South East Strategic Reservoir Option (SESRO)

Technical Supporting Document B1
Environmental Appraisal Report

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 and Affinity Water in the ongoing development of the proposed SROs. The intention of 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 and future funding requirements.
- Should a scheme be selected and confirmed in the companies' final Water Resources Management Plan, 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 and Affinity 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 and consideration should be given to that when reviewing the proposals. They are for the purposes of allocating further funding not seeking permission.

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 and Affinity Water's statutory duties. The information presented relates to material or data which is still in the course of completion. Should the solution presented in this document be taken forward, Thames Water and Affinity 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.

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Glossary

Term/Acronym	Definition
ACWG	All Company Working Group
ADC	Auxiliary Drawdown Channel
AOD	Above Ordinance Datum
Baseline	Also referred to as the 'baseline situation', this term describes the existing nature of the landscape and the visual environment within the study area at a fixed point in time, as well as any changes likely to occur independently of the proposed development, including the legislative and planning context and any relevant published guidance.
Baseline stochastic	This term describes the stochastic hydrological years simulated in both the Deployable Output modelling and the 1D hydraulic modelling with no SRO schemes/proposed development in place. It differs from the 'baseline situation' as it does not represent the existing or historical hydrological regime but a possible synthetic hydrological year which excludes climate change.
BAP	Biodiversity Action Plan – An internationally recognized program addressing threatened species and habitats and is designed to protect and restore biological systems. The original impetus for these plans derives from the 1992 Convention on Biological Diversity.
BNG	Biodiversity Net Gain – An approach used to improve a sites biodiversity value. Once applied, on completion, a site will have a positive ecological impact, delivering improvements through habitat creation or enhancement after avoiding or mitigating harm.
BOD	Biological Oxygen Demand
CAMS	Catchment Abstraction Management Strategy
CCI	Community Conservation Index
CEH	Centre for Ecology and Hydrology
CFD	Computerised fluid dynamics
Chlorophyll-a	Is a measure of the amount of algae growing in a waterbody and is used to describe the trophic condition of a waterbody. It is usually measured using a spectrophotometer with a narrow band width. Phosphorus is usually considered the "limiting nutrient" in aquatic ecosystems, controlling the pace at which algae and aquatic plants

Term/Acronym	Definition
	are produced. In excess quantities, phosphorus can lead to water quality problems such as eutrophication and harmful algal growth.
Construction	Construction, also referred to as the construction phase, refers to all activity on and offsite required to implement the proposed development. The construction phase is considered to commence with the first activity on site, e.g. the creation of site access or site clearance works, and ends with demobilisation.
CSOs	Combined Sewer Overflows
Defra	Department of the Environment, Food and Rural Affairs – Defra is the government department responsible for environmental protection, food production and standards, agriculture, fisheries and rural communities in the United Kingdom of Great Britain and Northern Ireland. Defra is a ministerial department, supported by 33 agencies and public bodies.
Development	Any proposal that results in a change to the landscape and/or visual environment.
DWSP	Drinking Water Safety Plan
EA	Environment Agency – A non-departmental public body with responsibilities relating to the protection and enhancement of the environment in England.
EAR	Environmental Appraisal Report
EDD	Emergency drawdown
EFI	Environmental Flow Indicator
EPSI	Empirically weighted Proportion of Sediment-sensitive Invertebrates
EQR	Ecological Quality Ratios
EQS	Environmental Quality Standards
EU	European Union
Effect	The nature of the change(s) likely to occur as a result of a particular impact.
Direct effect	An effect that is directly attributable to the Scheme
Indirect effect	An effect that results from the Scheme as a consequence of a direct effect(s), often occurring away from the site, or as a result of a

Term/Acronym	Definition
	sequence of interrelationships or a complex pathway.
Element	Individual parts which make up the landscape, for example trees, hedgerows or buildings.
Enhancement	Measures that seek to improve the landscape of the site and/or its wider setting beyond its baseline condition.
eDNA	environmental DNA
FCS2	Fisheries Classification Scheme 2
GES/GEP	Good Ecological Status/Good Ecological Potential – Artificial and Heavily Modified Water Bodies (A/HMWBs) are considered unable to attain GES due to the physical modifications that are necessary to maintain their function for society or their 'human use' as they provide important socio-economic benefits. They are, however, required to achieve Good Ecological Potential (GEP), through the implementation of a series of Mitigation Measures, which essentially aim to enhance the ecology in the water body without compromising its human use.
Geomorphology	The scientific study of the origin and evolution of topographic and bathymetric features created by physical, chemical or biological processes operating at or near the earth's surface. For example fluvial geomorphology is the study of the interactions between the physical shapes of rivers, their water and sediment transport processes, and the landforms they create.
HEV threshold	Hydroecological Validation threshold
HoF	Hands-off Flow
HRA	Habitats Regulation Assessment
ICM	Integrated Catchment Model
INNS	Invasive Non-Native Species
IUCN	International Union for Conservation of Nature
JNCC	Joint Nature Conservation Committee
km	Kilometre
km^2	Square Kilometre
Land use	This term refers to what land is used for and is based on broad categories such as urban, industrial, agriculture or forestry.

Term/Acronym	Definition
Landform	The shape and form of the land surface resulting from combinations of geology, geomorphology, slope, elevation and physical processes.
LiDAR	Light Detection and Ranging. A method for determining ranges (variable distance) by targeting an object or a surface with a laser and measuring the time for the reflected light to return to the receiver. It is commonly used to make digital 3D representations of areas on the Earth's surface and therefore determine the variability of a surface feature such as a *landform* (see above).
LIFE	Lotic invertebrate Index for Flow Evaluation, an indicator of a macroinvertebrate community's sensitivity to different flow regimes.
LWS	Local Wildlife Site
Magnitude of change	A judgement regarding the size and scale of the change, the geographical extent of the area that would be affected and the duration of the effect and its reversibility
MAGIC	Multi-Agency Geographic Information for the Countryside – A web-based interactive map to bring together information on key environmental schemes and designations in one place. Multi Agency Geographic Information for the Countryside (MAGIC) is a partnership project involving six government organisations who have responsibilities for rural policy making and management.
Mitigation	This term refers to those measures that are proposed to prevent/ avoid, reduce and where possible offset any adverse effects.
Ml/d	Megalitre(s) per day
MOU	Measure of Uncertainty
MoRPh	Modular River Physical Survey
N taxa	The number of truly aquatic scoring macrophyte taxa which were recorded.
NatureScot	NatureScot (previously Scottish Natural Heritage)
NAU	National Appraisal Unit
NE	Natural England – Executive non-departmental public body responsible for the natural environment.
NERC	Natural Environment and Rural Communities Act 2006
NIEA	Northern Ireland Environment Agency

Term/Acronym	Definition
NNR	National Nature Reserves – Reserves established to protect some of the most important habitats, species and geology in the United Kingdom, and to provide 'outdoor laboratories' for research. There are currently 224 NNRs in England with a total area of over 94,400 hectares – approximately 0.7% of the country's land surface. Natural England manages about two thirds of England's NNRs. The remaining reserves are managed by organisations approved by Natural England, for example, the National Trust, Forestry Commission, RSPB, Wildlife Trusts and local authorities.
NRW	Natural Resources Wales
NSIP	Nationally Significant Infrastructure Project
NWG	Northumbrian Water Group
°C	Degrees Celsius
O:E	Ratio of observed to expected biological metrics.
Operation	Also referred to as completion, this term describes the operation phase of the completed development and is considered to commence at the end of the construction phase, after demobilisation. The duration of the operation phase is dependent on the nature of the proposed development.
NGR	National Grid Reference
PCV	Prescribed concentration or value
PHI	Priority Habitat Inventory
PROTECH	Phytoplankton Responses to Environmental Change (model)
PRoW	Public Right of Way – A way over which the public have a right to pass and repass. The route may be used on foot, on (or leading) a horse, on a pedal cycle or with a motor vehicle, depending on its status. Although the land may be owned by a private individual, the public may still gain access across that land along a specific route. Public rights of way are all highways in law.
PSI	Proportion of Sediment-sensitive Invertebrates
PWWC	Passive Wedge-Wire Cylinder screens
RAG	Red, Amber, Green
RAPID	Regulators' Alliance for Progressing Infrastructure Development

Term/Acronym	Definition
Raw Water	Non-Potable Water
(d) RBMPs	(draft) River Basin Management Plans
RFDs	Reasons for Deterioration
RIVPACS	River Invertebrate Prediction and Classification System
RMNI	River Macrophyte Nutrient Index
RNAG	Reasons for Not Achieving Good
RWT	Raw Water Transfer
SAC	Special Area of Conservation – Areas of strictly protected sites designated under the EC Habitats Directive (92/43/EEC) on the conservation of natural habitats and of wild fauna and flora. The listed habitat types and species are those considered to be most in need of conservation at a European level (excluding birds).
SAGIS	Source Apportionment GIS
SAI–RAT	SRO Aquatic INNS Risk Assessment Tool
Sensitivity (of a receptor)	A judgement regarding the susceptibility of a receptor to the change arising because of the proposed development and the value attached to the receptor.
SESRO	South East Strategic Reservoir Option
SIMCAT	Simulation of Catchments model (Environment Agency)
spp.	Several species
SRO	Strategic Resource Option
SRP	Soluble Reactive Phosphorus – consists largely of the inorganic orthophosphate (PO_4) form of phosphorus. Orthophosphate is the phosphorus form that is directly taken up by algae, and the concentration of this fraction constitutes an index of the amount of phosphorus immediately available for algal growth. SRP is a measure of all the phosphorus in filtered samples (without digestion), while orthophosphate refers specifically to inorganic orthophosphate (PO_4). SRP usually consists largely of ortho-phosphate (OP) and, therefore, the terms are often used inter-changeably.
SSSI	Site of Special Scientific Interest – A conservation designation denoting to a protected area in the United Kingdom. The Sites are protected by law to conserve their wildlife or geology.

Term/Acronym	Definition
Stakeholder	The whole constituency of individuals and groups who have an interest in a subject, place or landscape.
Study area	The area within which it is considered that changes arising due to the proposed development would result in the highest and/or most important direct or indirect effects.
TDI	Trophic Diatom Index
Topography	Local detail or specific features of landform.
Total P	Phosphorus in natural waters consists of soluble reactive phosphorus (SRP), soluble unreactive or soluble organic phosphorus (SUP) and particulate phosphorus (PP). Total phosphorus (TP) is the sum of all phosphorus components. TP is typically measured by first digesting a water sample to convert all forms of phosphorus to orthophosphate, which is then measured by the ascorbic acid method. This test measures both dissolved and suspended orthophosphate as the sample is not filtered.
TVERC	Thames Valley Environmental Record Centre
TWARP	Thames Water Abingdon Reservoir Project
TWUL	Thames Water Utilities Limited
UK	United Kingdom
UKWIR	United Kingdom Water Industry Research
WFD	Water Framework Directive – The Water Framework Directive (2000/60/EC) is an EU directive which was transposed into law in England and Wales by the Water Environment (Water Framework Directive) (England and Wales) Regulations 2017 ('the WFD Regulation'). It aims to achieve good status of all water bodies (surface waters, groundwaters and the sites that depend on them, estuaries and near-shore coastal waters) and prevent any deterioration to these water bodies. It has introduced a comprehensive River Basin Management Plan system to protect and improve the ecological quality of the water environment. It is underpinned by the use of environmental standards.

Term/Acronym	Definition
WFD Classification	The WFD classification for a defined water body is produced by the assessment of a wide variety of different 'elements' which includes: • 'biological elements' such as phytoplankton, macrophytes, phytobenthos, benthic invertebrates and fish; • 'supporting elements' that include chemical measurements such as ammonia, dissolved oxygen, pH, phosphate, copper, zinc and temperature; and • 'supporting conditions' (sometimes referred to as hydromorphology) that assess the physical attributes of the water body such as 'river continuity', 'quantity and dynamics of flow' and 'morphology'. The assessment given for each element is also accompanied by a measure of certainty in the result. The status classification is published in the RBMP and provides a baseline condition against which compliance and future improvements can be measured.
WHPT ASPT	Whalley, Hawkes, Paisley & Trigg Average Score Per Taxon
WHPT N taxa	Whalley, Hawkes, Paisley & Trigg total number of scoring taxa
WHPT total	Total Whalley, Hawkes, Paisley & Trigg score
WINEP	Water Industry National Environment Programme
WQRA`	Water Quality Risk Assessment
WRMP	Water Resources Management Plan
WRSE	Water Resources in the South East
WTW	Water Treatment Works

Executive Summary

Following submission of the National Infrastructure Commission report 'Preparing for a Drier Future, England's Water Infrastructure Needs' in 2018, Ofwat derived the Strategic Resource Options (SRO) Programme, identifying where and how water could be transferred to areas of water deficit in England. The South East Strategic Reservoir Option (SESRO) has been identified as one of the SROs in Ofwat's Price Review 2019 (PR19) Final Determination.

SESRO is being jointly promoted and developed by Thames Water and Affinity Water under the Regulators' Alliance for Progressing Infrastructure Development (RAPID) SRO programme.

Several alternative capacity options have been considered for the SESRO, ranging from 75 Mm^3 to 150Mm^3, including some phased development options. All of the SESRO options are based on a fully bunded reservoir designs in the upper River Thames catchment. Water would be abstracted from the River Thames at Culham during periods of high flow and pumped into the reservoir. When flow in the River Thames is low and water is required in the catchment, water would be released back into the Thames for re-abstraction further downstream.

This Technical Supporting Document B1 Environmental Appraisal Report (Aquatic) has been prepared to:

- Support the submission of the main Gate 2 report and associated technical supporting documents to RAPID for governance.
- Provide the Aquatic Ecological and Hydrological Appraisal for SESRO for both the River Ock catchment (where the reservoir.
- Support the SESRO Gate 2 Water Framework Directive Assessment (WFD) (Technical Supporting Document B5 WFD) and T2AT Gate 2 WFD Assessment (Technical Supporting Document B3 WFD).
- Provide an overarching document, collating the findings of the environmental appraisal of aquatic environmental impacts from the scheme (and different options) and providing an overview of key results and findings at this stage.
- Build on the work undertaken for Gate 1 and update the aquatic environment and ecological appraisal of SESRO for Gate 2 providing a greater cost certainty and reduced environmental risk. This assessment also takes account of feedback from WRSE public consultation and other stakeholder engagement for Gate 1 and 2.

The report focuses on assessment of the largest (150 Mm^3) and smallest (75 Mm^3) options in terms of their overall holding capacity, discharge rate and overall footprint allowing for a relative assessment in change from the baseline as well as between the two options. Many of the elements of the 150 Mm^3 SESRO scheme will be common to the smaller schemes, and any alternative design would be developed and assessed in greater detail during subsequent project phases should a smaller scheme be included within the Final 2024 Water Resource Management Plan (WRMP24).

The assessments undertaken for this report follow the All Company Working Group (ACWG).[1] This has ensured consistency across SRO appraisals.

For the purpose of assessment and reporting, and in order to differentiate variations in baseline sensitivity and potential impacts throughout the study area, the study area is sub-divided into a number of study reaches as outlined in Table 1.1 and shown spatially in Figure 1.2 in Appendix A1.1 Figures. This is based on the approach at Gate 1, providing continuity within the Gated assessment process and broadly, these reaches include:

- watercourses within the Ock catchment (those within and adjacent to the reservoir footprint location); and
- the River Thames including the Reach upstream of SESRO (to which the Ock catchment discharges), and downstream of SESRO, terminating at Teddington Weir (which forms the tidal limit, and at which point additional flows released from SESRO will have been re-abstracted).

Hydrology

This chapter assesses the potential impacts of abstraction to, and discharge from, SESRO on the hydrological regime of the River Thames.

The assessment builds on recommendations made at Gate 1, specifically the alignment of hydrological modelling with WRSE water resource model outputs and the use of a hydrodynamic water quality model for detailed assessment of the Lower Thames. Not all recommendations were feasible within the timeframe of this programme, for instance, the assessment of impacts from climate change have been excluded at this time.

Methodology

The scheme assessment presented in this chapter is focussed primarily on the 150 Mm^3 SESRO option, as this is the variant currently selected in the Thames Water draft WRMP24. The 150 Mm^3 size variant also provides the upper envelope of potential impacts with the highest associated discharge of 321 Ml/d. Summary results have also been provided for the smallest size variant which has a volume of 75 Mm^3 and a discharge of up to 165 Ml/d, just greater than half that of the largest scheme. This assessment has been based on outputs from the SESRO River Thames hydrodynamic and water quality modelling provided by the Infoworks ICM model. Three selected years of hydrological data have been simulated in the Infoworks

[1] WRMP environmental assessment guidance and applicability with SROs, Mott MacDonald, (October 2020)

ICM model to represent different dry year conditions. These were chosen to represent a 'moderately dry' year, a 'drought' year and an 'extreme' year and were selected in association with Ricardo consultants who are responsible for the Severn to Thames Transfer (STT) interconnector SRO and London Reuse SRO assessments to provide a consistent baseline against which all the Thames Water SRO schemes can be reviewed. The selected hydrological years each run from April to March.

The effect of higher velocities during discharge has been the subject of a separate study investigating impacts on three weir pool Reaches at Culham, Clifton Hampden and Day's Lock (Appendix A3.1 Weir Pool Sensitivity Screening).

This EAR assessment uses the same stochastic data as the Deployable Output RSS Pywr model to further develop the method applied at Gate 1 which was based on historical simulations. This approach will start to align the SRO assessments although it is recognised that this is a complex process and requires further review and refinement over subsequent phases

Results

The results of the modelling undertaken for Gate 2 indicate that flows in the River Thames currently considered as being notably or exceptionally low would not occur as frequently if SESRO was developed. In addition, the modelling indicates that increases to the FDC over a long stochastic dataset would be evident for flows around Q60 or lower, however, the shift in the FDC is most notable at the lowest flows. The impact of abstraction at the higher flows to refill SESRO is having a lesser impact over a longer dataset.

As part of the environmental mitigation works the main watercourses across the site will be diverted to form both a Western Watercourse Diversion and the Eastern Watercourse Diversion. The Western Watercourse Diversion would have two channels, the realigned Cow Common Brook (part of the Cow Common Brook and Portobello ditch water body) and improvements (by way of channel restoration) to the East Hanney Ditch (part of the Childrey Brook and Norbrook at Common Barn water body). These two watercourses would not be connected.

For the River Ock, modelling has shown an overall slight (2%), flow reduction at the bottom-most part of the catchment as a result of rainfall falling into the reservoir rather than the river itself. There are also local changes in flows as a result of new routing and also parts of certain catchments that are closer to the reservoir. These include predicted changes to the lowermost Childrey Brook (approx. 8%) due to flow routing and also some reduction of the East Hanney Ditch catchment area. Flows in the new Cow Common Brook (the Western Watercourse Diversion) are expected to be reduced by 16% due to flow routing and a reduction in the catchment area.

Potential options for mitigation & considerations for subsequent project stages

The need to mitigate any changes in the hydrological regimes of the River Ock and the River Thames are determined largely by the sensitivity of receptors and the outcomes of the impact assessment for the aquatic environment, as presented in Chapter 5 Aquatic Ecology of this EAR.

Increases in velocity as a result of SESRO releases being triggered at their highest (maximum) discharge rate will be managed through the development of a release regime with incremental increases and/or decreases in flow. It was proposed at Gate 1 that flows will be increased gradually as SESRO is triggered and a simplified representation has been included in the current modelling, though the timing, duration and incremental volumes required should be considered further during subsequent project stages.

This assessment has focussed on the impact of augmenting drought years however further assessment of releases that occur on flows that may currently be considered as within the normal range is recommended as they may require mitigation. This could be achieved by reviewing the triggers that initiate and cease SESRO augmentation.

It is expected that increases (during augmentation) or decreases (during abstraction) in water levels and velocities along the River Thames will be mitigated through the operation of level management structures. It is recommended that this potential option for mitigation is revisited as the modelled representations of the structures are reviewed in subsequent stages.

A number of refinements have been identified in the modelling approach using the Infoworks and Pywr hydrological, and water quality models in relation to the hydrology, hydraulics, and operation of the River Thames control structures during abstraction and discharge (Appendix A2.1 SESRO River Thames calibration report). Additional survey data will be required to improve model representation of level management at key structures and the relationship to levels in backwaters and side streams, weir pools and in the main channel downstream of the augmentation to further inform hydro-ecological assessment.

Further monitoring and development of the hydraulic model for the River Ock is also recommended to improve modelling and assessment of low flow and water quality.

Fluvial Geomorphology

Numerous watercourses (both Main Rivers and Ordinary Watercourses)[2] lie within the scheme area and as such their drainage would need to be diverted to accommodate the scheme

[2] Main rivers are typically larger rivers and streams as defined by the EA's Main rivers map (https://environment.maps.arcgis.com/apps/webappviewer/index.html?id=17cd53dfc524433980cc333726a56386). Other rivers are defined as ordinary watercourses.

footprint and create a safe working area. These watercourses fall within Reaches 1 and 2 of the SESRO study area.

The findings of the fluvial geomorphology assessment at Gate 1 concluded that the geomorphological impacts of the proposed reservoir are expected to be experienced almost wholly within the Ock catchment (i.e., Reaches 1 and 2; Table 1.1). No geomorphological alterations are expected in the River Thames downstream of the point of abstraction and discharge (Reach 5, between Culham and the River Thame; Table 1.1).

Methodology

The aims of this Gate 2 fluvial geomorphology baseline assessment are to:

- provide a detailed desk-based characterisation of all the watercourses identified to be interacting with the scheme. For the purpose of this study, the largest reservoir option boundary has been used to identify these watercourses;
- present a site-based characterisation of the watercourses identified to be interacting with the scheme, subject to site access restrictions Provide recommendations for the fluvial geomorphology characteristics of the newly designed diversion channels;
- provide an impact assessment; and,
- highlight areas that require further assessment following the desk and site-based investigations.

The geomorphology assessment has focused on the largest option (150 Mm^3) given it has the largest catchment influence.

Results

Table 3.3 shows that a net total of 57.57 km of watercourse would need to be diverted/replaced as part of the proposed scheme. The BNG assessment (Technical Supporting Document B6 Biodiversity Net Gain) provides further details of how the condition of the habitat of these watercourses has been classified. The BNG assessment highlights that 43.67 km of this length is made up of ditch habitat, with over 83% of total ditches within the study area being diverted/replaced. Many of these ditches are assumed to be of poor condition.

A total of 13.90 km of riverine habitat would also need to be diverted/replaced as part of the development, which is over 85% of the total river length within the study area. Most of these rivers have been artificially modified to at least some extent and have been classified as being in moderate condition. As above, in some locations, watercourses displayed more variability and a natural planform with diverse habitat and therefore achieve a fairly, good condition.

Further precision in respect of the habitat quality of the watercourses diverted/replaced as part of the development will be acquired during subsequent project stages as they will benefit from full walkover surveys.

To achieve the required 10% BNG, the scheme is required to enhance a further 17.41 km of watercourse (16.44 km of river and 0.97 km of ditch) and create 31.05 km of new watercourse (25.65 km ditch and 5.40 km of canals and culverts).

Potential options for mitigation & considerations for subsequent project stages

The Western and Eastern Watercourse Diversions would incorporate natural channel design principles that would enable improved habitat heterogeneity to be delivered as part of the construction of the channels. The quality of this constructed habitat would be of a significantly higher value than the existing habitat found within the modified channels across the current site.

To compensate for the loss of ditch length many interconnected 'wetland' ditches will be cut to off-set the ditch loss on site. This, along with the improved watercourses would create a significantly improved structure, and complexity, to the riparian zone. The proposed design of the scheme includes creation of a Circular Drain which would take embankment surface water flows and transfer them to the River Ock, downstream of the Childrey Brook confluence. It would also provide additional aquatic ditch habitat (see also Technical Supporting Document B6 Biodiversity Net Gain).

The new watercourses would be constructed in the dry, as much as possible, to keep the existing habitat functioning while the new channels are constructed. It is envisaged, that following excavation of the watercourse and connection of water to them additional mitigation would be undertaken upon them to prompt their recovery towards a good condition. This additional step would aid recovery of these water bodies and help them move towards a good condition at a quicker rate.

At this Gate 2 stage, it can be concluded that because the newly designed (mitigation) river channels and interconnecting wetland ditches will be, (a) of significantly better quality than the baseline watercourses that will be diverted/replaced as part of the proposed scheme; and (b) greater in quantity (i.e. watercourse length) than the baseline watercourses that will be diverted/replaced as part of the proposed scheme, the quality of the fluvial geomorphology within the study area will experience an improvement relative to the status quo.

To refine the above conclusion, it is recommended that the following assessments are considered during subsequent project stages:

- Site walkovers of all of the watercourses within the indicative location for SESRO
- MoRPh surveys for 20% of the watercourses

- Furthered hydraulic understanding of the watercourses within the indicative location for SESRO, such that stream power characterisation can be ascertained more accurately
- Continued development of the design principles for the newly designed (mitigation) river channels and interconnecting wetland ditches

Water Quality

This chapter assesses modelled impacts of SESRO on water quality in watercourses in the River Thames catchment. Changes to water quality are expected because:

- Abstraction from the River Thames to refill the reservoir in the autumn and winter will reduce flows downstream and, thereby, can reduce dilution of downstream chemical inputs (e.g. from tributaries and sewage works).
- Release of water from the reservoir to the River Thames during drier periods will increase river flows and, thereby, increase dilution of chemical inputs downstream. The releases will also mix reservoir and river water which will further modify downstream water quality. In addition, they will change river travel times and thereby modify within river processes which will change downstream water quality.
- Modifications to the river channels in and around the SESRO site, including the removal of parts of the Cow Common Brook and creation of new channels, east and west of the reservoir will redirect chemical loads and flows, particularly in the Cow Common Brook catchment. This will reduce both loads and flow as a whole, and modify their spatial patterns, thereby modifying water quality.

Methodology

The aims of this Gate 2 water quality baseline assessment are to:

- characterise existing water quality in the watercourses identified to be affected by SESRO. This will provide a reference to enable the assessment of changes of water quality that may result from the scheme.
- present findings of the Gate 2 water quality impact assessments for SESRO and receiving watercourses.
- highlight data gaps and requirements to increase confidence in the assessment.

Results

In general, analysis of the modelling indicates that the impacts of SESRO on water quality in the River Thames are largely positive; in general, improving or making no change in river concentrations compared to the WFD thresholds. This is primarily the result of SESRO ‘improving’ concentrations during the long period of storage (the average retention based on Pywr outputs is greater than seven years) compared to the influent water from the River

Thames, because of normal reservoir attenuation, biological uptake, and sedimentation processes. In addition, the released water provides greater dilution of downstream inputs from tributaries and discharges.

One exception to this is a slight increase in ammonia immediately downstream of the reservoir. However, this needs to be caveated by the high degree of uncertainty in predicting reservoir ammonia concentrations since this chemical is highly dynamic in nature and can show a high degree of temporal variability. This may need to be revisited during subsequent project stages, perhaps by making greater reference to observed concentrations in other reservoirs. A marginal increase in BOD is also simulated further downstream for some scenarios at some times of the year, which is likely to be the result of increased velocities and reduced loss within the river (BOD does not contribute to WFD status)

In the River Ock, an increase occurs for ammonia and orthophosphate in the Childrey Brook, related to loss of flow from the catchment and routing of rainfall and local watercourse flows to the River Ock downstream of Marcham Mill (i.e. downstream of Childrey Brook confluence) which results in a reduced dilution of upstream point source inputs.

Potential options for mitigation & considerations for subsequent project stages

The primary negative impact of SESRO on modelled river water quality is a small increase in the Childrey Brook for ammonia and orthophosphate (<10%) which is likely to be due to reduced dilution of upstream point sources, primarily from Wantage sewage works. Lowering the effluent permit at Wantage for these chemicals from the current values of 2 mg/l P and 5 mg/l for ammonia (i.e. 1 mg/l for P and 3 mg/l for Ammonia) would offset this change.

Further potential options for mitigation are possible in terms of other point sources in the catchments, or diffuse sources such as catchment measures targeted at WFD reasons for not achieving good.

No mitigation is proposed for the River Thames because there are no clear negative impacts from SESRO (the increase in ammonia immediately remains uncertain). The only change in the River Thames that might require mitigation is the slight increase in BOD which is believed to be the result of increased river velocities. Noting BOD does not contribute to WFD status, further evaluation of modelling results is required to better understand the issue and identify any mitigation options, e.g., tightening of BOD permits at downstream sewage works.

Potential options for mitigation are available for SESRO reservoir if required including mixing/aeration and the use of alternative draw off depths. Currently the water quality models have just assumed a single draw off depth.

The model outputs presented in this Section present a largely positive outcome for water quality as a result of SESRO. There are, however, a number of uncertainties that should be given consideration for during subsequent project stages to improve confidence in this assessment:

- Several refinements would be beneficial in the Infoworks and Pywr hydrological, and water quality models in relation to the hydrology, hydraulics, and operation of the River Thames control structures during abstraction and discharge (Appendix A2.1 SESRO River Thames calibration report).
- The ammonia and BOD aspects of the reservoir modelling have a level of uncertainty because these determinands were not modelled in PROTECH; so, it was not possible to condition the Intermediate Reservoir Water Quality model against PROTECH. during subsequent project stages, they should either be included in PROTECH or another approach to ground truthing should be considered such as comparison with observed data from other reservoirs.
- Orthophosphate cannot be modelled in Infoworks ICM and total phosphorus was not modelled in PROTECH. To improve model interaction these inconsistencies should be addressed to improve the model linkages.
- Dissolved oxygen was not modelled in any of the reservoir models so the assumption was that the water released from SESRO will be at 100% saturation. Ideally, this assumption needs to be tested through explicit reservoir modelling of dissolved oxygen and/or the engineering options.
- For the SAGIS–SIMCAT modelling of the River Ock, the flow and chemical inputs and sources would ideally be 'ground truthed' by site investigations and additional monitoring of water quality sampling and flow (the existing data are over five years old). The development of a hydrodynamic model for the River Ock (to allow flow and water quality modelling) should also be continued.

Aquatic Ecology

This chapter considers the potential impacts of the construction and operation of SESRO on aquatic communities and species within the study area, with reference to watercourse study Reaches set out in Chapter 0. The assessment focusses on fish, macrophytes, aquatic macroinvertebrates (hereafter invertebrates), diatom, phytoplankton and zooplankton communities and species associated with watercourses within the study area.

Methodology

A source-pathway–receptor framework for aquatic ecology receptors was used, within which potential community and species changes as a result of the proposed scheme are considered. This framework has set the context for the supporting investigations and assessments presented for geomorphology, hydrology, and water quality. Qualitative and, where applicable at this stage, quantitative assessment of the identified pathways is discussed in the context of aquatic ecology receptor sensitivities.

Multiple data sources were reviewed to identify available baseline ecological data within the study area and further develop the baseline understanding developed at Gate 1. A detailed review of supplementary and scheme-specific data (noting survey access restrictions for the River Ock) was undertaken to characterise the aquatic ecology of the study area with reference to study Reaches.

Results

Based on currently available information, the majority of identified effects are considered likely to be either negligible or result in minor adverse or minor beneficial effects that are unlikely to affect the overall ecological integrity of affected Reaches.

Some effects have the potential to result in benefits that are considered likely to improve the overall ecological integrity of affected Reaches; notably the planned diversion, realignment, and creation of watercourse habitats within the Ock Catchment associated with Cow Common Brook, Childrey Brook and the River Ock.

A particular focus for subsequent project stages will be on reducing uncertainty for those elements with the potential to result in adverse effects that may reduce the overall ecological integrity of affected Reaches.

Identified adverse effects with risks to the overall ecological integrity of affected Reaches include potential flow reduction on the Childrey Brook and primary productivity/food-chain effects within the River Thames (Reach 5 and Reach 6).

Flow changes within the River Thames as a result of SESRO have the potential to be both beneficial and adverse (at different times and for different species) for the existing baseline ecology and may affect the overall ecological integrity of the affected Reaches, as discussed in Section 5.4.3. Whilst the assessment in future Gates will seek to improve certainty around the trajectory of change that may be anticipated relative to baseline; a key challenge will be resolving the subjectivity and philosophy of whether a potential change (for example, changes in the relative abundance of different fish species) is considered to be adverse or beneficial, particularly in the context of the extensive existing anthropogenic modifications of the river and its flow regime which has shaped the baseline ecological communities. Also, in terms of changes already under way including lowering of phosphate over time and the effects of climate change on the current baseline.

Potential options for mitigation & considerations for subsequent project stages

The assessments presented within this Chapter have considered the likely embedded (i.e., design) mitigation and ‘standard’ mitigation (such as fish rescue associated with channel diversions), prior to any further potential options for mitigation and/or compensation.

The assessment of construction-mediated effects at Gate 2 is restricted to those effects relating to the indicative footprint of the proposed scheme only (i.e., watercourse diversions, realignments etc). Mechanisms of effect associated with proposed scheme construction activities (such as accidental pollution incidents) will be controlled through good practice construction methodologies and supplementary construction mitigation as required. These types of effects will be assessed as part of formal approvals for the construction of the proposed scheme should it progress.

In addition to those measures already considered within the assessment, a number of further mitigation measures are potentially available and may be required to manage residual risks to ecology during construction and operational phases. These will be further developed as part of subsequent Gates. Such measures may broadly comprise (subject to need/feasibility):

- further constraints on the timing and/or magnitude of abstraction and release (beyond those dictated by operational constraints/capacity and existing licencing constraints on the River Thames);
- 'optimisation' of a ramp up flow release sequence for the reservoir;
- 'optimisation' of level control structures within affected Reaches;
- 'optimisation' of temperature changes through design of the reservoir offtake level;
- habitat improvements to provide increased ecological resilience of affected Thames Reaches to predicted hydraulic changes;
- bespoke habitat design, monitoring and (if necessary) adaptive management for watercourse diversions and realignments for specific target invertebrate, macrophyte and/or fish species and communities, subject to further baseline surveys of the affected watercourses;
- species translocations of specific invertebrates or macrophytes if required (subject to further baseline surveys of the affected watercourses; and
- catchment or point source measures to offset any residual effects on water quality within the Ock Catchment and Thames.

Next steps for the aquatic ecology assessment of SESRO relate to:

- improving confidence in the existing baseline, including:
    - ongoing SRO monitoring at existing Thames monitoring locations for fish, invertebrates, macrophytes and INNS to update and maintain baseline understanding;
    - full suites (including replicates) of ecological surveys within areas that were access constrained at Gate 2.

- improving confidence in the current supporting modelling and assessments of direction and magnitude of change predicted for the various scheme elements and Reaches including:
  - repeat and refined UKCEH algae experiments and modelling;
  - refined and/or validated Ock catchment modelling through extension of the 1D model to encompass this area;
  - refined Thames hydraulic modelling to include additional 'less dry' hydrological years and more detailed level-control structure representation to assist with optimisation studies;
  - sensitivity analysis of potential interaction between the Thames abstraction periods and out of bank flows.
- developing mitigation for any anticipated residual adverse effects, through iteration of the above confidence changes (in both baseline and assessment) and in line with those items identified in Section 5.5.

INNS

This chapter examines the potential risks of INNS introduction and spread to and from SESRO, via transfer pathways that may become active once the reservoir is operational. Excluded are risks associated with the construction of SESRO itself which will be controlled through good practice construction methodologies and supplementary construction mitigation as required – to be outlined and agreed as part of formal approvals for the construction of the Scheme during subsequent Gates.

Methodology

A detailed analysis has been undertaken to assess the risk of INNS being introduced and spread to and from SESRO, via transfer pathways that may become active once the reservoir is operational. This assessment has been based on an Environment Agency standardised risk assessment tool for use by all SROs at Gate 2 (the SAI–RAT). This allowed for a consistent approach to assessing different SESRO size options and relevant scenarios, developed to account for uncertainties around the final use of the reservoir and raw water transfers. Scenarios have taken into consideration different variations of INNS pathway-frequency to understand how this will alter risk. This included most likely (baseline) scenarios and a range of other scenarios; from no recreational activities at the site to 'worst-case scenarios' in which all INNS pathways are identified as present at maximum frequency.

Results

In relation to the risk assessment of the asset (the proposed SESRO reservoir), under 'baseline' conditions, the site was assessed to have a final asset risk score of 57.90%. The full removal of recreation (terrestrial and aquatic), as well as the removal of aquatic recreation only, would result in the reservoir having a final asset risk score of 21.27% or 33.65%, respectively. Conversely, should all recreational activities (e.g., angling, watersports, boating and walking) occur, or all pathways be set to maximum frequency of occurrence; the final asset risk score would become 78.28% or 88.46%, respectively.

The results highlight the risk of unmitigated recreational activities for INNS transfer, especially activities within water body. The size of the reservoir has no specific bearing on the viability of the identified activities and so was not considered within the asset assessment; option size is essentially irrelevant as a differentiator of asset risk. A key challenge of INNS risk management for the SRO programme, including SESRO, is balancing the risk of INNS transfer and spread with providing high quality multi-purpose and accessible public assets. It is highly unlikely that recreational access to SESRO, in all its forms, would be excluded purely on the basis of INNS risk management requirements. Therefore, some INNS risks will inevitably remain within the final plans for SESRO, balanced against wider aspirations for the use of the asset, and mitigated where possible based on available biosecurity measures.

Similarly, all raw water transfer scenarios from river to reservoir (and vice versa) were assessed to have a narrower range of potential risk. Whilst there is little variation between risk scores for the raw water transfers, the different scenarios applied accounted for differences of INNS pathway-frequency (including recreation requirements at the source and on the pathway itself). Whilst a degree of variation in the risk score was apparent between the scenarios as a result; the lack of significant change in risk highlights that the inherent risk of unmitigated movements of large water volumes is the key factor in driving the risk score for raw water transfers. This is further supported by the similarities in risk scores between the options, with both the smallest transfer and largest transfer option producing similar risk scores. The scenarios (occurrence and frequency of activities etc.) and the option size therefore account for little variation in the overall risk scores. The activity of transferring water from river to reservoir (and vice versa) is intrinsic to SESRO and thus further design mitigation is likely to be the key to reducing INNS transfer risk.

The provision of an emergency drawdown from the reservoir has been assessed as a separate element of SESRO due to the difference in operation to the main intake/outlet transfer. The emergency drawdown was assessed to be higher risk than the main raw water transfers to and from the reservoir, with a medium-use final risk score of 60.13%. For comparison, the final risk scores for the main outlet transfer (baseline) for the largest size option was 53.13%. As with the main raw water transfer risk assessment, the activity of transferring water from a reservoir to a river is inherently risky and therefore, design mitigation is again likely to be the key to reducing INNS transfer risk.

Potential options for mitigation and considerations for subsequent project stages

A generalised biosecurity module included within the SAI–RAT, identifies potential biosecurity measure types from a defined list of 30 options that may be considered by the user. This is an automated process taking account of the INNS transfer pathways identified to be present. These measures, alongside measures supplementary to those identified by SAI–RAT, have been further evaluated for both the management of the asset and raw water transfers. The selection of suitable biosecurity measures for further consideration as part of subsequent design stages is based on an initial assessment of the efficacy and feasibility of implementing the measures. Potential options for mitigation are provided in Appendix A6.3 INNS Mitigation Measures Appraisal and the outcomes are summarised in Table 6.24 and Table 6.25.

The findings of the Gate 2 INNS risk assessments will continue to inform future SESRO design iterations, including design mitigation for the raw water transfers and plans for the recreational use of the asset including appropriate biosecurity measures.

During subsequent project stages, option refinement would result in fewer scenarios, and more focus on developing and embedding design mitigation and broader mitigation measures most likely to be feasible and effective for the control of INNS. By this point, Thames Water's AMP7 WINEP Company-Wide INNS Plan is likely to have been fully developed, which may provide further evidence on measures that are most likely to be viable for implementation.

1. Introduction

1.1 Purpose of the Report

1.1 The South East Strategic Reservoir Option (SESRO) has been identified as one of the Strategic Resource Options (SROs) in Ofwat's Price Review 2019 (PR19) Final Determination.

1.2 This Technical Supporting Document B1 Environmental Appraisal Report (Aquatic) has been prepared to support the submission of the main Gate 2 report and associated technical supporting documents to RAPID for governance. It provides the Aquatic Ecological and Hydrological Appraisal for SESRO. This report also supports the SESRO Gate 2 Water Framework Directive Assessment (WFD) (Technical Supporting Document B5 WFD).

1.3 This Environmental Assessment Report (EAR) presents the findings from the aquatic assessments of SESRO as follows:

- Hydrology
- Fluvial Geomorphology
- Water Quality
- Aquatic Ecology
- Invasive Non-Native Species (INNS)

1.2 Water Resource Planning

1.4 All water supply companies in the UK have a statutory duty to consult upon and produce a Water Resources Management Plan (WRMP) every 5 years. The next plan, which will be issued in draft for consultation in November 2022, provides a strategic forecast of the companies' expected requirements and proposed investment to ensure a secure and resilient water supply to their customers from 2025 to 2100.

1.5 The WRMP process is supported by a non-statutory regional water resources resilience plan, which is produced for each region of the UK and provides the strategic regional context for the WRMP.

1.6 Thames Water and Affinity Water are both part of the Water Resources South East Group (WRSE), along with South East Water, Southern Water, Sutton and East Surrey Water and Portsmouth Water. The WRSE group published their emerging draft regional plan in January 2022, with an updated Draft Regional Resilience Plan in late summer 2022. The partner companies' Draft WRMPs are aligned with this regional strategy.

1.7 The WRMPs include a set of solutions to meet customers' future water supply needs. A number of these solutions involve strategically important and large-scale new developments that can be lengthy and complex to consent and develop. For this reason, a number of the strategic solutions need further investigation and feasibility studies completed for them to ensure uncertainties associated with them are better understood and that they are ready to consent and develop within the required timescales identified in the WRMP. The SESRO is one such option.

1.8 The feasibility studies for the different Strategic Resource Options (SRO) are completed under the RAPID gated process outlined in the All Company Working Group (ACWG).[3] To achieve consistency and meet RAPID requirements, the SRO Environmental Assessment approach outlined by the ACWG has been applied to all appraisals. Using this approach has allowed consistency in the assessment approach across SROs to present a uniform output to stakeholders and regulators to consider during determination. The SRO approach outlined in Figure 1.1 in Appendix A1.1 Figures, is applicable to all SROs.

1.9 For more detail on the Water Resource Planning process, please refer to the Main Gate 2 Report.

1.3 Context of this report

1.10 Following submission of the National Infrastructure Commission report 'Preparing for a Drier Future, England's Water Infrastructure Needs' in 2018, Ofwat derived the Strategic Resource Options (SRO) Programme, identifying where and how water could be transferred to areas of water deficit in England. The South East Strategic Reservoir Option (SESRO) has been identified as one of the SROs in Ofwat's Price Review 2019 (PR19) Final Determination.

1.11 SESRO is being jointly promoted and developed by Thames Water and Affinity Water under the Regulators' Alliance for Progressing Infrastructure Development (RAPID) SRO programme.

1.12 The Regulators' Alliance for Progressing Infrastructure Development (RAPID), a joint team made up of the three water regulators (Ofwat, the Environment Agency and the Drinking Water Inspectorate), was set up to support and oversee projects across several water companies. These projects include recycling, desalination, transfers between regions and reservoirs to identify optimal regional solutions that could be started in 2025–2030.

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[3] WRMP environmental assessment guidance and applicability with SROs, Mott MacDonald, October 2020

1.13 RAPID has introduced a new regulatory process which sets out the activities that need to be completed to a series of governance 'Gates', enabling key information to be presented and an assessment made on whether the scheme should continue for further feasibility assessment. The gates set out by RAPID are as follows:

- Gate 1 – Initial feasibility, design and multi-solution decision making (July 2021);
- Gate 2 – Detailed feasibility, design and multi-solution decision making (November 2022);
- Gate 3 – Finalised feasibility, pre-planning investigations and planning applications (Summer 2023); and
- Gate 4 – Planning applications, procurement strategy and land purchase (Summer 2024).

1.14 Figure 1.1 in Appendix A1.1 Figures, provides a summary of the environmental assessments required for each Gate of the RAPID Process.

1.2 Overview of report

1.15 Several alternative capacity options have been considered for SESRO (i.e. 150 Mm^3, 125 Mm^3, 100 Mm^3, 75 Mm3, 30+100 Mm^3 and 80+42 Mm^3). These have been described further within Technical Supporting Document B5 Water Framework Directive Report. The largest SESRO option (150 Mm3) is a fully bunded reservoir in the upper River Thames catchment. Water would be abstracted from the River Thames at Culham during periods of high flow and pumped into the reservoir during wetter months. When flow in the River Thames is low and water is required in the catchment, water would be released back into the Thames for re-abstraction further downstream.

1.16 This Environmental Appraisal Report covers an assessment of the largest (150 Mm^3) and smallest (75 Mm^3) options in terms of their overall holding capacity, discharge rate and overall footprint allowing for a relative assessment in change from the baseline as well as between the two options. Many of the elements of the 150 Mm^3 SESRO scheme will be common to the smaller schemes. Any design option that is taken forward will be subject to further development and assessment in subsequent project stages based upon up to date and more detailed information and analysis.

1.17 This EAR has been informed by desk-based assessments using publicly available information in line with the requirements of the Gate 2 submission. The work is at a preliminary stage and establishes an initial appraisal that can be built on during subsequent project stages. In future, this will also be informed by the undertaking of site surveys and collection of additional information and data that will inform an

Environmental Impact Assessment likely to be required as part of any future consenting process.

1.18 This EAR does not definitively scope potential environmental effects in or out at this stage and the recommendations for further technical work outlined within this EAR are subject to change as further information becomes available at subsequent project stages. Future work will be carried out in conjunction with relevant stakeholders to inform the approach to the Environmental Impact Assessment.

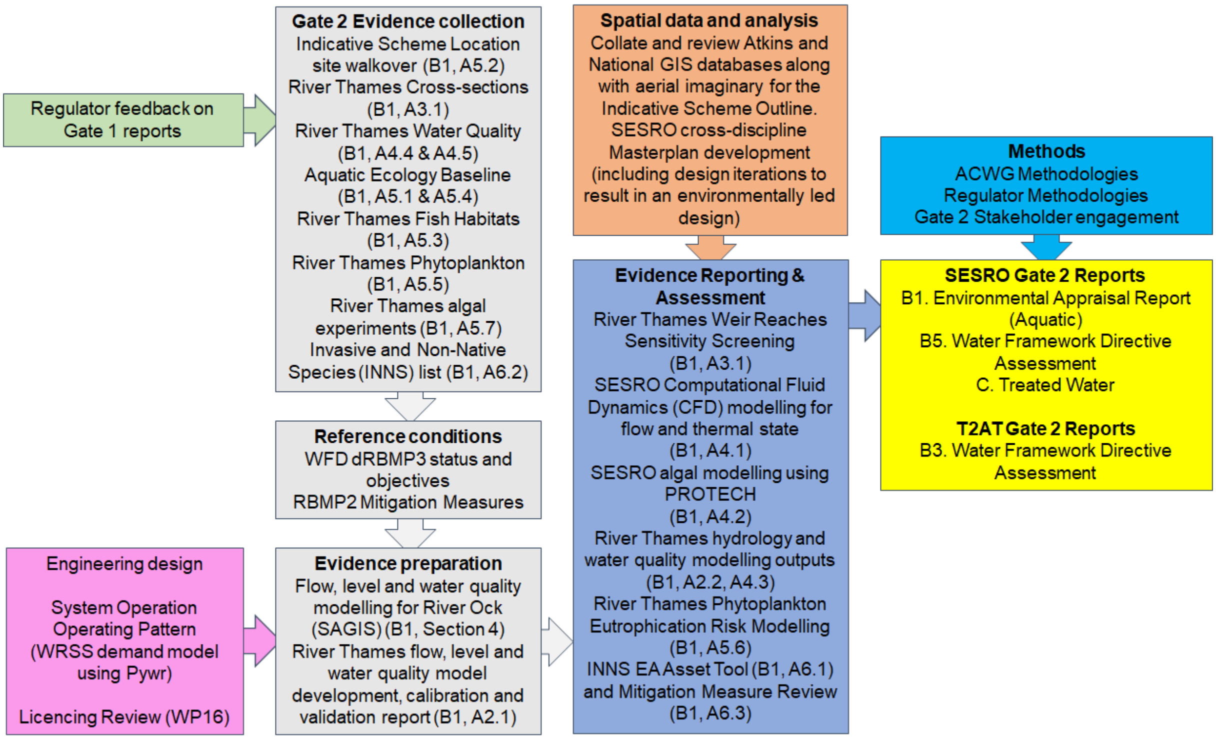
1.19 The details set out in this EAR are still at a formative stage and consideration should be given to that when reviewing the proposals. They are for the purposes of making decisions on progress and further funding, not seeking permission.

