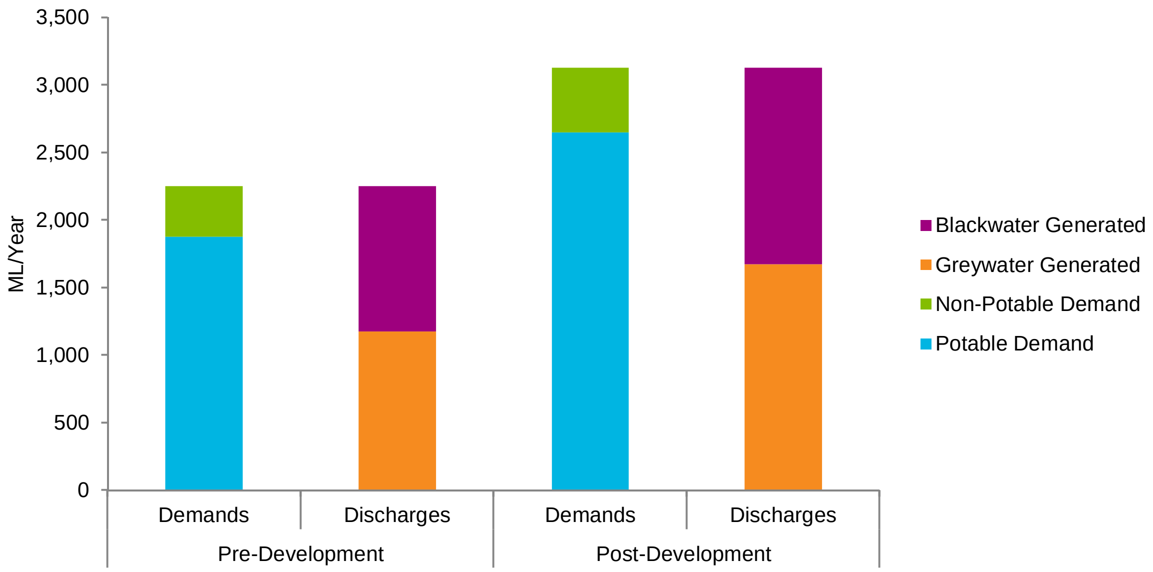


Figure 5-7: Overall anticipated increase in flow areas across the Opportunity Area

As these figures illustrate, without intervention, the proposed development across the Old Kent Road Opportunity Area 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.

To inform delivery testing, the increase across the Ruby Triangle and Cantium Case Study Areas is shown in

Figure 5-8 and Figure 5-9 below.

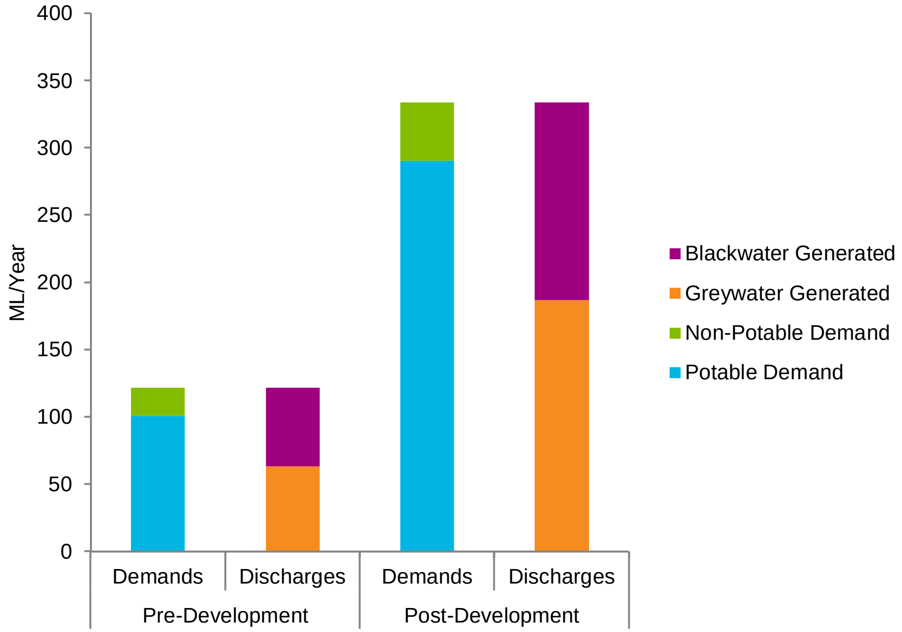


Figure 5-8: Anticipated increase in flow for Ruby Triangle

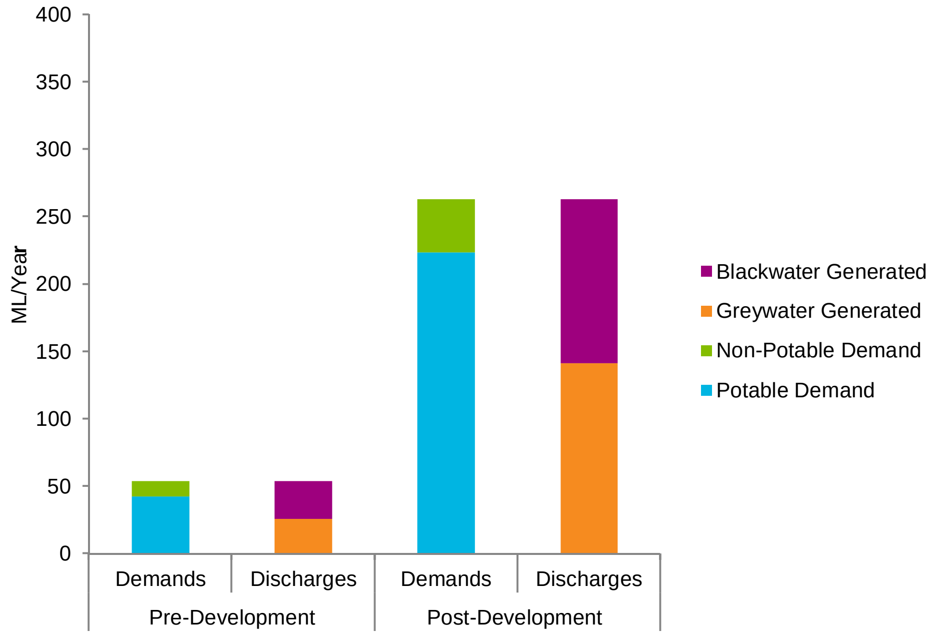


Figure 5-9: Anticipated increase in flow for Cantium

5.1.2 Water Balance Sensitivity Analysis

Analysis has been undertaken on the water balance calculations, to indicate the sensitivity to increases in population and climate impact. The post-development water demand and wastewater generation, responded largely linearly to changes in anticipated development population, in line with the litre per person per day end use assumptions (as fully detailed in Appendix B). Similarly, considering an increase in annual rainfall volume also resulted in a linear increase in the subsequent volume of roof water and stormwater flows generated in the post development scenario.

Anticipated increases in peak rainfall intensity (during storm events) have been incorporated into the climate change allowance used within the rainfall runoff calculations described in Section 5.2.2.

5.2 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 capacity in the sewer system. In addition, peak wastewater flow from site occupation is also a key factor for 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, whilst 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 the Opportunity Area and each Case Study area is indicated in Table 5-2.

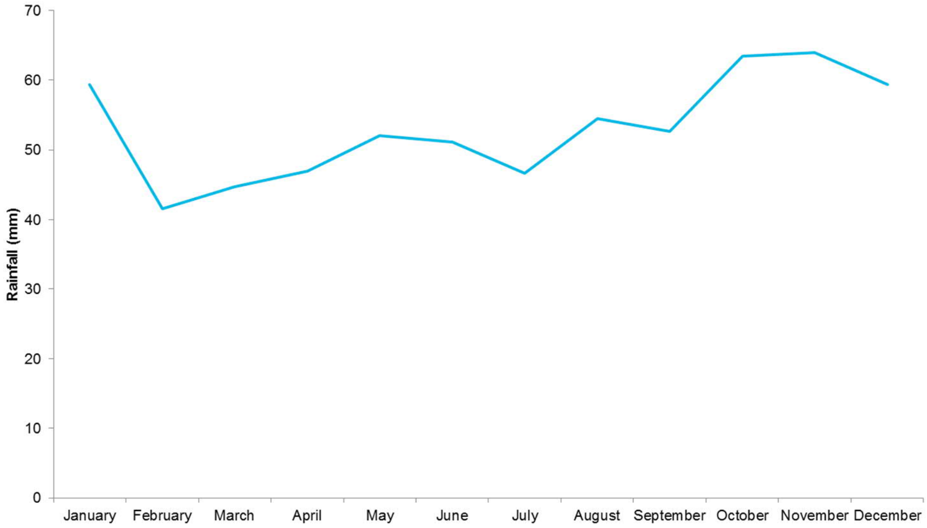
Table 5-2: Estimated increase in peak instantaneous foul sewer discharge (excluding infiltration)

Area	Estimated Peak Sewer Discharge (l/s)		Percentage Change
	Pre-Development	Post-Development	
Old Kent Road	169.3	228.9	35%
Ruby Triangle	9.2	22.8	148%
Cantium	4.5	19.1	324%

5.2.2 Rainfall, Runoff and Flooding

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 5-10. 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. The volume of rainfall that falls in a short space of time, during significant storm events has a significant impact on local drainage systems.

Figure 5-10: London average monthly rainfall recorded between 1961 and 2016



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 OKR Opportunity Area 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. As the Opportunity Area is served by a combined sewer system, reduction of surface water runoff can be used to offset increased peak foul flows arising from new development.

The minimum anticipated requirement is for all new development within to reduce site runoff to Greenfield rates. This is the rate at which runoff would naturally discharge from an undeveloped catchment. Currently, the Opportunity Area is 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 Opportunity Area, 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 and the associated volume of attenuation required to restrict discharge estimated. This is summarised in Table 5-3 below and presents results for the Opportunity Area as a whole, as well as the two Case Study areas.

It should be noted that these runoff rates and attenuation volumes have been estimated at a high level across a large area. Greenfield runoff rates have been estimated (using the Wallingford Procedure Modified Rational Method), as a L/s/ha value within each sub-catchment crossing the OKR Opportunity Area. However, these may vary significantly across the extent of each area. 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

Area	Estimated 1 in 100 year Runoff Rates (with climate change) (l/s)		Approximate Attenuation Storage Required (m^3)
	Pre-Development	Greenfield	
Old Kent Road	28,400	1,150	203,700
Ruby Triangle	2,670	75	8,950
Cantium	1,990	60	6,650

Considering these flows in comparison to the peak sewage flows described above, 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 Greenfield rates will be a key mechanism for creating capacity within the sewer system.

6. Potential Water Management Measures

This section highlights the various water management measures that could be implemented to mitigate the impact of the development anticipated within the Opportunity Area. In order to address the significant challenges of the development, a suite of measures will need to be delivered in combination. The majority of measures introduced in the following sections are scalable and complementary, or address separate aspects of the urban water cycle. Furthermore, several of these measures should be delivered within the development as standard best practice; whilst for others there are various available options/approaches. The selection of measures recommended for delivery is further discussed in Section 7.

In order to deliver against the water management objectives (as outlined in Section 1.4), interventions are required across each of the following categories:

- Water efficiency;
- Surface water management; and
- Alternative water supplies.

The delivery performance of these measures will vary across the Opportunity Area due to varying opportunities, constraints and water use characteristics. Similarly, different approaches will be required across the targeted development sites, as opposed to retained areas.

6.1 Assessing Options

6.1.1 Meeting IWMS objectives

Each of the measures described in the following section has been scoped and assessed at a high level, based on the key outcomes they will achieve, in line with the key water management objectives highlighted in Section 1.4. This process has considered the feasibility of each of the measures by analysing the opportunities and constraints identified in section 4 and using this to identify the extent to which each measure could be developed across the Opportunity Area given these constraints. This informs a high level assessment of the assumed technology that would need to be implemented for the measure to be feasible and also allows an estimate of the contribution that the measure could then make to the overall water management objectives, focusing on:

- Potential attenuation contribution to achieve the target of greenfield runoff rates; and
- Potential reduction in centralised potable demand and wastewater generation.

The scoring brackets associated with these metrics are outlined below.

Table 6-1: Scoring brackets used to assess each water management measure

	None	Low	Medium	High
Potential Reduction in Potable Demand and Wastewater Discharge	No reduction	Anticipated 0-9% reduction	Anticipated 10-19% reduction	Anticipated 20+% reduction
Potential Attenuation for Peak Storm Flow Reduction	No contribution	Anticipated 0-9% contribution to required attenuation	Anticipated 10-19% contribution to required attenuation	Anticipated 20+% contribution to required attenuation

6.1.2 Multi-Criteria Analysis

Once the performance of a measure is quantified in relation to feasibility, each of the measures have then been assessed in terms of the wider deliverability and sustainability considerations outlined in Section 3.2 to address the full range of water management objectives and performance criteria set out in Section 1.4 and aid in selecting a preferred combination of measures (the outcome of this is reported in Section 7).

The measures have been assigned an estimated capital cost and comparatively ranked as outlined below. It should be noted that, due to lack of detail regards site development detail, the costing across the area as a whole has been carried out at a very high level, based on estimated quantities and standard rates. The cost scoring brackets in Table 6-2 were defined as evenly stepped values, formulated using the general distribution of estimated costs for the various measures. However, this approach may not always be reflective of area and development-specific feasibility constraints so therefore should be interpreted with caution.

Table 6-2: Scoring brackets used to assess each water management measure

	Low	Medium	High	Very High
Indicative Cost	£0 - £14,000,000	£15,000,000 - £29,000,000	£30,000,000 - £44,000,000	£45,000,000 +

The remaining deliverability and sustainability aspects have been assessed comparatively on a qualitative basis, using quantitative indicators where possible. These have been assigned a score of None, Low, Medium or High.

It should be noted that these quantitative indicators have only been assessed for the anticipated new build areas across the development, due to limited data regarding existing retained areas. However, retrofit opportunities have also been highlighted where present in the below sections.

The assessment against the water management objectives, and each of the feasibility and sustainability criteria were translated into a comparative score between 0 and 3, and a relative weighting applied to each criteria, as shown in Table 6-3**.**

Table 6-3: Weightings applied to each criterion during the multi-criteria analysis

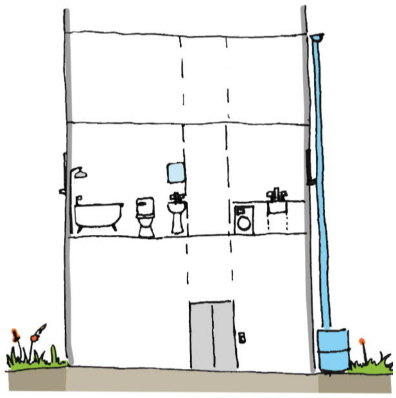
Category	Overall Rating	Performance Criteria	Relative Weighting
Core Water Management Objective	40%	Potential Reduction in Demand and Discharge OR Potential Attenuation for Storm Flow Reduction	100%
Deliverability	30%	Indicative Cost	20%
		Spatial requirements	20%
		Maintenance Requirements	20%
		Flexibility and Scalability	20%
		Regulatory and Public Acceptability	20%
Sustainability	30%	Carbon intensity	20%
		Blue-green space provided	30%
		Climate Resilience	30%
		Surface water quality	20%

These weightings have been defined to be reflective of discussions held with key project stakeholders and representative of the overall priorities for water management across the Opportunity Areas.

The MCA scores for each measure are also presented in the following sections. The supporting MCA assessment tables are contained in Appendix E.

6.2 Water Efficiency Measures

6.2.1 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.

