Annex A1: Beckton Water Recycling Conceptual Design Report

Standard Gate two submission for London Water Recycling SRO

Notice – Position Statement

This document has been produced as the part of the process set out by RAPID for the development of the Strategic Resource Options (SROs). This is a regulatory gated process allowing there to be control and appropriate scrutiny on the activities that are undertaken by the water companies to investigate and develop efficient solutions on behalf of customers to meet future drought resilience challenges.

This report forms part of suite of documents that make up the 'Gate 2 submission.' That submission details all the work undertaken by Thames Water in the ongoing development of the proposed SRO. The intention at this stage is to provide RAPID with an update on the concept design, feasibility, cost estimates and programme for the schemes, allowing decisions to be made on their progress.

Should a scheme be selected and confirmed in the Thames Water final Water Resources Management Plan (WRMP), in most cases it would need to enter a separate process to gain permission to build and run the final solution. That could be through either the Town and Country Planning Act 1990 or the Planning Act 2008 development consent order process. Both options require the designs to be fully appraised and, in most cases, an environmental statement to be produced. Where required that statement sets out the likely environmental impacts and what mitigation is required.

Community and stakeholder engagement is crucial to the development of the SROs. Some high-level activity has been undertaken to date. Much more detailed community engagement and formal consultation is required on all the schemes at the appropriate point. Before applying for permission Thames Water will need to demonstrate that they have presented information about the proposals to the community, gathered feedback and considered the views of stakeholders. We will have regard to that feedback and, where possible, make changes to the designs as a result.

The SROs are at a very early stage of development, despite some options having been considered for several years. The details set out in the Gate 2 documents are still at a formative stage.

Disclaimer

This document has been written in line with the requirements of the RAPID Gate 2 Guidance and to comply with the regulatory process pursuant to Thames Water's statutory duties. The information presented relates to material or data which is still in the course of completion. Should the solutions presented in this document be taken forward, Thames Water will be subject to the statutory duties pursuant to the necessary consenting process, including environmental assessment and consultation as required. This document should be read with those duties in mind.

Annex A1: Beckton Water Recycling Scheme Conceptual Design Report

Document no: J698-LR-DOC-240001-0D

Thames Water Utilities Ltd
J698

London Water Recycling
13 October 2022

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Client name:	Thames Water Utilities Ltd		
Project name:	London Water Recycling		
Client reference:	J698	Project no:	B22849AP
Document no:	J698-LR-DOC-240001-0D		
Date:	13 October 2022		

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Executive Summary

This report sets out the conceptual design for the Beckton Water Recycling scheme. This scheme was identified in the Water Resources Management Plan 2019 (WRMP19) Water Reuse Feasibility Study and WRMP19 Fine Screening process by Thames Water Utilities Limited (TWUL) and identified as a part of the London Effluent Reuse Strategic Resource Option (SRO) by the Regulators' Alliance for Progressing Infrastructure Development (RAPID).

As a part of London Effluent Reuse SRO, Beckton Water Recycling scheme was submitted for the standard Gate 1 assessment by RAPID, and it was agreed to be continued to be funded to Gate 2 as part of the standard gate track.

The SRO Gated process by RAPID, working alongside the regional planning stakeholder groups, will provide regulatory oversight of a set of regional water resource management plans that will adopt consistent assumptions to form a nationally coherent view.

Design elements in this report are listed below:

- 50Ml/d Advanced Water Recycling Plant in Beckton STW (WRSE Ref. TWU_KGV_HI-REU_reuse beckton 50)
- 100Ml/d Advanced Water Recycling Plant in Beckton STW (WRSE Ref. TWU_KGV_HI-REU_reuse beckton 100)
- 150Ml/d Advanced Water Recycling Plant in Beckton STW (WRSE Ref. TWU_KGV_HI-REU_reuse beckton 150)
- Beckton ARWP to Lockwood Reservoir Pumping Station Recycled Water Transfer Tunnel (WRSE Ref. TWU_KGV_HI-TFR_beckton to lockwood)
- Lockwood Reservoir Pumping Station to King George V Reservoir (KGV) Recycled Water Transfer Tunnel (WRSE Ref. TWU_KGV_HI-TFR_lockwood ps-kgv res)

Table S-1: Scheme Summary

Name	Beckton Water Recycling
Gate-2/ WRSE Reference	TWU_KGV_HI-REU_reuse beckton 50, TWU_KGV_HI-REU_reuse beckton 100, TWU_KGV_HI-REU_reuse beckton 150, TWU_KGV_HI-TFR_lockwood ps-kgv res, TWU_KGV_HI-TFR_beckton to lockwood
Scheme Type	Resource and Conveyance
WRZ	London. Potentially the Affinity Water WRZ if Beckton Water Recycling supplies water to Thames to Affinity Transfer (T2AT) SRO.
Engineering Scope	A portion of final effluent from the Beckton STW would be treated at a new Advanced Water Recycling Plant (AWRP) within the Beckton STW boundary to the North of the existing operational area. The Recycled Water would then be conveyed to a proposed discharge location on the River Lee Diversion to the North of the King George V Reservoir (KGV), upstream of the inlet to KGV, to supplement the raw water supply to the Lee Valley reservoirs.
Benefit	46, 89,130 and 252Ml/d Dry Year Annual Average (DYAA) and Dry Year Critical Period (DYCP) Deployable Output (DO) for the capacities of 50Ml/d, 100Ml/d,150Ml/d and 300 Ml/d, respectively
Mutual exclusivities	There are no other options or schemes that are mutually exclusive with the Beckton Water Recycling scheme.
Interdependencies	Beckton Water Recycling scheme does not have dependencies on other options. Beckton Water Recycling scheme is a potential source for one of the options in Thames to Affinity Transfer (T2AT) SRO. Recycled Water Transfer Tunnel from Lockwood Reservoir Pumping Station to KGV could be used by Teddington DRA in the London Effluent Reuse SRO and the Deephams Reuse, and the existing Thames Lee Tunnel (TLT) and the proposed Recycled Water Transfer Tunnel could be connected. To provide an additional resource to London WRZ, the following elements may also be required: ▪ Additional capacity to abstract from River Lee Diversion and Lee Valley Reservoirs and convey to WTWs in East London

Name	Beckton Water Recycling
	▪ Additional treatment capacity at WTWs in East London ▪ Potential network reinforcements

1. Introduction

1.1 Background

Thames Water Utilities Limited (TWUL) are engaged in development of Strategic Regional Water Resource Options (SROs) under the guidance of the Regulators' Alliance for Progressing Infrastructure Development (RAPID). RAPID was formed to help accelerate the development of new water infrastructure and design future regulatory frameworks, with collaboration between Ofwat, the Environment Agency (EA) and the Drinking Water Inspectorate (DWI).

Water resource options were developed for the reuse of Sewage Treatment Works (STW) effluent or blackwater (untreated sewage) reuse and direct river abstractions in London as part of TWUL's Water Resource Management Plan 2019 (WRMP19). London Effluent Reuse has been identified as in the Price Review 2019 (PR19) Final Determination (London Effluent Reuse SRO). At PR19, Ofwat announced a development fund for strategic water resource solutions linked to "Gates" to ensure efficient delivery and to protect customers. TWUL has been allocated funds to investigate and develop integrated strategic regional water resource solutions, including London Effluent Reuse SRO, between 2020 and 2025 to support long term resilience. The London Effluent Reuse SRO solution was submitted for the standard Gate 1 assessment by RAPID in 2021, and it will continue to be funded to Gate 2 as part of the standard Gated process in 2022.

London Effluent Reuse SRO incorporates four schemes: two schemes for reuse of final effluent from Mogden STW (Mogden Water Recycling scheme) and Beckton STW (Beckton Water Recycling scheme), a direct river abstraction scheme (Teddington Direct River Abstraction (DRA) scheme) and a fourth, blackwater or sewer mining treatment option within the Mogden STW catchment (Mogden South Sewer scheme). Abstracted effluent or sewage in these schemes is to be treated in each case through an Advanced Water Recycling Plant (AWRP) or a Tertiary Treatment Plant (TTP) and discharged to the River Thames or the River Lee Diversion for abstraction as a water resource.

This report sets out the conceptual design for the Beckton Water Recycling scheme. The proposal for the Beckton Water Recycling scheme is summarised as:

- A portion of final effluent from the Beckton STW would be treated at a new Advanced Water Recycling Plant (AWRP) within the Beckton STW boundary to the North of the existing operational area.
- The Recycled Water would be then transferred to a proposed discharge location on the River Lee Diversion above the inlet for King George V Reservoir (KGV), to supplement the raw water supply to the Lee Valley Reservoirs.
- Definitions of glossary and abbreviations in this report could be found in section 6 Glossary and Abbreviations.

1.2 Scheme Overview and Location

1.2.1 Scheme Overview and Location

Beckton STW is located on the North side of the tidal reach of the River Thames (Thames Tideway) at Barking (see (1) in Figure 1-1). A new AWRP would be constructed within the Beckton STW boundary to the North of the existing operational area (see (2) in Figure 1-1). This new works would abstract a portion of the final effluent flow from the Beckton STW and treat it for reuse with advanced treatment technologies, at this stage these are proposed to be Reverse Osmosis and Advanced Oxidation, to allow it to be discharged as a source water for drinking water abstraction. Waste flows from the AWRP would be returned to the STW's inlet works for treatment. The Recycled Water would be then conveyed to a proposed discharge location on the River Lee Diversion to the North of the King George V Reservoir (KGV), upstream of the inlet to KGV, to supplement the raw water supply to the Lee Valley reservoirs (see (3) to (6) in Figure 1-1).

The conveyance element from the Beckton STW to the KGV consists of two parts: a tunnel from the Beckton AWRP to Lockwood Reservoir Pumping Station site and a Thames Lee Tunnel (TLT) extension from Lockwood Reservoir Pumping Station site to KGV.

The first part of the conveyance route would go under Coppermills Water Treatment Works (WTW), then convey Recycled Water to the Lockwood Reservoir Pumping Station site.

The second part of the conveyance route would transfer the flow from the Lockwood site to the discharge location on the River Lee Diversion upstream of the KGV inlet. This conveyance leg could potentially be an extension of the existing Thames Lee Tunnel (TLT) which currently conveys raw water abstracted from the River Thames at Hampton Intake to the Lockwood Reservoir Pumping Station. If the TLT and the proposed Recycled Water Transfer Tunnel from Lockwood to KGV are connected, raw water from the River Thames could be transferred to the inlet of KGV for potentially increased resilience in the East London water supply system. Furthermore, Teddington DRA scheme in the London Effluent Reuse SRO would abstract raw water from the River Thames and discharge it into TLT at Teddington. Therefore, the Recycled Water Transfer Tunnel from Lockwood to KGV could be also used for Teddington DRA scheme. In addition, Deephams Reuse, which is currently in Thames Water draft WRMP24, could potentially use the TLT extension in the future to discharge recycled water.

The Beckton Water Recycling scheme will supply the London Water Resource Zone (WRZ) (see (5) and (6) in Figure 1-1). In addition, Thames to Affinity Transfer (T2AT) SRO considers Beckton Water Recycling as one of their potential water source options.

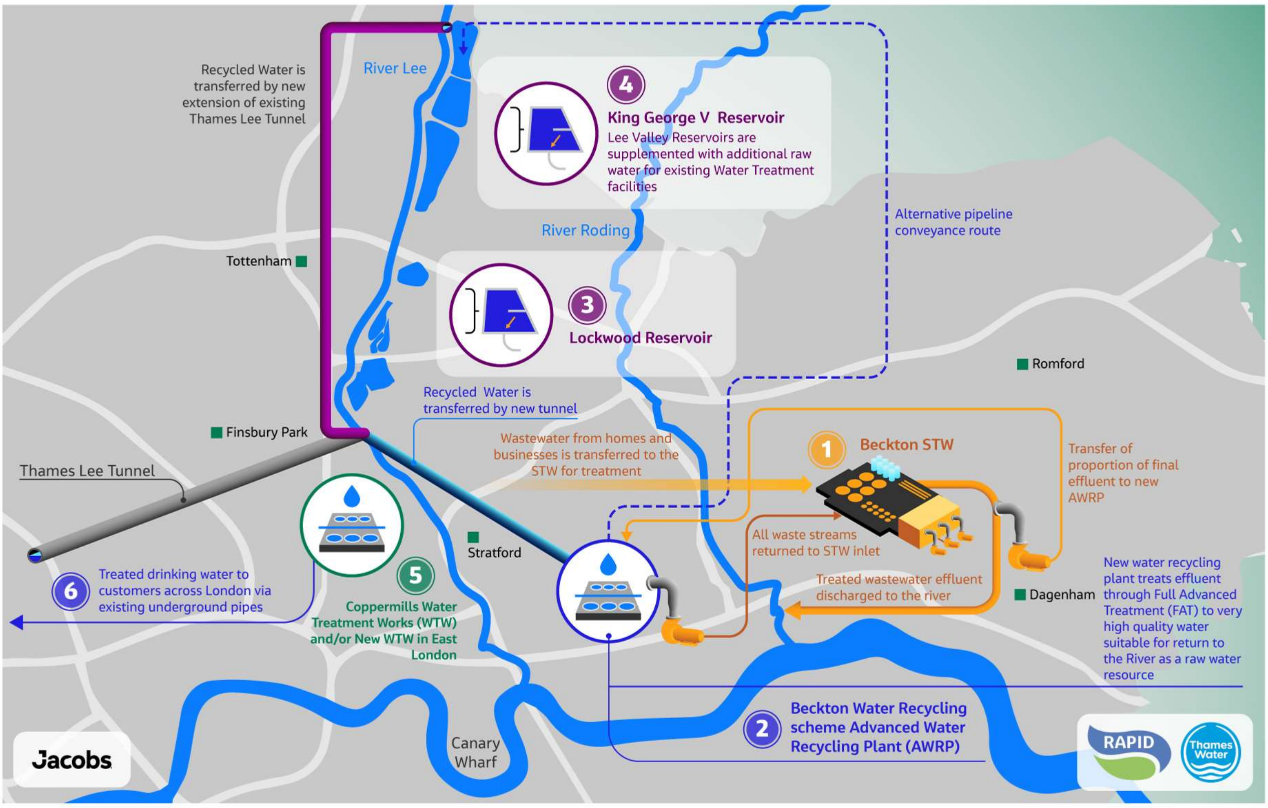

Figure 1-1: Beckton Water Recycling Scheme Overview

1.2.2 Gate 1 Development

In WRMP19, the tunnel route from Beckton AWRP to KGV, going through Lockwood Reservoir Pumping Station site were proposed. However, the route between Beckton AWRP and KGV through Lockwood Reservoir Pumping Station site is highly urbanised, there are limited sites which could allow tunnel shaft construction. Therefore, 3.5m-diameter tunnels was proposed to reduce the number of shafts though a 300Ml/d of flow would not require this size of tunnels.

Conveyance solutions with smaller-diameter pipelines were investigated in Gate 1 to reduce costs. A route on the East side of the KGV and William Girling Reservoirs, without going through Lockwood Reservoir Pumping Station, was proposed for this pipeline alternative. This alternative comprised a combination of 1m-diameter pipe jack sections and trenched sections, and it was sized for 100Ml/d scheme capacity.

The Gate 2 route appraisal for the pipeline alternative showed a number of conflicts between land use and planning policy designation that could not be fully mitigated. Where mitigation did exist this results in increasing scheme cost to the point that the pipeline conveyance AIC cost exceeds the tunnel option. Significant environmental impacts were also identified that could be mitigated but would have resulted in extending construction programmes to avoid key periods and delaying when a scheme could be operational. As a result of this appraisal TWUL wrote to RAPID to formally request the removal of the pipeline sub-option from Gate 2, which RAPD approved in May 2022.

The conveyance route and designs proposed in Gate 1 were further reviewed in conjunction with various aspects such as environmental, planning and engineering for Gate 2. Gate 2 design development includes walk-over surveys, scheme operational philosophy and hydraulic and pumping strategy development and incorporation of planning strategy. This has enabled a greater understanding of the constraints and reduced uncertainty in delivery of the schemes.

The table below list the key design changes from Gate 1 to Gate 2.

Table 1-1: Key Design Changes from Gate 1 to Gate 2

Gate 1 Conceptual Design	Gate 2 Conceptual Design
Two Recycled Water conveyance sub-options were proposed: ▪ 3.5m-diameter tunnels for 300Ml/d conveyance from Beckton AWRP to KGV via Lockwood Pumping Station (on West side of Lee Valley reservoirs) ▪ 100Ml/d pipeline on East side of Lee Valley reservoirs	100Ml/d pipeline sub-option was removed from proposal

1.3 Sizing and Phasing

1.3.1 Sizing and Phasing of Scheme

The results of Gate 2 environmental investigation showed negligible impacts to the River Lee Diversion Channel and middle Thames Tideway from a 300Ml/d sized Beckton scheme. Further assessment of Tideway salinity and potential for in-combination effect of a Mogden Water Recycling scheme and Beckton Water Recycling scheme are underway.

