Annex A4: Teddington DRA 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 A4: Teddington DRA Scheme Conceptual Design Report

Document no: J698-TD-DOC-210001-0D

Thames Water Utilities Ltd
J698

London Water Recycling
13 October 2022

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Executive Summary

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

As a part of London Effluent Reuse SRO, Teddington DRA 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:

- 50 Ml/d Tertiary Treatment Plant at Mogden STW (WRSE Ref. TWU_KGV_HI-RAB_teddington dra 50)
- 75 Ml/d Tertiary Treatment Plant at Mogden STW (WRSE Ref. TWU_KGV_HI-RAB_teddington dra 75)
- Treated Effluent Transfer Tunnel from Mogden STW to Teddington (WRSE Ref. TWU_WLJ_HI-TFR_teddingtondramog/ted)
- Abstracted Raw Water Transfer from the River Thames to Thames Lee Tunnel (WRSE Ref. TWU_KGV_HI-TFR_teddingtondrated/tlt)

Table S-1: Scheme Summary.

Name	Teddington DRA
Gate-2/ WRSE Reference	TWU_KGV_HI-RAB_teddington dra 50, TWU_KGV_HI-RAB_teddington dra 75, TWU_KGV_HI-TFR_teddingtondrated/tlt, TWU_WLJ_HI-TFR_teddingtondramog/ted
Scheme Type	Resource and Conveyance
WRZ	London. Potentially, Affinity Water's WRZ if Teddington DRA supplies water to Thames to Affinity Transfer (T2AT) SRO.
Engineering Scope	A portion of final effluent from Mogden STW would undergo treatment at a new Tertiary Treatment Plant within the Mogden STW boundary, sufficient to allow discharge into the river. The Treated Effluent would then be transferred to a new outfall location on the River Thames, upstream of Teddington Weir. The new River Thames Direct River Abstraction would be located upstream of the Treated Effluent discharge location and would connect into the Thames Lee Tunnel (TLT) which will convey the raw water to the Lee Valley reservoirs in East London.
Benefit	46Ml/d and 67Ml/d Dry Year Annual Average (DYAA) and Dry Year Critical Period (DYCP) Deployable Output for the capacities of 50Ml/d and 75Ml/d respectively
Mutual exclusivities	Combined capacity of Teddington DRA, Mogden Water Recycling and Mogden South Sewer schemes are subject to a limit of 200Ml/d.
Interdependencies	Teddington DRA scheme is a potential source for one of the options in Thames to Affinity Transfer (T2AT) SRO. Teddington DRA scheme does not have dependencies on other options. To provide an additional resource to London WRZ, the following elements may also be required: ▪ Additional treatment capacity at Water Treatment Works (WTWs) in East London. ▪ Potential additional transfer through TLT extension from Lockwood Shaft to the River Lee Diversion upstream of King George V Reservoir ▪ Additional treatment capacity at Kempton WTW. ▪ Upgrade to raw water systems in West London (not currently in CDR)

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 SRO 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 Teddington DRA scheme. The proposal for the Teddington DRA scheme can be summarised as:

- A portion of final effluent from Mogden STW would be subject to treatment at a new Tertiary Treatment Plant (TTP) located at Mogden STW. The Treated Effluent would be transferred to a new outfall on the River Thames upstream of Teddington Weir.
- A new abstraction from the River Thames, upstream of the Treated Effluent discharge location, would transfer water into the Thames Lee Tunnel for transfer to the Lee Valley Reservoirs in East London.

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

This scheme will abstract a proportion of final effluent at Mogden STW (See (1) in Figure 1-1). The abstracted final effluent would be treated in a new Tertiary Treatment Plant (TTP) within Mogden STW boundary, and Treated Effluent from the TTP would be conveyed and discharged into the River Thames just upstream of Teddington Weir which marks the river's tidal limit (see (2) and (3) in Figure 1-1). Then, the same quantity of water will be abstracted from the River Thames immediately upstream of the discharge location (see (4) in Figure 1-1), abstracted water would be pumped into a shaft connecting into the Thames to Lee Tunnel (TLT) which crosses the site. The TLT will convey flows to the Lee Valley Reservoirs for treatment at Coppermills Water Treatment Works (WTW).

Tertiary treatment is required to improve the effluent quality prior to discharge to the non-tidal section of the River Thames, upstream of the Teddington Weir. As the discharge location of the Treated Effluent will be in the most downstream section of the non-tidal section as well as being downstream of all the existing raw water intake points for WTWs, the water treatment design would focus on achieving water quality consent parameters suited to the receiving water environmental requirements for discharge to the freshwater River Thames and not on Drinking Water Standards. Addition of ferric for phosphorus removal, Nitrifying Sand Filters (NSFs) for further ammonia reduction and mechanical filters for BOD removal would be proposed for the tertiary treatment, and wastewater from the tertiary treatment plant (TTP) could be returned to Mogden STW inlet works.

There is minimal vacant land available within the Mogden STW site for development. It would be therefore proposed that TTP would be built in the footprint of existing storm tanks. Some of the existing storm tanks may need to be deepened to maintain the existing storm storage capacity at Mogden STW.

There is an opportunity that the abstracted water would be further transferred through a TLT extension from Lockwood Shaft near the Lockwood Reservoir to the River Lee Diversion upstream of the King George V (KGV) reservoir. The TLT extension is proposed as part of the Beckton Water Recycling scheme, to enhance resilience in water supply systems in East London. In addition, Thames to Affinity Transfer (T2AT) SRO considers Teddington DRA as one of their potential water source options.

The Teddington DRA scheme will supply London Water Resource Zone (WRZ). This scheme would benefit East London through the TLT. However, if the flow from the Teddington DRA scheme is conveyed through the TLT to East London, a fraction of flow currently abstracted from the River Thames to the TLT at the intake in Hampton could be diverted to WTW in West London. Consequently, deployable output of Teddington DRA scheme may possibly benefit West London.

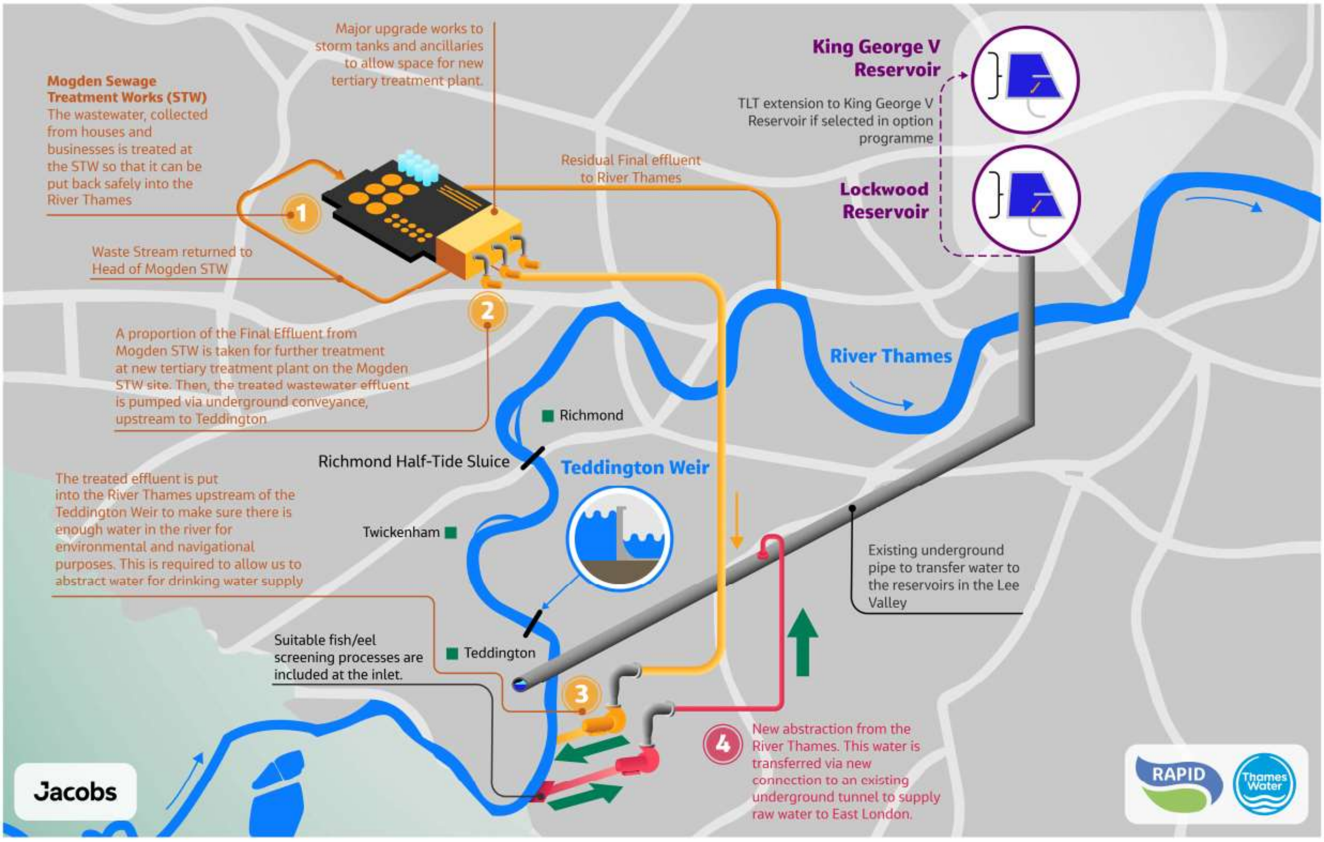

Figure 1-1: Teddington DRA Scheme Overview

1.2.2 Gate 1 Development

In WRMP19, the capacity of Teddington DRA scheme was proposed to be 300Ml/d. However, river modelling studies based on the 300Ml/d scenario identified that one of the likely impacts of the scheme would be a high increase in water temperature in the freshwater River Thames locally above Teddington Weir and in the Upper Tideway because of abstracting cooler river water and replacing with discharge of warmer Treated Effluent at Teddington. Therefore, a 300Ml/d Teddington DRA scheme was rejected in WRMP19 process.