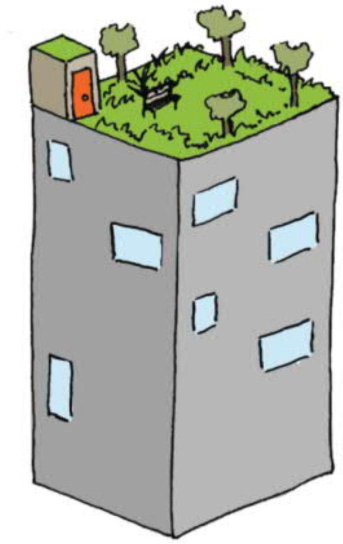
The installation of new water supply infrastructure may provide an opportunity for further installation of smart network technologies embedded within the metering program, to optimise water network operation. Such systems and technologies enable remote, real time monitoring of water usage, allowing rapid 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. Retrofit of water efficient devices across retained areas of the development could also provide a cost efficient means of increasing the sustainability of the overall Opportunity Area. Due to the expected age of many of these properties, this could have a substantial overall impact.

Criteria	Outcome
Assumed Technology	All new build developments constructed to the water efficiency requirements specified in the London Plan. Additional potential for opportunistic retrofit of new fittings in retained development areas.
Key Water Management Outcome	*Medium* - 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 residential development and 5% in new commercial development.
Indicative Cost	*Medium* - Estimated capital construction cost £15,000,000 - £29,000,000
Spatial Requirements	*Low* - Minimal requirements above standard fittings.
Maintenance Requirements	*Low* - Minimal requirements above standard fittings.
Regulatory and Public Acceptability	*High* - Supported by current planning policy and regulation. Potential for public acceptability uptake to decrease if user satisfaction diminishes.
Flexibility and scalability	*High* - Ability for gradual implementation and retrofit, harnessing latest available technologies.
Carbon Intensity	*Low* - Technologies can also result in reduced energy consumption, through reducing the energy consumption of pumping and hot water systems.
Blue-Green Space provided	*None*
Climate Resilience	*Medium* - Reduced consumption resulting in reduced strain on existing resources.
Surface Water Quality	*Low* - Marginal benefit through reduced flows to sewer, with reduced associated impact on River Thames (receiving waterbody).
Total MCA Score	**80%**

6.3 Surface Water Management Measures

6.3.1 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. Combined blue-green roofs can optimise outcomes by providing blue roof storage beneath a green roof layer.

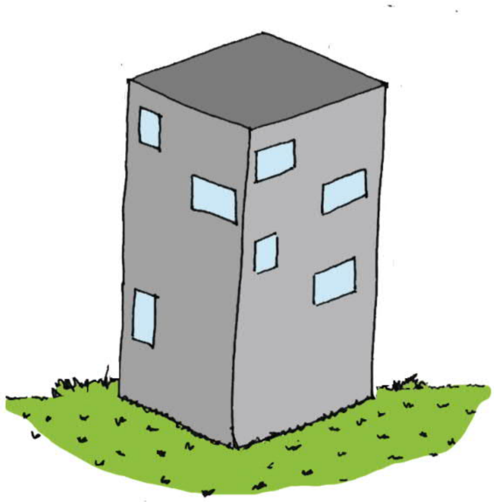
Green and blue roofs may be constructed on new buildings, or retrofitted onto existing surfaces, although, in some cases there will be restrictions on the ability to retrofit due to inadequate structural capacity or overly sloping surfaces, and retrofit is likely to be more expensive

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.

Criteria	Outcome
Assumed Technology	Intensive, landscaped green roofs installed on all new buildings. Opportunistic retrofit of lightweight, extensive green roofs on existing buildings.
Key Water Management Outcome	*Medium* – Estimated contribution of approximately 16% to overall on-plot attenuation requirement, which could be increased through integrated green-blue roof design. However, this volume may not all be available during storm events.
Indicative Cost	*Medium* - Estimated capital construction cost £15,000,000 - £29,000,000
Spatial Requirements	*Low* - no additional land take.
Maintenance Requirements	*Low* - irrigation required during establishment of vegetation, ongoing inspection and monitoring of vegetation cover, removal of litter or debris.
Regulatory and Public Acceptability	*High* - supported by current planning policy and potential to provide recreational and amenity benefit
Flexibility and scalability	*High* - ability for gradual implementation as development progresses. Limitations for retrofit on existing buildings, due to inadequate structural composition or overly sloping surfaces.
Carbon Intensity	*Low* - potential for carbon sequestration and building insulation, with reduced associated energy requirements.
Blue-Green Space provided	*High* - provision of green space, with the potential to provide recreational and amenity benefit, habitat for biodiversity, improved air and water quality and microclimate benefits.
Climate Resilience	*Medium* - provision of attenuation and vegetation to assist in mitigating the impacts of climate change on drainage systems. Delivery of drought tolerant species is recommended.
Surface Water Quality	*High* - vegetated system reducing the quantity and the speed of runoff and providing water quality benefits through filtration and bio-retention.
Total MCA Score	**77%**

6.3.2 Permeable Surfacing

Maximising permeable surfaces can increase the amount of water that is attenuated, treated and processed within the natural hydrological cycle. This can be achieved through maximising natural grassed surfaces or through hardscape solutions, such as permeable paving.



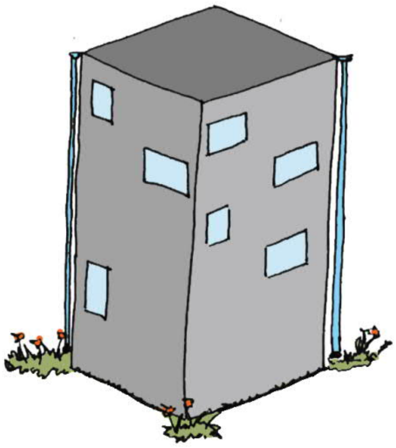
These measures are generally designed to promote infiltration of runoff into the ground beneath, promoting recharge of the water table and reducing runoff. This is highly beneficial where possible; however, contaminated land or soils with poor infiltration characteristics may present constraints in certain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

In these locations, where direct infiltration of surface water is not possible, lined permeable paving can also be used to provide attenuation and filtration of surface water.

Permeable paving is likely to be suitable for the development areas, as a spatially-effective means of providing multi-functional attenuation. A range of finishes are available. This is also likely to be suitable for streetscape areas, and may be retrofit into retained development areas.

Measures	Outcomes
Assumed Technology	Installation of permeable paving on all paved surfaces (assumed to cover 80% of plot external space) within new development plots. These systems may also be suitable for streetscape areas and to be retrofit on retained plot areas.
Key Water Management Outcome	*High* - Estimated contribution of up to approximately 40% to overall on-plot attenuation requirement, however, this will be largely dependent on design and plot-specific constraints.
Indicative Cost	*Low* – Estimated construction cost £0 - £14,000,000
Spatial Requirements	*Low* – No additional land take.
Maintenance Requirements	*Medium* - Regular inspection and maintenance, including removal of litter and debris and vegetation management.
Regulatory and Public Acceptability	*High* - Supported by current planning policy and able to be incorporated in low impact and multi-functional installations.
Flexibility and scalability	*High* - Scalable, with the ability for gradual implementation.
Carbon Intensity	*Medium* – Similar to non-permeable surface installations.
Blue-Green Space provided	*None*
Climate Resilience	*Medium* - Provision of attenuation to assist in mitigating the impacts of climate change on drainage. Capacity design for increased storm intensity will be required.
Surface Water Quality	*Medium* - Facilitates infiltration and some filtration of surface water flows.
Total MCA Score	**76%**

6.3.3 Bio-Retention Systems



Bio-retention systems are shallow landscaped and vegetated areas which harness on engineered soils, enhanced vegetation and filtration to remove pollution and reduce runoff downstream.

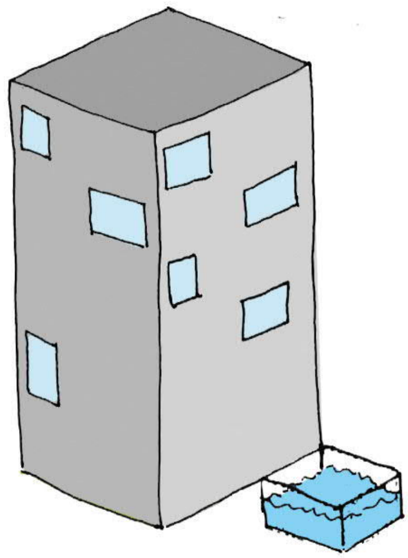
Rain gardens and tree pits both form a bio-retention function. As such, incorporating such features within the development can assist in absorbing runoff generated within the development, reducing flooding, improving water quality, providing irrigation for vegetation and enhancing amenity value.

Incorporation of these measures will also contribute towards providing the required attenuation storage. Where possible, these measures are designed to promote infiltration of runoff into the ground beneath, promoting recharge of the water table and reducing runoff; however, contaminated land or soils with poor infiltration characteristics may present constraints in certain locations.

Bio-retention features have the potential to provide substantial benefit to the development area, and are likely to be particularly suitable where integrated into landscaping and tree planting proposals. These features can also be retrofitted into retained developed areas in a cost effective way, providing a range of benefits to the urban environment.

Measures	Outcomes
Assumed Technology	Installation of bio-retention features within landscaped areas within development plots (assumed to cover approximately 20% of on plot space). These systems are also likely to be highly suitable for retrofit to new and retained streetscape areas.
Key Water Management Outcome	*Medium* - Estimated contribution of up to approximately 20% to overall on-plot attenuation requirement, however, this will be largely dependent on extent, design and plot-specific constraints.
Indicative Cost	*Low* – Estimated capital construction cost £0 - £14,000,000
Spatial Requirements	*Medium* - Reasonable surface spatial requirements, which may be difficult to achieve given the high density nature of the proposed development. However, this may be integrated within site landscaping and delivered to provide multiple benefits,
Maintenance Requirements	*Medium* - Regular inspection and maintenance, including removal of litter and debris and vegetation management.
Regulatory and Public Acceptability	*High* - Supported by current planning policy and potential to provide recreational and amenity benefit.
Flexibility and scalability	*High* - Scalable, with the ability for gradual implementation.
Carbon Intensity	*Low* - Potential for carbon sequestration.
Blue-Green Space provided	*High* - provision of green space, with the potential to provide recreational and amenity benefit, habitat for biodiversity, improved air and water quality and microclimate benefits.
Climate Resilience	*High* - Provision of attenuation and vegetation to assist in mitigating the impacts of climate change on drainage. Capacity design for increased storm intensity will be required.
Surface Water Quality	*High* - Vegetated systems providing water quality benefits through filtration and bio-retention.
Total MCA Score	**72%**

6.3.4 Below Ground Storage



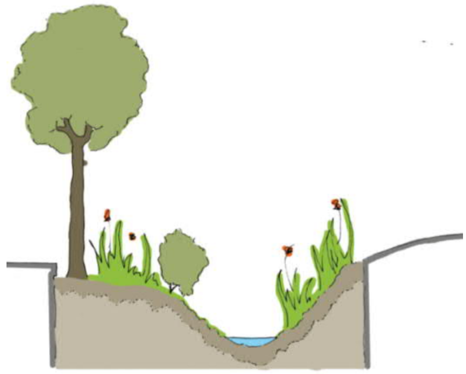
Underground geo-cellular storage can be implemented within site drainage systems to control and manage runoff generated on the site. These systems can be designed to withstand traffic loads, meaning that they can be installed under roads and car parks as well as recreational areas and other public open space. During high intensity rainfall events, these facilities provide on-site attenuation, restricting the rates of 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 benefits associated with green infrastructure; however, it may provide a practical means of achieving the required attenuation volumes, particularly within development plots, which are likely to be spatially constrained. Direct infiltration of attenuated water may also be possible, depending on geological conditions.

Below ground attenuation is likely to be less suitable for retrofit into existing areas, due to the constraints of existing infrastructure.

Criteria	Outcomes
Assumed Technology	Installation of geo-cellular storage within development plots, providing attenuation to achieve greenfield runoff rates.
Key Water Management Outcome	*High* - 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.
Indicative Cost	*Low* - Estimated capital construction cost £0 - £14,000,000
Spatial Requirements	*Low* - Significant volumes are required to meet Greenfield runoff rates. However, underground installation minimises effective land requirements.
Maintenance Requirements	*Medium* - Regular inspection of silt traps, manholes, pipework and pre-treatment devices, with removal of sediment and debris as required.
Regulatory and Public Acceptability	*High* - Supported by current planning policy and potential to provide recreational and amenity benefit.
Flexibility and scalability	*High* - Scalable, with the ability for gradual implementation. Below ground installation limits flexibility, and opportunities may be limited by, or impact upon, the deliverability of other underground infrastructure.
Carbon Intensity	*Low* - minimal ongoing energy requirements.
Blue-Green Space provided	*None*
Climate Resilience	*Medium* - Provision of attenuation to assist in mitigating the impacts of climate change on drainage. Capacity design for increased storm intensity will be required.
Surface Water Quality	*Medium* - Some water quality benefit provided through storage, sedimentation and reduced drainage flows; however, limited benefit as opposed to above ground surface water management.
Total MCA Score	**76%**

6.3.5 Strategic SuDS Networks

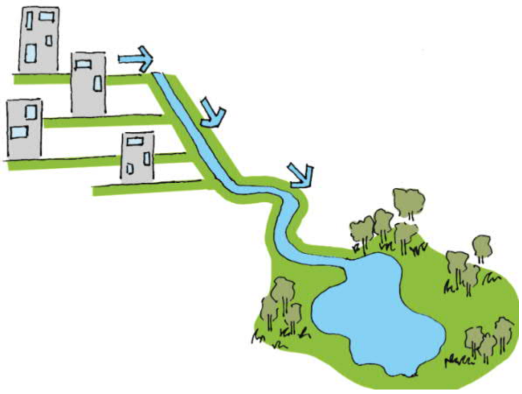


Where space permits, a strategic surface water network could be implemented within some parts of the Opportunity Area to manage and convey surface water, while providing attenuation and water quality treatment. As an alternative to traditional underground piped systems, this may be delivered using a connected sequential train of SuDS features, such as swales and filter strips. 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. Due to spatial requirements, these solutions must be considered early in the planning process. 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 balance of on-plot to downstream attenuation.

The design and configuration of strategic networks would require detailed consideration of spatial availability and constraints, topography, water quality and discharge. The overall feasibility and extent of such features would be highly dependent on spatial availability. 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.