1.20 This Technical Supporting Document must be read in conjunction with the Main Gate 2 Report, as well as Technical Supporting Document A1 Concept Design Report, which together provide additional information that help to define the basis for the environmental appraisal.

1.21 This report builds on the work undertaken for Gate 1 and updates the aquatic environment and ecological appraisal of SESRO for Gate 2. This assessment also takes account of feedback from WRSE public consultation and other stakeholder engagement for Gate 1 and 2. The Gate 1 Environmental Appraisal Report contains background information in terms of reports written to date. This information remains valid and has not been reviewed again for Gate 2.

1.22 As shown in Insert 1.1 below, the Environmental Appraisal Report draws from a range of evidence sources as well as (third party) evidence reports and assessments. These have all been appended and their appendix references have been summarised in Insert 1.1. Gate 1 feedback has been incorporated from the outset, as well as inputs from the engineering and other workstreams including the development of a SESRO Master Plan.

Insert 1.1 Investigations being undertaken for Gate 2 and their interactions, in order to show the full scope of work across environmental and engineering disciplines. Alphanumeric codes refer to appendix references.



1.23 The findings of this aquatic Environmental Appraisal Report have fed into the Water Framework Directive (WFD) assessment (Technical Supporting Document B5), the Biodiversity Net Gain Report (Technical Supporting Document B6) and the Strategic Environmental Assessment (SEA) (Technical Supporting Document B7). It has also fed into Technical Supporting Document A1 Conceptual Design Report (CDR).

1.24 It is noted that the Environmental Appraisal Report has focused on physical interactions with the River Ock catchment (as a result of the proposed location of the scheme, noting this is at a concept design stage) as well as the operational effects of the scheme on the River Thames. Potential effects of construction activities on the aquatic environment are covered as part of the WFD assessment (Technical Supporting Document B5). Flood risk is also not covered as part of this report, but this has been covered as part of the CDR (Technical Supporting Document A1). Finally, the benefits to the reservoir itself from providing open water habitat, wetlands, lagoons and/or floating platforms has been covered in the Conservation, Access and Recreation Strategy (Technical Supporting Document B3).

1.3 Description of study reaches

1.25 For the purpose of assessment and reporting, and in order to differentiate variations in baseline sensitivity and potential impacts throughout the study area, the study area is sub-divided into a number of study reaches as outlined in Table 1.1 and shown spatially in Figure 1.2 in Appendix A1.1 Figures. This is based on the approach at Gate 1, providing continuity within the Gated assessment process and broadly, these reaches include:

- watercourses within the Ock catchment (those within and adjacent to the reservoir footprint location); and
- the River Thames including the Reach upstream of SESRO (to which the Ock catchment discharges), and downstream of SESRO, terminating at Teddington Weir (which forms the tidal limit, and at which point additional flows released from SESRO will have been re-abstracted).

1.26 Field surveys to inform Gate 2 were constrained by availability of access to third party owned land within the Ock catchment. As the scheme is still in a relatively early stage of design (concept design), detailed baseline field surveys of permanent asset sites were not considered essential as desk-based assessment could proceed based upon other data sources (for example, aerial and previously collected). This is consistent with the level of work undertaken for Gate 2 on other SROs. As such, the Ock catchment work was constrained in so far as that only limited field investigations have been undertaken. There were no such field investigation constraints on the River Thames.

Table 1.1 SESRO study Reaches with description and corresponding WFD water body

Reach no.	Sub-Reach no.	Watercourse	Description	WFD water body
1	1.1	Cow Common Brook	Watercourses within the reservoir footprint	Cow Common Brook and Portobello Ditch (GB106039023360)
		Portobello Ditch		
		Landmead Ditch		
		Mere Dyke		
		Oday Ditches[4]		Thames (Evenlode to Thame) (GB106039030334)
	1.2	Childrey Brook (lower)		Childrey Brook and Norbrook at Common Barn (GB106039023380)
		East Hanney Ditch		
2	2.1	River Ock (lower)	Watercourses between the reservoir footprint and the River Thames. **Watercourses adjacent to and upstream of the footprint within the Ock catchment – not included at Gate 1 but included for additional context*	Ock and tributaries (Land Brook confluence to Thames) (GB106039023430)
	2.2	River Ock (upper)*		Ock (to Cherbury Brook) (GB106039023400)
	2.3	Stutfield Brook*		Stutfield Brook (Source to Ock) (GB106039023340)

[4] Oday ditches are included in Reach 1.1 (although technically within the Thames water body) as they are within the reservoir footprint, and they are most similar in character to ditches associated with Reach 1.1 that are also affected by reservoir footprint.

Reach no.	Sub-Reach no.	Watercourse	Description	WFD water body
	2.4	Childrey Brook (upper)*	*and reference sites at Gate 2.*	Childrey and Woodhill Brooks (GB106039023370)
	2.5	Letcombe Brook*		Letcombe Brook (GB106039023350)
	2.6	Marcham Brook*		Frilford and Marcham Brook (GB106039023420)
	2.7	Sandford Brook		Sandford Brook (source to Ock) (GB106039023410)
3	3	Ginge Brook	Watercourses east of the A34, *adjacent to and upstream of the footprint – included at Gate 1 based on potential risks from railway sidings and a potential watercourse diversion (no longer required) and retained for additional context and reference sites at Gate 2.*	Ginge Brook and Mill Brook (GB106039023660)
		Mill Brook		
4	4	River Thames	Upstream of SESRO (Evenlode to Culham)	Thames (Evenlode to Thame) (GB106039030334)
			Reach length – 27.0 km (along main branch of the Thames)	

Reach no.	Sub-Reach no.	Watercourse	Description	WFD water body
5	5	River Thames	Immediately downstream of SESRO combined intake/discharge structure up to the River Thame confluence	Thames (Evenlode to Thame) (GB106039030334)
			Reach length – 13.2 km	
6	6	River Thames	Between River Thame and Thames Water Datchet intake	Thames (Wallingford to Caversham) (GB106039030331)
			Reach length – 87.3 km	Thames (Reading to Cookham) (GB106039023233)
				Thames (Cookham to Egham) (GB106039023231)
7	7	River Thames	Between Thames Water Datchet intake and Affinity Water Sunnymeads intake	Thames (Cookham to Egham) (GB106039023231)
			Reach length – 2.8 km	
8	8	River Thames	Between Affinity Water Sunnymeads and Affinity Water Egham intake	Thames (Cookham to Egham) (GB106039023231)
			Reach length – 6.4 km	
9	9	River Thames	Between Affinity Water Egham and Affinity Water Chertsey intake	Thames (Cookham to Egham) (GB106039023231)

Reach no.	Sub-Reach no.	Watercourse	Description	WFD water body
			Reach length – 6.9 km	Thames (Egham to Teddington) (GB106039023232)
10	10	River Thames	Between Affinity Water Chertsey intake and Affinity Water Walton (Desborough Island) intake	Thames (Egham to Teddington) (GB106039023232)
			Reach length – 7.3 km	
11	11	River Thames	Between Affinity Water Walton and Thames Water Walton intake	Thames (Egham to Teddington) (GB106039023232)
			Reach length – 4.1 km	
12	12	River Thames	Between Thames Water Walton and Thames Water Hampton intake	Thames (Egham to Teddington) (GB106039023232)
			Reach length – 2.2 km	
13	13	River Thames	Between Thames Water Hampton intake and Teddington Weir (tidal limit)	Thames (Egham to Teddington) (GB106039023232)
			Reach length – 9.5 km	

1.4 Consultation

1.27 Regulator Technical Working Groups covering the aquatic environment assessment approach and findings have been held with the Environment Agency and Natural England on 22 November 2021, 1 March 2022, 7 April 2022 and 7 June 2022. See Table 1.2 below.

1.28 This is alongside meetings held for the Water Framework Directive assessment work (see Technical Supporting Document B5, WFD assessment) as well as assessment model development meetings (see Appendix A2.1).

1.29 Further details of the wider Stakeholder Engagement Strategy can be found within Technical Supporting Document D, Stakeholder and Customer Engagement.

Table 1.2 Consultation with the Environment Agency/Natural England during Gate 2 of the WFD assessment on SESRO

Date	Topic
22/11/2021	SESRO & T2AT Aquatic Environment Assessment Gate 2 Technical Liaison Group (TLG)
09/12/2021	SESRO & T2AT Aquatic Environment Assessment Gate 2 TLG
28/02/2022	SESRO WFD & BNG Gate 2 Interim Update
01/03/2022	SESRO & T2AT Aquatic Environment Assessment Gate 2 TLG
07/03/2022	SESRO WFD & BNG Gate 2 TLG
06/04/2022	SESRO WFD & BNG Gate 2 TLG
07/04/2022	SESRO WFD & BNG Workshop 3
07/06/2022	SESRO, T2AT and T2ST Aquatic Environment Assessment Gate 2 TLG
29/06/2022	SESRO WFD & BNG Gate 2 TLG

1.5 Report content

1.30 This report has been structured as follows:

- Chapter 2 covers hydrology conditions of the aquatic environment for SESRO and T2AT.
- Chapter 3 covers the fluvial geomorphology (shape and form) of the aquatic environment.

- Chapter 4 covers the water quality environment (SESRO and T2AT).
- Chapter 5 covers aquatic ecology, including fish, macroinvertebrates, macrophytes, diatoms and plankton.
- Chapter 6 covers an Invasive and Non-Native Species (INNS) risk assessment.
- Chapter 7 is a summary section of the main findings for each topic area and proposes the next steps.

1.31 For information, cumulative and in-combination effects have been reviewed at a strategic level as part of the update to the SEA, refer to Technical Supporting Document B7, Inputs into WRSE and WRMP24 Strategic Environmental Assessment (SEA).

1.6 Solution design and options

1.32 The South East Strategic Reservoir Option (SESRO) Strategic Resource Option (SRO) is being jointly promoted and developed by Thames Water and Affinity Water under the RAPID SRO programme. It is a raw water storage reservoir in the upper catchment of the River Thames.

1.33 Water would be abstracted from the River Thames during periods of high flow and stored in a reservoir, to be released back into the River Thames when there is a need to augment the flows in the River Thames. Water released from SESRO could be re-abstracted by existing or new infrastructure further downstream to supply customers of Thames Water, Affinity Water and possibly also South East Water.

1.34 The SESRO scheme also incorporates the future flexibility to abstract water direct from the reservoir, treat it on site and then transfer potable water either to the south to serve Southern Water or to the north, to support Thames Water's Swindon and Oxfordshire supply zones. The additional transfers and associated water treatment facilities are not included within the SESRO core scheme, although a provision of land allocation within the scheme is identified for such future use. The timing and precise need for these additional elements is still uncertain, but they are options that will continue to be explored as the SESRO scheme is developed.

1.35 SESRO is one of a number of raw water storage reservoirs that have been considered by Thames Water in the upper Thames catchment. Alternative options have been passed through an appraisal process and feasible options costed and assessed as part of WRMP24.

1.36 Several size variants of the SESRO scheme have been included in the Thames Water WRMP24 Constrained List of options, having passed through the screening process and been submitted as options to WRSE.

1.37 The following six reservoir sizes are under consideration for SESRO and are as follows (additional details can be found in Technical Supporting Document A1 Concept Design Report and B5 Water Framework Directive (WFD)):

- 150 Mm3 capacity reservoir
- 125 Mm^3 capacity reservoir
- 100 Mm^3 capacity reservoir
- 75 Mm^3 capacity reservoir
- 30+100 Mm^3 capacity phased reservoir
- 80+42 Mm^3 capacity phased reservoir

1.38 The 150 Mm^3 option is considered the largest scheme for the proposed location. We will optimise the design and assessment to the smaller sizes, if required by the need case to be confirmed in the draft WRSE Regional Plan and the draft WRMP24.

1.39 The 150 Mm^3 option, as the largest option for the proposed site, has formed the basis of the design work completed for Gate 2.[5] An indicative landscape and environment led Master Plan has been developed for Gate 2 (see Main Gate 2 Report, Figure 3.1), to provide a first illustration of how the engineering requirements of the scheme may be integrated with the expected environmental mitigation and with possible recreational uses of the site. This vision will be subject to change and refinement if SESRO progresses through scheme promotion, through future consultation, environmental assessment and associated design iterations.

1.7 Option configuration and operation

1.40 The combined river intake/outfall Structure would be located on the western bank of the River Thames upstream of Culham. Abstracted water would pass through a tunnel and pumping station and jetted into the reservoir at the base of an inlet tower.

[5] The largest scheme contains the most constraints and issues to resolve and hence was considered a better 'starting point' for the indicative Master Plan, enabling future iterations to smaller schemes, if required

1.41 Water being discharged back into the river would pass through an outlet tower and the same tunnel before flowing over a stepped gravity weir at the outfall, which would maximise aeration whilst avoiding scour to the River Thames.

1.42 The current conceptual design provisionally allows for the inclusion of the outfall for the Severn to Thames Transfer (STT) SRO project within the SESRO outfall, providing a more efficient combined solution should both schemes be implemented.

1.43 The intake for the reservoir would operate under strict conditions imposed by the Environment Agency's future environmental permit for the scheme. This would be sought as part of the scheme's consenting strategy:

- The abstraction into SESRO shall be controlled by a Minimum Residual Flow (MRF) that must be retained in the River Thames at Culham of 1,450Ml/d;
- The maximum pumping capacity at the intake shall not exceed 1,200 Ml/d;
- The maximum 24-hour abstraction shall be ≤ 1,000 Ml/d (and ≤ 150,000 Ml/yr);
- Abstraction will increase progressively at a rate of no more than 300 Ml/d; and
- Water would be discharged at a maximum rate of 600 Ml/d, with typical release rate between ~165 Ml/d and ~320 Ml/d depending on the size of the reservoir.

1.44 The need for water to be released from the reservoir would be triggered by conditions in the lower River Thames, governed by the Lower Thames Operating Agreement.[6] It is expected that the release would primarily be triggered during periods of low flow.

1.8 Key assets

1.45 The key components or assets required to deliver the scheme are as follows:

- Provision of a fully bunded raw water storage reservoir in Oxfordshire, 5km south-west of Abingdon.
- Pumping station at the toe of the embankment (on the north-east side of the reservoir) including both inflow pumps and outflow energy-recovery turbines.
- Conveyance tunnel to transfer flows via the pumping station to and from the intake/outfall structure on the River Thames near Culham.
- Auxiliary drawdown channel (ADC) linking the reservoir siphons to the River Thames, to allow drawdown of the reservoir in emergency scenarios. This could

[6] Further information may be found in Supporting Document G: Planning and Consents Strategy

also form a navigable channel and as plans progress for the SESRO scheme, there is an opportunity to engage with the promoter of any rehabilitation of the Wilts & Berks Canal for an ADC to form part of their scheme.

- Main access road into the site (from A415, Marcham Road) and diversion of the existing East Hanney to Steventon Road.
- Temporary rail siding to facilitate delivery of certain construction materials by freight train.
- Public access, parking and recreation facilities, public education facilities, landscaping and creation of aquatic/grassland habitats.
- Local stream channel diversion to both the east and the west of the reservoir and construction of compensatory floodplain.

1.46 Interaction with existing assets and other SROs, along with the scalability of the SESRO options is discussed within the main Gate 2 Report.

2. Hydrology

2.1 Introduction

2.1 The SESRO design is based on the abstraction of water from the River Thames upstream of Culham Lock and Sutton Courtenay pools which is then stored in a fully bunded reservoir. This water is to be released back to the River Thames at the same location during low flow periods to augment resources available for downstream abstraction to both Thames Water and Affinity Water.

2.2 This chapter assesses the potential impacts of abstraction to, and discharge from, SESRO on the hydrological regime of the River Thames. The chapter also considers potential changes to the River Ock due to the footprint of SESRO, noting there are no abstractions or discharges within the catchment.

2.3 The assessment builds on recommendations made at Gate 1, specifically the alignment of hydrological modelling with WRSE water resource model outputs and the use of a hydrodynamic water quality model for detailed assessment of the Lower Thames. Not all recommendations were feasible within the timeframe of this programme, for instance, the assessment of impacts from climate change have been excluded at this time.

2.4 The scheme assessment presented in this chapter is focussed primarily on the 150 Mm^3 SESRO option, as this is the variant currently selected in the Thames Water draft WRMP24. The 150 Mm^3 size variant also provides the upper envelope of potential impacts with the highest associated maximum permissible discharge of 321 Ml/d. Summary results have also been provided for the smallest size variant which has a volume of 75 Mm^3 and a maximum permissible discharge of 165 Ml/d, just greater than half that of the largest scheme.

2.2 Methodology

2.2.1 Aims

2.5 This assessment has been based on outputs from the SESRO River Thames hydrodynamic and water quality modelling provided by the Infoworks ICM model. This model was developed to provide a key tool to assess the impact of SESRO and other SROs on water quality in the River Thames. Further information on the development of the Infoworks ICM model is provided in a calibration and validation report included in Technical Appendix A2.1 Water Quality Model Calibration and Validation Report.

2.6 The hydrodynamic (HD) component of the model drives the water quality calculations by simulating flow (provided as a model input), depth and velocity through the hydraulic cross-sectional representation of the River Thames. The HD outputs have been used to produce a baseline and SESRO impacted dataset for this hydrological assessment. The relative differences in the model outputs have allowed an assessment of the potential impact of SESRO operations on the downstream flow and associated depth and velocity at Reaches along the River Thames.

2.7 Three selected years of hydrological data have been simulated in the Infoworks ICM model to represent different dry year conditions. These were chosen to represent a 'moderately dry' year, a 'drought' year and an 'extreme' year and were selected in association with Ricardo consultants who are responsible for the Severn to Thames Transfer (STT) SRO and Reuse EAR assessments to provide a consistent baseline against which all the Thames Water SRO schemes can be reviewed. The selected hydrological years each run from April to March.

2.8 The selection of years was the result of a dry year indexing review which considered low flows, low flow event durations and years with a range of preceding winter flows to capture different refill conditions.

2.9 The years were selected from hydrological timeseries taken from the Thames Water component of the WRSE Regional System Simulation (RSS) Pywr model. The underlying input hydrology to the RSS Pywr model is driven by rainfall and PET data from stochastic climate datasets developed for the WRSE region (400 replicates of a 48-year series, resulting in 19,200 years of data). Stochastic climate data and associated stochastic hydrological datasets are not simulations of historical or observed events but are synthetically generated data often referred to as including versions of history that never happened. They allow flow series to be created for periods longer than historical records and contain a range of conditions including some drier summers and wetter winters intended to allow stress testing of drought conditions that may not be possible from historical records.

2.10 Stochastic hydrology has been applied by the regional water resource groups to generate a long enough dataset to understand the impact of the proposed SROs on a 1-in-500 year Deployable Output (DO). The need to assess the schemes against a 1-in-500 year level of resilience is set out in the latest Environment Agency Water resource planning guidelines[7]. This EAR assessment uses the same stochastic data to further develop the method applied at Gate 1 which was based on historical simulations. This approach will start to align the SRO assessments although it is

[7] Water resource planning guidelines, Environment Agency, updated 4 April 2022.

recognised that this is a complex process and requires further review and refinement over subsequent phases as detailed in section 2.2.3.

2.11 This assessment has been structured around the SESRO study Reaches as defined in Table 1.1. The assessment approach for each Reach is summarised in Table 2.1 along with the Infoworks ICM model node location used to inform the assessment. All modelled output locations are shown in Figure 2.1 in Appendix A1.1 Figures.

Table 2.1 Approach to hydrological assessment for the SESRO study Reaches

Reach no.		Watercourse	Reach description	Hydrology assessment Approach
1	1.1	Cow Common Brook	Watercourses within the reservoir footprint.	Changes to flow within the impacted tributaries have been assessed as part of the SAGIS–SIMCAT flow and water quality modelling in Section 4.
		Portobello Ditch		
		Landmead Ditch		
		Mere Dyke		
	1.2	Childrey Brook (lower)		
		Hanney Ditch		
2	2.1	River Ock (lower)	Watercourses between the reservoir footprint and the River Thames.	Changes to flow within the impacted individual tributaries have been assessed as part of the SAGIS–SIMCAT flow and water quality modelling in Section 4. An assessment of the overall River Ock catchment against gauged flows has been made within this chapter.
	2.2	River Ock (upper)	*Watercourses adjacent to and upstream of the footprint within the Ock catchment – not included at Gate 1 but included for additional context and reference sites at Gate 2.*	
	2.3	Stutfield Brook		
	2.4	Childrey Brook (upper)		
	2.5	Letcombe Brook		
	2.6	Marcham Brook		
	2.7	Sandford Brook		

Reach no.		Watercourse	Reach description	Hydrology assessment Approach
3	3	Ginge Brook Mill Brook		Flows within the watercourses of Reach 3 are not impacted by SESRO and are therefore not assessed in this chapter.
4	4	River Thames	Upstream of SESRO (Evenlode to Culham) Reach length – 27.0 km (along main branch of the Thames).	Changes to flow, depth and velocity have been assessed from modelled River Thames outputs approximately 400m upstream of the combined SESRO intake/discharge location (Infoworks node AbLag.1_us*).
5	5	River Thames	Immediately downstream of SESRO combined intake/discharge structure up to the River Thame confluence. Reach length – 13.2 km	Changes to flow, depth and velocity have been assessed from modelled River Thames outputs immediately downstream of the combined SESRO intake/discharge location (Infoworks node SESRO_STT_dis.1_ds*).
6	6	River Thames	Between River Thame and Thames Water Datchet intake Reach length – 87.3 km	Changes to flow, depth and velocity have been assessed along the River Thames between the main contributing catchments: Infoworks node 41.113_JUNCT.1_ds* (downstream of the River Thame, ~20 km downstream of SESRO);

Reach no.		Watercourse	Reach description	Hydrology assessment Approach
				Infoworks node 38.SL-d.1_us* (downstream of the River Pang, ~40 km downstream of SESRO); Infoworks node 35.100.1_us* (upstream of the River Kennet, ~ 50 km downstream of SESRO); Infoworks node 35.067_JUNCT.1_us* (downstream of the River Kennet, ~ 51 km downstream of SESRO); Infoworks node 107_JUNCT.1_us* (downstream of River Loddon, ~60 km downstream of SESRO); and Infoworks node 23.045U_JUNCT.1_us* (upstream of Thames Water Datchet intake, ~100km downstream of SESRO).
7	7	River Thames	Between Thames Water Datchet intake and Affinity Water Sunnymeads intake Reach length – 2.8 km	The chapter includes a qualitative assessment of flows in the re-abstraction reaches due to uncertainties associated with the representation of the intakes at this stage of the modelling process. A quantitative assessment of percentile changes in flow, depth and velocity has
8	8	River Thames	Between Affinity Water Sunnymeads and Affinity Water Egham intake Reach length – 6.4 km	

Reach no.		Watercourse	Reach description	Hydrology assessment Approach
9	9	River Thames	Between Affinity Water Egham and Affinity Water Chertsey intake	not been completed downstream of Datchet intake where re-abstraction as noted above is occurring. Licensing for the scheme is yet to be determined but intakes will be managed to limit additional abstraction to the volume provided by the scheme augmentation, therefore returning summer augmented flows to baseline flows by the end of the study Reach. Due to the complexity of aligning the modelled timeseries, representation of the intakes will require refinement in future phases.
			Reach length – 6.9 km	
10	10	River Thames	Between Affinity Water Chertsey intake and Affinity Water Walton (Desborough Island) intake	
			Reach length – 7.3 km	
11	11	River Thames	Between Affinity Water Walton and Thames Water Walton intake	
			Reach length – 4.1 km	
12	12	River Thames	Between Thames Water Walton and Thames Water Hampton intake	
			Reach length – 2.2 km	
13	13	River Thames	Between Thames Water Hampton intake and Teddington Weir (tidal limit)	
			Reach length – 9.5 km	

**Further information on the Infoworks ICM node locations is provided in Technical Appendix A2.1 SESRO River Thames water quality modelling, Water quality model calibration and validation report.*

2.2.2 Datasets reviewed

2.12 The following reports have been referenced when completing this assessment:

- Environment Agency, Monthly Water Situation Reports, Thames Area.[8]
- Environment Agency, Water resource planning guidelines, updated April 2022.[9]

2.13 The following datasets have been referenced when completing this assessment:

- Hydrology Data Explorer, Environment Agency, River Thames at Sutton Courtenay.[10]
- National Flow River Archive (NRFA), 39046 – River Thames at Sutton Courtenay gauge daily flows (1973–2019).[11]
- NRFA, 39018 – Ock at Abingdon gauge daily flows (1962–1979).[12]
- NRFA, 39081 – Ock at Abingdon gauge daily flows (1979–present).[13]

2.2.3 Assumptions and limitations

2.14 The following assumptions have been made in the Thames Water SESRO RSS Pywr modelling (which underpins the operational representation of SESRO applied in the Infoworks ICM modelling). Due to the interdependencies of the proposed modelling approach and timescales for delivery, the RSS Pywr DO modelling was undertaken at an earlier stage in the Gate 2 process. The assumptions made have been carried through into the SRO representation in the Infoworks ICM model.

- Water can be abstracted from the River Thames to refill SESRO when flows at the point of abstraction are above a Hands-off Flow (HoF) of 1,450 Ml/d. The HoF value was identified at Gate 1 based on the Q_{50} calculated from recorded data at Sutton Courtenay gauging station (NFRA 39046 – River Thames at Sutton Courtenay). It is recognised that this HoF value may be reviewed in subsequent project stages as the Q_{50} flow changes with an increased length of the historical record. However, this assessment is based on the assumptions set at the start of the RSS Pywr DO modelling.

[8] Water situation: national monthly reports for England 2022 – GOV.UK (www.gov.uk)
[9] Water resources planning guideline – GOV.UK (www.gov.uk)
[10] www.environment.data.gov.uk/hydrology/station (Hydrology Data Explorer)
[11] NRFA Station Mean Flow Data for 39046 – Thames at Sutton Courtenay (ceh.ac.uk)
[12] NRFA Station Data for 39018 – Ock at Abingdon (ceh.ac.uk)
[13] NRFA Station Data for 39081 – Ock at Abingdon (ceh.ac.uk)

- The scheme design is based on abstraction above the HoF to a maximum of 1,000 Ml/d, assuming the HoF can be maintained as per Gate 1.
- The representation of this operation was identified to be incorrect towards the end of the RSS modelling with full abstraction being possible once flows are above the HoF, sometimes reducing flow below the HoF. This will be corrected in the next phase of modelling though subsequent test runs have identified that it does not have a significant impact on DO.[14] The three selected years were over abstracting below the HoF in RSS Pywr for 19 days in the moderately dry year, 13 days in the drought year and 14 days in the extreme year. Note that when the flows were simulated in the Infoworks ICM model, flows do not fall below the HoF in the moderately dry year due to a slightly elevated baseline.
- Simulated abstractions from the River Thames to SESRO can only increase by 300 Ml/d per day up to the maximum abstraction volume of 1000 Ml/d, i.e., ramping the abstraction series. Ramping of the abstraction was not included at Gate 1.
- Control rules have been added to the RSS Pywr model to manage refill of SESRO when storage is between 90% and 100%. [15] When the reservoir storage is greater than 90% full, abstraction is restricted to 10% of the reservoir storage split over 14 days. If after 28 days storage remains between 90% and 95% full, abstraction can increase to 2 x 10% of the storage split over 14 days, however, if storage has been at or above 95% for the 28 days the maximum abstraction rate can be reapplied to refill the reservoir. The rules never allow an abstraction rate higher than the base maximum abstraction rate, therefore the rules only affect abstraction rates for the small SESRO option size of 75 Mm^3. Restricted abstraction at high reservoir storage was not included at Gate 1.
- The SESRO option size of 150 Mm^3 has been simulated with a maximum permissible discharge of 321 Ml/d and the SESRO 75 Mm^3 option has been simulated with a maximum permissible discharge of 165 Ml/d as per Gate 1. A simplified representation of ramping has been applied in the Infoworks ICM model with half the maximum permissible discharge released in day 1 and the remaining release in day 2. No operational release regime has been defined for representation in the modelling. It has been identified that as RSS Pywr transitions

[14] Atkins SESRO – Enhanced RSS Modelling of SESRO and Thames to Affinity Transfer Schemes, 5208740/9/DG/001, 30/05/2022

[15] If storage has been above 90% for less than 28 days then fill at T Ml/d, but if above 90% for more than 28 days then fill at 2xT Ml/d, unless storage has been at or above 95% full for 28 days or more then fill at maximum inflow rate. T = 10% of storage capacity in Ml/14 days, i.e. 1,071 Ml/d for 150 Mm^3 (and so this constraint has no effect as there is a 1,000Ml/d maximum abstraction), and 535.7 Ml/d for the 75 Mm^3 SESRO option.

from discharging to abstracting the node can allow flow in both directions. This is rare in the simulation and a net reduction in the release volume as a result of simultaneous refill occurs in less than 2% of the simulated release days. It is important to note this is an artefact of the model representation; the scheme would not be operated in this way.

- A loss of 2% is applied to all releases before entering the River Thames to provide a simplified representation of river losses. This results in a release value of 315 Ml/d and 162 Ml/d for SESRO 150 Mm^3 and SESRO 75 Mm^3 respectively. It is recognised that detailed investigations of losses along the River Thames have been ongoing under different work packages in parallel to this modelling. Refinement of losses will be considered in subsequent phases. Losses were not included at Gate 1.
- SESRO release is triggered in the RSS Pywr model when both the simulated 10-day rolling Teddington naturalised flows are less than 3,000 Ml/d and Thames Water storage is below the LTOA HOF1 of the Lower Thames Control Diagram (also referred to as Drought Event Level 1 (DEL1)). A 4-day delay is applied to the node before discharge from SESRO enters the River Thames to represent travel time between Culham and Teddington. These assumptions are as per Gate 1.
- SESRO storage is represented in the RSS Pywr model with a 6% emergency storage provision. Direct rainfall timeseries (increasing reservoir storage) and evaporation timeseries (reducing reservoir storage) are applied to the surface of the reservoir. This was not included at Gate 1.
- In both the Thames Water RSS Pywr model without SESRO and with SESRO the existing abstractions to Affinity Water are fixed. This is because the model is configured to simulate the Thames Water network and assumptions on Affinity Water usage have to be made for separate simulations of the Affinity Water systems. For the Affinity Water intakes to optimise abstraction from the River Thames would require both the Affinity Water network and Thames Water network to be coupled which is a complex modelling exercise and has not been feasible within the timeframe of this work.
- The T2AT abstraction profile applied in the Thames Water SESRO RSS Pywr model has been derived from separate modelling of the Affinity Water network. A different profile is applied in the SESRO 150 Mm^3 and SESRO 75 Mm^3 model based on Affinity Water simulations undertaken to achieve a 100 Ml/d and 50 Ml/d DO benefit respectively.
- The modelling which was configured at the early stages of Gate 2 represented the T2AT transfer as a new intake adjacent to Datchet. It is understood that the design options have since developed and include abstraction from the existing Thames

Water intakes to the Lower Thames Reservoir for transfer to Affinity Water. It is recommended that this abstraction configuration is considered further during subsequent project stages.

2.15 The following assumptions are inherent in the baseline Infoworks ICM model noting that the model build, calibration and sign-off of the assumptions with the Environment Agency was completed in 2021 as detailed in Appendix A2.2 Water Quality Model Calibration and Validation Report:

- Level control structures along the River Thames (i.e., locks and weirs) are included within the model. These structures have been represented with some simplifications to allow sufficient calibration of water quality. Enhanced resolution of the HD model component to allow improved modelling of levels against Standard Head should be assessed. This would only be necessary for key reaches within the model: from Culham to the Thame, and from upstream of Datchet to Teddington. This may also benefit other SROs being assessed. This would require assessment of availability and conversion of Environment Agency level data, which we understand is recorded manually and is not digitised. Where data were limited or adjustment of model validation is challenging, further river monitoring may be required to understand the relationship between Standard Head Water Levels and levels at the model nodes.
- The representation has not been altered between the baseline and assessment runs and therefore allows for a relative comparison.
- Hydrological inputs to the Infoworks ICM model have been created using PDM hydrological models. The hydrological models are based on the same stochastic climate data as the RSS Pywr modelling though the catchment delineation and artificial influences are defined differently. To resolve some of the differences in the models, the hydrological series generated by the PDM models were scaled to align with the aggregated RSS Pywr flows. This assessment has focused on relative change between assessment scenarios as simulated by the Infoworks ICM model rather than absolute values and further review of the two hydrological datasets is recommended for subsequent phases.
- The model is reliant on an aggregation of Thames Water's Datchet, Laleham and Staines abstractions from Pywr which are then disaggregated to provide inputs to the InfoWorks ICM model. More granular model resolution within Pywr was not required for DO assessment and not feasible within the timescale of this analysis but would provide more robust data for future flow assessments.

2.16 Linking the outputs of two models (RSS Pywr and Infoworks ICM) with different primary objectives has been a complex process and one which requires further consideration going forward. It should be noted that the two models run on different timesteps; RSS Pywr on daily timesteps and the Infoworks ICM on 15-minute timesteps. Daily abstraction and discharge series have been converted from Ml/d to m^3/s so that they can be input to the Infoworks ICM model on a 15-minute timestep. This approach does create incompatibilities within a day at a 15-minute resolution and flow, depth and velocity outputs have been averaged back to daily data to smooth these inconsistencies.

2.17 The simulation outputs for this assessment do not currently include climate change scenarios which will be considered in future EAR assessments.

2.18 It is recognised that assessing three years of a 19,200-year dataset provides an indication of potential impacts of SESRO but does not capture the full range of conditions under which SESRO will be active. The number of years was capped to three to fit within the programme for this gate and care was taken to ensure the three years selected would capture a range of low flows conditions and durations. To develop the assessment further during subsequent project stages, it is recommended that higher flow conditions where augmentation may still be occurring are considered in subsequent assessments.

2.3 Understanding of the baseline

2.3.1 Ock catchment

2.19 There are no gauging stations located in the upper catchment of the River Ock that are recording flows in the smaller tributaries such as Childrey Brook or Cow Common Brrook. The River Ock is however currently gauged a short distance upstream of its confluence with the River Thames (NRFA station 39081 located at grid reference SU 481966). A historical gauging station was established in 1962 as a peak flow station (NFRA station 39018 located at grid reference SU 486969) but it is noted on the NRFA that there was significant bypassing of the weir and the station closed in 1979. A new station was subsequently installed in 1979 immediately upstream of the original station. The station is stated on the NRFA as being much improved compared to the original station but still imprecise at low flows. The catchment at the current gauging station has an area of 234 km^2. Recorded data prior to 1979 at NRFA station 39018 has been added to the record at NRFA station 39081 on the NRFA.

2.20 Low flow exceedance percentiles have been estimated for affected watercourses in the upstream catchment as part of the water quality assessment undertaken in Chapter 4 Water Quality. The flow exceedance percentiles are derived from

LowFlows2000[16] and input to SAGIS–SIMCAT software. Inflow series have not been generated for these watercourses as it would not be possible to validate the flows without additional hydrometric data, however this has been recommended to develop the assessment in subsequent stages.

2.21 Baseline flow percentiles based on the historical Environment Agency gauge record are stated in Table 2.2 based on a 99% complete record. There are no level or flow monitoring stations within the upstream catchment of the River Ock, and this has determined the approach to the impact assessment at Gate 2.

Table 2.2 River Ock Flow Exceedance Percentiles based on the historical gauged record (1962–2020)

Flow Exceedance Percentile	Flow (Ml/d)
Q_5	457.1
Q_{10}	311.9
Q_{50}	78.3
Q_{70}	48.7
Q_{95}	29.2 (noting low precision of low flow data)
Q_{mean}	136

2.3.2 River Thames

2.3.2.1 RSS Pywr Simulated Years

2.22 This EAR assessment is focussed to the impact of SESRO on three selected drought years. The assessment section does however include an overview of the number of years SESRO was triggered for abstraction and discharge over the long-term stochastic dataset, and the relative impact of this on flows at Sutton Courtenay. This is to place the selected years and SESRO dynamics in a long-term context.

2.3.2.2 Selected Hydrological Drought Years

2.23 The modelled baseline reference for the River Thames is focussed to three hydrological years selected from the 19,200-year stochastic dataset. The stochastic replicates and associated synthetic years that have been selected are stated in Table

[16] Low Flows 2000, UK Centre for Ecology and Hydrology, now licensed to Wallingford HydroSolutions (WHS)

2.3. As stated in paragraph 2.9, the stochastic dataset comprises 400 replicates of a 48-year series of data from 1950–1997. The synthetic years referenced in Table 2.3 are therefore not the historic years as they were observed but synthetic alternative versions of the years selected from the 400 replicates, all of which are driven by a stochastic climate dataset.

Table 2.3 Selected stochastic replicates and years

Scenario	Selected Hydrological Years: Stochastic Replicate	Selected Hydrological Years: Synthetic Year
Moderately Dry (indicative of approximately 1-in-5 year event based on the complete stochastic dataset)	Replicate 130	01/04/1991–31/03/1992
Drought (indicative of approximately 1-in-20 year event based on the complete stochastic dataset)	Replicate 100	01/04/1956–31/03/1957
Extreme (indicative of approximately 1-in-50 year event based on the complete stochastic dataset)	Replicate 322	01/04/1976–31/03/1977

2.3.2.3 Comparison of selected stochastic replicates against historical records

2.24 The three selected years have been compared to the historical record at Sutton Courtenay gauging station (NRFA station 39046) to understand how the flows compare to previously observed events and the overall flow regime, i.e., against a range of categorised high, low, and normal observed flows.

2.25 Data at Sutton Courtenay flow gauging station has been obtained from the Environment Agency Data Explorer.[10] This is the same record as provided on the NRFA (1973–2019) but it also includes quality codes and infilling of missing data in 2001 and 2002 by the Environment Agency. The catchment area at the gauging station is 3,414 km^2 (located at grid reference SU 517946).

2.26 The gauged record was established in October 1973; however, it contains missing data in the initial two years and noted uncertainty over low flow precision during this time. There is limited recorded data between 1975 and 1977 with missing low flow periods and no data recorded between March 1980 and August 1984. It is understood that Sutton Courtenay gauging station was the first ultrasonic gauge to be installed hence some periods of missing data occurred as the station was being established.

2.27 Whilst there is a reasonable record of data between 1984 and 1990 and ‘Good’ quality flags, there remains 58 days missing in 1985, 29 days missing in 1987 and 88 days missing in 1989 leaving those years incomplete.

2.28 The gauged data have, therefore, been reviewed from January 1991 until November 2019 when a failure was experienced at the gauge. It is recognised that there remain 64 days of missing data, nine of which have been infilled by the Environment Agency, however the remaining gaps are anticipated to have limited influence over the 28-year period. Records began again in October 2021 and should provide additional data for future analysis.

2.29 Monthly mean average values have been calculated for a 28-year period; the incomplete year of 2019 has been removed so as not to bias the data therefore the full period assessed is from 1991 to 2018. The monthly mean averages have been ranked in bands from ‘exceptionally low’ to ‘exceptionally high’, aligning with the Environment Agency categorisation set out in their monthly water situation reports, and detailed in Table 2.4.

Table 2.4 Flow Categories (as defined in the EA Water Situation Reports)

Categories	Percentage	Description
Exceptionally High	5%	Monthly mean values for each year of recorded data are ranked and categorised based on the percentage time that they have occurred, i.e., 5% of a 28-year record is just greater than 1 year therefore the highest monthly mean value determines the 'exceptionally high' category; the next 2 ranked means equate to 8% of the record and determine the 'notably high' band etc
Notably High	8%	
Above Normal	15%	
Normal	44%	
Below Normal	15%	
Notably Low	8%	
Exceptionally Low	5%	

EA Water Situation Report Categorisation (Water situation: national monthly reports for England 2022 – GOV.UK (www.gov.uk)

2.30 Figure 2.2 in Appendix A1.1 Figures shows the ranked monthly mean values from 1991 – 2018 with the monthly minimum daily value shown by a dashed line. The recorded data shows that from July through to the end of October the lowest 5% of monthly mean flows and subsequent 8% of the recorded monthly mean flows are very similar. The minimum flows from the daily record during this period are all below 150 Ml/d.

2.31 The three selected hydrological years have been overlaid on the historic ranking and are shown in Figure 2.3 in Appendix A1.1 Figures. The figure is repeated in Figure 2.4 in Appendix A1.1 Figures with the y-axis reduced to the low flow range to show the differences in the categorisation of the three years. The years include variable winter values to capture a range of refill conditions but were selected primarily based on their summer flows. The categorisation of each month of the selected years from *Exceptionally High* to *Exceptionally Low* is also stated in Table 2.2.5.

Table 2.2.5 Categorisation of each month of the three selected years based on a ranking of historic monthly mean values (as shown in Figure 2.3 and Figure 2.4 in Appendix A1.1 Figures)

Month	Moderately Dry	Drought	Extreme
Apr	Normal	Normal	Below Normal
May	Normal	Below Normal	Notably Low
Jun	Below Normal	Below Normal	Notably Low
Jul	Normal	Below Normal	Below Normal
Aug	Below Normal	Below Normal	Below Normal
Sep	Normal	Below Normal	Below Normal
Oct	Normal	Below Normal	Notably Low
Nov	Normal	Notably Low	Exceptionally Low
Dec	Normal	Exceptionally Low	Exceptionally Low
Jan	Normal	Notably Low	Notably Low
Feb	Normal	Normal	Above Normal
Mar	Normal	Above Normal	Above Normal

2.32 The monthly mean flows for the moderately dry year are within the middle of the *normal* range in April falling to the lower *normal* range and even just reaching the *below normal* category in June and August. During February and March, the monthly mean flows return to the middle of the *normal* range.

2.33 The summer to autumn monthly mean flows for the drought and extreme years are relatively more severe than the moderately dry year as is expected. The monthly mean flows in the drought year are categorised as being *below normal* from May to October, *notably low* in November and *exceptionally low* in December. The monthly mean flows for the extreme year are *below normal* or *normal* between April and October falling to *exceptionally low* in November and December. Between January and March, the monthly mean flows are less severe and are categorised as *notably low* in January and *normal* or *above normal* during February and March.

2.34 The moderately dry year has the shortest low flow period of the three years and has returned to being within the *normal* range by November. However, the years were selected to capture a range of extended low flow conditions, under which a longer period of augmentation would be required if SESRO was active. This is reflected in the extreme year which as noted above is within the *exceptionally low* category during November and December. The drought year is *notably low* in November and due to the limited increase in flow at the end of the year is categorised as *exceptionally low* in December.

2.35 The selected extreme year does not include any of the lowest monthly mean values of the complete 19,200 stochastic series as it was selected to represent a continuous timeseries of low flows during which augmentation from SESRO would be triggered allowing for a relative assessment of impact. The comparison of all three selected years against flows in the historical record supports that the years simulated for this assessment provide a reasonable range of low flow conditions for this Gate 2 assessment.

2.36 The RSS Pywr model is not a hydraulic model and is therefore insensitive to simulating low flows and water levels. This is an important difference as a sweetening flow was required in the Infoworks ICM model for the selected years to ensure sufficient depth was maintained through the structures as detailed further in Appendix A2.1 Water Quality Model Calibration and Validation Report. As a result, the flows simulated are slightly higher than the RSS Pywr dataset, however this does not affect the relative assessment of impact based on the Infoworks ICM results.

2.37 Baseline Q_{95} values for the SESRO study reaches have been calculated for the release period to allow an assessment of the change in flow whilst the scheme is delivering water; the dates 20 July to 29 November have been used to define the release period as this captures a consistent period of simulated releases from SESRO across all three assessment years. As the period of abstraction to refill SESRO is less consistent, baseline annual percentiles for Q_{50} and Q_{25} for each assessment year have been calculated. As these are not long-term exceedance percentiles (i.e., calculated for only the selected years and not the 19,200 years dataset) they should not be used in any other context than for the relative comparisons. All percentiles have been calculated based on the outputs of the Infoworks ICM model.

2.38 The exceedance percentile values are included Table 2.6 at the Infoworks ICM model nodes previously identified in Table 2.1. They have been identified to cover a point in study Reach 4, Reach 5, and a spatial distribution between the main contributing catchments along Reach 6 of the River Thames which comprises the River Thame, River Pang, River Kennet, and River Loddon. These have been considered as important assessment locations as they represent points at which the proportional influence of SESRO was anticipated to change. The distance of each assessment point downstream of SESRO is stated in Table 2.1.

2.39 The modelled outputs show that the catchment of the River Thame ~15 km downstream of SESRO provides the greatest proportional increase in flow across study Reach 6 with an increase in baseline flow of 70–100% between the moderately dry and extreme scenarios respectively. The River Kennet is then the next most significant inflow to the River Thames increasing the baseline flow by up to 32% in the moderately dry scenario.

2.40 Between the River Thame and the River Kennet contributing inflows, Infoworks ICM simulates higher low flows in the drought year than the moderately dry year. This is thought to be due to a slightly higher low flow for the drought year relative to the moderately dry year simulated for the River Thame and the River Pang inflows. Downstream of the River Kennet the Q_{95} baseline flows for the drought year return to being below that of the moderately dry year.

Table 2.6 Baseline Percentiles for Reach 4, Reach 5 and Reach 6

Assessment Reach	Infoworks Node	Moderately Dry	Drought	Extreme	Moderately Dry	Drought	Extreme	Moderately Dry	Drought	Extreme
		Q_{95} (Release period 20th June – 29th November) (Ml/d)			Annual Q_{50} (Ml/d)			Annual Q_{25} (Ml/d)		
Reach 4 – Evenlode to Culham	AbLag.1_us	390	331	259	2285	1539	1231	3845	2156	2008
Reach 5 – SESRO	SESRO_STT_dis.1_ds (note in the baseline run SESRO is not active)	391	331	259	2285	1539	1231	3845	2156	2008
Reach 6 – River Thame to Datchet	Downstream of River Thame – 41.113_JUNCT.1_ds	657	677	457	2568	1889	1454	4473	2547	2661
	Downstream of the River Pang – 38.SL-d.1_us	687	706	487	2607	1932	1487	4546	2615	2720
	Upstream of River Kennet – 35.100.1	707	727	504	2699	2020	1516	4695	2726	2770
	Downstream of River Kennet – 35.067_JUNCT.1_us	932	843	621	3521	2480	1697	5963	3432	3378

Assessment Reach	Infoworks Node	Moderately Dry	Drought	Extreme	Moderately Dry	Drought	Extreme	Moderately Dry	Drought	Extreme
		Q_{95} (Release period 20th June – 29th November) (Ml/d)			Annual Q_{50} (Ml/d)			Annual Q_{25} (Ml/d)		
	Downstream of River Loddon – 107_JUNCT.1_us	1049	954	722	3667	2600	1755	6226	3840	3566
	Upstream of Datchet Intake – 23.045U_JUNCT.1_us	1149	1057	854	3765	2721	1844	6348	3998	3692

2.3.2.4 Depth and Velocity

2.41 Water levels along the River Thames are managed by a series of structures each targeted within a defined range to maintain Standard Head navigational depth during low flows and manage flood risk at higher flows. Dependent on the upstream reach, water levels may be managed to a level high than Standard Head to manage issues such as shoals. Whilst this operation influences overall river levels, there is greater variation in levels between the structures than at the structures. It has been highlighted in Section 2.2.3 that some of the gate operations and spatial representations have been simplified at this stage of the modelling, for instance the River Thames at Clifton Lock is represented by a single modelled channel.

2.42 As data output locations from the Infoworks ICM model were configured at the start of the project along river reaches, the output data were not at the same position as the weirs. It has therefore not been possible to validate gate operation based on expected level range at the structures. It is important to note that a limit was applied to the number of node locations where timeseries data was recorded to manage run time run and limited observed data were readily available to validate the simulations at the gate structures. A high-level assessment has been undertaken of the levels at some structures as part of the Infoworks ICM model review which suggests that the model may be releasing too much water through the structures at low flows.

2.43 The outputs from the modelling exercise should therefore, at this stage, not be considered as absolute values for baseline characterisation but used to indicate relative change between baseline and each scheme size (SESRO 150 Mm^3 and SESRO 75 Mm^3) to inform the assessment outcomes. It is recognised that the relative difference in impacts between the SESRO 150 Mm^3 and SESRO 75 Mm^3 scheme may be sensitive to a change in the representation of the structures (rather than between baseline and the scheme).

2.3.2.5 Thames Water and Affinity Water abstractions

2.44 The Infoworks ICM modelled baseline and SESRO scenarios have also included abstraction timeseries for the Thames Water and Affinity intakes between Datchet and Teddington weir (Reach 6). The volumes abstracted at the intakes have been extracted from the RSS Pywr model for the equivalent scenario and hydrological year.