A scheme with advanced treatment (Reverse Osmosis and UV Advanced Oxidation Process) at Mogden STW and transfer and discharge directly into the TLT was also investigated in WRMP19. However, due to space constraints at Mogden STW, this alternative scheme was also rejected at WRMP19 stage.

In Gate 1, conceptual design of Teddington DRA scheme had been progressed assuming that the maximum scheme size would be 150Ml/d. However, during Gate 2, a size of75 Ml/d was adopted on the Teddington DRA scheme as a result of concerns raised by the Environmental Agency over potential impact within the River Thames from the scheme up to 150 Ml/d. This constraint has been investigated further through Gate 2, and environmental investigations has concluded that impacts on river temperature would be acceptable up to the scheme size of 100Ml/d. Maximum scheme size of 100Ml/d is now recommended for going forward, and further design details of a 100Ml/d scheme will be developed in the next design stage (see section 1.3).

A 3.5m-diameter tunnel, which had been originally proposed in WRMP19 for 300Ml/d scheme, was retained as the primary conveyance option for Treated Effluent transfer from the TTP at Mogden STW to Teddington discharge in Gate 1 conceptual design, whilst a smaller-diameter conveyance option has been developed in Gate 2 for smaller scheme sizes.

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.

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
Maximum scheme size had been assumed to be at 150Ml/d.	Environmental studies during Gate 2 showed impacts on river temperature would be acceptable up to the scheme size of 100Ml/d. Maximum scheme size of 100Ml/d is recommended for going forward.
A 3.5m-diameter tunnel with 3 shafts had been proposed for Treated Effluent transfer from Tertiary Treatment Plant in Mogden STW to Teddington Discharge.	A 1.8m-diameter tunnel with 8 shafts, which would accommodate 100Ml/d flow, was proposed for Treated Effluent transfer from Tertiary Treatment Plant in Mogden STW to Teddington Discharge.

1.3 Sizing and Phasing

1.3.1 Sizing and Phasing of Scheme

This adopted sizing of 75Ml/d has been investigated further through Gate 2, and environmental investigations has concluded that impacts on river temperature would be acceptable up to the scheme size of 100Ml/d. Maximum scheme size of 100Ml/d is now recommended for going forward, and further design details of a 100Ml/d scheme will be developed in the next design stage.

The table below shows recommendations for the scheme sizes of Teddington DRA scheme and its sub-options.

The total scheme size is selectable from multiple sub-option sizes for TTP (i.e. 50Ml/d and 75Ml/d). A100Ml/d scheme could consist of two 50M/d TTP sub-options with phasing. However, opportunities and benefit of a single-phase development of a 100Ml/d TTP may be considered in the next design stage.

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 1.8m-diameter Treated Effluent 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 1-2: Recommendations for Teddington DRA Scheme Size

Scheme Name	Description of Scheme	Constraint	Scheme Sub-Options	
Teddington DRA scheme	Final effluent harvest, tertiary treatment and convey treated effluent to River Thames. DRA for discharge to Thames Lee Tunnel (TLT)	Combined maximum capacity of 200 Ml/d made up of: Mogden Water Recycling – 150 Ml/d max Mogden South Sewer – less than 50 Ml/d Teddington DRA – 100 Ml/d max	Tertiary Treatment Plant	50 Ml/d
				75 Ml/d
			Conveyancing (e.g., tunnel, pipes, outfall and intake)	

1.3.2 Constraints Impacting Solution Sizing and Phasing

The key constraints impacting the solution sizing or phasing are:

- **Increases to receiving water body temperature:** The environmental assessment so far identified that temperature increases to the receiving water body during periods of operation constrained the scheme size to 100Ml/d or below, while discharge velocity does not appear to be a constraining factor. Refer to Annex B of Gate 2 Report for details on the investigations on environmental impacts on the receiving water body.
- **Availability of source water:** Combined maximum capacity of Teddington DRA, Mogden Water Recycling and Mogden South Sewer would be 200Ml/d due to availability of final effluent from Mogden STW. See section 2.2.1. for assessment of source water availability.
- **Availability of land at Mogden STW for development: The** site is very developed with little available land, thus necessitating a solution which modifies existing storm tanks to release space for the TTP development. Footprint of existing storm tanks would be sufficient to accommodate a 100Ml/d TTP. A single-phase development of TTP may be preferred to phased development due to availability of land in the STW.
- **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 Treated Effluent Transfer Tunnel is dictated by the practicable distances between proposed shafts rather than flow capacity of the tunnel.

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 network 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 raw water conveyance systems to transfer raw water from West London intakes on the, River Thames to Kempton WTW (if the Teddington DRA flow is conveyed through TLT to East London and the flow currently abstracted at Hampton Intake into TLT is used in Kempton WTW). ▪ TLT extension from Lockwood Shaft to River Lee Diversion upstream of King George V Reservoir (KGV) is potentially required, depending on water network reinforcement strategy in East London.
Water Treatment Works	▪ Additional treatment capacity at WTWs in East London. ▪ Additional treatment capacity at Kempton WTW
Potable Water Network Reinforcement	▪ Potable network reinforcements.
Others	▪ Teddington DRA scheme is identified as one of potential water source options for T2AT SRO.

1.4.2 Mutual Exclusivities

The combined capacity/ yield of Teddington DRA scheme, Mogden Water Recycling scheme and Mogden South Sewer scheme is limited to 200Ml/d because the three schemes use final effluent of Mogden STW or sewage from the Mogden STW catchment as a water source as detailed in section 2.2.1. These three schemes could be mutually exclusive when the cumulative capacities exceed the limit.

2. Conceptual Design

2.1 Design Principles

2.1.1 Overview

During the 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 needs 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 Teddington DRA 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 Effluent 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	1. Evidence of collaborative working across companies. 2. Evidence of working with Regulatory, Statutory (and, where practicable, local) stakeholders	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	Gate 2 Report – section 7	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

ACWG Design Principles	ACWG Gate 2 Indicators	Approach in Teddington DRA Gate 2 Designs	Documentation in Gate 2 Submission	Targets
companies and/or legislative boundaries to develop sustainable solutions and environmental enhancement for the wider benefit of society.	including Catchment Partnerships where appropriate. 3. Design Vision and Principles informed by this engagement (Stages 1-6 of design process).	England (NE) and Port of London Authority (PLA) to discuss scheme benefits and impacts, and opportunities for enhancement. Local Council (London Borough of Hounslow, Richmond upon Thames and Kingston upon Thames) have also been contacted for discussion.	Gate 2 Report - Annex D: Engagement Report	design objectives followed by proposals. 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 tunnel construction. Details of carbon efficient strategies are in section 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 the Mogden STW land for the tertiary treatment plant.	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. The combined maximum capacity of Teddington DRA and Mogden Water Recycling schemes were determined based on drought conditions/ scenario, excluding infiltration and trade flow from the available flow (see section 2.2.1). In accordance with the Drinking Water Safety Plan, this scheme has had a detailed assessment to allow for mitigation of any effects caused by abstraction / discharge of flows at the River Thames.	CDR section 2.2.1 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

ACWG Design Principles	ACWG Gate 2 Indicators	Approach in Teddington DRA Gate 2 Designs	Documentation in Gate 2 Submission	Targets
				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, 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	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 of the proposed intake screen at River Thames have been 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	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.

ACWG Design Principles	ACWG Gate 2 Indicators	Approach in Teddington DRA Gate 2 Designs	Documentation in Gate 2 Submission	Targets
	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 models for visualisation/animation, GIS systems, precedent pictures of similar schemes/components) *. 4. Survey information on local needs and preferences in design*	issues, agree approaches to monitoring and assessment, and then review findings and consider mitigation requirements.		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)).
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	1. Evidence of place-based balanced, holistic and long-term decision making in the description of design	The Gate 2 options appraisal includes detail of frequent collaborative reviews between the engineering, environmental, planning and commercial designers for this SRO. These reviews significantly influence the design development of the	Gate 2 Report – section 3.4 CDR section 2.1.2	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,

ACWG Design Principles	ACWG Gate 2 Indicators	Approach in Teddington DRA Gate 2 Designs	Documentation in Gate 2 Submission	Targets
sustainability. Work with partners to secure the long-term success of all measures.	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*. 4. Landscape/townscape character assessments and approach to design specific to context.*	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 engagement with local authorities are underway to best mitigate any new developments.	Gate 2 Report - Annex B: Environmental and Regulatory Assessments Gate 2 Report – Annex D: Engagement Report Gate 2 Report – Annex G: Planning Report	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. 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 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	1. Set out with opportunities and aspirations for high quality design within Design Vision and Principles.	The proposed River Abstraction and Outfall would be located on the River Thames which is an iconic natural heritage location for Londoners and for	CDR section 2.1.1, 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.

ACWG Design Principles	ACWG Gate 2 Indicators	Approach in Teddington DRA Gate 2 Designs	Documentation in Gate 2 Submission	Targets
contribution to its context. Develop proposals that reveal and celebrate its importance, provide visual delight and leave a positive legacy.	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 world. Ensuring engineering and functional integrity, the London Effluent Reuse 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.		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 location and arrangement of elements and design of mitigation within the project scope and budget.	1. Evidence of multi-disciplinary input into site selection* (See Note 2). 2. Initial project and, where appropriate, site appraisals (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.	Planning professionals, terrestrial habitat ecologists, carbon and energy analysts joined the Gate 1 design team which consisted of engineering and environmental consultants. As for 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.	Gate 2 Report – section 3.4	1.1. Early multidisciplinary input informing a design that solves multiple problems at once. 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	1. A description of potential opportunities to work with other projects/partners to achieve wider benefits.	Teddington DRA scheme is identified as one of potential water source options for T2AT SRO. There is a potential opportunity that DO from Teddington	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).