Criteria	Outcomes
Assumed Technology	SuDS networks installed in the place of conventional drainage systems to drain all roads and public space. Green infrastructure can also be retrofitted within the streetscape to collect, attenuate and convey storm water.
Key Water Management Outcome	*Low* – Potential to provide up to 5% of required attenuation volume; however, this will be highly dependent on installed features and spatial availability.
Indicative Cost	*Medium* - Estimated capital construction cost £15,000,000 - £29,000,000
Spatial Requirements	*Medium* - reasonable surface spatial requirements, which will be very difficult to incorporate into the dense development areas, and particularly challenging to retrofit in existing areas. However, where possible, this may be integrated within site landscaping and delivered to provide multiple benefits.
Maintenance Requirements	*Medium* - litter and debris clearance and removal, vegetation management, monitoring and repair of damaged or degraded areas. Above ground systems can increase the ease of identifying and undertaking required repairs.
Regulatory and Public Acceptability	*Medium* - multi-functional infrastructure can enhance the streetscape and public realm. Determining responsibility for ongoing maintenance may present some barriers.
Flexibility and scalability	*Medium* - delivery can likely be phased in line with construction of the street network; however, early consideration of topography, street layout and discharge is required to maximise benefit.
Carbon Intensity	*Low* - maximises passive conveyance and treatment by harnessing natural catchment hydrology. Potential for carbon sequestration.
Blue-Green Space provided	*High* - provision of green space, with the potential to provide recreational and amenity benefit, habitat for biodiversity, improved air and water quality and microclimate benefits.
Climate Resilience	*Medium* - provision of attenuation and increased permeability to assist in mitigating the impacts of climate change on drainage. Capacity design for increased storm intensity will be required.
Surface Water Quality	*High* - Promote evaporation and absorption of surface water and reduced pollutant loads through filtration and biological degradation. Drainage from industrial areas may contain high contaminants of pollutants which will require management.
MCA Score	**54%**

6.3.6 Downstream Stormwater Retention Ponds

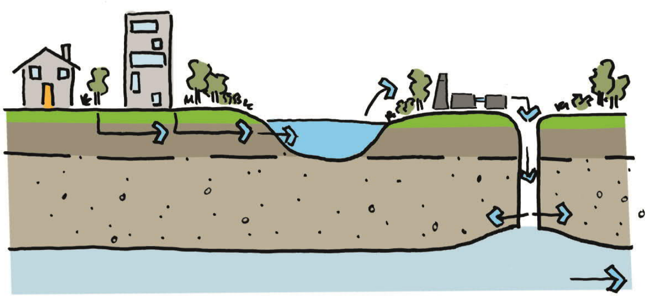


As an alternative or complementary measure to providing localised, on-plot storage of storm water runoff, downstream detention may also be provided. This could be in the form of a dry detention basin or a pond or wetland system, with the potential to provide additional quality and biodiversity benefits. 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 series of dispersed volumes, distributed within open spaces or used in conjunction with other means of providing attenuation. The natural topography of the Opportunity Area 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.

Criteria	Outcomes
Assumed Technology	Localised or combined storm water attenuation provided to the downstream of the hydrological catchment
Potential Attenuation Contribution	*High* - Potential to provide up to 100% of required dispersed or collective attenuation; however, this will be highly dependent on spatial availability, topography and hydro-geological conditions, including infiltration capacity as well as connectivity between areas of development and the attenuation feature.
Indicative Cost	*Medium* - Estimated capital construction cost £15,000,000 - £29,000,000
Spatial requirements	*High* - Significant spatial requirements. However, this may be integrated within landscaping and delivered to provide multiple benefits for the urban aesthetics, environment and community.
Maintenance Requirements	*Medium* - Litter/debris removal and cleaning, vegetation management, sediment monitoring and removal.
Regulatory and Public Acceptability	*Medium* - High quality design and delivery is required to prevent safety hazards and issues associated with eutrophication and undesirable aesthetics resulting from fluctuating water levels. Determining responsibility for ongoing maintenance may present challenges.
Flexibility and scalability	*Medium* - Site levels would need to be carefully considered in order to facilitate natural surface drainage pathways over as much of the Opportunity Area as possible. Physical barriers, such as infrastructure routes, would need to be navigated.
Carbon intensity	*Low* - delivery of associated green space may provide potential for carbon sequestration.
Blue-green space provided	*High* - provision of blue- green space, with the potential to provide recreational and amenity benefit, habitat for biodiversity, improved air and water quality and microclimate benefits.
Climate Resilience	*Medium* - Provision of attenuation to assist in mitigating the impacts of climate change on drainage. Capacity and exceedance design for increased storm intensity and safe containment of flooding will be required.
Surface water quality	*High* **-** Improved surface water quality through attenuation, sedimentation and biological uptake of contaminants.
Total MCA Score	**83%**

6.3.7 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. 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 the Groundwater Injection Technical Note contained in Appendix C.

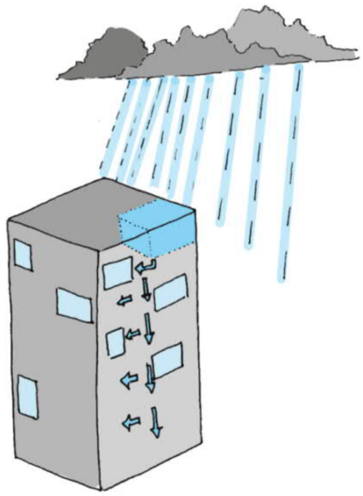
This note concluded that there is potential hydrogeological capacity for groundwater recharge within parts of the Opportunity Area. In some locations, the area is underlain by two regional aquifers, from which water is extracted for potable supply purposes in other areas of Greater London. Therefore, 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.

Storm water would need to be centrally collected and of an appropriate water quality. Considering the spatial layout of the development, installation of a centralised strategic stormwater collection system would be highly challenging, due to the spatially disparate nature of the new development areas, and the requirement for new stormwater collection infrastructure to cross retained areas. Liaison with the Environment Agency has confirmed that treatment prior to injection is likely to be a requirement, with treatment to potable standards indicated to be the required standards (in the absence of a detailed risk assessment). Treatment technologies may include passive, biological treatment processes (such as wetlands), in conjunction with additional tertiary stages (such as UV disinfection) or advanced water treatment technologies.

Measures	Outcomes
Assumed Technology	Storm water collection, treatment and re-injection system, incorporating biological water treatment and disinfection.
Key Water Management Outcomes Potential Discharge Reduction	*Medium* – Indirect water recycling to offset wider area supply, with a theoretical offset of 12%. Complete removal of surface water from the sewer system.
Indicative Cost	*Very High* – Estimated construction costs £45,000,000 +
Spatial requirements	*High* - Significant spatial requirements.
Maintenance Requirements	*High* - Litter/debris removal, cleaning, vegetation and sediment management. Ongoing operational and energy requirements associated with treatment and injection.
Regulatory and Public Acceptability	*Low* - Potential for regulatory barriers.
Flexibility and scalability	*Low* - Centralised system is likely to make it more difficult to phase delivery. Upfront spatial planning and rationalisation of levels and drainage pathways is essential.
Carbon intensity	*Very High* - Ongoing energy and maintenance requirements for treatment and injection.
Blue-green space provided	*High* – Dependant on delivery. However, potential provision of green space, with the potential to provide recreational and amenity benefit, habitat for biodiversity, improved air and water quality and microclimate benefits
Climate Resilience	*Low* - Climate dependant water source, with associated large storage requirements and less reliability of supply.
Surface water quality	*High* - attenuation, water quality treatment and removal of urban runoff from the sewer and surface water systems.
Total MCA Score	**48%**

6.4 Water Recycling Measures

6.4.1 Roof Water Recycling



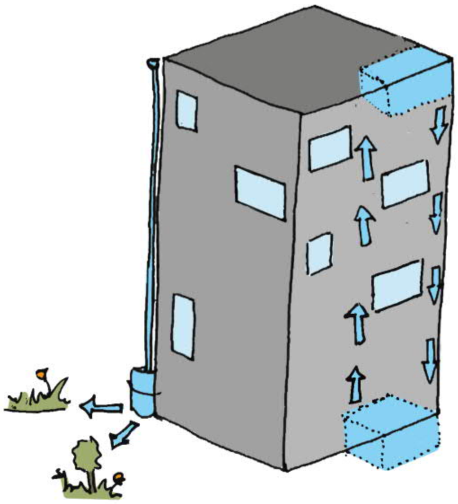
Rainwater can be collected from the rooftops of buildings and stored in underground or over ground tanks for reuse locally. The collected water may be used for garden watering or indoor non-potable uses, such as toilet flushing or hot water and laundry uses. As such, roof water collection contributes to a reduced discharge to the combined 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.

The retrofit of water butts or harvesting systems onto existing properties may be a cost effective way to reduce both surface water runoff and demand, and would be of particular benefit for residential and commercial properties, particularly where there are large roof areas and high outdoor or process water demands.

Criteria	Outcome
Assumed Technology	Localised roof water harvesting systems on all new buildings, including collection, filtration, UV disinfection, pumping and non-potable reticulation. Retrofit of roof water harvesting systems may also be suitable for existing buildings, with water available for outdoor or specific process re-use.
Key Water Management Outcomes	*Low* – Estimated demand and discharge reduction of up to 9% in new build developments. This will vary across properties depending on roof area, population and demand characteristics and availability of space for water storage.
Indicative Cost	*Very High* - Estimated construction costs £45,000,000 +
Spatial Requirements	*Low* - Spatial requirements for water storage, to manage variability in rainfall; however, below ground or rooftop storage can minimise additional land take.
Maintenance Requirements	*Medium* - Ongoing inspection and cleaning of collection systems, filters, valves and pumps. Requirement for ongoing treatment and pumping.
Regulatory and Public Acceptability	*Medium* - Perceived as a relatively high quality water source; however, potential for regulatory barriers, particularly if harvested supplies are required to be mixed with centralised supply to meet non-potable demand.
Flexibility and scalability	*High* - Ability for gradual implementation as development progresses.
Carbon Intensity	*Medium* - Ongoing energy requirements for pumping and reticulation. However, very high quality and can be used for a variety of end uses with minimal treatment requirements, and associated low-energy intensity of treatment.
Blue-Green Space provided	*None*
Climate Resilience	*Medium* - Climate dependant water supply with the requirement for substantial water storage volumes to mitigate seasonal fluctuations in water availability. However, presents an alternative supply option to decrease reliance on centralised system.
Surface Water Quality	*Medium* - Reduced discharge to drainage system.
Total MCA Score	**35%**

6.4.2 Grey Water Recycling



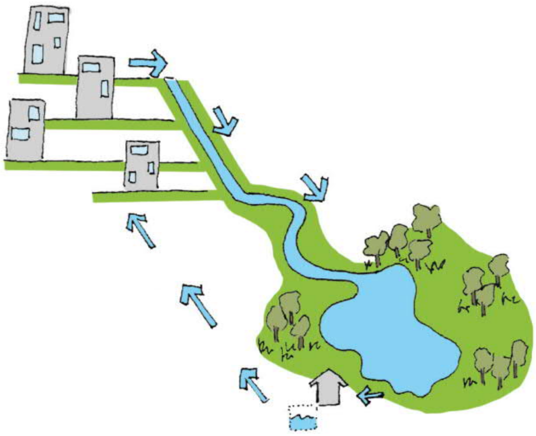
Grey water is wastewater that excludes toilet waste and is therefore of a higher quality than sewage. It includes waste from uses such as hand washing and showering. Water is collected using separate plumbing (to the standard sewage system), stored, treated and redistributed for non-potable use. Due 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 usually implemented as a localised solution at building or plot scale to significantly reduce both 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.

Greywater recycling is only feasible for new build developments, due to internal pipework requirements. This is generally most suitable on a plot or sub area scale.

Measure	Outcome
Assumed Technology	Installation of building scale greywater recycling and non-potable re-use systems for all new buildings.
Key Water Management Outcomes	*Medium* - Estimated water use reduction of up to 14% in new build developments. This will vary across properties depending on population and demand characteristics; however, surplus greywater is likely to be available to meet non-potable demand.
Indicative Cost	*High* - Estimated capital construction cost £30,000,000 - £44,000,000
Spatial Requirements	*Low* - Storage, treatment and distribution infrastructure integrated within building design. Minimal storage volumes are required due to consistency of supply. Below ground tanks can also minimise any additional land take.
Maintenance Requirements	*Medium* - Inspection and cleaning of collection and treatment systems including filters valves and pumps.
Regulatory and Public Acceptability	*Medium* - Potential for some public perception issues and regulatory barriers, depending on proposed end uses.
Flexibility and scalability	*High* - Highly scalable system with minimal space requirements.
Carbon Intensity	*High* - Ongoing energy and maintenance requirements. Potential for lost efficiencies through delivery of numerous localised solutions.
Blue-Green Space provided	*None*
Climate Resilience	*High* - Highly consistent supply of water with low climate dependency, resulting in minimal storage requirements.
Surface Water Quality	*Low* - Marginal benefit through reduced flows to sewer, with reduced associated impact on downstream receiving waterbodies.
Total MCA Score	**54%**

6.4.3 Downstream Stormwater Recycling

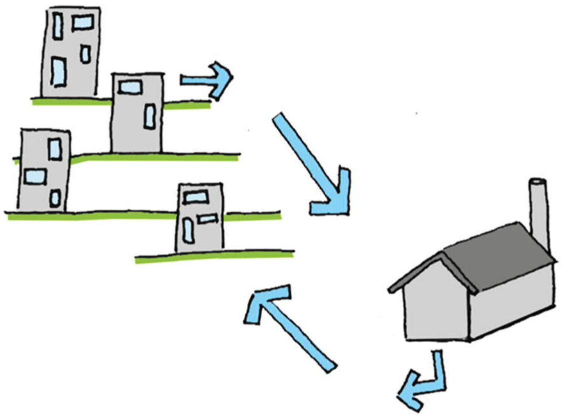


Stormwater treatment and harvesting from urban catchment areas can provide an alternative water source to offset centralised potable demands, while reducing storm flow in the sewer system. In this context stormwater is considered to include both roof water and surface runoff. Stormwater picks up a wide 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 can be supplied for outdoor irrigation use, for specific industrial process or for non-potable uses within residences and businesses. Due to the substantial infrastructure requirements, wastewater recycling is generally considered as for installation at a strategic, area-wide scale.

Considering the spatial layout of the development across the OKR Opportunity Area, installation of a strategic stormwater recycling system to support the overall area, would be highly challenging, due to the spatially disparate nature of the new development areas, and the requirement for new stormwater collection and redistribution infrastructure across retained 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, topography and spatial constraints.

Measures	Outcomes
Assumed Technology	Downstream storm water harvesting system incorporating wetland secondary treatment train, disinfection, balancing storage and re-distribution for non-potable re-use.
Key Water Management Outcomes Potential Discharge Reduction	*Medium* – Theoretical water use reduction of 12%; however, this would be entirely dependent on the ability to collect, convey and redistribute surface water across the development areas.
Indicative Cost	*Very High* – Estimated capital construction cost £45,000,000 +
Spatial requirements	*High* - Significant spatial requirements. However, this may be incorporated into urban landscape to provide high quality public realm and opportunities for recreational space and amenity.
Maintenance Requirements	*High* - Litter/debris removal, cleaning, vegetation and sediment management. Ongoing operational and energy requirements associated with treatment and distribution.
Regulatory and Public Acceptability	*Low* - Potential public perception issues with re-use of recycled storm water and potential for regulatory barriers, depending on proposed end use.
Flexibility and scalability	*Low* - Centralised system is likely to make it more difficult to phase delivery. Upfront spatial planning and rationalisation of levels and drainage pathways is essential.
Carbon intensity	*High* - Ongoing energy and maintenance requirements for treatment and distribution.
Blue-green space provided	*High* - provision of green space, with the potential to provide recreational and amenity benefit, habitat for biodiversity, improved air and water quality and microclimate benefits
Climate Resilience	*Low* - Climate dependant water source, with associated large storage requirements and less reliability of supply.
Surface water quality	*High* - attenuation, water quality treatment and removal of urban runoff from the sewer and surface water systems.
Total MCA Score	**50%**

6.4.4 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. Due to the substantial infrastructure requirements, wastewater recycling is generally considered as for installation at a strategic, area-wide scale.

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.

Considering the spatial layout of the development across the OKR area, installation of a strategic wastewater recycling system to support the overall area would be highly challenging, due to the spatially disparate nature of the new development areas, and the requirement for new collection and redistribution infrastructure to cross retained areas.