2.45 Table 2.7 lists the abstraction locations simulated in the RSS Pywr model in this Reach.

Table 2.7 Thames Water and Affinity Water RSS Pywr simulated intakes

Intake	Modelled chainage downstream of SESRO (km)	Supply Network
Proposed T2AT Intake location, as represented in model*	~100	Affinity Water
Datchet (aggregation of Datchet, Laleham, Staines)	~100	Thames Water
Sunnymeads	~108	Affinity Water
Chertsey (including Chertsey gravels)	~118	Affinity Water
Walton	~125	Affinity Water
Walton	~130	Thames Water
Hampton	~130	Thames Water
Surbiton	~137	Thames Water

**This is adjacent to the existing Datchet intake therefore impacting the same Reach as if it were abstracted through Datchet*

2.46 The Datchet intake in the RSS Pywr model is an aggregation of Datchet, Staines and Laleham. This aggregation does not impact supply assessments as they all abstract along the same Reach and to the North Thames reservoir system. For this environmental assessment however, disaggregation was required to simulate Reach by Reach impacts between Datchet and Teddington weir. The disaggregation was undertaken in consultation with Ricardo (who are undertaking the EAR for the STT and Reuse schemes) to ensure consistency in the approach to the baseline assessment.

2.47 As the outputs are from the Thames Water component of the RSS Pywr model, abstraction timeseries for Affinity Water are not dynamic and do not change between scenarios. They are fixed timeseries derived from separate modelling of the Affinity Water network. Whilst this is a limitation in the assumed dynamics of the intakes, conjunctive modelling of the two networks to optimise both company's abstractions would be a complex modelling exercise that would need to be considered in the timescales of future phases of work. The representation of Affinity abstractions as fixed timeseries mirrors the approach to the Thames Water DO modelling.

2.48 The RSS Pywr model is the 'decision-making' model in that it determines what volume of water SESRO will abstract from and discharge to the River Thames, based on other simulated operations in the Thames valley. The optimiser within the Pywr model determines where to abstract based on a range of factors but includes the relative health of sources or water availability, licence and asset constraints and operational rules. This can lead to 'hunting' in the abstractions as the optimiser tries to balance licence usage and source health on each day of the run. This behaviour would not be seen operationally as abstractions from sources would be incrementally increased and decreased. This is an artifact of the optimiser, and the data has been averaged during these periods to provide a more realistic operational regime. Timeseries from RSS Pywr have been used to provide input data (abstraction timeseries and SESRO releases) for the Infoworks 1D model which does not contain an optimiser for water supply network simulation.

2.49 All abstractions in the baseline scenario are limited by the current licence limits. Datchet, Staines, Laleham, Walton, Hampton and Surbiton are all limited by the Lower Thames Thames Water licence (reference 28/39/M/2) which has an annual limit of 663,716 Ml/year as applied in the RSS Pywr model.

2.50 The Thames Water licence is not enforced in the SESRO runs. This is to allow the RSS Pywr model to calculate the maximum potential DO that could be achieved from SESRO and to identify licence and asset capacity changes that may be required to facilitate increased abstraction. However, it is important to highlight that the licence will not be unlimited as the scheme details are refined and will be capped to allow for abstraction of flows augmented by SESRO, without increased abstraction of baseline flows.

2.51 The T2AT abstraction series is introduced in the SESRO simulations to represent the increased abstraction from the River Thames to Affinity Water. This was represented in the RSS Pywr modelling as a river intake which was the preferred option under consideration at the time that the modelling was completed, and the hydrodynamic modelling was being set-up. The intake is in the Reach immediately upstream of Datchet. It is understood that different options are being considered for the Affinity Water supply to be provided through the Thames Water intakes to the Lower Thames Reservoir option (Wraysbury Reservoir) which will require further review in subsequent phases.

2.52 The T2AT abstraction profile run with the SESRO 150 Mm^3 scheme represents a 100 Ml/d DO benefit to Affinity Water whilst the profile for the SESRO 75 Mm^3

scheme represents a 50 Ml/d DO benefit. This is not the same as a 100 Ml/d and 50 Ml/d abstraction as the impact of the abstraction volume relative to DO is influenced by the conjunctive effects of storage and the operation of the supply network and other sources. For example, the maximum daily abstraction volume in the 100 Ml/d DO benefit profile is 73 Ml/d across the three selected years (though variable across the year) and the maximum abstraction volume in the 50 Ml/d DO benefit profile is 21 Ml/d across the three selected years.

2.4 Assessment outcomes

2.4.1 Impact of the SESRO footprint on the River Ock

2.53 The outcome of the SAGIS–SIMCAT assessment (documented in more detail in Section 4) resulted in a predicted reduction in river flows in the River Ock due to a reduction in the catchment to the reservoir area.

2.54 SAGIS–SIMCAT simulated changes to the Q_{mean} and Q_{95} flow values for Childrey Brook, Cow Common Brook and East Hanney Ditch, taking account of potential flows in the proposed eastern and western diversions and along the embankment toe drain.

2.55 Q_{mean} and Q_{95} values for the River Ock upstream of the River Thames were modelled as reducing by 4 Ml/d and 0.7 Ml/d respectively. The exceedance percentile values as detailed in Chapter 4 Water Quality are repeated in Table 2.8 though should be read in the context of Chapter 4. Historical observed data for the equivalent percentiles are also tabulated and show a good correlation with the baseline SAGIS–SIMCAT results.

Table 2.8 Exceedance Percentile changes as simulated by SAGIS–SIMCAT

	Ock above Thames			Historical Observed Data – Ock at Abingdon (NFRA 39081)
	Baseline	SESRO 150 Mm^3 option	Relative change	
Flow Q_{Mean} (Ml/d)	142	138	-4	136
Flow Q_{95} (Ml/d)	30.7	30	-0.7	29.2

2.56 A reduction in flow from the River Ock will reduce the flow in the receiving River Thames. A 4 Ml/d reduction in flows at Q_{mean} is less than 1% of the Q_{mean} flow at Sutton Courtenay as stated on the NFRA (2,358 Ml/d). A 0.7 Ml/d reduction in the Q_{95}

flow is also less than 1% of the Q_{95} flow at Sutton Courtenay as stated on the NFRA. However, it is important to note that a reduction in low flows in the River Ock may not result in an equivalent reduction in low flows on the River Thames if the timing of the recessions differ. It is also noted that the NFRA statistics at Sutton Courtenay should be treated with a degree of caution as only 87% of the record is complete as detailed previously in Section 2.3.2.2.

2.57 As there is limited data in the upstream reaches of the River Ock it is recommended that additional monitoring is undertaken in subsequent stages to further develop the assessment and gain a better understanding of the flow regime in the smaller channels that may be affected.

2.4.2 Modelled impact of SESRO operation on the River Thames flow regime based on 19,200 years of stochastic simulations

2.58 Figure 2.5 in Appendix A1.1 Figures is a heatmap of the years that SESRO 150 Mm^3 was triggered across the 19,200-year RSS Pywr run. The model was run with demand savings active, but drought permits disabled at a 1:500 demand. The simulated 48 years (1950–1997) are on the y-axis and the 400 replicates (as described in paragraph 2.9) are on the x-axis; years in blue are those where SESRO is releasing. SESRO was active in ~63% of the simulated years, often being utilised in sequential years.

2.59 The full stochastic dataset has been reviewed to understand the potential impact that SESRO may have on the River Thames over a longer timeseries, encompassing a broader range of hydrological events than those represented by the three selected years. Figure 2.6 in Appendix A1.1 Figures shows Flow Duration Curves (FDC's) based on the 19,200 years of simulated flows at Sutton Courtenay a short distance downstream of SESRO with and without the 150 Mm^3 reservoir. The exceedance percentile is also tabulated in Table 2.9. The difference between the FDCs indicates that, with SESRO being triggered in ~63% of the simulated years, flows lower than Q_{60} (as calculated from the baseline stochastic dataset) will increase with the most notable differences occurring at the lower flows, i.e., Q_{70}–Q_{80} or lower. Based on the stochastic simulation, the long term Q_{95} flow once SESRO is available will equate to a flow close to Q_{80} in the baseline run. This flattens the lower end of the flow duration curve and reduces the range between Q_{60} and Q_{95}.

2.60 The impact on the baseline FDC decreases closer to Q_{60} as during wetter summers there is a reduced requirement for flow augmentation and SESRO would either be triggered for fewer days or not at all.

2.61 Abstraction for SESRO has been simulated as occurring ~34% of the time at variable rates and in 60% of years of the 19,200-year dataset at its maximum rate of abstraction. This has a smaller impact on the FDC as shown in Figure 2.6 in Appendix A1.1 Figures and in Table 2.9, primarily reducing flows relative to baseline between Q_{20} and Q_{60} (flows at Q_{10} are abstracted less than 2% of the 19,200-year simulation and at Q_1 this is <1% of the 19,200 years). This also highlights that whilst the peak flows of a moderately dry year may be abstracted into SESRO, the highest flows (i.e., greater than Q_{20}) over a long-term series are unlikely to be reduced.

2.62 The maximum abstraction amount of 1,000 Ml/d is a lesser proportion than the release amount is of the low flows and therefore the proportional reduction in flow relative to baseline from abstraction will be less than the proportional increase in flow from augmentation. As noted above, within an individual year a portion of the highest flows may be abstracted for refill, but depending how much of the reservoir volume was used for augmentation, refill may be completed within a relatively short period and will be dependent on flow above the HoF. This may lead to SESRO being refilled before the peak occurs in a wetter year.

Table 2.9 Simulated 19,200-year Baseline and SESRO 150 Mm^3 FDCs

Exceedance Percentile	Baseline Simulation	SESRO 150 Mm^3 Simulation	% Change
1	11781	11696	<−1%
5	7133	7042	−1%
10	5384	5284	<−2%
20	3660	3551	−3%
30	2701	2587	−4%
40	2043	1933	−5%
50	1545	1489	−4%
60	1105	1139	3%
70	811	878	8%
80	583	728	25%
90	427	628	47%
95	361	553	53%
99	289	437	52%

2.63 Reviewing the pattern of releases across the simulation it is also clear that when SESRO is triggered, it releases the maximum volume possible for the scheme, i.e., 315 Ml/d (including losses) for the 150 Mm^3 size scheme. This is partially due to the way in which Pywr functions, as once the optimiser utilises a source it is likely to use it at its maximum capacity, if the water is available. Operationally a refined release regime may be applied. With the current modelled representation, the low flows within an individual year will be shifted by a consistent daily augmentation volume when SESRO is releasing. This is important as it would mean that the baseline variations in flow across the summer are retained. The timing of releases has been found to occur most often between June and November, extending into January of the following year in more extreme events. An indicative representation of this dynamic is shown in Figure 2.7 in Appendix A1.1 Figures. This is not the result of a simulation (as the RSS Pywr model has not been configured for historical simulations) but simply demonstrates how within a year flow variability would be maintained with a relatively constant period of augmentation. The recorded Sutton Courtenay series has been shown as a baseline series from 2009 to 2013. Focusing only on the summer period, 2009 has been ranked within the lower end of the normal range of flow and 2013 within the higher end of normal flows whilst 2011 represents a summer drought year with exceptionally low flows. An indicative increase in flow during each year is shown in red with an uplift of 315 Ml/d from June to January during this period to convey how flows may have changed if SESRO had been triggered in these years. If augmentation continues when flows in the River Thames are starting to recover but reservoir storage is still recovering, higher flows could also be augmented. This is an area that has not been assessed in the context of an individual year but is recommended for further investigation as the operation of the scheme is defined in subsequent phases.

2.64 The assessment of the selected dry years is considered in Section 2.4.3 in addition to an assessment of how the proportional increase in flows decreases with increasing distance downstream of SESRO.

2.4.3 Modelled impact on dry years – River Thames

2.65 The simulated release period for each of the years is given in Table 2.10 for SESRO 150 Mm^3 and in Table 2.11 for SESRO 75 Mm^3. The release period ranges from 145 days (40% of the year) to 204 days (56% of the year) for the three years under the SESRO 150 Mm^3 scheme. The number of days that SESRO is active is only slightly reduced under the SESRO 75 Mm^3 scheme ranging from 133 days (36% of the year) to 197 days (54% of the year) which is assumed to be due to SESRO being triggered to meet a slightly lower demand for the smaller scheme, as the hydrology remains unchanged. As all three years are dry years, there will be wetter years when SESRO is still required but for a reduced number of days, and in more severe events the augmentation may continue for a longer period.

Table 2.10 SESRO 150 Mm^3 simulated release period

Hydrological Event	Simulated Release Period	Simulated Days Augmentation	% of year
Moderately Dry	8 July to 29 November	145	40
Drought	23 June to 8 January	200	55
Extreme	15 June to 4 January	204	56

Table 2.11 SESRO 75 Mm^3 simulated release period

Hydrological Event	Simulated Release Period	Simulated Days Augmentation	% of year
Moderately Dry	20 July to 29 November	133	36
Drought	29 June to 8 January	194	53
Extreme	21 June to 4th January	197	54

2.66 The change in flow during the three dry scenarios as a result of SESRO has been assessed and compared back to the monthly mean ranking of observed historical data at Sutton Courtenay.

2.67 Figure 2.8 in Appendix A1.1 Figures shows the three simulated years with SESRO 150 Mm^3 operating against the monthly mean ranking of observed data at Sutton Courtenay. The figure is repeated in Figure 2.9 in Appendix A1.1 Figures with the y-axis reduced for the low flow range. The categorisation of monthly mean flows for the selected years is also tabulated in Table 2.12.

Table 2.12 Change in categorisation of each month of the three selected years as a result of SESRO, based on a ranking of historic data (as shown in Figures 2.8 and Figures 2.9, Appendix A1.1 Figures)

Ranking of selected stochastic years based on observed data	Stochastic Moderately Dry	Stochastic Moderately Dry – SESRO	Stochastic Drought	Stochastic Drought – SESRO	Stochastic Extreme	Stochastic Extreme – SESRO
Apr	Normal	Normal	Normal	Normal	Below Normal	Below Normal
May	Normal	Normal	Below Normal	Below Normal	Notably Low	Notably Low
Jun	Below Normal	Below Normal	Below Normal	Normal	Notably Low	Normal
Jul	Normal	Normal	Below Normal	Normal	Below Normal	Normal
Aug	Below Normal	Normal	Below Normal	Normal	Below Normal	Normal
Sep	Normal	Above Normal	Below Normal	Above Normal	Below Normal	Above Normal
Oct	Normal	Normal	Below Normal	Normal	Notably Low	Normal
Nov	Normal	Normal	Notably Low	Below Normal	Exceptionally Low	Below Normal
Dec	Normal	Below Normal	Exceptionally Low	Notably Low	Exceptionally Low	Notably Low
Jan	Normal	Below Normal	Notably Low	Notably Low	Notably Low	Notably Low
Feb	Normal	Normal	Normal	Normal	Above Normal	Normal
Mar	Normal	Normal	Above Normal	Normal	Above Normal	Normal

2.68 In the context of the historical ranking, releases from SESRO are shifting the monthly mean summer flows in a moderately dry year from the lower range of *normal* to the upper range of *normal* and in the month of September would change the categorisation from *normal* to *above normal*. Abstraction into SESRO would conversely decrease the monthly means flow in December and January and these months would move from *normal* to *below normal*.

2.69 Following on from the above, *below normal* monthly would mean flows in the baseline drought year would be considered as *normal* based on historical data during June, July, and August and *above normal* again in September. Flows during November and December would shift from being considered as *notably low* and *exceptionally low* respectively to *notably low* with prolonged flow augmentation. The summer flow of the extreme year would follow a similar pattern with baseline *notably low* or *below normal* flows being in the upper range of historically *normal* flows, but again during a more severe extended drought would change flows from *exceptionally low* to *notably low*. The impact of abstraction to SESRO in the extreme year would reduce the monthly mean flows in February and March from *above normal* to *normal*.

2.70 In June the ordering of the three years changes with the extreme year having the highest June monthly average, followed by the drought year and moderately dry year. This is due to SESRO being triggered earlier in a more extreme year, therefore despite lower baseline flows, the monthly average with a higher number of days of SESRO releases increases the average above that of a slightly wetter year.

2.71 The three years provide a snapshot of the patterns that may be experienced if SESRO were active and suggest that, immediately downstream of SESRO, flows that would have previously been considered as *exceptionally low* and *notably low* across the summer are not likely to occur and instead drier years will be replaced with flows that have historically been considered as at the upper range of *normal* or even *above normal*. Autumn flows which may have previously been *exceptionally low* are more likely to be *notably low* in the historical context due to prolonged augmentation periods.

2.72 Monthly mean flows during January, February and March may be reduced within the *normal* range or could reduce the frequency of flows during this period from *above normal* to within the *normal* range.

2.73 Whilst the flow series for the SESRO 75 Mm^3 scheme are not shown in the figures, it is assumed that a release of 162 Ml/d (rather than 315 Ml/d) for a similar release period as detailed in Table 2.11 would result in a shift of the baseline years from *notably low* and *below normal* to the mid-range of the *normal* flows during the summer months following a similar relative pattern to SESRO 150 Mm^3.

2.74 To assist in analysis of the changes to the flow regime in the River Thames, analysis was undertaken of the low flows in each of the 19,200 stochastic years without SESRO being active. The annual low flows were characterised by the Q_{95} for each year. The return periods for these baseline annual Q_{95} values were calculated based on their rankings. The annual Q_{95} values for the selected dry years with and without SESRO were calculated and were compared to the distribution of baseline values to establish how much the return period of the low flows changed due to augmentation by SESRO. The results of this analysis are shown in Table 2.13 Based on these values, the annual Q_{95} within the extreme year has a return period of 1-in-500 years (note that this is based on only the annual Q_{95}), however with SESRO augmentation the Q_{95} would be equivalent to a baseline event with a return period of 1.5 years. The relative change reduces with a less extreme year as the Q_{95} of the moderately dry year has a return period of 4 years, whilst with SESRO augmentation this changes to 1.25 years.

Table 2.13 SESRO 150 Mm^3 annual Q_{95} values and their return periods based upon the distribution of annual Q_{95} values from the baseline

Scenario	Annual Q_{95} (Ml/d)	Return Period of Baseline and SESRO augmented flows based only on annual Q_{95} values and the baseline distribution
Baseline Extreme Q_{95}	226	1-in-500 years
Baseline Drought Q_{95}	310	1-in-10 years
Baseline Moderately Dry Q_{95}	361	1-in-4 years
Median Q_{95} from the baseline	454	1-in-2 years
Extreme Q_{95} with SESRO 150 Mm^3 active	533	1-in-1.5 years
Moderately Dry Q_{95} with SESRO Mm^3 active	579	1-in-1.4 years
Drought Q_{95} with SESRO Mm^3 active	678	1-in-1.25 years

2.4.4 Relative impact for SESRO study reaches on flow, depth, and velocity

2.75 The relative impact of the SESRO 150 Mm^3 scheme operation on flow, depth and velocity along the wider study reaches as simulated with the Infoworks ICM model are detailed in Table 2.14 below.

2.76 The assessment considers separately change as a result of SESRO abstraction and change as a result of SESRO release and has been assessed based on proportional increases in flow percentiles from the baseline in each selected year. As the percentiles are based only on one year of data, they have been used only to assess relative change and do not reflect the percentile exceedance values of the overall flow regime at each location.

2.77 The Q_{95} assessment of flow augmentation has been based on a specific period of the year (20 July to 29 November) during which flows in all three simulated years are increased by flow augmentation. This is to ensure that the change stated is as a result of SESRO release.

2.78 The Q_{50} and Q_{25} assessment of abstraction from the River Thames to SESRO for refill is based on the annual timeseries to capture change in mid to high flows.

2.79 The assessment states the potential change in flow and associated average depth and velocity across a cross section at the stated model node.

2.80 As described in Table 2.14, the proportional increase in Q_{95} for the release period decreases from ~120% immediately downstream of SESRO under the SESRO 150 Mm^3 scheme to a ~70% proportional increase downstream of the River Thame inflow during the extreme event. Based on results from the SESRO 75 Mm^3 simulation this impact would be approximately half with a ~60% proportional increase immediately downstream of SESRO reducing to a ~35% increase downstream of the River Thame. This relative difference aligns with the maximum permissible discharge for SESRO 75 Mm^3 being half the volume of SESRO 150 Mm^3. Similarly, the proportional increase in flow downstream of the River Kennet is 50% in an extreme year under the SESRO 150 Mm^3 scheme whilst the proportional increase is ~25% under the SESRO 75 Mm^3 scheme.

2.81 The impact of this increase on depth as a cross sectional average is approximately 20 cm for the drought and moderately dry events immediately downstream of SESRO. The change in level is influenced by the structures along the River Thames therefore there a consistently decreasing change between each node is not seen in the data, though in all three years the change in water level is between 11 cm and 17 cm from upstream of the River Kennet inflow to downstream of the River Loddon inflow. Again, the results of the SESRO 75 Mm^3 simulation show an impact that is approximately half that of SESRO 150 Mm^3 with a 10 cm increase in depth immediately downstream of SESRO decreasing to a 6 cm increase downstream of the River Kennet inflow.

2.82 Increases in the average cross-sectional velocity for Q_{95} are 103% immediately downstream of SESRO in the extreme year and 33% in the moderately dry year. This equates to a 0.1 m/s and 0.05 m/s increase compared to baseline. The SESRO 75 Mm^3 simulation results in an impact that is half that of SERSO 150 Mm^3 in the extreme year (54%) though less than half in the moderately dry year (25%). Downstream of the River Loddon inflow there is a 14% increase in velocity under SESRO 150 Mm^3 in the moderately dry year which is 8% with the SESRO 75 Mm^3 scheme, whilst in an extreme year the velocity increase is 22% in the SESRO 150 Mm^3 scheme and 12% under the SESRO 75 Mm^3 scheme.

2.83 The level and therefore velocity changes stated are based on the Infoworks ICM simulation and are relative to the assumptions regarding the gate operations. It is assumed that level changes within this range would be managed on the ground if required to mitigate adverse impacts. It is recognised that level changes within weir streams and side-channels have not been explicitly modelled and levels may respond differently to those managed within the navigation channels. To increase the resolution of the modelling requires additional data that was not possible at Gate 2; however, this will be reviewed for subsequent project stages.

2.84 A more detailed assessment of velocity changes in the upper weir reaches downstream of the proposed outfall location has been completed separately and is included in Appendix 3.1 Weir Pool Sensitivity Screening.

2.85 As noted in Table 2.1, Gate 2 has identified a number of limitations associated with the representations of network abstractions as simulated from DO modelling at the spatial resolution and timestep required for input to the Infoworks ICM model and this is an area recommended for development during subsequent project stages.

2.86 The reaches between Datchet intake and Teddington Weir have not been split out in -Table 2.14. It can be seen from the timeseries plots in Appendix A2.2 Supplementary Hydrology Results that, taking an extreme year as an example, low flows remain above the baseline downstream of Datchet when SESRO is active. However, downstream of Sunnymeads intake, low flows fall just below those in the baseline run which is also the case at the Laleham and Chertsey intakes. Downstream of the Colne inflow and upstream of the Walton intake, flows during the low flow period have almost returned to baseline levels, aligning at the Walton and Hampton intakes. The reduction in flows relative to the baseline in the summer is not representative of how the scheme will operate but is a limitation of how the increased abstraction to utilise augmented flow has been disaggregated from the single Datchet node in the RSS Pywr model to a representation of how it might be split across Datchet, Laleham and Staines, upstream and downstream of the Colne inflow in particular. In addition, the comparison of abstractions will be affected by the increased demand that the SESRO model is running at. The modelling has shown that whilst these assumptions do not affect DO, they require refinement in subsequent phases if flows are to be used for environmental assessment purposes.

2.87 In addition, the winter flows are showing increased levels of abstraction in the SESRO simulation relative to baseline despite being outside of the release period. This is again a model limitation rather than a representation of the proposed abstraction regime. It is occurring as a result of the licence constraint not being enforced in the SESRO run to enable assessment of the potential DO benefit of the scheme. The licensing and management of the scheme in this Reach would be aligned to the operational principal that any increased abstraction would be limited to the additional flow provided through augmentation by SESRO (i.e., a "put and take" condition).

2.88 As uncertainties have been identified with regards to the distribution of flow in this Reach the associated depth and velocity data has not been reviewed further at this stage.

2.89 The implication of the flow, depth, and velocity changes as simulated and reported in this chapter are assessed in *Chapter 4 Water Quality* and *Chapter 5 Aquatic Ecology*.

Table 2.14 Flow, depth, and velocity change at SESRO study Reach 4, 5 and 6

Reach no.		Watercourse	Mechanism	Moderately Dry	Drought	Extreme
SESRO Study Reaches along the River Thames						
4	4	Upstream of SESRO (Evenlode to Culham) Reach length – 27.0 km (along main branch of the Thames) *(AbLag.1_us)*	Hydrological change from flow augmentation	In the Reach upstream of SESRO the Q_{95} flow is 390 Ml/d. There are no simulated changes in this Reach.	Baseline Q_{95} flow is 331 M/d. There are no simulated changes in this Reach.	Baseline Q_{95} is 259 M/d. There are no simulated changes in this Reach.
		The change in flow, depth and velocity over the simulated years is shown in Section 1 and 8 of Appendix A2.2 Supplementary Hydrology Results for SESRO 150 Mm^3 and SESRO 75 Mm3 respectively.	Hydrological change from SESRO refill	In the Reach upstream of SESRO the Q_{50} flow is 2285 Ml/d and Q_{25} 3845 Ml/d. There are no simulated changes in this Reach.	The Q_{50} flow is 1539 Ml/d and Q_{25} is 2156 Ml/d. There are no simulated changes in this Reach.	The Q_{50} flow is 1231 Ml/d and Q_{25} 2008 Ml/d. There are no simulated changes in this Reach.

Reach no.		Watercourse	Mechanism	Moderately Dry	Drought	Extreme
5	5	Immediately downstream of SESRO combined intake/discharge structure up to the River Thame confluence. Reach length – 13.2 km *(SESRO_STT_dis.1_ds)* The change in flow, depth and velocity over the simulated years are shown in Section 2 and 9 of Appendix A2.2 Supplementary Hydrology Results for SESRO 150 Mm^3 and SESRO 75Mm^3 respectively.	Hydrological change from flow augmentation	At the SESRO combined intake and discharge location, augmentation from SESRO during a moderately dry year results in a proportional increase in the Q_{95} flow of ~80% (from 391 Ml/d to 706 Ml/d). This results in a simulated 17% change in depth (increase of 23 cm) and a 33% change in velocity (increase of 0.05 m/s).	Augmentation during a drought year results in a proportional increase in Q_{95} flow of 95% (from 331 M/d to 646 Ml/d). This results in a 15% change in depth (increase of 20 cm) and a 55% change in velocity (increase of 0.1 m/s).	Augmentation during an extreme year results in a proportional increase in Q_{95} of ~120% (from 259 M/d to 574 Ml/d) This results in a 5% change in depth (increase of 7 cm) and a 103% change in velocity (increase of 0.1 m/s).
			Hydrological change from SESRO refill	Annual Q_{50} flows are 1% higher so in this selected year it is not impacted by abstraction for refill to SESRO, however at Q_{25} there is a 6% reduction from 3853 Ml/d to 3633 Ml/d.	Annual Q_{50} and Q_{25} flows are 7% and 8% higher so in this selected year flows are not impacted by abstraction for refill to SESRO. The results show that the drier summer is extending the range of flows across which augmentation is	Annual Q_{50} flows are 24% higher in this selected year therefore the severe drought has resulted in continued augmentation even as flows begin to increase however at Q_{25} there is a 5% reduction from 2008 Ml/d to 1911 Ml/d.

Reach no.		Watercourse	Mechanism	Moderately Dry	Drought	Extreme
					occurring. The need to refill will also be influenced by the timing of flow increasing above the HoF and relative impact of the summer drawdown from previous winter refill.	
6	6	River Thames Between River Thame and Thames Water Datchet intake Reach length – 87.3 km *(Modelled River Thames outputs from node 41.113_JUNCT.1_ds (downstream of the River Thame);* *38.SL-d.1_us (downstream of the River Pang inflow);* *35.100.1 (upstream of the River Kennet); 35.067_JUNCT.1_us (downstream of the River Kennet); and*	Hydrological change from flow augmentation	The proportional increase in flow as a result of SESRO release in a moderately dry year is shown to decrease between the River Thame and Datchet intake with the River Thame, Pang, Kennet, and Loddon all increasing the baseline flow of the River Thames. Downstream of the River Thame the proportional increase in flow at Q_{95} decreases notably from ~80% to ~50%. This reduces to 44% downstream of the	The proportional increases in a drought year are similar to a moderately dry event. Downstream of the River Thame the proportional increase in flow at Q_{95} decreases notably from 95% to ~50%. This reduces to 45% downstream of the Pang inflow, ~40% downstream of the Kennet inflow and ~30% downstream of the Loddon inflow.	The proportional increase in an extreme year is similar to a moderately dry and drought event though the overall proportional increase as a result of SESRO is greater relative to a smaller base flow. Downstream of the River Thame the proportional increase in flow at Q_{95} decreases from ~120% to ~70%. This reduces to 65% downstream of the Pang inflow, 50% downstream of the Kennet inflow and 44% downstream of the

Reach no.	Watercourse	Mechanism	Moderately Dry	Drought	Extreme
	107_JUNCT.1_us (downstream of the River Loddon). The change in flow, depth and velocity over the simulated years are shown in Sections 3 to 6 and 10 to 13 of Appendix A2.2 Supplementary Hydrology Results for SESRO 150 Mm^3 and SESRO 75Mm^3 respectively.		Pang inflow, ~35% downstream of the Kennet inflow and 30% downstream of the Loddon inflow. The associated change in depth and velocity is influenced by structures in the model. The structures are level dependent and will hold back water along the reaches of the River Thames resulting in increases in depth where the proportional contribution of flow has decreased. Downstream of the River Thame there remains a 17% increase in water level (20 cm). This reduces to 2% downstream of the Pang inflow however is being influenced by localised structures with increased	The associated change in depth aligns with the moderately dry scenario with a 16% increase in water level (16cm) downstream of the River Thame and ~9% increase downstream of the Loddon inflow (12cm). Downstream of the River Thame inflow there is a 16% increase in velocity further increasing to 36% downstream of the River Pang. Upstream of the Kennet the velocity increase is 9% and 16% (0.07m/s) downstream of the River Loddon.	Loddon inflow. The proportional change in depth is also slightly greater than the moderately dry and drought scenario though the absolute increase is similar. Downstream of the River Thame there is a ~20% increase in water level (20 cm) reducing to 12% downstream of the River Loddon (13cm). Downstream of the River Thame inflow there is a 25% increase in velocity further increasing to 54% downstream of the River Pang. Upstream of the Kennet the velocity increase is 14% and 22% (0.08m/s) downstream of the River Loddon.

Reach no.	Watercourse	Mechanism	Moderately Dry	Drought	Extreme
			uncertainty in this area though subsequently increases to a 16% increase upstream of the Kennet inflow, a 10% increase downstream of the Kennet inflow and 9% increase downstream of the Loddon inflow (12cm). Downstream of the River Thame inflow there is a 16% increase in velocity further increasing to 39% downstream of the River Pang. This increase in velocity reflects that levels have decreased at this location and localised structures are releasing greater proportions of water than simulated at other gates. At the River Kennet the velocity increase is 15% (0.04m/s) and 14% (0.07m/s) downstream of		

Reach no.		Watercourse	Mechanism	Moderately Dry	Drought	Extreme
				the River Loddon.		
			Hydrological change from SESRO refill	The annual Q_{50} flow remains higher than baseline from downstream of the River Thame to downstream of the River Loddon again indicating that SESRO is actually still releasing as flow increases. At Q_{25} there is a 4% proportional reduction in flows downstream of the River Thame reduction to a 2% proportional reduction in the Q_{25} flow downstream of the River Loddon from 6226 Ml/d to 6087 Ml/d.	Annual Q_{50} and Q_{25} flows are 13% and 4% higher downstream of the River Thame indicating in this year that SESRO is augmenting for an extended period and has not abstracted for refill across this period.	Annual Q_{50} and Q_{25} flows are reduced by 11% downstream of the River Thame and by 10% downstream of the River Loddon from 3566 Ml/d to 3223 Ml/d.
6		Upstream of Datchet 23.045U_JUNCT.1_us The change in flow, depth and velocity over the simulated years are shown in Section 7 and 14 of Appendix A2.2 Supplementary Hydrology		Whilst study Reach 6 includes flows upstream of Datchet, the Infoworks ICM node immediately upstream of Datchet is impacted by re-abstraction for the T2AT transfer. Upstream of this location is the Jubilee River split therefore the River Kennet and River Loddon provide the lower most assessment points before the Thames Water and Affinity intakes. There is increased uncertainty in the data extracted at this specific location and complexity in how it can be assessed due to the spatial distribution of data upstream. In an extreme year the proportional increase in flow		

Reach no.		Watercourse	Mechanism	Moderately Dry	Drought	Extreme
		Results for SESRO 150 Mm^3 and SESRO 75Mm^3 respectively.		reduces from 44% downstream of the Loddon to 36% immediately upstream of Datchet. This will be in part due to an increased baseline flow and part due to abstraction for transfer, though the modelled data were not showing a significant decrease at this location from re-abstraction. Changes to the representation of the intake has been recommended during subsequent project stages as the preferred option into Wraysbury reservoir would make this intake redundant.		
7–10	7 - 10	Between Thames Water Datchet intake and Teddington weir The change in flow over the simulated years for selected locations are shown in Section 15 and 16 of Appendix A2.2 Supplementary Hydrology Results for SESRO 150 Mm^3 only in this instance as described in the table.		As noted in Table 2.1 Gate 2 has identified a number of limitations in transferring the representations of network abstractions as simulated from DO modelling at the spatial resolution and timestep required for input to the Infoworks model and this is an area recommended for development at Gate. Consequently, the reaches between Datchet intake and Teddington weir have not been split out or stated as percentage changes however, it can be seen from the timeseries plots in Section 4 of Appendix A2.2 that in an extreme year, low flows remain above the baseline downstream of Datchet. Downstream of Sunnymeads intake, low flows fall just below that of the baseline run and remain below the baseline run at the Laleham and Chertsey intakes until downstream of the River Colne inflow. Downstream of the Colne inflow and upstream of the Walton intake flows during the low flow period have almost returned to baseline levels, aligning at the Walton and Hampton intakes. The reduction in flows relative to the baseline in the summer is not representative of how the scheme will operate but is a limitation of how the increased abstraction to utilise augmented flow has been disaggregated from the single Datchet node in the RSS Pywr model to a representation of how it might split across Datchet, Laleham and Staines, upstream and downstream of the Colne inflow in particular. The model has shown that whilst these assumptions do not affect		

Reach no.	Watercourse	Mechanism	Moderately Dry	Drought	Extreme
			DO, they require refinement in subsequent phases is flows are used for environmental assessment. In addition, the winter flows are showing increased levels of abstraction in the SESRO simulation relative to baseline despite it being outside of the release period. This is again a model limitation and not representative of the proposed abstraction regime. It is occurring as a result of an unlimited licence being applied in the SESRO run which for Gate 2 has been set as un-constraining to test the potential DO of the scheme. The licensing and management of the scheme in this Reach would be aligned to the operational principal that any increased abstraction would be limited to the additional flow provided through augmentation by SESRO. As uncertainties have been identified with regards to the distribution of flow in this Reach the associated depth and velocity data has not been reviewed further at this stage.		

2.5 Potential options for mitigation considered

2.90 The results of the modelling undertaken for Gate 2 indicate that flows in the River Thames currently considered as being notably or exceptionally low would not occur as frequently if SESRO was developed. In addition, the modelling indicates that increases to the FDC over a long stochastic dataset would be evident for flows around Q_{60} or lower, however, the shift in the FDC is most notable at the lowest flows. The impact of abstraction at the higher flows to refill SESRO is having a lesser impact over a longer dataset.

2.91 The need to mitigate any changes in the hydrological regimes of the River Ock and the River Thames are determined largely by the sensitivity of receptors and the outcomes of the impact assessment for the aquatic environment, as presented in Chapter 5 Aquatic Ecology of this EAR.

2.92 Increases in velocity as a result of SESRO releases being triggered at their highest (maximum) discharge rate will be managed through the development of a release regime with incremental increases and/or decreases in flow. It was proposed at Gate 1 that flows will be increased gradually as SESRO is triggered and a simplified representation has been included in the current modelling, though the timing, duration and incremental volumes required should be considered further during subsequent project stages.

2.93 This assessment has focussed on the impact of augmenting drought years however further assessment of releases that occur on flows that may currently be considered as within the normal range is recommended as they may require mitigation. This could be achieved by reviewing the triggers that initiate and cease SESRO augmentation.

2.94 It is expected that increases (during augmentation) or decreases (during abstraction) in water levels and velocities along the River Thames will be mitigated through the operation of level management structures. It is recommended that this potential option for mitigation is revisited as the modelled representations of the structures are reviewed in subsequent stages.

2.95 See Section 4.4. For the River Ock, modelling has shown a flow reduction in the lowermost Childrey Brook (8%) due to these flows being diverted further downstream. Overall, there is a slight (2%) flow reduction at the bottom-most part of the catchment as a result of rainfall falling into the reservoir rather than the river itself.

2.6 Considerations for subsequent project stages

2.96 To further develop the findings from Gate 2, it is recommended that the following work is undertaken during subsequent project stages:

- Collection of additional hydrometric data with a focus on smaller watercourses within and upstream of the indicative location for SESRO within the River Ock catchment.
- Collection of groundwater/surface water interaction monitoring via in-situ piezometers within the River Ock catchment.
- Refinement of the modelling approach recognising that both the RSS Pywr model and the Infoworks ICM model were developed for different primary purposes at Gate 2, i.e., DO assessment and flow/level/water quality simulations respectively. This would include a review of the PDM hydrology generated for the Infoworks ICM model and representation of key structures in addition to the disaggregation of the Thames Water intakes in the RSS Pywr model.
- A number of refinements have been identified in the modelling approach using the Infoworks and Pywr hydrological, and water quality models in relation to the hydrology, hydraulics, and operation of the River Thames control structures during abstraction and discharge (Appendix A2.1 SESRO River Thames calibration report). Additional survey data will be required to improve model representation of level management at key structures and the relationship to levels in backwaters and side streams, weir pools and in the main channel downstream of the augmentation to further inform hydro-ecological assessment.
- Development of a 1D hydraulic model for the River Ock that is focussed to simulating low flows and water quality. This could be completed as an extension to the Infoworks ICM model of the River Thames.
- Refinement of the representation of the intake structures including minimum operating flows and future licence limits, in addition to the representation of the T2AT transfer into Wraysbury reservoir as the scheme details are developed going forward.
- Assessment of a wider range of years during subsequent project stages during which SESRO may be releasing to capture impacts of augmentation at less extreme flows. Consideration of the pattern of refill over sequential years would also further develop the understanding of the conditions during which SESRO is both abstracting and discharging, though future assessments of multiple years may be limited to flow outputs from RSS Pywr due to run time constraints of Infoworks ICM.

- It is recommended that future assessments also incorporate climate change which was not feasible for this assessment within the timescales of Gate 2.

3. Fluvial Geomorphology

3.1 Introduction

3.1 Numerous watercourses (both Main Rivers and Ordinary Watercourses[17]) lie within the scheme area and as such their drainage would need to be diverted to accommodate the scheme footprint and create a safe working area. These watercourses fall within Reaches 1 and 2 of the SESRO study area (as per Table 1.1).

3.2 Many of these are historically land drainage ditches and modified streams. Given that context, it is important to understand the baseline fluvial geomorphological characteristics of the affected watercourses, and the extent to which they would be impacted, to ensure proportionate mitigation can be provided and that appropriate design considerations are built into the process for the new diversion channels. The baseline can also be used to highlight opportunities for betterment as a result of the scheme.

3.3 The findings of the fluvial geomorphology assessment at Gate 1 concluded that the geomorphological impacts of the proposed reservoir are expected to be experienced almost wholly within the Ock catchment (i.e. Reaches 1 and 2 Table 1.1), with which this chapter is concerned.

3.4 There would also be hydrological alterations (but crucially, in the context of this chapter, no geomorphological alterations) in the River Thames downstream of the point of abstraction and discharge (Reach 5, between Culham and the River Thame; Table 1.1). These hydrological alterations are the subject of a separate study investigating impacts on three weir pool Reaches at Culham, Clifton Hampden and Day's Lock (Appendix A3.1 Weir Pool Sensitivity Screening).

3.2 Methodology

3.2.1 Aims

3.5 The aims of this Gate 2 fluvial geomorphology baseline assessment are to:

- provide a detailed desk-based characterisation of all the watercourses identified to be interacting with the scheme. For the purpose of this study, the largest reservoir option boundary has been used to identify these watercourses;

[17] Main rivers are typically larger rivers and streams as defined by the EA's Main rivers map (https://environment.maps.arcgis.com/apps/webappviewer/index.html?id=17cd53dfc524433980cc333726a56386). Other rivers are defined as ordinary watercourses.

- present a site-based characterisation of the watercourses identified to be interacting with the scheme, subject to site access restrictions;
- provide recommendations for the fluvial geomorphology characteristics of the newly designed diversion channels;
- provide an impact assessment; and,
- highlight areas that require further assessment following the desk and site-based investigations.

3.2.2 Datasets reviewed

3.6 To undertake the desk study for fluvial geomorphology, the following data sets have been reviewed:

- Ordnance Survey historic maps available via the National Library of Scotland[18]
- Google Earth imagery[19]
- LiDAR data[20]
- NRFA gauge data[21]
- Environment Agency Catchment Data Explorer[22]
- Fluvial Geomorphology of the Ock Catchment: Catchment Baseline Survey and Fluvial Audit (TWUL 2005)

3.2.3 Watercourse delineation

3.7 All watercourses were identified using Main River and Ordinary Watercourse GIS layers, as well as inspection of aerial imagery and OS base maps. These were used alongside the indicative location for SESRO to identify the watercourses that will directly interact with the proposed scheme. Those that were identified through the Main River and Ordinary Watercourse layers were named as they were displayed within this data. Additional watercourses were identified through inspection of the aerial imagery. All watercourses were coded based on the named river or ditch into which they flow. This provided a comprehensive list of named watercourses and associated tributaries, with some professional judgement required to assign the ditch network to the appropriate watercourse where it was unknown or disconnected. The

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[18] https://maps.nls.uk/geo/explore/side-by-side/#zoom=5&lat=56.00000&lon=-4.00000&layers=1&right=ESRIWorld
[19] https://earth.google.com/web/
[20] https://environment.data.gov.uk/DefraDataDownload/?Mode=survey
[21] https://nrfa.ceh.ac.uk/data/station/info/39018
[22] https://environment.data.gov.uk/catchment-planning/

following map shows the outcome of the watercourse delineation exercise, with the names of each watercourse labelled as what it will be referred to hereafter.

3.2.4 Walkover

3.8 A walkover was undertaken on 8 and 9 November 2021. The weather across the two days was dry with little wind and an average temperature of 10° Celsius. According to the Gauge Map,[23] the River Ock at Abingdon experienced average levels over the two days of 51.55 mAOD[24] which is within the lower quarter of the typical range the river.

3.9 The walkover was constrained to the Public Right of Way (PRoW) network and Highways across the site, which meant that not all the watercourses within the indicative location for SESRO could be observed. Those locations that were visited are shown in Figure 3.2 in Appendix A1.1 Figures.

3.2.5 Stream power assessment

3.10 Stream power is a measure of the energy a watercourse has available to erode and transport sediment at a given point. Stream power calculations have been undertaken for the five principal watercourses; The River Ock, Cow Common Brook catchment, Mere Dyke Catchment, Childrey Brook catchment within the indicative location for SESRO.

3.11 Stream power is typically expressed as 'unit' stream power to relate the total amount of available energy to the channel width at a given location during bank full flow. Stream power (ω) is measured in Watts per metre squared (W/m^2) and calculated using the following equation:

$$\omega = (pgQs) / d$$

(Where p is the density of water (1000 kg/m^3), g is the acceleration due to gravity (9.81 m/s^2), Q is bank full discharge (in m^3/s), s is slope (in m/m), and d is the bank full channel width (in m)).

3.12 Values of around 35 W/m^2 have been tentatively reported to reflect relatively "stable channels".[25] Higher values relate to channels that are typically prone to adjustment by net erosion. Channels with lower values than 35 W/m^2 are typically prone to net

[23] https://www.gaugemap.co.uk/
[24] mAOD = metres above ordnance datum
[25] Brookes, A., 1988. Channelized rivers: perspectives for environmental management. Wiley, Chichester, 336pp.

deposition. In terms of driving 'significant' geomorphic change (i.e., complete channel adjustment), unit stream powers in the region of 300 W/m^2 have been suggested for alluvial channels.[26]

3.13 LiDAR data has been used to determine the bank full width of each water body as well as the slope. In the absence of site-specific hydrological data, discharge was calculated using the Q_{MED}[27] value presented for the River Ock (NGR SU 48600 96900, just upstream of Abingdon) on the National River Flow Archive and divided proportionately based on the catchment area of each contributing water body within the indicative location for SESRO.

3.3 Understanding of the baseline

3.3.1 Baseline overview

3.14 For the purpose of this study, the largest indicative location for SESRO has been used (150 Mm^3) when assessing the watercourses that fall within the study area.

3.15 The site is in a lowland landscape primarily used for arable agriculture with some pasture and two large solar panel farms (Landmead Solar farm NGR SU 43450 94144, and Hill Farm Solar Farm NGR SU 44796 93090). The topography of the landscape is mostly flat with subtle variation associated with catchment boundaries. There are various water courses of differing size and form within the boundary of the project. The position of these watercourses is shown in Figure 3.1 in Appendix A1.1. Where watercourse names were are unknown a code has been assigned. The watercourse network includes a large number of ditches that follow field boundaries, some of these are straightened channels and/or follow surface water flow pathways, others are completely man-made to assist land drainage. There are also several Main Rivers, as described below. The majority of the watercourses within this lowland catchment have been substantially modified from a geomorphological perspective to be linear and flat to facilitate land drainage. There is also a large network of agricultural drainage ditches that ultimately flow into the arterial watercourses, most notably Cow Common Brook.

3.16 The superficial deposits across the indicative footprint of the reservoir are largely alluvium, Northmoor sand and gravel member, Lower facet, Head and Summertown–Radley Sand and Gravel member. The bedrock geology is mainly Ampthill Clay

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[26] Magilligan, F.J., 1992. Thresholds and the spatial variability of flood power during extreme floods. Geomorphology, 5(3–5), pp.373–390.
[27] Q_{MED} = The mean annual maxima flood

Formation and Kimmeridge Clay Formation (undifferentiated) – Mudstone, Stanford Formation, Lower Greensand Group and Gault Formation.[28]

3.17 For all the named watercourses within the scheme area, -Table 3.1 shows the WFD water body that they fall within. The table does not include all of the coded ditches, but these fall within the same WFD water body as the watercourse into which they flow (and they are coded accordingly e.g., ditches flowing into Cow Common Brook are coded 'CCB…').

3.18 It is appropriate to highlight that whilst -Table 1.1 identifies a suite of Reaches with which this EAR will assess, the fluvial geomorphology assessment is only concerned with those watercourses that would require realignment and/or physical alteration. Therefore, the Reaches assessed are Reach 1 (1.1 and 1.2), Reach 2 (2.1 and 2.7), and Reach 4. Individual watercourses within these Reaches are broken down further in Table 3.1, below. As the other Reaches listed in Table 1.1 are not part of this assessment (e.g., Reach 2.2 – River Ock (upper) where there would be no impact to the baseline fluvial geomorphology) they are not mentioned any further.

3.19 Abstraction for SESRO has been simulated as occurring ~34% of the time across the 19,200-year long-term stochastic dataset on the River Thames at Sutton Courtney, as reported in Section 2.4.2. This therefore calls into question the impact that the altered high-flow hydrology may have on the baseline geomorphological characteristics of the River Thames downstream of the abstraction location.

3.20 Evidence suggests that the SESRO abstraction primarily reduces higher flows relative to baseline between Q_{20} and Q_{60} as shown in Table 2.9. The modelled flow duration curve for SESRO 150 Mm^3 highlights that flows at Q_{10} are abstracted less than 2% of the 19,200-year simulation and at Q_1 this is <1% of the 19,200 years. So, whilst it is correct to state that the peak flows of a moderately dry year may be abstracted into SESRO, the highest flows (i.e., greater than Q_{20}) over a long-term series – better reflecting the timescales over which the geomorphological characteristics of the river are governed – are unlikely to be altered relative to the long-term baseline. Therefore, the evidence provided from hydrological modelling demonstrates that the impact of SESRO on geomorphologically competent flows in the River Thames – that is flows that have sufficient energy to mobilise bed sediment and/or instigate erosion that would facilitate morphological change; commonly accepted to be flows at or close to bank full that would occur statistically once per year to once every two years – is negligible. It follows, therefore, that there is no risk of reach-scale changes in the baseline geomorphological characteristics of the River Thames as a result of SESRO.