ACWG Design Principles	ACWG Gate 2 Indicators	Approach in Teddington DRA Gate 2 Designs	Documentation in Gate 2 Submission	Targets
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.	2. A statement within the Design Vision on the SRO's aspirations and capability to deliver additional value.	DRA scheme would replace raw water from Hampton Intake and provide benefit to West London, if it partners with water supply reinforcement projects in West London.		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 your experience and knowledge widely.	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 will be developed and monitored at subsequent gates. 3. Initial narrative (description) of the value of the scheme in plain English.	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 are described in section 4.3 in Gate 2 Report.	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. 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:

- Mogden STW Final Effluent abstraction
- Tertiary Treatment Plant (TTP) at Mogden STW
  - 50Ml/d-yield Tertiary Treatment Plant
  - 75Ml/d-yield Tertiary Treatment Plant
- Waste Stream Collection and Discharge at Tertiary Treatment Plant in Mogden STW
- Treated Effluent Transfer Tunnel from Mogden STW to Teddington Discharge site on the River Thames
- Treated Effluent Discharge to the River Thames, upstream of Teddington Weir
- Teddington River Abstraction
  - Intake from the River Thames, upstream of Teddington Weir
  - Abstracted Raw Water Transfer
  - Thames Lee Tunnel connection

The conceptual design for the following potential option component is included in the Beckton Water Recycling Conceptual Design Report:

- TLT extension from Lockwood Reservoir Shaft to River Lee Diversion upstream of King George V Reservoir (KGV)

2.2.1 Assessment of Source Flow Availability

In Gate 1 conceptual design, a check of final effluent flow recorded in Mogden 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 420Ml/d and the Average Daily Flow (ADF) was 494Ml/d at the proposed final effluent abstraction location.

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. 4.2 updated on 10 July 2019).

SOLAR estimates STW influent in the future, utilising predicted population growth. All flows into Mogden 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 Mogden STW in 2031 would be 305Ml/d. Domestic flow does 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 Mogden STW during drought conditions.

Table below lists approximate source flows required for different option sizes in Mogden Water Recycling, Teddington DRA and Mogden South Sewer schemes. These three schemes would use final effluent from Mogden STW as their water source. For example, an approximately 252Ml/d of final effluent would be required for a 200Ml/d capacity of Mogden Water Recycling scheme. Because the projection of available final effluent from Mogden STW would be 305Ml/d, it would be recommended that combined maximum capacities (total yield of Treated Effluent/ Recycled Water) of Teddington DRA, Mogden Water Recycling and Mogden South Sewer would be 200Ml/d.

Table 2-2: Yields of Treated Effluent/ Recycled Water and Abstraction of Final Effluent/ Sewage in Mogden Water Recycling, Teddington DRA and Mogden South Sewer Schemes

Flow	Units	Yield of Treated Effluent/ Recycled Water	Estimated Abstraction of Final Effluent or Sewage*
Mogden Water Recycling	Ml/d	50	63
	Ml/d	100	126
Teddington DRA	Ml/d	50	58
	Ml/d	75	87
Mogden South Sewer	Ml/d	50	60

*Mogden Water Recycling and Teddington DRA schemes would abstract Final Effluent from Mogden STW, while South Sewer scheme would abstract untreated sewage from the catchment of Mogden STW.

2.2.2 Source Water (Mogden STW Final Effluent) Abstraction Design Components

The existing 3m wide, 2m deep final effluent channel runs along the South edge of the Mogden STW from West to East, and to the North alongside the existing storm tanks on the East side of the STW. Overflows from the existing storm tanks directly discharge into the final effluent channel along the eastern perimeter of the storm tanks. Therefore, final effluent would be abstracted upstream of the storm tank overflow along the southern edge of the existing storm tank to prevent untreated storm tank overflows being transferred to the treatment facilities. Abstracted final effluent will be treated in the new TTP within Mogden STW.

2.2.3 Treatment Design Components

The Treated Effluent discharge would provide compensation flow upstream of the Teddington Weir following raw water abstraction a little further upstream. The discharge location will be in the most downstream reach of the non-tidal section of the river Thames and downstream of all existing raw water abstraction points; it is therefore considered that the Treated Effluent is not required to conform to Drinking Water Standards. The tertiary treatment design is therefore focused on achieving environmental quality consent parameters for the discharge to the freshwater River Thames.

At this stage of design, conditions for the discharge of Treated Effluent to the River Thames are based on that of the Hogsmill STW discharge permit which is for the same reach of the river as this proposed discharge. The Hogsmill STW Discharge permit has tighter Emission Limit Values (ELVs) for Suspended Solids, BOD, Ammonia and Phosphorus discharge and the selected tertiary treatment will reduce these parameters contained within the Mogden STW final effluent. The proposed process comprises tertiary nitrification to reduce 95%ile ammonia compliance and chemical dosing and tertiary filtration for 95%ile phosphate compliance and Biochemical Oxygen Demand (BOD) compliance.

There are opportunities to consider alternative treatment trains and development of the conceptual design as the project progresses and this level of tertiary treatment may not be required depending on the performance of Mogden STW in the future. Therefore, treatment designs described in this report are indicative.

2.2.3.1 Water Quality

2.2.3.1.1 Mogden STW Secondary Effluent Quality

A summary of the key water parameters is presented in Table 2-3. The key Hogsmill STW discharge consent values are also included for reference when considering these basis of design parameters. The Hogsmill STW also currently discharges into the same reach of the river as is the proposed TTP, therefore, it provides a reasonable basis for establishing the Treated Effluent design envelope.

Table 2-3: Key TTP Feed Water Quality Parameters

Parameter	Unit	Average	95%ile	Hogsmill STW Discharge Permit
General				
BOD	mg/l	5.4	12.2	9 (95%ile)
Phosphorus	mg/l	3.5	5.4	1 (annual average)
Ammonia. NH_3	mg/l	0.4	1.7	3 (95%ile)
Suspended Solids	mg/l	15.7	36.0	25 (95%ile)
pH	ph Unit	7.4	7.6	6.5-9.5
Alkalinity (as $CaCO_3$)	mg/l	201.2	230.4	N/A

BOD

The existing Mogden STW provides full carbonaceous and nitrification activated sludge treatment. The Mogden STW final effluent has a 95%ile BOD concentration of 12.2mg/l. Treatment to reduce BOD concentrations in the discharging water is required to achieve the discharge consent of 9mg/l on a 95%ile basis. This requires a high degree of solids reduction. This is proposed via tertiary cloth pile filters. Further sampling of final effluent soluble and particulate BOD fractions may be required as conditions for the discharge consent are consolidated in discussion with the regulator.

Phosphorus

The existing Mogden STW does not include chemical dosing for phosphorus removal. Phosphorus reduction is required to achieve the existing Hogsmill STW consent level of 1mg/l total phosphorus (annual average). Chemical phosphorus removal via ferric sulphate dosing and tertiary filtration has been designed to achieve a discharge concentration 50% of the Hogsmill STW phosphorus consent of 1mg/l.

Ammonia

The Mogden STW final effluent has a 95%ile BOD concentration of 1.7mg/l which is well below the 3mg/l Hogsmill consent, indicating that tertiary Ammonia removal may not be required if a similar consent was determined by the EA for the Teddington Treated Effluent discharge. This presents an opportunity to rationalise and optimise the treatment process as the design progresses but at this stage nitrifying sand filters have been included on the basis that further ammonia reduction may be required.

Suspended Solids

The existing Mogden STW comprises conventional activated sludge and final settlement tank treatment trains to produce a secondary clarified effluent. The secondary effluent has a 95%ile suspended solids concentration of 36mg/l which will need to be significantly reduced to meet compliance with the Hogsmill STW discharge consent of 25mg/l. Solids reduction via tertiary cloth pile filtration has been proposed in this conceptual design. Design development will further consider the risk of fluctuation in solids loading, recognising the upgrade works ongoing at Mogden STW and future likely process performance. The final effluent ratio of Total Suspended Solid (TSS) to BOD appears high and existing process performance will be further considered as design progresses.

2.2.3.1.2 Treated Effluent Quality

The Hogsmill STW currently discharges into the same reach of river and therefore this discharge consent has been used as a proxy for the Treated Effluent quality target and used as the basis of design. Appropriate water quality targets will be confirmed through engagement of the EA.

The TTP Treated Effluent quality has been projected as shown in the table below, assuming indicative tertiary treatment process, including ferric sulphate dosing, Nitrifying Sand Filters (NSFs) and mechanical cloth filters.

As shown in Table 2-4, the proposed TTP treatment process could achieve the discharge consent targets of the Hogsmill STW based on 95%ile Mogden STW Final Effluent quality. As the design progresses, it is recommended to undertake frequent final effluent quality monitoring to demonstrate a robust dataset which reflects recent final effluent discharge quality.