Site appraisal work examined the footprint of multiple AWRPs and the space available within the boundary of the Beckton STW. It was determined that a capacity up to 300Ml/d could be located within the STW boundary but that sizes in-excess of this would need additional land outside the STW boundary.

Therefore, the maximum size of Beckton scheme would remain as 300Ml/d as carried forward from Gate 1.

The total scheme size is selectable from multiple sub-option sizes for AWRP (i.e. 50Ml/d, 100Ml/d and 150Ml/d). For example, an ultimate development of 300Ml/d AWRP could comprise two 150Ml/d sub-options/ phases.

Conveyance assets would not be constructed in phases because it is not expected that phasing of construction of conveyance elements would bring cost or social benefits. The size of the 3.5m-diameter Recycled Water Transfer Tunnel is dictated by the practicable distances between proposed shafts which is governed by Health and Safety considerations during construction. The area is heavily urbanised, and land available for new shaft construction is severely limited which leads to a trade-off between tunnel diameter and shaft spacing.

Table below shows recommendations for the scheme sizes of Beckton Water Recycling scheme and its sub-options.

Table 1-2: Recommendations for Beckton Water Recycling Scheme Size

Scheme Name	Description of Scheme	Constraint	Scheme Sub-Options	
Beckton Water Recycling scheme	Final effluent harvest, reuse, convey recycled water to Lee Valley reservoirs	Maximum capacity of 300Ml/d	Advanced Water Recycling Plant (AWRP) options	50 Ml/d
				100 Ml/d
				150 Ml/d
			Conveyancing	Beckton to Lockwood Tunnel
				Lockwood to KGV Tunnel

1.3.2 Constraints Impacting Solution Sizing and Phasing

The key constraints impacting the solution sizing and phasing are:

- **Availability of land at Beckton STW for development:** The site is very developed with only a parcel of land at the North end of the site available, which has water courses and high-voltage overhead power lines further constraining the extent of development.
- **Availability of land for conveyance or tunnel shafts:** The nature of the urban or sub-urban environment, and designated sites limits open-cut trenching pipeline options and constraints the potential shaft locations. The diameter of Recycled Water Transfer Tunnel is dictated by the practicable distances between proposed shafts rather than flow capacity of the tunnel.
- **Effect on Salinity in the Middle Thames Tideway:** Potential impacts on the Middle Thames Tideway due to reduction of final effluent discharge from Beckton STW into the Tideway limit the maximum scheme size.

1.4 Links with Other Options, Schemes and Elements

1.4.1 Dependencies

Water resource options require several different elements (from source to treated water transmission) to be implemented for the resource option to deliver benefit. Table 1-3 lists system elements that may be required to deliver a full water resource utilisation for this scheme. Water distribution reinforcements required irrespective of the specific scheme selected have not been included.

Table 1-3: Interdependent Elements

Type	Interdependent Elements
Water Sources	N/A
Abstraction and Conveyance	▪ Additional capacity to abstract from River Lee Diversion and Lee Valley Reservoirs and convey to WTWs in East London.
Water Treatment Works	▪ Additional treatment capacity at WTWs in East London.
Drinking Water Network Reinforcement	▪ Potable network reinforcements
Others	▪ Beckton Water Recycling scheme is identified as one of the potential water source options for T2AT SRO.

1.4.2 Mutual Exclusivities

There are no other options or schemes that are mutually exclusive with the Beckton Water Recycling scheme. Further assessment of Tideway salinity and potential for accumulated impacts from multiple options including Beckton Water Recycling scheme is underway.

2. Conceptual Design

2.1 Design Principles

2.1.1 Overview

During Gate 2 Conceptual Design process, the All Company Working Group (ACWG) issued "ACWG Design Principles, Process and Gate 2 Interim Guidance" to maintain consistency throughout SROs.

The ACWG Design Principles comprise the four principles of the National Infrastructure Commission (Climate, People, Place, Value) with two cross-cutting principles that apply across all four categories. Table 2-1 summarises approaches taken in Gate 2 conceptual design.

2.1.2 London Effluent Reuse SRO Design Vision

For the London Effluent Reuse SRO, Thames Water have set out their design vision: to create a resilient water future for customers in Greater London and the Southeast. This design vision focuses on the key principles of climate, people, places and value. Thames Water supports the need to protect the environment and our climate through the principles of sustainability, while ensuring the water supply, to our people, is resilient in terms of quality and quantity. Thames Water endeavours to create this resource supply in ways that meet the needs and expectations of our customers and all stakeholders. The project will protect and enhance the natural environment whilst providing the best value to customers.

Growing populations, climate effects and reduction in suitable raw water supply for the region mean there will be a significant supply deficit in future periods of dry weather.

Conventional water resources are becoming strained and so innovative, sustainable solutions such as water recycling are increasingly important. Thames Water is committed to delivering a new water recycling strategic resource option (SRO) to meet the future needs by the early 2030's.

The scale of the challenge is reflected in the extent of the supply deficit the region will see in drought conditions. This will require scheme sizes having the potential to deliver an additional 300Ml/d of new water. By employing water reuse schemes in the region, Thames Water can avoid reliance on additional river abstraction thereby protecting local rivers and reservoir habitats.

As a company, Thames Water need to deliver wide-ranging solutions, including demand management and leakage reduction, new storage facilities, new transfers from other companies and enhanced network capacity. These present challenges in terms of protecting the environment and providing best value to customers, but also offers opportunities to take significant steps in delivering a design vision to create a resilient water future. The London Effluent Reuse SRO presents an opportunity to deliver this vision, that is regionally focused, resilient for the future and supporting us in protecting the environment.

Thames Water's starting point is that it will deliver value for money by applying the best in worldwide design and construction. It is recognised that good design saves resources and reduces carbon footprint; therefore, our commitment through the early design stages will ensure that all viewpoints are considered.

Thames Water's design vision commitment is:

- To provide a secure, resilient and high-quality new resource of raw water to Greater London and supplement the water supply to the region, ensuring beautiful and functional design with a pride of being a part of the community.
- Through robust and detailed environmental and ecological assessments, to protect and promote the recovery of nature and achieve Environmental Net Gain, while limiting and mitigating any effects on the local environment.
- To develop solutions that provide social amenity value, environmental benefits and any additional values to the region.
- To work collaboratively with all stakeholders to ensure the best value for the customer and the environment, meeting needs of the communities.
- To create a long-term, sustainable solution that recycles an existing resource to reduce the water footprint.

Table 2-1: Overview of Gate 2 Design Approaches to ACWG Design Principles

ACWG Design Principles	ACWG Gate 2 Indicators	Approach in Beckton Water Recycling Gate 2 Designs	Documentation in Gate 2 Submission	Targets
Cross Cutting Design Principles 1. Be specific: Develop project-specific design vision and principles based on an understanding of the objectives of each project and the people and places it will affect.	1. Draft Design Vision, Narrative and Principles.	See section 2.1.2 for Design Vision of London Effluent Reuse SRO. The Gate 2 Report content gives an overview of the design vision for this scheme and the London Reuse SRO as a whole.	CDR section 2.1.2. Gate 2 Report	1.1. Development of project specific vision and principles mapped against the NIC and ACWG Principles. 1.2. Development of a clear, concise narrative describing the story behind your Vision and Principles.
2. Safe and well: Actively and collectively develop designs that can be built, used, and maintained without unacceptable risks to the health and safety of workers - particularly during hazardous construction and operational activity. Manage risks to members of the public thoughtfully with an approach that balances maximising wellbeing benefits with protection from risks that could cause significant harm.	2. Outline Designers Risk Assessment highlighting potential significant and/or unusual risks with potential mitigations.	Principal Designer was appointed in conformance with the CDM Regulations 2015. Please see section 3.1.3 for CDM implementation and outline of the potential significant and/ or unusual risks in the scheme. Drinking Water Safety Plans have been created for this scheme to ensure the customer's and environment's safety is paramount for the design vision.	CDR section 3.1.3 Gate 2 Report Annex C: Water Safety Plan	2.1. No accidents, incidents or harm to people during construction and operation. 2.2. Use of best practice procedures in design risk management following HSE Guidance and CDM Legislation. 2.3. Design informed by understanding potential risks to the public and management of these so far as reasonably practicable. Use of appropriate guidance including but not limited to: a. RoSPA and the National Water Safety Forum's Guiding Principles for Managing Drowning and Water Safety Risks. b. Visitor Safety in the Countryside. 2.4. Consideration of security early in the design of fence, gate and boundary treatments.
Climate 1. Nature knows no boundaries: Water is essential to all life and managing our response to climate change is a collective and urgent activity. Projects must be developed to work across companies and/or legislative boundaries to develop sustainable	1. Evidence of collaborative working across companies. 2. Evidence of working with Regulatory, Statutory (and, where practicable, local) stakeholders including Catchment Partnerships where appropriate.	Design work, cost estimate and carbon analysis have been carried out in coordination with ACWG to ensure collaboration across companies. Regular meetings have been held with Environment Agency (EA), Natural England (NE) and Port of London Authority (PLA) to discuss scheme	Gate 2 Report –section 7 Gate 2 Report – Annex D: Engagement Report	1.1. Collaborative working across companies and with stakeholders. 1.2. Timely - preparation of proposals ready to construct in 2025-2030 will involve early and rigorous development of design objectives followed by proposals.

solutions and environmental enhancement for the wider benefit of society.	3. Design Vision and Principles informed by this engagement (Stages 1-6 of design process).	benefits and impacts, and opportunities for enhancement. Local Councils (London Borough of Newham, Barking and Dagenham, Redbridge, Waltham Forest, Haringey and Enfield) are also being contacted for discussion.		1.3. Alignment with other relevant environmental policy, plans and strategies such as Catchment Management and Local Nature Recovery Plans (see also Place 2).
2. Resource and carbon efficient throughout: Projects shall seek to reuse existing assets, eliminate waste (including waste of water) and make efficient use of materials and transport across the whole of the project lifecycle.	1. Submissions to meet expectations of RAPID Gate 2 Guidance. 2. Narrative on the SRO approach to avoiding and reducing the use of carbon and other resources and Inclusion of the approach in the Design Vision and Principles.	In Gate 2, it was attempted to establish carbon efficient strategies based on Net Zero 2030 route map, as well as PAS 2080. Opportunities of increasing efficiency of transportation were investigated, considering use of barges for shipping spoils from pipeline construction. Details of carbon efficient strategies are in 2.2.8 of this CDR, and environmental reports are in Annex B of the Gate 2 Report. Optimised design to reduce material waste and carbon use have been accounted for, including the main design principle to reuse Thames Water land for the AWRP location and outfall location.	Gate 2 Report – section 6.5 Gate 2 Report Annex B Environmental and Regulatory Assessments CDR section 2.2.8	2.1. Lifecycle Carbon: Projects shall support the water industry commitment to achieve Net-Zero in terms of operational carbon in accordance with the industry roadmap. Projects must be efficient in embodied carbon in both construction and operation. 2.2. Projects should investigate if existing infrastructure assets could be repurposed and reused. 2.3. Projects should look to avoid unnecessary construction and minimise use of materials. 2.4. Projects should seek to minimise the use and waste of water.
3. Resilient and adaptable: Design for anticipated future demand at the appropriate scale. Build in the resilience to absorb and recover from the impacts of the extreme events and incremental stresses likely to arise from climate change.	1. Submissions to meet expectations of RAPID Gate 2 Guidance noting the climate change scenario(s) the schemes have been designed to cope with. 2. Review of local plans and strategies that may impact resilience*	DO analysis was carried out for climate change scenarios (see section4). The maximum capacity of Beckton Water Recycling scheme was determined based on drought conditions/scenario, excluding infiltration and trade flow from the available flow (see section2.2.1). In accordance with Drinking Water Safety Plan, this scheme has had a detailed assessment to allow for mitigation of any effects caused by discharge of flows at the River Lee Diversion, and any effects due to a reduction of final effluent discharge into the River Thames.	CDR section 2.2.1, section 4. Gate 2 Report - Annex C: Drinking Water Safety Plan	3.1. Designs should be developed to include proportionate measures to anticipate future extreme events and stresses so that they can resist, absorb, recover and, where necessary, be adapted. 3.2. Designs would support the digitisation of the network at a catchment level using data to inform design, optimise solutions and improve operational efficiency in real time. 3.3. Where proposals add to the resilience of the broader system this should be accounted for in its social value (see Value 3).

				3.4. The layout and design of specific elements of infrastructure should be taken in cognisance of planned future development of the immediate area. 3.5. Deploy nature-based approaches to resilience wherever possible (see also Place 2).
People 1. Understand and respond to your Community's needs: Develop a full understanding of the social context that will be impacted by the project over its lifecycle. Design for how local communities will encounter the infrastructure in their everyday lives during both construction and operation.	1. Indicator for Target 1.1 to be decided by others. 2. Initial appraisal of the scheme and its potential to contribute to the UN's Sustainable Development Goals - or other Social Value evaluation process (see also Value 2 and 3). 3. Review of relevant regional/local policy and demographic information and narrative around how it has shaped the draft Vision and Principles for the option.	The Design Vision sets out the key principle of customer engagement to demonstrate the quality and security that water reuse brings. Drinking Water Safety Plans were carried out at these early stages and a Planning Consultant has provided detailed input and direction to meet the requirements of regional/local policy. As part of the scheme site and conveyance route appraisal, all potential options have been assessed under a multi-criteria framework (section 3.4, Gate 2 Report).	Gate 2 Report – section 3.4 Gate 2 Report – Annex C: Drinking Water Safety Plan Gate 2 Report – Annex D: Engagement Report Gate 2 Report – Annex G: Planning Report	1.1. Reliable supply of water to customers 1.2. Designs developed to maximise their social value. 1.3. Proposals reflect local community views as to how they interact with and experience the infrastructure as far as possible.
2. Engage widely, early and meaningfully: Work with stakeholders and local communities to develop their understanding of the importance of nature and water conservation. Develop co-design approaches to aspects of the design of infrastructure and associated landscape where practicable.	1. Summary of feedback from stakeholders (either project specific or received to date through the WRMP/Regional Plan process) and narrative around how it has shaped the draft Vision and Principles for the option. 2. Inclusion of engagement activities within the design programme of the project plan for Gate 3 and beyond showing adequate time for community (public) consultation to inform both site selection (where possible) and developed design. 3. The development of tools that will enable successful engagement (e.g., digital	Continuous and open communication between stakeholders has been carried out with stakeholders such as the EA, NE, PLA, DWI, NAU and Ofwat. Digital 3D graphics the proposed outfall at River Lee Diversion are being prepared to enhance effective communication with stakeholders, in addition to scheme schematic diagrams (section 1.2). Early and collaborative engagement has been undertaken with regulators and key stakeholders (as above) to identify key issues, agree approaches to monitoring and assessment, and then review findings and consider mitigation requirements.	Gate 2 Report – section 7 Gate 2 Report – Annex D: Engagement Report Gate 2 Report – Annex G: Planning Report	2.1. Stakeholders and communities understand the need for the scheme and the nature/appearance of the proposed solution(s). 2.2. The views of local stakeholders have shaped the design, where possible. 2.3. Engagement and consultation with communities has influenced the design (including but not limited to site selection, layout, materials, detailing) making it more acceptable to them. 2.4. The project provides the public with information on the importance of water and/or nature conservation (e.g., through information boards, artwork or digital information)).

	models for visualisation/animation, GIS systems, precedent pictures of similar schemes/components) *. 4. Survey information on local needs and preferences in design*			
3. Improve access and inclusion: Consider how people move around your works. Maximise opportunities to support active travel and improve recreational access to waterside and green spaces that can improve outcomes for wellbeing, health, local economy, social inclusion and education.	1. Mapping of interface with PRoW network* 2. Evidence of engagement with local access groups* 3. Review of Local Cycling and Walking and Infrastructure Plans (LCWIPs) information or similar and note of how the project may impact/enhance it.*	The Gate 2 Planning Consultants have prepared plans for engaging the community and accounting for their concerns and desires. Considerations were made in option designs to minimise negative visual and auditory effects for the local community, such as keeping most of engineering assets in public areas below ground, with above-ground assets blended into the local surrounds. A dedicated Navigation Assessment has been undertaken to determine potential for impacts on river users in the Thames Tideway at key locations identified by the PLA. Further engagement and community activities will occur at Gate 3 and onward.	Gate 2 Report – Annex D: Engagement Report Gate 2 Report – Annex G: Planning Report	3.1. Find opportunities to improve people's health, wellbeing and understanding of the natural environment, through access to waterside and green spaces for recreational and other purposes (see Note 1). 3.2. Maximise opportunities for workers to access sites via sustainable transport during construction and operation. Minimise disruption to travel routes in areas affected by a project during construction and operation.
Place 1. Take care: Develop proposals in the spirit of stewardship looking to both the past and future of each context to understand and develop its landscape, cultural heritage, health and sustainability. Work with partners to secure the long-term success of all measures.	1. Evidence of place-based balanced, holistic and long-term decision making in the description of design considerations and development of design vision and principles. 2. Statement on SRO approach to achieving Environmental Net Gain within the Design Vision and Principles. 3. Evidence of review of adopted (or emerging) spatial plans, strategies for the areas impacted by your works*.	The Gate 2 options appraisal includes detail of frequent collaborative reviews between the engineering, environmental, planning and commercial designers for this scheme. These reviews significantly influence the design development of the schemes in line with the place-based principles. The majority of permanent land requirements for this scheme are on land currently owned by Thames Water, with minor land acquisition required for things such as conveyance shafts, which would be entirely below-ground post-construction. Planning reviews and	Gate 2 report – section 3.4 CDR section 2.1.2. Gate 2 Report – Annex B: Environmental and Regulatory Assessments Gate 2 Report – Annex D: Engagement Report Gate 2 Report – Annex G: Planning Report	1.1. Achieve Environmental Net Gain (ENG). 1.2. Adopt measures in the design that enhance the environment and help avoid future problems - e.g. adoption of SuDS solutions that improve cooling, attenuate surface water run-off and improve infiltration and biodiversity. 1.3. Have clear and realistic long-term strategies for how operational and mitigation proposals will be managed and maintained. Develop partnerships with local communities where this has a mutual benefit.