[28] https://mapapps2.bgs.ac.uk/geoindex/home.html

Accordingly, the baseline geomorphological characteristics of the River Thames are not reported in this chapter.

3.21 Moreover, whilst there may be a risk of minor and localised morphological change at the location of the SESRO discharge into the River Thames, this will be accounted for in the design and regulatory permitting process, as is the case for all new major outfalls, in order to achieve a solution that manages this risk to acceptable level. On balance, therefore, there is insufficient risk of morphological change on the River Thames, as a result of SESRO, that would justify the provision of reach-scale baseline reporting for the fluvial geomorphology topic.

Table 3.1 WFD water body for each watercourse within the scheme area.

WFD water body Reach number as per Table 1.1	Named watercourse as it appears in this fluvial geomorphology chapter (Figure 3.1, Appendix A1.1)
Cow Common Brook and Portobello Ditch GB106039023360 **Reach 1 (1.1)**	Gorse Willow Ditch
	Mere Dyke East
	Old Canal[29]
	Orchard Farm Ditch
	Steventon Ditch West
	Landmead Ditch
	Mere Dyke
	Portobello Ditch
	Steventon Ditch East
	Mere Dyke West
	Cow Common Brook
Childrey Brook and Norbrook at Common Barn GB106039023380 **Reach 1 (1.2)**	Childrey Brook and East Hanney Ditch
Ock and tributaries (Land Brook confluence to Thames) GB106039023430 **Reach 2 (2.1)**	River Ock
Sandford Brook (source to Ock) GB106039023410 **Reach 2 (2.7)**	Sandford Brook
Thames (Evenlode to Thame) GB106039030334 **Reach 4**	Oday Ditches

[29] This is the disused Wilts and Berks Canal

3.3.2 Cow Common Brook and tributaries (Reach 1 (1.1))

3.3.2.1 Desk-based review of baseline conditions

Cow Common Brook

3.22 The Cow Common Brook, which forms part of the Cow Common Brook and Portobello Ditch WFD Water Body (GB106039023360), is a main river and flows through the centre of the site and is 4.9 km long before flowing into the River Ock on the boundary of the scheme. For all its course the river runs through arable land. The planform is predominantly straight as a result of substantial artificial geomorphic modification and has been since at least 1900 as shown in the 1885–1900 OS Maps. Only a section of approximately 600 m downstream of Hanney Road has been straightened since that time, with this section formerly sinuous. Between the railway and Steventon Road/ Hanney Road, the Cow Common Brook presents a relatively natural planform. A sinuous course is accompanied by relatively thick and mature riparian vegetation coverage. Furthermore, the Geomorphic Regime Analysis Report[30] indicates the local presence of a gravel supply (presumably from the channel banks) and the subsequent development of bedforms within the channel. The rest of the channel is likely to have limited geomorphic or ecological value on account of its apparently limited morphological and flow diversity and also displays more sparse riparian vegetation cover. It is estimated from aerial imagery and LiDAR data[20] to be approximately 1.5 m wide with an average slope of 0.002 m/m (which represents a relatively flat profile).

3.23 There are also ten ditches (CCB1–CCB10) that flow into the Cow Common Brook. These are all artificial manmade drainage ditches, forming field boundaries, with a straight planform. In total the length of Cow Common Brook and associated tributaries within the indicative location for SESRO is 15.8 km.

Portobello Ditch and the Old Canal

3.24 Portobello Ditch, a tributary of the Cow Common Brook, is also a main river and WFD water body as part of the Cow Common Brook and Portobello Ditch Water Body (GB106039023360). It flows from just west of Station Road in Grove outside of the study area to where it flows into Cow Common Brook within the indicative location for SESRO east of Ardington Lane. In total, Portobello Ditch is 5.1 km in length, with 1.1 km within the indicative location for SESRO. Within the indicative location for SESRO, the ditch has experienced significant planform modification, resulting in a relativity straight watercourse. It flows mainly through arable land for much of its course, which is the likely reason for the modification and the planform of the

[30] Cascade Consulting (2006) Geomorphic Regime Analysis, Upper Thames Major Resource Development, Thames Water Utilities Ltd.

Portobello Ditch has not altered since the 1888 OS Map. For most of its course the Portobello Ditch retains a thin strip of riparian vegetation, making it difficult to see the condition of the bed and banks from aerial imagery. The LiDAR data[20] suggests that the watercourse has an average width of 7 m and an average slope of 0.003 m/m. The straightened planform, lack of morphological diversity and steep banks are unlikely to offer much in the way of flow and habitat diversity.

3.25 Portobello Ditch has a tributary; Old Canal that flows along the course of the old Wilts and Berks Canal within the extent of the indicative location for SESRO from the railway line to Portobello Ditch which in total is 0.9 km. The alignment of the channel has remained the same since the 1888 OS map along the railway line. The banks of Old Canal are heavily vegetated making it difficult to see the bed and banks from the aerial imagery. The LiDAR data[20] suggest that the wetted width of the channel is on the order of 1–2 m with an average slope of 0.004 m/m.

3.3.2.2 Site-based review of baseline conditions

Cow Common Brook

3.26 Six locations on Cow Common Brook (Figure 3.3 in Appendix A1.1 Figures) and associated ditches were visited during the November walkover (locations can be found on Figure 3.2):

- Location 1 – NGR SU 43681 91353 on Cow Common Brook outside of the indicative location for SESRO ~200 m upstream of the railway
- Location 2 – NGR SU 43335 92149 at the upstream most point of CCB2
- Location 3 – NGR SU 43525 92405 at the confluence of CCB2 and Cow Common Brook
- Location 4 – NGR SU 43533 92427 on Cow Common Brook 25 m upstream of the confluence with Portobello Ditch
- Location 5 – NGR SU 45279 94030 on CCB1
- Location 6 – NGR SU 45287 94564 on Cow Common Brook at the confluence of CCB8 and CCB9.

3.27 At location 1, upstream on Cow Common Brook, the wetted width of the channel was 2 m, with 1 m high bank and a bank full width of 7.5 m. The water depth on the day was 5cm with no perceptible flow. The bed substrate was largely silt/clay with no in channel vegetation but some leaf litter present. The face of both banks was mainly trees and scrub. There was evidence of historical modification to the bank profile, with a steep toe with well-established trees indicating that this is not recent.

3.28 At location 2 on CCB2, visibility was poor as the hedgerow eclipses the channel however there was water present within the ditch.

3.29 At location 3, at the confluence of CCB2 and Cow Common Brook, the channel had a wetted width of 1.5 m and is over deepened with bank heights of 2.5 m on the right bank and 3 m on the left bank. These banks were almost vertical. The bed substrate consisted predominantly of silt, with leaf litter covering the majority of the bed. In the channel, fool's water cress (*Helosciadium nodiflorum*) was extensive, duck weed (*Lemnoideae*) was present as was some lichen on the toe of the bank. The banks display bare earth with some tall ruderal herbs and grasses, willow (*Salix* sp.) and elder (*Sambucus* sp.) trees are also occasionally present on the bank face and bank top. The channel is heavily modified as it is over deep, likely due to historical modification, but some sinuosity is retained.

3.30 At location 4, on Cow Common Brook, the channel had a wetted width of 2 m, with 2.5 m high banks. Again, the banks were almost vertical. The bed substrate was again predominately silt. Duck weed and fool's water cress were both extensive and bank vegetation was largely tall ruderal herbs and grasses with sporadic trees. The channel is heavily modified with signs of over deepening and although there are some abrupt (artificial) right angled bends, likely as a result of anthropogenic disturbance, there is no obvious realignment or straightening of the channel.

3.31 At location 5, the wetted width was 0.5 m with a 3 m high bank on the right bank and 2 m high bank on the left bank. The water depth was ~0.05 m with no perceptible flow. The bed substrate was predominantly silt, with sedges (*Carex* sp.) present in the channel along with traces on water mint (*Mentha aquatica*) and reedmace (*Typha* sp.*)*. The right bank was topped with hedgerow and the left bank was only grass as vegetation had been strimmed.

3.32 At location 6, the channel is 1–1.5 m wide with 2.5–3 m high banks. The water depth was not fully visible but appeared to be ~0.15 m. Upstream of the bridge the flow was slow, but downstream there was some rippled flow. The bed substrate consisted of extensive gravel downstream of the bridge. Marginal vegetation including reeds (*Phalaris arundinacea)* and grasses were present on the bank edge. There was a trace of fool's water cress in the channel upstream of the bridge. The bank tops largely consisted of brambles and some scrub with ruderal herbs. The channel is heavily modified upstream of the bridge, which is 3 m wide over the farm track, with a culvert taking the river underneath the track. The culvert is a 900 mm concrete pipe that is 5 m long.

Portobello Ditch

3.33 Four locations of Portobello Ditch were seen during the November 2021 site visit (Figure 3.4 in Appendix A1.1 Figures); two on the main ditch, Location 7 – NGR SU 43092 91633 and Location 8 – NGR SU 43123 91790 and two on PD1, Location 9 – NGR SU 42392 91856 and Location 10 – NGR SU 42697 91941 (locations can be found on Figure 3.2).

3.34 At the most upstream location on the main ditch the channel had a wetted width of 1 m with a bank full width of 5-10 m and bank height of 2.5 m. The water depth was ~10cm with no perceptible flow and was impounded by a culvert. The bed substrate was predominantly silt but a discrete patch of gravel was visible. There was no in channel vegetation present, but the bed had a high volume of leaf litter. The banks largely consisted of brambles, herbs, grasses, and shrub with two large ash trees (*Fraxinus*) on the right bank. The channel is heavily modified with evidence of historic over-deepening, but the bank height reduces downstream of the culvert. At the second location on the main ditch the wetted width was 1–1.5 m with a bank full width of 8 m. The water depth on the day was ~5cm. The bed substrate is largely silt and clay with extensive amounts of fool's water cress present. As with upstream the channel is heavily modified and over deepened.

3.35 At the most upstream location on PD1, the channel is 0.5 m and 1 m high was it was dry on the day of the visit. The bed of the channel was earth with no in channel vegetation present. The banks were mainly hawthorn hedgerow and did not show evidence that it has been recently managed. At the second location of PD1 the channel was 1 m wide with 3.5 m high bank on the left bank and 1.5 m on the right bank. Again, this was dry on the day of visit with an earth bed that was vegetated with terrestrial grasses and herbs. The banks were largely grasses, herbs and nettles with an ash tree on the left bank face. The channel does not appear to be recently managed, but the deep banks suggest historic over deepening.

3.36 Two locations on the Old Canal were also visited 300 m apart (Figure 3.5 in Appendix A1.1 Figures); Location 11 – NGR SU 42718 91911 (most upstream) and Location 12 – NGR SU 42976 92020 (most downstream). At the upstream location, the wetted width was 1.5 m with a bank full width of 15 m. The left bank was very steep, almost vertical with a height of 5 m and the right bank was still steep but slightly gentler slopes with a height of 4 m. The water depth was approximately 5cm on the day with no perceptible flow. The bed substrate was largely silt and clay with no channel vegetation. However, brambles growing on the bank were overgrowing the channel. As it is the Old Canal the channel is heavily modified, with very steep artificial banks although it does not look recently managed. The second location on the Old Canal had a 2 m base width and a 15 m bank full width. The water depth on the day was

~5cm. The bed substrate was largely earth and silt with channel vegetation consisting of sedges and leaf litter. Grasses, nettles, and trees (ash and willow) were present on the banks. As with the first location, the channel is heavily, modified and they flow is ponded with no perceptible flow.

3.3.3 Landmead Ditch and tributaries (Reach 1 (1.1))

3.3.3.1 Desk-based review of baseline conditions

Landmead Ditch

3.37 Landmead Ditch is a main river that is 1.12 km long and flows from Landmead Farm in the north-west of the site into the Cow Common Brook on the indicative location for SESRO. It also has three associated tributaries (LD1 and LD2, LD3) and in total the four watercourses are around 6 km in length. Landmead Ditch, LD1, LD2 and LD3 are all straight in planform and are likely to be artificial man-made drainage ditches with the planform of all three having remained the similar since the publication of the first edition OS Map in 1888 From aerial imagery the watercourses appear to have moderate amounts of riparian vegetation, with some mature trees, making it difficult to see the condition of the bed and banks. From both aerial imagery and LiDAR data[20] is it estimated that the average width of the watercourses is 0.5–1 m and an average slope of 0.004 m/m.

3.3.3.2 Site-based review of baseline conditions

3.38 One location on the Landmead Ditch (Location 13 – NGR SU 44065 94735, at Landmead Farm) was visited during the November walk over survey (Figure 3.6 in Appendix A1.1 Figures). The location can be found on Figure 3.2. The channel was wet during the site visit, but it was not possible to see the bed or water depth. The wetted and bank full width of the channel was ~0.5 m. The banks of the ditch are steep, almost vertical with a height of ~1 m. There are sporadic natural trees on the bank of the river with most of the bankside vegetation being scrub. There was limited in channel vegetation although some marginal vegetation was encroaching into the channel.

3.3.4 Mere Dyke (Reach 1 (1.1))

3.3.4.1 Desk-based review of baseline conditions

Mere Dyke

3.39 The Mere Dyke is a main river that forms the lower part of a system of drainage ditches draining into the River Ock. It flows into the River Ock outside of the indicative location for SESRO at New Cut Mill, forming at the confluence with Mere Dyke East and Mere Dyke West, west of Steventon Road. There are seven tributaries associated with mere Dyke; MD1–MD7, all of which, including the Mere Dyke flow through predominantly arable land. For most of its course, including the seven tributaries, the planform is straight, with some (artificial) right-angled bends. The planform of the ditches has remained much of the same since the 1888 OS map and appear to be artificial man-made drainage ditches. The majority of the length of the ditches retain a small strip of riparian vegetation, making it difficult to see the condition of the bed and banks from aerial imagery. From LiDAR data[20] the average slope of the main ditch is 0.0007 m/m with a typical width of 1.5 m however this is likely to be skewed by the vegetation. In total, including the seven associated drainage ditches, the total length of Mere Dyke is 10.7 km.

Mere Dyke East

3.40 Mere Dyke East is an ordinary watercourse and is a small tributary of the Mere Dyke, with its source at Steventon Road just east of the indicative location for SESRO before flowing into Mere Dyke. Again, the planform of the ditch is entirely straight for its full course, and has retained the same planform since the 1888 OS Map. As with the majority of ditches through this area, it flows through arable land and retains a small strip of riparian vegetation making it difficult to see the condition of the bed and banks from aerial imagery. From LiDAR data[20] and aerial imagery the average slope of the ditch is 0.002 m/m with a typical width of 1 m however this is likely to be skewed by the vegetation. The total length of Mere Dyke East within the indicative footprint is 0.32 km.

Mere Dyke West

3.41 Mere Dyke West is an ordinary watercourse and a tributary of the Mere Dyke, with its source at Drayton Copse before flowing into the Mere Dyke west of Steventon Road. Mere Dyke West is an artificial drainage ditch, forming field boundaries with a straight planform including some (artificial) right-angled bends which have been present since at least the 1888 OS Map river alignment. Again, the ditch flows predominantly through arable land, retaining a small strip of riparian vegetation which makes it difficult to see the condition of the bed and banks from aerial imagery. There are two associated tributaries of Mere Dyke West, MDW1 and MDW2, both of which are also straight artificial man-made drainage ditches. From LiDAR data[20] the average slope of the main ditch is 0.001 m/m with a typical width of 1.5 m. However, this is likely to be skewed by the vegetation. In total, including the two associated drainage ditches, the total length of Mere Dyke West is 3.42 km.

Steventon Ditch East

3.42 Steventon Ditch East is an ordinary watercourse and artificial drainage ditch which flows from south of the railway line outside of the indicative location for SESRO to the confluence with Mere Dyke West east of Steventon Road within the indicative scheme boundary. Within the indicative location for SESRO, the ditch is straight and has remained stable since at least the first OS Map in 1888. Within the indicative location for SESRO, the ditch flows through arable land and past an electricity substation. There is an additional small tributary; SDE1 which flows west to east along Hanney Road into Steventon East Ditch and again is an artificial drainage ditch. The ditches have some riparian vegetation which make it difficult to see the condition of the bed and bank from aerial imagery. From LiDAR data[20] the average slope of the main ditch is 0.003 m/m with a typical width of 2 m however this is likely to be skewed by the vegetation. In total, including SDE1, the total length of Steventon Ditch East is 1.58 km.

Orchard Farm Ditch

3.43 Orchard Farm Ditch is an ordinary watercourse and has three associated tributaries (OFD1 and OFD2) and flows from Orchard Farm to the south of the scheme into Mere Dyke Ditch to the east of the scheme within the indicative location for SESRO. Historic maps from 1888 show that that the ditch used to flow adjacent to the Old Canal, however since the canals closure has been diverted further south into Mere Dyke. The remainder of the ditch has not altered in planform since the 1888 OS maps. For most of its course the ditch runs through arable farmland, with a small section through a solar farm. The main ditch and associated tributaries appear to be artificial drainage ditches, forming field boundaries. The upper half of the Orchard Farm Ditch, and the three additional ditches are straight in planform, lacking any sinuosity. However, downstream of Kiln Lane the ditch has more variability in planform, displaying some sinuosity. The ditches some mature riparian vegetation which make it difficult to see the condition of the bed and bank from aerial imagery. From LiDAR data[20] the average slope of the main ditch is 0.004 m/m with a typical width of 1.5 m however this is likely to be skewed by the vegetation. In total, including the two associated drainage ditches, the total length of Orchard Farm Ditch is 4.62 km.

Gorse Willow Ditch

3.44 Gorse Willow Ditch is an ordinary watercourse and has three associated tributaries (GD1, GD2 and GD2). It flows into the Orchard Farm Ditch north of Hanney Road. Gorse Willow Ditch and the three tributaries are all artificial drainage ditches, which are straight for their entire course. They appear on OS maps from 1888, apart from the upstream western section which does not appear on any historic maps. The planform of the ditches has not changed since the first OS map along any of their course. The headwaters of the main ditch flow adjacent to Steventon Storage Depot and the remainder of the downstream sections flow past large solar panel farms which until prior to 2017 were agricultural fields. The main ditch is culverted under

Hanney Road and a farm track that runs perpendicular to the ditch. It is not possible to see the bed or banks of the channels from the aerial imagery apart from the crossing at Hanney Road which shows artificial banks, but large parts of the ditches have established dense riparian vegetation. From LiDAR data[20] the average slope of the main ditch is 0.004 m/m with a typical width of 1.5 m however this is likely to be skewed by the dense vegetation. In total, including the three associated drainage ditches, the total length of Gorse Willow Ditch is 3.23 km.

Steventon Ditch West

3.45 Steventon Ditch West is an ordinary watercourse and has three associated tributaries (SDW1 and SDW2). Its source is at the southern extent of the indicative location for SESRO at the trainline and flows into Orchard Farm Ditch northeast of Willow Brook Farm. Steventon Ditch and the three tributaries are all man-made artificial drainage ditches with are straight for their entire course. The all flow through predominately arable land, with a small section of the main ditch bordering a solar farm on the left bank. The alignment of the ditches has not altered since the first OS Map in 1888. The main ditch is culverted under Hanney Road. However, some marginal vegetation makes it difficult to see the condition of the bed and banks of the river from aerial imagery. From LiDAR data[20] the average slope of the main ditch is 0.005 m/m with a typical width of 1.5 m however this is likely to be skewed by the dense vegetation. In total, including the three associated drainage ditches, the total length of Steventon Ditch is 4.07 km.

3.3.4.2 Site-based review of baseline conditions

Mere Dyke

3.46 One location on the Mere Dyke were visited during the November walkover (Figure 3.7 in Appendix A1.1 Figures); Location 14 – NGR SU 46958 93840 on the Mere Dyke downstream of the confluence with MD1. The location can be found on Figure 3.2. At this location, the channel was 1 m wide with 1.75 m high banks. The water depth was ~5cm on the day, with the bed substrate being composed of largely fine gravel with some silt also on the bed around the culvert. There were extensive amounts of fool's water cress choking the channel. The channel is heavily modified with uniform banks indicative of drainage management. One location MD1 was also visited (Location 15 – NGR SU 46441 94230). However, a tree blocking the path made access difficult. This watercourse was a straightened, agricultural field drain.

Mere Dyke West

3.47 One location on Mere Dyke West was visited during the November walkover (Figure 3.8 in Appendix A1.1 Figures); Location 16 – NGR SU 45654 93953 near to the confluence with Orchard Farm Ditch. The location can be found on Figure 3.2. Here the channel was 1.5 m wide with 1.5 m high banks. The bed substrate was largely silt overlain with leaf litter, with a trace of gravel and a boulder which appeared to be a washed out from the reinforcement at the culvert. There were traces of fool's water cress in the more open section of the channel. The majority of the channel, at this location, is shaded by woodland (field maple (*Acer campestre*), blackthorn (*prunus spinosa*) and willow). The channel is not obviously modified but downstream of the culvert steep banks suggest more modification than upstream.

3.3.5 Childrey Brook and East Hanney Ditch (Reach 1 (1.2))

3.3.5.1 Desk-based review of baseline conditions

Childrey Brook

3.48 Childrey Brook is a main river and tributary of the River Ock, with the confluence located at Marcham Mill and source at Childrey, west of Wantage. In total, the river is 19.5 km long. The river is split into two WFD water bodies; Childrey and Woodhill Brooks (WFD water body ID: GB106039023370) and Childrey Brook and Norbrook at Common Barn (WFD water body ID: GB106039023380). The Childrey Brook runs adjacent to the study area from the A338 to the confluence with Landmead Brook, a total length of approximately 1.5 km. It flows predominantly through arable farmland; however, the watercourse sits outside of the indicative location for SESRO. Through this Reach, Childrey Brook displays limited in channel morphological or flow diversity, and only sparse riparian vegetation coverage however upstream retains a relatively sinuous planform through most of its course. The section displays little in the way of any planform change since the 1885–1900 OS maps. This is comparable to most of the whole watercourse. The aerial imagery and LiDAR data[20] shows that the Childrey Brook adjacent to the indicative location for SESRO is approximately 6 m wide with an average slope of 0.0009 m/m.

East Hanney Ditch

3.49 East Hanney Ditch is a main river and tributary of the Childrey Brook and runs from the railway line (to the south of the indicative location for SESRO) to the confluence with the Childrey Brook and Norbrook at Common Barn WFD water body for a total length of 4.7 km, 3.7 km of which is within the indicative location for SESRO. The ditch lacks any sinuosity for all of its length and is likely to have been artificially created for agricultural drainage. It first appears on OS maps in 1892–1942 since which there has been no alteration to its planform. For much of its course the ditch flows through agricultural land, with a solar farm present to the right bank in the downstream section. The ditch maintains a thin strip of mature riparian vegetation down each bank making it difficult to see the channel from aerial imagery. However, there are discrete gaps in the vegetation. The LiDAR data[20] and aerial imagery suggest that the ditch is ~1 m wide. However, the dense vegetation is unlikely to facilitate accurate measurements. The LiDAR data also estimates an average slope of 0.002 m/m across its entire length. However, again this is likely to be skewed by vegetation cover. There are an additional seven man-made agricultural drainage ditches that flow into the East Hanney Ditch (HD0–HD6) for a total length of 4.2 km. These are all straight with limited to no sinuosity. However, they do retain a thin strip of riparian vegetation along most of their length.

3.3.5.2 Site-based review of baseline conditions

Childrey Brook

3.50 Childrey Brook was visited during the November walkover surveys, outside of the indicative location for SESRO at NGR SU 44829 95441, Location 17 (Figure 3.9 in Appendix A1.1 Figures). The location can be found on Figure 3.2.

3.51 The river at this location on the day had a 2 m wetted width and a bank full width of 6 m. The banks were slightly embanked, suggesting historical dredging and were ~1.5–2 m high above bed level. The depth of the channel appeared to be approximately 0.5 m however an actual measurement was not possible. The bed of the channel largely consisted of silt and sand with the flow presenting a smooth (laminar-like) flow with some ripples. However, there were no obvious morphological features such as pool and riffle sequences. Branched bur reed (*Sparganium erectum*) was present on the margins of the channel, extending into the channel, with forget me not also present alongside submerged unbranched bur reed (*Sparganium emersum)* and a trace of non-native pondweed (*Elodea* sp. – the species was not determined) The channel morphology was characterised by deep banks suggesting evidence of some historical over deepening and dredging.

East Hanney Ditch

3.52 Three locations on East Hanney Ditch were visited during the November site visit; Location 18 – NGR SU 42174 92168 (1 km upstream of Steventon Road; Figure 3.10a in Appendix A1.1 Figures), Location 19 – NGR SU 42389 92479 (600 m upstream of Steventon Road; Figure 3.10b in Appendix A1.1 Figures) and Location 20 – NGR SU 43132 94651 (on the farm track to Common Barn; Figure 3.10c in Appendix A1.1 Figures). All locations can be found on Figure 3.2. It was only possible to take detailed notes at the second location, 600 m upstream of Steventon Road. Here the channel was ~0.5 m wide and the banks were 2.5 m high relative to bed level. It was not possible to see the depth of the water, but the channel was wet and being impounded by a culvert. Downstream of this, there was very little water visible. It was not possible to see the condition of the bed of the channel. In the channel grasses, willow herb, nettles and tall ruderals were present. The channel appeared to be heavily modified with deep banks and no riparian buffer zone. Photographs from the other two locations confirm a very similar condition of the channel.

3.3.6 River Ock (Reach 2 (2.1))

3.3.6.1 *Desk-based review of baseline conditions*

3.53 The River Ock is a main river and tributary of the River Thames, with the confluence located in Abingdon-on-Thames, Oxfordshire, downstream of the study area. It falls within the Ock and Tributaries (Land Brook confluence to Thames) (WFD water body ID: GB106039023430). In total, the WFD water body is ~20 km long. The majority of the river is located outside of the study area, with a 0.85 km stretch located within the indicative location for SESRO. This section, which is located between Marcham Mill and the A34, has been straightened since the alignment shown in the 1888–1913 OS map with the rest of the river retaining much of its historical planform/sinuosity. The section of the Ock either side of the A34 appears to have been straightened to power New Cut Mill sometime prior to the late 1800s. The River Ock within the indicative location for SESRO is approximately 10 m wide, flowing mainly through farmland with sparse riparian vegetation along each bank. The LiDAR data[20] suggests the river has an average slope of 0.00013 m/m within the study area. The catchment, as a whole, is categorised by a dominant supply of fine-grained sediment as a result of the surrounding farmland, promoting large areas of deposition and some localised de-stabilisation[30]. There appears to be little in the way of flow or morphological diversity.

3.3.6.2 *Site-based review of baseline conditions*

3.54 One location on the River Ock (Figure 3.11 in Appendix A1.1 Figures) was visited during the November site visit, outside of the indicative location for SESRO (approximately 500 m north of the boundary) at NGR SU 44703 95709 (Location 21). The location can be found on Figure 3.2. At this location, the river had a wetted width of 5 m and a bank full width of 11 m. The banks of the river were ~2 m high on both the left and right bank. It was not possible to see the bed of the river due to the high turbidity of the water. Banks consisted of earth and clay. There was an extensive amount of bur reed in the channel, with traces of forget-me-not (*Myosotis* sp.). The bankside vegetation consisted of tall ruderal herbs (nettles, willow herb (*Epilobium* sp.) and tassel (*Garrya elliptica*) with trees present predominantly on the left bank. The channel, although not heavily modified, has been over widened but retaining some sinuosity, with evidence to suggest it has undergone historic dredging.

3.3.7 Sandford Brook (Reach 2 (2.7))

3.3.7.1 Desk-based review of baseline conditions

3.55 Sandford Brook is a WFD river water body (Sandford Brook (Source to Ock); GB106039023410) and main river that flows into the River Ock to the east of the indicative location for SESRO. There are two associated drainage ditches that flow into Sandford Brook within the indicative location for SESRO; SB1 and SB2. The majority of the Sandford Brook sits outside of the indicative location for SESRO with only 1.91 km (including SB1 and SB2) of 14.7 km within. Again, the majority of Sandford Brook flows through predominantly arable land, with intermittent tree cover in the riparian zone. From LiDAR data[20] the average slope of the main ditch is 0.002 m/m with a typical width of 1.5 m.

3.3.8 Oday Ditches (Reach 4)

3.3.8.1 Desk-based review of baseline conditions

3.56 Oday Ditches are a network of ditches (mainly ordinary watercourses) that that flow into the River Thames just upstream of Ginge Brook and form part of the Thames (Evenlode to Thame) WFD water body (ID: GB106039030334). The majority of the Oday Ditch network sits outside of the indicative location for SESRO. However, within the indicative scheme boundary there are parts of the main Oday Ditches watercourse and six associated tributaries (OD1–OD6). The ditches are predominantly straight and are shaped like artificial drainage ditches; they have retained the same planform since the 1888 OS maps. The majority of the network retains a small strip of marginal vegetation making it difficult to see the condition of the bed and banks from aerial imagery. As with the majority of this area, the ditch network flows predominantly through arable land. From LiDAR data[20] the average slope of the main ditch is 0.003 m/m with a typical width of 3 m. In total, including the three associated drainage ditches, the total length of Oday Ditches is 2.93 km.

3.3.8.2 Site-based review of baseline conditions

3.57 Five locations on Oday Ditches were visited during the November site visit (Figure 3.12 in Appendix A1.1 Figures); Location 22 – NGR SU 47988 95451 at the most downstream extent of OD1, Location 23 – NGR SU 48630 95343 on OD2 downstream of Stonehill Lane, Location 24 – NGR SU 48750 95229 at the upstream extend of OD3, Location 25 – NGR SU 49385 95077 on OD4 adjacent to Peep O Day Lane and Location 26 – NGR SU 49303 94911 on OD4 just upstream of the confluence with the main river, again adjacent to Peep O Day Lane. All locations can be found on Figure 3.2.

3.58 At location 22, on OD1, the channel was <1 m wide and the water depth and bed substrate were not visible. There was an overgrown hedgerow shading the channel and obscuring the view. The channel appeared mostly dry however sounds of trickling water could be heard. The ditch was a heavily modified agricultural drainage ditch. At location 23, on OD2, the channel was again <1 m wide with over deepened banks of c.3 m high from bed level. The water depth and bed substrate were not visible. The channel was heavily shaded by a hedgerow and there was litter in the channel, as well as a culvert taking the ditch under a track. The ditch is heavily modified however the established and dense hedgerow suggests this modification is not recent. At location 24, on OD3, the channel was 0.5 m wide with 1–1.5 m high banks. The water depth was <5cm with no susceptible flow and the bed substrate was largely silt/earth. The channel was choked with mainly terrestrial herbs, grasses, and scrub. The channel is heavily modified, straight, and embanked from historical dredging. At location 25, on OD4, the wetted width of the channel was 2.5 m with a water depth of 0.3 m and ponded flow. The bed substrate was largely silt with no in channel vegetation but some wood present. The channel is heavily modified and straightened alongside the adjacent footpath. It also appears to be artificially widened. There is a culvert present that carries the ditch underneath the quarry access track. The culvert is c.5 m and 1 m wide consisting of a corrugated metal arch. Finally, at location 26, near the confluence of OD4 and the main river, the wetted width of the channel was 2.5 m with shallow banked c0.5 m high. The depth of the water was not visible, and the flow appeared very slow and smooth. The bed substrate was also not visible. Willow was shading the channel and providing some in channel diversity just upstream of a culvert under the footpath. There was limited in channel vegetation surrounding the culvert. However, the more open sections had a mix of marginal sp. The banks were largely made up of short grasses. The channel did not appear to be heavily modified.

3.3.9 Stream power assessment – all arterial watercourses (Reach 1 & 2)

3.59 A stream power assessment was undertaken on all of the arterial watercourses referred to in this section: Cow Common Brook, River Ock, Childrey Brook and Mere Dyke. As there are no flow data available within the study area, the River Ock at Abingdon[31] was used as a donor catchment. In the absence of field data, the Q_{MED} flow has been simply apportioned to the catchment area of each watercourse. The results are presented in Table 3.2-.

3.60 The stream power calculations for all watercourses presented below are very low (i.e., comfortably below the 35 W/m^2 threshold). These results are consistent with the desk- and field-based observations presented earlier in this section.

[31] https://nrfa.ceh.ac.uk/data/station/peakflow/39081

Table 3.2 Stream Power calculations

Catchment	Area of each catchment (km^2)	River Ock Area (km^2)	Percentage of Ock Catchment (%)	QMED Ock at Abingdon (m^3/s)	Proportional QMED Flow (m^3/s)	Slope (m/m)	Width (m)	Stream Power (W/m^2)
Cow Brook Common	27.24	234	11.64	10.3	1.20	0.002	2	**11.7**
Mere Dyke	7.65	234	3.27	10.3	0.34	0.0007	1	**2.3**
Childrey Brook	5.01	234	2.14	10.3	0.22	0.0009	6	**0.3**
River Ock	20.71	234	8.85	10.3	0.91	0.0001	3	**0.4**

3.3.10 Summary

3.61 The characteristics of each watercourse within the indicative location for SESRO have been described based on both desk study and, where possible, a site visit. It is appropriate to conclude that the majority of the length of all watercourses within the indicative location for SESRO are, or take the form of, historically modified channels that convey water from arable land to the surrounding arterial watercourses. These are mainly straight in planform and are over deepened with varying amounts of riparian vegetation and little to no quantity and/or dynamics of flow and very low unit stream power. Local exceptions to this are select locations of the Cow Common Brook, Mere Dyke, the River Ock, Portobello Ditch, Old Canal and East Hanney Ditch which, in places, display a more natural and varied planform and cross-sectional profile, with some localised morphological features present (e.g., gravel bedforms) (see Appendix A5.2 Habitats and Geomorphology Baseline Ock Watercourses).

3.4 Assessment outcomes

3.62 The previous sections have outlined the baseline conditions of the watercourse that would be affected by the proposed scheme.

3.63 Using the 150 Mm^3 reservoir option as a ‘maximum’ (in terms of both storage and indicative footprint), Table 3.3 shows the length of watercourse that would be diverted/replaced as part of the scheme footprint (including all tributaries) along with length calculations. These lengths have been calculated for the project to inform Biodiversity Net Gain (BNG) requirements to ensure that the project delivers the appropriate net gain. Further information on BNG is documented in Technical Supporting Document B6, BNG Report.

Table 3.3 Water body length diverted/replaced as part of the proposed development for each WFD water body (150 Mm^3 reservoir option) according to BNG (Technical Supporting Document B6 BNG Report).

Reach	WFD water body	Sum of 150 Mm^3 Baseline length (km)	Sum of 150 Mm^3 Retained length (km)	Sum of 150 Mm^3 Length diverted or replaced (km)
1 (1.1)	Cow Common Brook and Portobello Ditch	54.862	7.073	47.789
1 (1.2)	Childrey Brook and Norbrook at Common Barn	7.875	1.457	6.418
2 (2.1)	Ock and tributaries (Land Brook confluence to Thames)	0.930	0.799	0.131
2 (2.7)	Sandford Brook (source to Ock)	1.909	1.608	0.300
4	Thames (Evenlode to Thame)	2.933	0	2.933
	Grand Total	**68.510**	**10.938**	**57.572**

3.64 Table 3.3Table 3.3 shows that a net total of 57.57 km of watercourse would need to be diverted/replaced as part of the proposed scheme. The BNG assessment provides further details of how the condition of the habitat of these watercourses has been classified. However, a brief summary is as follows: 43.67 km of this length is made up of ditch habitat, with over 83% of total ditches within the study area being diverted/replaced. Many of these ditches are assumed to be of poor condition in the absence of any site-based survey.

3.65 13.90 km of riverine habitat would also need to be diverted/replaced as part of the development, which is over 85% of the total river length within the study area. Most of these rivers have been artificially modified to at least some extent and have been classified as being in moderate condition. As above, in some locations, watercourses displayed more variability and a natural planform with diverse habitat and therefore achieve a fairly, good condition.

3.66 Further precision in respect of the habitat quality of the watercourses diverted/replaced as part of the development will be acquired during subsequent project stages as they will benefit from full walkover surveys.

3.5 Potential options for mitigation considered

3.67 To achieve the required 10% Biodiversity Net Gain, the scheme is required to enhance 17.41 km of watercourse (16.44 km of river and 0.97 km of ditch) and create 31.05 km of new watercourse (25.65 km ditch and 5.40 km of canals and culverts). A brief summary of how this mitigation would be provided, as explained in the BNG assessment (Technical Supporting Document B6 BNG Report), is provided below.

3.68 As part of the environmental mitigation works the main watercourses across the site will be diverted to form both a Western Watercourse Diversion and the Eastern Watercourse Diversion. The Western Watercourse Diversion would have two channels, the realigned Cow Common Brook (part of the Cow Common Brook and Portobello ditch water body) and improvements (by way of channel restoration) to the East Hanney Ditch (part of the Childrey Brook and Norbrook at Common Barn water body). These two watercourses would not be connected.

3.69 The diversions of these water bodies would incorporate natural channel design principles that would enable improved habitat heterogeneity to be delivered as part of the construction of the channels. This includes a greater degree of width and depth variation and overall structure of the riverbed. The quality of this constructed habitat would be of a significantly higher value than the existing habitat found within the modified channels across the current site. To compensate for the loss of ditch length many interconnected ‘wetland’ ditches will be cut to off-set the ditch loss on site. These would involve cutting ditches which will have more gently sloping banks on either side and some form of design mechanism (such as s wood installed across the end of the features and/or the construction of blind-ended ditches) to inhibit flow. This would create a ‘wetland’ ditch which would have a much greater habitat quality value when compared to the maintained ditches that currently exist across the site (see also Technical Supporting Document B6 Biodiversity Net Gain). This, along with the improved watercourses would create a significantly improved structure, and complexity, to the riparian zone. The proposed design of the scheme includes creation of a Circular Drain which would take embankment surface water flows and transfer them to the River Ock, downstream of the Childrey Brook confluence. It would also provide additional aquatic ditch habitat (see also Technical Supporting Document B6 Biodiversity Net Gain).

3.70 The new watercourses would be constructed in the dry, as much as possible, to keep the existing habitat functioning while the new channels are constructed. It is envisaged, that following excavation of the watercourse and connection of water to them additional mitigation would be undertaken upon them to prompt their recovery towards a good condition. This includes both selective marginal planting as well as macro-invertebrate translocation immediately before, or after, connection of water to these water bodies after severing the water flow that previously flowed through the scheme footprint. This additional step would aid recovery of these water bodies and help them move towards a good condition at a quicker rate.

3.6 Considerations for subsequent project stages

3.71 At this Gate 2 stage, it can be concluded that because the newly designed (mitigation) river channels and interconnecting wetland ditches will be (a) of significantly better quality than the baseline watercourses that will be diverted/replaced as part of the proposed scheme and (b) greater in quantity (i.e. watercourse length) than the baseline watercourses that will be diverted/replaced as part of the proposed scheme, the quality of the fluvial geomorphology within the study area will experience an improvement relative to the status quo.

3.72 To refine the above conclusion, it is recommended that the following assessments are undertaken during subsequent project stages:

- Site walkovers of all of the watercourses within the indicative location for SESRO
- MoRPh surveys for 20% of the watercourses
- Furthered hydraulic understanding of the watercourses within the indicative location for SESRO, such that stream power characterisation can be ascertained more accurately
- Continued development of the design principles for the newly designed (mitigation) river channels and interconnecting wetland ditches

4. Water Quality

4.1 Introduction

4.1 This section assesses impacts of SESRO on water quality in watercourses in the River Thames catchment. Changes to water quality are expected because:

- Abstraction from the River Thames to refill the reservoir in the autumn and winter will reduce flows downstream and, thereby, can reduce dilution of downstream chemical inputs (e.g., from tributaries and sewage works).
- Release of water from the reservoir to the River Thames during drier periods will increase river flows and, thereby, increase dilution of chemical inputs downstream. The releases will also mix reservoir and river water which will further modify downstream water quality. In addition, they will change river travel times and thereby modify within river processes which will change downstream water quality.
- Modifications to the river channels in and around the SESRO site, including the removal of parts of the Cow Common Brook and creation of new channels, east and west of the reservoir will redirect chemical loads and flows and eliminate inputs from part of the catchment. This will reduce both loads and flow as a whole, and modify their spatial patterns, thereby modifying water quality.

4.2 These impacts are assessed in detail below by a review of data and water quality modelling outputs.

4.2 Methodology

4.2.1 Aims

4.3 The aims of this Gate 2 water quality baseline assessment are to:

- characterise existing water quality in the watercourses identified to be affected by SESRO. This will provide a reference to enable the assessment of changes of water quality that may result from the scheme.
- present findings of the Gate 2 water quality impact assessments for SESRO and receiving watercourses.
- highlight data gaps and requirements to increase confidence in the assessment.

4.2.2 Datasets reviewed

4.4 The following data have been used to develop the water quality baseline:

- Observed water quality data from the Environment Agency (WIMS[32]) for the period 2013 to 2020.
- Observed water quality data from Thames Water (i.e., at their intakes) for the period 2015 to 2022.
- Observed water quality data collected for the current project (December 2020 to present) (Appendix A4.4 Sonde Water Quality Data and Appendix A4.5 Water Quality Spot Data).[33]
- Baseline model outputs from an Infoworks ICM water quality model for the main channel of the River Thames, developed for this project. (Appendix A2.1 SESRO River Thames calibration report).
- Baseline model outputs from an SAGIS–SIMCAT water quality model for the River Ock catchment, developed for this project.

4.3 Understanding of the baseline

4.3.1 River Ock and Cow Common Brook (Reaches 1–2)

4.3.1.1 Overview

4.5 Figure 4.1 in Appendix A1.1 shows key features in the River Ock catchment in relation to the impact of SESRO, including historical monitoring points, sewage works, CSOs and septic tanks. Many of the monitoring points have ceased to be used. The key remaining locations shown by the blue arrows, at the end of the Cow Common Brook (POCR0070), immediately upstream of the confluence between the River Ock and the River Thames (POCR0013) and at the bottom end of the Childrey Brook (POCR0001).

4.3.1.2 Cow Common Brook (Reach 1 (1.1))

4.6 Only one monitoring station has been recently active on this watercourse, close to the downstream boundary, and sampling ceased there in 2017. Figure 4.2 in Appendix A1.1 Figures shows the concentrations of key WFD determinands (summary data is also presented in Table 4.1). Ammonia concentrations were generally low but with distinct peaks each summer. The 90th percentile[34] concentration was 0.14 mg/l N, which corresponds to High WFD status. The WFD status for this water body in dRBMP3 for ammonia was High.

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[32] Water Information Management System

[33] Atkins (2022). Thames Water Strategic Resource Options. Water Quality Monitoring 2020. Technical Note. Reference: 5200973-ATK-WQ-TN-011-P02 issued 30/10/2020

[34] Statistics calculated for full data period

4.7 DO % saturation levels show a clear drop in the second half of the summer each year. The 10th percentile DO % saturation was 31%, which is equivalent to Poor WFD status. The WFD status in dRBMP3 for dissolved oxygen in this water body was Bad.

4.8 Orthophosphate concentrations were high with peaks of greater than 1 mg/l P in the summer. The average concentration was 0.39 mgP/l which is equivalent to Poor WFD status. The WFD status in dRBMP3 for phosphate in this water body was Poor.

4.9 Nitrate concentrations were also high, although in his case this was in the winter with low concentrations in the summer.

4.10 These strong seasonal patterns with particularly poor water quality in the summer may partly be the result of the clay nature of the catchment that will result in low inputs of base flow during the summer. This would result in very low flows at this time of year and, therefore, little dilution of pollution inputs to the watercourse.

4.11 The average pH value in the Cow Common Brook was 7.9 and average temperature value was 10.7 °C for the 2013 to 2017 data period which corresponds to High status. The WFD status in dRBMP3 for these determinands was High. No data were available for priority hazardous substances.

4.3.1.3 Childrey Brook (Reach 1 (1.2))

4.12 Only one monitoring station has been recently active on this watercourse (2013 to 2021 shown), close to the downstream boundary.

4.13 In contrast to the Cow Common Brook, peak ammonia concentrations occur in the winter with low summer concentrations with the exception of a summer peak in 2019 (Figure 4.3 in Appendix A1.1). The 90th percentile concentration is 0.16 mg/l which corresponds to High WFD status. The WFD status in dRBMP3 for ammonia was High.

4.14 The brook generally stays well oxygenated throughout with a 10th percentile value of 68% saturation which is equivalent to WFD Good Status. The WFD status in dRBMP3 for dissolved oxygen was Good.

4.15 Orthophosphate concentrations broadly range between 0.1 and 0.3 mg/l apart from a single higher value above 0.7 mg/l P in 2019. The average concentration is 0.22 mg/l which corresponds to Poor WFD status. The WFD status in dRBMP3 for phosphate was Moderate.

4.16 Nitrate concentrations are high, ranging generally between 8 and 12 mg/l N. There is no WFD status for Nitrate.

4.17 The average pH value in the Childrey Brook was 8.02 and average temperature value was 10.98 for this 2013 to 2020 data period which corresponds to High status. The WFD status in dRBMP3 for these determinands was High. No data were available for priority hazardous substances.

4.3.1.4 Ock above Thames (Reach 2 (2.1))

4.18 The River Ock sampling location is located above the confluence between the Ock and the River Thames. It is therefore downstream of both the Childrey Brook and Cow Common Brook (approximately. 4 km downstream).

4.19 Ammonia concentrations are low throughout the record (2013 to 2020), not exceeding 0.1 mg/l. The 90th percentile concentration is 0.07 mg/l N which is equivalent to High WFD status (Figure 4.4 in Appendix A1.1 Figures). The WFD status in dRBMP3 for ammonia in this water body was High.

4.20 Dissolved oxygen % saturation levels remained high throughout with a 10th percentile value of 75%, which was equivalent to High WFD status. The WFD status in dRBMP3 for dissolved oxygen in this water body was Good.

4.21 The average orthophosphate concentration is 0.25 mg/l P which corresponds to Poor WFD status. The WFD status in dRBMP3 for phosphate in this water body was Poor.

4.22 Nitrate concentrations are high, generally between 6 and 10 mg/l N.

4.23 The average pH value at this monitoring station was 8.04 and average temperature value was 10.9 for this 2013 o 2020 data period which corresponds to High status. The WFD status in dRBMP3 for these determinands was High. No data were available for priority hazardous substances.

4.3.1.5 Other Reach 1 watercourses

4.24 There are currently no water quality data available for the other watercourses in Reach 1: Mere Dyke, Portobello Ditch and Landmead Ditch.

Table 4.1 Summary observed for Cow Common Brook, Childrey Brook and River Ock

Determinand	Metric	Cow Common Brook (POCR007)	Childrey Brook (POCR001)	River Ock (POCR013)
Ammonia	90th %ile	0.14 mg/l N	0.16 mg/l N	0.07 mg/l N
Dissolved	10th	31% sat	68% sat	75% sat

Determinand	Metric	Cow Common Brook (POCR007)	Childrey Brook (POCR001)	River Ock (POCR013)
Oxygen	%ile			
Ortho-phosphate	Mean	0.39 mg/l	0.22 mg/l	0.25 mg/l
Nitrate	Mean	6.13 mg/l	9.2 mg/l	6.6 m/l
pH	Mean	7.9	8.02	8.04
Temperature	Mean	10.7 $°C$	10.98 $°C$	10.9 $°C$

4.3.2 River Thames between Culham and Teddington Lock (Reaches 4–13)

4.3.2.1 Overview

4.25 The observed water quality data for the main channel of the river Thames in relation to WFD targets for key water quality determinands are presented in this section. The determinands selected are those that are relevant for WFD compliance (as identified in dRBMP3 – i.e., physico- chemical parameters, and priority hazardous substances) and nutrients, (relevant to eutrophication of the river and estuary).[35] There are no data available for the Oday Ditches (also part of Reach 4).

4.3.2.2 Ammonia (ammoniacal nitrogen)

4.26 Figure 4.5 in Appendix A1.1 summarizes observed ammonia concentrations (mean and 90th percentile) in the main channel of the River Thames between the SESRO discharge/abstraction point and Teddington Lock compared to the WFD High status threshold concentration (90th percentile, 0.3 mg/l). Along this entire stretch of the River Thames the ninetieth percentile concentration is well below the upper boundary for High WFD status. There is an increase in concentration toward Teddington Lock which may be related to inputs from the River Wey and urban areas of west London. Ammonia is classified as High status in the latest River Basin Management Plan (dRBMP3) in all the River Thames reaches.