Table 2-4: Proposed TTP Projected Treated Effluent Quality

Parameter	Unit	Mogden STW Final Effluent (95%ile of data 2004 - 2020)	Projected Water Quality of TTP Treated Effluent (95%ile)	Hogsmill STW Discharge Permit
BOD	mg/l	12.2	7	9 (95%ile)
Phosphorus	mg/l	5.4	0.5	1 (annual average)
Ammonia. NH_3	mg/l	1.7	0.1	3 (95%ile)
Suspended Solids	mg/l	36.0	10	25 (95%ile)
pH	ph Unit	7.6	6.8	6.5-9.5
Alkalinity (as $CaCO_3$)	mg/l	230.4	174	N/A

2.2.3.2 Proposed Treatment Scheme

As described above, suspended solids, BOD, ammonia and phosphorus would be the main parameters of concern for this TTP design. A two-stage tertiary treatment process consisting of nitrifying sand filters and mechanical cloth filters would address the high suspended solids concentration fed to the plant. Nitrifying sand filters allow for nitrification and TSS/BOD removal. Chemical phosphorus removal through ferric sulphate dosing could be upstream of final tertiary cloth pile filters to achieve the assumed total phosphorus compliance requirements.

Indicative treatment process for Teddington DRA scheme would be:

- Ferric sulphate dosing (for chemical phosphorus reduction)
- Nitrifying Sand Filters (for ammonia, BOD and suspended solids reduction)
- Mechanical Cloth Filters (for final solids reduction)
- Associated backwash and desludging equipment for filter units

Chlorination of the Treated Effluent prior to transfer, together with de-chlorination prior to discharge, may be required for virus reduction, following further water quality analysis and development of pathogen removal targets.

2.2.3.2.1 Ferric Sulphate Dosing

Ferric sulphate would be dosed to the incoming Final Effluent stream via direct injection to a coagulation tank for effective mixing and contact time for phosphorus precipitation. A dedicated ferric sulphate storage tank and dosing skid would be supplied. Ferric dosing requirements have been estimated based on average Final Effluent phosphorus concentrations to achieve a Treated Effluent output concentration of 0.5mg/l.

The assumed dose point could be upstream of the tertiary nitrifying sand filters, but as design progresses, it may be considered to be better suited upstream of the tertiary cloth pile filters depending upon the performance assessment of specific supplier selection. The TTP feed stream has a high phosphorus content and large quantities of chemical sludge can be generated upon addition of ferric which could be problematic for nitrifying sand filters and may impact the filters' ammonia reduction efficiency. Chemical sludges generated through backwash would be returned to the Mogden STW, upstream of primary treatment and downstream of storm overflow points.

2.2.3.2.2 Nitrifying Sand Filters (NSF)

Continuous flow nitrifying sand filters are proposed to provide BOD, ammonia, and solids reduction. The sand filter can handle peak solids loadings for short periods of time whilst achieving ammonia removal through an attached biomass nitrification process. For this, a process air supply is required. Nitrifying sand filter units can operate in a continuous contact filtration process with no moving parts meaning they do not need to be taken offline making it an ideal model for this TTP design. The proposed filter vessel would be housed and built into tanks with a 2m bed height. The 50Ml/d and 75Ml/d designs will consist of 5 No. and 8 No. banks of ten filter cells, respectively.

A summary of indicative unit configuration and sizing is provided in Table 2-5.

Table 2-5: Indicative NSF Configurations

Scheme Design	50Ml/d	75Ml/d
Design Hydraulic Loading Rate	58Ml/d	87Ml/d
Filter Banks	5	8
Total Filter Cells	50 (10 per bank)	80 (10 per bank)
Total Filter Area	300m^2 (60m^2 per bank)	480m^2 (60m^2 per bank)
Total Filter Media Volume	765m^3 (153m^3 per bank)	1,224m^3 (153m^3 per bank)
Ammonia Removal	87.7kg/day	131.6kg/day

Dirty wash water is collected and returned to the wastewater return pumping station for return to the head of the Mogden STW.

Air supply for nitrification is supplied using containerised compressed air systems. The filter media would consist of natural, graded quartz sand which commonly does not need replacing.

2.2.3.2.3 Mechanical Cloth Filters

Mechanical cloth filters would provide a final solids removal barrier. These units comprise filter discs with cloth type filter pile used to capture suspended solids particles all installed in tanks.

As water flows into the concrete tank, suspended solids and other contaminants accumulate on the outside of the filter media, causing the water level in the filter to rise. Backwashing would occur sequentially such that not all discs are backwashed at the same time to allow for full flow operation. Suction pumps would be used for backwashing which are supplied with the package unit, with dirty backwash being discharged through a solids collection system.

During the operation of the filter unit, accumulated solids build-up results in sludge layer formation on the bottom of the tank. Sludge pumps would be used and included within the unit to de-sludge the tank, using the same solids collection system. As with backwashing the de-sludging process would occur sequentially, allowing for the continuous operation of the filter to provide a filtered effluent.

Dirty wash water and sludge could be transferred to the wastewater return pumping station for return to the head of the Mogden STW.

Table 2-6: Indicative Mechanical Cloth Filter Configurations

Scheme Design	50Ml/d	75Ml/d
Design Hydraulic Loading Rate	52.2Ml/d	78.4Ml/d
Filter Units	3 (Duty/Duty/Standby)	4 (Duty/Duty/Duty/Standby)
Total Filter Discs	84 (28 per unit)	112 (28 per unit)
Total Filter Area	420m^2 (140 m^2 per bank)	560m^2 (140 m^2 per bank)
Backwash Suction Pumps	36 (12 per unit)	48 (12 per unit)

2.2.3.2.4 Chemical Dosing

The units for the TTP would not require chemical cleaning or chemicals for enhanced backwashing. The only chemical usage could be phosphorus removal.

Ferric Sulphate solution would be dosed upstream of tertiary filtration for chemical phosphorus removal and formation of flocs for downstream solids removal. Ferric sulphate solution would be dosed to a coagulation tank for mixing efficiency.

Chemical deliveries to the TTP would be via a common hard standing area which would drain to a dedicated chemical spill tank so that any accidental spills could be contained, treated and disposed of in an appropriate manner.

There might be biofilm growth and operational intervention might be required to clean/disinfect the conveyance system to Teddington discharge. This would require consideration of further waste streams and disposal routes. As design develops and the operational regime design is developed, the need for conveyance maintenance, prevention of growth, need for scouring, cleaning and/or sweetening flow will also need to be further reviewed.

2.2.3.2.5 Process Unit Summary

Indicative process units are summarised in the following tables.

Table 2-7: Indicative 50Ml/d Process Unit and Structure Sizes

Process item	Approximate building / structure area (m^2)	Approximate Length (m)	Approximate Width (m)	Approximate Height above ground (m)
Wastewater Equalisation Tank	-	20	9	-
Final Effluent Pumping Station	268	26	11	6
Coagulation Dosing Chamber	257	20	9	10
Nitrifying Sand Filter (NSF)	1125	39	29	9
Mechanical Cloth Filter	142	12	12	4
Chemical Storage	242	11	21	8
Treated Effluent Pumping Station Shaft	-	-	15	-
Treated Effluent Pumping Station	268	26	11	6

Table 2-8: Indicative 75Ml/d Process Unit and Structure Sizes

Process item	Approximate building / structure area (m^2)	Approximate Length (m)	Approximate Width (m)	Approximate Height above ground (m)
Wastewater Equalisation Tank	-	25	11	-
Final Effluent Pumping Station	301	27	11	6
Coagulation Dosing Chamber	257	25	11	10
Nitrifying Sand Filter (NSF)	1362	42	33	9
Mechanical Cloth Filter	212	12	18	4
Chemical Storage	345	11	31	8
Treated Effluent Pumping Station Shaft	-	-	16	-
Treated Effluent Pumping Station	301	27	11	6

2.2.3.3 Waste Streams Management

The operation of NSF and mechanical cloth filters result in backwashing and desludging waste streams that could be collected in the Wastewater Equalisation Tank prior to discharge to the Wastewater Return Pumping Station and returned to the inlet of the Mogden STW.

Projected quality parameters of the waste stream are shown in Table 2-9.

In Gate 2 design, it was assumed that Mogden STW would have sufficient capacity to accept the return of the TTP backwash waste streams, however further assessment is required to confirm this at future stage.

Table 2-9: Projected TTP Waste Stream Flow and Composition

Parameter	Units	50Ml/d Plant Design	75Ml/d Plant Design
Waste Stream Flow	Ml/d	8	12
pH	ph Unit	6.8	6.8
Alkalinity (as CaCO3)	mg/l	174	174
Suspended Solids	mg/l	400	400
Suspended Solids (Load)	kg/d	3,220	4,830
BOD	mg/l	45	45
BOD (Load)	kg/d	361	542
Ammonia	mg/l	12	12
Ammonia (Load)	kg/d	95	142
Phosphorus	mg/l	0.5	0.5
Phosphorus (Load)	kg/d	4	6

2.2.4 Conveyance Design Components

2.2.4.1 Conveyance Design General Considerations

The general assumptions used to develop the conceptual design of this tunnel are listed below:

- The proposed tunnel would have an Internal Diameter (ID) of 1.8m.
- The spacing of intermediate shafts is limited by operational, health and safety considerations governed by the diameter and construction techniques. A maximum safe distance (for H&S purposes during construction) of 1000m has been assumed between shafts and is based on industry best practise (British Tunnelling Society (BTS) and the Pipe Jacking Association (PJA) and Health and Safety Executive (HSE), Tunnelling and Pipejacking Guidance for Designers (known as the PJA Guidance).
- 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 the requirements to drive a 1.8m ID tunnel using a tunnel boring machine (TBM), drive shafts would require to be approximately 10.5m ID with a construction site area of approximately $2500m^2$. Reception shafts are also assumed to be 10.5m ID. Given the reduced tunnelling operations at reception shafts, the construction site area would be correspondingly reduced.
- Considerations 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.
  - Minimising impact to surrounding areas.
  - Nature of the land and its current use for ease of procurement.
  - 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 Conveyance Route

The treated effluent transfer tunnel is envisaged to be constructed in multiple drives using a trenchless method, such as 'pipe jack' technology. Pipe jacking is an alternative method of lining a tunnel, as distinct from a segmental lining. It is a technique that is used from very small diameters (microtunnelling) up to 2500mm ID. Powerful hydraulic jacks are used to push specially strengthened pipes through the ground behind a shield or TBM. The TBM is received at a reception shaft and may be launched onwards in a series of drives or taken away to start again at another drive shaft. The pipes remain in the ground and are cement-grouted into place, displacing any lubricating fluid used during the jacking process.