	4. Landscape/townscape character assessments and approach to design specific to context.*	engagement with local authorities are underway to best mitigate any new developments.		1.4. Develop proposals in light of a clear understanding of the area's landscape and history.
2. Protect and promote the recovery of nature: Focus on the role of landscape, its capacity to accommodate infrastructure and shape places. Work collaboratively and employ holistic, landscape-scale approaches that support and deliver biodiversity net gain as well as multiple other benefits.	1. Statements on your approach to achieving BNG and aspirations to contribute to the recovery of nature within Design Vision and Principles. May include specific reference to local Green-Blue Infrastructure Strategies/ (emerging) Local Nature Recovery Plans, catchment management plans and other measures to improve watercourse quality.	In Gate 2, baseline ecological surveys have been carried out in the potential plant sites and conveyance routes where the project could impact the local ecosystem and the nature. The findings of surveys are being considered in the option appraisal process to select the optimum locations and conveyance routes. Measures to protect and promote the nature and ensure the BNG target will be established in the future design stage based on the ecological survey data and characteristics of the sites/ routes selected through the option appraisal process. Engagement with local EA and NE officers on potential BNG opportunity sites further supported this work.	Gate 2 Report – Annex B: Environmental and Regulatory Assessments Gate 2 Report – Annex D: Engagement Report	2.1. Achieve at least 10% Biodiversity Net Gain (BNG). 2.2. Deploy nature-based approaches to integration and mitigation as the first-choice solution where possible. 2.3. When looking at options to provide compensation or enhancement prioritise measures that support achieving good ecological condition for affected watercourses and bodies as a whole. When making an intervention, mitigate infrequent impacts by developing proposals that keep them local and short lived. 2.4. Work with landowners and land managers to develop mutually beneficial solutions where practicable.
3. Design all features beautifully, with honesty and creativity: Our utility infrastructure can be a source of pride and a positive contribution to its context. Develop proposals that reveal and celebrate its importance, provide visual delight and leave a positive legacy.	1. Set out with opportunities and aspirations for high quality design within Design Vision and Principles. 2. Development of a project plan stating how these aspirations will be developed/achieved. 3. Favourable independent design review outcomes* 4. See also Place 1.	The proposed Recycled Water outfall would be located on the River Lee Diversion. Ensuring engineering and functional integrity, the London Effluent SRO will deliver designs of these components beautifully with a pride of being a part of the community. It is planned that architects and landscaping specialists will be engaged in design work at the future stages, with minimal consequences visually and for local access.	CDR section 2.2.4.	3.1. Develop a utilities architecture that speaks to its purpose and enhances its context. This applies to buildings, structures and landscape. 3.2. Develop designs and, where appropriate, artworks that bring narrative (meaning), beauty and interest to the proposals. 3.3. Consideration of context in every aspect of design including its location, layout, form, scale, appearance, landscape, materials and detailing.
Value 1. Maximise embedded value: Work collaboratively across specialisms and with stakeholders to maximise the benefits of the scheme by being smart with the	1. Evidence of multi-disciplinary input into site selection* (See Note 2). 2. Initial project and, where appropriate, site appraisals	Planning professionals, terrestrial habitat ecologists, carbon and energy analysts joined the Gate 1 design team which consisted of engineering and environmental consultants. As for	Gate 2 Report – section 3.4	1.1. Early multidisciplinary input informing a design that solves multiple problems at once.

location and arrangement of elements and design of mitigation within the project scope and budget.	(including constraints and opportunities) undertaken by a multi-disciplinary team (steps 1-5 in design development process). 3. A statement within the Design Vision on the SRO's aspirations and capability to deliver embedded value which should include Social Value, BNG and ENG.	engineering designs, inputs from an outfall/abstraction design specialist, a high-voltage electrical overhead line specialist, geotechnical engineers and a structural engineer were introduced at Gate 2 to improve design development. Site and conveyance route appraisal have been started in Gate 2, and it is expected to be completed in Gate 3.		1.2. Design of infrastructure capable of adaptation to reasonable future demands (see also Climate 3). 1.3. Site selection processes and layouts that assist (or as a minimum, do not prevent) local development except where absolutely necessary. 1.4. Reinstatement, landscape and mitigation proposals that improve the existing situation, - e.g., through better biodiversity, carbon sequestration, surface water infiltration and reduced run-off. 1.5. Deliver benefits efficiently by exploiting the two-way relationship between infrastructure and natural capital to enable multiple benefits to be delivered simultaneously.
2. Understand how you could provide additional value: Identify opportunities to contribute wider regional benefits outside of the project scope. In particular look for synergies with relevant catchment management plans and proposals that support the delivery and enjoyment of a healthy water environment.	1. A description of potential opportunities to work with other projects/partners to achieve wider benefits. 2. A statement within the Design Vision on the SRO's aspirations and capability to deliver additional value.	The Beckton Water Recycling scheme is identified as one of the potential water source options for T2AT SRO.	CDR section 1.4	2.1. Strategic project selection is informed by cross-sectoral engagement to maximise social benefit and reduce the use of customers money (see note 3). 2.2. Work closely with partners and focus on landscape scale schemes that improve hydrology, aquatic ecology and reduce/sequester carbon and provide opportunities for access to recreation and visual delight. 2.3. Be honest and realistic with partners as to what you might be able to offer as an organisation.
3. Capture and measure embedded and additional value: Have clear narratives about how you are contributing to society beyond the core scope of your project. Quantify these benefits so they can be considered meaningfully in conversations on value, financing and risk. Share	1. Details of the best-value metrics used in determination of the Regional Plans and WRMPs and a clear narrative on how these have influenced option selection so far. 2. Inclusion of a description within the project plan of how these	WRSE is progressing further assessments of the options, considering factors beyond cost to deliver additional value, improve the region’s environment further and benefit wider society. Wider resilience benefits of each solution have been reassessed. Details of the best-value metrics used	Gate 2 Report - section 4.3	3.1. Gathering of project specific data and improvement in the tools we have to measure and monitor added and additional value across the sector. 3.2. Full consideration of potential benefits in the Cost Benefit analysis and investment case for the SRO.

your experience and knowledge widely.	will be developed and monitored at subsequent gates. 3. Initial narrative (description) of the value of the scheme in plain English.	are described in section 4.3 in Gate 2 Report.		3.3. Clear communication of value of the scheme to stakeholders, communities and within the industry.

*Activity may occur at Gate 2 or Gate 3 depending on maturity of the proposals.

2.2 Scheme Components and Operating Philosophy

The conceptual design for each of following option components are developed in this report:

- Beckton STW Final Effluent abstraction
- Beckon Advanced Water Recycling Plant (AWRP)
  - 50Ml/d Process unit
  - 100Ml/d Process unit
  - 150Ml/d Process unit
- Recycled Water Conveyance
  - Beckton AWRP to Lockwood Reservoir Pumping Station Recycled Water transfer tunnel
  - Lockwood Reservoir Pumping Station to KGV Recycled Water transfer tunnel
- Recycled Water Discharge at River Lee Diversion
- Waste stream collection and discharge
  - Ultrafiltration waste stream and neutralized chemical cleaning wastewater (to be discharged to Beckton STW inlet works)
  - Reverse osmosis concentrate (to be discharged to Beckton STW inlet works)

2.2.1 Assessment of Source Flow Availability

In Gate 1 conceptual design, a check of final effluent flow recorded in Beckton STW from 2016 to 2020 was carried out, and it was found that the Dry Weather Flow (DWF), as a nonparametric 80% exceeded daily flow, during this period was 995Ml/d and the Average Daily Flow (ADF) was 1126Ml/d.

However, these values include infiltration and trade flows which may reduce significantly in drought conditions. Therefore, availability of source flow was considered further in Gate 2, and a review was undertaken of projected flows received by the Mogden STW in Strategic Overview of Long term Assets and Resources (SOLAR) analysis (SOLAR, AMP6 ver. 3.3 updated on 1 July 2019).

SOLAR estimates STW influent in the future, utilising predicted population growth. All flows into Beckton STW essentially leave the site as final effluent though there is a small amount of volume loss during treatment which account for sludge and evaporation.

According to SOLAR, projected domestic flow to be received by Beckton STW in 2031 would be 595Ml/d. Domestic flows do not include infiltration or trade flows, and it is assumed that domestic flow would not reduce significantly during periods of drought. Therefore, this value would provide a conservative estimate of available effluent from Beckton STW during drought conditions. It is estimated that a 377.4Ml/d of final effluent would be required to yield a 300Ml/d of Recycled Water. Therefore, there would be sufficient flow to feed the AWRP.

2.2.2 Source Water Abstraction Design Components

Beckton STW final effluent would be obtained from the existing final effluent channel in Beckton STW, which runs adjacent to the River Roding on the east side of the STW. The effluent from these treatment streams would be abstracted via wet wells connected onto the side of the final effluent channel to capture the required volume and pumped via screens to the new AWRP to the North of the Beckton STW operation area.

2.2.3 Treatment Design Components

The AWRP conceptual design proposes treatment process which is globally referred to as Full Advanced Treatment (FAT). FAT is globally accepted for Indirect Potable Reuse (IPR) and uses Reverse Osmosis (RO) and UV Advanced Oxidation Process (UVAOP) for treatment. There are alternative non-FAT treatment options for IPR; however, at this stage the RO based process is proposed because Thames Water have experience operating similar membrane-based treatment trains, for example, in the Beckton Desalination and in the Old Ford Water Recycling plant.

The FAT process would produce ultra-pure/ deionised water which is corrosive and aggressive to transfer and discharge to the receiving water course. Therefore, a remineralisation process using Lime and CO_2 dosing would be required downstream of the FAT process.

Design work has developed a methodology for the required treatment, based on compliance with discharge under the Water Framework Directive.

2.2.3.1 Water Quality

2.2.3.1.1 AWRP Feed Quality

A summary of the key water parameters in the AWRP feed water (i.e., Beckton STW final effluent) is presented in Table 2-2. The Prescribed Concentration or Value (PCV) for drinking water, where applicable, are also included for reference.

Table 2-2: Key AWRP Feed Water Quality Parameters

Parameter	Unit	Average	95%ile	Drinking Water Regulatory PCV
General				
BOD	mg/l	4.0	11.3	
Total Organic Carbon, TOC	mg/l	7.3	11.0	No abnormal change
Suspended Solids	mg/l	16.4	34.0	
Total Dissolved Solids, TDS	mg/l	761.2	948.7	
Ammonia. NH_3	mg/l	0.5	1.5	
pH	ph Unit	7.4	7.6	6.5-9.5
Alkalinity (as $CaCO_3$)	mg/l	210.5	241.0	
Salts & Anions				
Chloride, Cl	mg/l	138.4	183.8	250
Nitrate, NO_3	mg/l	13.1	21.0	50
Phosphate, PO_4	mg/l	6.2	13.5	
Sulphate, SO_4	mg/l	91.7	110.2	250
Silica, SiO_2	mg/l	11.2	68.7	
Microbiological				
Cryptosporidium	No./l	1.05	3.03	
E. Coli	mpn/100ml	15,418	24,200	0
Metals				
Aluminium	µg/l	72.6	232.5	200
Barium	µg/l	3.00	18.7	
Manganese	µg/l	29.6	62.4	50
Iron	µg/l	184.1	330.7	200
Calcium	mg/l	106.0	340.0	
Chromium	µg/l	1.1	1.6	50
Copper	µg/l	10.2	18.3	2000
Magnesium	mg/l	1.7	10.0	
Potassium	mg/l	7.8	19.4	
Sodium	mg/l	15.0	100.9	
Strontium	mg/l	0.41	0.48	
Human made organics				

Parameter	Unit	Average	95%ile	Drinking Water Regulatory PCV
1,4-Dioxane	µg/l	2.2	13.2	
Disinfection By-products				
NDMA	µg/l	0.01	0.01	
Total THM	µg/l	9.5	10.0	100
Per- and Polyfluoralkyl Substances (PFAS)				
Perfluorododecanoic acid	µg/l	0.004	0.050	0.1†
Total PFAS*	µg/l	0.061	0.159	0.5†

*Based on Perfluorodecanoic acid, Perfluorododecanoic acid, Perfluoroheptanoic acid, Perfluorohexanoic acid, Perfluorononanoic acid, Perfluorooctanesulfonic acid, Perfluorooctanoic acid, Perfluoropentanoic acid, Perfluoroundecanoic acid.

†The proposed EU Directive recasting recommends a parametric (limit) value for individual PFAS compounds of 0.1 µg/l and 0.5 µg/l for PFAS in total.

Total Organic Carbon (TOC)

The feed water has a 95%ile TOC concentration of 11mg/l which indicates relatively high level of organics and would constitute a risk of Trihalomethanes (THM) formation in chlorine disinfection. It could be proposed to dose pre-formed monochloramine to control biological fouling of the membranes, which militates against the risk of disinfection by-product formation. RO provides excellent removal of TOC, typically in excess of 95% removal in potable reuse applications.

Nitrogen and Phosphorous

Assessed Beckton STW final effluent indicates high levels of Total Nitrogen (TN). High nitrogen concentrations could result in greater fouling to membranes because of the higher level of organics associated with the water.

The high phosphate levels within the feed water is likely to require pre-treatment to prevent the accumulated build-up of scalants within the RO membranes that could also reduce the recovery of the system. Sulphuric acid dosing to lower the pH ahead of the RO membranes would be provided to address this.

Suspended Solids

The feed water has 95%ile suspended solids concentration of 34mg/l which may be problematic for UF operation. Design development will further consider the risk that this may pose, recognising the upgrade works ongoing at Beckton STW and likely future performance.

Solvents and Industrial Chemicals

Solvents are not present in the Beckton final effluent at significant levels and no specific treatment would be required.

The final effluent quality data shows high levels of 1,4-Dioxane, an industrial chemical which could provide treatment challenges, with a 95%ile of 13.2µg/l. This would require more than 90% removal (1-log) to achieve a finished water quality concentration of 1µg/l, a common target in potable reuse applications. Most potable reuse applications assume 0.5-log removal (68%) of 1,4-dioxane through UVAOP to ensure good oxidation of a variety of chemicals. Enhanced source control measures in the Beckton wastewater collection system would be required such that the UVAOP system will remove 1,4-Dioxane to adequate levels. Dischargers and isolated sources may need to be identified in catchment study.

Microbiological

There are significant levels of microbiological parameters in the Beckton STW final effluent. The AWRP treatment train would provide a multi-barrier disinfection and removal of pathogens, including bacteria, viruses and protozoa. Indicative treatment log removals are summarised in Table 2-3.

Table 2-3: Indicative Pathogen Log Removal Credits for Proposed AWRP Treatment Processes

Pathogen	Beckton STW*	UF	RO	UVAOP	Pipeline Cl_2†	Total
Virus	0	0	1.5	6	6	13.5
Giardia	0	4	1.5	6	0	11.5
Cryptosporidium	0	4	1.5	6	0	11.5

*Pathogen reduction across the Beckton STW is expected but has not been quantified in this table until site specific pathogen testing at Beckton STW is conducted.

†Level of pathogen log removal from conveyance disinfection using sodium hypochlorite or other preferred disinfectant chemical.

Metals

Although 95%ile concentrations of Iron, Manganese and Aluminium in the final effluent are all above the PCV values, the treatment train would reduce these parameters to concentrations well below the PCV.