4.27 Figure 4.6 in Appendix A1.1 Figures shows the relationship between the observed concentration and percentile river flow at four selected monitoring stations (as shown on Figure 4.1 in Appendix A1.1 Figures); this shows no clear relationship or

[35] The plots are not directly comparable to dRBMP3 as they cover and extended period 2015–2022

evidence that ammonia concentrations would be different under drought conditions when SESRO would operate.

4.3.2.3 Biochemical Oxygen Demand (BOD)

4.28 Limited data were available for BOD since this determinand was removed from the Environment Agency's standard suite of analysis for routine river monitoring several years ago. According to the 2015 WFD Directions,[36] BOD should also not be used for classifying water bodies. The only monitoring station with data was immediately above Teddington Lock (2019–2020 only). The BOD concentrations measured at this location correspond to High WFD (Figure 4.7 in Appendix A1.1 Figures). There is insufficient BOD data to make a meaningful comparison with river flow.

4.3.2.4 Dissolved oxygen

4.29 Statistics for dissolved oxygen (2015–2020) along the River Thames between Culham and Teddington Lock are shown in Figure 4.8 in Appendix A1.1 Figures. At all locations, dissolved oxygen saturation levels corresponded to WFD High status although at the bottom end of the river stretch considered here, dissolved oxygen levels are close to the WFD high status threshold. Dissolved oxygen WFD status is High or Good (Reading to Cookham and Egham to Teddington) for these reaches in dRBMP3.

4.30 A slight reduction in dissolved oxygen at low river flows is evident (Figure 4.9 in Appendix A1.1 Figures), with dissolved oxygen saturation levels falling below 70% under lower flow conditions whilst remaining above 60% (equivalent to Good status).

4.3.2.5 Orthophosphate

4.31 Orthophosphate[37] concentrations decrease along the River Thames between Culham and the Wye tributary but increase again toward Teddington Lock (Figure 4.10 in Appendix A1.1 Figures). Comparison with the WFD 'Good' and 'Moderate' thresholds is also shown in Figure 4.10 in Appendix A1.1 Figures, indicating orthophosphate concentrations mostly correspond to Moderate WFD status, and Poor WFD status at the upper end of the plotted reaches. The WFD status for phosphate in dBMP3 is Moderate in all these reaches.

4.32 Orthophosphate concentrations show a clear increase under low flow conditions when SESRO would be operational; this is due to importance of point source inputs

[36] The Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015.

[37] Note that orthophosphate is generally used to define WFD status although the WFD should strictly be related to soluble reactive phosphorus

for phosphorus that are subject to less dilution under low flow conditions (Figure 4.11 in Appendix A1.1 Figures).

4.3.2.6 Nitrate

4.33 Mean nitrate concentrations are stable over the length of the River Thames with concentrations of 7–8 mgN/l (Figure 4.12 in Appendix A1.1 Figures). Concentrations tend to be higher at low flows when SESRO would release water to the Thames (Figure 4.13 in Appendix A1.1 Figures). These higher concentrations may be related to reduced dilution. There is no WFD standard for nitrate.

4.3.2.7 Chlorophyll-a

4.34 The only Environment Agency monitoring location with sufficient data for chlorophyll-a is just upstream of Teddington Lock. The time series for this location is presented in Figure 4.14 in Appendix A1.1 Figures. More detailed data has been collected by Centre for Ecology and Hydrology (CEH) at Runnymede, which is shown in Figure 4.15 in Appendix A1.1 Figures (chainage location = 155km for comparison with other data). This dataset often shows large chlorophyll-a peaks in the spring, but this is variable between years with smaller peaks in 2016 and 2017. In addition, summary chlorophyll-a data from SESRO 2020–2022 monitoring for chlorophyll-a is shown in Table 4.1.

4.3.2.8 Temperature

4.35 Observed temperature (mean and 90th percentile) are shown in Figure 4.16 in Appendix A1.1 Figures. This shows little change in temperature along the length of the Thames with a possible exception of a slight increase in the 90th percentile in the lower Reaches.

4.3.2.9 pH

4.36 Observed pH from the SESRO 2020–2020 is summarise in Table 4.1. pH shows little variation along the length of the Thames with mean values between 8.05 and 8.15 at all locations.

4.3.2.10 Other chemicals

4.37 Summary SESRO 2020–2022 monitoring data for chemicals at risk of failure of WFD thresholds in dRBMP3 are show in Table 4.1. Where monitoring data are available, fluoranthene, mercury and perfluoro octane sulfonic acid (PFOS) all exceed the WFD threshold at many of the monitoring locations.

Table 4.2 Summary data from SESRO water quality monitoring

Determinand		Culham	Maple Durham	Hambleden	Cookham*	AfW Sunnymeads	AfW Egham	AfW Chertsey	TWUL Walton	AfW Walton	TWUL Hampton	Teddington
benzo(b)fluoranthene	**Mean**	0.0046	0.0036	0.0044	0.0074	0.0047	0.0057	0.0073	0.0119	0.0106	0.0104	0.0136
benzo(g,h,i)perylene	**Mean**	0.0046	0.0036	0.0047	0.0070	0.0049	0.0057	0.0070	0.0102	0.0100	0.0095	0.0125
chlorophyll	**Mean**	11.2	13.9	14.7	14.2	21.5	22.2	19.7	12.4	16.4	10.8	24.1
chlorophyll	**95%ile**	14.2	40.2	31.3	24.4	56.8	52.2	44.6	28.2	40.2	14.6	74
cypermethrin	**Mean**	0.000053	0.000044	0.000059	0.000040	0.000042	0.000040	0.000050	0.000063	0.000044	0.000061	0.000053
fluoranthene	**Mean**	0.0035	0.0047	0.0065	0.0078	0.0055	0.0063	0.0075	0.0112	0.0124	0.0102	0.0118
mercury dissolved	**Mean**	0.0092	0.0091	0.0156	0.0069	0.0074	0.0084	0.0091	0.0064	0.0126	0.0060	0.0071
perfluoro octane sulfonic acid (PFOS)	**Mean**	0.0065	0.0060	0.0052	0.0055	0.0051	0.0056	0.0056	0.0053	0.0052	0.0062	0.0065
tributyltin compounds	**Mean**	0.00013	0.00004	0.00006	0.00007	0.00008	0.00010	0.00010	0.00011	0.00009	0.00010	0.00011
pH	**Mean**	8.08	8.05	8.07	8.09	8.15	8.12	8.15	8.08	8.07	8.12	8.05

Note these values are not directly comparable to dRBMP3 as they cover a different period

Yellow shading shows failure of WFD threshold

**Gate 2 proxy site for Datchet*

4.3.3 Understanding of the Water Quality Modelling Baseline

4.3.3.1 Overview

4.38 The assessment of impacts of SESRO on water quality is based on an Infoworks ICM model of the River Thames (linked to reservoir models as shown in -Table 4.3) and a SAGIS–SIMCAT model of the River Ock system both of which have been developed by Atkins. Both have a model baseline which is described below. In the Infoworks model three hydrological scenarios have been run to assess impacts when SESRO is operational, either augmenting flows in the River Thames or abstracting from the Thames to refill SESRO. These three scenarios were based on a stochastic flow time series for a moderately dry year, a drought year, and an extreme drought year.

4.39 For SIMCAT, the data period that was applied is 2010 to 2012, the current period for Environment Agency SAGIS–SIMCAT models.

4.40 The different approach in terms of time periods in these two models is appropriate for this stage of the project because the impacts on the River Thames are related to releases from SESRO during dry periods, whereas the impacts on the River Ock and associated watercourses are caused by the physical creation of the reservoir so apply at all times (the three year data period for SAGIS–SIMCAT is typical for studies with this modelling system since it seeks to estimate WFD metrics which are based on long term means of percentiles).

4.3.3.2 River Thames Model Baseline

4.41 The assessment of impacts of SESRO on water quality in the River Thames is based on outputs from the Infoworks River Thames water quality model (also used for the hydrological assessment – see Chapter 2). A model build and calibration report for this model is provided in Appendix A2.1 SESRO River Thames calibration report.

4.42 The linkages between reservoir models and the Infoworks ICM model (i.e., inputs to the Thames from SESRO) that underpin this assessment are summarised in Table 4.3 (information on the linkages between the hydrology in the Infoworks ICM model and other models is provided in Chapter 2).

Table 4.3 Key model linkages between ICM and reservoir models

Determinand		Reference
Temperature	Outputs from Computational Fluid Dynamics (CFD) model	Appendix A4.1 Abingdon Reservoir Computational Fluid Dynamics (CFD) Flow and Thermal State
Total P, Nitrate, Ammonia, Nitrite, BOD, Silicate*	Outputs from Intermediate Reservoir Water Quality (IRWQ) Model	Appendix A2.1 SESRO River Thames calibration report
Dissolved oxygen*	Assumed to be at 100% saturation at the temperature of the reservoir outflow**	None
Algae	Outputs from PROTECH reservoir algae model	Appendix A4.2 Initial hydraulic stress and climate change scenarios for Abingdon Reservoir using PROTECH

** Technical issues with the Infoworks model prevented meaningful modelling on silica at this point in time but it was modelled in the reservoir models*

*** On the basis that the reservoir mixing system maintains mixed conditions in the reservoir and engineering solutions will ensure well aerated water is released to the Thames*

4.43 Key findings from the reservoir modelling studies are:

- CFD (Appendix A4.1 Abingdon Reservoir Computational Fluid Dynamics (CFD) Flow and Thermal State). The key output from the modelling is that artificial mixing increased the vertical movement of water from the bottom layer, also increasing horizontal movement of water although shallow stratification remained in the top layer of the reservoir. Temperature profiles obtained with and without air mixing showed that the patterns were observed to be similar, but the overall temperature was reduced with mixing.
- PROTECH (Appendix A4.2 Initial hydraulic stress and climate change scenarios for Abingdon Reservoir using PROTECH)– Because nutrients only pass into SESRO during the autumn and winter with no further inputs during the algal growth

period in the summer, algal biomass in the reservoir will be relatively low with maximum chlorophyll-a below 10µg/l in the drought and extreme drought scenarios. Biomass was higher for the moderately dry scenario but still below 20µg/l. Because nutrients are largely 'used up' by mid-summer, biomass is higher in the first half of the summer.

- Intermediate reservoir water quality model (Appendix A2.1 SESRO River Thames calibration report). The outputs of this modelling, conditioned for some determinands by the PROTECH outputs, showed attenuation of peaks and average concentrations compared the influent water because of within reservoir processes (biological uptake and settling). It also shows the strong influence of the refill period on nutrient concentration, rising rapidly and then declining once the refill is completed.

4.44 It is important when viewing water quality outputs from the Infoworks ICM model to understand that the three model scenarios represent hydrological conditions ranging from moderately dry to extreme drought conditions and are, therefore, not directly comparable to WFD standards that are typically related to an extended period (i.e., >= 3 years) and, therefore, likely to include a range of hydrological conditions and not necessarily focused on drier/lower flow periods. It is also important to note that the hydrological scenarios are related to stochastic data and not all real years. The model does, however, provide information on the direction and magnitude of change in water quality during the conditions when SESRO operates; these changes are likely to be reduced in relation to long-term compliance with WFD standards because this will generally include years in which SESRO operates less or does not operate at all.

4.3.3.3 River Ock Model Baseline

4.45 The model configuration for the baseline SAGIS–SIMCAT model is shown in Figure 4.1 in Appendix A1.1 Figures, showing key features.

4.46 The model was calibrated against observed data using standard SAGIS–SIMCAT calibration tools developed for UKWIR. Figure 4.17 to Figure 4.21 in Appendix A1.1 Figures show model outputs for the Cow Common Brook, including source apportionment outputs and comparison between model results and observed data. Table 4.4 compares model outputs and observed data at every monitoring station in Figure 4.12 in Appendix A1.1 Figures. In most cases, the comparison between observed data and model output is good, although ammonia is underpredicted and orthophosphate overpredicted in the Ock above Thames (othophosphate is also over predicted, but less so at the other two sites).

4.47 The apportionment outputs show septic tanks provide an important input to ammonia concentrations in the Cow Common Brook catchment and to a lesser degree in the Childrey Book catchment. Septic tanks are also important for orthophosphate concentrations although this chemical is dominated by arable and livestock inputs. Arable provides the dominant input for nitrate.

Table 4.4 Comparison between model output and observed data (mg/l) at key monitoring locations

Monitoring station	Mean	
	Observed	Calibated Model
Ammonia (90th Percentile) mg/l		
Childrey Brook	0.16	0.16
Cow Common Brook	0.13	0.01
Ock above Thames	0.07	0.03
Dissolved Oxygen (10th percentile) mg/l		
Childrey Brook	7.34	8.04
Cow Common Brook	4.59	4.49
Ock above Thames	11.6	10.37
Orthophosphate (Mean) mg/l P		
Childrey Brook	0.223	0.29
Cow Common Brook	0.39	0.48
Ock above Thames	0.13	0.22
Nitrate (Mean) mg/l N		
Childrey Brook	9.3	9.4
Cow Common Brook	5.27	5.27
Ock above Thames	7.94	7.86

4.4 Assessment outcomes

4.4.1 Cow Common Brook and River Ock (Reaches 1 & 2)

4.48 Figure 4.22 in Appendix A1.1 Figures shows the modified version of the SAGIS–SIMCAT model of the River Ock that includes SESRO and modified watercourses around the reservoir. This applies the same calibration adjustments as the original Ock model within the same water bodies.

4.49 Impacts of the change in the catchment and course of the streams are made Table 4.5 for locations that are present in both the baseline and post SESRO version of the model (shown by the blue arrows in Figure 4.22 in Appendix A1.1 Figures). For the Cow Common Brook, comparison is also made with the end of the new Western Watercourse Diversion which takes most of the flow from the old Cow Common Brook catchment. Notable results are as follows:

- River flows decline slightly in the lowermost River Ock (just upstream of the River Thames) because of the loss of upstream catchment. This does not result in a reduction in river water quality because the water quality of the Cow Common Brook was similar to or worse than the upstream Ock and inputs from this source are reduced by reduced flow.
- Comparing the end of the old Cow Common Brook with the end of the new Western Watercourse Diversion of the Cow Common Brook, flow is reduced by around 16% which is partly due to the loss of some of the catchment to the reservoir area but also partly because of some of the flow is diverted to the east. The bottom end of the channel of the Cow Common Brook has lower flow because the upstream catchment is lost. Most of the water falling on the embankment will flow into the Circular Drain, which is currently designed to flow into the River Ock downstream of Marcham Mill and thus bypasses the Cow Common Brook and Childrey Brook. Substantial improvements in all modelled chemicals occur however when comparing the end of the new western diversion of the Cow Common Brook with the end of the old Cow Common Brook. This is likely to be the result of changes in inputs from the upstream catchment and longer travel times through the new Western Watercourse Diversion which will increase within river losses.
- A decline in river flow also occurs in the Childrey Brook (Q_{95} and Q_{MEAN}) which is due to the loss of catchment area to the reservoir embankment and flow diverted from the East Hanney Ditch catchment to the bottom of the old Cow Common Brook via the new western diversion. For ammonia and orthophosphate, a reduction in water quality occurs which is likely to be due to reduced dilution of point source inputs upstream of the Childrey Brook monitoring station which includes Wantage sewage works. The change in both chemicals is less than 10% (7% for ammonia and 9% for orthophosphate) with no change in predicted WFD class.

Table 4.5 Results for simulated water quality locations common to the baseline and new SESRO 150 Mm^3 configuration of the Ock/Cow Common Brook Catchment (see Figure 4.25 in Appendix A1.1 Figures for locations)

	Childrey Brook (A)		Cow Common Brook (B)	New CCB (D)		Ock above Thames (C)	
	Old	SESRO	Old	New	SESRO	Old	SESRO
Flow Q_{Mean}	33.3	30.2	9.05	1.1	7.58	142	138
Flow Q_{95}	10.2	9.4	1.47	0.24	1.53	30.7	30
Ammonia 90th percentile	0.138	0.148	0.096	0.15	0.047	0.025	0.025
Dissolved Oxygen 10th percentile	7.96	8.23	4.63	4.56	6.92	10.37	10.48
BOD 90th percentile	3.2	3.38	1.02	1.09	0.799	1.14	1.14
Orthophosphate Mean	0.285	0.31	0.47	0.31	0.32	0.223	0.219
Nitrate Mean	9.39	9.18	5.41	5.15	4.6	7.86	7.69

Units = mg/l

Table 4.6 Simulated water quality in the new watercourses following SESRO construction compared to the old watercourses

	Cow Common Brook (old)		Eastern diversion		Embankment circular drain			Western Diversion			East Hanney Ditch
	Mid	End	1	2	3	4	5	6	7	8	9
Flow Q_{Mean}	3.2	9.05	1.62	0.78	0.46	0.27	0.67	2.05	5.45	6.14	0.39
Flow Q_{95}	0.52	1.47	0.31	0.14	0.11	0.06	0.16	0.38	1.06	1.21	0.09
Ammonia 90th percentile	0.05	0.096	0.12	0.204	0.17	0.25	0.133	0.124	0.064	0.035	0.07
Dissolved Oxygen 10th percentile	3.3	4.63	4.75	1.6	2.54	3.94	2	5.67	6.97	6.88	6.11
BOD 90th percentile	1.41	1.02	1.03	1.31	1.24	1.3	1.2	1.13	0.93	0.81	1.39
Orthophosphate Mean	0.44	0.47	0.35	0.32	0.41	0.32	0.29	0.53	0.39	0.33	0.142
Nitrate Mean	6.71	5.41	5.71	6.7	5.3	4.68	5.2	7.84	5.24	4.91	12.39

Units in mg/l

4.50 Comparison is made between the diverted watercourses following the construction of SESRO and the old Cow Common Brook in Table 4.6. The patterns are complex because chemical input loads and flows are being distributed around the catchment in new ways with some reaches improved and some worsened. Concentrations are also affected by changes in travels times along new longer watercourses. Key results are:

- All locations correspond to High WFD status for ammonia. The highest concentrations occur in the streams with the least flow.
- All locations correspond to High WFD status for BOD.
- Dissolved oxygen concentrations are lower near the headwaters where flows are low and therefore have little opportunity for reaeration. The lowest concentrations are in the embankment drain and near the head of the eastern diversion. Otherwise, concentrations tend to be higher than in the original Cow Common Brook.
- In most of the new watercourses, orthophosphate concentrations are lower than in the original Cow Common Brook, an exception being the most upstream point on the western diversion.
- Flow is reduced in the East Hanney Ditch because the Western Watercourse Diversion would take a proportion of the flow from the water body and in addition some of the water body is lost to the embankment. In SAGIS–SIMCAT, flow into each Reach in a water body is proportional to the length of the Reach, such that accretion to the western diversion is likely to be overestimated since in reality drainage from the western side of the water body would still drain into the East Hanney Ditch.

4.51 In reviewing these results, the limitations of the SAGIS–SIMCAT model in this context need to be understood. The modelling allows the impact of losing part of the catchment on downstream flows and quality and of reallocating flow and loads to new water courses. Diffuse input flows and chemical inputs are, however, assumed to be evenly distributed across each model area (i.e., water body or divided water body) so the fine spatial details within this area are not fully represented. Furthermore, the detailed distribution of chemical inputs such as from farmyards, manure application and domestic and industrial activities are unknown at the local scale. It is not possible therefore to have a high degree of confidence in the outputs at this spatial scale. Gathering such information by site surveys and pollution investigations which then could be added to the model when available would increase confidence in the model outputs at this scale. At the larger scale the outputs are more reliable and show that increasing the length of water courses improves the water quality of the water passed down from the Cow Common Brook catchment into the River Ock. Although flows are inevitably reduced, this does not result in reduction in water quality in the River Ock in the short distance before it Reaches the River Thames.

4.4.2 River Thames (Reaches 4–13)

4.52 Figure 4.23 to Figure 4.25 in Appendix A1.1 Figures show examples of the Infoworks ICM model output at three locations (below SESRO, above confluence with the Rive Kennet and above Datchet, comparing baseline results with the SESRO 150 Mm^3 reservoir option for the Extreme Drought scenario at three model output locations along the River Thames (outputs for other hydrological scenarios are shown in Appendix A4.2 Initial hydraulic stress and climate change scenarios for Abingdon Reservoir using PROTECH). Further summary results for other locations along the River Thames are provided in Appendix A4.3 Supplementary Water Quality Results.

4.53 For most of the modelled determinands, concentrations are reduced immediately downstream of SESRO (Figure 4.23 in Appendix A1.1 Figures) during the period of release from SESRO (mid-June to early-January) because of the influence of reservoir processes and the consequent differences between reservoir and river wate quality (dilution and travel time effects only come into play further downstream). The only exception is ammonia for which an increase is simulated, immediately below SESRO, although concentrations continue to remain well within High WFD status. This is due to the reservoir having higher simulated concentrations than the very low simulated concentrations in the River Thames. Ammonia tends to be a dynamic chemical in reservoirs and, therefore, strongly influenced by within-reservoir processes as well as inputs from wildfowl and rainfall. Because of these complexities and uncertainties, ammonia may need to be revisited during subsequent project stages to determine if the within class deterioration is likely to be ‘real’. Temperature tends to be reduced by the SESRO releases although the magnitude of this change is variable over time. Dissolved oxygen concentrations in the River Thames tends increase during the period of SESRO releases but, again the magnitude of this change is variable. Algae in the River Thames are simulated to decrease because the reservoir algal biomass simulated by PROTECH is lower than that modelled in the river during the release period (this applies to all 3 hydrological scenarios).

4.54 Model results for downstream locations tend to be broadly similar (see Figure 4.24 and 4.25 in Appendix A1.1 Figures), but in these cases the influence of dilution/velocities become evident. Ammonia concentrations in the River Thames above the confluence with the River Kennet and upstream of Datchet are lower for the SESRO discharge scenario than the baseline, which is likely to be due to increased dilution of inputs from tributaries and sewage works. For BOD the reduction in concentration immediately downstream of SESRO reverses at Datchet. This is likely to a result of increased river velocities (reduced travel times) that will reduce within river losses when SESRO releases occur.

4.55 There is little indication in these results that abstraction from the River Thames to SESRO during refill negatively impacts water quality (February and March). The only exception is an increase in ammonia upstream of the Kennet and to a lesser degree upstream of Datchet, presumably due to reduce dilution of point source inputs downstream of SESRO.

4.56 A comparison between the model results for the SESRO 150 Mm^3 and 75 Mm^3 reservoir options for the Extreme Drought scenario and locations described above for the 150 Mm^3 reservoir option is provided in Table 4.7. This shows similar patterns of model outputs for the two reservoir options in terms other percentage difference of the mean concentration from the baseline. The magnitude of the change in almost all cases is, however, less for the 75 Mm^3 option. This is because the retention time in the 75 Mm^3 option is less resulting in less change in concentration whilst in storage. Daily releases are also lower. The influence of dilution and river velocity will be similar between the 75 Mm^3 and 150 Mm^3 options as these are not affected by the reservoir retention time, but rather the volume of water released from the reservoir, which is similar between the options.

Table 4.7 Comparison between Infoworks ICM model results (Extreme Drought hydrological scenario) for the 75 Mm^3 and 150 Mm^3 reservoir options – percentage difference from baseline

	Downstream SESRO		Upstream of Kennet		Upstream of Datchet	
	75 Mm^3	150 Mm^3	75 Mm^3	150 Mm^3	75 Mm^3	150 Mm^3
Total P mean	−11.09	−17.07	−8.46	−14.48	−5.82	−10.61
Ammonia	23.3	102	−5.45	5.5	−4.81	−6.56
Nitrate	−11.84	−18.54	−7.31	−12.55	−5.44	−9.72
BOD	−20.1	−26	−1.58	−1.6	-0.66	-0.69
Dissolved Oxygen	0.57	0.90	0.16	0.19	0.22	0.35
Temperature	−1.03	−1.65	−0.59	−1.00	−0.55	−1.05
Algae	−5.40	−9.49	−1.78	−3.40	−1.13	−2.20

Percentage values are mean for all determinands apart from BOD and ammonia for which the 90th

percentile is used
Negative percentage values indicate a reduction in concentration compared to the Baseline

4.57 A comparison between the hydrological scenarios is presented in Table 4.8 for the 150 Mm^3 reservoir option. The model outputs are consistent between scenarios differing mainly in the magnitude of the change from the baseline, which is likely to be mainly related to the duration of the release of water from SESRO (4½ months for moderately dry, 6 months for drought and 7 months for extreme drought).

Table 4.8 Comparison between Infoworks model mean results for the 150 Mm^3 reservoir options for the three hydrological scenarios – percentage difference from baseline

	Downstream SESRO			Upstream of Kennet			Upstream of Datchet		
	Extreme Drought	Drought	Mod Dry	Extreme Drought	Drought	Mod Dry	Extreme Drought	Drought	Mod Dry
Total P	−17.07	−12.39	−4.86	−14.48	−13.33	−9.17	−10.61	−7.73	−5.89
Ammonia	102	85.71	98.49	5.5	−5.10	0.63	−6.56	−1.34	−2.59
Nitrate	−18.54	−14.24	−12.54	−12.55	−9.45	−6.38	−9.72	−7.08	−4.56
BOD	−26	−21.21	−19.79	−1.6	−4.35	−2.49	-0.69	−0.07	0.57
Dissolved Oxygen	0.90	0.69	0.40	0.19	0.68	0.15	0.35	0.75	0.29
Temperature	−1.65	−1.30	−0.55	−1.00	−2.03	−0.53	−1.05	−0.67	−0.64
Algae	−9.49	−6.97	−20.42	−3.40	−2.46	−1.58	−2.20	−1.32	−1.22

Values are mean for all determinands apart from BOD and ammonia for which the 90th percentile is used

Negative values indicate a reduction in concentration compared to the Baseline

4.4.3 Summary

4.58 In general, the analysis indicates that the impacts of SESRO on water quality in the River Thames are largely positive; in general, improving or making no change in river concentrations compared to the WFD thresholds. This is primarily the result of SESRO 'improving' concentrations during the long period of storage (the average retention based on Pywr outputs is greater than 7 years) compared to the influent water from the River Thames, because of normal reservoir attenuation, biological uptake, and sedimentation processes. In addition, the released water provides greater dilution of downstream inputs from tributaries and discharges.

4.59 One exception to this is a slight increase in ammonia immediately downstream of the reservoir; however, this needs to be caveated by the high degree of uncertainty in predicting reservoir ammonia concentrations since this chemical is highly dynamic in nature and can show a high degree of temporal variability. This may need to be revisited during subsequent project stages, perhaps by making greater reference to observed concentrations in other reservoirs. A marginal increase in BOD is also simulated further downstream for some scenarios at some times of the year, which is likely to be the result of increased velocities and reduced loss within the river (BOD does not contribute to WFD status)

4.60 In the River Ock, an increase occurs for ammonia and orthophosphate in the Childrey Brook, related to loss of flow from the catchment and routing of rainfall and local watercourse flows to the River Ock downstream of Marcham Mill (i.e., downstream of Childrey Brook confluence) which results in a reduced dilution of upstream point source inputs.

4.5 Potential options for mitigation considered

4.5.1 River Ock

4.61 The primary negative impact of SESRO on river water quality is a small increase in the Childrey Brook for ammonia and orthophosphate (<10%) which is likely to be due to reduced dilution of upstream point sources, primarily from Wantage sewage works. Lowering the effluent permit at Wantage for these chemicals from the current values of 2 mg/l P and 5 mg/l for ammonia (i.e., 1 mg/l for P and 3 mg/l for Ammonia Table 4.9) would offset this change.

Table 4.9 Impact of tightening of permit at Wantage sewage works on concentration in the Childrey Brook (at sample point POCR0013)

	Childrey Brook (A)		
	Baseline	New	New (Mitigation)
Ammonia 90th percentile	0.138	0.148	0.115
Orthophosphate mean	0.285	0.31	0.236

Units in mg/l

4.62 Further mitigation is possible in terms of other point sources in the catchments, or diffuse sources such as catchment measures targeted at WFD reasons for not achieving good.

4.5.2 River Thames

4.63 No mitigation is proposed for the River Thames because there are no clear negative impacts from SESRO (the increase in ammonia immediately remains uncertain). The only change in the River Thames that might require mitigation is the slight increase in BOD which is believed to be the result of increased river velocities. Further evaluation of modelling results is required to better understand the issue and identify any mitigation options, e.g., tightening of BOD permits at downstream sewage works.

4.64 Mitigation options are available for SESRO if required including mixing/aeration and the use of alternative draw off depths. Currently the water quality models have just assumed a single draw off depth.

4.6 Considerations for subsequent project stages

4.65 The model outputs presented in this Section present a largely positive outcome for water quality as a result of SESRO. There are, however, a number of uncertainties that should be given consideration during subsequent project stages to improve confidence in this assessment:

- Several refinements would be beneficial in the Infoworks ICM and RSS Pywr hydrological, and water quality models in relation to the hydrology, hydraulics, and operation of the River Thames control structures during abstraction and discharge (Appendix A2.1 SESRO River Thames calibration report). Additional survey data will be required to improve model representation of level management at key structures and the relationship to levels in backwaters and side streams, weir pools and in the main channel downstream of the augmentation to further inform hydro-ecological assessment. Any refinements will have a ‘knock on’ change on water quality so, if taken forward, water quality outputs will need to be compared once the modifications have taken place. Note the River Thames ICM modelling calibration report (Appendix A2.1 SESRO River Thames calibration report) includes a section on future refinements to the model.

- The ammonia and BOD aspects of the reservoir modelling have a level of uncertainty because these determinands were not modelled in PROTECH; so, it was not possible to condition the Intermediate Reservoir Water Quality model against PROTECH. During subsequent project stages , they should either be included in PROTECH or another approach to ground truthing should be considered such as comparison with observed data from other reservoirs.
- Orthophosphate cannot be modelled in Infoworks ICM and total phosphorus was not modelled in PROTECH. To improve model interaction these inconsistencies should be addressed to improve the model linkages.
- Dissolved oxygen was not modelled in any of the reservoir models so the assumption was that the water released from SESRO will be at 100% saturation. Ideally, this assumption needs to be tested through explicit reservoir modelling of dissolved oxygen and/or the engineering options to ensure 100% saturation assessed in more detail.
- For the SAGIS–SIMCAT modelling of the River Ock, if the model is continued to be used in future, the flow and chemical inputs and sources would ideally be ‘ground truthed’ by site investigations and additional monitoring of water quality sampling and flow (the existing data are over 5 years old). The development of a 1D hydrodynamic model for the River Ock (to allow flow and water quality modelling) should also be continued.

5. Aquatic Ecology

5.1 Introduction

5.1 This chapter considers the potential impacts of the construction and operation of SESRO on aquatic communities and species within the study area, with reference to watercourse study Reaches set out in Section 0. The assessment focusses on fish, macrophytes, aquatic macroinvertebrates (hereafter invertebrates), diatom, phytoplankton and zooplankton communities and species associated with watercourses within the study area.

5.2 The following sections summarise an extensive baseline collation exercise (both review of supplementary data made available to the project and collection of new scheme specific data), with detailed baseline data processing, calculation of biotic indices and analysis underpinning these summaries reported in Appendix A5.1 Ecological Data Baseline. Community and population (notable species) sensitivities within the study area are highlighted within the baseline to set the context for the assessment of potential scheme impacts (both beneficial and adverse) that follows.

5.3 A source-pathway–receptor framework for aquatic ecology receptors is set out, within which potential community and species changes as a result of the proposed scheme are considered. This framework has set the context for the supporting investigations and assessments presented for geomorphology, hydrology, and water quality. Qualitative and, where applicable at this stage, quantitative assessment of the identified pathways is discussed in the context of aquatic ecology receptor sensitivities.

5.4 Watercourse habitats are also considered as mediators of potential impact mechanisms on watercourse aquatic ecology, with more detailed baseline habitat descriptions provided in Chapter 3 Fluvial Geomorphology, as well as in supporting Appendix A5.2 Habitats Baseline – Ock Watercourses and Appendix A5.3 Habitats Baseline – River Thames Fish Habitats. Other aquatic habitats are also considered, focussed at this stage on statutory and non-statutory designated sites that support aquatic habitats and species and that could, conceptually, potentially experience change relative to baseline condition through indicative footprint or watercourse mediated effects. A separate Habitats Regulations Assessment (HRA) has been prepared for SESRO at Gate 2 which considers potential effects on European designated sites.

5.5 Finally, data gaps and assessment priorities during subsequent project stages of the assessment process are discussed.

5.2 Methodology

5.2.1 Baseline methodology

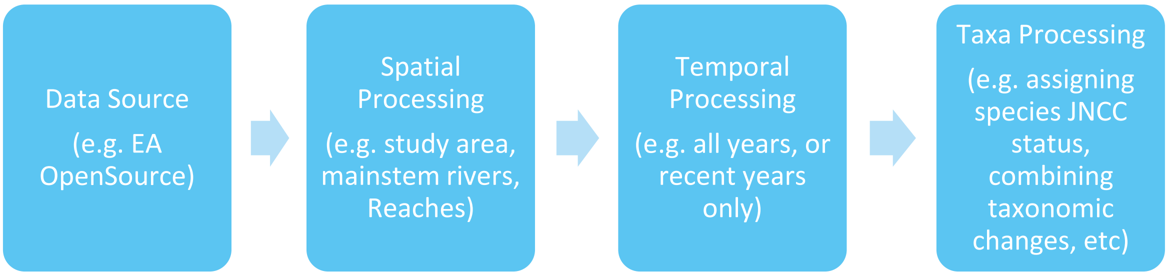
5.6 Multiple data sources were reviewed to identify available baseline ecological data within the study area and further develop the baseline understanding developed at Gate 1. A detailed review of supplementary and scheme-specific data (noting survey access restrictions for the River Ock) was undertaken to characterise the aquatic ecology of the study area with reference to study Reaches set out in Section 3 and shown in Figure 1.2 in Appendix A1.1 Figures. The location of named Main Rivers and Ordinary Watercourses, as well as unnamed Ordinary Watercourses (and codes assigned to these) within study Reaches associated with the indicative location for SESRO, are shown in Figure 3.1 Appendix A1.1 Figures. Full details of the baseline data collection, processing and analysis methodology are set out in Appendix A5.1 Ecological Data Baseline. Datasets reviewed are listed in Section 5.2.2.

5.7 The Environment Agency Catchment Data Explorer was reviewed to establish the ecological status and biological classification of water bodies within the study area based on River Basin Management Plan 2 (RBMP2) and draft RBMP3 (dRBMP3).

5.8 A screening exercise was undertaken for statutory and non-statutory designated sites based on a Thames Valley Environmental Record Centre (TVERC) data request. This sought to identify those sites that are both designated on account of aquatic features and that could conceptually be at risk of change as a result of the proposed scheme. At Gate 2, this screening exercise has focussed on the study area associated with Reaches up to and including Reach 5 of the River Thames; i.e., all Reaches associated with or adjacent to indicative footprint (Reaches 1, 2 and 3); as well as the Reaches of the Thames immediately upstream and downstream of the Ock confluence and SESRO intake/discharge (Reaches 4 and 5). This screening exercise is reported in full in Appendix A5.1 Ecological Data Baseline.

5.9 The data collation and processing exercise for all taxonomic datasets broadly reflects the process outlined in Insert 5.1. Specific criteria for each type of data and dataset were applied during the processing as outlined in Appendix A5.1 Ecological Data Baseline. Data collection methods are also described in Appendix A5.1 Ecological Data Baseline.

Insert 5.1 Broad approach to baseline data gathering



5.10 Broadly, two types of data were used to build an understanding of the baseline aquatic ecology, including community and population sensitivities across the study area and within each Reach:

- Community biological metrics; and
- Species records.

5.11 Analysis of biological metrics focussed on Environment Agency monitoring data since 2010 to provide a recent temporal baseline for the overall character of communities within the study area. This cut off minimises risks of comparing metrics derived under different taxonomic approaches historically undertaken by the Environment Agency and ensures that the baseline is broadly representative of recent/current conditions, given that there have been significant water quality improvements in the River Thames over the duration of the historical monitoring period. The period selected includes records following a range of antecedent flow conditions – including lower than average flow years in the South East of England (in particular, 2011) as well as higher than average flow years (such as, 2012 and 2013).[38]

5.12 Given the high volume of Environment Agency data for invertebrates and macrophytes within the study area, community biological metrics were summarised by calculating the mean, minimum and maximum score for each study Reach over any records obtained since 2010. These metrics are used to characterise typical baseline community types, their preferred environmental conditions (and sensitivities), and their variability within each Reach over the duration of the monitoring period. Given the relatively low volume of Environment Agency diatom data within the study area, biological metrics from SRO monitoring were also used to supplement the analysis for diatoms.

[38] Gate 1 Annex B1 EAR Figures – Figure 5.6 Illustration of average daily flows per year across modelling inflow record.

5.13 Observed: Expected (O:E) metric ratios were also calculated for all Environment Agency sites where community data (invertebrates, macrophytes, and diatoms) are used in WFD classifications, in order to compare observed communities to what would be expected for the river typology of each water body in the study area in the absence of environmental stressors. O:E ratios were calculated for all samples since 2010 at these sites (as presented within Appendix A5.1 Ecological Data Baseline), meaning that any trends in data (deteriorations or improvements) over time could be identified.

5.14 The presence of notable species and INNS was assessed using Environment Agency, SRO, and TVERC species records for the full record period (since the 1960s for Environment Agency and TVERC data). The full record period was included at Gate 2 to ensure that all protected and notable species recorded at any point in time were identified. This supports a review of whether such species are likely to persist under the existing baseline or, for example, whether a further programme of survey may be required to confirm this during subsequent Gates.

5.15 Species were identified as INNS if listed in legislation (Regulation (EU) 1143/2014,[39] WFD High Impact INNS,[40] Wildlife and Countryside Act – Schedule 9[41]) or listed in high-profile credible INNS lists (GB non-native species secretariat species alerts,[42] INNS Working Group,[43] UKWIR INNS report 2016[44]). INNS were split into 'high priority' INNS (those species which have statutory constraints), and 'other' INNS (those which do not sit within legislation but are named on INNS lists from high-profile credible sources). Full details are provided in Appendix A5.1 Ecological Data Baseline and Appendix A6.2 INNS List.

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[39] European Commission (2015) *EU Regulation 1143/2014 on Invasive Alien Species* [online]. Available at: https://ec.europa.eu/environment/nature/invasivealien/list/index_en.htm [Accessed on: 07/03/2022].
[40] Gov.UK (2015) *The Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015* [online]. Available at: https://www.legislation.gov.uk/uksi/2015/1623/pdfs/uksiod_20151623_en_auto.pdf [Accessed on: 07/03/2022].
[41] Gov.UK (2021) *Wildlife and Countryside Act 1981 – Schedule 9* [online]. Available at: https://www.legislation.gov.uk/ukpga/1981/69/schedule/9 [Accessed on: 07/03/2022].
[42] GB Non-Native Species Secretariat (2022) *Species alerts – GB non-native species secretariat* [online]. https://www.nonnativespecies.org/non-native-species/species-alerts/ [Accessed on: 10/05/2022].
[43] INNS cross-party working group (2020) *INNS taxa list*.
[44] UKWIR (2022) *Invasive and Non-Native Species (INNS) Implications on the Water Industry* [online]. Available at: https://ukwir.org/Invasive-and-Non-Native-Species-(INNS)-Implications-on-the-Water-Industry [Accessed on: 07/03/2022].

5.16 Notable species are those listed on the latest Joint Nature Conservation Committee (JNCC) Conservation Designations Spreadsheet[45] with a status assessment of at least Near Threatened (IUCN) or a 'rare or scarce' type listing within UK red lists, with those of protected[46]/principal[47]/qualifying[48] status further highlighted within reporting. Those invertebrates with a Community Conservation Index (CCI)[49] Conservation Score greater than 5 (i.e., species which are at least regionally notable) were also included. Full definitions of notable designations are outlined in Table A.9 in Appendix A5.1 Ecological Data Baseline.

5.17 Supplementary data reports relevant to SESRO and the study area were also reviewed for any information relevant to the baseline aquatic ecology of the River Ock catchment watercourses and the River Thames. This includes, but is not limited to, a series of reports which were completed by Thames Water between 2007 and 2009 based on the Thames Water Abingdon Reservoir Project (TWARP) as it was defined at the time.

5.18 A site visit to the watercourses within and adjacent to the SESRO site was also undertaken by Atkins in November 2021. This visit aimed to broadly characterise the baseline watercourse habitats within the site. Due to access constraints this characterisation was limited to locations where the watercourses intersect Public Rights of Way. This report is included in Appendix A5.2 Habitats Baseline – Ock Watercourses.

5.19 Additionally, a bespoke instream fish habitat survey was conducted by Atkins and APEM in 2021. This specifically targeted juvenile coarse fish habitats given the well-defined coarse fish assemblage of the upper Thames and the greater sensitivity of juvenile life stages to the potential impacts of SESRO (i.e. to hydraulic change). It also targeted the reach with conceptually the greatest potential for changes in hydraulic

[45] Joint Nature Conservation Committee (2020) *Conservation Designations Spreadsheet* [online]. Available at: https://jncc.gov.uk/our-work/conservation-designations-for-uk-taxa/ [Accessed on: 09/11/2021]. Contains JNCC/NE/NRW/SNH/NIEA data © copyright and database right 2020.
[46] Protected species include those formally protected through legislation such as the *Wildlife and Countryside Act 1981* (as amended) or European Protected Species receiving protection under *The Conservation of Species and Habitats Regulations 2017*.
[47] Species of Principal Importance are those identified within *the Natural Environment and Rural Communities (NERC) 2006*.
[48] Qualifying species are Annex II species as identified under the Habitats Directive, i.e. those species that are nor formally protected but are species of Community interest whose conservation requires the designation of Special Areas of Conservation.
[49] Chadd, R. and Extence, C. (2004) The conservation of freshwater macroinvertebrate populations: a community-based classification scheme. *Aquatic Conservation: Marine and Freshwater Ecosystems*, 14: 597–624.

habitat provision as a result of SESRO (i.e. Reach 5, as defined during Gate 1). This report is included in Appendix A5.3 Habitats Baseline – River Thames Fish Habitats.

5.20 The main findings of these reports with regards to the baseline, have been summarised under the relevant sections and study Reaches.

5.2.2 Datasets/reports reviewed

5.21 Key datasets that have been reviewed as part of Gate 2 include:

- Environment Agency Ecology and Fish Data Explorer data;[50]
- Environment Agency supplementary data requests including Fisheries Classification Scheme 2 (FCS2)[51] data and Lyons *et al.* (2021);[52]
- Environment Agency WFD Ecological status for the 2015 and 2019 cycles;[53]
- 2020 and 2021 SRO Monitoring Programme data; including fish, invertebrates, macrophytes, diatoms, specialist depressed river mussel (*Pseudanodonta complanata*) surveys, multi-purpose eDNA monitoring[54] and bespoke INNS surveys within the study area;
- Thames Valley Environmental Records Centre (TVERC) data;[55] and
- Supplementary data from Thames Water AMP7 WINEP investigations into INNS.

5.22 Detailed baseline data processing and analysis associated with these datasets is reported in Appendix A5.1 Ecological Data Baseline. The associated raw datasets are also included in Appendix A5.4 Baseline Taxa Data. All Environment Agency and SRO monitoring locations included within the baseline reporting and associated with the identified datasets are shown in Figure 5.1 to Figure 5.7 respectively, in Appendix A1.1 Figures.

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[50] Environment Agency (2021) *Ecology and Fish Data Explorer* [online]. Available at: https://environment.data.gov.uk/ecology/explorer/ [Accessed on: 25/11/2021].
[51] WFD-UKTAG (2008) *Rivers Assessment Methods Fish Fauna: Fisheries Classification Scheme 2*. Available at: https://wfduk.org/resources%20/river-fish [Accessed on: 22/02/2022].
[52] Lyons, J., Hateley, J., Peirson, G., Eley, F., Manwaring, S. and Twine, K. (2021) An assessment of hydroacoustic and electric fishing data to evaluate long term spatial and temporal fish population change in the River Thames, UK. *Water*, 13: 2932.
[53] Environment Agency (2022) *Catchment Data Explorer* [online]. Available at: https://environment.data.gov.uk/catchment-planning/ [Accessed on: 13/04/2022].
[54] eDNA monitoring focussed on watercourses associated with the Scheme footprint, where access for conventional survey methods was restricted. This was supplemented by INNS eDNA sampling on the River Thames.
[55] TVERC (2022) *Thames Valley Environmental Records Centre Data Request* [online]. Available at: https://www.tverc.org/cms/content/data-searches [Accessed on: 23/03/2022].

5.23 Scheme-specific habitat surveys were also undertaken as part of Gate 2 including:

- Walkover surveys (from public access points) of watercourses within and adjacent to the SESRO site in November 2021. This report is provided as Appendix A5.2 Habitats Baseline – Ock Watercourses.
- Instream fish habitat survey of the Thames between Culham and Little Wittenham conducted in November 2021. This report is provided as Appendix A5.3 Habitats Baseline – River Thames Fish Habitats.

5.24 In addition, supplementary data reports collected under previous investigations into the feasibility of the Thames Water Abingdon Reservoir Project (TWARP) were made available by Thames Water to the current project and included in the baseline review. A summary of each report is provided in Appendix A5.1 Ecological Data Baseline. This includes the following reports:

- Thames Water (2007) Larval and Juvenile Fish Populations of the upper River Thames – Survey results for 2007;[56]
- Thames Water (2007) Phytoplankton Baseline Report;[57]
- Thames Water (2008) Larval Fish, Phytoplankton, Zooplankton and Water Quality Monitoring at Selected Sites in the Thames 2007;[58]
- Thames Water (2009) Aquatic Macroinvertebrate Survey;[59]
- Thames Water (2009) Fisheries Baseline Survey;[60]
- Thames Water (2009) Invasive Species Review;[61]
- Thames Water (2009) Midges and Mosquitos Review;[62]
- Thames Water (2009) Native Crayfish Baseline Survey 2006–2008;[63]
- Thames Water (2009) Rare Mollusc and Mussel Survey;[64]

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[56] APEM and Cascade Consulting (2007) *Larval and Juvenile Fish Populations of the upper River Thames – Survey results for 2007*. Report on behalf of Thames Water.
[57] Cascade Consultancy (2007) *Phytoplankton Baseline Report*. Report on behalf of Thames Water.
[58] APEM and Cascade Consulting (2008) *Larval Fish, Phytoplankton, Zooplankton and Water Quality Monitoring at Selected Sites in the Thames 2007*. Report on behalf of Thames Water.
[59] Cascade Consulting and APEM (2009) *Aquatic Macroinvertebrate Survey*. Report on behalf of Thames Water.
[60] Cascade Consulting and APEM (2009) *Fisheries Baseline Survey*. Report on behalf of Thames Water.
[61] Cascade Consulting (2009) *Invasive Species Review*. Report on behalf of Thames Water
[62] Cascade Consulting (2009) *Midges and Mosquitos Review*. Report on behalf of Thames Water
[63] Applied Ecology Ltd and Cascade Consulting (2009) *Native Crayfish Baseline Survey 2006–2008*. Report on behalf of Thames Water
[64] Malacological Services and Cascade Consultancy (2009) *Rare Mollusc and Mussel Survey*. Report on behalf of Thames Water

- Thames Water (2009) Riverine Macrophyte Survey;[65] and
- Thames Water (2009) Riverine Plankton and Diatom Survey.[66]

5.25 A specific literature review was also undertaken to develop a baseline understanding of the zooplankton community in the River Thames, and more broadly to understand the drivers of zooplankton community dynamics in large temperate river systems, as reported within this EAR. The following reports were reviewed:

- Bass and May (1996) Zooplankton interactions in the River Thames: literature review;[67]
- Freeman (2019) River phytoplankton biological controls on a microscopic level;[68]
- Bass *et al.* (1997) Zooplankton interactions in the River Thames;[69]
- Thames Water (2009) Riverine Plankton and Diatom Survey;[70] and
- Ruse and Love (1997) Predicting phytoplankton composition in the River Thames, England.[71]

5.26 The Centre for Ecology and Hydrology (CEH) has produced reports specific to the SRO schemes (including SESRO) investigating the phytoplankton community in the Thames and how this could be affected by SESRO operation. These reports are summarised within this EAR and included as:

- Appendix A5.5 Water Quality and Phytoplankton Monitoring;
- Appendix A5.6 Phytoplankton Growth and Community Monitoring; and
- Appendix A5.7 Algal Growth Rate Studies.