Measures	Outcomes
Assumed Technology	Package wastewater treatment plant to treat incoming sewage, incorporating advanced water treatment, wastewater collection and redistribution for non-potable reuse within homes and businesses.
Key Water Management Outcomes Potential Discharge Reduction	*Medium* - Estimated water use reduction of up to 12% reduction in new build areas.
Indicative Cost	*Very High* – Estimated construction costs £45,000,000 +
Spatial Requirements	*Medium* - Spatial requirements associated with infrastructure for wastewater collection, treatment, storage and distribution.
Maintenance Requirements	*High* - Ongoing operational and energy requirements associated with treatment and distribution.
Regulatory And Public Acceptability	*Low* - Potential public perception issues with re-use of recycled storm water and potential for regulatory barriers, depending on proposed end use. Potential community concerns associated with potential for noise and odour (these can be mitigated)
Flexibility And Scalability	*Medium* - May be more difficult to phase delivery in line with development; however, new technologies have the potential for innovative designs with modular composition.
Carbon Intensity	*High* - Ongoing energy and maintenance requirements.
Blue-Green Space Provided	*Low* - Minimal provided through traditional design. However, new technologies may provide opportunities for use of green, biological treatment processes.
Climate Resilience	*High* - Highly reliable supply with limited climate dependence.
Surface Water Quality	*Low* - Marginal benefit through reduced flows to sewer, with reduced associated impact on downstream receiving waterbodies.
Total MCA Score	**44%**

7. Strategy Development

In order to address the significant water management challenges of the Opportunity Area, a suite of complementary measures will need to selected, covering each of the key categories listed (water efficiency, surface water management, and alternative water supplies). The MCA scores for each measure have been comparatively assessed within these categories, to provide an indication of the most preferential measures and how these can be combined into a preferred option scenario.

The development of a preferred option scenario has been split into two types across the Opportunity Area. This is because, growth is planned around several core areas of regeneration linked to the Old Kent Road corridor and proposed Bakerloo line extension, with the remaining areas of the Opportunity Area being largely retained. A slightly different strategy approach is required according to whether new build/regeneration areas are being considered compared to retained areas, as different measures would be more appropriate in each circumstance.

The recommended option scenario approach is discussed for both new build/regeneration areas and retained areas below. It should be noted that water efficiency as a measure is considered equally across new build/regeneration (incorporation into new buildings) and retained areas (retrofitting).

7.1 Water Efficiency

It is recommended that all new build areas are constructed to the maximum possible standards in water efficiency. This is underpinned by the London Plan requirement for all new developments to achieve a water efficiency target of 105 l/person/day, aligned with the optional efficiency standards specified in the building regulations. This can be achieved by wholesale installation of water efficient fixtures and fittings across new build developments.

No alternative measures have been proposed to achieve water efficiency; however, the overall MCA scoring has indicated that this is considered one of the most effective ways to achieve the overall area objectives, through reducing both demand and discharge.

Within retained areas of the OKR Opportunity Area, there are viable options to achieve reductions in current water use through the retrofit of water efficient technologies. Given the expected age of many of the current residential, commercial and industrial properties in the area, it is likely that substantial improvement could be offered through retrofit of modern fittings and fixtures. There are also likely to be opportunities for targeted technological and process improvements for high water use industrial properties.

In addition to community engagement, it is also essential to achieving water use reduction through behavioural change. Wherever possible, educational opportunities or incentive programmes should be harnessed within the development area, to assist in cultivating the new communities' engagement with sustainability and promote water efficient behaviours.

Water metering and the utilisation of smart network technologies is also highly recommended to monitor water use, incentivise reduction, target leakage and assess the effectiveness of the water management interventions within the opportunity areas. Thames Water has indicated that the area may be suitable for early introduction of their progressive metering programme and this option should be developed further with Thames Water.

7.2 Surface Water Management

7.2.1 New Build/Regeneration Areas

Many of the core areas of regeneration will incorporate new open spaces, revised road layouts and public amenity space with an emphasis on linking areas of growth with strategic green corridors and access routes. However, the fragmented nature of the core areas of regeneration across the Opportunity Area combined with limitations of numerous small surface water sub-catchments and major transport infrastructure routes, means that the opportunities to develop Opportunity Area-wide SuDS features are limited. This is reflected in the MCA scores for the Opportunity Area wide measures which reflects the often onerous technological requirements and cost of delivering these.

Therefore, the surface water management strategy for the Opportunity Area as a whole will need be focused on the following elements:

1) 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.
2) Strategic SuDS conveyance and attenuation features developed within core areas of regeneration to provide conveyance and attenuation of runoff from development plots and public realm areas. There is also an opportunity for early planning of strategic storage features to provide for streetscape and residual plot attenuation requirements. Separate features will be required to accommodate surface water runoff from adopted highways and development parcels that will be retained in private ownership in order to enable these features to be adopted by the Highway Authority or the Lead Local Flood Authority, respectively.
3) Ultimate discharge of the collected and treated runoff.

The provision of sufficient attenuation, in order to achieve greenfield rates, will release capacity within the existing combined sewer network to enable additional foul flows generated by the development to be accommodated.

Various options for providing attenuation across these different surface water management elements have been comparatively assessed using the MCA scores generated, as further discussed below. A summary of the recommended water management approach is subsequently presented in Table 7-1.

7.2.1.1 Source Control

Within development plots, attenuation should be provided through a variety of following measures, as described in Section 6. These are listed in the order of preference indicated through the MCA process.

1) Green roofs;
2) Permeable paving and underground attenuation; and
3) Bio-retention systems.

While an order of preference is indicated, these features all received very similar MCA scores and hence should be promoted interchangeably. In general, green roofs and bio-retention received higher scores on the basis of the greater multi-function benefits provided through the delivery of blue-green space, while permeable paving and underground attenuation were primarily judged as beneficial due to the high volume of attenuation that could be achieved, with low effective footprint requirement. Bio-retention achieved a lower score due to the higher land take requirement compared to the other measures.

In order to maximise benefits across the development plots as a whole, it is recommended that a combination of measures is installed. Green or combined blue-green roofs should be maximised on all development plots. These features are likely to present a particularly advantageous opportunity for surface water management. It is generally recommended that accessible, intensive green or blue-green roofs should be installed on all new buildings, across the development. This will increase the provision of amenity and biodiversity benefit and increase current public access to green space across the area. Where appropriate, these systems may be combined with rainwater harvesting or infiltration systems.

An emphasis should be placed on permeable surfaces and the integration of green, surface SuDS systems within site landscaping where possible, in order to optimise water quality and wider sustainability benefits.

Considering the proposed plot layouts and likely building density, it is acknowledged that underground attenuation is likely to be required to achieve attenuation volumes for core areas of regeneration. Through the MCA process, this option ranked reasonably high because of the relatively low capital costs, high attenuation rates (high score against performance criteria), and favourable deliverability scores. However, the aforementioned source control features ranked preferentially higher and hence underground storage should be considered only when the above source control options have been maximised and where strategic conveyance and attenuation within core areas of regeneration are unlikely to be achievable or score favourably. Section 7.2.1.2 below sets out the limitations of strategic conveyance and attenuation and the low MCA score this achieved for the Opportunity Area as a whole, but this should be reviewed on a case by case basis for more discrete, core areas of regeneration.

The exact configuration of source control measures will be dependent on development-specific spatial and geological constraints. However, the opportunities and constraints assessment within the IWMS process highlighted the permeable nature of the geology within the Opportunity Area, particularly the superficial geology in the central and southern portions and hence all developers should aim to maximise infiltration and provide attenuation volumes necessary to achieve greenfield runoff rates subject to a risk assessment related to potential contamination. This will prevent inundation of strategic surface water conveyance networks and facilitate the management of water quality throughout the surface water treatment train.

7.2.1.2 Strategic Conveyance

To facilitate strategic management of runoff across the core areas of regeneration, an above ground conveyance network for surface water could be possible within some of the more discrete areas of regeneration, particularly where new (or enhanced) streetscape is proposed. Ideally, this would be delivered as a strategic interconnected network of streetscape swales and green infrastructure to drain roads or public spaces, to convey, attenuate and filter storm water flows along the natural catchment hydrology. However, considering the proposed spatial streetscape layout, the disconnected nature of regeneration areas within the wider Opportunity Area and the numerous surface water catchments which limit hydrological connectivity, it is unlikely that such a network could be spatially accommodated in most cases within the Opportunity Area. This is reflected in the relatively lower MCA score allocated to this measure.

Alternatively, the installation of more localised SuDS features, such as permeable surfaces and bio-retention areas is likely to be more spatially appropriate for streetscape areas. Both of these measures achieved higher MCA scores. As highlighted above, permeable surfacing was deemed as preferential largely on the basis of low spatial impact and high attenuation capacity, while bio-retention areas were judged to provide greater multi-functional benefits. Therefore, it is recommended that these features are installed in combination within streetscape areas to maximise benefit.

While above ground measures should be prioritised, supporting underground drainage infrastructure is likely to be necessary to convey flows across the area and manage areas of spatial and topographical fragmentation. Underground geo-cellular attenuation is less likely to be suitable for streetscape areas, due to infrastructure and maintenance constraints. However, oversized pipework could additionally provide similar benefit in maximising attenuation volumes within the conveyance network.

7.2.1.3 Strategic Attenuation

As highlighted above, source control systems should be maximised within plot areas to provide as close to greenfield discharge rates from each development plot as possible. 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 spatially constrained development plots.

Downstream attenuation approaches received the highest MCA score of all the measures described, due to the potential to provide substantial attenuation volumes, while delivering blue-green space to enhance the local streetscape and environment and provide biodiversity and amenity benefits in public realm areas. This would also assist to address the current local levels of deficiency in access to green space.

The aforementioned constraints would limit Opportunity Area wide storage options from being implemented without the introduction of pumped pipe systems; therefore emphasis is placed here on localised downstream storage within core areas of regeneration. Open spaces within many of the core areas of regeneration have been mapped and present opportunity to provide above ground detention or swale features to provide strategic storage across several development plots and potentially closely align with the streetscape drainage network. Due to the spatial requirements for surface water management elements, this should be considered at an early stage in the master planning process, through integration within designated open green space or public realm areas.

7.2.1.4 Discharge

Ultimate discharge of surface water will be considered in line with the SuDS hierarchy, with opportunities for water recycling and infiltration maximised wherever possible, before consideration of discharge to the combined sewer system. Reuse of surface water, through rainwater harvesting is further considered in Section 7.3 below.

The geology underlying the OKR is likely to present opportunities for infiltration in many areas, particularly the central and southern portions. No specific areas of contamination have been identified but it is acknowledged that data sources for the IWMS were limited and there is an industrial legacy in many of the core areas of regeneration which represent a risk in terms of historic land contamination. Therefore, feasibility of infiltration via a suitable contamination and groundwater risk assessment will need to be conducted on a site by site basis. Where contamination risk is likely to be minimal, discharge to ground should be adopted in the first instance due to the numerous inherent benefits, including complete removal of surface water from the combined sewer system and contribution to regional groundwater.

The IWMS option appraisal stage has determined that from a hydrogeological perspective, there may also be opportunities for strategic discharge to ground, through aquifer recharge. However, there are numerous inherent feasibility issues associated with this due to the substantial challenge of collecting, conveying and storing surface water at a centralised location across the development area. Additionally, the requirement for achieving potable water quality is considered to make this cost-prohibitive, due to the number and intensity of required treatment stages and technologies. As such, analysing the spatial and topographical fragmentation of the Opportunity Area, the disparate nature of the development areas, and the limited areas of large open space, this has not been assessed as a feasible option for the new development and regeneration areas.

Additionally, the constraints analysis has highlighted that there are limited surface waterbodies in the vicinity of the OA to accept attenuated discharge. Burgess Park Lake is located adjacent to the area; however, broad scale topography indicates that water from the majority of the development could not be naturally gravitated to discharge in this location and would require a pumped solution. Resurrecting the Grand Surrey Canal route is proposed, which could provide localised discharge opportunities in the form of swale features with discharge to ground for adjacent development areas. However, whilst there is a strategic greenway vision for the route, there are no proposals to provide continuous lengths of space where hydrological connectivity could be maintained. The study area consists of a mixture of industrial, commercial and residential land uses, and the multiple landownership may hinder the feasibility of this option. As such, this opportunity does not offer a strategic discharge option for the Opportunity Area. Therefore, where infiltration or reuse is not feasible, surface water will be discharged to the combined sewer system at greenfield rates using the hierarchy of SuDS features highlighted above. Despite this, and notwithstanding potential contamination risk, infiltration is a significant opportunity across much of the Opportunity Area and hence there is potential to reduce surface water volumes discharging to sewer post development even when green SuDS features are lined.

7.2.2 Retained Areas

Within retained areas of the Opportunity Area, installation of SuDS within the streetscape will be highly constrained by existing infrastructure and spatial limitations, reducing the applicability of strategic solutions. However, there are likely to be opportunities for local collection of stormwater using strategically located green infrastructure integrated within the streetscape. Retrofit of landscaped features may be suitable in areas such as traffic calming features, parking bays, verges and central reservations or through tree and vegetation planting along the footway. Porous paving and hardscape solutions may also be appropriate in retained areas. Following the same hierarchy highlighted above, runoff should be preferentially infiltrated. Where this is not possible, the SuDS features will deliver critical attenuation, loss through evapotranspiration and treatment prior to discharge to the combined sewer system.

It is recognised that improvements in surface water management will be more reliant on opportunities arising through incremental renovation and redevelopment across the area. Within all new development, greenfield rates should be achieved, with a preference for green, surface SuDS measures and infiltration, following the considerations highlighted above.

However, within certain areas, there may be opportunities for targeted SuDS retrofits, particularly including retrofit of green roofs and blue-green infrastructure in commercial or industrial properties.

7.3 Alternative Water Supplies

The delivery of water recycling measures is inherently more costly, energy intensive and will involve more substantial ongoing operational and maintenance costs than the surface water management requirements. However, this is the only viable means by which to further reduce water demand and wastewater discharge across the Opportunity Area, in order to achieve all of the IWMS water management objectives. Therefore, the delivery of non-potable water recycling solutions within the development area is highly recommended, wherever feasible.

7.3.1 New Build/Regeneration Areas

A variety of possible approaches to water recycling within the development area have been highlighted in Section 6.4, including re-use of collected roof water, and potential recycling of greywater, stormwater and wastewater.

Each of these approaches is applicable at various scales. In general, both, stormwater and wastewater recycling are considered to be more regional solutions, requiring substantial centralised infrastructure for collection, storage and treatment of reclaimed supplies. Additionally, separate area-wide pipe systems are required in order to distribute the non-potable supply and keep it separate from the potable systems.

This presents numerous inherent feasibility challenges, due to the fragmented and spatially disparate nature of the core regeneration areas, across the Opportunity Area as a whole. This would require new collection and redistribution pipework to be installed between the new build areas and a centralised collection and treatment facility, which would need to cross through retained areas. There are numerous operational and regulatory complexities associated with delivery and ongoing management of strategic recycling solutions, presenting challenges in ownership, delivery and operation, potentially requiring cooperation between numerous developers and a large strategic network to be operated and maintained by a third party. As such, considering cost and feasibility implications of such a system, a strategic area-wide solution is has been assessed as not feasible.

In contrast, rainwater and greywater recycling are both generally considered as localised solutions, able to be delivered on a building, plot, or sub-area scale. Therefore, these solutions provide flexibility in managing the scale and phasing of development delivery. In addition, operation and maintenance is considered to be simplified by retaining responsibilities within a given building facilities management.

The MCA process has indicated greywater recycling is likely to be the most preferential approach of the recycling technologies considered. The primary reason for this is because roof water supplies are generally inadequate to service non-potable demand (as determined from the water balance), from a purely volumetric perspective. This will be further exacerbated by the variability of rainfall volumes across the year, limiting the ability to maximise available supplies and creating a need for substantial storage volumes to manage this variability in inflow.