Pesticides and Other Organics

A large number of organic chemicals are present in the final effluent, and the most significant ones are various pesticides, including metaldehyde and mecoprop. While individually none of these exceed the PCV limit, it is possible that on occasions their combined total may exceed the PCV limit for total pesticides. The full advanced treatment processes are effective in removing pesticides. In addition, it is envisaged that catchment management schemes would control metaldehyde contamination. The use of metaldehyde has been banned by Defra since March 2022. It is expected environmental levels of the chemical will reduce over time.

Endocrine Disrupting Compounds (EDCs) and other Contaminants of Emerging Concern (CECs)

These include several contaminants such as nonylphenols, per and polyfluoroalkyl substances (PFAS) and N-Nitrosodimethylamine (NDMA). There is limited sampling data and, in most cases, no PCV limits have been set by the regulators in the UK. A multibarrier treatment process could be proposed, in alignment with global best practice, to remove these compounds.

2.2.3.1.2 Advanced Recycled Water Quality

A high-level mass balance has been completed to project the potential Recycled Water quality concentrations. The assessment has been completed using Mogden STW final effluent (95%ile) data to make projection with the worst-case feed water quality. Parameters for metals, disinfection by-products, organic compounds and microbiological components have been determined using assumed removal efficiencies.

As shown in Table 2-4, the projected Recycled Water quality would not exceed the Water Supply Regulations PCVs and would also be below 50% of the PCV, which is a common internal target for the water industry.

Table 2-4: Projected AWRP Recycled Water Quality Parameters

Parameter	Unit	Average	95%ile	Drinking Water Regulatory PCV
General				
BOD	mg/l	0.3	0.7	
Total Organic Carbon, TOC	mg/l	0.5	0.7	No abnormal change
Suspended Solids	mg/l	0.03	0.05	
Ammonia. NH_3	mg/l	0.1	0.2	
Total Nitrogen, TN	mg/l	20.6	32.7	
pH	ph Unit	8.4	8.3	6.5-9.5
Alkalinity (as $CaCO_3$)	mg/l	60.0	69.0	
Salts & Anions				
Chloride, Cl	mg/l	1.7	2.7	250

Parameter	Unit	Average	95%ile	Drinking Water Regulatory PCV
Nitrate, NO_3	mg/l	1.2	2.2	50
Nitrite, NO_2	mg/l	0.03	0.07	0.5
Sulphate, SO_4	mg/l	0.3	0.6	250
Microbiological				
Enterococci	No./100ml	0.06	0.16	
E. Coli	mpn/100ml	2.4E-01	3.8E-01	0
Metals				
Aluminium	µg/l	9.1	29.3	200
Barium	µg/l	2.4	3.2	
Boron	µg/l	14.1	17.2	1000
Manganese	µg/l	3.7	7.9	50
Iron	µg/l	23.2	41.6	200
Calcium	mg/l	22.4	25.8	
Chromium	µg/l	0.1	0.2	50
Copper	µg/l	1.3	2.3	2000
Magnesium	mg/l	0.006	0.008	
Strontium	mg/l	0.05	0.06	
Human made organics				
1,4-Dioxane	µg/l	0.9	5.3	
Benzo(α)pyrene	µg/l	0.1	0.4	1
Disinfection By-products				
NDMA	µg/l	0.003	0.005	
Total THM	µg/l	0.60	0.63	

2.2.3.2 Treatment Technology Options

Full Advanced Treatment (FAT) process using UF, RO and UVAOP is proposed for Beckton Water Recycling scheme in Gate 2 conceptual design. Another potable reuse treatment technology which is globally accepted would be Ozonation with Granular Activated Carbon (GAC) treatment process. The following sections discuss advantages and disadvantages of these two alternatives.

2.2.3.2.1 Full Advanced Treatment (FAT) with UF, RO and UVAOP Option

Full Advanced Treatment (FAT), using UF, RO and UVAOP systems, is a globally accepted and implemented treatment process for indirect potable reuse treatment schemes. The outline of indicative FAT process is shown in the figure below.

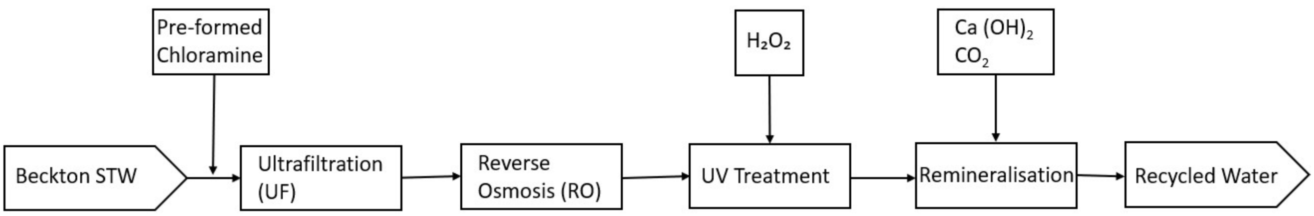

Figure 2-1: Outline of Indicative Full Advanced Treatment (FAT) Process

Note: This diagram shows outline treatment process outline only. Additional chemical dosing and other auxiliary processes are likely to be required.

This treatment process can effectively remove and/or inactivate pathogens and organic chemicals that could be dangerous to human health, including pathogens such as protozoa, bacteria, and viruses, and organic chemicals often referred to as Contaminants of Emerging Concern (CEC) such as PFAS, NDMA and THMs. The use of a FAT system could remove up to 7.5 and 11.5-log of viruses and cryptosporidium, respectively.

However, it presents several drawbacks as follows:

- The use of RO membranes generates a concentrated brine which would need to be treated or disposed of. This could be problematic for inland treatment facilities where ocean disposal is unavailable and expensive brine treatment would be required.
- A large footprint is generally required for the treatment streams and conditioning processes.
- Operation could be energy and chemical intensive.

In the case of Beckton Water Recycling scheme, the Beckton AWRP would be located within the Beckton STW, and there is a potential for the STW to receive and treat the RO concentrate brine. Thus, high-cost brine treatment systems may not be required to mitigate environmental impacts from RO concentrate discharge.

Indicative plant layouts have also been developed for the proposed treatment systems in the Beckton AWRP. It has been indicated that there would be adequate space for the proposed 300Ml/d plant with UF, RO and UVAOP technologies.

Energy saving and chemical reducing practices, such as Energy Recovery Devices, optimised chemical cleaning practices and Chemical Dose Optimisation, could be used to mitigate high cost and carbon emissions.

2.2.3.2.2 Ozonation with Granular Activated Carbon (GAC) Option

The alternative treatment system involving use of Ozonation with Granular Activated Carbon (GAC) includes Nitrifying Sand Filters (NSF) with ferric dosing, ozonation/GAC and Ion Exchange (for nitrate removal). Outline of indicative treatment process is shown in Figure 2-2 below.

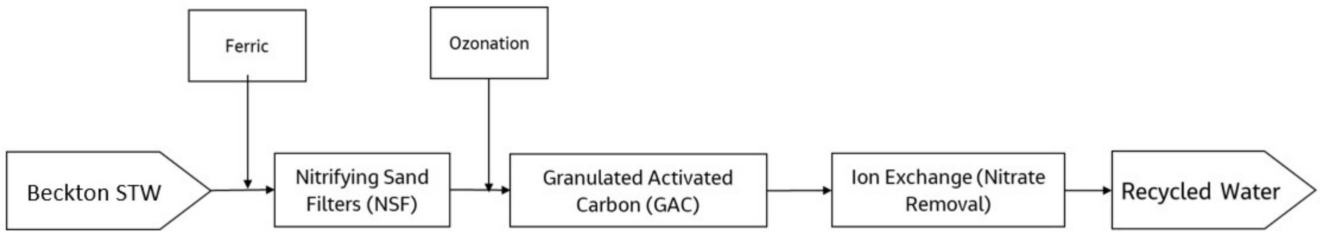

Figure 2-2: Outline of Alternative Ozone/GAC Treatment Process

Note: This diagram shows Ozone/GAC treatment process outline only. Additional chemical dosing and other auxiliary processes are likely to be required.

It would be recommended to include a Biological Activated Carbon (BAC) filter system to provide nutrient removal upstream of the GAC. A flocculation/sedimentation stage may also be desirable upstream of the Ozonation process to lower TOC levels prior to the O_3, BAC and GAC stages. To provide a similar level of pathogen removal/reduction to the FAT process, the inclusion of a UV or UVAOP system would be preferred downstream of the GAC. In this case, the use of NSF and Ion Exchange systems could be omitted. Furthermore, upstream source reduction of ammonia/nitrates in STW would be preferable.

The use of ferric dosing upstream of NSFs provides reduction of carbonaceous organics, phosphate and ammonia. However, because of a high phosphate concentration in the Beckton STW final effluent, it is likely that a clarification stage for chemical sludge from ferric dosing would be required in addition to NSFs.

These solids from ferric dosing would ultimately be backwashed and transferred to the Beckton STW. Whilst it is envisaged the Beckton STW would have sufficient capacity, chemical sludges could be problematic for secondary biological treatment processes.

The ozonation/GAC process provides microbiological and pathogen reduction and disinfection. Dosing ozone (O_3) is advantageous as it oxidises heavy molecular weight organics. However, high concentrations of ozone could form disinfection by-products, most notably bromate and N-nitrosodimethylamine (NDMA). Additionally, nitrates exert a significant ozone demand which may be problematic with the NSF.

The GAC media could remove trace organics through adsorption mechanisms and resultingly the adsorption capacity of the media decreases over time. This is usually controlled through frequent sampling and media monitoring to replace GAC media prior to exhaustion. Without provision of an upstream BAC filter, GAC filter media is likely to require frequent replacement/regeneration due to heavy bulk organic matter loading.

The Beckton STW final effluent has a 95%ile nitrate concentration of 21.0mg/l which must be significantly reduced. The use of the Ion Exchange process could provide a removal efficiency of up to 90%. In a similar principle to the GAC filters, high nitrate loading to the Ion Exchanger leads to breakthrough and therefore requires monitoring and regular resin regeneration.

2.2.3.3 Proposed Treatment Scheme

Indicative treatment process for Beckton Recycled Water scheme would be:

- Upstream AWRP Equalisation Tank (to provide retention of final effluent flows from STW during operational disturbances or diurnal variation which may occur at Beckton STW)
- Fine screening (as protection to the UF Membranes and RO system)
- Pre-formed monochloramine dosing (for prevention of bio-fouling on the UF and RO membranes)
- Ultrafiltration membrane treatment (for pathogen removal and as pre-treatment to the RO membranes)
- Anti-scalant and sulphuric acid dosing (for scale prevention on RO membranes and pH control prior to the membranes)
- Reverse Osmosis membranes (for the removal of pathogens, chemicals, anions, metals and some organics)
- Advanced Oxidation Process (AOP) consisting of UV irradiation and hydrogen peroxide addition (for removal of recalcitrant compounds such as metaldehyde and disinfection purposes)
- Remineralisation with lime (calcium hydroxide) and carbon dioxide

Remineralisation would be required to prevent corrosion of the Recycled Water conveyance by the demineralised water produced by the RO. This process is also required so that the water discharged into the environment will not have a detrimental impact on the ecology in the River Lee Diversion.

Chlorination of the Recycled Water before conveyance, together with dechlorination prior to river discharge, may also be required for virus reduction, subject to further water quality analysis and development of pathogen removal targets.

2.2.3.3.1 Equalisation Tank

Final effluent from the Beckton STW would be fed into an equalisation tank. The purpose of the tank is to provide an operational buffer in the event of upstream STW operational issues, as well as during low flow STW influent periods.

The equalisation tank sizing would be optimised as the design progresses, considering diurnal flows, land limitations and STW operational conditions.

2.2.3.3.2 Pre-formed Chloramine Addition

Pre-formed monochloramines would be added upstream of the UF plant for the purpose of bio-fouling control. Monochloramine reduces the risk of disinfection by-products such as THMs or Halogenic Acetic Acid (HAA).

Monochloramines would be prepared on-site by batching sodium hypochlorite solution with liquid ammonium sulphate. Separate feed systems would be required for both chemicals involved.

2.2.3.3.3 Fine Screening and Ultrafiltration

The abstracted water would be screened using 100–200micron mesh filter strainers. The screens are designed to remove materials which could cause abrasive damage to the membranes downstream. Automatic self-cleaning through regular backwash sequences is recommended. The dirty backwash water would be transferred to the Wastewater Return Pumping Station.

The screened raw water would then fed to the Ultrafiltration (UF) plant. The plant could consist of pressurised UF membrane trains. A summary of indicative UF configurations is provided in Table 2-5.

Table 2-5: Indicative UF Configurations

Scheme Design	50Ml/d	100Ml/d	150Ml/d
Permeate Capacity	59Ml/d	118Ml/d	177Ml/d
Total No. Trains	6 No. Duty + 1 No. Standby	12 No. Duty + 2 No. Standby	18 No. Duty + 2 No. Standby
Membrane Flux Rate	60Lmh	60Lmh	60Lmh
Total No. Membrane Modules	1,120 (160 modules/train)	2,240 (160 modules/train)	3,200 (160 modules/train)
Total Membrane Area	56,000m² (8,000m² per train)	112,000m² (8,000m² per train)	160,000m² (8,000m² per train)

Standby trains would be included to achieve desired output flow during cleaning sequences. The membranes would be supplied with pressurised inlet flow from the UF Feed Pumping Station. The UF plant would also be supplied with a dedicated backwash plant, composed of duty/standby backwash pumps and a set of duty/standby air scour blowers. Each membrane cell should be backwashed frequently to remove fouling.

Waste from the backwash process would drain via gravity to a backwash holding tank and be transferred to the Wastewater Return Pumping Station. Additionally, the membranes would require a daily Chemically Enhanced Backwash (CEB) using sodium hypochlorite and citric acid solutions whilst the AWRP is in use.

A Clean in Place (CIP) plant would also be provided, designed for periodic (monthly, whilst in use) cleaning of the UF membranes to remove both organic and inorganic fouling through the use of chemicals. The system would consist of a CIP solution recirculation pumping system, heated water tank and dedicated chemical dosing pumps fed from the bulk sodium hypochlorite and citric acid storage tanks. The resultant spent CIP chemical solution effluent then would feed into the UF neutralisation tank where it would be neutralised using caustic soda and sodium bisulphite prior to discharge to the Wastewater Return Pumping Station.

Preservation and planned maintenance activities for membranes would be required when the plant is not in use.

2.2.3.3.4 Reverse Osmosis Membranes

Permeate from the UF system would pass forward into a RO Feed Tank, from which an RO Transfer Pumping Station would discharge flows through a cartridge filtration stage, prior to the Reverse Osmosis stage.

Each RO train would be fitted with a designated RO feed pump which feeds the RO train at the high pressure required for the chosen membrane selectivity. The RO projections indicate an initial RO feed pressure of approximately 120 psi (8.3 bar). A minimum permeate recovery of 85% would be achieved using a 3- stage RO systems. Indicative RO plant configurations are shown in Table 2-6.

Table 2-6: Indicative RO Plant Configurations

Scheme Design		50Ml/d	100Ml/d	150Ml/d
Permeate Capacity		50Ml/d	100Ml/d	150Ml/d
Total No. Trains		3 No. Duty + 1 No. Standby	7 No. Duty + 1 No. Standby	9 No. Duty + 1 No. Standby
Membrane Flux Rate		18Lmh	18Lmh	18Lmh
Total No. Pressure Vessels		712 (178 No. per Train)	1,224 (153 No. per Train)	1,780 (178 No. per Train)
Pressure Vessels per Train	Stage 1	101	87	101
	Stage 2	51	44	51
	Stage 3	26	22	26
Total Membrane Area (based on 6 elements per pressure vessel with 37.16m² each)		157,320m² (39,330m² per train)	269,696m² (33,712m² per train)	393,300m² (39,330m² per train)

An interstage turbocharger, or other alternative energy recovery device (ERD), could be utilized with the RO system to capture energy from the residual pressure in the RO concentrate. To achieve a minimum system recovery of 85%, prevention of the formation of foulants and scalants, such as calcium phosphate, would be required by adjusting pH in the feed water. Feed water pH control could be in the form of a trim sulphuric acid dosing system prior to RO membrane feed.

Similarly, to the UF plant, redundant trains would be proposed to achieve desired output capacity during cleaning sequences.

A RO Permeate Flushing Tank which collects RO permeate for the purposes of RO cleaning operations would be required. The use of permeate reduces the risk of the formation of scale that is associated with the use of potable water at high pH conditions when sodium hypochlorite is added. This scaling could present issues with clogged chemical feed lines and dosing point diffusers.

In addition, RO permeate would be used as service water in the formation of monochloramine for biogrowth control. The monochloramine makeup water should have low to no bromide concentration to avoid the formation of bromamines which can form Disinfection By-products (DBPs). The use of RO permeate reduces the risk of bromamine formation.