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[65] Cascade Consulting, APEM and Ecology Consultancy (2009) *Riverine Macrophyte Survey*. Report on behalf of Thames Water

[66] APEM and Cascade Consulting (2009) *Riverine Plankton and Diatom Survey*. Report on behalf of Thames Water

[67] Bass, J.A.B. and May, L. (1996) *Zooplankton interactions in the River Thames: literature review*. Final report to the Environment Agency

[68] Freeman, A. (2019) *River phytoplankton biological controls on a microscopic level.* Thesis submitted for the degree of Doctor of Philosophy. Department of Geography and Environmental Science, University of Reading.

[69] Bass, J.A.B., May, L., Esteban, G.F. and Collett, G.D. (1997) *Zooplankton interactions in the River Thames – Report to the Environment Agency (Thames Region)*, IFE Report Ref. No T0403v7/1.

[70] APEM and Cascade Consulting (2009) *Riverine Plankton and Diatom Survey*. Report on behalf of Thames Water.

[71] Ruse, L. and Love, A. (1997) Predicting phytoplankton composition in the River Thames, England. *Regulated Rivers, Research and Management*, 13: 171–183

5.27 Other relevant and published documents used to assess the baseline phytoplankton community are:

- Bowes *et al.* (2016) Identifying multiple stressor controls on phytoplankton dynamics in the River Thames (UK) using high-frequency water quality data;[72] and
- Bowes *et al.* (2012) Nutrient and light limitation of periphyton in the River Thames: implications for catchment management.[73]

5.2.3 Assessment methodology

5.28 A source–pathway–receptor framework for considering change to aquatic ecology receptors was developed and has framed supporting investigations and assessments presented for geomorphology, hydrology, and water quality at Gate 2 within this EAR. This framework is broadly summarised in Insert 5.2.

5.29 Insert 5.2 also indicates those supporting studies, modelling or information that informs the potential impact assessment of a given source/pathway on a given receptor, based on the matrix presented.

5.30 Where proposed scheme size is relevant, all supporting information includes an assessment of the largest SESRO size option presently defined (150 Mm^3). Thereafter, and due to the variable methods underpinning each supporting assessment, additional SESRO size options considered range from all size options (e.g., for the indicative footprint), or the smallest SESRO size option (75 Mm^3; e.g., for the 1D Hydrodynamic Modelling) to provide the range of potential change associated with different options. In addition, certain supporting studies (such as CEH algae experiments) are underpinned by proposed scheme concepts only (mixing of reservoir and river water in certain proportions) rather than being specific to any given size option.

5.31 The aquatic ecology assessment reported below does not reproduce all supporting studies presented elsewhere in this EAR and its supporting appendices. Rather it relates the conclusions of these supporting studies to the aquatic ecology sensitivities

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[72] Bowes, M.J., Loewenthal, M., Read, D.S., Hutchins, M.G., Prudhomme, C., Armstrong, L.K., Harman, S.A., Wickham, H.D., Gozzard, E. and Carvalho, L. (2016) Identifying multiple stressor controls on phytoplankton dynamics in the River Thames (UK) using high-frequency water quality data. *Science of the Total Environment*, 569–570: 1489–1499.

[73] Bowes, M.J., Ings, N.L., McCall, S.J., Warwick, A., Barrett, C., Wickham, H.D., Harman, S.A., Armstrong, L.K., Scarlett, P.M., Roberts, C., Lehmann, K. and Singer, A.C. (2012) Nutrient and light limitation of periphyton in the River Thames: implications for catchment management. *Science of the Total Environment*, 434: 201–212.

defined as part of the Gate 2 baseline, to infer potential consequences (neutral, beneficial, or adverse) based on understanding at Gate 2.

5.32 The potential impact pathways and the supporting information informing each pathway within this EAR are broadly identified as:

- Footprint: direct habitat loss, gain or severance within the Ock Catchment[74] and Thames[75] – Chapter 3 Fluvial Geomorphology; Technical Supporting Document B5 Water Framework Directive Report; Technical Supporting Document B6 Biodiversity Net Gain Report.
- Operational Regime: changes in flow/level/habitat availability within the Ock Catchment and Thames – Chapter 2 Hydrology; Appendix A3.1 Weir Pool Sensitivity Screening*;* Chapter 4 Water Quality (in respect of SAGIS–SIMCAT flow modelling).
- Operational Regime: changes in water quality within the Ock Catchment and Thames – Chapter 4 Water Quality.
- Operational Regime: changes to barrier porosity (function of existing fish passes) within the Ock Catchment and Thames; and fish impingement/entrainment at new and existing intake/discharge structures within the Thames – Technical Supporting Document A1 Concept Design Report*;* Chapter 2 Hydrology; Chapter 4 Water Quality (in respect of SAGIS–SIMCAT flow modelling).
- Operational Regime: changes in community structure/function mediated by primary productivity changes within the Ock Catchment and Thames – Chapter 4 Water Quality; Appendix A5.6 Phytoplankton Growth and Community Modelling; Appendix A5.7 Algal Growth Rate Studies*.*

5.33 The predicted direction and magnitude of receptor change associated with each pathway is reported (by Reach) within the assessment, based on the definitions outlined in Table 5.1. The assessment of effects considers the likely embedded (i.e., design) mitigation (e.g., channel diversion and structure design) and 'standard' mitigation (such as fish rescue associated with channel diversions), prior to any further mitigation and/or compensation.

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[74] Ginge Brook and Mill Brook are not within the Ock hydrological catchment but form part of the Ock Environment Agency Operational Catchment.
[75] Restricted to footprint of combined intake/discharge structure. No other footprint mediated effects on the Thames are anticipated.

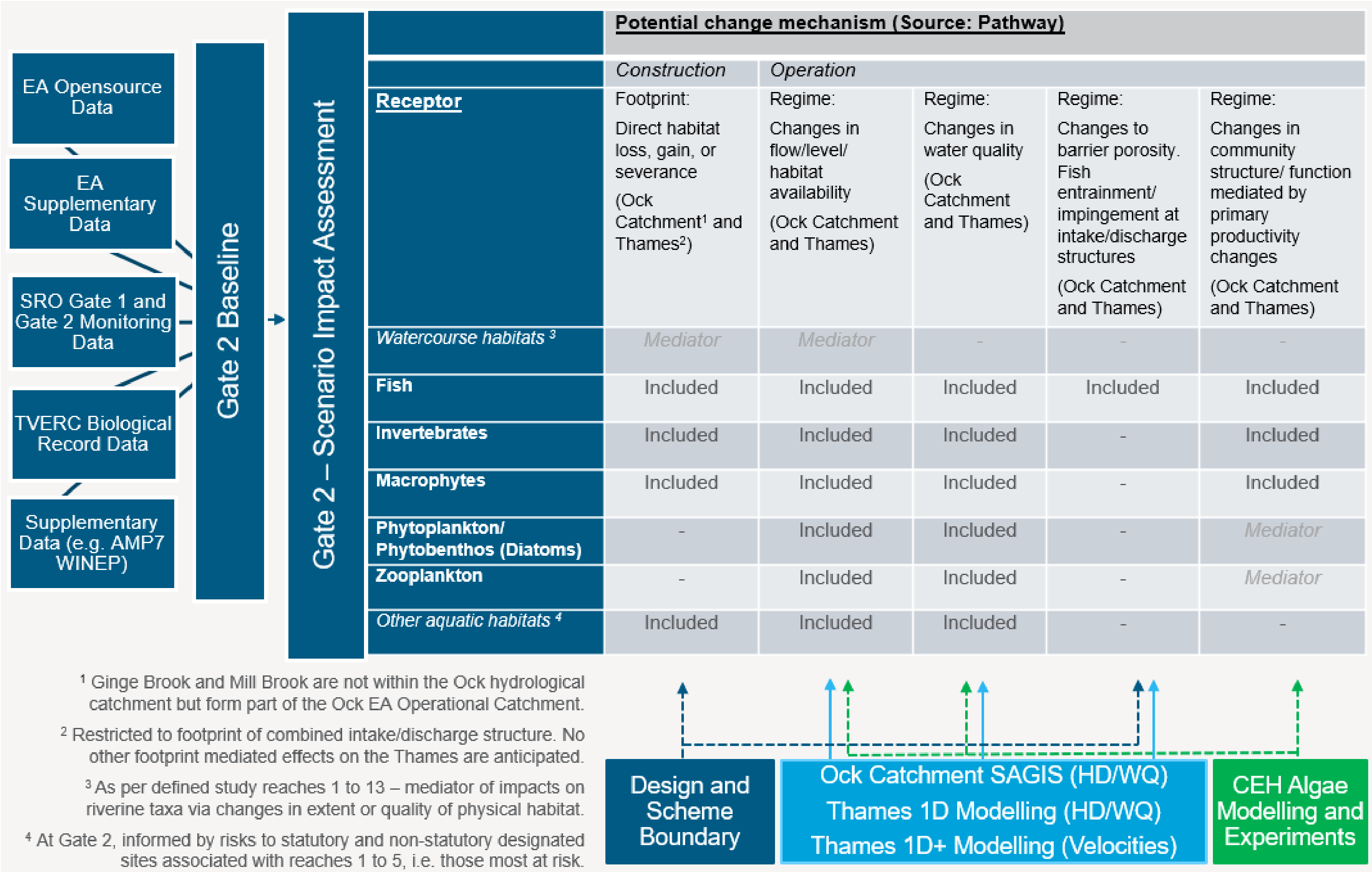
5.34 The potential risks of INNS introduction and spread to and from SESRO, via transfer pathways that may become active once the reservoir is operational, are assessed in Chapter 6 INNS Risk Assessment.

Table 5.1 Gate 2 assessment of potential effects for aquatic ecology

Description of potential effect	Symbology within assessment tables
Major beneficial change in aquatic ecological community receptors, with the potential to improve the overall ecological integrity of the Reach.	⇧
Minor beneficial change in aquatic ecological community receptors, unlikely to affect the overall ecological integrity of the Reach.	⇧
No or negligible change in aquatic ecological community receptors.	⇔
Minor adverse change in aquatic ecological community receptors, unlikely to affect the overall ecological integrity of the Reach.	⇩
Major adverse change in aquatic ecological community receptors, with the potential to reduce the overall ecological integrity of the Reach.	⇩

5.35 The assessment of construction-mediated effects at Gate 2 is restricted to those effects relating to the indicative footprint of the proposed scheme only (i.e., potential habitat loss, gain and severance as indicated in the matrix outlined in Insert 5.2). Mechanisms of effect associated with proposed scheme construction activities (such as accidental pollution incidents) will be controlled through good practice construction methodologies and supplementary construction mitigation as required. These types of effects will be assessed as part of formal approvals for the construction of the proposed scheme, should it progress.

Insert 5.2 Source–Pathway–Receptor Assessment Framework for aquatic ecology at Gate 2



	Potential change mechanism (Source: Pathway)				
	Construction	*Operation*			
Receptor	Footprint: Direct habitat loss, gain, or severance (Ock Catchment[1] and Thames[2])	Regime: Changes in flow/level/ habitat availability (Ock Catchment and Thames)	Regime: Changes in water quality (Ock Catchment and Thames)	Regime: Changes to barrier porosity. Fish entrainment/ impingement at intake/discharge structures (Ock Catchment and Thames)	Regime: Changes in community structure/ function mediated by primary productivity changes (Ock Catchment and Thames)
Watercourse habitats [3]	*Mediator*	*Mediator*	-	-	-
Fish	Included	Included	Included	Included	Included
Invertebrates	Included	Included	Included	-	Included
Macrophytes	Included	Included	Included	-	Included
Phytoplankton/ Phytobenthos (Diatoms)	-	Included	Included	-	*Mediator*
Zooplankton	-	Included	Included	-	*Mediator*
Other aquatic habitats [4]	Included	Included	Included	-	-

[1] Ginge Brook and Mill Brook are not within the Ock hydrological catchment but form part of the Ock EA Operational Catchment.

[2] Restricted to footprint of combined intake/discharge structure. No other footprint mediated effects on the Thames are anticipated.

[3] As per defined study reaches 1 to 13 – mediator of impacts on riverine taxa via changes in extent or quality of physical habitat.

[4] At Gate 2, informed by risks to statutory and non-statutory designated sites associated with reaches 1 to 5, i.e. those most at risk.

5.2.4 Assumptions and limitations

5.36 Whilst there is a significant volume of baseline data within the study area and potential sensitivities of the Thames and Ock catchment are relatively well understood, the main limitation of the baseline assessment is the uneven spatial and temporal distribution of the data meaning that some Reaches have less information and as a result reduced baseline certainty. INNS and/or notable species could be present, but unrecorded, due to the inherent limitations of ecological survey (e.g. survey timing that may 'miss' certain species) and the spatial distribution of the monitoring locations. In particular, there are limited data for ditches within the indicative footprint as most surveys were located on the main rivers rather than side channels and ditches. Access to these locations for SRO monitoring was restricted at Gate 1 and Gate 2. Whilst eDNA sampling from public access and TVERC data requests have helped overcome this data gap at Gate 2, further survey using standard methods will be required as part of subsequent Gates to verify the baseline of these Reaches. In particular, there is a risk that the Gate 2 baseline may underestimate the current value of these ditches for aquatic invertebrate communities.

5.37 The TVERC data was clipped to only include records within 25 m of the centreline of watercourses within the Ock catchment or the main River Thames (constrained to the upstream limit of Reach 4 and the downstream limit of Reach 5) in order to support the identification of aquatic species within the dataset and to spatially constrain the data to records associated with watercourses present within the study area. As such, records may not necessarily relate to species occupying the active channel of the watercourse; i.e., may be from adjacent riparian/wetland areas.

5.38 Regarding the assessment of potential effects of SESRO, a number of assumptions and limitations underpin respective supporting EAR studies and third-party sources. These are addressed within respective chapters of this EAR (for example in relation to EAR water quality and hydrological assessments), in addition to those supplementary citations that have informed the assessment. See, in particular, limitations discussed in relation to hydrological modelling in Section 2.2.3.

5.3 Understanding of the Baseline

5.3.1 WFD Status baseline

5.39 The WFD Ecological Status for 2015 (i.e. RBMP2) and 2019 (i.e. dRBMP3) cycles is presented in -Table 5.2. Water bodies within the Ock Operational Catchment (Reaches 1 to 3) and the Thames (Evenlode to Thame; Reaches 4 and 5) are not designated artificial or heavily modified water bodies. All other Thames water bodies within the study area are designated heavily modified water bodies. Whilst a summary of baseline Ecological Status is presented here for context, the WFD

Compliance Assessment of the proposed scheme has been undertaken and reported separately in Technical Supporting Document B5 Water Framework Directive Report. The WFD compliance assessment has been undertaken against published dRBMP status (i.e., 2019 status); however, 2015 RBMP status has been included for completeness and for context on the direction of change within affected water bodies. Notably, WFD biological classification elements of three water bodies have deteriorated over this time period. This includes: Ginge Brook and Mill Brook (Biological elements: High to Moderate), Thames (Reading to Cookham) (Invertebrates: High to Good), and Thames (Egham to Teddington) (Invertebrates: Good to Poor). For Ginge Brook and Mill Brook, this change is a result of the inclusion of the Macrophytes and Phytobenthos element in the dRBMP2, which was not classified in 2015 RBMP. The cause of the deterioration in the two Thames waterbodies is unclear as Reasons For Deterioration (RFDs) have not yet been published for these water bodies.

5.40 For most WFD water bodies within the study area, the fish element is not currently classified. The Thames water bodies specifically have relatively few WFD fish data classifications because the survey methodology typically used on the River Thames is bespoke and non-compliant with WFD standard methods.[76]

5.41 The River Thames Reaches 4 to 9 (up to and including *Thames (Cookham to Egham)* water body) are all at Moderate Ecological Status/Potential according to the 2019 interim classifications. However, with the exception of Reaches 4 and 5 (*Thames (Evenlode to Thame)* water body), all biological elements are at Good class or higher for these water bodies. The lower Thames Reaches (from *Thames (Egham to Teddington)* downwards) are at Poor Ecological Potential on account of the Poor class of invertebrates and macrophytes/phytobenthos elements.

5.42 Most water bodies within the River Ock catchment are at Poor Ecological Status with a Poor biological element class, apart from *Ock (to Cherbury Brook)*, *Stutfield Brook (Source to Ock)*, *Childrey and Woodhill Brooks, Frilford and Marcham Brook,* and *Ginge Brook and Mill Brook*; all of which are at Moderate status with a biological element class of at least Moderate.

[76] Pers. comm. Stuart Manwaring (Environment Agency) via email on 03/11/2021.

Table 5.2 Baseline Ecological Status/Potential and Biological Classification

Reach	WFD Water Body Name	RBMP2 Status (2015)	Draft RBMP3 Status (2019)
1.1	Cow Common Brook and Portobello Ditch	Ecological Status ‘Poor’	Ecological Status ‘Poor’
		Biological elements ‘Poor’	Biological elements ‘Poor’
		Fish ‘Not classified’	Fish ‘Not classified’
		Invertebrates ‘Moderate’	Invertebrates ‘Moderate’
		Macrophytes and Phytobenthos ‘Poor’	Macrophytes and Phytobenthos ‘Poor’
1.2	Childrey Brook and Norbrook[77] at Common Barn	Ecological Status ‘Poor’	Ecological Status ‘Poor’
		Biological elements ‘Poor’	Biological elements ‘Poor’
		Fish ‘Not classified’	Fish ‘Not classified’
		Invertebrates ‘High’	Invertebrates ‘High’
		Macrophytes and Phytobenthos ‘Poor’	Macrophytes and Phytobenthos ‘Poor’
2.1	Ock and tributaries (Land Brook confluence to Thames)	Ecological Status ‘Poor’	Ecological Status ‘Poor’
		Biological elements ‘Poor’	Biological elements ‘Poor’
		Fish ‘Poor’	Fish ‘Poor’
		Invertebrates ‘High’	Invertebrates ‘High’
		Macrophytes and Phytobenthos ‘Good’	Macrophytes and Phytobenthos ‘Good’
2.2	Ock (to Cherbury Brook)	Ecological Status ‘Moderate’	Ecological Status ‘Moderate’
		Biological elements ‘Good’	Biological elements ‘Good’
		Fish ‘Not classified’	Fish ‘Not classified’
		Invertebrates ‘Good’	Invertebrates ‘Good’
		Macrophytes and Phytobenthos ‘Good’	Macrophytes and Phytobenthos ‘Good’
2.3	Stutfield Brook (Source to Ock)	Ecological Status ‘Moderate’	Ecological Status ‘Moderate’
		Biological elements ‘Moderate’	Biological elements ‘Moderate’
		Fish ‘Not classified’	Fish ‘Not classified’
		Invertebrates ‘Moderate’	Invertebrates ‘Good’

[77] Also named Nor Brook on Ordnance Survey maps.

Reach	WFD Water Body Name	RBMP2 Status (2015)	Draft RBMP3 Status (2019)
		Macrophytes and Phytobenthos 'Moderate'	Macrophytes and Phytobenthos 'Moderate'
2.4	Childrey and Woodhill Brooks	Ecological Status 'Moderate'	Ecological Status 'Moderate'
		Biological elements 'Moderate'	Biological elements 'Moderate'
		Fish 'Not classified'	Fish 'Not classified'
		Invertebrates 'Moderate'	Invertebrates 'Moderate'
		Macrophytes and Phytobenthos 'Moderate'	Macrophytes and Phytobenthos 'Moderate'
2.5	Letcombe Brook	Ecological Status 'Poor'	Ecological Status 'Poor'
		Biological elements 'Poor'	Biological elements 'Poor'
		Fish 'Not classified'	Fish 'Poor'
		Invertebrates 'High'	Invertebrates 'High'
		Macrophytes and Phytobenthos 'Poor'	Macrophytes and Phytobenthos 'Moderate'
2.6	Frilford and Marcham Brook	Ecological Status 'Moderate'	Ecological Status 'Moderate'
		Biological elements 'Moderate'	Biological elements 'Moderate'
		Fish 'Not classified'	Fish 'Not classified'
		Invertebrates 'Good'	Invertebrates 'Good'
		Macrophytes and Phytobenthos 'Moderate'	Macrophytes and Phytobenthos 'Moderate'
2.7	Sandford Brook (source to Ock)	Ecological Status 'Poor'	Ecological Status 'Poor'
		Biological elements 'Poor'	Biological elements 'Poor'
		Fish 'Not classified'	Fish 'Not classified'
		Invertebrates 'Good'	Invertebrates 'Good'
		Macrophytes and Phytobenthos 'Poor'	Macrophytes and Phytobenthos 'Poor'
3	Ginge Brook and Mill Brook	Ecological Status 'Moderate'	Ecological Status 'Moderate'
		Biological elements 'High'	Biological elements 'Moderate'
		Fish 'Not classified'	Fish 'Not classified'

Reach	WFD Water Body Name	RBMP2 Status (2015)	Draft RBMP3 Status (2019)
		Invertebrates 'High'	Invertebrates 'High'
		Macrophytes and Phytobenthos 'Not classified'	Macrophytes and Phytobenthos 'Moderate'
4 **5**	Thames (Evenlode to Thame)	Ecological Status 'Moderate'	Ecological Status 'Moderate'
		Biological elements 'Moderate'	Biological elements 'Moderate'
		Fish 'Moderate'	Fish 'Good'
		Invertebrates 'Moderate'	Invertebrates 'Moderate'
		Macrophytes and Phytobenthos 'Not classified'	Macrophytes and Phytobenthos 'Not classified'
6	Thames Wallingford to Caversham	Ecological Potential 'Moderate'	Ecological Potential 'Moderate'
		Biological elements 'Moderate'	Biological elements 'High'
		Fish 'Not classified'	Fish 'Not classified'
		Invertebrates 'Moderate'	Invertebrates 'High'
		Macrophytes and Phytobenthos 'Good'	Macrophytes and Phytobenthos 'Not classified'
	Thames (Reading to Cookham)	Ecological Potential 'Moderate'	Ecological Potential 'Moderate'
		Biological elements 'High'	Biological elements 'Good'
		Fish 'Not classified'	Fish 'Not classified'
		Invertebrates 'High'	Invertebrates 'Good'
		Macrophytes and Phytobenthos 'Not classified'	Macrophytes and Phytobenthos 'Not classified'
	Thames (Cookham to Egham)	Ecological Potential 'Moderate'	Ecological Potential 'Moderate'
		Biological elements 'Good'	Biological elements 'Good'
		Fish 'Not classified'	Fish 'Not classified'
		Invertebrates 'Good'	Invertebrates 'Good'
		Macrophytes and Phytobenthos 'Not classified'	Macrophytes and Phytobenthos 'Not classified'

Reach	WFD Water Body Name	RBMP2 Status (2015)	Draft RBMP3 Status (2019)
7 **8**	Thames (Cookham to Egham)	Ecological Potential 'Moderate'	Ecological Potential 'Moderate'
		Biological elements 'Good'	Biological elements 'Good'
		Fish 'Not classified'	Fish 'Not classified'
		Invertebrates 'Good'	Invertebrates 'Good'
		Macrophytes and Phytobenthos 'Not classified'	Macrophytes and Phytobenthos 'Not classified'
9	Thames (Cookham to Egham)	Ecological Potential 'Moderate'	Ecological Potential 'Moderate'
		Biological elements 'Good'	Biological elements 'Good'
		Fish 'Not classified'	Fish 'Not classified'
		Invertebrates 'Good'	Invertebrates 'Good'
		Macrophytes and Phytobenthos 'Not classified'	Macrophytes and Phytobenthos 'Not classified'
	Thames (Egham to Teddington)	Ecological Potential 'Poor'	Ecological Potential 'Poor'
		Biological elements 'Poor'	Biological elements 'Poor'
		Fish 'Not classified'	Fish 'Not classified'
		Invertebrates 'Good'	Invertebrates 'Poor'
		Macrophytes and Phytobenthos 'Poor'	Macrophytes and Phytobenthos 'Poor'
10 **11** **12** **13**	Thames (Egham to Teddington)	Ecological Potential 'Poor'	Ecological Potential 'Poor'
		Biological elements 'Poor'	Biological elements 'Poor'
		Fish 'Not classified'	Fish 'Not classified'
		Invertebrates 'Good'	Invertebrates 'Poor'
		Macrophytes and Phytobenthos 'Poor'	Macrophytes and Phytobenthos 'Poor'

5.43 Reasons for not achieving good (RNAG) are outlined in full within the WFD Compliance Assessment (Technical Supporting Document B5 Water Framework Directive Report). Broadly speaking (and excluding those water bodies included for reference ecological characterisation only, i.e., Reaches 2.2 to 2.6 and Reach 3) key RNAGs closely related to failures of biological elements within the study area include:

- **Reach 1.1: Cow Common Brook and Portobello Ditch**
  - Point source – continuous sewage discharge from urban and transport and domestic general public responsible for **macrophytes and phytobenthos**, phosphate and dissolved oxygen;
  - Diffuse source – poor livestock and nutrient management in the agriculture and rural land management category responsible for **macrophytes and phytobenthos**, phosphate and dissolved oxygen;
  - Physical modification – land use (arable) in the agriculture and rural land management category responsible for **invertebrates**;
  - Natural – drought responsible for dissolved oxygen and other natural conditions responsible for **invertebrates**; and
  - Suspect data – responsible for **macrophytes and phytobenthos**.
- **Reach 1.2: Childrey Brook and Norbrook at Common Barn**
  - Point source – sewage discharge both intermittent and continuous from the water industry responsible for phosphate and **macrophytes and phytobenthos**;
  - Diffuse source – poor livestock management in the agriculture and rural land management category responsible for **phosphate and macrophytes and phytobenthos**; and
  - Physical modification – land use (arable) in the agriculture and rural land management category responsible for **macrophytes and phytobenthos**.
- **Reach 2.2: Ock and tributaries**
  - Point source – continuous and intermittent sewage discharge from the Water Industry responsible for phosphate;
  - Diffuse source – poor livestock and nutrient management in the agriculture and rural land management category responsible for phosphate; and
  - Physical modification – land drainage and barriers to ecological discontinuity from agriculture and land use management responsible for **fish**.
- **Reaches 4 and 5: Thames (Evenlode to Thame)**
  - Point source – continuous sewage discharge from the Water Industry responsible for phosphate and tributyltin compounds (as of 2019 tributyltin compounds are now at Good status, so no longer an issue);
  - Diffuse source – poor nutrient management in the agriculture and rural land management category responsible for phosphate;

- Invasive non-native species – North American signal crayfish responsible for **invertebrates**;
- Suspect data – responsible for **invertebrates**;

- **Reach 6: Thames (Wallingford to Caversham)**
  - Point source – continuous sewage discharge from the Water Industry responsible for phosphate;
  - Diffuse source – from agriculture and rural land management for phosphate; and
  - Physical modification – in the categories of Recreation, Navigation and Local and Central Government responsible for Mitigation Measures Assessment.
- **Reach 6: Thames (Reading to Cookham)**
  - Point source – continuous sewage discharge from the Water Industry responsible for phosphate; and
  - Physical modification – by local and central government, the water industry and for navigation responsible for Mitigation Measures Assessment.
- **Reaches 6 – 9: Thames (Cookham to Egham)**
  - Point source – continuous sewage discharge from the Water Industry responsible for **macrophytes and phytobenthos** combined, phosphate and temperature;
  - Diffuse source – poor nutrient management in the agriculture and rural land management category responsible for **macrophytes and phytobenthos** combined and phosphate. Transport Drainage in the urban and transport sector responsible for phosphate;
  - Physical modification – by local and central government, the water industry and for navigation responsible for Mitigation Measures Assessment. Water level management in impounded water bodies responsible for temperature; and
  - Flow – surface water abstraction by the water industry responsible for hydrological regime and low flow (not drought) responsible for temperature.
- **Reaches 10 – 13: Thames (Egham to Teddington)**
  - Point source – continuous sewage discharge from the Water Industry responsible for **macrophytes and phytobenthos** combined, phosphate and temperature;
  - Diffuse source – poor nutrient management in the agriculture and rural land management category responsible for **macrophytes and phytobenthos**

combined and phosphate. Transport Drainage in the urban and transport sector responsible for phosphate;

- Physical modification – by local and central government, the water industry and for navigation responsible for Mitigation Measures Assessment. Water level management in impounded water bodies responsible for temperature; and
- Flow – surface water abstraction by the water industry responsible for hydrological regime and low flow (not drought) responsible for temperature.

5.3.2 Designated aquatic sites baseline

5.44 A number of statutory and non-statutory designated sites are present within the Ock catchment and the River Thames within the study area. A separate Habitats Regulations Assessment (HRA) (Technical Supporting Document B4 Habitats Regulations Assessment) has been prepared for SESRO at Gate 2 which considers potential effects on European designated sites in earnest.

5.45 Sites not designated on account of aquatic habitats or species; and/or are not dependent on hydrological linkage to watercourses within the study area for the maintenance of their interest features were screened out (see Section 5.2.3 and Appendix A5.1 Ecological Data Baseline). Sites considered unlikely to be affected by the proposed scheme were also screened out, for example because they were outside of the indicative footprint and/or located upstream of watercourses that may experience changes in water quality or quantity. Those sites which are both designated on account of aquatic habitats or species and which, conceptually, may be at risk (either to footprint or through watercourse mediated changes), are identified in Table 5.3.

Table 5.3 Statutory and non-statutory designated sites associated with Reaches 1 to 5 and conceptually at risk from proposed scheme potential effects

Reach	Site name	Designation	Aquatic habitats within citation	Conceptually at risk of change (to footprint or through watercourse mediated effects)
1.1	The Cuttings and Hutchins Copse	Oxfordshire Local Wildlife Site	Includes the Cuttings which are a series of ponds alongside the railway. There is also a small area of sedge swamp and some wet woodland.	Y – potentially within indicative footprint
5	Hayward's Eyot	Oxfordshire Local Wildlife Site	Formerly an island, now comprises of channels either side of site with springs, ponds, and reedbed.	Y – hydrologically connected to the Thames in an area that could, conceptually, experience changes as a result of the proposed scheme
	Clifton Hampden Meadows	Oxfordshire Local Wildlife Site	Floodplain meadow with swamp and wet grassland areas.	
	Clifton Hampden Wood	Oxfordshire Local Wildlife Site	Includes wet woodland and wetland plants.	
	Little Wittenham	SAC* SSSI	Woodland with ponds, streams, calcareous flushes with extensive tufa deposits), and damp hollows fed by springs. Also a backwater of the River Thames.	
	Dorchester Meadow	Oxfordshire Local Wildlife Site	Floodplain meadow.	
	Dorchester Gravel Pits (Allen Pit)	Oxfordshire Local Wildlife Site	Former gravel pit which is now standing water habitat.	

*Note this citation is included for completeness but the qualifying feature of the SAC (great crested newt) and the habitats on which they depend, are not functionally linked to the area of the Little Wittenham site where potential risks from Thames have been identified (i.e. the Thames backwater). The HRA concluded no Likely Significant Effect (LSE) for this SAC.

5.46 A single site (The Cuttings and Hutchins Copse Local Wildlife Site; LWS) has the potential to fall within the indicative footprint due to its proximity to the proposed reservoir options. All other sites identified within Table 5.3 are conceptually at risk only by virtue of their connection (typically periodic; i.e., during flood events, rather than permanent) to the River Thames downstream of SESRO, and may be at risk should significant changes in frequency of and/or quality of water inundation be predicted. These risks are considered further within assessment sections of this Chapter.

5.47 In addition to those sites identified in -Table 5.3, SESRO sits within the impact zone[78] for three Sites of Special Scientific Interest (SSSIs) with aquatic features; Barrow Farm Fen SSSI, Frilford Heath Ponds and Fens SSSI and Culham Brake SSSI.

5.48 Culham Brake SSSI relies on surface water for maintenance of its aquatic interest features and sits adjacent to the Thames upstream of any influence of SESRO and as such is screened out of the Gate 2 assessment.

5.49 Frilford Heath Ponds and Fens SSSI (upstream of the site, adjacent to Marcham Brook, i.e., Reach 2.6) and Barrow Farm Fen SSSI (upstream of the site, adjacent to Sandford Brook, i.e., Reach 2.7) will not be directly affected by footprint or watercourse-mediated changes. However, Barrow Farm Fen SSSI, as well as other sites including non-statutory designated sites in the environs, are likely to be partly reliant on groundwater interaction[79] for the maintenance of aquatic interest features. The SESRO WFD assessment at Gate 2 concluded no potential compliance issues for groundwater bodies (and the designated sites they support) and SESRO itself does not fall within any defined WFD groundwater body. No specific risk has therefore been identified at this stage. However, the potential for groundwater-mediated effects to such sites, for example should the reservoir affect groundwater behaviour in the area by virtue of displacement that translates into a change for sites ‘upstream’ of SESRO, will be kept under review as part of subsequent Gates.

5.3.3 Fish community and notable species baseline

5.50 Baseline descriptions of the fish community and any notable fish species associated with each Reach within the study area are outlined in Table 5.4. For each Reach, the data sources which have been used to inform the baseline descriptions are identified

[78] The arbitrary rapid initial assessment zone for potential risks to SSSIs for planning purposes as available on https://magic.defra.gov.uk/magicmap.aspx.
[79] Barrow Farm Fen SSSI Citation https://designatedsites.naturalengland.org.uk/PDFsForWeb/Citation/1001521.pdf [accessed 3 June 2022]

alongside the baseline and interim WFD classifications for fish where these are available.

5.51 Detailed baseline data processing and analysis underpinning these summaries are reported in Appendix A5.1 Ecological Data Baseline. This appendix includes a matrix showing the Reaches within which notable and INNS fish species have previously been recorded across the available data sources. All Environment Agency and SRO monitoring locations included within the baseline reporting are shown in Figure 5.1 and Figure 5.2 in Appendix A1.1 Figures. The baseline description for Reach 5 also refers to the Thames Fish Habitat Survey which is presented in Appendix A5.3 Habitats Baseline – River Thames Fish Habitats.

5.52 The non-Thames watercourses (i.e., Reaches 1 to 3 as outlined in Table 1.1) are broadly characterised by low species richness (one to six species) and abundance. The lower Childrey Brook (Reach 1.2) and lower River Ock (Reach 2.1) are exceptions, with comparatively greater species richness (eight and 12 species respectively) and abundance compared to the rest of the Ock Catchment.

5.53 Fish species recorded at relatively high abundance within the non-Thames watercourses are typically minor species such as 3-spined stickleback, gudgeon, minnow and stone loach although larger species such as roach, are also abundant. Dace and bullhead are abundant in the River Ock, although bullhead have also been recorded in low numbers in most of the other non-Thames Reaches. Brown/sea trout have been recorded in Mere Dyke (Reach 1.1), lower Childrey Brook (Reach 1.2), lower River Ock (Reach 2.1), and Letcombe Brook (Reach 2.5). No INNS fish have been recorded in the non-Thames watercourses.

5.54 The River Thames (Reaches 4 to 13) supports a comparatively species-rich fish community in contrast to the non-Thames watercourses (Reaches 1 to 3) within the study area due to its size and concomitant fisheries habitat provision. The River Thames Reaches support between 18 and 24 species and there is high commonality between the Reaches in terms of species records. The Thames community is dominated (both in terms of species and abundance) by coarse fish. The highest densities apparent from the underpinning survey data across all Reaches are associated with roach and bleak, both known for their shoaling behaviour. Bleak and roach feed on invertebrates and algae, with juveniles in particular feeding primarily on small planktonic animals, although roach will also feed on aquatic plants and attached algae.[80]

5.55 Notable species recorded in the Thames Reaches include European eel (recorded in every study Reach), as well as other, less abundant, notable species including Atlantic salmon, barbel, brown/sea trout, bullhead, and lamprey. Lamprey records were generalised due to the low number of records across the study area including the upper and lower Thames, and high proportion of family-level records. However, those records which were species-level were all brook lamprey (*Lampetra planeri*).

5.56 The INNS common carp varieties have been recorded in every Thames Reach, typically at low abundance. Sunbleak and zander (also INNS) have also been reported in some Reaches in very low numbers, however, the identification of sunbleak is unconfirmed as it may have been confused with a bleak or bleak hybrid.[81] Of these, common carp and zander are high-priority INNS.

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[80] Maitland, P.S. (2004) *Keys to the freshwater fish of Britain and Ireland, with notes on their distribution and ecology*. Freshwater Biological Association Scientific Publication No. 62. Cumbria, UK: Freshwater Biological Association.

[81] Pers. comm. Environment Agency via email on 17/03/2022

Table 5.4 Baseline fish community and notable species by study area Reach

Reach	WFD (2015)	WFD (2019)	Data sources		Baseline description
1.1	Not classified	Not classified	EA		**Cow Common Brook:** There were limited data available for Cow Common Brook relative to other Reaches. Two sites were surveyed in 2008 for Thames Water as part of the Fisheries Baseline Survey (2009)[82]. Four species were found across both sites. The most abundant species were stone loach (*Barbatula barbatula)*, 3-spined stickleback (*Gasterosteus aculeatus*) and minnow (*Phoxinus phoxinus*), all species with medium to high tolerance to environmental disturbance as defined by FCS2. The other species was pike (*Esox lucius*) which also has medium tolerance to disturbance. More recently, eDNA sampling at three sites in 2021 only recorded 3-spined stickleback. No notable fish species or INNS have been recorded in Cow Common Brook in any dataset. **Portobello Ditch, Landmead Ditch, Mere Dyke, Oday Ditches,[83] and selected feeder ditches**: These ditches were sampled for eDNA in 2021. There were four fish species recorded in Mere Dyke (10-spined stickleback, ruffe (*Gymnocephalus cernuus*), and the notable species brown/sea trout* (*Salmo trutta*) and bullhead* (*Cottus gobio*), but no fish eDNA was found in other ditches surveyed suggesting that other than Mere Dyke, the ditches within the indicative footprint typically do not support fish.
			SRO eDNA	✔	
			SRO		
			TVERC		
			Supplementary	✔	
1.2	Not classified	Not classified	EA	✔	**Lower Childrey Brook:** The Childrey Brook supports eight species based on Environment Agency monitoring data and recent (2021) SRO eDNA sampling. These species are: 3-spined stickleback, gudgeon (*Gobio gobio*), minnow, pike, roach (*Rutilus rutilus*), stone loach, and the notable species bullhead* and brown/sea trout*; species with a wide range of tolerances (low to high) to environmental disturbance as defined by FCS2. TVERC records also include one record of bullhead near the Ock confluence in 2004. No INNS were reported
			SRO eDNA	✔	
			SRO		

[82] Cascade Consulting and APEM (2009) *Fisheries Baseline Survey*. Report on behalf of Thames Water.
[83] Oday ditches are included in Reach 1.1 (although technically the Thames water body) as they are within the indicative footprint and they are most similar in character to Ock Reaches/ditches.

Reach	WFD (2015)	WFD (2019)	Data sources		Baseline description
			TVERC	✔	in Childrey Brook across all datasets. Two sites were also surveyed in 2008 for Thames Water (sites 7 and 8) as part of the Fisheries Baseline Survey (2009)[84]. Eight species of fish (stone loach, roach, perch (*Perca fluviatilis*), gudgeon, dace (*Leuciscus leuciscus*), chub (*Squalius cephalus*), bullhead, and 10-spined stickleback) were recorded across these sites. The most abundant species were roach and gudgeon, species with high and medium tolerance to environmental disturbance, as defined by FCS2, respectively. The notable species bullhead was also recorded at site 8. **East Hanney Ditch:** Three sites on East Hanney Ditch were sampled for eDNA in 2021, but no fish eDNA was recorded at any site.
			Supplementary	✔	
2.1	Poor	Poor	EA	✔	**Lower River Ock:** The River Ock supports a diverse fish community (12 species recorded across Environment Agency monitoring, eDNA sampling in 2021, and TVERC records) including lithophilic (coarse substrate spawning) species, such as brown/sea trout* and dace. Supplementary report accounts (Fisheries Baseline Survey, 2009)[85] indicate that there is a healthy self-sustaining population of bullhead*, taken to indicate the presence of areas of well-oxygenated water flowing over a coarse substrate of gravel and cobbles. However, the most recent WFD fish classification information for the Ock (2014) is Poor (site EQR 0.17); the absence of chub and dace from the observed community having contributed to this, although both have been recorded
			SRO eDNA	✔	
			SRO		
			TVERC	✔	

[84] Cascade Consulting and APEM (2009) *Fisheries Baseline Survey*. Report on behalf of Thames Water.
[85] Cascade Consulting and APEM (2009) *Fisheries Baseline Survey*. Report on behalf of Thames Water.

Reach	WFD (2015)	WFD (2019)	Data sources		Baseline description
			Supplementary	✔	in other non-WFD classified sampling within the Ock. There have been multiple observations of the notable species bullhead and brown/sea trout (including *subsp. fario*) across samples, and one lamprey* (Petromyzontidae: unidentified species) was found in 2005; all of which have a low tolerance to environmental disturbance as defined by FCS2. No INNS were recorded in Environment Agency, SRO, or TVERC datasets. The Invasive Species Review (2009)[86] also recorded that the INNS common carp (*Cyprinus carpio*) was present within the River Ock catchment, however, the location of the species record(s) was unspecified, so it is unknown which Reach (2.1 to 2.7) the record(s) come from. Taken together, the evidence from these data sources highlights the potential importance of the River Ock for lithophilic species and, with the information to date, the River Ock may be considered as being particularly ecologically sensitive to impacts associated with flow changes. **Nor Brook:** There were no available fish data from Nor Brook.
2.2	Not classified	Not classified	EA		**Upper River Ock****: There were little data available for the Upper River Ock. Three species of fish (stone loach, and the notable species bullhead* and brown/sea trout*) were recorded in one survey conducted in 2008 for Thames Water (Fisheries Baseline Survey, 2009).[87] Bullhead have also been recorded several times in the TVERC data, most recently in 2020. These three species are all associated with oxygen rich, flowing watercourses with gravel/cobble beds and have a low or medium tolerance to environmental disturbance as defined by FCS2.
			SRO eDNA		
			SRO		
			TVERC	✔	
			Supplementary	✔	

[86] Cascade Consulting (2009) *Invasive Species Review*. Report on behalf of Thames Water.
[87] Cascade Consulting and APEM (2009) *Fisheries Baseline Survey*. Report on behalf of Thames Water.

Reach	WFD (2015)	WFD (2019)	Data sources		Baseline description
2.3	Not classified	Not classified	EA		**Stutfield Brook**:** The only available fish data from Stutfield Brook is one observation of the notable species bullhead* recorded in TVERC data from 2020.
			SRO eDNA		
			SRO		
			TVERC	✓	
			Supplementary		
2.4	Not classified	Not classified	EA		**Upper Childrey Brook**:** The only available fish data from the Upper Childrey Brook are from two sites which were surveyed in 2008 for Thames Water (sites 6 and 10) (Fisheries Baseline Survey, 2009)[88]. Six species of fish (stone loach, roach, minnow, gudgeon, 10-spined stickleback, and 3-spined stickleback) were recorded across these sites. The most abundant species were minnow, roach and gudgeon, all of which are typically tolerant to high or medium levels of environmental disturbance as defined by FCS2.
			SRO eDNA		
			SRO		
			TVERC		
			Supplementary	✓	
2.5	Not classified	Poor	EA	✓	**Letcombe Brook**:** Only three species have been recorded in Letcombe Brook. These are stone loach, and the notable species bullhead* and brown/sea trout* (including *subsp. fario*). These species are all associated with oxygen rich, flowing watercourses with gravel/cobble beds and have a low or medium tolerance to
			SRO eDNA		

[88] Cascade Consulting and APEM (2009) *Fisheries Baseline Survey*. Report on behalf of Thames Water.

Reach	WFD (2015)	WFD (2019)	Data sources		Baseline description
			SRO		environmental disturbance as defined by FCS2.
			TVERC	✔	
			Supplementary		
2.6	Not classified	Not classified	EA		**Marcham Brook**:** There were no available fish data from Marcham Brook. However, a post-pollution survey of Marcham Brook in 2015 recorded brown trout*, bullhead*, stone loach, minnow, pike, gudgeon and 3-spined stickleback.[89]
			SRO eDNA		
			SRO		
			TVERC		
			Supplementary		
2.7	Not classified	Not classified	EA		**Sandford Brook:** There were limited data available for Sandford Brook. One site was sampled for eDNA in 2021. This survey recorded bullhead*, 3-spined stickleback, minnow, and chub; species with a wide range of tolerances (low to high) to environmental disturbance as defined by FCS2. The notable species bullhead was also recorded in the TVERC data (three records, the most recent in 2020).
			SRO eDNA	✔	
			SRO		
			TVERC	✔	

[89] Pers. comm. Stuart Manwaring (Environment Agency) via email 30/08/2022.

Reach	WFD (2015)	WFD (2019)	Data sources		Baseline description
			Supplementary		
3	Not classified	Not classified	EA		**Ginge Brook and Mill Brook**:** There were no available fish data from Ginge Brook and Mill Brook.
			SRO eDNA		
			SRO		
			TVERC		
			Supplementary		
4	Moderate	Good	EA	✔	**River Thames (Upstream of SESRO (Evenlode to Culham)):** Across all data sources, 22 fish species have been recorded within Reach 4. Species assemblages were primarily composed of coarse species; roach and bleak (*Alburnus alburnus*) in particular being present in high abundance. These species are eurytopic, though typically most commonly associated with slow flowing, enriched waters and are considered to be highly tolerant to environmental disturbance as defined by FCS2. There was commonality in the species assemblages found across surveys and data sources. The most recent WFD fish classification information for the Thames (Reach 4) is Poor (site EQR 0.05); the
			SRO eDNA	✔	
			SRO	✔	
			TVERC	✔	

Reach	WFD (2015)	WFD (2019)	Data sources		Baseline description
			Supplementary	✔	absence of bullhead and minnow from the observed community, and lower than expected abundance of pike and roach, having contributed to this. Although all of these species have been recorded in other non-WFD classified sampling within this Reach. Notable species recorded in Reach 4 include barbel* (*Barbus barbus*), brook lamprey*, brown/sea trout* (including *subsp. fario*), bullhead*, European eel* (*Anguilla anguilla*), and lamprey* (Petromyzontidae: unidentified species), species with low tolerance to environmental disturbance, apart from barbel which have medium tolerance, and European eel which have high tolerance. INNS recorded include zander (*Sander lucioperca*) and common carp varieties. In addition to those data sources underpinning the above, supplementary project reports from Thames Water and the Environment Agency are available for the Thames that do not strictly align to the Reaches defined here for the purpose of this assessment (i.e., overlap Reaches 4, 5 and 6). These reports were undertaken in part to understand sensitivities associated with the fish community downstream of SESRO. For simplicity these data are therefore summarised under Reach 5; i.e., the Reach immediately downstream of SESRO.
5			EA	✔	**River Thames (Immediately downstream of SESRO combined intake/discharge structure up to the River Thame confluence):** Across all data sources, 22 fish species have been recorded within Reach 5. There was consistency in the species assemblages found across surveys and data sources. Species assemblages were primarily composed of coarse species; roach and bleak being present in high abundance. These species are eurytopic, though typically most commonly associated with slow flowing, enriched waters, and are considered to be highly tolerant to environmental disturbance as defined by FCS2. The most recent WFD fish classification information for the Thames (Reach 5 at Sutton Pools) is Moderate (site EQR 0.37); the absence
			SRO	✔	
			SRO eDNA	✔	
			TVERC	✔	

Reach	WFD (2015)	WFD (2019)	Data sources		Baseline description
			Supplementary	✔	of gudgeon and minnow from the observed community having contributed to this, although all have been recorded in other non-WFD classified sampling within this Reach. Notable species recorded in Reach 5 include barbel*, brown/sea trout* (including *subsp*. *fario*), bullhead*, and European eel*, species with low tolerance to environmental disturbance, apart from barbel which have medium tolerance, and European eel which have high tolerance. INNS include zander, and common carp varieties. SRO surveys also recorded the INNS sunbleak (*Leucaspius delineatus*), but this identification is unconfirmed. Sunbleak could have been confused with a bleak or bleak hybrid (pers. comm. Environment Agency on 17/03/2022). The Thames Fish habitat survey (Appendix A5.3 Habitats Baseline – River Thames Fish Habitats) found that the dominant habitat type along the River Thames in Reach 5 is deep glide, which covered 82.4% of the surveyed area. This provides suitable holding, feeding and refuge habitat for adult fish. Juvenile fish habitat was most commonly found in the margins and was estimated to cover at least 15.5% of the channel through Reach 5. Most of this juvenile habitat was emergent reeds (8.2%) or limited cover with fine substrate (6.2%). Large wood, which provides cover for both juvenile and adult fish, occupied 5.3% of the channel. Sutton Pools was found to provide particularly good juvenile habitat due to the presence of macrophytes and emergent plants, which are limited in Clifton and Culham Cuts due to the steep artificial banks present in these areas. It was therefore concluded that Sutton Pools provides the most diverse area of fish habitat for both juvenile and adult life stages within the surveyed area, with shallow areas of fine to medium substrate, emergent reeds, large wood, weir pool, and deep glide habitats present.