Conversely the water balance demonstrates that there is likely to be surplus greywater to meet all non-potable demands. This solution additionally offers greater climate resilience and associated certainty of supply, and lower storage requirements, leading to fewer spatial challenges. For these reasons, this is recommended as the primary option for non-potable reuse across the Opportunity Area.

However, this balance between available roof water and demand will vary across development plots, so may become more feasible for certain developments, or where additional factors mean that recycling is only appropriate for commercial areas.

As such, it is recommended that the optimal recycling solutions are assessed for each development plot. The balance of available flows and demands will vary across development plots, as will spatial and operational considerations. There may be opportunities for combined rainwater and greywater recycling systems to achieve cost and infrastructure efficiencies. Separate collection of rainwater for outdoor irrigation should also be considered at all properties, in conjunction with the development attenuation and storm water management approach. This can be delivered in a cost efficient way through simple features such as water butts.

Additionally, it should not be assumed that only a single, unique approach to recycling will be appropriate. A variety of stormwater conveyance and storage infrastructure will be required across the development area, which may be harnessed to provide more appropriate localised opportunities for irrigation of public green spaces, further reducing the demand on centralised potable supplies with lower required water treatment, and therefore cost of supply.

In the long term, the overall objective should be to provide a diverse portfolio of fit-for-purpose supply solutions, allowing greater operational flexibility and system resilience.

7.3.2 Retained Areas

Within retained areas of the Opportunity Area, retrofit of dedicated non-potable internal distribution pipework within properties is unlikely to be feasible, which will limit the applicability of most recycling options.

However, there may be individual properties which could be targeted for retrofit of rainwater harvesting systems. This is likely to be most advantageous in industrial or commercial properties where there are large available roof catchments, and specific, high demand process water uses which could be met with non-potable supplies. In order to maximise benefit, this is likely to require a targeted approach to retrofit, based on the individual water use characteristics.

Additionally, as regeneration of the area is gradually stimulated, all new properties should be installed with an alternative means of water supply through delivery of localised rainwater or greywater systems.

Table 7-1 – Summary of preferred option scenario across the OKR Opportunity Area

Strategy Element	New Build/Regeneration Areas	Retained Areas
Demand management and water efficiency	• All properties constructed to the maximum possible standards in water and energy efficiency. • Delivery of smart network technologies and water metering solutions. • Delivery of educational opportunities and incentive programs integrated within the development.	• Targeted water efficiency retrofits and process improvements, including incentive schemes to encourage property owners to undertake retrofit. • All new build developments and refurbishments to achieve maximum possible levels of water efficiency. • Agree extension of Thames Water's progressive metering programme into existing property.
Surface Water Management	• All new development areas to achieve greenfield runoff rates, with preferential reuse and infiltration of surface water in accordance with the London Plan drainage hierarchy. • Maximise on plot source-control measures through installation of green and blue-green roofs, bio-retention systems and permeable surfaces. • Installation of spatially appropriate SuDS, permeable surfacing and green infrastructure for conveyance of runoff and to provide public realm attenuation. Seek opportunity to provide above ground attenuation for core areas of regeneration within public open space. • Residual attenuation requirements met through either underground systems on plot or potentially shared local scale above ground attenuation features within key areas of regeneration.	• Targeted SuDS retrofitting within existing development areas, particularly including retrofit of green roofs and blue-green infrastructure. • All new build developments and refurbishments to maximise the provision of attenuation towards the aim of achieving Greenfield rates, with a preference for green SuDS measures. • Retrofit of sustainable drainage systems within the streetscape wherever spatially possible, including integration of water management infrastructure within delivery of any newly planned green space or streetscape regeneration.
Alternative water supplies	• All new development areas should be installed with an alternative means of water supply for non-potable demands through localised rainwater or greywater reuse.	• Targeted retrofit of roof water recycling schemes for properties with high outdoor use or process demands. • All new properties installed with an alternative means of water supply for non-potable demands.

8. Case Study Area Delivery Testing

Subsequent to the formulation of the overall strategy across the OKR Opportunity Area, more detailed analysis has been undertaken for the Ruby Triangle and Cantium Case Study areas. These areas are further progressed in terms of the building massing and spatial delineation of individual plots, allowing further identification of key constraints and opportunities and greater refinement of the water management strategy in these areas.

In particular, the aim of this more detailed analysis is to demonstrate the deliverability of the preferred option scenario and identify suitable water use reduction, and sustainable surface water management measures, taking into account site-specific constraints to determine appropriate infrastructure sizing and technology, and identifying potential layouts. Through this process, an integrated approach has been taken in considering the delivery of suitable surface water management measures, whilst harnessing opportunities to combine flood risk reduction with local amenity enhancement, ecological improvement and provision of open space.

The detailed methodology, including key assumptions, constraints and technical detail, as utilised in the design and testing of surface water management measures, is detailed in Appendix D.

The resulting outline designs for Ruby Triangle and Cantium, as conceptualised during the delivery testing phase, are contained within Appendix F.

Outline costing was also developed for the defined approaches, as summarised below, with detailed cost breakdowns contained in Appendix H.

Finally, the assumptions applied in development of the case study areas have also been tested for applicability actual site proposals. This exercise was undertaken to determine whether the assumptions are reasonable and pragmatic when applied to more advanced planning proposals, and hence to test whether the foundation on which the IWMS recommendations are based in also reasonable and practicable. The detailed output from the assumption testing is provided in Appendix I and demonstrates that the assumptions are in most cases applicable and in some cases likely to be conservative.

8.1 Water Efficiency

As highlighted in Section 7.1, all new build areas should be constructed to the maximum possible standards in water efficiency. This is underpinned by the London Plan requirement for all new developments to achieve a water efficiency target of 105 l/person/day, aligned with the optional efficiency standards specified in the building regulations.

As this measure is required through current policy, any associated cost should already be embedded within the costing for current development proposals.

8.2 Surface Water Management

Surface water management is the key focus of the proposed water management strategy, due to the critical nature of this element in alleviating capacity issues in the combined sewer system. This also represents the greatest uncertainty with respect to the strategy delivery, due to the substantial dependency of a successful SuDS system on ground conditions, topography, infrastructure and layout.

Due to the lack of detailed site specific information at strategy level, the delivery testing phase has focused on a conceptual surface water management strategy, based on the area-wide principles outlined. This is based on the key objective of achieving overall development discharge at greenfield runoff rates (up to the 1% AEP plus climate change storm event), with reduced discharge volume where additionally possible.

In line with the water management options described, the surface water management strategy has comprised of considering conceptual design of measures within various spaces of the development, and how these might be combined for optimal benefit. This includes:

- The range of preferential on-plot surface water management measures;
- Communal downstream attenuation solutions, delivered within open spaces, through a possible offset approach (as further discussed in Chapter 9).; and
- Streetscape surface water management measures.

A range of design assumptions, parameters and constraints have been utilised through this process, as fully described in the supporting Delivery Testing Technical Appendix D.

8.2.1 On-plot attenuation

The design for on-plot surface water management has aimed at attenuating all runoff within the plot boundary to achieve greenfield runoff rates, through the use of SuDS, utilising underground attenuation for residual attenuation requirements.

The potential surface water mitigation measures highlighted have been taken forward, considering the area-specific site layout and spatial constraints. As the areas of open space and green area within each plot is limited, the use of large surface planting and landscaping, or other spatially significant features have been discounted in considering the primary attenuation provision. Therefore, this has been conceptualised primarily utilising green roofs, and permeable pavements, with some additional benefit calculated through bio-retention planters. Geo-cellular attenuation tanks are then utilised for the residual attenuation.

A review of broad scale geology indicates that infiltration is likely to be feasible across the majority of the Case Study areas (and should be harnessed wherever possible). However, due to the unknown localised hydrogeological conditions, and the possible presence of contaminated land, a conservative approach has been adopted, making no allowance for infiltration within the conceptual infrastructure sizing and conceptual design.

8.2.1.1 Key findings

Based on the key assumptions and design parameters, the following conclusions have resulted from the on-plot delivery testing:

- Although technically challenging, there is indicated to be sufficient capacity within each plot to attenuate 100% of surface water runoff generated from the 1 in 100 year return period storm event, with a 40% allowance for climate change (with discharge at greenfield rates). This can be achieved through the outlined design approach.
- The analysis shows that to achieve on plot attainment of greenfield runoff, there is a significant reliance on below-ground attenuation, installed in either a single or a double layer arrangement, below the plot open space; this works against one of the key IWMS objectives to “maximise wider sustainability benefits” in delivering the preferred strategy.
- An average of 10% of the required attenuation can be achieved using green roofs installed within the development plots.
- An average of 8% of the required attenuation can be achieved using permeable pavements installed within the development plots.
- Raised planters and landscaped green spaces within the plot boundary have not been incorporated within the attenuation requirements of the drainage strategy. However, these features will additionally contribute a proportion of the required plot attenuation volume. These results in underground storage providing 82% of the required attenuation.
- Each on-plot attenuation system has been designed with a single point of restricted discharge, directed to the sewer system (at greenfield rates), where conveyance pathways are feasible.

8.2.1.2 Capital and operational costs

The capital and operational costs for the on-plot drainage elements have been derived based on the conceptual design, illustrated in Appendix F.

Assuming attenuation to greenfield rates, the total on-plot capital cost is £ £5,420,000 for the Ruby Triangle Case Study area and £4,250,000 for Cantium Case Study area. A full breakdown of capital cost is contained in Appendix H.

The estimated unit capital and operational costs, per cubic meter of surface water managed, are outlined below.

Table 8-1 Capital and operational costs for on-plot surface water management

Surface water management component	Capital costs (£/m^3)	Operational costs (£/m^3)
Geo-cellular attenuation tanks	£380.00	£0.55
Permeable pavements	£1,285.00	£0.60
Green roof	£2,540.00	£18.00

8.2.2 Communal space attenuation

Within each Case Study area, a number of designated open spaces will be provided. These spaces will be used for a variety of functions, including recreation, amenity and bio-diversity. Communal surface water attenuation solutions have been conceptualised in these spaces in line with the preferred option strategy for regeneration areas, to provide an alternative attenuation/discharge location where it is not feasible or preferable for all surface water to be managed within the boundaries of the development plots. Due to the greater spatial flexibility in these areas, consideration has been given to surface water attenuation measures which provide multi-functional benefits, such as improved amenity and biodiversity enhancement.

The communal space attenuation features have been designed to fit the land-use assumptions outlined in Appendix D. In particular, 15% of each pocket of communal space has been assumed as available for a dedicated surface water management feature, with an additional 35% of the communal space available to act as a multi-functional area.

The dedicated component of the surface water attenuation feature has been conceptualised as a detention pond, with capacity for the 1 in 30 year return period storm event, to ensure full utilisation of the space. The surrounding multi-functional area will be dry under most events; however, it will provide additional attenuation during larger storm events. The overall feature has been designed with capacity for the 1 in 100 year plus 40% climate change event.

For the Cantium Case Study area, an additional attenuation swale has been conceptualised for the proposed linear park, following the same land use and capacity assumptions as above. Appendix F demonstrates conceptual layouts for the two Case Study areas incorporating these features.

8.2.2.1 Key findings

Based on the key assumptions and design parameters, the following conclusions have resulted from the communal space delivery testing:

- The detention ponds, linear swale and multi-functional spaces provide an average capacity suitable to attenuate approximately 30% of the plot and communal space runoff for a 1 in 100 year storm event with 40% climate change allowance, with a restricted outflow rate of 5l/s.
- The detention ponds have the capacity to attenuate 100% of the volume for a 1 in 30 year return period storm even (without use of the multi-functional space for attenuation).

- Where possible, localised infiltration measures can be utilised to provide further surface water attenuation.
- It is recommended that the sizing and design of the attenuation features is revisited once the communal spaces and linear park areas within the two Case Study areas have been designed to a suitably advanced stage, and greater understanding of local geological and topographic conditions is available.
- Topography and plot layouts have been considered to understand possible conveyance routes between the development plot and the communal spaces. However, the conveyance routes indicated in Appendix D are only indicative and will require refinement when further detail is available regards proposed land levels and road layouts.
- The communal spaces have been designed conceptually to outfall into the existing combined sewer at a restricted rate of 5l/s.

8.2.2.2 Capital and operational costs

The capital and operational costs for the communal space attenuation features have been derived based on the conceptual design, illustrated in Appendix F.

Assuming full spatial utilisation (providing an average of 30% of total on-plot attenuation capacity), the total expected capital cost is £1,040,000 for the Ruby Triangle Case Study area and £320,000 for Cantium Case Study area. A full breakdown of capital cost is contained in Appendix H.

The estimated unit capital and operational costs, per cubic meter of surface water managed, are outlined below.

Table 8-2 Capital and operational costs for communal surface water management features

Surface water management component	Capital costs (£/m^3)	Operational costs (£/m^3)
Detention ponds	£370.00	£0.95
Linear swale (Cantium)	£580.00	£0.40

8.2.3 Streetscape drainage system

Streetscape areas have been considered as a part of the public realm, including all land along and adjoining the streets, footway and cycle ways. Potential surface water mitigation elements have been considered based primarily on the anticipated spatial availability and design layout for the streetscape areas. Considering these constraints, tree planters, oversized pipework and strategically located tanked blocks of permeable pavement have been conceptualised to provide attenuation for streetscape areas.

8.2.3.1 Key findings

Based on the key assumptions and design parameters, the following conclusions have resulted from the streetscape delivery testing:

- The oversized pipe network, tree planters and permeable pavement blocks provide an instantaneous attenuation volume of up to 30% of the streetscape runoff (assuming discharge of 5L/s), preventing rapid surface flow of runoff.
- The oversized pipes and adjoining streetscape drainage network is sufficient to convey the streetscape runoff to the 1 in 100 year storm event with 40% climate change allowance.
- Tanked permeable pavements have been proposed at junctions, where it has been assumed that raised tables will be utilised. However, further location for tanked pavements can be explored to increase the instantaneous attenuation volume provided, depending on geology and other streetscape provisions.

- Tree planters have been conceptualised at a rate of 1 every 6 to 8 metres, to suit the canopy cover requirements across the Case Study areas. Additional planters could be located depending on the provision of other street furniture and geological conditions.

8.2.3.2 Capital and operational costs

The capital and operational costs for the streetscape attenuation features have been derived based on the conceptual design. The total expected capital cost for these streetscape measures is £2,080,000 for the Ruby Triangle Case Study area and £1,150,000 for the Cantium Case Study area. A full breakdown of capital cost is contained in Appendix H.

The estimated unit capital and operational costs, per cubic meter of surface water managed, are outlined below.

Table 8-3 Capital and operational costs for streetscape surface water management features

Surface water management component	Capital costs (£/m^3)	Operational costs (£/m^3)
Drainage network (including oversized pipes)	£250.00	£4.15
Tree planters	£1730.00	£3.51
Tanked permeable paving	£435.00	£0.60

8.3 Water Recycling

As highlighted in Section 7.3, it is recommended that all new development plots additionally give consideration to the installation of an alternative means of water supply, in order to achieve the next enhanced level of water sustainability across the area as a whole.

In general, localised greywater recycling is recommended for installation at a building or plot scale. Within the Case Study areas, this has been generally assessed as the most effective means of offsetting non-potable demand. However, plot specific design and constraints may influence this, so rainwater harvesting should also be considered on a plot by plot scale, in order to assess the preferable solution for each individual development.

In conjunction with plumbed non-potable solutions, the collection of rainwater from green roof areas using harvesting systems or water butts should additionally be considered, particularly to provide water to service any proposed green landscaped areas within the development plots.

9. Case Study Area Delivery mechanisms and Offset Policy

The Case Study delivery testing assessment has highlighted that meeting the water management objectives of the IWMS within the confines of a development plot can be both technically and economically challenging. It also highlighted that in doing so, it increases the reliance on underground storage, which in turn reduces the opportunity to meet the IWMS objective of maximising sustainability of the preferred option scenario strategy.