A CIP system would also be provided for bi-monthly RO membrane cleaning whilst in use. The system would consist of a cleaning solution recirculation pumping system, heated water tank and dedicated chemical dosing pumps fed from the bulk sulfuric acid and scale inhibitor storage tanks. The resultant spent CIP chemical solution effluent then would feed into the RO neutralisation tank where it would be neutralised using caustic soda prior to discharge to the Wastewater Return Pumping Station.

Preservation and planned maintenance activities for membranes would be required when the plant is not in use.

2.2.3.3.5 UV Advanced Oxidation Process - Hydrogen Peroxide Dosing and UV Activation

In the UV/ H_2O_2 process, UV light dissociates hydrogen peroxide into hydroxyl radicals which subsequently oxidize organic contaminants. Advanced Oxidation Processes (AOPs), such as the UV/ H_2O_2 process, are effective for breaking down recalcitrant organic chemicals including 1,4-dioxane and N-Nitrosodimethylamine (NDMA) that are not readily degraded by other oxidation processes, for example ozonation.

UV systems for purposes of UVAOP require a high UV dose, typically in excess of 500mJ/cm^2. The proposed UVAOP system would be capable of providing a minimum NDMA log destruction of 1.2 log and a 1,4-dioxane log destruction of 0.5 log based on final effluent data analysis from Beckton STW, which are common design criteria for UVAOP systems used in potable reuse applications. High concentrations of 1,4-dioxane in the Beckton STW final effluent may require more than 0.5-log removal.

Indicative UVAOP system configuration is provided in Table 2-7. Standby trains have not been assumed because maintenance requirements are limited and are likely to occur during plant shutdowns. A hydrogen peroxide dosing system would also be provided with dedicated dosing pumps fed by bulk chemical storage tank.

Table 2-7: Indicative UVAOP Configurations

Scheme Design	50Ml/d	100Ml/d	150Ml/d
Total No. Trains	2 No. Duty + 0 No. Standby	4 No. Duty + 0 No. Standby	5 No. Duty + 0 No. Standby
Hydrogen Peroxide (H_2O_2) Dose	4mg/l	4mg/l	4mg/l
Total No. Lamps (low pressure, high output)	1,152	2,304	2,880
Total Duty Load	262.1kW	486.7kW	711.4kW

2.2.3.3.6 Remineralisation (Lime and CO_2)

Following UVAOP treatment, the disinfected water stream would require treatment to reduce the corrosivity and acidity of the water. Remineralisation using lime and carbon dioxide dosing would reduce the aggressivity of the water. The remineralisation process involves preparation of a saturated lime solution which would be mixed with carrier water (RO permeate) and dosed to the main RO permeate. After addition of lime, the RO permeate would then be dosed with CO_2. This would be done by saturating a small stream of carrier water with CO_2 (stored in liquid form onsite) and delivering this to a static mixer.

The following Recycled Water quality targets were assumed to determine remineralisation requirements:

- Alkalinity of 60mg/l as $CaCO_3$
- Langelier Saturation Index (LSI) of 0.15

The targets were set based on previous Indirect Potable Reuse (IPR) scheme designs and research findings for recommended water quality to reduce impacts of corrosion on transfer pipelines.

Furthermore, RO permeate with low pH and high CO_2 content could occur; therefore, CO_2 stripping may be required as part of the remineralisation process. Carbon dioxide stripping has not been assumed in Gate 2. Further consideration will be required to determine requirements.

2.2.3.3.7 Chemical Dosing

Chemical dosing would be required throughout the plant for optimum performance, water quality management and to maximise membrane lifetime. The main chemicals that would be used in the plant and their locations are listed below:

- Pre-formed monochloramine would be dosed upstream of the UF plant to provide anti-foulant protection to downstream processes. The monochloramine solution would be produced onsite using sodium hypochlorite and liquid ammonium sulphate.
- Sulphuric Acid (H_2SO_4) would be dosed upstream of the RO membranes. The acid would be dosed to provide pH correction to prevent the formation of scalants and precipitates within the RO membranes.
- Anti-scalant would also be dosed upstream of RO membranes to prevent scaling.
- Sodium Bisulphite would be dosed downstream of the UV plant for the reduction in hydrogen peroxide and monochloramine residual prior to remineralisation feed.
- Hydrogen Peroxide (H_2O_2) would be dosed prior to UV irradiation to allow for the formation of the strongly oxidising hydroxyl radicals necessary within the UVAOP for the degradation of recalcitrant compounds.
- Lime, Calcium Hydroxide ($Ca(OH)_2$)), and Carbon Dioxide (CO_2) would constitute the chemicals used within the remineralisation process. Lime would be used to increase the alkalinity of the Recycled Water to an acceptable level and to increase calcium content. CO_2 gas would be injected to control the corrosivity of the water by controlling the calcium carbonate saturation index, the Langelier Saturation Index (LSI). Remineralisation chemicals would be dosed downstream of the UVAOP.
- Sodium hypochlorite disinfection would potentially be required downstream of UVAOP also to provide best practice in virus removal. This would also require dechlorination prior to river discharge. Water quality analysis and agreed pathogen removal targets would further inform the proposed treatment process as work progresses.
- Cleaning Chemicals that would be used within the UF and RO membrane systems to maintain membrane performance through removal of scaling and biological fouling and provide membrane longevity are:
  - UF Cleaning Solution: the CIP solutions include Sodium Hypochlorite (NaOCl) and Citric Acid. Daily Chemical Enhanced Backwashes (CEB) are completed using a Sodium Hypochlorite solution.
  - RO Cleaning Solution: additional anti-foulants are required for RO CIP, and often include Citric Acid, Sodium EDTA, Sodium Tripolyphosphate and Sodium Dodecilsulphonate.
- Neutralisation agents Sodium Hydroxide (NaOH) and Sodium Bisulphite. Spent chemical cleaning solutions would need to undergo neutralisation prior to discharge to the wastewater return pumping station use these agents.

As noted above, chlorine dosing and dechlorination prior to conveyance may also be required.

Chemical deliveries to the AWRP would be via a common hard standing area which drains to a dedicated chemical spill tank so that any accidental spills can be contained, treated and disposed of in an appropriate manner. Two chemical spill tanks would be used: one for alkaline wastes and the other for acidic wastes. These tanks would be linked to the site washwater pumping station.

2.2.3.3.8 Process Unit Summary

Indicative process units are summarised in the tables below.

Table 2-8: Indicative 50Ml/d Process Unit and Structure Sizes

Process item	Approximate building / structure area (m^2)	Approximate Length (m)	Approximate Width / Diameter (m)	Approximate Height above ground (m)
Pump station shaft	-	-	9 (dia.)	-
Final Effluent Pumping Station	208	23	9	5
Equalisation Tank	968	45	22	10
UF Feed Pumping Station	347	23	15	6
Ultrafiltration Building	1987	39	51	8
RO Feed Tank	145	-	14 (dia.)	7
RO Feed Pumping Station	347	23	15	10
Reverse Osmosis Building	2587	65	40	12
UV Advanced Oxidation Building	588	37	16	6
Remineralisation	958	51	19	15
Chemical Storage	1283	32	40	12
Recycled Water Pumping Station	347	23	15	6
Wastewater Return Pumping Station	74	12	6	6
RO Concentrate Pumping Station	74	12	6	6
Administration Building	569	38	15	8

*This table excludes transformer, standby power and fuel tank

Table 2-9: Indicative 100Ml/d Process Unit and Structure Sizes

Process item	Approximate building / structure area (m^2)	Approximate Length (m)	Approximate Width / Diameter (m)	Approximate Height above ground (m)
Pump station shaft	-	-	13 (dia.)	-
Final Effluent Pumping Station	236	24	10	6
Equalisation Tank	1,829	70	27	10
UF Feed Pumping Station	401	24	17	6
Ultrafiltration Building	2830	68	41	10
RO Feed Tank	278	-	19 (dia.)	8
RO Feed Pumping Station	401	24	17	6
Reverse Osmosis Building	3,130	68	46	15
UV Advanced Oxidation Building	641	34	19	6
Remineralisation	1,092	36	30	17
Chemical Storage	1,666	33	46	15
Recycled Water Pumping Station	401	24	17	6
Wastewater Return Pumping Station	74	12	6	6
RO Concentrate Pumping Station	74	12	6	6
Administration Building	569	37	15	8

*This table excludes transformer, standby power and fuel tank

Table 2-10: Indicative 150Ml/d Process Unit and Structure Sizes

Process item	Approximate building / structure area (m^2)	Approximate Length (m)	Approximate Width / diameter (m)	Approximate Height above ground (m)
Pump station shaft	-	-	16 (dia.)	-
Final Effluent Pumping Station	301	27	11	6
Equalisation Tank	2,800	80	35	10
UF Feed Pumping Station	635	27	23	6
Ultrafiltration Building	3,243	82	40	8
RO Feed Tank	419	-	23 (dia.)	8
RO Feed Pumping Station	635	27	23	6
Reverse Osmosis Building	3,860	86	45	12
UV Advanced Oxidation Building	958	41	24	6
Remineralisation	1,576	62	26	15
Chemical Storage	1,831	41	45	12
Recycled Water Pumping Station	635	27	23	6
Wastewater Return Pumping Station	74	12	6	6
RO Concentrate Pumping Station	74	12	6	6
Administration Building	568	37	15	8

*This table excludes transformer, standby power and fuel tank

2.2.3.4 Waste Streams Management

Waste streams are produced from the UF plant (including strainer backwash, UF backwash and neutralised CEB wastewater) and RO plant (including neutralised CIP wastewater and RO concentrate). Gate 1 conceptual design proposed the option of discharging RO concentrate to the Beckton STW final effluent channel whilst discharging UF plant waste to the head of the Beckton STW. In Gate 2, a possibility of combining all waste streams in the proposed Wastewater Return Pumping Station and discharging it into the head of the Beckton STW was investigated to reduce the costs.

However, further assessment of STW capacity to accept and treat the combined wastewater stream is required. Therefore, at this stage, conveyance designs have assumed requirements for separate pipelines for the wastewater from UF plant and the RO concentrate as adequacy of the capacity of Beckton STW has not been confirmed.

Table 2-11 and Table 2-12 show projected composition and load of combined waste stream flow based on 95%ile final effluent quality feed to the AWRP.

Table 2-11: Projected AWRP Combined Waste Stream Composition

Parameter	Units	Combined Waste Stream Composition
pH	ph Unit	7.6
Alkalinity (as CaCO3)	mg/l	938
Suspended Solids	mg/l	167
TDS	mg/l	4,393
Total Organic Carbon	mg/l	53
Nitrate (NO3)	mg/l	94
Total Nitrogen	mg/l	114
Phosphate	mg/l	65

Table 2-12: Projected AWRP Combined Waste Stream Flow and Load

Parameter	Units	50Ml/d Plant Design	100Ml/d Plant Design	150Ml/d Plant Design
Waste Stream Flow	Ml/d	13	26	38
Alkalinity (as CaCO3) Load	kg/d	12,024	24,071	35,976
Suspended Solids Load	kg/d	2,141	4,287	6,406
TDS Load	kg/d	56,306	112,721	168,467
Total Organic Carbon (TOC) Load	kg/d	681	1,364	2,038
Nitrate (NO_3) Load	kg/d	1,199	2,400	3,587
Total Nitrogen Load	kg/d	1,462	2,928	4,376
Phosphate (PO_4) Load	kg/d	838	1,678	2,507

2.2.4 Conveyance Design Components

2.2.4.1 Conveyance Design General Considerations

The general assumptions used to develop the tunnel are as follows:

- The first section of conveyance would be between the Beckton AWPR shaft to Lockwood Reservoir Pumping Station.
- The second section of conveyance would be between Lockwood Reservoir Pumping Station and the River Lee Diversion upstream of King George V (KGV) Reservoir inlet which also has the potential to convey additional flows from the existing Thames Lee Tunnel.
- Both sections of tunnel would have an internal diameter (ID) of 3.5m.
- The direction that the tunnel would be driven between shafts, which shaft sites will contain drive shafts and which will contain reception shafts, would ultimately be a decision made later in the design process, with input from stakeholders including the contractor for the works.
- Based upon space requirements for a Tunnel Boring Machine (TBM), drive shafts and reception shafts would require to be 12.5m ID with a construction site area of approximately 5,000m^2.
- Intermediate shafts would be 10.5m ID with a construction site area of approximately 2,500m^2. Some shafts may have to be resized to 12.5m ID if the tunnel alignment is altered and a change in TBM launch direction is required. This will be assessed at later stages of the project when further geotechnical and settlement information is known.
- Intermediate shafts would be required along the tunnel alignment in accordance with health and safety tunnelling guidelines and for future maintenance and operational purposes. Generally, these would be constructed at intervals of up to 2.5km between shafts.
- Consideration would be given to the items, including but not limited to, below in the site/ route selection process:
  - Area of land available.
  - Ease of access for construction vehicles and transportation of material.
  - Distances between shafts (as described above).
  - Minimising impact to surrounding areas.
  - Nature of the land and its current use for ease of procurement.
  - Minimising construction impact.
  - The 3rd party impacts of the shaft locations

- A review of other underground assets and services and ensuring there are no clashes or that mitigation measures are minimised.

The conveyance route will be selected through stakeholder engagement as the design develops with supplementary information including route geology.

2.2.4.2 Tunnel Route

The total length of the conveyance route from the Beckton Advanced Water Recycling Plant to the River Lee Diversion is approximately 22.3km. The proposed tunnel route is via two sections as per the following:

- Beckton AWRP to Lockwood Reservoir Pumping Station
- Lockwood Reservoir Pumping Station to KGV (Thames Lee Tunnel Extension)

The route could be constructed using two TBM drives. Both tunnels would be constructed within the first phase of the Beckton Water Recycling scheme if the scheme is developed in multiple phases. Should Beckton Water Recycling scheme be selected for delivery in early 2030's a third TBM may be required to reduce the lead time and meet this completion time.

2.2.4.3 Tunnel Shafts

Indicative shaft details for the Recycled Water Transfer Tunnels are listed in tables below:

Table 2-13: Beckton AWRP to Lockwood Reservoir Pumping Station Recycled Water Transfer Tunnel Indicative Shaft Details

Shaft	Shaft Internal Diameter (m)	Approximate Ground Level (mAOD)	Approximate Shaft Depth (m)	Approximate Shaft Base Level (mAOD)
Beckton AWRP Shaft Site	12.5	4	42.5	-38.5
Shaft Site 1	10.5	3	39.5	-36.5
Shaft Site 2	10.5	14	47.6	-33.6
Shaft Site 3	10.5	15	44.8	-29.8
Shaft Site 4	10.5	6	30.0	-24.0
Shaft Site 5	10.5	10	28.4	-18.4
Lockwood Primary Shaft Site	12.5	9	26.7	-17.7

Table 2-14: Lockwood Reservoir Pumping Station to KGV Recycled Water Transfer Tunnel (Thames Lee Tunnel Extension) Indicative Shaft Details

Shaft	Shaft Internal Diameter (m)	Approximate Ground Level (mAOD)	Approximate Shaft Depth (m)	Approximate Shaft Base Level (mAOD)
Lockwood Secondary Shaft Site	12.5	9	26.7	-17.7
Shaft Site 7	10.5	10	28.3	-18.3
Shaft Site 8	10.5	17	35.9	-18.9
Shaft Site 9	10.5	14	33.7	-19.7
River Lee Diversion / KGV Shaft Site	12.5	15	35.3	-20.3

2.2.4.3.1 Beckton AWRP Shaft Site

This shaft would be located within the land allocated for the proposed AWRP in the Beckton STW site. This shaft could be the drive shaft for the tunnel drive from Beckton AWRP to the Lockwood site. This site could offer sufficient site space for driving the TBM and has an opportunity to use the river for spoil removal.

2.2.4.3.2 Intermediate Shaft Sites

Several intermediate shafts would be equipped along the proposed tunnel route between the Beckton Shaft site and Lockwood Primary Shaft site to launch and receive the TBM undertaking the tunnel construction. The compounds could be sized at approximately 2500m^2 to enable storage, transportation and construction works. The internal diameter of the intermediate shafts would be approximately 10.5m. It is not envisaged that spoil from TBMs would be removed from the intermediate shafts but extracted from the launch shafts.

2.2.4.3.3 Lockwood Shafts Site

The Lockwood Primary and Secondary Shafts would be located near the existing Lockwood Reservoir Pumping Station. These shafts could act as the reception shafts for the Beckton to Lockwood drive as well as the KGV to Lockwood for the Thames Lee Tunnel (TLT) Extension.