The first shaft would be within the Mogden STW site close to the proposed Tertiary Treatment Plant (TTP), and the proposed shaft at Teddington discharge would be located in close proximity to the River Abstraction Site on the River Thames.

There will be several intermediate shafts along the tunnel route between a drive shaft and a reception shaft. Drive shaft compounds will have a larger land requirement than reception shaft compounds due to their purposes as TBM launch sites which require more area for material transportation and storage as well as plant logistics.

2.2.4.3 Tunnel Shafts

Indicative shaft details for the Treated Effluent Transfer Tunnel are listed in Table 2-10 below:

Table 2-10: Mogden STW to Teddington Tunnel Indicative Shaft Details

Shaft	Shaft Internal Diameter (m)	Approximate Ground Level (mAOD)	Approximate Shaft Depth (m)	Approximate Shaft Base Level (mAOD)
Mogden STW Shaft Site	10.5	7.1	27.1	-20
Shaft Site 2	10.5	8.8	27.5	-18.7
Shaft Site 3	10.5	8.2	25.3	-17.1
Shaft Site 4	10.5	7.1	22.2	-15.1
Shaft Site 5	10.5	6.3	20.4	-14.2
Shaft Site 6	10.5	6.2	19.4	-13.2
Shaft Site 7	10.5	7.7	19.4	-11.6
Teddington Shaft Site	10.5	7.2	17.9	-10.7

2.2.4.3.1 Mogden STW Shaft Site

The proposed shaft at Mogden STW would be located within Thames Water-owned land at Mogden STW near the proposed TTP.

A shaft is required for construction of the tunnel. After commissioning, the shaft would be used to transfer Treated Effluent from the treatment works to the main tunnel. There is sufficient land within Mogden STW for construction of the shaft although the site is relatively constrained. Some amendments to normal operational access would be required during the works.

2.2.4.3.2 Intermediate Shaft Sites

Several intermediate shafts would be required along the route to launch and receive the TBM undertaking the tunnel construction. Drive shafts would be used to facilitate access to the tunnel, launch the TBM, remove spoil, store materials and jacking pipes and provide ventilation during construction.

The intermediate shafts for this size of tunnel would have an internal diameter of 10.5m and would be capped with a concrete cover after completion of the works. The shaft concrete cover would be permanent and would be positioned below the ground surface to minimise impacts on current use of the land, with access covers for personnel and plant accessible at ground surface.

2.2.4.3.3 Teddington Shaft Site

A shaft would be required at the Teddington discharge site for construction of the tunnel and to transfer Treated Effluent from the invert of the tunnel to the River Thames outfall. The location of the proposed shaft is close to the River Thames to reduce the distance to the discharge point and to limit the impact of construction activities. The shaft concrete cover would be permanent, and would be positioned below the ground surface, with access covers for personnel and plant at ground surface.

2.2.4.4 Treated Effluent Discharge Arrangement

Treated Effluent would be discharged into the River Thames upstream of the Teddington Weir. The Treated Effluent will then blend with the main river flow and compensate for the abstraction being made at the new river intake to the Thames Lee Tunnel (TLT) upstream of the discharge. The new river outfall structure would be designed to reduce the discharge velocity into the river of less than 0.3m/s. This low velocity is intended to minimise disturbance to the aquatic life in the river as well as to avoid introducing turbulent currents that may disturb boats or other craft using the river.

The new river outfall would be a buried reinforced concrete structure. The buried structure is intended to be unobtrusive, although access covers and covers to valve spindle might be visible at the ground level. The Treated Effluent would discharge at the surface of the river. The riverbank at the location of the discharge outfall would extend over the river edge as a vertical timber wharf. Vertical bars would be fitted under the wharf structure to prevent unauthorised access and to prevent accumulation of debris when not in use.

Modelling work is being carried out to confirm suitable discharge velocities for the Teddington Weir fish pass and to ensure that there are no adverse effects on scouring and on the fish as well as to limit the effect on navigation. Design of the outfall is to be further developed through feedback from modelling results and conversations with regulatory authorities and local communities.

2.2.4.5 River Abstraction Arrangement

The river intake at Teddington would be located immediately upstream of the proposed new outfall. The indicative arrangement of river abstraction is shown on the figures below. The intake would comprise of coarse screens, mechanical fine screens and a settling chamber to remove sand or silts that may be drawn in. A low velocity intake with eel screen (self-cleaning band screen) is considered at this stage.

For the intake to work effectively the screens would be positioned in the river flow, some 3 to 5m from the riverbank. This is to prevent silting or blocking of the intake. To minimise the visual impact, the overall height of the structure and screens could be minimised in the detailed design to blend in with the existing topography. The mechanical and electrical (M&E) equipment would be secured in kiosks and a permanent fenced enclosure would be required. In addition, a power supply and vehicular access to the intake structure would be needed.

Designs and arrangement of the river intake structure will be further developed through conversations with regulatory authorities, confirming design requirements from the environmental and functional aspects. In addition, it is recommended that landscape specialists and architects be engaged into the design work to provide a positive legacy with visual delight in the community.

Figure 2-1: Indicative 3D Visualisation Representation of Teddington DRA Intake on the River Thames – Bird Eye's View

Figure 2-2: Indicative 3D Visualisation Representation of Teddington DRA Intake on the River Thames - Elevation View

2.2.4.6 Raw Water (River Water) Transfer Pipeline and Connection to TLT at Teddington

A Thames Lee Tunnel (TLT) Connection Shaft is proposed near to the proposed river intake at the River Thames, adjacent to the location of the Treated Effluent outfall. A connection shaft would extract flows from the intake on the Thames via a pumping station.

Abstracted flow in the Raw Water Transfer Pipeline would be monitored by a flow meter in a chamber located after the pumping station. The flow meter would be connected to the inter-site control system to control pumps in the TTP, Lockwood Reservoir Pumping Station and the Teddington River Abstraction, such that flows in the entire conveyance system will be centrally controlled.

Connection to the TLT would be via a shaft positioned close to the existing tunnel which would be connected via an adit or a vertical connection from the base of the shaft. Flow would be conveyed via pipework to the base of the shaft where it would connect into the tunnel.

The TLT was designed to work as a gravity system; however, due to the limitations of the vertical alignment of the tunnel, under certain conditions, the tunnel could operate as a siphon at higher flow rates. The impact of introducing additional flows at Teddington on the TLT will be further assessed at the next stage of the project.

2.2.4.7 Tunnel Profile and Existing Infrastructure

The depth of the Treated Effluent Transfer Tunnel would vary from an invert level of -20.0mAOD at Mogden STW to -10.7mAOD at Teddington. The tunnel would be with a gradient of 1:500, sloping uphill from Mogden STW to Teddington. This would enable the tunnel to be drained down back to Mogden STW which would have operational advantage if taking the tunnel out of use or in event of a process treatment quality failure reaching the tunnel. There may be an opportunity to reverse this slope with pumps being used to discharge the water in the tunnel into the River Thames.

These depths would locate the tunnel within London Clay based upon available borehole records. The depth is assumed to provide sufficient clearance beneath the top of clay along the entire alignment. Further ground information along the route will be required to confirm tunnel profile.

As the tunnel would be within London Clay, it is not envisaged that the tunnel and shaft construction would present any significant risks associated with ground movement. A first phase settlement analysis will be required to estimate predicted settlements.

An initial review of services information indicated the tunnel would not clash with any major transportation or utilities in the vicinity. A preliminary investigation of third-party crossings along the Teddington and Mogden STW tunnel corridor was undertaken based on available information. The only significant transport infrastructure would be the overground railway and A316 Chertsey Road. Discussions with relevant asset owners will be required to confirm the permissible settlements for crossings and depths of buried utilities. Some assets will need pre-and post-condition surveys, as part of the agreement, together with any protection, repair, or monitoring to allow construction to proceed.

2.2.4.8 Pumping Stations

Pumping stations (PS) are required for raw water abstraction, inter process and Treated Effluent pumping. The key pumping requirements would be as follows.

- **Final Effluent Pumping Station:** To abstract final effluent from the existing final effluent channel in Mogden STW and transfer to the proposed Tertiary Treatment Plant (TTP) in proximity to the abstraction location within the STW. This PS would be located within Mogden STW.
- **Wastewater Pumping Station:** To transfer wastewater generated through treatment in TTP to the inlet of the Mogden STW for treatment. This PS would be located within Mogden STW.
- **Treated Effluent Pumping Station:** To transfer Treated Effluent from the proposed TTP in Mogden STW to the first tunnel shaft of Treated Effluent Transfer Tunnel which would lead to Teddington discharge location on the River Thames. This PS would be located within Mogden STW.
- **Teddington Shaft Discharge Pumps:** To lift conveyed Treated Effluent from the tunnel shaft at the Teddington Discharge site on the riverbank and discharge through the outfall. The pumps would be located inside the tunnel shaft at the Teddington Discharge site.

- **River Abstraction Pumping Station:** To transfer raw water abstracted from the River Thames at the proposed Teddington Intake to the TLT connection in proximity. This PS would be located near the Teddington Intake.