Allowing developers to meet these objectives utilising measures beyond their plot could, as highlighted above, provide an effective way of better meeting the study objectives whilst enabling otherwise acceptable development. This is a principle often referred to as offsetting.

Through planning conditions and s106 obligations, the current policy framework could be used to deliver solutions to meeting drainage policies offsite; however, it is evident that these mechanisms alone are not delivering the high levels of performance required. This is because other important issues are regularly prioritised over drainage when negotiating planning agreements. Setting a more specific offset policy, either within the wider Opportunity Area AAP or specifically for the Case Studies, that provides greater detail as to the requirements for investigating and investing in offsite solutions would provide more weight to these requirements and drive better performance.

9.1.1 Offset Principles

Generally associated with environmental performance policies, such as for carbon compliance and biodiversity, 'offsetting' is the process by which developers are allowed to meet, or 'offset', part of their policy requirements through alternative measures off-site. Recognising the risk of diminishing returns from continued investment into measures to improve performance on-site, and in some cases the inability to meet requirements on-site at all, the overarching principle of offsetting is to provide a more flexible approach to delivering an equivalent performance through more cost effective measures elsewhere.

Having consulted with CIRIA, who manage the SusDrain community of parties interested in sustainable drainage, it is thought that any approach to using offsetting within surface water management policies of the OKR Opportunity Area would be the first of its kind. There are however several examples of offset policies from other environmental issues such as Southwark's own carbon offset policy[9] and emerging approaches around biodiversity offsetting that provide useful lessons around key issues for developing an offset approach for drainage, including:

- Minimum on-site performance - Although overarching targets will be the same for all developments, it may be necessary to require a minimum level of on-site performance. Indeed most current offset policies require development to meet minimum performance levels. Setting this minimum performance is not straight-forward as different sites will have differing abilities to meet different levels of performance.

  As such, one method would be to base performance on capacity of the most constrained site while another approach would be to aggregate the potential of different sites and use the average. The modelling undertaken for the Case Study sites above indicates that an average of 70% of run-off would need to be managed onsite (on-plot).

- Variable on-site performance - As an offset should provide flexibility and a more cost-effective approach to developers to meet their policy requirements (once they have met the minimum on-site performance), it is their prerogative as to whether they should pursue an offset approach or not. As every site is different, it might prove beneficial for a particular developer to do more on site. If this were to be the case, there is a risk that there would be fewer developer contributions flowing into an offset fund for a specific measures such a communal Case Study wide scheme.

[9] http://www.southwark.gov.uk/planning-and-building-control/section-106-and-community-infrastructure-levy/zero-carbon-homes-and-the-carbon-offsetting-fund

- Offset Ratio - The offset ratio is the volume of residual surface water management required to meet the policy target or a specific development site, divided by the volume of surface water managed and delivered through the offset scheme and using the offset payment generated by that development. If all the surface water is managed by the scheme, then the offset ratio is 1. Usually this would be the requirement for offsetting however there might be mitigating circumstances such as if a scheme delivers another public benefit. As such, there may be cases where the council would accept a ratio of less than 1.

- Verification - Coupled with the offset ratio is the need to verify the level of offset required and the performance of proposed offset measures.

- Proximity to development - Most offset policies advocate delivering offset solutions within close proximity to the development. Although this is largely political in the case of carbon offsetting where reductions are universally beneficial, there is an emphasis on delivering solutions with additional public benefits such as reducing fuel poverty. This is particularly the case for a drainage offset where the drainage issues are much more closely linked to the local geography (i.e. the capacity of the drainage network). For example, where measures are needed in the OKR Opportunity Area to mitigate the peak flow rate due to the constrained capacity of the Crossness WwTW catchment in order to increase its capacity to treat foul water and reduce flood risk and CSO discharges.

- Additionality - It is important that the improvement in performance delivered through the offset is truly additional i.e. it was not going to be delivered anyway. This may be important especially if the offset contribution is providing a top up to upgrade an existing or planned scheme from a third party, such as Thames Water, or several parties are paying to fund a specific measure to serve them all.

- Offset Delivery Model – There are generally two models of delivering offset solutions.

    - Developer managed – perhaps the simplest approach is to allow the developer to identify opportunities for offsetting their performance target. Although these approaches reduce the risk for the local authority they do need to be verified and there is less opportunity for measures to be coordinated to meet strategic outcomes.

    - Fund managed programmes – allowing developers to pay into a fund that pools contributions for larger capital projects or several smaller measures. This model provides flexibility for the developer, allowing them to leverage the economies of scale from bigger projects or distribute across a number of projects.

9.2 Options for a Drainage Offset Policy

Offset policies for the OKR Opportunity Area could be developed at either the Opportunity Area scale or the Case Study area scale. Each would have different approaches to delivery.

9.2.1 Opportunity Area Offset Policy

This policy would relate to any new development over a specified scale e.g. 10 homes or more. It would require developers who cannot meet greenfield run-off rates on plot to mitigate for an unmet attenuation equivalent to be delivered elsewhere in the opportunity area (but within the same sewer catchment) to increase capacity within the Crossness WwTW network.

This commitment could be met either by the developer directly funding approved or verified measures secured through planning conditions, or as the requirement is necessary, directly related to the development and reasonable, it could be secured through a section 106 payment to LBS for them to identify and deliver suitable measures on the developer’s behalf. In this instance it would not be necessary to prescribe an offset value as the cost of measures would be determined on a case by case basis. This could, however, be time consuming and difficult to enforce.

An alternative approach would be for LBS to identify a suite of suitable projects across the Opportunity Area (or within the wider Crossness catchment) that could deliver improved capacity in the drainage catchment (potentially including the Case Study specific measure below). Funding from developers would contribute to the programme of implementation. The rate of funding would be set at the average cost/m^3 for delivering the suite of measures and charged relative to the required unmet attenuation from each development. Although this would require greater effort in the recruitment of projects and verification of improved drainage performance (probably by LBS), it could be used to target more significant problem areas within the Borough.

An analysis of potential measures, that could include demand reduction measures as well as distributed attenuation measures, has not been undertaken directly as part of this IWMS. The GLA has, however, undertaken a pan-London assessment of the feasibility and cost of retrofitting SuDS measures and estimated a rate per m^3 of just under £600. As projects are likely to be smaller and ad hoc, they are less likely to have the economies of scale of the larger, more strategic drainage solutions tested in the Case Study areas. There are also rules over the number of developments that can contribute to pooled funding of infrastructure through s106. As such, it is likely that a programme of catchment capacity improvement measures would need to be delivered by recognising the programme on Regulation 123 infrastructure lists and delivered through Community Infrastructure Levy (CIL) contributions.

As AAPs are statutory planning documents, they are afforded more weight than SPDs. As such, these policies are likely to be easier to enforce. A summary of the benefits and risks associated with Opportunity Area wide solutions is set out in Table 9-1.

Table 9-1: Opportunity Area wide offset policy - benefits and risk summary

Benefits	Risks
• Reduces risks associated with phasing. • Can target areas of greatest need. • Greater weight afforded to AAP policies.	• Requires greater coordination and management. • Will require verification of improvements to local drainage network. • Less economies of scale. • Risk of delivery falls to the fund management.

9.2.2 Case Study Offset Policies

Offset policies for specific Case Study areas are likely to focus on allowing developers within the Case Study to mitigate for any unmet drainage requirements through a dedicated communal SuDS system such as those outlined in the preceding sections for the Cantium and Ruby Triangle Case Study areas. In this regard, there are parallels with the delivery of any communal enabling infrastructure.

As the opportunities to deliver communal schemes are dependent on the configuration of each of the Case Study areas, the potential attenuation volume and associated costs will be specific to each area. Furthermore, to meet the three statutory tests of planning obligations[10], the offset cost must be related to the specific infrastructure solution required to enable development. The analysis above indicates that the communal areas can accommodate, on average, 30% of the attenuation volume required to meet greenfield runoff rates at a cost rate of between £190/m^3 (Ruby Triangle) and £460/m^3 (Cantium) excluding management costs; delivering an overall cost saving to developers of between £90m^3 (Cantium) and £160m^3 (Ruby Triangle) compared with meeting 100% of the required attenuation volume on plot. These costs would need to be incorporated into policies specific for each Case Study.

Where five or less developers are contributing to the scheme, the drainage measures could be secured through s106, however if there are more than five, this strategic infrastructure would need to be delivered through CIL receipts. LBS could enable the development of the network or alternatively a

[10] Three statutory tests for planning obligations are ‘necessary to make the development acceptable in planning terms, directly related to the development and fairly and reasonably related in scale and kind to the development’

third party, such as Thames Water or the developer with the strategic SuDS on their plot could provide the upfront capital for delivery and CIL/s106 receipts could pay back the investment.

The delivery challenge for Case Study specific schemes is the development phasing. Ideally, the SuDS network would be available for each development plot to connect with the network from the outset as costs are likely to increase as more of the Case Study is built out. There is, however a risk that some developers may decide to increase on-site performance and therefore reduce the funding for payback. To manage this risk, the offset policy could follow the example set by the GLA's energy hierarchy which, once minimum onsite performance targets are met, developers have to demonstrate the feasibility of connecting to a local district heating network[11]. Similarly, as Case Study offset policy could be supported by strengthening the existing drainage hierarchy to require developers to meet a minimum runoff target on site (e.g. 70% in these cases) and be required to provide a drainage statement that sets out the potential for meeting the overarching target of green field runoff rates by using the communal scheme. Measures would need to be put in place to ensure there was capacity in the communal scheme.

Table 9-2: Case Study Offset Policy - benefits and risk summary

Benefits	Risks
• Provides coordinated approach if developers/land owners in each Case Study area can be encouraged to agree an overarching plan/strategy • Reduces costs associated with build out. • Delivers a more cost effective way of meeting higher water management targets	• Improved onsite performance reduces potential payback. • Cost of payback gets greater as time goes by. • If the strategic communal scheme cannot be delivered from the outset costs may increase

9.2.3 Conclusions and recommendations

Offset policies, whether set for the Opportunity Area as a whole or Case Studies are likely to help improve the overarching water management objectives by diverting a greater proportion of development's peak flow away from the constrained drainage catchment and doing so in a way that meets the wider sustainability aims of the IWMS.

Although policies within the AAP would have greater material weight, the complexity of managing a higher number of potential offset measures is likely to place a greater burden on LBS than focusing on strategic solutions for each of the Case Study areas.

Strategic solutions within each of the Case Studies are likely to provide cost savings for developers in meeting a greenfield runoff rates, compared to providing all of the required attenuation volumes on plot. In turn, this would allow a greater range of additional benefits (biodiversity, water quality and sustainability) to be realised. It could also allow greater value to be derived from each plot by allowing different land uses. However, as each area of regeneration is unique in configuration, the offset costs would need to be specifically developed for each area considered and included in Case Studies where there are being produced.

On balance, the recommendation from the IWMS case study and delivery testing is to pursue the option to identify a suite of suitable SuDS and water management projects across the Opportunity Area that could deliver improved capacity in the drainage catchment and from which to derive a rate of funding would be set at the average cost/m^3 for delivering the suite of measures and charged relative to the required unmet attenuation from each development. LBS will undertake further study to derive this charge as an addition to the IWMS.

[11] https://www.london.gov.uk/what-we-do/planning/planning-applications-and-decisions/pre-planning-application-meeting-service-0

10. Stage 4 – Strategy Delivery

In addition to the potential for an offset policy, this section of the report considers other means by which the various options identified for the Opportunity Area as a whole 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 Opportunity Area 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 scale (i.e. within core areas of regeneration such as the Case Study areas tested) and that therefore the solutions for each of these will vary. There are a variety of mechanisms that would enable contributions to be obtained from individual plot developers. However, the preferred mechanism for delivering new (or improvements to existing) strategic infrastructure will be highly dependent on a large number of factors; particularly, the means by which infrastructure costs are recovered from the private sector, and the authority that will be responsible for operating and maintaining the asset.

Further discussions with the key regional stakeholders and individual developers are required to confirm the most appropriate of these potential mechanisms. These discussions should examine whether funding may be obtained from the following sources:

- Developers will be required to deliver SuDS and water recycling measures, at least partly on plot to restrict the peak surface water discharge rate to greenfield and minimise potable water demand through the introduction of appropriate planning policy (in particular the draft APP water and flood risk based policy). If it is not practical to provide the required SuDS and water recycling measures on plot, and/or wider sustainability benefits can be realised considering off-plot communal measures, as described in section 9 of this IWMS, the offset approach may be used to allow developers to contribute to the cost of features that are provided within the wider Opportunity Area.
- CIL funding may be used to generate funding towards strategic features situated within areas of Public Open Space, such as SuDS that serve more than one development plot that will be maintained by the Local Authority. However, limited funding is likely to be obtained from this source, as it is required to support a range of competing infrastructure projects, and the offset policy may therefore be required to obtain additional funding for strategic SuDS features;
- S106 / S278 Agreements could be used to deliver surface water drainage networks that would collect, attenuate and improve the quality of surface water runoff from existing or proposed highways. These network would be adopted and maintained by the Highway Authority;
- Thames Water could use funding obtained from OFWAT to reinforce strategic potable water infrastructure to support development, as part of the rolling five year Asset Management Plan (AMP); or
- An Inset Appointee could be engaged to procure a bulk water and wastewater connections to the Thames Water potable water and combined sewer networks, and to construct, operate and maintain new potable water supply networks under OFWAT licences, providing that land can be made available for strategic infrastructure. Further details relating to an Inset Appointee are defined within Section 10.4.3.2. This procurement strategy should be considered in the event that insufficient funding may be obtained from the sources identified above.

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.

10.1 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.

10.1.1 Location and Scale of the works

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 appropriate plot developers.

There are also a number of solutions at a regeneration area scale, which would involve works outside of the plot boundaries in order to yield benefits to the wider OKR Opportunity Area, rather than being specific to an individual plot or development parcel. These measures could conceivably be carried out by several different parties depending on the form of infrastructure. For example, Thames Water could deliver strategic improvements to the potable water supply network using funding obtained from OFWAT, whilst LBS could deliver strategic SuDS features situated in areas of public open space using funding obtained from the CIL or offset policy. Alternatively, an Inset Appointee could be engaged to construct, operate and maintain new water supply and drainage infrastructure within the site, providing that land may be provided.

10.1.2 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, which would need to be procured and delivered at an early stage. For the latter, this could represent a significant opportunity for Thames Water or an Inset Appointee to deliver improvements to the strategic potable water supply network, and for LBS to deliver strategic SuDS, and then for the individual plot developers to connect to these systems.

10.1.3 Cash flow for the works

It is recognised that certain strategic solutions (particularly the communal SuDS systems tested for the Case Study areas) will involve significant cost, and that these costs will have to be incurred at an early stage in the overall development, unless the incremental approach is taken. 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 fully fund strategic solutions, as the impact on their cash flow and hence the viability of their developments would be significant. It may be necessary for the LBS to obtain funding to deliver strategic SuDS, and for Thames Water or an Inset Appointee to deliver strategic improvements to the potable water supply network, while recognising that there may be cross-charging mechanisms to the plot developer(s). Alternatively, an Inset Appointee could be engaged to construct, operate and maintain new water supply and drainage infrastructure within the site, providing that land may be provided.

10.1.4 Potential for integrated infrastructure delivery

Development of the Opportunity Area 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.

10.1.5 Overall duration of the works

There is recognition that the delivery of the planned growth within the Opportunity Area could take place over many 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 is more suited to Thames Water, the LBS or an Inset Appointee, as these parties may assess the long term impact that initial solutions will ultimately have upon the wider network. These parties are also more likely to be able to implement strategic solutions 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.