Sutton Pools has been specifically noted to function as important spawning and nursery habitat for some fish species by providing relatively warm, low velocity off-river habitat with abundant food for larval fish. The Fisheries Baseline Survey (2009)[90] found that Sutton Pools is an important spawning site for perch and roach, although early migration of larval perch from Sutton Pools to the main river suggests that such off-river habitats may not provide optimum nursery conditions for the developing perch fry. A survey comparing the larval fish communities between main river and off-river habitats[91] found that larval chub dominated the fish community in off-river habitats (Sutton Pools and Abingdon Marina (SESRO Reach 4)), suggesting that these sites provide particularly important nursery habitat for chub too. Similarly, this survey only recorded larval rudd within the off-river habitats, however, larval dace, stone loach, or minnow were only found within the main river, demonstrating that not all species use these sites for spawning or nursery habitat and therefore that off-line habitats contribute towards maintaining a diverse fish community. It is also thought that these relatively lower velocity habitats could provide refuge for larval fish which might otherwise be washed downstream, however the narrow openings to these habitats may make it difficult for fish to access them when flows are high.[92]

However, despite the importance of Sutton Pools and other off-river habitats, these supplementary fish surveys[93&94] agree that the highest density and species richness of larval and juvenile fish in the Thames is located in areas of marginal macrophytes within the main river channel. Phytophilic (plant-spawning) species (e.g., roach and bleak) are particularly successful in the River Thames, including at Sutton Pools, whereas spawning success for lithophilic species (e.g., gudgeon, barbel, and dace) is much more spatially restricted.

Lyons *et al*. (2021)[95] reported on annual hydroacoustic surveys 1994–2018 conducted on the Thames between Abingdon and Benson (covering at least parts of SESRO Reaches 4, 5, and 6). The fish community recorded in these surveys was similar to that reported from other data sources, being primarily composed of roach, bleak, perch, and chub. The margins were dominated by roach, but bleak dominated deeper mid-river habitats. For surveys conducted in the river margins, roach contributed 60.87% and bleak 17.17% to the total catch. Roach and bleak abundance for surveys conducted in the mid-river were 29.4% and 60.67%, respectively. The only other species that contributed more than 2% to the captured population were chub and perch. In the margin surveys, chub and perch contributed 4.29% and 9.20%, respectively. Chub and perch contributed 2.34% and 2.63%, respectively, to mid-river surveys. Surveys showed that fish density was

Reach	WFD (2015)	WFD (2019)	Data sources		Baseline description
					annually variable, with cyclical peaks in abundance every six to seven years. Over the combined period of hydroacoustic monitoring, there was no significant difference in mean fish density between the surveyed sections within the study area. Fish distribution was spatially patchy and sometimes clustered around habitat interrupting features (such as bridges, tributary confluences, lotic off-river features, navigation lock and backwater channel confluences, weirs, sluices, and islands) but many clusters (~60%) were located more than 100 m from any channel interrupting habitat feature. High summer flows in 2007 were linked to high fish densities in the following years, but no such peak was recorded after high summer flows in 2012. The authors tentatively hypothesise that the summer 2007 floodplain inundation may have benefited cohorts of roach and bleak from preceding years by providing rich summer feeding areas, indicated by increases observed in acoustic abundance during subsequent years.
6	Not classified	Not classified	EA	✔	**River Thames (Between River Thame and Thames Water Datchet intake):** Across all data sources, 24 fish species have been recorded within Reach 6. There was consistency in the species assemblages found across surveys and data sources. Species assemblages were primarily composed of coarse species; roach and bleak being present in high abundance. These species are eurytopic, though typically most commonly associated
			SRO eDNA	✔	

[90] Cascade Consulting and APEM (2009) *Fisheries Baseline Survey*. Report on behalf of Thames Water.
[91] APEM and Cascade Consulting (2008) *Larval Fish, Phytoplankton, Zooplankton and Water Quality Monitoring at Selected Sites in the Thames 2007*. Report on behalf of Thames Water.
[92] APEM and Cascade Consulting (2008) *Larval Fish, Phytoplankton, Zooplankton and Water Quality Monitoring at Selected Sites in the Thames 2007*. Report on behalf of Thames Water.
[93] Cascade Consulting and APEM (2009) *Fisheries Baseline Survey*. Report on behalf of Thames Water.
[94] APEM and Cascade Consulting (2008) *Larval Fish, Phytoplankton, Zooplankton and Water Quality Monitoring at Selected Sites in the Thames 2007*. Report on behalf of Thames Water.
[95] Lyons, J., Hateley, J., Peirson, G., Eley, F., Manwaring, S. and Twine, K. (2021) An assessment of hydroacoustic and electric fishing data to evaluate long term spatial and temporal fish population change in the River Thames, UK. *Water*, 13: 2932.

Reach	WFD (2015)	WFD (2019)	Data sources		Baseline description
	Not classified	Not classified	SRO	✔	with slow flowing, enriched waters and are considered to be highly tolerant to environmental disturbance as defined by FCS2. Notable species recorded in Reach 6 include Atlantic salmon* (*Salmo salar*), barbel*, brook lamprey*, brown/sea trout*, bullhead*, and European eel*, species with low tolerance to environmental disturbance, apart from barbel which have medium tolerance, and European eel which have high tolerance. INNS include common carp varieties. Other supplementary project reports are available from Thames Water and the Environment Agency and are summarised under Reach 5.
			TVERC		
	Not classified	Not classified	Supplementary	✔	
7			EA	✔	**River Thames (Between Thames Water Datchet intake and Affinity Water Sunnymeads intake):** Across all data sources, 23 fish species have been recorded within Reach 7. There was consistency in the species assemblages found across surveys and data sources. Species assemblages were primarily composed of coarse species; roach and bleak in particular being present in high abundance. These species are eurytopic, though typically most-commonly associated with slow flowing, enriched waters and are considered to be highly tolerant to environmental disturbance as defined by FCS2. Notable species recorded in Reach 7 include Atlantic salmon*, barbel*, brook lamprey*, brown/sea trout* (including *subsp*. *fario*), bullhead*, European eel*, and lamprey* (Petromyzontidae: unidentified species), species with low tolerance to environmental disturbance, apart from barbel which have medium tolerance, and European eel which have high tolerance. INNS include zander, and common carp varieties. SRO surveys also recorded the INNS sunbleak, but this identification is unconfirmed.
			SRO eDNA	✔	
			SRO	✔	
			TVERC		
			Supplementary		
8			EA	✔	**River Thames (Between Affinity Water Sunnymeads and Affinity Water Egham intake):** Across all data sources, 19 fish species have been recorded within Reach 8. There was consistency in the species assemblages found across surveys and data sources. Species assemblages were primarily composed of coarse species; dace, roach and bleak being present in high abundance. These species are eurytopic, though typically most commonly associated with slow flowing, enriched waters and are considered to be
			SRO eDNA	✔	
			SRO	✔	

Reach	WFD (2015)	WFD (2019)	Data sources		Baseline description
			TVERC		moderately to highly tolerant to environmental disturbance as defined by FCS2. Notable species recorded in Reach 8 include bullhead*, barbel*, and European eel*, species with low, medium, and high tolerance to environmental disturbance respectively. INNS include common carp varieties. SRO surveys also recorded the INNS sunbleak but this identification is unconfirmed.
			Supplementary		
9			EA	✔	**River Thames (Between Affinity Water Egham and Affinity Water Chertsey intake):** Across all data sources, 19 fish species have been recorded within Reach 9. There was consistency in the species assemblages found across surveys and data sources. Species assemblages were primarily composed of coarse species; roach and bleak in particular being present in high abundance. These species are eurytopic, though typically most commonly associated with slow flowing, enriched waters and are considered to be highly tolerant to environmental disturbance as defined by FCS2. Notable species recorded in Reach 9 include Atlantic salmon*, barbel*, bullhead*, and European eel*, species with low tolerance to environmental disturbance, apart from barbel which have medium tolerance, and European eel which have high tolerance. INNS include common carp varieties.
			SRO eDNA	✔	
			SRO		
	Not classified	Not classified	TVERC		
			Supplementary		
10			EA	✔	**River Thames (Between Affinity Water Chertsey intake and Affinity Water Walton (Desborough Island) intake):** Across all data sources, 22 fish species have been recorded within Reach 10. There was consistency in the species assemblages found across surveys and data sources. Species assemblages were primarily composed of coarse species; roach and bleak in particular being present in high abundance. These species are eurytopic, though typically most commonly associated with slow flowing, enriched waters and are considered to be highly tolerant to environmental disturbance as defined by FCS2. Notable species recorded in Reach 10 include Atlantic salmon*, barbel*, brown/sea trout*, bullhead*, and European eel*, species with low tolerance to environmental disturbance, apart from barbel which have medium tolerance, and European eel which have high tolerance. INNS include zander and common carp varieties.
			SRO eDNA	✔	
			SRO	✔	
			TVERC		
			Supplementary		

Reach	WFD (2015)	WFD (2019)	Data sources		Baseline description
11			EA	✔	**River Thames (Between Affinity Water Walton and Thames Water Walton intake):** Across all data sources, 18 fish species have been recorded within Reach 11. There was consistency in the species assemblages found across surveys and data sources. Species assemblages were primarily composed of coarse species; roach and bleak being present in high abundance. These species are eurytopic, though typically most commonly associated with slow flowing, enriched waters and are considered to be highly tolerant to environmental disturbance as defined by FCS2. Notable species recorded in Reach 11 include Atlantic salmon*, barbel*, bullhead*, and European eel*, species with low tolerance to environmental disturbance, apart from barbel which have medium tolerance, and European eel which have high tolerance. INNS include common carp varieties. SRO surveys also recorded the INNS sunbleak but this identification is unconfirmed.
			SRO eDNA		
			SRO	✔	
			TVERC		
			Supplementary		
12			EA	✔	**River Thames (Between Thames Water Walton and Thames Water Hampton intake):** Across all data sources, 18 fish species have been recorded within Reach 12. There was consistency in the species assemblages found across surveys and data sources. Species assemblages were primarily composed of coarse species; dace, roach and bleak being present in high abundance. These species are eurytopic, though typically most commonly associated with slow flowing, enriched waters and are considered to be moderately to highly tolerant to environmental disturbance as defined by FCS2. Notable species recorded in Reach 12 include bullhead*, European eel*, and lamprey* (Petromyzontidae: unidentified species), species with low tolerance to environmental disturbance, apart from European eel which have high tolerance. INNS include common carp varieties. SRO surveys also recorded the INNS sunbleak, but this identification is unconfirmed.
			SRO eDNA	✔	
			SRO	✔	
			TVERC		
			Supplementary		
13			EA	✔	**River Thames (Between Thames Water Hampton intake and Teddington Weir (tidal limit)):** Over all data sources, 23 fish species have been recorded within Reach 13. There was consistency in the species assemblages found across surveys and data sources. Species assemblages were primarily composed of
			SRO eDNA	✔	

Reach	WFD (2015)	WFD (2019)	Data sources		Baseline description
			SRO	✔	coarse species; roach and bleak being present in high abundance. These species are eurytopic, though typically most commonly associated with slow flowing, enriched waters and are considered to be highly tolerant to environmental disturbance as defined by FCS2. Notable species recorded in Reach 13 include Atlantic salmon*, barbel*, brown/sea trout*, bullhead* and European eel*, species with low tolerance to environmental disturbance, apart from barbel which have medium tolerance, and European eel which have high tolerance. INNS include zander and common carp varieties. SRO surveys also recorded the INNS sunbleak but this identification is unconfirmed.
			TVERC		
			Supplementary		

Notes:
**Notable species designations associated with species marked using an asterisk (i.e., their protected/designated/notable status) are outlined in Appendix A5.1 Ecological Data Baseline.*
*** Indicates Reaches that have been included as reference Reaches only, i.e., there are no scheme interactions within these Reaches.*

5.3.4 Invertebrate community and notable species baseline

5.57 Baseline descriptions of the invertebrate community and notable invertebrate species associated with each Reach within the study area are outlined in Table 5.5. For each Reach, the data sources which have been used to inform baseline descriptions are identified, alongside the baseline and interim WFD classifications for invertebrates where these are available.

5.58 Detailed baseline data processing and analysis underpinning these summaries are reported in Appendix A5.1 Ecological Data Baseline. This appendix includes a matrix showing the Reaches within which notable and INNS invertebrate species have previously been recorded across the available data sources. All Environment Agency and SRO monitoring locations included within the baseline reporting are shown in Figure 5.2, Figure 5.3, Figure 5.4 and Figure 5.7 in Appendix A1.1 Figures.

5.59 Biological metrics were used to characterise community condition and sensitivity to changes in environmental gradients (flow, sediment, water quality, etc). Metrics used in the description of community condition and sensitivity in Table 5.5[96] include:

- Whalley, Hawkes, Paisley & Trigg (WHPT):[97] an index that is primarily used to assess community impacts from (and sensitivity to) changes in organic water quality, but will also show responses to toxic pollution, siltation, habitat quality reduction and reduced flows. Derived metrics include Average Score Per Taxon (WHPT ASPT) and total number of scoring taxa (WHPT N taxa).
- Lotic-invertebrate Index for Flow Evaluation (LIFE):[98] an index used to assess community flow preference and sensitivity to changes in flow velocity. LIFE scores can be calculated on family-level or species-level data depending on the taxonomic resolution of the data collection. These indexes are hereafter referred to as LIFE(F) and LIFE(S) respectively.

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[96] Cascade Consulting and APEM (2009) *Fisheries Baseline Survey*. Report on behalf of Thames Water.
[96] APEM and Cascade Consulting (2008) *Larval Fish, Phytoplankton, Zooplankton and Water Quality Monitoring at Selected Sites in the Thames 2007*. Report on behalf of Thames Water.
[97] APEM and Cascade *Larval Fish, etc.*
[97] Cascade Consulting and APEM (2009) *Fisheries Baseline Survey*. Report on behalf of Thames Water.
[97] APEM and Cascade *Larval Fish, etc.*
[98] Lyons, J., Hateley, J., Peirson, G., Eley, F., Manwaring, S. and Twine, K. (2021) An assessment of hydroacoustic and electric fishing data to evaluate long term spatial and temporal fish population change in the River Thames, UK. *Water*, 13: 2932

- Proportion of Sediment-sensitive Invertebrates (PSI)[99] and Empirically weighted Proportion of Sediment-sensitive Invertebrates (EPSI):[100] indices designed to assess community impacts from (and sensitivity to) changes in sedimentation. PSI and EPSI scores can be calculated on family-level or mixed-level data depending on the taxonomic resolution of the data collection. These indexes are hereafter referred to as PSI/EPSI(F) and PSI/EPSI(S) respectively.
- The Community Conservation Index (CCI):[101] an index used to describe the conservation value of the invertebrate community, based on both taxa richness and the presence of notable species.

5.60 Biological indices for invertebrate communities from the non-Thames watercourses (Reaches 1 to 3) are broadly indicative of good water quality. There are exceptions such as Cow Common Brook (Reach 1.1), upper Childrey Brook (Reach 2.4) and Marcham Brook (Reach 2.6) where historically low ASPT is evident and lower than would be expected under unimpacted reference conditions for watercourses of their typology). Water quality data (Chapter 4 Water Quality) suggest that low flows in summer can result in water quality issues (including very low dissolved oxygen). Most Reaches support communities indicative of sedimented to heavily sedimented bed conditions, with moderate tolerance to reduced flows. There are exceptions; including the upper River Ock (Reach 2.2), Sandford Brook (Reach 2.7) and Ginge Brook (Reach 3) invertebrate communities, that exhibit high sensitivity to flow reduction; and Cow Common Brook, upper and lower Childrey Brook, Stutfield Brook (Reach 2.3), and Marcham Brook where low LIFE O:E scores indicate low flow stress.

5.61 Within the indicative footprint (Reaches 1.1 and 1.2) relatively few notable species have been recorded. Most are considered notable within the context of reporting solely on the basis of CCI scores rather than a JNCC accepted status assessment (e.g., at least Near Threatened (IUCN), 'rare or scarce' type listing within UK red lists or

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[99] Extence, C.A., Chadd, R.P., England, J., Dunbar, M.J., Wood, P.J. and Taylor, E.D. (2011) The assessment of fine sediment accumulation in rivers using macroinvertebrate community response. *River Research and Applications*, 29(1): 17–55.
[100] Turley, M.D., Bilotta, G.S., Chadd, R.P., Extence, C.A., Brazier, R.E., Burnside, N.G. and Pickwell, A.G.G. (2016) A sediment-specific family-level biomonitoring tool to identify the impacts of fine sediment in temperate rivers and streams. *Ecological Indicators*, 70: 151–165.
[101] Chadd, R. and Extence, C. (2004) The conservation of freshwater macroinvertebrate populations: a community-based classification scheme. *Aquatic Conservation: Marine and Freshwater Ecosystems*, 14: 597–624.

protected[102]/principal[103]/qualifying[104] species status). Some notable species have not been recorded for at least 15 years and are no longer considered likely to be present (for example white-clawed crayfish in the Letcombe Brook). Throughout the study area, beetles and caddisfly make up a significant proportion of all notable species, with true flies also a significant component notable records in the non-Thames Reaches.

5.62 Broadly, the invertebrate communities inhabiting the River Thames (Reaches 4 to 13) are indicative of good water quality, sedimented to heavily sedimented bed conditions and exhibit a low to moderate sensitivity to flow reduction. The exception is Reach 4 which has a higher mean LIFE score over the sampling period and higher sensitivity to flow reduction than communities recorded within other Thames Reaches. LIFE O:E scores are mostly at or near the reference state expected for a community of the watercourse typology, often exceeding the Environment Agency Hydroecological Validation (HEV) threshold below which the community would be described as being 'flow stressed'.[105] However, the most complete temporal sampling record available (within Reach 6) indicates that LIFE scores are variable over the sampling period, and broadly indicative of low flow stress within the study area.

5.63 The conservation value of the Thames community is variable but is typically much higher (up to Very High according to the maximum CCI score) than the non-Thames watercourses within the study area based on currently available data. This relates to the variable presence of a few rare species (e.g., the mayfly *Ephemera lineata*, the caddisflies *Leptocerus lusitanicus* and *Oecetis notata*, and the riffle beetles *Macronychus quadrituberculatus* and *Stenelmis canaliculata*) within sampling across the time period. Many of these species are typically associated with large lowland river systems, and so their rarity in the context of UK distribution may be a reflection of the relative scarcity of these types of rivers nationally as well as the lower volume of sampling in such systems.

5.64 Fine-lined pea mussel *Pisidium tenuilineatum* was recorded in both non-Thames Reaches (Reach 1.2 Childrey Brook and Reach 2.1 Lower River Ock) and Thames

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[102] Protected species include those formally protected through legislation such as the *Wildlife and Countryside Act 1981* (as amended) or European Protected Species receiving protection under *The Conservation of Species and Habitats Regulations 2017*.

[103] Species of Principal Importance are those identified within the *Natural Environment and Rural Communities (NERC) 2006*.

[104] Qualifying species are Annex II species as identified under the Habitats Directive, i.e. those species that are nor formally protected but are species of Community interest whose conservation requires the designation of Special Areas of Conservation.

[105] Environment Agency (2012) *Hydroecological validation using macroinvertebrate data.* Operational Instruction 318_10.

Reaches (Reaches 4, 6 and 13). It was not recorded in watercourses associated with the indicative location for SESRO and, within the Thames, occurs only very locally and in very low abundance, downstream of Oxford with the few specimens recorded considered likely to represent adventives (arising in abnormal positions) rather than populations.[106]

5.65 At least one INNS is present in every Reach. In non-Thames Reaches, the most commonly occurring invertebrate INNS is New Zealand mud snail, with American signal crayfish and an invasive freshwater shrimp (*Crangonyx pseudogracilis/ floridanus*) present in some Reaches. Of these, American signal crayfish is the only high priority INNS. The Thames Reaches support more INNS than are found in Reaches 1 to 3, with at least seven INNS recorded in all Reaches 4 to 13. Common INNS in the Thames Reaches include New Zealand mud snail, zebra and quagga mussels, Asian clam, Caspian mud shrimp, *Crangonyx pseudogracilis/ floridanus* demon shrimp and signal crayfish. Zebra mussel, demon shrimp, and signal crayfish are high priority INNS.

[106] Malacological Services and Cascade Consultancy (2009) *Rare Mollusc and Mussel Survey*. Report on behalf of Thames Water.

Table 5.5 Baseline macroinvertebrate community and notable species by study area Reach

Reach	WFD (2015)	WFD (2019)	Data sources		Baseline Description
1.1	Moderate	Moderate	EA	✔	**Cow Common Brook**: Mean biological metrics (post-2010 surveys only) are indicative of an invertebrate community suffering from stress due to reduced water quality (WHPT Total: 64.8; WHPT-ASPT: 4.4), in a watercourse with a sedimented bed (PSI(S): 26.4). The invertebrate community is moderately sensitive to reduced flows (LIFE(S): 6.8). O:E ratios for LIFE(S/F) and PSI(S/F) indicate that the invertebrate community is periodically impacted by reduced flows and fine sediment, however, this has only been assessed three times since 2010 (in 2013 and 2015). The CCI range (4.1–4.3) identifies the community as having Low conservation value. It is dominated by common species (especially Chironomidae (true fly)) that are tolerant of a wide range of environmental conditions, with beetles and molluscs making up a high proportion of the assemblage. Supplementary reports from Thames Water indicate that the brook sometimes dries up. The Native Crayfish Baseline Survey (2009)[107] determined that this made the brook poor habitat for crayfish. Thames Water surveyed three sites on Cow Common Brook for invertebrates in 2006 (Aquatic Macroinvertebrate Survey, 2009)[108] and found 64 taxa (range per sample: 26 to 43 taxa), with beetles the most diverse order. The only notable species observation (entire record period) from Cow Common Brook is more than 20 years old; the beetle *Agabus biguttatus** was recorded in 2000. The only INNS recorded in any of the datasets (entire record period) is the freshwater snail New Zealand mud snail
			SRO eDNA	✔	
			SRO		
			TVERC	✔	
			Supplementary	✔	

[107] Applied Ecology Ltd and Cascade Consulting (2009) *Native Crayfish Baseline Survey 2006–2008*. Report on behalf of Thames Water.
[108] Cascade Consulting and APEM (2009) *Aquatic Macroinvertebrate Survey*. Report on behalf of Thames Water.

					(*Potamopyrgus antipodarum*), which was recorded in low numbers in 1999 and 2000. The Invasive Species Review (2009)[109] recorded five INNS within the indicative footprint: Caspian mud shrimp (*Chelicorophium curvispinum*), the freshwater shrimp (*Crangonyx pseudogracilis*), zebra mussel (*Dreissena polymorpha*), American signal crayfish (*Pacifastacus leniusculus*), and New Zealand mud snail. However, the location of the species record(s) was unspecified, so it is unknown which watercourse these record(s) come from. **Portobello Ditch, Landmead Ditch, Mere Dyke, Oday Ditches,[110] and selected feeder ditches**: Ditch surveys (12 sites from ditches within the indicative location for SESRO) from Thames Water in 2006 (Aquatic Macroinvertebrate Survey, 2009)[111] found that most of the ditches contained similar assemblages, dominated by beetles and molluscs, but with no notable species. SRO eDNA samples collected in 2021 also did not record any notable species or INNS.
1.2	High	High	EA	✔	**Lower Childrey Brook**: Mean biological metrics (post-2010 surveys only) are indicative of good water quality (WHPT Total: 132.8; WHPT-ASPT: 5.3), with a sedimented riverbed (PSI(S): 24.5). The invertebrate community here is moderately sensitive to reduced flows (LIFE(S): 6.9). O:E ratios for LIFE(S/F) and PSI(S/F) indicate that the invertebrate community is impacted by reduced flows and fine sediment, however, this has not been assessed since 2013. The CCI (6.6) has only been assessed on one occasion since 2010; as having Moderate conservation value, being dominated by common species which are tolerant of poor environmental conditions, with high abundance of molluscs in particular. Two notable species have been recorded in Reach 1.2 (entire record period), including the native white clawed crayfish* (*Austropotamobius pallipes*) (likely now absent), and caddisfly
			SRO eDNA	✔	
			SRO		
			TVERC	✔	
			Supplementary	✔	

[109] Cascade Consulting (2009) *Invasive Species Review*. Report on behalf of Thames Water.
[110] Oday ditches are included in Reach 1.1 (although technically the Thames water body) as they are within the indicative footprint and they are most similar in character to Ock Reaches/ditches.
[111] Cascade Consulting and APEM (2009) *Aquatic Macroinvertebrate Survey*. Report on behalf of Thames Water.

					*Brachycentrus subnubilus**. A supplementary survey (Killeen, 2001[112]) reported in Thames Water's Rare Mollusc and Mussel Survey (2009)[113] also found fine-lined pea mussel* in 1998. The only INNS recorded in any of the datasets is the New Zealand mud snail and the freshwater shrimp *Crangonyx pseudogracilis/floridanus*. Native white clawed crayfish were known to be historically present at Marcham Mill. A small population estimated at 148 individuals was found at this site in 1998, and one individual was recorded in 2000, but a resurvey in 2004 found only dead natives (thought to be caused by a pollution incident). The Thames Water specialist Native Crayfish Baseline Survey (2009)[114] resurveyed these sites in 2006 to confirm if white clawed crayfish populations had recovered, but none were found and the report concluded that white clawed crayfish are no longer present within Childrey Brook. **East Hanney Ditch**: The only notable species that has been recorded in East Hanney Ditch (entire record period) is the beetle *Agabus chalconatus** which was recorded in 1999 in Environment Agency monitoring data. There has not been any Environment Agency monitoring since 2000 so the absence of this species in data from the last 20 years may reflect a lack of sampling. However, three eDNA samples were collected from East Hanney Ditch in 2021 and these samples found no notable species or INNS.
2.1	High	High	EA	✔	**Lower River Ock:** Mean biological metrics (post-2010 surveys only) are indicative of good water quality (WHPT Total: 113.2; WHPT-ASPT: 5.1). LIFE(S), PSI(S) and CCI has not been assessed since 2010. Mean PSI(F) (44.8) indicates that the riverbed is moderately sedimented, and LIFE(F)
			SRO eDNA	✔	

[112] Killeen, I.J. (2001) *An assessment of freshwater mollusca with particular reference to species of conservation value*. Supporting document for Abingdon Reservoir Environmental Statement. Prepared for Thames Water.
[113] Malacological Services and Cascade Consultancy (2009) *Rare Mollusc and Mussel Survey*. Report on behalf of Thames Water.
[114] Applied Ecology Ltd and Cascade Consulting (2009) *Native Crayfish Baseline Survey 2006-2008*. Report on behalf of Thames Water.

			SRO		(6.9) indicates that the community is moderately sensitive to reduced flows. O:E ratios for LIFE(F) and PSI(F) indicate that the invertebrate community is unimpaired by reduced flows and fine sediment, however, this has not been assessed since 2013. Samples are dominated by common species, including several caddisfly and mayfly, and high numbers of molluscs. Twelve notable species have been recorded in Reach 2.1 (entire record period). These are: fine-lined pea mussel*, the true bug *Mesovelia furcata**, five beetle species (*Gyrinus urinator**, *Anacaena bipustulata**, *Hydraena testacea**, *Riolus subviolaceus**, and *Notaris scirpi**), three caddisfly species (*Brachycentrus subnubilus**, *Potamophylax rotundipennis**, and *Ceraclea albimacula**), and two true flies (*Simulium angustitarse** and *Oxycera pardalina**). Thames Water's Rare Mollusc and Mussel Survey (2009)[115] suggested that the River Ock population of fine-lined pea mussel is of national importance. The only INNS recorded in any of the datasets is New Zealand mud snail and the freshwater shrimp *Crangonyx pseudogracilis/floridanus*, but the Thames Water Native Crayfish Baseline Survey (2009)[116] found small numbers of American signal crayfish in 2006. Supplementary reports from Thames Water include invertebrate surveys on the River Ock (upper and lower) in 2006 and 2008 (Aquatic Macroinvertebrate Survey, 2009).[117] These surveys found that the River Ock was characterised by rich assemblages of caddisflies and beetles, but most species were nationally common and there were no species of high conservation interest. The River Ock had higher species richness and abundance than all other sampled sites in the Ock catchment. The Invasive Species Review (2009)[118] recorded three INNS within the Ock catchment: the
			TVERC	✔	
			Supplementary	✔	

[115] Malacological Services and Cascade Consultancy (2009) *Rare Mollusc and Mussel Survey*. Report on behalf of Thames Water.
[116] Applied Ecology Ltd and Cascade Consulting (2009) *Native Crayfish Baseline Survey 2006-2008*. Report on behalf of Thames Water.
[117] Cascade Consulting and APEM (2009) *Aquatic Macroinvertebrate Survey*. Report on behalf of Thames Water.
[118] Cascade Consulting (2009) *Invasive Species Review*. Report on behalf of Thames Water.

					freshwater shrimp *Crangonyx pseudogracilis,* American signal crayfish, and New Zealand mud snail. However, the location of the species record(s) was unspecified, so it is unknown which Reach (2.1 to 2.7) these record(s) come from. **Nor Brook:** There were no available invertebrate data from Nor Brook.
2.2	Good	Good	EA	✔	**Upper River Ock**:** Mean biological metrics (post-2010 surveys only) are indicative of good water quality (WHPT Total: 98.5; WHPT-ASPT: 5.2), with a moderately sedimented riverbed (PSI(S): 50.0). The invertebrate community here is highly sensitive to reduced flows (LIFE(S): 7.7). O:E ratios for LIFE(S/F) and PSI(S/F) indicate that the invertebrate community is unimpaired by reduced flows and fine sediment, however, this has not been assessed since 2015. The CCI (3.9) has only been assessed on one occasion since 2010; as having Low conservation value, being dominated by common species, with high abundance of molluscs and riffle beetles (Elmidae) in particular. Two notable species have been recorded in Reach 2.2 (entire record period): the beetle *Anacaena bipustulata**, and the caddisfly *Lepidostoma basale**. The only INNS recorded in any of the datasets is New Zealand mud snail and American signal crayfish. Other supplementary project data were available from Thames Water and is summarised under Reach 2.1.
			SRO eDNA		
			SRO		
			TVERC		
			Supplementary	✔	
2.3	Moderate	Good	EA	✔	**Stutfield Brook**:** Mean biological metrics (post–2010 surveys only) are indicative of good water quality (WHPT Total: 95.7; WHPT-ASPT: 5.1), with a sedimented riverbed (PSI(S): 32.0). The invertebrate community here is moderately sensitive to reduced flows (LIFE(S): 7.1). O:E ratios for LIFE(S/F) and PSI(S/F) indicate that the invertebrate community is sometimes impacted by reduced flows and fine sediment. The CCI range (4.5 to 8.2) indicates a community of Low to Moderate conservation value. It is dominated by common species, with high
			SRO eDNA		
			SRO		
			TVERC	✔	

			Supplementary		abundance of molluscs and riffle beetles (Elmidae) in particular. Only one notable species has been recorded in Reach 2.3 (entire record period): the caddisfly *Potamophylax rotundipennis**. There have been three INNS recorded across the datasets. These are New Zealand mud snail, the freshwater shrimp *Crangonyx pseudogracilis/floridanus* (a freshwater shrimp), and American signal crayfish.
2.4	Moderate	Moderate	EA	✔	**Upper Childrey Brook**:** Mean biological metrics (post-2010 surveys only) are indicative of good water quality (WHPT Total: 70.7; WHPT-ASPT: 4.1), with the riverbed being highly sedimented (PSI(S): 11.6). The invertebrate community here is insensitive to reduced flows (LIFE(S): 6.4). O:E ratios for LIFE(S/F) and PSI(S/F)) are consistently below the Environment Agency HEV[119] threshold (especially for PSI) indicating that the invertebrate community is impaired by reduced flows and fine sediment. The CCI range (4.1 to 9.1) indicates a community of Low to Moderate conservation value. It is dominated by common species which are tolerant of poor environmental conditions, with high abundance of molluscs in particular. Only one notable species has been recorded in Reach 2.4 (entire record period): the caddisfly *Mystacides nigra**. The only INNS recorded in any of the datasets is the New Zealand mud snail.
			SRO eDNA		
			SRO		
			TVERC		
			Supplementary		
2.5	High	High	EA	✔	**Letcombe Brook**:** Mean biological metrics (post-2010 surveys only) are indicative of good water quality (WHPT Total: 142.2; WHPT-ASPT: 5.4). LIFE(S), PSI(S) and CCI has not been assessed since 2010. Mean PSI(F) (57.0) indicates that the riverbed is moderately sedimented, and family-level LIFE(F) (7.2) indicates that the community is moderately sensitive to reduced flows. O:E ratios for LIFE(F) and PSI(F) indicate that the invertebrate community is unimpaired by reduced flows and fine sediment, however, this has not been assessed since 2013. Samples have generally high diversity, but are dominated by common species, especially crustaceans and
			SRO eDNA		
			SRO		
			TVERC	✔	

[119] Environment Agency (2012) *Hydroecological validation using macroinvertebrate data*. Operational Instruction 318_10.

			Supplementary	✔	Chironomidae (true fly). Fourteen notable species have been recorded in Reach 2.5 (entire record period); including the white clawed crayfish*, which was regularly recorded in 2000–2004 in the headwaters at Wantage (TVERC data) but has not been recorded since. The other notable species are: four beetle species (*Elodes elongata**, *Riolus subviolaceus**, *Drupenatus nasturtii**, and *Gymnetron villosulum**), two caddisflies (*Rhyacophila fasciata** and *Potamophylax rotundipennis**), and seven true flies (*Dicranomyia lucida**, *Eloeophila apicata**, *Beris fuscipes**, *Oxycera analis**, *Oxycera morrisii**, *Oxycera pardalina**, *Stratiomys potamida**). The only INNS recorded in any of the datasets is the New Zealand mud snail.
2.6	Good	Good	EA	✔	**Marcham Brook****: Mean biological metrics (post-2010 surveys only) are indicative of good water quality (WHPT Total: 97.9; WHPT-ASPT: 4.5). LIFE(S), PSI(S) and CCI has not been assessed since 2010. Mean PSI(F) (36.3) indicates that the riverbed is sedimented, and LIFE(F) (6.6) indicates that the community is moderately sensitive to reduced flows. O:E ratios for LIFE(F) and PSI(F) indicate that the invertebrate community is periodically impacted by reduced flows and fine sediment, however, this has not been assessed since 2013. It is dominated by common species, with high abundance of molluscs and crustaceans in particular. Five notable species have been recorded in Reach 2.6 (entire record period). These are: Desmoulin's whorl snail* (*Vertigo moulinsiana*), depressed river mussel* (*Pseudanodonta complanata*), the mayfly *Paraleptophlebia cincta**, the caddisfly *Brachycentrus subnubilus**, and the native white clawed crayfish* which has not been observed since one individual was recorded in 2001. The Native Crayfish Baseline Survey (2009)[120] conducted by Thames Water in 2008 found no native crayfish, concluding that this species is no longer present in Marcham Brook. The only INNS recorded in any of the datasets is the New Zealand mud snail.
			SRO eDNA		
			SRO		
			TVERC	✔	
			Supplementary	✔	

120 Applied Ecology Ltd and Cascade Consulting (2009) *Native Crayfish Baseline Survey 2006-2008*. Report on behalf of Thames Water.

2.7	Good	Good	EA	✔	**Sandford Brook**: Mean biological metrics (post-2010 surveys only) are indicative of good water quality (WHPT Total: 104.1; WHPT-ASPT: 5.8), with the riverbed being moderately sedimented (PSI(S): 44.4). The invertebrate community here is highly sensitive to reduced flows (LIFE(S): 8.2). O:E ratios for LIFE(S/F) and PSI(S/F) suggest that the invertebrate community is unimpaired by reduced flows and fine sediment, however, this has not been assessed since 2015. The CCI (10.3) has only been assessed on one occasion since 2010; as having Fairly High conservation value, related to the presence of the true fly *Simulium angustitarse**. It is dominated by common species, especially Chironomidae (true fly) and crustaceans, with several abundant mayfly species. Twenty-four notable species have been recorded in Reach 2.7 (entire record period). These are: Desmoulin's whorl snail*, two damselflies (*Coenagrion mercuriale** and *Coenagrion pulchellum**), the dragonfly *Gomphus vulgatissimus**, five beetles (*Agabus uliginosus**, *Enochrus quadripunctatus**, *Chaetarthria seminulum**, *Limnebius papposus**, and *Elodes elongata**), and 15 true flies (including two cranefly, one blackfly, eight soldier fly, two horsefly, one hoverfly, and one marsh fly). This includes many observations of the rare damselfly *Coenagrion mercuriale* in Dry Sandford Pit SSSI and Parsonage Moor. The only INNS recorded in any of the datasets is New Zealand mud snail, but American signal crayfish were recorded in 2004 according to the Native Crayfish Baseline Survey (2009).[121]
			SRO eDNA	✔	
			SRO		
			TVERC	✔	
			Supplementary	✔	
3	High	High	EA	✔	**Ginge Brook and Mill Brook****: Mean biological metrics (post-2010 surveys only) are indicative of good water quality (WHPT Total: 127.3; WHPT-ASPT: 5.8), with the riverbed being slightly sedimented (PSI(S): 67.1). The invertebrate community here is sensitive to reduced flows (LIFE(S): 8.2), but LIFE(S/F) O:E ratios indicate that the community is not impaired by reduced flows. PSI(S/F) ratios show that the community is also not impacted by fine sediment. The CCI
			SRO eDNA		
			SRO		

[121] Applied Ecology Ltd and Cascade Consulting (2009) *Native Crayfish Baseline Survey 2006-2008*. Report on behalf of Thames Water.

			TVERC Supplementary	✔ ✔	range (7.3 to 11.3) indicates a community of Moderate to Fairly High conservation value. The species most commonly linked to high CCI in Reach 3 are the caddisfly *Lepidostoma basale** and beetle *Riolus subviolaceus**. It is dominated by common species, especially Chironomidae (true fly) and crustaceans, with several abundant mollusc, mayfly, and riffle beetle (Elmidae) species. There have been eight notable species recorded in Reach 3 (entire record period). These are: the shrimp *Niphargus aquilex**, two beetles (*Riolus cupreus** and *Riolus subviolaceus*), and five caddisflies (*Rhyacophila fasciata**, *Tinodes unicolor**, *Brachycentrus subnubilus**, *Lepidostoma basale*, and *Potamophylax rotundipennis**). No INNS have been recorded in the datasets, but the Thames Water Native Crayfish Baseline Survey (2009)[122] found American signal crayfish in Ginge Brook in 2006, probably sourced from the established population in the Thames.
4	Moderate	Moderate	EA SRO eDNA SRO TVERC Supplementary	✔ ✔ ✔ ✔ ✔	**River Thames (Upstream of SESRO (Evenlode to Culham)):** Mean biological metrics (post-2010 surveys only) are indicative of good water quality (WHPT Total: 107.1; WHPT-ASPT: 5.5), despite the riverbed being sedimented (PSI(S): 38.1). The invertebrate communities have moderate sensitivity to reduced flows (LIFE(S): 7.3) and are not impaired by reduced flows according to the LIFE(S/F) O:E ratios. PSI(M/F) ratios show that the community is also not impacted by fine sediment. The CCI range (1.0 to 31.5) indicates a community of Low to Very High conservation value. This wide range is linked to occasional records of the rare mayfly *Ephemeroptera lineata**, fine-lined pea mussel*, and beetle *Riolus subviolaceus**. Seventeen notable species have been recorded in Reach 4 (entire record period). These are: the Thames ram's horn snail* (*Gyraulus acronicus*: which was only recorded once in 1998), three mussel species (depressed river mussel*, swollen river mussel* (*Unio tumidus*), and fine-lined pea mussel), four mayflies (*Baetis buceratus**, *Procloeon bifidium**, *Kageronia fuscogrisea**, and *Ephemera lineata*), the damselfly *Coenagrion pulchellum**, the dragonfly *Gomphus*

122 Applied Ecology Ltd and Cascade Consulting (2009) *Native Crayfish Baseline Survey 2006-2008*. Report on behalf of Thames Water.

					*vulgatissimus**, three beetles (*Gyrinus urinator**, *Hydraena nigrita**, and *Riolus subviolaceus*), and four caddisflies (*Brachycentrus subnubilus**, *Limnephilus politus**, *Ceraclea senilis**, and *Mystacides nigra**). There were also eight INNS including New Zealand mud snail, Asian clam (*Corbicula fluminea*), American signal crayfish, bloody red shrimp (*Hemimysis anomala*), Caspian mud shrimp, the freshwater shrimp *Crangonyx pseudogracilis* and *Crangonyx pseudogracilis/floridanus*, and demon shrimp (*Dikerogammarus haemobaphes*). In addition to those data sources underpinning the above, other supplementary project reports from Thames Water are available for the Thames that do not strictly align to the Reaches defined here for the purpose of this assessment (i.e., overlap Reaches 4, 5 and 6). These reports were broadly undertaken to understand sensitivities associated with the invertebrate community and the presence of rare mussels and molluscs downstream of SESRO. For simplicity these data are therefore summarised under Reach 5; i.e., the Reach immediately downstream of SESRO.
5			EA	✔	**River Thames (Immediately downstream of SESRO combined intake/discharge structure up to the River Thame confluence):** Mean biological metrics (post-2010 surveys only) are indicative of good water quality (WHPT Total: 106.3; WHPT-ASPT: 5.0), despite the riverbed being heavily sedimented (PSI(S): 17.6). The invertebrate communities have low sensitivity to reduced flows (LIFE(S): 6.9) and are not impaired by reduced flows according to the LIFE(S/F) O:E ratios. PSI(S/F) ratios suggest that the community is periodically impacted by fine sediment. The CCI range (11.3 to 28.2) indicates a community of Fairly High to Very High conservation value. This is
			SRO eDNA	✔	
			SRO	✔	
			TVERC	✔	

			Supplementary	✔	less variable than other Thames Reaches, however, there were fewer post-2010 samples (only four) in this Reach for which CCI had been calculated, compared to other Thames Reaches. The high conservation value largely relates to the presence of the rare mayfly *Ephemeroptera lineata**. Supplementary data from the Rare Mollusc and Mussel Survey (2009)[123] conducted by Thames Water in 2006 at sites in Reaches 4, 5 and 6 show that the Thames supports a high density of molluscs (21 gastropods, 11 bivalves, and four large unionid species). This report found nationally important populations of fine-lined pea mussel* and depressed river mussel*. Only a couple of dead Thames ram's horn snails* were found in surveys. Given that the only other observation of this species in any dataset is from 1998 it is possible that this species is no longer present in the Thames. Supplementary invertebrate surveys by Thames Water in 2005–2008 (Aquatic Macroinvertebrate Survey, 2009)[124] at sites in Reaches 4, 5 and 6 found that the community was typical of a relatively unpolluted nutrient rich lowland UK river, with similar species lists to Environment Agency monitoring samples. Notably, samples from Sutton Pools were less species rich, lacking crustaceans and caddisfly, than those elsewhere in the Thames. Nine notable species have been recorded in Reach 5 (entire record period). These are: three mussel species (swollen river mussel*, depressed river mussel*, and river orb mussel* (*Sphaerium rivicola*)), two mayflies (*Kageronia fuscogrisea** and *Ephemera lineata*), the dragonfly *Gomphus vulgatissimus**, two beetles (*Gyrinus urinator** and *Riolus subviolaceus**), and the caddisfly *Brachycentrus subnubilus**. There were also nine INNS including New Zealand mud snail, zebra mussel, quagga mussel (*Dreissena rostiformis bugensis*), Asian clam, American signal crayfish, bloody red shrimp, Caspian mud shrimp, the freshwater shrimp *Crangonyx*

[123] Malacological Services and Cascade Consultancy (2009) *Rare Mollusc and Mussel Survey*. Report on behalf of Thames Water.
[124] Cascade Consulting and APEM (2009) *Aquatic Macroinvertebrate Survey*. Report on behalf of Thames Water.

					pseudogracilis/floridanus, and demon shrimp. The Invasive Species Review (2009)[125] recorded seven INNS within the River Thames (Reaches 4 to 13): Asian clam, Caspian mud shrimp, the freshwater shrimp *Crangonyx pseudogracilis,* zebra mussel, Chinese mitten crab (*Eriocheir sinensis*), American signal crayfish, and New Zealand mud snail. However, the location of the species record(s) was unspecified, so it is unknown which Reach (4 to 13) these record(s) come from.
6	Moderate	High	EA	✔	**River Thames (Between River Thame and Thames Water Datchet intake):** Mean biological metrics (post-2010 surveys only) are indicative of good water quality (WHPT Total: 125.9; WHPT-ASPT: 5.1), despite the riverbed being sedimented (PSI(S): 28.7). The invertebrate communities have moderate sensitivity to reduced flows (LIFE(S): 7.0) and are generally not impaired by reduced flows according to the LIFE(S/F) O:E ratios. However, O:E ratios from the
			SRO eDNA	✔	
	High	Goo d	SRO	✔	

[125] Cascade Consulting (2009) *Invasive Species Review*. Report on behalf of Thames Water.

			TVERC		site with the most complete record (site: 82437) are sometimes below the Environment Agency HEV[126] threshold of flow stress (0.945) (notably 2015–2017) suggesting that flow reductions sometimes limit the invertebrate community. PSI(S/F) ratios suggest that the community is also periodically impacted by fine sediment at some sites. The CCI range (4.6 to 38.6) indicates a community of Low to Very High conservation value. This wide range relates to occasional records of the rare mayfly *Ephemeroptera lineata**, fine-lined pea mussel*, the beetles *Macronychus quadrituberculatus** and *Stenelmis canaliculata**, and the caddisfly *Leptocerus lusitanicus**. Twenty-nine notable species have been recorded in Reach 6 (entire record period). These are: four mussel species (swollen river mussel*, depressed river mussel*, river orb mussel*, and fine-lined mussel), the leech *Dina lineata**, four mayflies (*Baetis buceratus**, *Procloeon bifidium**, *Kageronia fuscogrisea**, and *Ephemera lineata*), the damselfly *Coenagrion pulchellum**, the dragonfly *Gomphus vulgatissimus**, the true bug *Micronecta scholtzi**, nine beetles (*Haliplus laminatus**, *Nebrioporus depressus**, *Gyrinus urinator**, *Helochares lividus**, *Enochrus melanocephalus**, *Macronychus quadrituberculatus*, *Oulimnius troglodytes**, *Riolus subviolaceus**, and *Stenelmis canaliculata*), and eight caddisflies (*Metalype fragilis**, *Holocentropus stagnalis**, *Brachycentrus subnubilus**, *Ceraclea albimacula**, *Ceraclea senilis**, *Leptocerus lusitanicus*, *Mystacides nigra**, and *Ylodes conspersus**). There were also ten INNS including New Zealand mud snail, zebra mussel, quagga mussel, Asian clam, American signal crayfish, bloody red shrimp, Caspian mud shrimp, the freshwater shrimp *Crangonyx floridanus* and *Crangonyx pseudogracilis/floridanus*, and demon shrimp. Other supplementary reports are available from Thames Water and are summarised under Reach 5.
	Good	Good	Supplementary	✔	

[126] Environment Agency (2012) *Hydroecological validation using macroinvertebrate data*. Operational Instruction 318_10.