The Lockwood Reservoir Pumping Station extracts from the TLT and delivers flows to the Lee Valley system. Therefore, selection of this site would allow integration of the Beckton and TLT extension schemes into existing infrastructure. The proposed construction site is constrained as there are high voltage power lines and a tower as well as being surrounded by waterbodies and embankments. Further assessments on impact, mitigations and liaison will be required in conjunction with the appropriate All Panels Reservoir Engineer (APRE).

2.2.4.3.4 River Lee Diversion/ KGV Shaft Sites

This shaft would be located to the North of the KGV intake on the West bank of the River Lee Diversion. This site is within Thames Water's operational area which is preferable to limit impact of works during construction and ease of future maintenance access.

The shaft could be used as the drive shaft for the TBM which could be driven to the Lockwood Pumping Station site. The proposed site has several constraints such as overhead power lines, underground power lines, water main and high-pressure gas main in close proximity to the site.

2.2.4.4 Tunnel Connections in Lockwood Reservoir Pumping Station Site

The Recycled Water flows from Beckton AWRP into the Lockwood Primary Shaft would need to be transferred into the Lockwood Secondary Shaft in order to be sent forwards into the KGV Discharge. This connection would be made using an approximately 30m-long, smaller-diameter pipeline that would start from the submersible pumps at Primary Shaft and feed into the top of the Lockwood Secondary Shaft. There is an opportunity that the pumping between the two shafts will be eliminated with a low-level, controlled connection.

The existing Thames Lee Tunnel (TLT) and the proposed Recycled Water Transfer Tunnel between Lockwood Reservoir Pumping Station and KGV could be potentially connected to improve water resources resiliency in East London (TLT extension). The TLT Extension would convey raw water from the River Thames and Recycled Water from the Beckton AWRP. The existing pumps in the Lockwood Reservoir Pumping Station have been reviewed, and the initial assessment suggested that the existing pumps are capable to convey TLT flow to the proposed TLT extension.

2.2.4.5 Recycled Water Discharge Arrangement

A new discharge arrangement would be required on the River Lee Diversion, within Thames Water's operational area for KGV inlet.

Each pump in the KGV Shaft would deliver flow in pipes directly to the discharge structure. This would avoid the need for a valve chamber and pipe manifold at ground level and allow the system to operate efficiently over a range of flow rates. Delivery pipes would exit the KGV Shaft at or near ground level, and each delivery pipe would terminate at the discharge structure which allows the recycled water to pass into a wide, open channel at a much-reduced velocity. The flow would then pass under the riverside path in a shallow culvert and over a weir into the River Lee. Line of sight screening would be provided between the footpath and the discharge structure.

Modelling work is being carried out to confirm environmental impacts. Designs of the outfall is to be further developed through feedback from modelling results and conversations with regulatory authorities and local communities.

2.2.4.6 Tunnel Profile and Existing Infrastructure

The tunnel invert would vary between -17.7m and -38.5mAOD, approximately at depths between 26.7m and 47.6m below ground level. The tunnel would be constructed with varying gradients between 1:250 and 1:3500 uphill from Beckton STW towards the Lockwood Shaft Site. The gradient would allow the tunnel to be drained down back to Beckton STW when required for maintenance. The section between Lockwood and KGV would have a downward sloping tunnel with a gradient of 1:3500 which would allow the tunnel to be drained into the River Lee Diversion. Drain down for both tunnel sections could be done by gravitation and extraction at the shafts by using the abstraction pumps.

Borehole records located near the different shaft sites have been reviewed, which show the presence of London Clay, Lambeth Group, Thanet Sands and Chalk. Ideally the tunnel would be constructed within London Clay or Chalk, however the London Clay formation was not found to be contiguous, and the top of chalk was found at depths uneconomical for shaft construction. Consequently, the tunnel would be primarily within Thanet Sands and the Lambeth Group. A first phase settlement assessment will be required to estimate predicted settlements.

A utilities search was undertaken, and initial consultation was undertaken with relevant critical stakeholders. The information acquired was used to amend the proposed tunnel alignment and profiles, considering acceptable safe clearance at crossings with the utilities such as power lines and gas mains.

Most of the reservoirs in the Lee Valley fall under the 1975 Reservoirs Act and therefore the effects of the tunnel on the integrity of the reservoirs will need to be assessed in detail at the next stage of design with input from All Reservoirs Panel Engineer (ARPE).

2.2.4.7 Pumping Stations

Pumping stations (PS) are required for the abstraction pumps, inter process and Recycled Water conveyance pumps. The key pumping requirements would be as follows.

Final Effluent Pumping Station: To abstract final effluent from the existing final effluent channel in Beckton STW and transfer to the proposed Advanced Water Recycling Plant (AWRP) in proximity to the abstraction location within the STW. This PS would be located within Beckton STW.

UF Transfer Pumping Station: To transfer UF waste generated through treatment in AWRP to the inlet of the Beckton STW for treatment. This PS would be located within AWRP.

RO Transfer Pumping Station: To transfer RO concentrate generated through treatment in AWRP to the inlet of the Beckton STW for treatment. This PS would be located within AWRP.

Waste Return Pump Station: To transfer Waste Water generated through treatment in AWRP to the inlet of the Beckton STW for treatment. This PS would be located within the AWRP.

Lockwood Shaft Pumping Station: To lift conveyed Recycled Water from the Lockwood Primary Shaft to the Lockwood Secondary Shaft. The pumps would be located inside the tunnel shaft at the Lockwood site.

KGV Shaft Pumping Station: To lift conveyed Recycled Water from the KGV Shaft at the discharge site on the River Lee Diversion and discharge to the outfall. The pumps would be located inside the tunnel shaft at the KGV Discharge site.

2.2.5 Operating Philosophy

The water recycling schemes would operate intermittently as required during periods of drought in the Thames Water Drought Plan framework. Anticipated operational utilisation rates are set out in section 4.1 in the Gate 2 Report.

It was assumed that the water recycling schemes would be utilised and operated as one of the strategic drought schemes in the Thames Water Drought Plan and that the trigger of utilisation would be same as the strategic drought schemes in the current Drought Plan. Strategic drought schemes are sources of water that are permitted for use during drought period but are not used as part of day to day' baseline supply. Thames Water Draft Drought Plan 2022 lists five strategic drought schemes including Thames Gateway Water Treatment Works (TGWTW).

In the Thames Water Drought Plan, utilisation of the strategic drought schemes is triggered by:

- Naturalised flow over Teddington Weir receding down to 3000Ml/d on average for 10 days during the course of a drought event (defined as having a Drought Event Level (DEL) equal to or greater than DEL1), and Reservoir storage levels having fallen to the 800-700/600Ml/d flow requirement at Teddington Weir.

2.2.5.1 Operating Modes

Operations of international and domestic water reuse and desalination plants, including Thames Water Gateway Desalination plant, were reviewed. Interviews with technical and operational staff from these plants were held to assess various operational modes

The types of operating modes considered were:

- **Normal Operation:** Treatment plant and conveyance assets are operating in normal automatic control (25-100% of maximum capacity) and delivering Recycled Water or Treated Effluent to the intended discharge location.
- **Hot Standby:** Operating mode where a plant runs at a proportion of total flow (25% or less of maximum capacity), with a 'duty' stream under Normal Operation and with parts of the plant in standby and is able to return into Normal Operation within a day to two weeks. Conveyance assets would transfer part of, or all Treated Effluent/ Recycled Water generated in the plants for "sweetening".
- **Cold Standby:** Operating mode where process units are available to return to Normal Operation mode within several weeks. Recycled Water or Treated Effluent would not be produced or be produced in minimal amount of flow which would be run to waste. Conveyance assets would be drained down.
- **Care and Maintenance:** Operating mode under which the asset is not delivering any water, but maintenance is carried out in order to keep the plant serviceable and able to return into Normal Operation mode within a few months. Process assets would be in preservation mode to allow maintenance only, and any maintenance flows from the plant would run to waste. Conveyance assets would be drained down.
- **Non-operational:** Treatment plant and conveyance element are out of service and there is minimal ongoing expenditure.

Non-operational mode would pose major risks to the treatment plant. Fully offline treatment assets are unlikely to be suitable for restart without major replacement works and timely re-commissioning which would be costly and not practicable. The Cold Standby mode may not be recommended as it would offer negligible benefits over the Hot Standby mode posing higher risks due to the conveyance assets being drained down.

2.2.5.2 Operating Models

Three operating models were assessed at Gate 2:

Continuous Sweetening Flow Model: The system would be in Hot Standby mode during non-drought periods and would generate Treated Effluent/ Recycled Water at lower rate (i.e., 25% of full capacity or less) to enable timely commissioning when supply is required.

Cautious Restart Model: The system would be in Hot Standby mode during non-drought periods for approximately 6 months of the year (in the months of highest likelihood of droughts) to facilitate timely recovery to Normal Operation mode. During the other 6 months, the system would be in "Care and Maintenance" mode, with the conveyance drained and any flows through the plant for maintenance would be discharged to the STW inlet. Alternatively, the conveyance system could be kept full, and a very small sweetening flow slowly discharges at the proposed outfall following periodic operation of the plant. However, additional chlorination would likely be required to prevent biomass build up. The process and conveyance assets would require relatively complex ramp-up procedures each year from Care and Maintenance mode to Hot Standby mode.

Infrequent Restart Model: The system would be in Hot Standby mode during non-drought periods for approximately 3 months of the year (in the months of highest likelihood of droughts) to facilitate timely recovery to Normal Operation mode. During the other 9 months, the system would be in Care and Maintenance mode, with the conveyance drained and any flows through the plant for maintenance would be discharged back to the STW inlet. The process and conveyance assets would require relatively complex ramp-up procedures each year from Care and Maintenance mode to Hot Standby mode.

The Continuous Sweetening Flow model, which would have high operational costs, but with lower operational complexity and risks, would be recommended for all the London Effluent Reuse SRO schemes at this stage. Details of operating model will be further reviewed and optimised in terms of costs, carbon output, environmental impacts, operational complexity, reliability and security.

Beckton Recycled Water scheme has two differing factors from the other London Effluent Reuse SRO schemes in operation and maintenance:

- The AWRP process does not have biological processes that can take many weeks or months to reach required treatment capacity. With a detailed plan of asset maintenance or replacement and periodic pass forward flows through plant equipment, the ramp up time from Care and Maintenance mode to Hot Standby mode is likely to be 6-8 weeks maximum and so a restart model could be more feasible.
- In Care and Maintenance Mode, the preference is to drain the tunnels fully and not to discharge any AWRP maintenance flows through the tunnels (run-to-waste). The size and length of the Beckton conveyance tunnels and the slope of the tunnels for drainage means this is a simpler, less time-intensive process when compared to a pressurised pipeline. Additionally, modern tunnels suffer minimal groundwater ingress and therefore the tunnel can remain empty with lower risk / maintenance requirements.

2.2.5.3 Advanced Water Recycling Plant Chemical Consumption

Chemicals required for operation of the AWRP for pre-treatment and cleaning purposes would include: Ammonium Sulphate, Sodium Hypochlorite, Sulphuric Acid, Anti-Scalant, Hydrogen Peroxide, Sodium Bisulphite, Lime, Carbon dioxide, Citric Acid, and RO CIP Chemicals (including Sodium Tripolyphosphate, Sodium Dodecilsulphonate and Sodium EDTA).

2.2.5.4 Maintenance Requirements

2.2.5.4.1 Advanced Water Recycling Plant

Advanced Water Recycling Plant would have multitude of ancillary systems which feed into the main process stages of Ultrafiltration (UF), Reverse Osmosis (RO) membrane, hydrogen peroxide dosing and UV treatment (UVAOP) and remineralisation. Key items for maintenance of AWRP would include the followings:

- AWRP general maintenance – continuous, automated water quality monitoring of feed water, permeate and concentrate. Frequent MEICA maintenance for all pumps, instruments, valves, etc. and normal fault finding and resolution to ensure strict water quality parameters.
- Replacement of RO membranes – expected every 5 years (assuming suitable maintenance including automated flushing cycles and chemical cleaning regimes (CIP))
- Replacement of UF membranes – expected every 5 years (assuming suitable maintenance including automated flushing cycles and chemical cleaning regimes (CIP))
- Replacement of UV lamps – expected every 5 years
- Energy Recovery Devices – turbines / pressure exchange modules require frequent inspections and troubleshooting to ensure efficient generation of recovered energy.

2.2.5.4.2 Conveyance

When in Normal Operation, the tunnels would operate with the shafts at either end acting as balancing tanks. Recycled Water would be pumped into the shaft at Beckton STW and other pumps at the Lockwood and KGV shafts would draw water out at the other end of the tunnel. A single networked control system would simultaneously control all the pumps at the various shafts to maintain suitable water levels in the shafts to allow the pumps to operate and to provide the driving head to push the water along the connecting tunnels.

When the scheme is in Care and Maintenance Mode, the tunnel would be pumped dry and left drained until it is used again. The tunnels could be emptied from the lowest points at the Beckton AWRP and the KGV Shaft. Modern tunnels suffer very little ground water ingress; therefore, the tunnel can remain drained with minimal risk. Periodic inspections of the tunnel to confirm the condition when drained and clearing out of any settled materials or organic matter infrequently would be required. There are potentially some areas of running sands along the tunnel route and periodic checks to assess any ingress and removal would be required. The tunnel would be unlikely to need any capital maintenance for a significant number of years.

The conveyance pump sets would have duty and standby units and the control system would be designed to ensure utilisation is spread equally between the pumps to equalise wear. The pumps are specified that one can be removed for maintenance and repair without compromising the operation of the system.

At times when the tunnel is in Care and Maintenance Mode, the pumps would be kept active and in working condition by running flows to waste occasionally (or using drinking water). This would also help to prevent any corrosion and deterioration of the pump components.

It has been assumed that a sweetening flow of a proportion of the maximum flow would be sufficient to keep the flow “sweet” for the conveyance elements whilst in Hot Standby Mode. This would be needed in order to avoid the water in the tunnel deteriorating when the option is in minimum turndown and not in Normal Operation Mode. Optimum rate of sweetening flow will be determined in the future design stage. At this stage, it is estimated that a 15Ml/d of sweetening flow would be required for the tunnels regardless of the scheme capacity. As it was assumed that the AWRP would constantly generate recycled water at approximately 25% of the scheme capacity during non-draught periods in the Continuous Sweetening Flow model, flows greater than 15Ml/d could be returned to the Beckton STW final effluent channel during non-draught periods in the scheme with a large capacity. The optimum rate of sweetening flow both for AWRP and conveyance system will be determined in the future design stage.

The outfall structure on the River Lee Diversion is located in Thames Water’s land and is intended to require minimal maintenance. Besides the pumps installed in the KGV Shaft, regular visual inspections would need to be carried out on the outfall to ensure that windblown debris does not build up in the channel and culvert and that the discharge weirs and security screens remain clear. Care would be taken to remove any weeds or plants that may self-seed in the open channel. Routine inspection and maintenance of the air valves on the delivery pipes would need to be carried out, particularly before and during the outfall operation.

2.2.5.5 Fail Safe Shutdown System

In the event of a water quality failure, the scheme would “fail safe”, via a run-to-waste back to the Beckton Sewage Treatment Works. The treatment facilities would be monitored at Critical Control Points (CCPs) for the required water quality parameters and will initiate an auto-shutdown/diversion of flow in the event of registering out of bound (“critical limit”) quality parameters or catastrophic failure of the plant.

If the AWRP fails in the events such as power loss and treatment or chemical failure, then there would be a lock in of flow passing through the plant (with offline balancing tanks to store pass forward flow during shutdown if necessary). The Final Effluent Transfer Pumping Station, which would be feeding the AWRP, would automatically shut down on failure.

The locked in process flow would then be run-to-waste, where all flows would pass to the AWRP Waste Return Pumping Station, to return all locked-in flows to the Beckton STW inlet works for treatment.

2.2.6 Inter Site Control System Requirements

The following might be required for the inter site control system:

- Communication links between the Beckton AWRP and the proposed Lockwood Primary Shaft Pumping Station (PS) may be provided to relay the water levels in the shafts and PS operational status and control. In the event of a power outage at Lockwood Shaft Pumping Station, Recycled Water transfer from the Beckton AWRP to Lockwood and from Lockwood to KGV would stop.
- Communication links between the Beckton AWRP and the KGV Shaft Pumping Station might be provided to relay the water levels in the shafts and PS operational status and control. In the event of a power outage at the Lockwood Primary Shaft Pumping Station, Recycled Water transfer from the Beckton AWRP to Lockwood and from Lockwood to KGV would stop.

- Communication links between the proposed Lockwood Primary Shaft Pumping Station and the KGV Shaft Pumping Station would be provided to relay operational status between sites. In the event of a power outage at Lockwood Primary Shaft Pumping Station, Recycled Water transfer from the Beckton AWRP to Lockwood and from Lockwood to KGV would stop.
- Connection to the wider Thames Water Production Planning system might be provided to regulate operating capacity based on current river and reservoir levels.
- If the TLT were to be connected to the Recycled Water Transfer Tunnel from Lockwood to KGV, communication links between the existing TLT system, including the existing Lockwood Reservoir Pumping Station, and the proposed Beckton Water Recycling system would be established.