10.1.6 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 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 will benefit of the wider development and require a significant degree of control over the final outcome, then it’s more likely that this will be best managed by Thames Water, LBS or Inset Appointee.

10.1.7 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 deregulation is that there will be potential 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 by Multi Utility Services Companies (MUSCOs), which incorporate water supply networks that are installed and operated by the MUSCO. One example is King Cross, where a MUSCO procured bulk water and wastewater connections to the Thames Water potable water and sewer networks, respectively, before constructing, operating and maintaining potable water networks and wastewater networks under OFWAT licences.

10.2 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 potential water recycling solutions, whilst recognising that some solutions will be applicable across more than one of these options.

10.2.1 Foul Water

Delivery of planned growth within the Opportunity Area will generally involve increasing development density and the water balance calculations indicate that foul flows will substantially increase. It will therefore be necessary to install new foul sewers as part of the process of separating out surface water and foul water drainage within the largely combined 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.

10.2.1.1 New Foul Sewers

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

- New foul sewers that extend through land controlled by the developer or LBS 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.

10.2.1.2 Network Reinforcements

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.

10.2.2 Surface Water

A cascading system of SuDS is the preferred strategy approach across the Opportunity Area, to allow the peak discharge from rainfall events with a return period of 1 in 100 years (plus climate change) to be restricted to greenfield rates, whilst also ensuring that urban pollutants are removed. Notwithstanding the potential for offset policies to be adopted, the following section defines the design standards, procurement options and adopting authority for each component of the SuDS treatment train.

10.2.2.1 Source Control Features within Development Plots

The preferred option scenario is for a range of SuDS 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. The MCA process has highlighted green roofs, permeable surfacing, and bio-retention systems as the preferential options with below ground attenuation measures being used as part of the provision of residual attenuation requirements.

SuDS systems that are installed on plot should generally be designed and installed by individual developers, in line with the London Plan, Local Plan and AAP policy and guidance given by the LLFA. 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.

10.2.2.2 Site Control Features within areas of Public Open Space

The IWMS has highlighted the potential for site control features in open spaces to provide secondary attenuation and contaminant removal (in addition to, or in place of residual attenuation being provided in plot based underground storage). 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, from several plots at a time, to be restricted to permissible rates

Site control features should be designed in accordance with the requirements of the LLFA with clear ongoing management and maintenance plans. 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. Site Control features should ideally be situated within areas of public open space and maintained either by LBS, Thames Water or an Inset Appointee using funding obtained from the CIL or the offset policy. Further detail on the offset policy is referenced in section 9.

10.2.2.3 Surface Water Sewers

Infiltration is the preferred method for discharge owing to the favourable geology across much of the Opportunity Area. However, where a review of hydrogeological conditions or a risk assessment identifies that infiltration is not feasible, new surface water sewers that directly connect to public surface water sewers will be required. These 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 should be designed in accordance with the requirements of the LLFA to allow them to be adopted.

10.2.2.4 Highway Drainage

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. SuDS that are retrofitted to existing streets to enable surface water to be managed more effectively should also be designed and adopted in this manner.

10.2.3 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 blocks 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.

10.2.4 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 localised water recycling measures, with greywater recycling identified as the preferred measure. The following section defines the procurement options and adopting authority for each element of the water supply network.

10.2.4.1 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 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. 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 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 LBS, 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.

10.2.4.2 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/or 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.

10.2.4.3 Water Recycling

Localised greywater recycling (potentially mixed with rainwater harvesting) has been identified as potential methods of reducing potable water demand. 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 Opportunity Area 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 greywater recycling or rainwater harvesting 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. On plot rainwater harvesting and greywater recycling systems are being deployed more frequently within developments in order to enable developers to comply with the requirements of planning policy and BREEAM. Examples of developments in London that include on plot water recycling systems are presented below:-
  - The Kings Cross development, which accommodates 2,000 new homes, incorporates four unique water recycling systems, including standalone rainwater harvesting systems, standalone greywater recycling systems and combined systems that provide a total treatment capacity of 24m^3 per day.
  - The Holland Green development incorporates a greywater recycling system that provides a total treatment capacity of 10,000 litres per day to serve three new apartment buildings incorporating 62 flats, which are grouped around a Design Museum;
  - The Three Quays development incorporates a greywater recycling system that provides a total treatment capacity of 8 cubic metres per day to serve 159 apartments situated within a high end residential block situated next to the Tower of London.
- 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 for non-potable water supplies with OFWAT and there is therefore potential for area wide solutions to be considered by Thames Water.

11. Conclusions and Recommendations

11.1 Preferred option scenario

Through the assessment of constraints and development of an Opportunity Area wide water balance, a range of feasible water management measures have been identified and tested against their ability to meet the core water management objectives set for the IWMS, which are summarised as:

- Minimise the volume and rate of water discharging to the combined sewer;
- Minimise the demand for additional potable supplies; and
- Achieve the above objectives in a way that maximises wider sustainability benefits.

Each potential water management measure has been subject to an MCA process to establish the most effective means of combining measures to achieve these aims. Measures have been combined to develop a preferred option scenario for delivery across the Opportunity Area. The option scenario development included water management measures across three main water management categories: delivering water efficiency, managing surface water runoff, and providing alternative water supplies.

The MCA process concluded that the potential for Opportunity Area wide measures to achieve greenfield runoff rates and reduce potable demand are limited by a combination of:

- The fragmented nature of core areas of regeneration making connectivity between development areas for drainage and supply networks significantly challenging;
- Complex surface water drainage pathways, limited by topography and existing infrastructure resulting in the need for pumped solutions in order to connect all areas of redevelopment and regeneration for drainage and water supply;
- No strategic opportunities for connecting to existing surface water bodies, resulting in reliance on infiltration and/or discharge to sewer via attenuation; and
- High cost (capital and operational) for area wide schemes such as groundwater recharge or area wide wastewater (or storm) water recycling schemes due to the limited space available for treatment and the level of treatment required to make these feasible.

The preferred option scenario therefore focuses on localised measures delivered on a plot by plot scale, and where feasible, maximising the opportunity for shared or communal infrastructure within areas of core regeneration throughout the Opportunity Area. The following summary of measures forms the preferred option scenario strategy for the Old Kent Road Opportunity Area and it is recommended that this hierarchy of water management measures is used as the preferred strategy by developers for each area of regeneration/development:

- Water efficiency measures maximised in new build and retrofitted to existing property alongside accelerated implementation of Thames Water’s progressive metering programme and incentive programmes for retrofitting;
- Maximisation of source control based Sustainable Drainage Systems on a plot by plot basis, focusing on green roofs, localised bio-retention and permeable surfaces;
- Installation of Sustainable Drainage Systems, for conveyance of surface water runoff and above ground attenuation features for areas of public realm and streetscape. Seek to provide communal above ground features within areas of planned open space within the public realm and develop an offset approach to delivering these;
- Provide underground storage in addition to communal features to ensure residual runoff is limited to greenfield rates;
- Maximise infiltration to ground from the above features where a hydrogeological and contamination risk assessment demonstrates this is feasible; and

- Implement localised greywater recycling, supplemented by rainwater harvesting where possible to supply a source of water for non-potable uses.

11.2 Strategy Testing

The feasibility of delivery of the preferred option scenario was tested at both the Cantium and Ruby Triangle Case Study core areas of regeneration. This testing largely focused on the core water management objective of achieving greenfield runoff rate but considered how the objective of maximising sustainability could be best achieved. Conceptual design of potential measures was developed based on indicative proposed layout plans for the two Case Study areas to demonstrate how the proposed measures within the preferred option scenario could be delivered.

The testing process provided costed conceptual designs to deliver measures solely on plot and by providing shared communal infrastructure; the aim of approaching the testing in two ways was to inform the need for the development of a potential offset policy whereby developers within the Case Study are allowed to mitigate for any unmet drainage requirements they cannot achieve on plot through a dedicated communal SuDS system such as those outlined in the IWMS.

This process demonstrated that the measures within the preferred option scenario can be feasibly and practically delivered for the tested areas both solely on plot, and through a combination of on plot source control with residual attenuation provided via on plot SuDS and 30% through communal above ground SuDS. Based on the Case Study areas tested, this demonstrates the need for an offset policy may not necessarily be supported in order to meet the preferred option scenario delivery.

However, the process identified a significant cost differential when providing 30% of the required attenuation via communal above ground SuDS systems compared with providing 100% of the attenuation required to meet greenfield runoff rates on plot. Based on high level conceptual design, this has been estimated at between £90m^3 for Cantium and £160m^3 for Ruby Triangle. In addition to the cost saving, the provision of communal above ground SuDS would ensure that measures to maximise sustainability are preferentially selected and hence deliver the additional IWMS water management objective.

11.3 Potential for Offsetting

The potential for developing an offset policy and associated cost has been considered in the IWMS. Whilst the need for an offset policy to achieve the strategy aims may not be fully supported in every case, it is recommended that an offset strategy should be developed to:

- Provide flexibility to developers in meeting their policy requirements to be set through the AAP, particularly those with spatially constrained plots which differ in comparison to the high level spatial assumptions which had to be applied for the Case Study testing;
- Provide developers with a means to meet their policy requirements but at a potentially lower cost; and
- Ensure delivery of more sustainable above ground SuDS features as opposed to focusing more of the attenuation in underground SuDS systems which would be needed to attain runoff rate targets on plot.

11.3.1 Developing an offset approach

Offset policies for the OKR Opportunity Area could be developed at either the Opportunity Area scale or the Case Study area scale. Each would have different approaches to delivery and a different offset cost.

An Opportunity Area wide approach would require a policy to relate to any new development over a specified scale e.g. 10 homes or more, and would require developers who cannot meet greenfield run-off rates on plot to mitigate for an unmet attenuation equivalent to be delivered elsewhere. This commitment could be met either by the developer directly funding approved or verified measures and secured through planning conditions, or as the requirement is necessary, directly related to the development and reasonable, it could be secured through a section 106 payment to LBS for them to identify and deliver suitable measures on the developers behalf.

An alternative approach would be for LBS to identify a suite of suitable projects that could deliver improved capacity in the drainage catchment. Funding from developers would contribute to the programme of implementation. The rate of funding would be set at the average cost/m^3 for delivering the suite of measures and charged relative to the required unmet attenuation from each development. The GLA has recently undertaken a pan-London assessment of the feasibility and cost of retrofitting SuDS measures and estimated a rate per m^3 of just under £600 which could be used as a guide for an Opportunity Area wide offset cost.

Offset policies for specific Case Study areas are likely to focus on allowing developers within the Case Study to mitigate for any unmet drainage requirements through a dedicated communal SuDS system such as those outlined in the IWMS for the Cantium and Ruby Triangle Case Study areas. As the opportunities to deliver communal schemes are dependent on the configuration of each of the Case Study areas, the potential attenuation volume and associated costs will be specific to each of the core areas of regeneration throughout the Opportunity Area. Furthermore, to meet the three statutory tests of planning obligations[12], the offset cost must be related to the specific infrastructure solution required to enable development. The analysis undertaken for the two example Case Study areas (Cantium and Ruby Triangle) indicates that the unit cost per m^3 of attenuation provided by the communal SuDS designed at a conceptual level is between £190/m^3 (Ruby Triangle) and £460/m^3 (Cantium) excluding management costs and this could be used as a starting range for other core areas of regeneration within the Opportunity Area.

The IWMS recommends that an Opportunity Area approach is pursied for the offset mechanism, and an additional study be undertaken to identify the scope of potential SuDS measures across the Opportunity Area to derive an average cost/m^3 to be charged relative to the required unmet attenuation from each development. In addition to an offset approach, strategic solutions within each of the Case Studies are likely to provide cost savings for developers in meeting greenfield runoff rates compared to providing all the required attenuation solely on plot and this would allow a greater range of additional benefits (biodiversity, water quality and sustainability) to be realised. These options should be explored by developers and facilitated by LBS where masterplans involve more than one developer for larger areas of regeneration.

11.3.2 Strategy Delivery Recommendations

In terms of infrastructure providers, the delivery strategy has identified a range of means by which the required infrastructure will need to be delivered and operated. There will be a significant requirement on developers to provide on-plot solutions, with support from either Thames Water or an Inset Appointee in delivering strategic network improvements and upgrades. There is also the potential for LBS, Thames Water or an Inset Appointee to provide capital funding and management schemes for communal SuDS or non-potable measures within each of the core areas of regeneration within the Opportunity Area. In parallel with the further development of the offset policy, it is recommended that LBS, Thames Water, potential Inset Appointees and the Environment Agency form a IWMS working group to determine the optimal approach to providing and maintaining the required infrastructure.

[12] Three statutory tests for planning obligations are 'necessary to make the development acceptable in planning terms, directly related to the development and fairly and reasonably related in scale and kind to the development'

Appendix A Legislation, policy and guidance influencing the IWMS

The growth within the Opportunity Area 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
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 IWMS 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.
Flood Risk Regulations	The Flood Risk Regulations implement the requirements of the European Floods Directive (PDF, 73KB) which aims to provide a consistent approach to managing flood risk across Europe. The approach is based on a 6 year cycle of planning which includes the publication and update of: • Preliminary Flood Risk Assessments (PFRAs); • Hazard and risk maps; and • Flood risk management plans.
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.
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.
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 Southwark) 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' .
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.

Directive / Legislation / Guidance	Description
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[13], 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[14]. The two key aspects of the WFD relevant to the wastewater assessment in this WCS are the policy requirements that: • development must not cause a deterioration in status of a waterbody[15]; 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.
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.

Local Policy

Southwark Plan 2007

Saved Policy 3.9:

All developments should incorporate measures, to:

- Reduce the demand for water; and
- Recycle grey water and rainwater.

In addition, all new developments must use preventative measures to ensure that they do not lead to a reduction in water quality. New developments should not result in an increase in surface run-off, which could result in increased flood risk and pollution. The LPA will require Major Developments to incorporate sustainable methods of drainage, unless it can be demonstrated that this is not practical.

Southwark Core Strategy 2011

Strategic Policy 13 - High Environmental Standards:

[13] 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.
[14] UK Environmental Standards and Conditions (Phase I) Final Report, April 2008, UK Technical Advisory Group on the Water Framework Directive.
[15] 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

- Part 7: Requiring developments to minimise water use and use local sources of water where possible;

- Part 8 Setting high standards and supporting measures for reducing water pollution. This includes making sure developments are designed to cope with climate conditions as they change during the development's lifetime;

- Part 9: Allowing development to occur in the protected Thames flood zone as long as it is designed to be safe and resilient to flooding and meets the Exceptions Test;

- Part 10: Requiring developments to help reduce flood risk by reducing water run-off, using sustainable urban drainage systems and avoiding the paving over of gardens and creation of hard standing areas.

- Targets:

    - BREEAM[16]: Community facilities, including schools, should achieve at least "very good"; New health facilities must be "excellent" and any refurbishment should achieve "very good"; all other non-residential development should achieve at least "excellent".

    - Major development must reduce surface water run-off by more than 50%;

    - Major housing developments must achieve a potable water use target of 105 litres per person per day.

Emerging Policy (Draft New Southwark Plan)

- DM52 - Open Space and Open water:

    - New publically accessible open space, green links and green infrastructure must be provided in major development. Such spaces should be designed to provide multiple benefits (e.g. habitat creation, Sustainable Urban Drainage Systems);

- DM53: Biodiversity:

    - Planning permission will be granted for development that:

        - Includes features that enhance biodiversity in development, such as green and brown roofs and habitat restoration and expansion.

- DM55 – High Environmental Standards:

    - Planning permission will be granted for development that:

        - Achieves a BREEAM rating of 'Excellent' for major non-residential and non-self-contained residential development.