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 the Thames Water Gateway Desalination plant, were reviewed. Interviews with technical and operational staff from these plants were held to assess practicability of 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 mode 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 be 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 lengthy re-commissioning which could 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 recommissioning 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 high 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 back 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.

Teddington DRA scheme has two differing factors from the other London Effluent Reuse schemes in operation and maintenance.

- The tertiary treatment process is simpler in terms of re-commissioning the plant from Care and Maintenance mode into Hot Standby mode and only has one conveyance asset for the Treated Effluent transfer (tunnel from Mogden STW to Teddington).
- However, the proposed Nitrifying Sand Filter process would take up to 6 to 8 weeks to fully establish the nitrification process for start-up once the biomass on the sand filter has been lost.

2.2.5.3 Tertiary Treatment Plant Chemical Consumption

The TTP would not require chemicals for cleaning purposes. Ferric sulphate would be used at the plant for the purposes of phosphorus removal during operation.

2.2.5.4 Maintenance Requirements

2.2.5.4.1 Tertiary Treatment Plant Process Units

The minimum flow rate to the Nitrifying Sand Filter should be generally at $4m^3/m^2/h$, and it is important to keep flows constantly to maintain biomass on the filter. Failure to maintain biomass will result in significantly reduced nitrifying capabilities resulting in a higher ammonia concentration. Establishing biomass would take 6 to 8 weeks during the summer and may be longer during the winter period.

The mechanical filters would operate by filtering water through filter discs fitted with filter pile type cloth. The filters are generally capable of being started up within a short period of time. They can be operated at low or no flow; however, they will require periodic backwashing when not in use. The water being filtered passes through the pile cloth, so the solids collect on the outside of the pile cloth creating a head loss. At a pre-set water level, the cleaning cycle would be initiated. Cleaning equipment may consist of suction shoes and suction pumps.

Since the water flows from outside to inside of the disc, the tank around the discs will see some settlement of solids occurring (and other such debris) which creates a build-up of sludge at the bottom of the tank. This sludge could be removed by sludge pumps.

Backwash suction shoes and suction pumps as well as sludge pumps would be maintained and serviced in accordance with the manufacturer's recommendations and might be sent for inspection and rebuild after 10 years operation.

2.2.5.4.2 Conveyance

When in Normal Operation, the tunnel from Mogden STW to Teddington would operate with the shafts at either end acting as balancing tanks. Treated Water would be pumped into the shaft at Mogden STW and pumps at Teddington shaft would draw water out at the other end of the tunnel. A single networked control system would simultaneously control the pumps at the two shafts to maintain water levels within a controlled range to suit the pumps and to provide the driving head to push the water along the connecting tunnel.

When the scheme is in Care & Maintenance mode, the tunnel would be pumped dry and left drained until it is used again. 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.

The pumps would need regular maintenance and periodic operation to keep parts operable when the system is in Care & Maintenance mode.

The outfall structure is intended to require minimal maintenance. Inspections would be carried out to ensure the structure, including access covers, have not been damaged and that it does not represent a hazard to the public. The valve operation would be checked, and a visual internal inspection of the buried structure would be carried out. The inspection would monitor the build-up of any silt inside the structure and check for the accumulation of debris.

The new river intake screen on the abstraction would require regular inspection and maintenance. Mechanical and electrical equipment would require regular maintenance in line with the equipment manufacturer's recommendations. After periods of inactivity, it is important that the screens are cleared of any debris and the silt trap is cleaned to ensure the intake will operate effectively.

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 Mogden 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 Tertiary Treatment Plant (TTP) fails due to 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 TTP, would automatically shut down on failure.

The locked in process flow would then be run-to-waste with all flows passing to the Tertiary Treatment Plant's Wastewater Return Pumping Station, to return all locked-in flows to the Mogden STW inlet works for treatment.

2.2.6 Inter Site Control System Requirements

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

- Communication links between the Mogden STW and the River Abstraction Pumping Station (PS) may be required to relay PS operational status and control. In the event of a power outage at Teddington River Abstraction site, Treated Effluent transfer from Mogden STW to Teddington would stop.
- Communication links between the Mogden STW and the Teddington Shaft PS might be required to relay PS operational status and control. In the event of a power outage at Teddington Shaft PS, the Treated Effluent transfer from Mogden STW to Teddington would stop.
- Communication link between the River Abstraction PS and Teddington Shaft PS might be required to relay operational status between sites. In the event of a power outage at either site, conveyance at the other site would stop.

- Connection to the wider Thames Water Production Planning system might be required to regulate operating capacity based on current river and reservoir levels.

2.2.7 Power Requirements

There are three sites requiring new or upgraded power supplies:

- Mogden Sewage Treatment Works (STW)
- Teddington Shaft Pumping Station (PS)
- River Abstraction Pumping Station (PS)

2.2.7.1 Potential Power Requirements at Mogden Sewage Treatment Works

The existing High Voltage (HV) power distribution network within Mogden STW could be utilised to supply power to the new Tertiary Treatment Plant (TTP). However, the existing Mogden STW power supply may need to be upgraded or modified. Additionally, HV feeders to the new HV switchboard/ transformer located locally to the treatment process may need to be provided by the existing HV switchboards. This may require the existing HV switchboards to be modified.

Should there not be sufficient power capacity available at Mogden STW and modification of the existing infrastructure is not feasible, a new 11kV power supply may need to be arranged terminating at the new HV Switchboard. A supply transformer may be located outdoors in a fenced enclosure adjacent to a new Electrical Building in TPP site.

The power supply for TTP could be potentially used to provide power to the TBM for tunnel construction, prior to construction of the TTP. The supply could be utilised by the TBM on a temporary basis until such time that tunnelling is completed and thereafter the supply would be transferred to the TTP HV Switchboard on a permanent basis.

2.2.7.2 Potential Power Requirements at Teddington Shaft Pumping Station

The location of the pumping station would require a first-time LV power supply provided by the local DNO. The new power supply to the site would terminate at the site LV MCC. The MCC would provide power for discharge pumps which would be located within the shaft 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 Requirement at River Abstraction Pumping Station

The River Abstraction Pumping Station would require a first-time LV power supply provided by the Local DNO. The new power supply to the River Abstraction Pumping Station will be terminated at the PS MCC. The PS MCC may provide power to abstraction pumps, band screens, washwater pump and to building services and ventilation.

In the event of a supply failure, the River Abstraction Pumping Station will require standby power in order to match abstracted flows from the River Thames with the discharged flow from the proposed TTP. The MCC will have a generator incomer section incorporated into the design with space onsite allocated for the inclusion of a standby generator, diesel storage tank and bunding.

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.

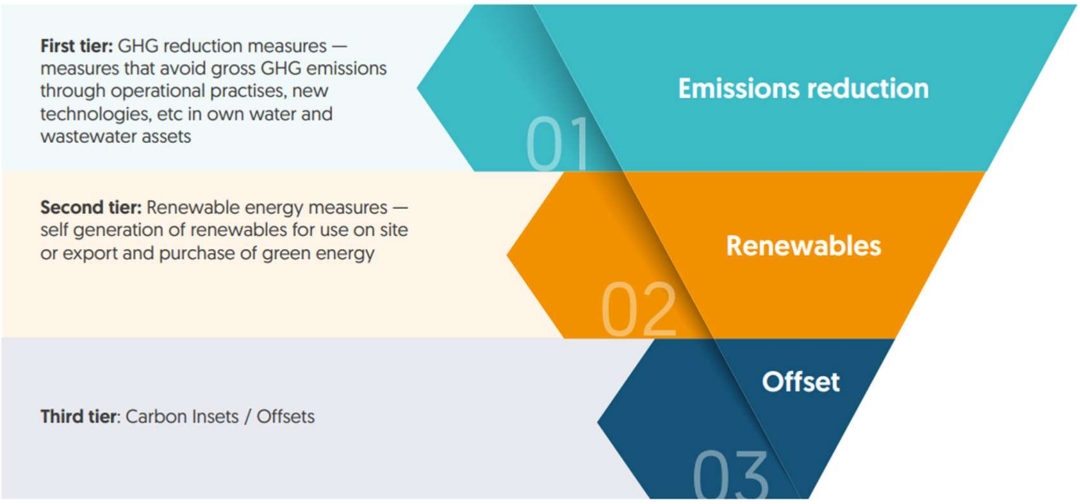

Figure 2-3: Emission Reduction Hierarchy

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 2-11: 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 - 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

2.2.9 Richmond Lock and Weir

The Port of London Authority (PoLA) owns and operates Richmond Lock and Weir, which is also the base for the Upper River Harbour Service patrols between Putney and Teddington Lock. They operate the lock and the weir in accordance with the Richmond Footbridge, Sluice, Lock and Slipway Act 1890 and Port of London Act 1968 (as amended), which requires an upstream water level of 1.9m to 2.0m AOD is maintained to ensure sufficient water depth for navigation upstream during all tidal ranges.

Situated between Teddington and Richmond, the weir comprises three vertical steel sluice gates suspended from a footbridge. Each gate weighs 32.6 tonnes and is 20 metres wide and 3.64 metres in depth.

For around two hours each side of high tide, the sluice gates are raised into the footbridge structure above, allowing ships and boats to pass through the barrage. For the rest of the day the sluice gates are closed and passing river traffic must use the lock alongside the barrage.

PoLA raised concerns that the depleted water in the downstream reach (due to reduction in Mogden STW effluent discharging) would result in a greater differential head across the weir gates leading to greater loss of flow under and around the gates impacting their ability to maintain upstream water level in accordance with their operating agreements under the Acts. The weir gates have gaps beneath them where the apron they close onto has scoured over the years, this leakage increasing is the concern. PoLA confirmed that at very low river levels they are challenged already in maintaining the required upstream depth.