2.2.7 Power Requirements

There are three sites requiring new or upgraded power supplies.

- Beckton Advanced Water Recycling Plant (AWRP)
- Lockwood Primary Shaft Pumping Station (PS)
- KGV Shaft Pumping Station

In addition, Tunnel Boring Machines (TBM) might require upgrade or reinforcement of the network at some shaft sites temporarily during construction.

2.2.7.1 Potential Power Requirements at Beckton AWRP

The electrical supply and distribution for the proposed AWRP could be arranged as an 11kV supply terminating at a new High Voltage (HV) switchboard, located within a new HV electrical Switchroom. An 11kV radial supply from the AWRP HV switchboard would feed local step-down transformers which in turn would provide power to sub-fed Low Voltage (LV) Motor Control Centres (MCCs). All phasing options would have similar layouts with only variations being in number of local step-down transformers and sub-fed LV MCCs.

2.2.7.2 Potential Power Requirements at Lockwood Primary Shaft Pumping Station

The pumping station would require a first-time low voltage power supply provided by the local DNO. The new power supply would terminate at the site LV MCC. The local MCC would provide power to pumps as well as to building services and ventilation for the electrical building. The pumps would be controlled by VSD motor starters housed within the MCC. The MCC might require a building sufficiently sized to include both the MCC alongside DNO metering and communication equipment.

2.2.7.3 Potential Power Requirements at KGV Shaft Pumping Station

The pumping station would require a first-time high voltage power supply provided by the local DNO. The new power supply to the site would terminate at the site LV MCC via a single step-down transformer. The local MCC would provide power to pumps, which would be located within the shaft. Additionally, the MCC would provide power to building services and ventilation for the electrical building. The pumps will be controlled by VSD motor starters housed within the MCC. The MCC might require a building sufficiently sized to include both the MCC alongside DNO metering and communication equipment.

2.2.8 Greenhouse Gas Mitigation, Energy Recovery and Renewable Energy Opportunities

Estimates of capital carbon (embodied carbon) and operational carbon for London Effluent Reuse schemes could be found in section 6 of the Gate 2 Report and Annex A.5 of the Gate 2 Report.

To maximise alignment with PAS 2080 and the Water UK Net Zero 2030 Routemap, the emissions hierarchy, which is detailed in the figure below, would be followed when deciding which approach to prioritise to mitigate emissions. This prioritises in order demand reduction, efficiency gains and renewable energy integration before pursuing offsets to remove residual carbon emissions. Due to the complexity and long lifetime of these schemes, it is important to take a holistic approach to carbon mitigation, which uses a combination of approaches.

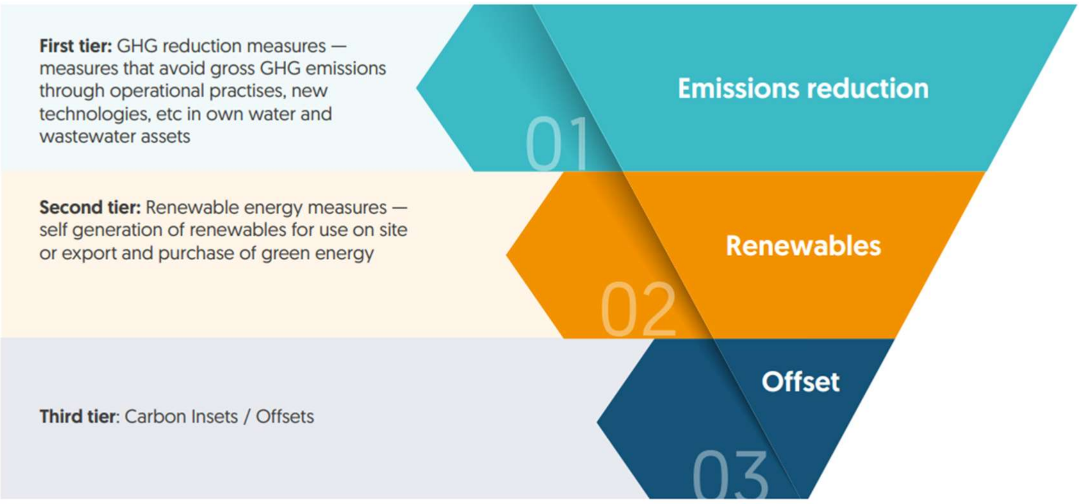

Figure 2-3 Emission Reduction Hierarchy

Capital emissions represent the majority share of total Greenhouse Gas (GHG) emissions in the short term - as such, focusing on reducing capital emissions will likely yield significant reductions across the early stage of a site's operational life. A focus on 'designing out' carbon can reduce both capital and operational emissions, in particular for building heating and plant efficiency.

While annual operational emissions are less than those released due to material sources, over time, across the lifetime of a site operational emissions would contribute significantly. Therefore, reducing operational emissions will achieve the great reduction of GHG emissions in the long term. This approach is also line with the Water UK and TWUL targets of net zero operational carbon by 2030.

It should be noted that operational GHG emissions from electricity demand would be zero for London Effluent Reuse SRO because all electricity purchased would be zero carbon via either a Renewable Energy Guarantee of Origin (REGO) contract or Power Purchase Agreement (PPA) as per Water UK Net Zero 2030 commitment. However, carbon values reported in section 6.5 and Annex A.5 of Gate 2 Report include electricity carbons for operation.

Table below lists the potential GHG mitigation approaches, providing a high-level ranking of their potential impact on emissions reduction, including potential influence on reduction of scope 2 and scope 3 carbon, and alignment with the emissions hierarchy.

Table 2-15: Summary and Ranking of Potential Carbon Emission Reduction Approaches for London Effluent Reuse schemes

Approach to mitigate carbon emissions	Emissions Hierarchy Category	Potential for emissions reduction	Ability for Thames Water to Influence	List of options
Energy management & efficiency (highest priority)	Emissions reduction	High	High	- Improved pump efficiency - Metering - Smart control systems - Catchment level analytics
Renewable energy on site	Renewable energy	High	High	- Solar - Wind - Storage
Procured Renewable Energy	Renewable energy	High	High	- Sleeved power purchase agreement (PPA) - Synthetic PPA - Private Wire PPA - REGO-backed Green Tariffs
Resource Efficiency and Chemical Supply	Emissions reduction	High	Low	- Supply chain contracts

Approach to mitigate carbon emissions	Emissions Hierarchy Category	Potential for emissions reduction	Ability for Thames Water to Influence	List of options
				- Reduced resource use
Embodied emissions reduction	Emissions reduction	Moderate	High	- Low carbon concrete - Low carbon steel - Recycled materials - Locally sourced materials
Engineering design	Emissions reduction	Moderate	Moderate	- Conveyance routes - Land use - Building size - Building heating
Construction emissions	Emissions reduction	Low	Moderate	- Reduced transport - Vehicle energy use - Renewable onsite power - Temporary buildings
Insets	Offset	Low	Moderate	- Peatland restoration - Grassland restoration - Tree planting
Offsets (lowest priority)	Offset	Low	High	- UK Emissions Trading Scheme (ETS) - Voluntary Offset Market

2.3 Opportunities and Future Benefits Realisation

Key opportunities identified in the conceptual design are listed in Table 2-16 below.

Table 2-16: Key Opportunities – Beckton Water Recycling Conceptual Design

Category	Opportunities
Process System Design	Equalisation tanks were sized assuming 4-hour retention the new AWRP. There may be an opportunity to reduce the retention time following further design work, such that volume and footprint of the tanks would be reduced.
Process System Design	There is an opportunity to rationalise and develop best outcome treatment requirements through pilot work and/or full engagement with stakeholders with regards to expectation of treatment processes, customer acceptability and engagement and environmental outcomes. This may consider non-RO treatment trains and more detailed water quality risk assessment.
Process System Design	There is an opportunity to reduce redundant RO membrane trains as the London Effluent Reuse schemes would need less redundancy in comparison to conventional water treatment plants because: ▪ The schemes would not supply water directly to the customers. Therefore, failure of the system would not immediately impact the customers. ▪ Supply from the schemes are required only during drought periods. This could significantly reduce the required plant footprint and costs. Reasonable Level of Service for this scheme would need to be investigated.
Conveyance System Design	According to the hydraulic assessments it may be possible to remove the pumps from the Lockwood Primary Shaft and rely entirely on the pumps at Beckton AWRP and KGV Shaft to control the flows in the tunnels. In addition, if the two tunnels could be constructed at the same time, Lockwood Reservoir PS site may require only one shaft. Further, a syphon system could be implemented between the proposed shaft at Lockwood and the existing TLT terminal shaft (existing Lockwood Shaft) if the water level in the Lockwood Secondary Shaft remains lower than the existing TLT terminal shaft.
Conveyance System Design	The Gate 2 conceptual design assumed discharge pumps suitable for 300Ml/d flows for the proposed tunnels. If the ultimate scheme size is smaller than 300Ml/d, the number of pumps could be reduced.

3. Scheme Delivery

3.1 Overview of Construction Process

3.1.1 Advanced Water Recycling Plant

The Advanced Water Recycling Plant (AWRP) is proposed to be located within the existing Beckton STW to the North of the existing operational area. This is near the site entrance on Jenkins Lane and the existing Safety and Security Centre. The existing infrastructure in the Beckton STW, including roads, drainage and services as well as boundary fencing, access barriers, gates and security, could be utilised.

The extent of the site is constrained by a pond which runs along the South-eastern edge of the site boundary and a fenced off footpath running along the Northern and Eastern edges of the site. Additionally, there are two electrical pylons carrying overhead cables across the site, and sufficient clearance will be required from the permanent structures and for any work during construction.

Construction elements of AWRP would be either reinforced concrete or steel-clad buildings housing treatment and mechanical, electrical, instrumentation control and automation (MEICA) equipment. Gated access would be provided from the existing car park at the entrance of the Beckton STW.

The site could accommodate the 150Ml/d single-phase plant development with all process buildings and tanks in above-grade and single-storey configurations. As for the two-phase 150Ml/d capacity AWRP (i.e., 50Ml/d+100Ml/d phasing), construction elements would be both above and below-grade due to the space constraints on site. Equalisation Tank would be located underneath the Ultrafiltration (UF) building. For 300Ml/d capacity AWRP (150Ml/d+150Ml/d phasing), construction elements would also be both above and below-grade due to the space constraints on site. Equalisation Tank, Neutralisation Tank and Reverse Osmosis (RO) Feed Tank could be in basement level, and facilities associated with UF, RO, UF Transfer Pumping Station, RO Transfer Pumping Station, Chemical Storage and the UV Advanced Oxidation Process could be in the same building and on the ground floor and the first floor.

Construction of the AWRP would need to be coordinated with the shaft construction for the Recycled Water Transfer Tunnel as it would be located within the AWRP site.

3.1.2 Conveyance

3.1.2.1 Tunnel Construction

The proposed tunnel alignment between Beckton AWRP and River Lee Diversion would be constructed using a Tunnel Boring Machine (TBM) which is lowered to the base of the drive shaft, where a cutter head at the front excavates the ground ahead whilst a mechanical erector located behind in the TBM installs pre-cast concrete segments to form the tunnel lining. Typically for a 3.5m internal diameter tunnel, six segments making a ring 1.3m wide and 225mm thickness would be used. The TBM bore diameter would include a 100mm overcut, which provides clearance to enable the machine to advance. The annulus left would then be grouted. A 3.5m ID tunnel therefore requires a tunnel cut of 4.15m. The tunnelling is shown to be on the critical path of construction activities and the provision of an additional TBM would reduce the construction period.

For the Recycled Water conveyance, a tunnel ID of 3.5m has been assumed. This would be the minimum recommended diameter for long tunnel drives based upon current health and safety guidelines for construction. This would allow sufficient space for a refuge within the TBM in case of smoke or fire between workers at the front of the TBM and the emergency access shaft. There would also be practical considerations for diameter of tunnel such as ease of material supply, ventilation, spoil removal and operation.

The type of TBM depends on the ground conditions expected. If the alignment passes through a variety of conditions, it may be beneficial to split the tunnel alignment into several tunnel drives using different machines for the different ground conditions.

The choice of drive location and direction of drive depends on factors such as the available space at each shaft, ease of material supply and spoil removal and the gradient of the tunnel. The tunnel conceptual design would be to construct the tunnel using two drives:

- Beckton AWRP to Lockwood Reservoir Pumping Station
- River Lee Diversion upstream of KGV inlet to Lockwood Reservoir Pumping Station

Back shunts would be required at the base of the drive shafts, to set up the TBM, which includes the carriages behind the main machine for ventilation, spoil conveyors, electrical power. Typically, the back shunt would be constructed with a sprayed concrete lining and its length would depend on the length of the carriage train.

3.1.2.2 Secondary Lining

To avoid contamination of the water supply, the tunnel would be designed to prevent seepage of water into and out of the tunnel. This can be achieved using high-quality segmental lining with robust seals.

However, a secondary lining may need to be considered depending on the ground conditions and confining pressure of surrounding ground. This would be achieved with a reinforced in-situ concrete lining. A secondary lining would have an impact on both the cost of the tunnel works and the overall construction programme. This will need to be determined at the future stage of design.

3.1.2.3 Shaft Construction

This conceptual design indicates the most likely shaft construction method, but the final choice depends on many factors, particularly influenced by the details of the ground conditions that would emerge from ground investigations.

3.1.2.3.1 Segmental Shaft Construction

Segmental lining is the most common method of construction, and often preferred, as it is generally the quickest and least expensive, and it can be adapted to many ground conditions. Segments are installed by two methods, caisson jacking or underpinning, and the method used depends on the ground and groundwater conditions:

- Caisson jacking involves the assembly of segmental rings on the surface over a cutter head and jacking this into the ground. As the assembly advances, ground is excavated from inside and additional rings are placed on top. This method is particularly suitable in soft ground. After it reaches the required depth, the annulus around the shaft is grouted to limit further ground movements and mobilise friction with the surrounding soil. In wet ground, to balance water pressure, the shaft is left full of water, and ground is excavated below water. This is termed a ‘wet caisson’.
- Underpinning involves excavating ground below existing rings and installing segments beneath these. This process is repeated to the base of the shaft and then the annulus is grouted. The method is most applicable when the ground is stable on excavation and there are limited inflows of ground water.

It is common practice to start a shaft by caisson jacking in softer superficial soils and switch construction to underpinning as the competence of the ground improves.

3.1.2.3.2 Sprayed Concrete Lining Shaft Construction

Sprayed concrete lining (SCL) requires good stable ground conditions with self-supporting soil such as London Clay and is therefore not suitable for all ground conditions. As openings are easier to create in SCL linings than segmental linings, it is sometimes advantageous to switch from segmental to SCL at the base of shafts where openings are most often located. Typically, SCL will be used to construct the lower part of the shaft once the segments are within the London Clay formation. The SCL lining will normally require a secondary in-situ concrete lining to form a smooth surface and for control of seepage.

3.1.2.3.3 Secant Pile Construction

Secant piling (or diaphragm walls for larger shafts) is generally the most expensive method of construction but may be necessary in difficult ground and ground water conditions. The secant lining will normally require a secondary in-situ concrete lining to form a smooth surface and for control of seepage.

3.1.2.4 Lockwood Shaft Site Construction

The Lockwood Primary and Secondary Shafts would be constructed using one of the methods detailed in section 3.1.2.3 whilst looking at the solution that would minimise the extent of any settlement at the toe of the Lockwood reservoir.

The construction site is highly congested with a small available footprint but is located so it is in close proximity to the TLT Lockwood Shaft (Lockwood Reservoir Pumping Station). There are overhead power lines crossing the site so in order to enable construction operations a horizontal gantry crane would need to be equipped to provide low lifting clearances. Design liaison will be required with the utilities providers to confirm standoff distances and method statements for safe working.

The pipeline that connects Lockwood Primary Shaft with the Secondary Shaft would be located closer to the surface level, and the connecting pipeline could potentially be installed using open cut methods.

The Lockwood Secondary Shaft may be connected to the existing Lockwood Reservoir Pumping Station for the TLT extension with a smaller diameter pipeline constructed by open-cut installation methods. The new pipework would be connected to the existing outlet pipework of the TLT Lockwood Reservoir Pumping Station with new valves, actuators and control system.

3.1.2.5 Outfall Construction

The proposed outfall North of the KGV reservoir would be situated on Thames Water land and would discharge recycled water into the River Lee Diversion upstream of KGV inlet.