- DM62 – Reducing Water Use and Improving Water Quality:

    - Planning permission will be granted for residential development that has a 'safe to drink' water use of no more than 105 litres per person per day, excluding an allowance of 5 litres or less per person per day for external water use; and

    - All new development must incorporate measures to:

        - Reduce the demand for mains water treated to drinking standard; and

        - Enable the use of grey water and/or rainwater for non-drinking uses.

- DM63 – Reducing Flood Risk:

16 BREEAM requirements include water use targets

  - Planning permission will only be granted for development that is designed to be safe and resilient to flooding where located within an area of flood risk and meets the Exceptions test where located within Flood Zones 2 or 3.

  - Planning permission will be granted for major development that reduces surface water run-off by more than 50% relative to the existing run-off from the site, through the application of water sensitive urban design and Sustainable Urban Drainage Systems (SUDS).

- DM64 – Infrastructure:

  - Developments should consider the requirements and impacts on water and wastewater infrastructure and work with Thames Water to determine water supply and wastewater infrastructure capacity and any upgrade requirements. Development will be required to deliver supporting infrastructure at an early stage of development to ensure the impacts of development are effectively mitigated.

Draft Old Kent Road Area Action Plan 2016

AAP 23: Flood risk and sustainable urban drainage systems

- Applications for major developments creating new floor space should demonstrate that SuDS have been incorporated and meet the following design standards: •

  - *Quantity:* schemes should be designed to reduce flows to a 'greenfield rate' of run-off (5 litres/ second/ hectare), where feasible. Where it is demonstrated that a greenfield run-off rate is not feasible, runoff rates should be minimised as far as possible.

  - *Quality:* the design should follow the SUDS 'management train', maximising source control and seeking to provide the relevant number of 'treatment stages'.

  - *Amenity and biodiversity* - the design should maximise amenity and biodiversity benefits, while ensuring flow and volumes of run-off entering open space are predictable and water at the surface is clean and safe. Schemes should maximise areas of landscaping and/or other permeable surfaces to support this.

- Applications for major developments creating new floor space should also evaluate the feasibility of providing greywater reuse systems to supply non-potable water demand.

- Developers will be expected to demonstrate a collaborative approach to working with Southwark Council and surrounding developers to design, implement and manage offsite surface water and greywater management measures that address surface and waste-water disposal capacity issues.

Appendix B Water Balance Methodology and Assumptions

Baseline Site Conditions

Limited information has been sourced on the current site conditions for the Opportunity 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 included daily demands for each District Metered Areas (DMAs) within the OKR OA.

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 largely based on forecast growth data, as provided by Southwark Council, including:

- Housing and employment population projections.
- Development layout and form.
- Designated areas of open space.
- Phasing assumptions.

The anticipated development within the Opportunity Area has been focused within spatially defined site allocations and considered across four, five year phases from 2016 up to 2036, in line with the London Plan. Further detail of the growth assumptions are fully detailed in the IWMS report. Across each known site allocation, assumptions have been made about the development layout and land cover, which are summarised below:

- Within development plots, external areas have been assumed to be 50% permeable and 50% impermeable.
- Residual area within allocated development area, but outside the plot boundary (comprising highway and surrounding public realm), an assumption of 20% permeability has been made.
- Allocated areas of green space have been assumed at 100% permeable.

Post Development Conditions

The post development site conditions have assumed net growth in 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 roof water 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 B-1 and B-2 below.

Table B-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 B-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 B-3 and B-4 below.

Table B-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 B-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 the Opportunity Area 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 C Groundwater Injection Technical Note

Appendix D Delivery Testing Technical Note

Appendix E Multi-Criteria Analysis

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Criteria		Water Efficient Devices	Green Roofs	Permeable Paving	Bioretention	Underground Attenuation	Strategic SuDS Networks	Downstream Attenuation	Stormwater harvesting	Wastewater recycling	Greywater recycling	Roof water recycling	Groundwater Injection
Core Objectives	*Potential Reduction in Demand and Discharge OR Potential Attenuation for Storm Flow Reduction*	✓✓	✓✓	✓✓✓	✓✓	✓✓✓	✓	✓✓✓	✓✓	✓✓	✓✓	✓	✓✓
Deliverability	*Capital Cost*	✓✓	✓✓	✓✓✓	✓✓✓	✓✓✓	✓	✓✓			✓		
	Operational and maintenance requirements	✓✓✓	✓✓	✓✓	✓✓	✓✓	✓✓	✓✓			✓	✓	
	Space Requirements	✓✓✓	✓✓✓	✓✓✓	✓	✓✓✓	✓	✓		✓✓	✓✓✓	✓✓	
	Flexibility and scalability	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓	✓	✓✓			✓✓✓	✓✓✓	
	Regulatory and Acceptability Challenges	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓	✓✓✓	✓		✓	✓	
Sustainability	*Carbon Intensity*	✓✓✓	✓✓✓	✓✓	✓✓✓	✓✓	✓✓✓	✓✓✓			✓	✓✓	
	Blue-green space provided	✓✓✓	✓✓✓		✓✓✓		✓✓✓	✓✓✓	✓✓✓				✓✓✓
	Climate Resilience	✓✓✓	✓✓✓	✓✓	✓✓	✓✓	✓✓	✓✓	✓✓	✓✓✓	✓✓✓	✓✓	✓✓
	Surface water quality	✓✓	✓✓✓	✓✓	✓✓✓	✓✓	✓✓✓	✓✓✓	✓✓✓✓	✓✓	✓✓	✓✓	✓✓✓
Measure Ranking		80%	77%	76%	72%	76%	54%	83%	50%	44%	54%	35%	48%

KEY

✓✓✓	High benefit
✓✓	Medium benefit
✓	Low benefit
	No benefit

Appendix F Conceptual Design Drawings

Appendix G Constraint Maps

Appendix H Cost Breakdown

Ruby Triangle – Estimated Capital Costs

Item	Qty	Unit	Rate	Total	15% Main Contractor's Preliminaries	10% Professional fees	15% Contingency / Risk	Sub-Total	Total	Rounded Cost
Streetscape drainage										
Oversized pipe drainage									£1,222,717.38	£1,220,000
Pipe size d=225mm	1,185	m	180.00	£213,300.0	£31,995.00	£24,529.5	£40,473.68	£310,298.2		
Pipe size d=450mm	393	m	320.00	£125,760.0	£18,864.00	£14,462.4	£23,862.96	£182,949.4		
Pipe size d=525mm	211	m	370.00	£78,070.0	£11,710.50	£8,978.1	£14,813.78	£113,572.3		
Pipe size d=600mm	369	m	430.00	£158,670.0	£23,800.50	£18,247.1	£30,107.63	£230,825.2		
- Chamber										
Chamber for pipe size d=225mm		nr	1,040.00	£0.0	£0.00	£0.0	£0.00	£0.0		
Chamber for pipe size d=450mm	6	nr	1,550.00	£9,300.0	£1,395.00	£1,069.5	£1,764.68	£13,529.2		
Chamber for pipe size d=525mm	11	nr	1,700.00	£18,700.0	£2,805.00	£2,150.5	£3,548.33	£27,203.8		
Chamber for pipe size d=600mm	12	nr	1,850.00	£22,200.0	£3,330.00	£2,553.0	£4,212.45	£32,295.5		
- Gully	310	nr	450.00	£139,500.0	£20,925.00	£16,042.5	£26,470.13	£202,937.6		
- Outfall	5	nr	15,000.00	£75,000.0	£11,250.00	£8,625.0	£14,231.25	£109,106.3		
Planters									£139,656.00	£140,000
- Planters, dimension 1m*1m*1m	192	nr	500.00	£96,000.0	£14,400.00	£11,040.0	£18,216.00	£139,656.0		
Tanked pavements									£724,191.74	£720,000
Required Area 1, 1,720 units	1,882	m	100.00	£188,183.8	£28,227.57	£21,641.1	£35,707.88	£273,760.4		
Required Area 2, 1,200 units	1,313	m	100.00	£131,291.0	£19,693.65	£15,098.5	£24,912.47	£190,995.6		
Required Area 3, 1,030 units	1,127	m	100.00	£112,691.5	£16,903.72	£12,959.5	£21,383.21	£163,937.9		
Required Area 4, 600 units	656	m	100.00	£65,645.5	£9,846.83	£7,549.2	£12,456.24	£95,497.8		
Green Roofs									£2,028,379.75	£2,030,000
- Green Roofs	21,451	m2	65.00	£1,394,315.0	£209,147.25	£160,346.2	£264,571.27	£2,028,379.7		
On-Plot attenuation									£2,796,676.86	£2,800,000
- Excavate and Create Attenuation	7,539	m3	190.00	£1,432,410.0	£214,861.50	£164,727.2	£271,799.80	£2,083,798.4		
- Pipework and Pumping	7,539	m3	65.00	£490,035.0	£73,505.25	£56,354.0	£92,984.14	£712,878.4		
On-Plot Source Control									£585,362.31	£590,000
- Permeable paving	7,316	m2	55.00	£402,380.0	£60,357.00	£46,273.7	£76,351.61	£585,362.3		
Communal Area Retention / Pond / Swale									£1,039,782.56	£1,040,000
- Excavate & Create Pond	2,819	m3	250.00	£704,750.0	£105,712.50	£81,046.3	£133,726.31	£1,025,235.1		
- Inlet & Outlet	1	item	10,000.00	£10,000.0	£1,500.00	£1,150.0	£1,897.50	£14,547.5		

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Cantium – Estimated Capital Costs

Item	Qty	Unit	Rate	Total	15% Main Contractor's Preliminaries	10% Professional fees	15% Contingency / Risk	Sub-Total	Total	Rounded Cost
Streetscape drainage										
Oversized pipe drainage									£682,655.99	£680,000
Pipe size d=225mm	514	m	180.00	£92,520.0	£13,878.00	£10,639.8	£17,555.67	£134,593.5		
Pipe size d=450mm	287	m	320.00	£91,840.0	£13,776.00	£10,561.6	£17,426.64	£133,604.2		
Pipe size d=525mm	490	m	370.00	£181,300.0	£27,195.00	£20,849.5	£34,401.68	£263,746.2		
- Chamber										
Chamber for pipe size d=225mm		nr	1,040.00	£0.0	£0.00	£0.0	£0.00	£0.0		
Chamber for pipe size d=450mm	8	nr	1,550.00	£12,400.0	£1,860.00	£1,426.0	£2,352.90	£18,038.9		
Chamber for pipe size d=525mm	6	nr	1,700.00	£10,200.0	£1,530.00	£1,173.0	£1,935.45	£14,838.5		
- Gully	80	nr	450.00	£36,000.0	£5,400.00	£4,140.0	£6,831.00	£52,371.0		
- Outfall	3	nr	15,000.00	£45,000.0	£6,750.00	£5,175.0	£8,538.75	£65,463.8		
Planters									£94,558.75	£90,000
- Planters, dimension 1m*1m*1m	130	nr	500.00	£65,000.0	£9,750.00	£7,475.0	£12,333.75	£94,558.8		
Tanked pavements									£381,991.25	£380,000
Required Area 1, 430 units	470	m	100.00	£47,046.0	£7,056.89	£5,410.3	£8,926.97	£68,440.1		
Required Area 2, 1,030 units	1,127	m	100.00	£112,691.5	£16,903.72	£12,959.5	£21,383.21	£163,937.9		
Required Area 3, 940 units	1,028	m	100.00	£102,844.6	£15,426.70	£11,827.1	£19,514.77	£149,613.2		
Green Roofs									£1,603,338.17	£1,600,000
- Green Roofs	16,956	m2	65.00	£1,102,140.0	£165,321.00	£126,746.1	£209,131.07	£1,603,338.2		
On-Plot attenuation									£2,055,125.33	£2,060,000
- Excavate and Create Attenuation	5,540	m3	190.00	£1,052,600.0	£157,890.00	£121,049.0	£199,730.85	£1,531,269.9		
- Pipework and Pumping	5,540	m3	65.00	£360,100.0	£54,015.00	£41,411.5	£68,328.98	£523,855.5		
On-Plot Source Control									£589,602.90	£590,000
- Permeable paving	7,369	m2	55.00	£405,295.0	£60,794.25	£46,608.9	£76,904.73	£589,602.9		
Communal Area Retention / Pond / Swale									£323,318.19	£320,000
- Excavate & Create Pond	429	m3	250.00	£107,250.0	£16,087.50	£12,333.8	£20,350.69	£156,021.9		
- Inlet & Outlet	1	item	2,500.00	£2,500.0	£375.00	£287.5	£474.38	£3,636.9		
- Linear Park - Swale feature	450	m	250.00	£112,500.0	£16,875.00	£12,937.5	£21,346.88	£163,659.4		

Ruby Triangle and Cantium – Estimated Operational Costs

Location	Reference	Category of OPEX	UoM	Value	Cost	Source	Year of Cost	Total OPEX per annum (current prices)
Ruby Triangle	Communal Space 1	Ponds	m^2	364	£ 2.07	HR Wallingford	2004	£ 752.77
Ruby Triangle	Communal Space 2	Ponds	m^2	139	£ 2.07	HR Wallingford	2004	£ 287.46
Ruby Triangle	Communal Space 3	Ponds	m^2	272	£ 2.07	HR Wallingford	2004	£ 562.51
Ruby Triangle	Communal Space 4	Ponds	m^2	1924	£ 2.07	HR Wallingford	2004	£ 3,978.93
Ruby Triangle	Communal Space 5	Ponds	m^2	302	£ 2.07	HR Wallingford	2004	£ 624.55
Cantium	Communal Space	Ponds	m^2	461	£ 2.07	HR Wallingford	2004	£ 953.37
Cantium	Linear Park	Swale	m^2	540	£ 2.07	HR Wallingford	2004	£ 1,116.75
Cantium	Linear Park	Multi-functional area	m^2	1260	£ 2.98	BCIS Building Maintenance Prices	2017	£ 3,754.80
Ruby Triangle	Streetscape	Inlet pipe and NRV	nr	1	£ 1,776.00	AECOM estimate	N/A	£ 1,776.00
Ruby Triangle	Streetscape	Outlet pipe and flow control	nr	1	£ 1,776.00	AECOM estimate	N/A	£ 1,776.00
Ruby Triangle	Streetscape	Planters (1m3)	nr	192	£ 4.15	BCIS Building Maintenance Prices	2017	£ 796.80
Ruby Triangle	Streetscape	Permeable Paving	m3	872	£ 1.38	HR Wallingford	2004	£ 1,202.23
Cantium	Streetscape	Planters (1m3)	nr	130	£ 4.15	BCIS Building Maintenance Prices	2017	£ 539.50
Cantium	Streetscape	Permeable Paving	m^3	460	£ 1.38	HR Wallingford	2004	£ 634.20
Ruby Triangle	On Plot	Green Roof	m^2	21451	£ 1.50	BCIS Occupancy Cost Plan	2014	£ 32,125.70
Ruby Triangle	On Plot	Permeable Paving	m^3	458	£ 1.38	HR Wallingford	2004	£ 631.44
Ruby Triangle	On Plot	Attenuation Tanks	m^3	7359	£ 1.25	AECOM estimate	N/A	£ 9,198.75
Ruby Triangle	On Plot	Plot Gullies	nr	108	£ 15.00	AECOM estimate	N/A	£ 1,620.00
Ruby Triangle	On Plot	Plot Manholes	nr	27	£ 15.00	AECOM estimate	N/A	£ 405.00
Ruby Triangle	On Plot	Plot Inspection Chambers	nr	54	£ 15.00	AECOM estimate	N/A	£ 810.00

Appendix I Site Assessments

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