Initial hydraulic assessment in Gate 2 assumed a range of gaps under the weir gates where the apron has been scoured against a maximum differential head now and with future reduced downstream depth in low flow conditions (50mm) to assess the change in potential losses under the weir gates. The findings are that less than 1% additional flow under the gates is anticipated. We do not believe this would materially impact the upstream depth being maintained. At future Gate stage we will consider this in more detail with PoLA.

2.3 Opportunities and Future Benefits Realisation

2.3.1 Thames Lee Tunnel extension

In the London Effluent Reuse SRO, Beckton Water Recycling scheme proposes a 3.5m-diameter Recycled Water Transfer Tunnel from the existing Lockwood Reservoir Pumping Station (PS) site, where the terminal shaft of Thames Lee Tunnel (TLT) located, to the proposed outfall at River Lee Diversion upstream of the existing inlet of the King George V Reservoir (KGV), which is the largest and the most upstream of the Lee Valley reservoirs.

Currently, flow from TLT is pumped to Lockwood, Banbury and High Maynard reservoirs through Lockwood Reservoir PS. There is an opportunity that the existing TLT Lockwood shaft and pumping station would be modified to provide a bypass feed to the proposed 3.5m-diameter Recycled Water Transfer Tunnel (TLT extension), such that all or a portion of DO from Teddington DRA scheme and potentially the other existing flow within TLT could be transferred to the KGV inlet.

This arrangement could potentially bring significant resilience benefit to the East London water supply system because KGV currently can only be filled by the River Lee Diversion which can have flow below the hands-off flow condition, restricting abstraction in drought conditions.

Benefit of DO from Teddington DRA being transferred to KGV will be investigated through modelling of the cross London raw water supply system.

2.3.2 Other Key Opportunities

Other key opportunities identified in the conceptual design are listed in Table 2-12 below.

Table 2-12: Key Opportunities – Teddington DRA Conceptual Design

Category	Opportunities
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. There may be an opportunity to reduce the tertiary treatment requirements by optimising the treatment process.
Process System Design	There is an opportunity to reduce the ferric sulphate dosing requirements for phosphorus removal upon confirmation of phosphorus discharge limits.
Process System Design	There is an opportunity that a platform could be built above the existing storm tanks for Tertiary Treatment Plant construction. This solution may negate requirements for deepening existing storm tanks to maintain the total storm storage capacity for STW. Further structural and geotechnical investigation will be required to assess feasibility of this option.
Conveyance System Design	The pumping station at the Teddington Abstraction site could be combined within the structure of the proposed connection shaft at TLT. This could reduce the land area and length of the pipe required.
Conveyance System Design	If the tunnel diameter was increased to 3.5m then the number of intermediate shafts could be reduced. In addition, a TBM could be arranged so that the spoil could be handled at one shaft. This gives the opportunity of potential removal of spoil via barge on the River Thames by any shaft sited close to the river. However, this opportunity would come at significantly higher capital cost than the smaller diameter option which is currently proposed.

Category	Opportunities
Conveyance System Design	Optimum tunnel diameter has been chosen based on practical construction, as a pure hydraulic analysis would indicate a reduced diameter may be feasible for the scheme in small capacities but may introduce construction complexity. Alternative methodologies could be explored to deliver a more economical solution if the scheme is selected in a small capacity such as 50 Ml/d.
Synergy with other TWUL Objectives for Mogden STW upgrade	There is a possibility that Mogden STW will require additional storm storage capacity in the future. Due to the engineering scope to either deepen or modify the storm tanks at Mogden STW to provide space for the new Tertiary Treatment Plant, there is an opportunity to synergise and meet the requirement by upgrading additional existing storm tanks as part of Teddington DRA scheme. This may increase the value of the project.
Synergy with other TWUL Objectives for Mogden STW upgrade	There are future requirements for increased capacity at Mogden STW for growth which are likely to require process intensification within the existing plant footprints and tanks. The technology selected could offer a synergy with the TTP as final effluent quality may be improved, meaning less tertiary treatment would be required.

3. Scheme Delivery

3.1 Overview of Construction Process

3.1.1 Tertiary Treatment Plant

It is proposed that a new Tertiary Treatment Plant (TTP) is constructed within the Mogden STW. However, there is no vacant land available in the Mogden STW. The primary option considered during Gate 2 is to deepen some of the eight existing storm tanks located to the east of the STW, which would allow the storage capacity of the storm tanks to be maintained on a smaller footprint, thereby freeing up land for the TTP.

Gate 2 conceptual design work confirmed that the site for the existing storm tanks could accommodate TTP up to 100Ml/d capacity, maintaining the existing storm storage capacity.

Alternatively, the TTP could be built on a platform built above the existing storm tanks. Feasibility of this opportunity will need to be investigated further. Optimal design will be further considered in the future design work.

As the Mogden STW will be in operation during the construction of the new TTP, deepening of the existing storm tanks would need to be carried out in sequence, replacing them with the new deeper storm tanks. It would be desirable to complete the storm tank replacement in the season of low precipitation. Timing and procedures of construction would be determined through discussion with the EA and plant operation. A temporary relaxation for the required storm storage capacity may be required during the construction. Construction of the TTP would be carried out after completion of the storm tank replacement.

The TTP would be located within the Mogden STW, therefore, the existing infrastructure in the Mogden STW, including access roads, drainage and services as well as boundary fencing, access barriers/gates and security, could be utilised during construction.

3.1.2 Conveyance

3.1.2.1 Tunnel Construction

The tunnel alignment between Mogden STW and Teddington discharge site would be excavated using a tunnel boring machine (TBM) and the tunnel lining would be pushed in by pipe-jacking. The TBM would be lowered to the base of a drive shaft, from where it would excavate to a reception shaft with the lining jacked in behind using hydraulic rams fixed in the base of the launch shaft. The TBM would have a bored diameter of approximately 2.2m to include for the pipe thickness and an overcut, which provides clearance to enable the machine to advance and steer and to facilitate jacking of the lining. The annulus left would be grouted soon after tunnel lining is completed. The pre-cast segments that follow the TBM are divided into separate pipe categories: lead pipes that are located at the front of the drive, trail pipes that follow the pipeline drive and the intermediate jacking stations that are used to provide additional jacking forces to extend longer drive lengths. For an assumed internal pipe diameter of 1.8m the outside diameter would typically be 2140mm and the length of the segment 2.47m. Every third or fifth pipe would include socket holes that allow to apply grout or lubrication in order to reduce friction during jacking.

The internal diameter of the tunnel of 1.8m has been assumed as this is the minimum recommended diameter for the drive lengths of up to 1000m based upon current HSE guidelines. This is to allow the escape of workers from the tunnel in an emergency. The ease of emergency evacuation can be difficult in a small tunnel, particularly past spoil conveyors, muck skips and other equipment.

The type of TBM depends on the ground conditions expected. Although there is little existing ground investigation data, in this area we would anticipate that the subsoil the TBM is to excavate would be London Clay, albeit geotechnical anomalies are always a possibility.

The choice of drive location and direction of drive depends on factors such as the available space at each shaft site, likelihood of impact to the surroundings, ease of material supply and spoil removal.

Back shunts will normally be required at the base of the drive shafts, to set up the backup equipment for the TBM, which typically includes the rail-mounted skips, ventilation kit, 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 Shaft Construction

This conceptual design indicates the most likely shaft construction method, but the final choice will depend on many factors, particularly details of the ground conditions that would emerge from ground investigations, as well as construction and operational health and safety considerations.

3.1.2.2.1 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, or SCL shaft construction, if ground conditions improve, but the reverse cannot happen.

3.1.2.2.2 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 Outfall Construction

The proposed outfall located upstream of the Teddington Weir is intended to discharge Treated Effluent into the River Thames. The outfall structure is intended to be discrete and would be mostly buried in the riverbank. An open excavation would be required to construct the outfall structure. The working area would be secured during construction by security hoarding around the site perimeter and access to the site would be controlled.

The foundations of the structure would be below the river level and a temporary U-shaped steel sheet pile wall would need to be built out from the riverbank 2 to 3m into the river to allow a dry excavation for construction. Depending on the specific site ground conditions, the steel sheet pile wall may be extended around the whole excavation perimeter. A blinding layer of concrete would be laid across the bottom of the excavation to give a stable working level.

The structure base, walls and internal weir of the outfall could be cast in situ. The top cover slabs are likely to be precast concrete planks and could be cast off site and craned into position. Once complete, the structure would be backfilled to the original ground profile and the temporary sheet piles would be removed. The riverbank profile on either side of the structure would be reinstated, as would the surface along the river and over the outfall opening to the river.

3.1.2.4 River Abstraction Construction

The proposed river intake at Teddington would be located immediately upstream of the new outfall structure and is intended to abstract from the River Thames.

An open excavation would be required to construct the new intake. The working area around the excavation would be secured during construction by security hoarding around the site perimeter and access to the site would be controlled.

The foundations of the structure would be below the river level and a temporary steel sheet pile caisson would be installed around the excavation area to allow construction to proceed. A blinding layer of concrete would be laid across the base of the excavation to give a stable working level. The length of the sheet piles required will depend on the site-specific ground conditions.

The new intake structure would be constructed from reinforced concrete. The structure base and walls would be cast in situ and the top cover slabs are likely to be precast concrete planks and could be cast off site and craned into position. When complete, the excavation would be backfilled around the structure and the mechanical and electrical equipment could be installed. The temporary sheet piles would then be removed and the riverbank profile on either side of the structure would be reinstated. Mechanical and electrical equipment at ground level would be enclosed in kiosks or by secure fencing. The permanent works would also include installation of electrical power supply, vehicular access and connection pipework to the TLT.