The concept design has assumed that there would be multiple pipes, which could be 1 to 4 pipes depending on required flow, delivering Recycled Water pumped from the KGV Shaft. These pipes would exit the KGV Shaft below ground level and be laid in a trench to allow sufficient working space between pipes. The trench would be open cut with sloped sides. Once installed the trench would be backfilled and the final ground level would be raised locally to ensure there is sufficient soil cover over the pipes.

The delivery pipes would terminate at the outfall structure, which is intended to slow the flow of Recycled Water to an acceptable velocity before discharging into the River Lee Diversion. The foundations of this structure would be at approximately the same level as the river, and dewatering of the excavation may be required to ensure a dry working area.

The outfall structure would be constructed from cast-in-situ reinforced concrete, although consideration may be given to pre-casting some elements off site, transporting to the site and installing in position by crane. A short open channel between the outfall structure and a culvert under the riverbank footpath would be lined with a geotextile and gabion mattress.

The culvert under the footpath could also be constructed from pre-cast concrete or a combination of in-situ and pre-cast elements. To construct this culvert a temporary U-shaped steel sheet pile wall would be built 1 to 2m from the riverbank into the river to allow a dry excavation for construction immediately next to the river.

3.1.3 CDM Implementation

During the Gate2 process, the Principal Designer (i.e., Jacobs Engineering U.K. Limited) was appointed by TWUL in accordance with the Construction Design and Management (CDM) Regulations 2015.

Potential key and location-specific construction phase hazards have been identified by the design team. Site visits were carried out by the design team to verify feasibility of the conceptual designs as well as to gather information on site conditions which could potentially cause health and safety hazards. Hazard information was also gathered from geotechnical review and previous knowledge of the hazards associated with the ground and locations of the proposed works.

Potential measures which could be taken to eliminate the hazards or to mitigate the risks during Gate 2 were incorporated into the conceptual design, fundamentally through the route vertical and horizontal alignment process, and potential actions to facilitate elimination or mitigation actions to be taken at the future design stages were identified.

Particular significant or unusual health and safety risks associated with Beckton Water Recycling scheme include:

- Construction work near the existing high-voltage electrical overhead lines and pylons in Beckton AWRP site and Lockwood Reservoir Pumping Station site.
- Potentially very high levels of contamination in excess of those associated with conventional brownfield sites, especially in the areas of Beckton and the historically industrial areas close to the River Lea.
- Tunnelling and shaft construction in potentially challenging and complex hydro-geologies with differing and potentially artesian groundwater pressures.
- Tunnelling beneath or in vicinity of major reservoirs, where the risk of excessive ground movements requires robust establishment of ground conditions and properties, and likely greater than conventional ground movement analyses and monitoring.
- Ensuring that sufficient space is provided for construction compounds, laydown, deliveries and spoil and waste disposal to allow segregation and separation of plant and workers

A new or extended appointment of Principal Designer is required to be made on completion of Gate 2. The hazard information collected in Gate 2, as well as the potential measures identified to be taken at the future stages will be provided over to Principal Designer appointed at the next design stage. Key activities following completion of Gate 2 will likely include the initial compilation of Pre-Construction Information, the identification and planning for intrusive ground investigations and monitoring to understand the site-specific risks from hazards such as contamination, complex hydro-geology, unexploded ordnance (UXO) and buried obstructions utilities, and the establishment of action plans to address key hazards which apply across much of the conveyance route and shaft locations. Further enquiries would need to be made to establish records of key critical structures which impact the construction such as the impounding reservoirs and the foundations of elevated highways, bridges and gantries.

3.2 Transportation of Construction Materials and Spoils

3.2.1 Segment Delivery

The work sites would require segments to be delivered for shaft and tunnel construction. These would also be transported to site using Heavy Goods Vehicle (HGVs). It has been assumed that all tunnel segments would be transported to the relevant drive site and lowered into the tunnel. The tunnel segments could be transported to Beckton by barge reducing the impact upon local road networks.

3.2.2 Spoil Disposal

The work sites would generate spoil from shaft excavation, and at the drive shafts, from tunnel excavation. The spoil produced would normally be transported along tunnels using skips, which are hoisted to surface at shafts, or by conveyors.

An area would be required at the construction sites for temporary storage of the spoil to enable tunnelling work to proceed for 24 hours per day, while awaiting transport off site by lorry or barges. If a slurry machine is used for tunnelling, further space is required for a plant for separation of spoil from the slurry mix before it is transported off site.

For the construction of the Beckton AWRP to Lockwood Tunnel, the spoil could potentially be removed for one of the tunnel drives from the drive shaft site at Beckton using barge transportation via the Beckton jetty. For the purposes of this CDR however, it is assumed spoil will be exported by road. Suitable spoil disposal locations would also need to be identified.

For the tunnel boring from KGV reservoir towards Lockwood there would be potentially feasible options to reduce the local impact during spoil removal and reducing vehicle movements on adjacent roads. Barges could be used to move spoil along the Lee Valley Navigation without using local roads.

The proposed AWRP site in the Beckton STW currently has excavated materials from previous construction works within the STW. These materials would need to be removed, and the site would have to be re-graded for proper site drainage. Volume of the spoil required to be removed from the AWRP site would depend on the nature of the excavated materials stored on the site and conditions of the original grade under the stored excavated materials.

3.2.3 Vehicle Movement during Construction

A summary of indicative vehicle movements at the individual site locations during construction are presented in the tables below. Whilst it may be possible that spoil and materials could be removed/delivered via river barge, thus reducing the number of vehicular movements, the estimation presented in the tables assumes that no barge transportation would be used for material transportation and spoil disposal.

Table 3-1: Summary of Indicative Vehicle Movement Estimation for the Advanced Water Recycling Plant (AWRP) Construction

Option Element	Estimated total no. of HGVs for spoil	Estimated total no. of HGVs for concrete, rebar and structural fill	Comments
AWRP 50Ml/d Phase	1500	3400	
AWRP 100Ml/d Phase	2000	4300	
AWRP 150Ml/d Phase	2500	5400	

Note: The calculation does not include vehicle movement required for site grading or removing the excavation materials currently piled on site.

Table 3-2: Summary of Indicative Vehicle Movement Estimation for Shaft and Tunnel Construction

Reference site	Estimated total no. of HGV vehicle movements for spoil	Estimated total no. of HGV vehicle movements for tunnel or shaft segments	Comments
Beckton AWRP Shaft Construction	1300	200	Shaft sinking at Beckton
Beckton to Lockwood Intermediate Shaft Sites	4000	400	Combined Intermediate Shaft Sites along the tunnel routes.
Beckton AWRP to Lockwood Tunnel Construction	36000	6700	TBM Drive, spoil conveyed back to primary drive site
Lockwood Shaft Sites	1600	100	Primary and Secondary shafts acting as Reception shafts. 34m pipeline that connects those two shafts to be constructed.
Lockwood to KGV Intermediate Shaft Sites	2100	100	Combined Intermediate Shaft Sites along the tunnel routes.
River Lee Diversion/ KGV Shaft Site	1100	200	Shaft sinking at KGV site
KGV to Lockwood Tunnel Construction	25800	4800	TBM Drive, spoil conveyed back to primary drive site

3.3 Delivery Programme

Table 3-3 shows approximate indicative duration of programme elements. Potential schedule for contract management elements could be found in Annex F of the Gate 2 Report.

Realistic procurement periods have been assumed within delivery programme based on experience within the construction industry. Potential programme savings could be made by:

- Utilising standard products and equipment could result in shorter procurement durations.
- Work elements were assumed to be sequential with minor overlap (e.g. civil work followed by MEICA work in treatment plant construction, no concurrent shaft construction, etc.). This also represents the most robust schedule for project delivery. A contractor may decide to undertake works concurrently potentially leading to a shorter overall construction duration for these elements.
- There is 3 - 6 months of commissioning at the end of each main construction component (e.g. conveyance, treatment plant, river abstraction, etc.). Commissioning could happen concurrently as parts of construction stage. Therefore, there is an opportunity to reduce these periods when designs mature.

- The working calendar was assumed to be 5-day work week with no allowance for night working. If planning consent can be granted for 24-hour or weekend working, construction duration could be reduced.
- Conservative production rates for construction schedules were used.

Table 3-3: Indicative Duration of Programme Elements

Task Name	Approximate Duration (months)
Pre-Construction Stage	30
Detailed Design	17
Procurement	17
Enabling Works	24
Construction Stage	32
Commissioning Stage	20
System Commissioning Works	14
Performance Testing	6
Defects Period	11

4. Water Resources

The Deployable Outputs (DO) for Becton Water Recycling were estimated as 46 Ml/d, 89 Ml/d and 130 Ml/d, for both the Dry Year Annual Average (DYAA) and the Dry Year Critical Period (DYCP), for the capacities of 50 Ml/d, 100 Ml/d and 150 Ml/d respectively. Details of the estimation of DO for the London Effluent Reuse SRO could be found in the Thames Water draft Water Resources Management Plan 2024. This scheme will benefit the London WRZ.

5. Assumptions and Risks

The information presented in this document relates to material or data which is still in the course of completion. Should the solutions presented in this document be taken forward, Thames Water will be subject to the statutory duties pursuant to the necessary consenting process, including environmental assessment and consultation as required. This document should be read with those duties in mind.

5.1 Key Assumptions

Key assumptions that have been made in this conceptual design report are listed below:

- The site to the North of the Beckton STW operation area would be available for AWRP development.
- Beckton STW final effluent would not require further polishing to reduce suspended solids prior to feed the AWRP.
- Concentrate from the RO plant can be discharged to the Beckton STW inlet works, and the STW has adequate capacity to accept the waste stream.
- There would be no obstacles with purchasing additional land required.
- The conveyancing could agree settlement limits, mitigation measures and monitoring with other existing tunnelled utilities and transportation tunnels on the alignment of the proposed tunnel.
- Existing assets including the TLT and pumping stations could provide theoretical yields. It is recommended there would be testing carried out at future stages of the project.

5.2 Key Risks

Key risks associated with this scheme are listed as follows:

- There is a risk that land in the proposed site to the North of the existing operational area in Beckton STW is not available or not sufficient, and additional land purchase will be required or relocation to another site will be required.
- There is high likelihood of encountering contaminated land on the site at Beckton STW and at other sites along the conveyance route.
- There is a risk that waste stream from AWRP could not be discharged into the Beckton STW inlet works.
- There is a risk that connection to the Distribution Network may require a network upgrade.
- There is a risk that tunnel or shaft construction will encounter unexpected ground conditions.
- The proposed tunnel would cross several existing infrastructure networks. Mitigation measures for potential settlement need to be considered in more detail.
- The nature of the urban or sub-urban environment, and designated sites limits open-cut trenching pipeline options and constraints the potential shaft locations.

6. Glossary and Abbreviations

Term	Definition
London Effluent Reuse SRO	Term to describe the Strategic Resource Option group for all four schemes as set out in the PR19 Final Determination.
London Effluent Reuse Scheme	Term when describing an individual option of the SRO.
Beckton Water Recycling scheme	Option to develop a water reuse/recycling plant at Beckton STW including abstraction, treatment and conveyance scope. One of the four schemes in London Effluent Reuse SRO.
Mogden Water Recycling scheme	Option to develop a water reuse/recycling plant at a site near Kempton WTW for Mogden STW effluent including abstraction, treatment and conveyance scope. One of the four schemes in London Effluent Reuse SRO.
Mogden South Sewer scheme	Option to develop a sewage reuse/recycling plant at a site near Kempton WTW for untreated sewage from South Sewer which discharges into Mogden STW, including abstraction, treatment and conveyance scope. One of the four schemes in London Effluent Reuse SRO.
Teddington DRA scheme	Option to develop a water reuse plant at Mogden STW taking effluent for tertiary treatment then discharging to River Thames including abstraction, treatment and conveyance scope. One of the four schemes in London Effluent Reuse SRO.
Final Effluent	Water treated and discharged from existing secondary treatment process in Beckton Sewage Treatment Works or Mogden Sewage Treatment Works
Treated Effluent	Water treated in the proposed Tertiary Treatment Plant (TTP)
Recycled Water	Water treated in the proposed Advanced Water Recycling Plant (AWRP)
catchment	The area of region where all water flows to a single point, e.g., for a wastewater catchment, all wastewater flows to a single STW for treatment.
component	The key engineering items that contribute to each option e.g., pipeline, advanced water recycling plant.
concentrate	The concentrated waste stream produced by the Reverse Osmosis membranes.
conveyance	Refers to the assets which make up a transfer of fluid from one location to another, e.g., pipeline, tunnel, pumping station and outfall.
scheme	Refers to the overall system for one of four 'Options' within the London Effluent Reuse SRO for providing water resource benefit to the region, e.g., Beckton Water Recycling, Mogden Water Recycling, Teddington DRA and Mogden South Sewer.

Acronym	Definition
ACWG	All Company Working Group
ADF	Average Daily Flow
AMP	Asset Management Plan
AOP	Advanced Oxidation Process
APS	Asset Planning System (Thames Water system)
ARPE	All Reservoirs Panel Engineer
ASP	Activated Sludge Process
AWRP	Advanced Water Recycling Plant
BAC	Biological Activated Carbon
BNG	Biodiversity Net Gain
BOD	Biological Oxygen Demand
CCPs	Critical Control Points
CDC	Coagulation Dosing Chamber

Acronym	Definition
CDM	Construction Design Management
CDR	Conceptual Design Report
CEB	Chemically Enhanced Backwash
CEC	Contaminants of Emerging Concern
CIP	Clean in Place
CS	Chemical Storage
DAF	Dissolved Air Floatation
Defra	Department for Environment, Food and Rural Affairs
DEL	Drought Event Level
DI	Ductile Iron
DNO	Distribution Network Operator
DO	Deployable Output
DPC	Direct Procurement for Customers
DRA	Direct River Abstraction
DWF	Dry Weather Flow
DWI	Drinking Water Inspectorate
dWRMP	Draft Water Resource Management Plan
DWSP	Drinking Water Safety Plan
DYAA	Dry Year Annual Average
DYCP	Dry Year Critical Period
EA	Environment Agency
EDC	Endocrine Disrupting Compounds
EIA	Environmental Impact Assessment
ELV	Emission Limit Value
ENG	Environmental Net Gain
EPB	Earth Pressure Balance
EQS	Environmental Quality Standard
EQT	Equalisation Tank
FAT	Full Advanced Treatment
FEPS	Final Effluent Pumping Station
GAC	Granular Activated Carbon
GHG	Greenhouse Gas
GIS	Geographic Information System
HGV	Heavy Goods Vehicle
HSE	Health and Safety Executive
HV	High Voltage
ICA	Instrumentation Control and Automation
ID	Internal Diameter
IPR	Indirect Potable Reuse
KGV	King George V Reservoir
LSI	Langelier Saturation Index
M&E	Mechanical & Electrical
MCC	Motor Control Centres
MCF	Mechanical Cloth Filter

Acronym	Definition
MEICA	Mechanical, Electrical, Instrumentation, Control and Automation
Ml/d	Mega litres per day
NIC	National Infrastructure Commission
NSFs	Nitrifying Sand Filters
NTU	Nephelometric Turbidity Unit
PACl	Polyaluminium Chloride
PCV	Prescribed Concentration or Value
PFAS	Per- and Polyfluoroalkyl Substances
PR19	Price Review 2019
PRoW	Public Right of Way
PS	Pumping Station
RAPID	Regulatory Alliance for Progressing Infrastructure Development
REM	Remineralisation
RGF	Rapid Gravity Filtration
RO	Reverse Osmosis Building
ROPS	RO Feed Pumping Station
ROT	RO Feed Tank
RPv1	Regional Plan version 1
RWPS	Recycled Water Pumping Station
SAC	Special Area of Conservation
SEA	Strategic Environmental Assessment
SCL	Sprayed Concrete Lining
SINC	Sites of Importance for Nature Conservation
SOC	Strategic Outline Case
SOLAR	Strategic Overview of Long term Assets and Resources
SPA	Special Protection Area
SRO	Strategic Resource Option
SSSI	Site of Special Scientific Interest
STT	Severn Thames Transfer
STW	Sewage Treatment Works
TBM	Tunnel Boring Machine
TDS	Total Dissolved Solids
TEPS	Treated Effluent Pumping Station
THM	Trihalomethanes
TLT	Thames Lee Tunnel
TN	Total Nitrogen
TOC	Total Organic Carbon
TSS	Total Suspended Solid
TTP	Tertiary Treatment Plant
TWUL	Thames Water Utilities Ltd
T2AT	Thames to Affinity Transfer
UF	Ultrafiltration Building
UFPS	UF Feed Pumping Station
UV	Ultraviolet

Acronym	Definition
UVAOP	UV Advanced Oxidation Process Building
WFD	Water Framework Directive
WRMP19	Water Resource Management Plan 2019
WRMP24	Water Resource Management Plan 2024
WRSE	Water Resource South East
WRZ	Water Resource Zone
WTW	Water Treatment Works