3.1.2.5 Raw Water (River Water) Transfer Pipe and Thames Lee Tunnel Connection

To abstract flow from the river and direct it into the Thames Lee Tunnel (TLT), a pumping facility and connection will be required into the existing tunnel. The depth to tunnel invert is approximately 40m, the TLT is 2.6m ID and the incoming pipe would be 1.2m ID. For safety of construction the shaft should be a minimum of 7.5m ID, which should also be sufficient for installing the internal pipework. It is assumed that it will be highly desirable to minimise the period of shutdown of the TLT. An assessment of the impact of construction works in the vicinity of the live TLT is required to determine implications to operation of the TLT and to determine limitation of construction works.

The proposed construction method would be:

- Sink 7.5m diameter shaft directly over the TLT, using segments or Sprayed Concrete Lining (SCL)
- Construct underream 8m diameter in lower part of shaft. This is to mitigate hydraulic flotation forces on the shaft base
- Construct shaft base and portal structure over top of TLT
- In TLT depressurisation break into top of TLT and construct pressure structure like other TLT shafts
- Install pipework to TLT connection in shaft
- Re-open tunnel

The TLT is constructed by a version of Wedge Block Technology called Donseq, this works using the external pressure of the ground locking wedge blocks through friction. The connection will have to be carefully designed to ensure structural integrity of the tunnel is maintained. This will require a limited shutdown of the TLT to undertake preparatory works. As the TLT is such a critical asset with limited opportunity for outages it will take significant planning. TLT undergoes temporary periodic shutdowns for inspection and maintenance works. Upon further discussion with the asset owner this period of time could be used as an opportunity to carry out construction works.

The precise method of construction to intercept the existing tunnel may alter according to operational limitations and the contractor’s preferences.

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 Teddington DRA scheme include:

- Existing Thames Lee Tunnel (TLT) was constructed in "Don-Seg" segments, which are unbolted and held in position by compression against the ground. There are potential safety risks and difficulties during construction in connection to the TLT, as a result of dismantling these segments, which would need to be internally supported.
- Proposed Tertiary Treatment Plant (TTP) is proposed to be built in the footprint of existing storm tanks in Mogden STW. To maintain the existing capacity of the storm tanks, some of the storm tanks would be deepened. There are potential safety risks during construction, which are associated with structural integrities of the existing storm tanks and excavation possibly through water bearing gravels.
- 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 in Mogden STW.
- Potential Tunnel route would have river crossings which could lead scour hollow risks.

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 existing TLT and the foundations of 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 be transported to site using Heavy Goods Vehicle (HGVs). The number of HGVs for transportation of shaft/tunnel segments and the tunnel secondary lining (if applicable) has been estimated, see section 3.2.3.

3.2.2 Spoil Disposal

The work sites would generate spoil from shaft excavation, the drive shaft would also generate spoil 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 waiting for transport off site by lorry during daytime working hours or transfer to barges or rail wagons if these forms of transport are possible. If a slurry machine is used for tunnelling, further space would be required for a plant for separation of spoil from the slurry mix before it is transported off site.

Other methods of spoil removal could be considered at a later stage such as barge transportation for sites located near to the River Thames. The use of barges would reduce the impact of tunnel works on the surrounding traffic network. Rail transport is unlikely suitable in this area.

3.2.3 Vehicle Movement during Construction

A summary of indicative vehicle movements for spoil disposal and material transportation during construction are presented in the following tables:

Table 3-1: Summary of Indicative Vehicle Movement Estimation for the Tertiary Treatment Plant Construction

Option Element	Estimated total no. of HGVs for spoil	Estimated total no. of HGVs for concrete, rebar and structural fill	Comments
TTP 50Ml/d	400	2100	It was assumed that excavated materials from deepening Storm Tanks will be used to fill the site for TTP.
TTP 75Ml/d	500	2300	It was assumed that excavated materials from deepening Storm Tanks will be used to fill the site for TTP.

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

Shafts	Estimated total no. of HGVs for spoil	Estimated total no. of HGVs for segments	Comments
Mogden STW Site Shaft Construction	600	100	Shaft sinking at Mogden STW site
Intermediate Shafts Construction	3000	600	Combined Intermediate Shaft Sites along the tunnel routes.
Intermediate Shafts Tunnel Construction	3400	1300	TBM drive between the Intermediate sites.
Teddington Site Shaft Construction	400	80	Shaft sinking at Teddington site.
TLT Connection Shaft	400	40	Tunnel Connection

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 (Teddington DRA)

Project Phase	Approximate Duration (months)
Pre-Construction Stage	17
Detailed Design	14
Procurement	11
Enabling Works	10
Construction Stage	27
Commissioning Stage	13
System Commissioning Works	8
Performance Testing	6
Defects Period	11

4. Water Resources

The Deployable Outputs (DO) for Teddington DRA were estimated as 46 and 67 Ml/d, for both the Dry Year Annual Average (DYAA) and the Dry Year Critical Period (DYCP), for the capacities of 50 Ml/d and 75 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 TTP would be situated on the site of the existing storm tanks requiring deepening existing tanks to maintain capacity. It was assumed structural conditions of existing facilities and geotechnical conditions will be suitable to perform required work.
- The raw water quality in the River Thames at the intake location is the same quality of the water already in the Thames Lee Tunnel which is currently abstracted at Hampton Intake and will therefore be suitable for discharge into the Lee Valley reservoirs.
- There will be no obstacles with purchasing additional land required.
- It has been assumed that wastewater from the proposed Tertiary Treatment Plant will be directed to the inlet of the Mogden STW. These flows are assumed not to cause any concern to the hydraulic and treatment capacity in the Mogden STW.
- It was assumed that the abstraction location will be the north bank of the River Thames upstream of the Treated Effluent discharge location and Teddington Weir, this has been assessed as part of the environmental assessments detailed in Annex B of Gate 2 Report.
- Environmental Quality Standards (EQS) for parameters of design of Tertiary Treatment Plant (TTP) are not available. However, it has been assumed the discharge consent for the Hogsmill STW, which discharges relatively upstream of the proposed TTP discharge location will be indicative of the acceptable discharge consent. This will be reviewed and revised, and changes will be incorporated into the design as further information becomes available.
- It is assumed that TWUL have assessed and will further assess the in-combination water resources modelling of flows in the Thames Lee Tunnel (TLT) to ensure that at all times, the Teddington DRA scheme would be able to suitably discharge abstracted flows to the TLT without hydraulically overloading the asset.

5.2 Key Risks

Key risks associated with this scheme are listed as follows:

- The treatment technologies have been selected, assuming that the discharge requirements for the existing Hogsmill STW will be applicable to the Treated Effluent discharge for the Teddington DRA scheme. There is a risk that requirements for water treatment will be more onerous for the Teddington DRA scheme.
- It is proposed to return the TTP waste streams, which include NSF and cloth filter backwash and desludging, to the inlet of the Mogden STW. Should assessment indicate the STW does not have sufficient capacity, alternative wastewater treatment will be required.
- Ferric dosing quantities are based on average phosphorus content within the Mogden STW final effluent. Any change in operation at the Mogden STW that could result in a change in final effluent phosphorus content will have an impact on this design. Additionally, any increase in phosphorus loading is likely to increase solids loading to the NSF and a settlement stage, such as primary clarification or lamella system, prior to the filter plant may be required. Further monitoring and sampling of the Mogden STW final effluent is required.
- There is a risk that structural conditions of the existing storm tanks and associated facilities in Mogden STW are not suitable for the proposed construction methods and that different construction methods will need to be used for modifying the existing storm tanks and TTP construction.

- There is a risk that geotechnical conditions around the existing storm tanks in Mogden STW are not suitable for the proposed construction methods and that different construction methods will need to be used for modifying the existing storm tanks and TTP construction.
- The TLT has limited shutdown availability to carry out the connection of a new intake.
- The TLT construction type makes the connection of a new shaft or adit more difficult than anticipated.
- Further modelling of the TLT is required to understand the impact of the Teddington intake at higher flows and when the tunnel might be performing as a siphon.
- 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)
AWRP	Advanced Water Recycling Plant
BNG	Biodiversity Net Gain
BOD	Biological Oxygen Demand
CCPs	Critical Control Points
CDC	Coagulation Dosing Chamber
CDM	Construction Design Management
CDR	Conceptual Design Report
CEC	Contaminants of Emerging Concern
CS	Chemical Storage
DAF	Dissolved Air Floatation

Acronym	Definition
Defra	Department for Environment, Food and Rural Affairs
DI	Ductile Iron
DNO	Distribution Network Operator
DO	Deployable Output
DPC	Direct Procurement for Customers
DRA	Direct River Abstraction
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
EIA	Environmental Impact Assessment
ELV	Emission Limit Value
ENG	Environmental Net Gain
EPB	Earth Pressure Balance
EQS	Environmental Quality Standard
EQT	Equalisation Tank
FEPS	Final Effluent Pumping Station
GAC	Granular Activated Carbon
GIS	Geographic Information System
HGV	Heavy Goods Vehicle
HSE	Health and Safety Executive
HV	High Voltage
ICA	Instrumentation Control and Automation
ID	Internal Diameter
KGV	King George V Reservoir
M&E	Mechanical & Electrical
MCC	Motor Control Centres
MCF	Mechanical Cloth Filter
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
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

Acronym	Definition
ROT	RO Feed Tank
RPv1	Regional Plan version 1
RWPS	Recycled Water Pumping Station
SAC	Special Area of Conservation
SEA	Strategic Environmental Assessment
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
UVAOP	UV Advanced Oxidation Process Building
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