7			EA	✔	**River Thames (Between Thames Water Datchet intake and Affinity Water Sunnymeads intake):** There are no Environment Agency samples post-2010 but there is likely to be similarity between the modern-day assemblages and metrics of Reach 7 and the surrounding Reaches. This is due to their connectivity and the fact that Reach 7 has similar habitat to the rest of the Thames where there is a high level of commonality in the community between Reaches. Eleven notable species have been recorded in Reach 7 (entire record period). These are: the swollen river mussel*, the leech *Glossiphonia verrucata**, four mayflies (*Baetis buceratus**, *Procloeon bifidium**, *Kageronia fuscogrisea**, and *Ephemera lineata**), the dragonfly *Gomphus vulgatissimus**, the beetle *Stenelmis canaliculata**, and three caddisflies (*Brachycentrus subnubilus**, *Leptocerus lusitanicus**, and *Mystacides nigra**). There were also eight INNS including New Zealand mud snail, zebra mussel, quagga mussel, Asian clam, bloody red shrimp, Caspian mud shrimp, the freshwater shrimp *Crangonyx pseudogracilis/floridanus*, and demon shrimp.
			SRO eDNA	✔	
			SRO	✔	
			TVERC		
			Supplementary		
8			EA	✔	**River Thames (Between Affinity Water Sunnymeads and Affinity Water Egham intake):** Mean biological metrics (post-2010 surveys only) are indicative of good water quality (WHPT Total: 148.5; WHPT-ASPT: 5.1), despite the riverbed being sedimented (PSI(S): 28.6). The invertebrate communities have low sensitivity to reduced flows (LIFE(S): 6.6). The CCI range (13.5 to 29.4) indicates that the community ranges from Fairly High to Very High conservation value. This is less variable than other Thames Reaches, however, there were fewer post-2010 samples (only two) in this Reach for which CCI had been calculated, compared to other Thames Reaches. The high CCI is related to the presence of the notable caddisflies *Leptocerus lusitanicus** and *Ceraclea senilis**. Eight notable species have been recorded in Reach 8 (entire record period). These are: two mussel species (swollen river mussel* and river orb mussel*), the mayfly *Procloeon bifidium**, the beetle *Macronychus quadrituberculatus**, four caddisflies (*Brachycentrus subnubilus**, *Ceraclea senilis*, *Leptocerus lusitanicus*, and *Mystacides nigra**). There were also eight INNS
			SRO eDNA	✔	
			SRO	✔	
			TVERC		
			Supplementary		

					including New Zealand mud snail, zebra mussel, quagga mussel, Asian clam, bloody red shrimp, Caspian mud shrimp, the freshwater shrimp *Crangonyx pseudogracilis/floridanus*, and demon shrimp.
9			EA	✔	**River Thames (Between Affinity Water Egham and Affinity Water Chertsey intake):** Mean biological metrics (post-2010 surveys only) are indicative of good water quality (WHPT Total: 124.5; WHPT-ASPT: 24.2), despite the riverbed being sedimented (PSI(S): 38.1). The invertebrate communities have low sensitivity to reduced flows (LIFE(S): 6.9) and are not impaired by reduced flows according to the LIFE(S/F) O:E ratios. PSI(S/F) ratios suggest that the community is periodically impacted by fine sediment. The CCI range (6.4 to 33.3) indicates a community of Moderate to Very High conservation value. This wide range relates to occasional records of the rare mayfly *Ephemeroptera lineata**, the caddisfly *Oecetis notata**, and the beetles *Macronychus quadrituberculatus** and *Stenelmis canaliculata**. Eighteen notable species have been recorded in Reach 9 (entire record period). These are: three mussel species (swollen river mussel*, depressed river mussel*, and river orb mussel*), the leech *Dina lineata**, the freshwater shrimp *Niphargus aquilex**, the mayfly *Ephemera lineata*, three beetles (*Gyrinus urinator**, *Macronychus quadrituberculatus*, and *Stenelmis canaliculata*), the spongefly *Sisyra terminalis**, seven caddisflies (*Brachycentrus subnubilus**, *Potamophylax rotundipennis**, *Limnephilus binotatus**, *Ceraclea senilis**, *Leptocerus lusitanicus**, *Mystacides nigra**, and *Oecetis notata*), and the blackfly *Simulium angustitarse**. There were also eight INNS including New Zealand mud snail, zebra mussel, quagga mussel, Asian clam, bloody red shrimp, Caspian mud shrimp, the freshwater shrimp *Crangonyx pseudogracilis/floridanus*, and demon shrimp.
			SRO eDNA	✔	
			SRO	✔	
	Good	Poor	TVERC		
			Supplementary		
10			EA	✔	**River Thames (Between Affinity Water Chertsey intake and Affinity Water Walton**

			SRO eDNA	✔	**(Desborough Island) intake)**: Mean biological metrics (post-2010 surveys only) are indicative of good water quality (WHPT Total: 136.6; WHPT-ASPT: 5.1), despite the riverbed being sedimented (PSI(S): 20.2). The invertebrate communities have low sensitivity to reduced flows (LIFE(S): 6.9). The CCI range (24.8 to 28.4) indicates a community of Very High conservation value. This is less variable than other Thames Reaches, however, there were fewer post-2010 samples (only four) in this Reach for which CCI had been calculated, compared to other Thames Reaches. The high CCI is related to the presence of the rare mayfly *Ephemeroptera lineata**, the caddisflies *Leptocerus lusitanicus** and *Oecetis notata**, and the beetle *Stenelmis canaliculata**. Eight notable species have been recorded in Reach 10 (entire record period). These are: swollen river mussel*, the mayfly *Ephemera lineata*, the beetle *Stenelmis canaliculata*, and five caddisflies (*Brachycentrus subnubilus**, *Ceraclea senilis**, *Leptocerus lusitanicus*, *Mystacides nigra**, and *Oecetis notata*). There were also seven INNS including New Zealand mud snail, zebra mussel, quagga mussel, Asian clam, Caspian mud shrimp, the freshwater shrimp *Crangonyx pseudogracilis/floridanus*, and demon shrimp.
			SRO	✔	
			TVERC		
			Supplementary		
11			EA	✔	**River Thames (Between Affinity Water Walton and Thames Water Walton intake)**: Mean biological metrics (post-2010 surveys only) are indicative of good water quality (WHPT Total: 103.6; WHPT-ASPT: 4.7), despite the riverbed being heavily sedimented (PSI(S): 14.8). The invertebrate communities have low sensitivity to reduced flows (LIFE(S): 6.6). The CCI range (3.0 to 28.8) indicates a community of Low to Very High conservation value. This wide range relates to occasional records of the rare mayfly *Ephemeroptera lineata**, the caddisflies *Leptocerus lusitanicus** and *Oecetis notata**. Fifteen notable species have been recorded in Reach 11 (entire record period). These are: two mussel species (swollen river mussel* and depressed river mussel*), the leech *Dina lineata**, the mayfly *Ephemera lineata*, the damselfly *Coenagrion pulchellum**, two beetles (*Macronychus quadrituberculatus** and *Stenelmis canaliculata**), the spongefly *Sisyra terminalis**, and six caddisflies (*Brachycentrus subnubilus**, *Ceraclea albimacula**, *Ceraclea senilis**, *Leptocerus*
			SRO eDNA		
			SRO	✔	
			TVERC		
			Supplementary		

					lusitanicus, *Mystacides nigra**, and *Oecetis notata*). There were also eight INNS including New Zealand mud snail, zebra mussel, quagga mussel, Asian clam, bloody red shrimp, Caspian mud shrimp, the freshwater shrimp *Crangonyx pseudogracilis/floridanus*, and demon shrimp.
12			EA		**River Thames (Between Thames Water Walton and Thames Water Hampton intake):** There were no Environment Agency samples post-2010 but there is likely to be similarity between the modern-day assemblages and metrics of Reach 12 and the surrounding Reaches. This is due to their connectivity and the fact that Reach 12 has similar habitat to the rest of the Thames where there is a high level of commonality in the community between Reaches. Four notable species have been recorded in Reach 12 (entire record period). These are: swollen river mussel*, the leech *Glossiphonia verrucata**, and two caddisflies (*Brachycentrus subnubilus** and *Mystacides nigra**). There were also eight INNS including New Zealand mud snail, zebra mussel, quagga mussel, Asian clam, American signal crayfish, Caspian mud shrimp, the freshwater shrimp *Crangonyx pseudogracilis/floridanus*, and demon shrimp.
			SRO eDNA	✔	
			SRO	✔	
			TVERC		
			Supplementary		
13			EA	✔	**River Thames (Between Thames Water Hampton intake and Teddington Weir (tidal limit)):** Mean biological metrics (post-2010 surveys only) are indicative of good water quality (WHPT Total: 106.1; WHPT-ASPT: 4.7), despite the riverbed being heavily sedimented (PSI(S): 11.4). The invertebrate communities have low sensitivity to reduced flows (LIFE(S): 6.6) and are not impaired by reduced flows according to the LIFE(S/F) O:E ratios. PSI(S/F) ratios suggest that the community is periodically impacted by fine sediment. The CCI range (7.4 to 22.1) indicates a community of Low to Very High conservation value. This wide range relates to occasional records of the rare mayfly *Ephemeroptera lineata**. Nine notable species have been recorded in Reach 13 (entire record period). These are: four mussel species (swollen river mussel*, depressed river mussel*, river orb mussel*, and fine-line pea mussel*), the mayfly *Ephemera lineata*, the beetle *Stenelmis canaliculata**, the spongefly *Sisyra terminalis**, and two caddisflies (*Brachycentrus subnubilus** and *Mystacides nigra**).
			SRO eDNA	✔	
			SRO	✔	
			TVERC		
			Supplementary		

					There were also nine INNS including New Zealand mud snail, zebra mussel, quagga mussel, Asian clam, Chinese mitten crab, bloody red shrimp, Caspian mud shrimp, the freshwater shrimp *Crangonyx pseudogracilis/floridanus*, and demon shrimp.

Notes:

** Notable species designations associated with species marked using an asterisk (i.e., their protected/designated/notable status) are outlined in Appendix A5.1 Ecological Data Baseline.*

*** Indicates Reaches that have been included as reference Reaches only, i.e., there are no scheme interactions within these Reaches.*

5.3.5 Macrophyte community and notable species baseline

5.66 Baseline descriptions of the macrophyte community and notable macrophyte species associated with each Reach within the study area are outlined in -Table 5.6. For each Reach, the data sources which have been used to inform the baseline descriptions are identified, alongside the baseline and interim WFD classifications for Macrophytes and Phytobenthos (combined) where these are available.

5.67 Detailed baseline data processing and analysis underpinning these summaries are reported in Appendix A5.1 Ecological Data Baseline. This appendix includes a matrix showing the Reaches within which notable and INNS macrophyte species have previously been recorded across the available data sources. All Environment Agency and SRO monitoring locations included within the baseline reporting are shown in Figure 5.4, Figure 5.5. and Figure 5.7 in Appendix A1.1 Figures. Where there was no available baseline macrophyte data, the baseline summary has been based upon observations made during a site visit in 2021, the full report of which is presented in Appendix A5.2 Habitats Baseline – Ock Watercourses.

5.68 Biological metrics were used to characterise community condition and sensitivity to changes in environmental gradients (predominantly nutrient water quality). Metrics used in the description of community condition and sensitivity in Table 5.6 include:[127]

- River Macrophyte Nutrient Index (RMNI): an index used to assess the impacts of nutrient enrichment on macrophyte communities, with higher scores indicating that the surveyed community prefers high nutrient concentrations.
- The number of taxa (N taxa) and the number of functional groups: these are measures of the diversity of a community. N taxa is the number of truly aquatic scoring taxa observed. Functional groups are assigned based on morphological characteristics, and the number of functional groups is a count of the number of groups which are represented within a survey.
- The percentage cover of filamentous algae: an indicator of acute nutrient releases. High algal cover can occur at sites where there are chronic or sudden increase of nutrient concentrations.

5.69 The macrophyte communities found in non-Thames watercourses (Reaches 1 to 3) are reflective of nutrient enriched, slow flowing watercourses. Cow Common Brook (Reach 1.1) and the lower Childrey Brook (Reach 1.2), in particular, had high RMNI scores, with O:E ratios indicative of Poor macrophyte WFD class. Species richness (N

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[127] WFD-UKTAG (2014*) UKTAG River Assessment Method Macrophytes and Phytobenthos. Macrophytes (River LEAFPACS2)* [online]. Available at: https://wfduk.org/resources/rivers-macrophytes [Accessed on: 22/02/2022].

taxa) and the number of functional groups was lower in the Ock catchment watercourses than in the Thames.

5.70 The Reaches with highest mean taxa richness in the Ock catchment are the lower Childrey Brook and the lower River Ock (Reach 2.1), and the highest mean functional diversity was in the upper River Ock (Reach 2.2) and Ginge Brook (Reach 3). Algae cover is generally low across all of the study Reaches, excepting Sandford Brook (Reach 2.7) and Cow Common Brook; however, algal cover was only surveyed once at these sites so survey conditions may not have been representative of longer-term conditions. There were no notable macrophytes recorded within the indicative footprint (Reaches 1.1 and 1.2), but notable species were recorded elsewhere in the Ock Catchment, including many notable species which were only recorded in and/or within the immediate environs of the Sandford Brook.

5.71 Broadly, the macrophyte communities of the River Thames (Reaches 4 to 13) are typical of large base-rich, lowland rivers, with high RMNI scores indicative of communities which prefer nutrient enriched conditions. The N taxa and number of functional groups are indicative of diverse habitat, although these indexes are very variable between Reaches, with Reach 10 having particularly low N taxa and number of functional groups. O:E ratios for Thames surveys conducted since 2012 are indicative of Good to High WFD class. There are a few notable species present in the Thames, generally with low percentage cover, however, Loddon pondweed was abundant in Reach 9. The only notable species recorded in Reach 5 (i.e., downstream of SESRO to confluence with Thame) are not obligate hydrophytes (i.e., are not explicitly associated with the river channel itself); see Table 5.6-.

5.72 The only macrophyte INNS which were recorded within the non-Thames watercourses are Canadian waterweed and Himalayan balsam, and these were only present in a small number of Reaches (lower Childrey Brook, Letcombe Brook: 2.5, Marcham Brook: 2.6, and Ginge Brook). In the Thames, INNS are present in every Reach, especially Nuttall's waterweed which was present in all Reaches. All these species are high-priority INNS.

5.73 Throughout the study area, WFD failures in the macrophyte and phytobenthos biological element are attributed primarily water quality issues associated with point and diffuse source pollution (see Section 5.3.1).

Table 5.6 Baseline macrophyte community and notable species by study area Reach

Reach	WFD (2015)	WFD (2019)	Data sources		Baseline Description
1.1	Poor	Poor	EA	✔	**Cow Common Brook:** There was only one post-2010 Environment Agency survey from Reach 1.1 (undertaken in 2013). The biological metrics calculated for this survey are indicative of macrophyte assemblages that prefer nutrient enriched watercourses (RMNI: 8.5). The N taxa for this sample is low (5), with representatives from 5 functional groups. The percentage cover of filamentous algae was high (37.5%); however, this site was only surveyed once so survey conditions may not have been representative of longer-term conditions. These metrics are indicative of Poor WFD class. The most dominant species in the Environment Agency data (25–50% cover) were reed sweet-grass (*Glyceria maxima*) and branched bur-reed (*Sparganium erectum*). No notable species or INNS have been recorded in Cow Common Brook in any dataset (entire record period). The Invasive Species Review (2009)[128] recorded five INNS within the reservoir footprint: New Zealand pygmyweed (*Crassula helmsii*), Nuttall's waterweed (*Elodea nuttallii*), Japanese knotweed (*Fallopia japonica*), Himalayan balsam (*Impatiens glandulifera*), and rhododendron (*Rhododendron ponticum*). However, the location of the species record(s) was unspecified, so it is unknown which watercourse these record(s) come from. **Portobello Ditch, Landmead Ditch, Mere Dyke, Oday Ditches,[129] and selected feeder ditches**: There are no available macrophyte data from these ditches. However, site visit observations from 2021 (Appendix A5.2 Habitats Baseline – Ock Watercourses) suggest that Portobello Ditch and Mere Dyke have limited macrophyte interest, with extensive fool's-watercress (*Helosciadium nodiflorum*) dominant in un-shaded reaches. The Oday Ditches were also heavily shaded by bankside trees and hedgerows in some sections, which restricted in-
			SRO		
			TVERC		
			Supplementary	✔	

[128] Cascade Consulting (2009) *Invasive Species Review*. Report on behalf of Thames Water.
[129] Oday ditches are included in Reach 1.1 (although technically the Thames water body) as they are within the reservoir footprint and they are most similar in character to Ock reaches/ditches.

Reach	WFD (2015)	WFD (2019)	Data sources		Baseline Description
					channel vegetation at these sites. At spot check sites where shading was absent, however, the ditches were choked with terrestrial herbs, grasses, and scrub. Other feeder ditches which were visited also tended to contain terrestrial vegetation, suggesting that many of these ditches regularly dry up. It was not possible to access all ditches, including Landmead Ditch, due to access constraints, but it is likely (given their comparable position within the catchment) that the watercourses are similar in character to those ditches of a similar size nearby.
1.2	Poor	Poor	EA	✔	**Lower Childrey Brook:** Mean biological metrics (post-2010 surveys only) are indicative of macrophyte assemblages that prefer nutrient enriched watercourses (RMNI: 8.5). The mean N taxa is 9, with representatives from 7 functional groups on average. The mean percentage cover of filamentous algae was moderate (13.1%). Metrics from the site used to assess the macrophyte biological quality element for WFD classification in this Reach are indicative of Poor class. The most dominant species in the Environment Agency data (generally >25% cover) were reed sweet-grass, branched bur-reed, and unbranched bur-reed (*Sparganium emersum*). Supplementary macrophyte surveys by Thames Water in 2006 and 2008 (Riverine Macrophyte Survey, 2009)[130] found that macrophyte percentage cover in the Ock Catchment (survey sites were spread over the lower River Ock and lower Childrey Brook) was higher (in relative terms) than in the Thames, but the typical species recorded here were also recorded in the Thames. The most abundant species in the lower Childrey Brook were unbranched bur-reed and filamentous algae (*Cladophora* spp.). The most upstream site of Childrey Brook (site 1) was noteworthy for having fewer macrophyte species and abundant filamentous algae due to heavy shading at this site. No notable species have been recorded in the lower Childrey Brook in any dataset (entire record period). The INNS Canadian waterweed (*Elodea canadensis*) and Himalayan balsam
			SRO		
			TVERC		
			Supplementary	✔	

[130] Cascade Consulting, APEM and Ecology Consultancy (2009) *Riverine Macrophyte Survey*. Report on behalf of Thames Water.

Reach	WFD (2015)	WFD (2019)	Data sources		Baseline Description
					have been recorded. In one of the three Environment Agency surveys, Canadian waterweed percentage cover was 25–50%. Small numbers of giant hogweed (*Heracleum mantegazzianum*) are also known to be present at Venn Mill.[131] **East Hanney Ditch:** There are no available macrophyte data from these ditches. However, spot checks at two sites on Hanney Ditch during the site visit in 2021 (Appendix A5.2 Habitats Baseline – Ock Watercourses) suggested that the upstream sections were dominated by terrestrial vegetation (grasses and ruderal herbs), indicating that the ditch likely dries up. At a spot check just upstream of the confluence with Childrey Brook the water surface was covered with duck weed where the channel was ponded by a culvert section.
2.1	Good	Good	EA	✔	**Lower River Ock:** Mean biological metrics (post-2010 surveys only) are indicative of macrophyte assemblages that prefer nutrient enriched watercourses (RMNI: 7.9). The mean N taxa is 7, with representatives from 5 functional groups on average. The mean percentage cover of filamentous algae was moderate (13.8%). The most dominant species in the Environment Agency data were unbranched bur-reed and branched bur-reed. Supplementary macrophyte surveys by Thames Water in 2006 and 2008 (Riverine Macrophyte Survey, 2009)[132] found that vegetation cover in the Ock Catchment (survey sites were spread over the lower River Ock and lower Childrey Brook) was higher (in relative terms) than in the Thames, but the core set of species was
			SRO		
			TVERC	✔	

[131] Pers. comm. Graham Scholey (Environment Agency) via email 16/08/2022.
[132] Cascade Consulting, APEM and Ecology Consultancy (2009) *Riverine Macrophyte Survey*. Report on behalf of Thames Water.

Reach	WFD (2015)	WFD (2019)	Data sources		Baseline Description
			Supplementary	✔	similar to those from the Thames. The most abundant species in the lower River Ock were arrowhead (*Sagittaria sagittifolia*), unbranched bur-reed, yellow waterlily (*Nuphar lutea*), flowering-rush (*Butomus umbellatus*) and filamentous algae. The most downstream site in the River Ock (site 7) was noteworthy for containing abundant river water-crowfoot (*Ranunculus fluitans*). The notable species ragged-robin* (*Lychnis flos-cuculi*) and common valerian* (*Valeriana officinalis*) were recorded once each in 2003 in TVERC data. No INNS have been recorded in the lower River Ock in any dataset (entire record period). The Invasive Species Review (2009)[133] recorded six INNS within the Ock catchment: Canadian waterweed, Nuttall's waterweed, Japanese knotweed, giant hogweed, Himalayan balsam, and rhododendron. However, the location of the species record(s) was unspecified, so it is unknown which Reach (2.1 to 2.7) these record(s) come from. **Nor Brook:** There are no available macrophyte data from Nor Brook. However, a spot check on Nor Brook from the site visit in 2021 (Appendix A5.2 Habitats Baseline – Ock Watercourses) found that the channel vegetation was comprised of emergent linear leaved and free-floating macrophytes.
2.2	Good	Good	EA	✔	**Upper River Ock**:** Mean biological metrics (post-2010 surveys only) are indicative of macrophyte assemblages that prefer nutrient enriched watercourses (RMNI: 7.6). The mean N taxa is 6), with representatives from 6 functional groups on average. The mean percentage cover of filamentous algae was very low (0.9%). Metrics from the site used to assess the macrophyte biological quality element for WFD classification in this Reach are indicative of Good class. The most dominant species in the Environment Agency
			SRO		
			TVERC	✔	

[133] Cascade Consulting (2009) *Invasive Species Review*. Report on behalf of Thames Water.

Reach	WFD (2015)	WFD (2019)	Data sources		Baseline Description
			Supplementary		data were water forget-me-not (*Myosotis scorpioides*) and unbranched bur-reed. The notable species ragged-robin* was recorded once in 2015 in TVERC data. No INNS have been recorded in the upper River Ock in any dataset (entire record period).
2.3	Moderate	Moderate	EA	✔	**Stutfield Brook**:** Mean biological metrics (post-2010 surveys only) are indicative of macrophyte assemblages that prefer nutrient enriched watercourses (RMNI: 7.8). Stutfield Brook has a low mean N taxa (3), with representatives from 3 functional groups on average. The mean percentage cover of filamentous algae was low (3.8%). Metrics from the site used to assess the macrophyte biological quality element for WFD classification in this Reach range from indicating Poor to Good class. The most dominant species in the Environment Agency data were fool's-watercress and reed canary-grass (*Phalaris arundinacea*). Macrophyte coverage was lower than other reaches in the Ock catchment; no species had greater percentage cover than 10%. No notable species or INNS have been recorded in Stutfield Brook in any dataset (entire record period).
			SRO		
			TVERC		
			Supplementary		
2.4	Moderate	Moderate	EA	✔	**Upper Childrey Brook**:** Mean biological metrics (post-2010 surveys only) are indicative of macrophyte assemblages that prefer nutrient enriched watercourses (RMNI: 8.0). The upper Childrey Brook has a low mean N taxa (3), with representatives from 3 functional groups on average. The mean percentage cover of filamentous algae was very low (0.1%). Metrics from the site used to assess the macrophyte biological quality element for WFD classification in this Reach range from indicating Poor to Moderate class. The most dominant
			SRO		
			TVERC		

Reach	WFD (2015)	WFD (2019)	Data sources		Baseline Description
			Supplementary		species in the Environment Agency data were great willowherb (*Epilobium hirsutum*), greater pond-sedge (*Carex riparia*), and branched bur-reed. Macrophyte coverage was lower than other reaches in the Ock catchment; no species had greater percentage cover than 10%. No notable species or INNS have been recorded in the upper Childrey Brook in any dataset (entire record period).
2.5	Poor	Moderate	EA	✔	**Letcombe Brook**:** Mean biological metrics (post-2010 surveys only) are indicative of macrophyte assemblages that prefer nutrient enriched watercourses (RMNI: 7.4). Letcombe Brook has a low mean N taxa (4), with representatives from 3 functional groups on average. The mean percentage cover of filamentous algae was moderate (14.2%). Metrics from the site used to assess the macrophyte biological quality element for WFD classification in this Reach range from indicating Poor to Good class. The most dominant species in the Environment Agency data were water forget-me-not and watercress (*Rorippa nasturtium-aquaticum* agg.). Macrophyte coverage was considerably lower than other reaches in the Ock catchment; no species had greater percentage cover than 5%. The notable species fringed waterlily* (*Nymphoides peltata*) and marsh speedwell* (*Veronica scutellata*) were each recorded once in 2005 in TVERC data, as were two regionally notable species. The INNS Himalayan balsam was also recorded at one Environment Agency site.
			SRO		
			TVERC	✔	
			Supplementary		
2.6	Moderate	Moderate	EA	✔	**Marcham Brook**:** Mean biological metrics (post-2010 surveys only) are indicative of macrophyte assemblages that prefer nutrient enriched watercourses (RMNI: 7.9). The mean N taxa is 7, with representatives from 5 functional groups on average. The mean percentage cover of filamentous algae was low (1.5%). Metrics from the site used to assess the macrophyte biological quality element for WFD classification in this Reach are indicative of Good class. The most dominant species in the Environment Agency
			SRO		
			TVERC	✔	

Reach	WFD (2015)	WFD (2019)	Data sources		Baseline Description
			Supplementary		data were great willowherb and Himalayan balsam (a high-priority INNS). Macrophyte coverage was considerably lower than other reaches in the Ock catchment; no species had greater percentage cover than 2.5%. Eight notable species have been recorded in Marcham Brook (entire record period). These are: wild celery* (*Apium graveolens*), distant sedge* (*Carex distans*), ragged robin*, wood sorrel* (*Oxalis acetosella*), marsh cinquefoil* (*Potentilla palustris*), marsh valerian* (*Valeriana dioica*), common valerian*, and marsh speedwell*. The INNS Himalayan balsam was recorded at all Environment Agency sites.
2.7	Poor	Poor	EA	✔	**Sandford Brook:** Mean biological metrics (post-2010 surveys only) are indicative of macrophyte assemblages that prefer nutrient enriched watercourses (RMNI: 7.9). Sandford Brook has a low mean N taxa (3), with representatives from 2 functional groups on average. The mean percentage cover of filamentous algae was high (25%), although this was only calculated for one sample so survey conditions may not have been representative of longer-term conditions. Metrics from the site used to assess the macrophyte biological quality element for WFD classification in this Reach range from indicating Poor to Good class. The most dominant species in the Environment Agency data was great willowherb, which had percentage cover of 10 to 25% at one site. Thirty-seven notable species have been recorded in and/or within the immediate environs Sandford Brook (entire record period) including three *Sphagnum** (moss) species (Habitats Directive – Appendix V), 17 red listed species, two nationally scarce, and 15 regionally notable species, most of which were recorded in Dry Sandford Pit SSSI and Parsonage Moor, and Cothill NNR. No INNS have been recorded in Sandford Brook in any dataset.
			SRO		
			TVERC	✔	
			Supplementary		
3	Not class	Mod erat	EA	✔	**Ginge Brook and Mill Brook**:** Mean biological metrics (post-2010 surveys only) are indicative of macrophyte

Reach	WFD (2015)	WFD (2019)	Data sources		Baseline Description
			SRO		assemblages that prefer nutrient enriched watercourses (RMNI: 7.7). The mean N taxa is 8, with representatives from 6 functional groups on average. The mean percentage cover of filamentous algae was low (6.6%), although this was only calculated for one sample. Metrics from the site used to assess the macrophyte biological quality element for WFD classification in this Reach are indicative of Moderate class. The most dominant species in the Environment Agency data are water forget-me-not and watercress. Macrophyte coverage is considerably lower than other reaches in the Ock catchment; no species had greater percentage cover than 5%. The regionally notable species greater spearwort* (*Ranunculus lingua*) was recorded once in 1995 in TVERC data, the only notable species which has been recorded in Ginge Brook (entire record period). The INNS Himalayan balsam was also recorded in one Environment Agency survey.
			TVERC	✔	
			Supplementary		
4	Not classified	Not classified	EA	✔	**River Thames (Upstream of SESRO (Evenlode to Culham)):** Mean biological metrics (post-2010 surveys only) are indicative of macrophyte assemblages that prefer nutrient enriched watercourses (RMNI: 7.9), The mean N taxa (6) and number of functional groups (5) is relatively low compared to the other Thames study reaches. The mean percentage cover of filamentous algae was very low (0.5%). Environment Agency and SRO surveys show that the macrophyte community is typical of large base-rich, lowland rivers. The most dominant species were common reed (*Phragmites australis*) and greater pond-sedge and the INNS Nuttall's waterweed. Just upstream of the proposed SESRO intake/discharge point in 2020 there was particularly high percentage cover (10–25%) of Nuttall's waterweed and filamentous algae recorded in the SRO data. Eight notable species have been recorded in Reach 4 (entire record period). These are: tufted-sedge* (*Carex elata*), water-violet* (*Hottonia palustris*), round-fruited rush* (*Juncus compressus*), summer snowflake* (*Leucojum aestivum subsp*. *aestivum*), goldenrod* (*Solidago virgaurea*), strawberry clover* (*Trifolium fragiferum*), marsh valerian*, and common valerian*. Three INNS have been recorded: water fern (*Azolla*
			SRO	✔	
			TVERC	✔	
			Supplementary	✔	

Reach	WFD (2015)	WFD (2019)	Data sources		Baseline Description
					filiculoides), Nuttall's waterweed, and Himalayan balsam. In addition to those data sources underpinning the above, a supplementary project report from Thames Water is available for the Thames that does not strictly align to the reaches defined here for the purpose of this assessment (i.e., overlap reaches 4, 5 and 6). This report was broadly undertaken to understand sensitivities associated with the macrophyte community downstream of SESRO. For simplicity this report is therefore summarised under Reach 5; i.e., the Reach immediately downstream of SESRO.
5			EA		**River Thames (Immediately downstream of SESRO combined intake/discharge structure up to the River Thame confluence):** There were no Environment Agency samples post-2010 but there is likely to be similarity between the modern-day assemblages and metrics of Reach 5 and the surrounding reaches. This is due to their connectivity and the fact that Reach 5 has similar habitat to the rest of the Thames where there is a high level of commonality in the community between reaches. SRO surveys show that the macrophyte community is typical of large base-rich, lowland rivers. The most dominant species were yellow waterlily, the INNS Nuttall's waterweed, branched bur-reed, reed sweet-grass, and greater pond-sedge. According to SRO data, Nuttall's waterweed covered more than 75% of the survey section below Sutton Courtenay Hydroelectric Power weir at Sutton Pools in 2020 (but in 2021 the species made up only 1–2.5% cover at a nearby site located just upstream of the weir). This implies that the macrophyte community within Sutton Pools is spatially variable in response to the arrangement of the weirs, channels, and pools. Supplementary macrophyte surveys by Thames Water in 2005–2008 (Riverine Macrophyte Survey, 2009)[134] found that the community was mainly confined to the margins and was characterised by typical lowland, slow
			SRO	✔	
			TVERC	✔	
			Supplementary	✔	

[134] Cascade Consulting, APEM and Ecology Consultancy (2009) *Riverine Macrophyte Survey*. Report on behalf of Thames Water.

Reach	WFD (2015)	WFD (2019)	Data sources		Baseline Description
					flowing, clay river (i.e., generally eutrophic) species which are tolerant of turbidity. Macrophyte communities were similar across sites but submerged plants like spiked water-milfoil (*Myriophyllum spicatum*) were more abundant in weir streams, probably because of the lower amount of dredging/weed cutting in these areas. Two notable species have been recorded in Reach 5 (entire record period). These are: wild celery* and common valerian*. Three INNS have been recorded: water fern, Nuttall's waterweed, and Himalayan balsam. The Invasive Species Review (2009)[135] recorded eight INNS within the River Thames reaches: water fern, New Zealand pygmyweed, Canadian waterweed, Nuttall's waterweed, Japanese knotweed, giant hogweed, Himalayan balsam, and rhododendron. The location of the species record(s) was unspecified, so it is unknown which Reach (4 to 13) these record(s) come from.
6	Good	Not classified	EA	✔	**River Thames (Between River Thame and Thames Water Datchet intake):** Mean biological metrics (post-2010 surveys only) are indicative of macrophyte assemblages that prefer nutrient enriched watercourses (RMNI: 8.1), The mean N taxa is 16, with representatives from 10 functional groups on average. The mean percentage cover of filamentous algae was moderate (11.7%). Metrics from sites used to assess the macrophyte biological quality element for WFD classification in this Reach are indicative of Moderate to High class. Environment Agency and SRO surveys show that the macrophyte community is typical of large base-rich, lowland rivers. The most dominant species were yellow water-lily, the INNS Nuttall's waterweed, unbranched bur-reed, and arrowhead. Four notable species have been recorded in Reach 6 (entire record period). These are: Loddon pondweed*
	Not classified	Not classified	SRO	✔	
			TVERC		

[135] Cascade Consulting (2009) *Invasive Species Review*. Report on behalf of Thames Water.

Reach	WFD (2015)	WFD (2019)	Data sources		Baseline Description
	Not classified	Not classified	Supplementary	✔	(*Potamogeton nodosus*), tormentil* (*Potentilla erecta*), marsh ragwort* (*Senecio aquaticus*), and common valerian*. Three INNS have been recorded: water fern, Nuttall's waterweed, and Himalayan balsam. Other supplementary project data were available from Thames Water and is summarised under Reach 5.
7			EA	✔	**River Thames (Between Thames Water Datchet intake and Affinity Water Sunnymeads intake):** Mean biological metrics (post-2010 surveys only) are indicative of macrophyte assemblages that prefer nutrient enriched watercourses (RMNI: 7.8), The mean N taxa is 17, with representatives from 11 functional groups on average. The mean percentage cover of filamentous algae was low (6.2%). Metrics from the site used to assess the macrophyte biological quality element for WFD classification in this Reach are indicative of Moderate to High class. Environment Agency and SRO surveys show that the macrophyte community is typical of large base-rich, lowland rivers. The most dominant species were unbranched bur-reed, *Fontinalis antipyretica* (a moss), amphibious bistort (*Persicaria amphibia*), and arrowhead. The INNS Nuttall's waterweed was also abundant, as was river water-crowfoot, a species which is indicative of fast flowing water. Three notable species have been recorded in Reach 7 (entire record period). These are: Loddon pondweed*, marsh cinquefoil*, and common valerian*. Four INNS have been recorded: Canadian waterweed, Nuttall's waterweed, Himalayan balsam, and duck-potato (*Sagittaria latifolia*).
			SRO	✔	
			TVERC		
			Supplementary		
8			EA		**River Thames (Between Affinity Water Sunnymeads and Affinity Water Egham intake):** There were no Environment Agency samples post-2010 but there is likely to be similarity between the modern-day assemblages and metrics of Reach 8 and the surrounding reaches. This is due to their connectivity and the fact that Reach 8 has similar habitat to the rest of the Thames where there is a high level of commonality in the
			SRO	✔	
			TVERC		

Reach	WFD (2015)	WFD (2019)	Data sources		Baseline Description
			Supplementary		community between reaches. SRO surveys show that the macrophyte community is typical of large base-rich, lowland rivers. The most dominant species were branched bur-reed, filamentous algae, and the INNS Nuttall's waterweed. Macrophyte coverage was considerably lower than other reaches in the Thames; no species had greater percentage cover than 5%. Three red listed notable species have been recorded in Reach 8 (entire record period). These are: Loddon pondweed*, marsh ragwort *, and common valerian*. The only INNS which have been recorded is Nuttall's waterweed.
9			EA	✔	**River Thames (Between Affinity Water Egham and Affinity Water Chertsey intake):** Mean biological metrics (post-2010 surveys only) are indicative of macrophyte assemblages that prefer nutrient enriched watercourses (RMNI: 7.9), The mean N taxa is19, with representatives from 13 functional groups on average. The mean percentage cover of filamentous algae was low (2.3%). Metrics from the site used to assess the macrophyte biological quality element for WFD classification in this Reach are indicative of Good to High class. Environment Agency surveys show that the macrophyte community is typical of large base-rich, lowland rivers. The most dominant species were unbranched bur-reed and yellow water-lily. The INNS Nuttall's waterweed was also abundant, as was the notable species Loddon pondweed*, a species which is limited to a few calcareous and moderately eutrophic rivers in the south of the UK. The only notable species which has been recorded in Reach 9 (entire record period) is Loddon pondweed. Three INNS have been recorded: Nuttall's waterweed, floating pennywort (*Hydrocotyle ranunculoides*), and duck-potato.
			SRO	✔	
	Poor	Poor	TVERC		
			Supplementary		
10			EA	✔	**River Thames (Between Affinity Water Chertsey intake and Affinity Water Walton (Desborough Island)**

Reach	WFD (2015)	WFD (2019)	Data sources		Baseline Description
			SRO	✔	**intake):** Mean biological metrics (post-2010 surveys only) are indicative of macrophyte assemblages that prefer nutrient enriched watercourses (RMNI: 6.8). The mean N taxa (6) and number of functional groups (5) is relatively low compared to the other Thames study reaches. The mean percentage cover of filamentous algae was very low (0.3%). Environment Agency and SRO surveys show that the macrophyte community is typical of large base-rich, lowland rivers. The most dominant species was yellow water-lily and the INNS floating pennywort, both of which are floating-leaved species, indicating slow-flowing conditions. Macrophyte coverage was considerably lower than other reaches in the Thames; only one species had greater percentage cover than 1%. Two notable species have been recorded in Reach 10 (entire record period). These are: marsh cinquefoil* and common valerian*. Five INNS have been recorded: Himalayan cotoneaster (*Cotoneaster simonsii*), Canadian waterweed, Nuttall's waterweed, floating pennywort, and Himalayan balsam.
			TVERC		
			Supplementary		
11			EA	✔	**River Thames (Between Affinity Water Walton and Thames Water Walton intake):** There was only one post-2010 Environment Agency survey from Reach 11 (taken in 2011). The biological metrics calculated for this survey are indicative of macrophyte assemblages that prefer nutrient enriched watercourses (RMNI: 7.6). The N taxa for this sample is 15, with representatives from 12 functional groups. The percentage cover of filamentous algae was moderate (17.5%). Environment Agency and SRO surveys show that the macrophyte community is typical of large base-rich, lowland rivers. The most dominant species were arrowhead, gypsywort (*Lycopus europaeus*), and filamentous algae. The INNS Himalayan balsam, a riparian species, was also abundant. The only notable species which has been recorded in Reach 11 (entire record period) is *Nitella mucronata var. gracillima**, which is regionally notable. Two INNS have been recorded: Nuttall's waterweed and Himalayan balsam.
			SRO	✔	
			TVERC		
			Supplementary		

Reach	WFD (2015)	WFD (2019)	Data sources		Baseline Description
12			EA		**River Thames (Between Thames Water Walton and Thames Water Hampton intake):** There were no Environment Agency samples post-2010 but there is likely to be similarity between the modern-day assemblages and metrics of Reach 12 and the surrounding reaches. This is due to their connectivity and the fact that Reach 12 has similar habitat to the rest of the Thames where there is a high level of commonality in the community between reaches. SRO surveys show that the macrophyte community is typical of large base-rich, lowland rivers. The most dominant species were arrowhead, filamentous algae, *Octodiceras fontanum* (a bryophyte), and the INNS Nuttall's waterweed. Macrophyte coverage was lower than other reaches in the Thames; no species had greater percentage cover than 5%. No notable species have been recorded in Reach 12 in any dataset (entire record period). Two INNS have been recorded: Canadian waterweed and Nuttall's waterweed.
			SRO	✔	
			TVERC		
			Supplementary		
13			EA	✔	**River Thames (Between Thames Water Hampton intake and Teddington Weir (tidal limit)):** Mean biological metrics (post-2010 surveys only) are indicative of macrophyte assemblages that prefer nutrient enriched watercourses (RMNI: 7.8). The N taxa for this sample is 12, with representatives from 9 functional groups. The mean percentage cover of filamentous algae was moderate (9.8%). Metrics from the site used to assess the macrophyte biological quality element for WFD classification in this Reach are indicative of Moderate to High class. Environment Agency and SRO surveys show that the macrophyte community is typical of large base-rich, lowland rivers. The most dominant species were *Fontinalis antipyretica* (a moss), filamentous algae, unbranched bur-reed, and horned pondweed (*Zannichellia palustris*). The only notable species which has been recorded in Reach 13 (entire record period) is marsh cinquefoil*. Four INNS have been recorded: Canadian waterweed, Nuttall's waterweed, floating pennywort, and
			SRO	✔	
			TVERC		
			Supplementary		

Reach	WFD (2015)	WFD (2019)	Data sources		Baseline Description
					Himalayan balsam.

Notes:

** Notable species designations associated with species marked using an asterisk (i.e., their protected/designated/notable status) are outlined in Appendix A5.1 Ecological Data Baseline.*

*** Indicates Reaches that have been included as reference Reaches only, i.e., there are no scheme interactions within these Reaches.*

5.3.6 Phytobenthos and Phytoplankton community baseline

5.74 Baseline descriptions of the phytobenthos and phytoplankton community associated with each Reach within the study area are outlined in Table 5.7. For each Reach, the data sources which have been used to inform the baseline descriptions are identified, alongside the baseline and interim WFD classification for Macrophytes and Phytobenthos (combined) where these are available.

5.75 Phytobenthos and phytoplankton are microscopic photosynthetic organisms. Phytobenthos live attached to the riverbed (either on mineral sediments or plants), whereas phytoplankton live suspended within the water column. Phytobenthos assessment for WFD river classification is based upon monitoring of benthic diatoms. Phytoplankton are not used in the WFD river classification.

5.76 Detailed baseline data processing and analysis underpinning phytobenthos summaries are reported in Appendix A5.1 Ecological Data Baseline. All Environment Agency and SRO monitoring locations included within the baseline reporting are shown in Figure 5.6 and Figure 5.7 in Appendix A1.1 Figures.

5.77 Biological metrics were used to broadly characterise phytobenthos community condition and sensitivity to changes in environmental gradients (predominantly sediment and water quality). Metrics used in the description of community condition and sensitivity in Table 5.7 include:

- Trophic Diatom Index (TDI);[136] an index which categorises a diatom community's preference to nutrient levels.
- The percentage (%) of motile taxa and percentage (%) of pollution tolerant valves;[137] indices which can indicate the presence of pollution or smothering via fine sediment or excessive macrophyte growth.

5.78 Phytoplankton are not monitored for (and do not form part of) WFD river classification, but they are an important component of the River Thames aquatic ecosystem. The Centre for Ecology and Hydrology (CEH) has produced reports specific to the SRO schemes (including SESRO) investigating the phytoplankton community in the Thames and how this could be affected by SESRO operation. These reports are

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136 WFD-UKTAG (2014) *UKTAG River Assessment Method Macrophytes and Phytobenthos. Phytobenthos – Diatoms for Assessing River and Lake Ecological Quality (River DARLEQ3)*. Available at: https://wfduk.org/resources/rivers-phytobenthos-0 [Accessed on: 22/02/2022].

137 WFD-UKTAG (2014) *UKTAG River Assessment Method Macrophytes and Phytobenthos. Phytobenthos – Diatoms for Assessing River and Lake Ecological Quality (River DARLEQ3)*. Available at: https://wfduk.org/resources/rivers-phytobenthos-0 [Accessed on: 22/02/2022].

appended as Appendices A5.5 Water Quality and Phytoplankton Monitoring, A5.6 Phytoplankton Growth and Community Modelling, and A5.7 Algal Growth Rate Studies. These reports do not strictly align to the Reaches defined within this EAR. For simplicity, the relevant findings of these reports, and other supporting documents, have been summarised under Reach 5; i.e., the Reach immediately downstream of SESRO. The reports which have supplemented the baseline assessment of phytoplankton are:

- Appendix A5.5 Water Quality and Phytoplankton Monitoring: CEH reported weekly monitoring of nutrient concentrations and phytoplankton communities in the River Thames (at Culham (SESRO Reach 5), Reading (Reach 6), Datchet (Reach 6), Sunnymeads (Reach 8), Egham (Reach 9), Chertsey (Reach 10), Walton (Reach 11), Surbiton (Reach 13), and Teddington (Reach 13)) over the period March to October 2021.
- Appendix A5.6 Phytoplankton Growth and Community Modelling: CEH developed a Eutrophication Risk Model to investigate how the size and timing of phytoplankton blooms could change as a result of SESRO operation and climate change. It uses long term water quality and algal composition data (summarised here in terms of the current baseline) to identify the thresholds in river flow, water temperature, nutrients, and solar radiation (which collectively dictate phytoplankton growth and community dynamics in the River Thames), and then considers how often these conditions would be met under future scenarios. The analysis is based on data from the lower Thames at Runnymede (Reach 8). A similar investigation was conducted by Bowes *et al.* (2016)[138] at Reading (Reach 6).

5.79 Across all watercourses, TDI was indicative of diatom (phytobenthos) assemblages that prefer nutrient enriched watercourses. Biological metrics from Environment Agency and SRO monitoring and the Riverine Plankton and Diatom Survey (2009) suggest that TDI is typically higher in the River Ock and Childrey Brook than in the River Thames. However, the most recent Environment Agency survey data (2014) from the lower Childrey Brook (Reach 1.2) is indicative of Good WFD class; suggesting the community is only slightly impacted relative to reference conditions for a river of this type. The TDI O:E ratios from the Thames are spatially and temporally variable, and indicative of High to Bad WFD class, suggesting that conditions are highly variable and that nutrient enrichment does impair the diatom community relative to

[138] Bowes, M.J., Loewenthal, M., Read, D.S., Hutchins, M.G., Prudhomme, C., Armstrong, L.K., Harman, S.A., Wickham, H.D., Gozzard, E. and Carvalho, L. (2016) Identifying multiple stressor controls on phytoplankton dynamics in the River Thames (UK) using high-frequency water quality data. *Science of the Total Environment*, 569-570: 1489-1499.

reference state. Combined, data from the River Thames indicates a broad trend (particularly from 2021 SRO samples) of deteriorating conditions moving towards lower Reaches 10, 11, and 13. The mean percentage of diatom valves which are motile is moderate or high at all sites, which may be indicative of high siltation levels within the channel (as indicated by other biological metrics), though recent evidence[139] suggests that the percentage of motile taxa can be quite a poor indicator of sediment condition. The mean percentage of pollution tolerant valves is also low for all Reaches suggesting that the diatom communities within the study area are not significantly impaired by organic pollution.

5.80 Phytoplankton monitoring in the Thames has shown that chlorophyll (a measure of phytoplankton biomass) follows a consistent annual pattern of increasing in the spring, driven by growth of diatoms, peaking in the Thames from the end of April to early May, with the size of the peak increasing with distance downstream. By June, diatoms and nano-chlorophytes have reduced in number and pico-chlorophytes are dominant and continue to be so through to the autumn, before all phytoplankton drop to low numbers throughout the winter. Diatom and chlorophyll concentrations sometimes produce very large peaks in late August to end September, and high-frequency (hourly) monitoring has shown that these usually only last approximately 3 to 4 days. Cyanobacteria make up only a small proportion of the total phytoplankton biomass, and their blooms tend to be sporadic and short-lived, but are most common in August.

[139] Jones, J.I., Douthwright, T.A., Arnold, A., Duerdoth, C.P., Murphy, J.F., Edwards, F.K. and Pretty, J.L. (2017) Diatoms as indicators of fine sediment stress. *Ecohydrology*, 10(5): e1832.

Table 5.7 Baseline phytobenthos and phytoplankton communities by study area Reach

Reach	WFD (2015)	WFD (2019)	Data sources		Baseline Description
1.1	Poor	Poor	EA		**Cow Common Brook, Portobello Ditch, Landmead Ditch, Mere Dyke, Oday Ditches,[140] and selected feeder ditches**: There were no available monitoring data from Reach 1.1.
			Supplementary		
1.2	Poor	Poor	EA	✔	**Lower Childrey Brook:** There was only one post-2010 Environment Agency diatom survey from Reach 1.2 (undertaken in 2010). The biological metrics calculated for this survey are indicative of diatom assemblages that prefer nutrient enriched watercourses (TDI: 76.2). The TDI O:E ratio for this sample is indicative of Good WFD class suggesting that nutrients do not impair the diatom community. This survey found a relatively high percentage of motile taxa (39.9%), which may be indicative of high siltation levels within the channel (as indicated by other biological metrics), though recent evidence[141] suggests that the percentage of motile taxa can be quite a poor indicator of sediment condition. The percentage of pollution tolerant valves was low (13.5%), suggesting that the diatom community is not impaired by organic pollution. Supplementary diatom surveys by Thames Water in 2006 (Riverine Plankton and Diatom Survey, 2009)[142] (at sites spread across the lower and upper Childrey Brook, and the lower River Ock) found that TDI scores in the River Ock and Childrey Brook were high relative to
			Supplementary	✔	

[140] Oday ditches are included in Reach 1.1 (although technically the Thames water body) as they are within the reservoir footprint and they are most similar in character to Ock Reaches/ditches.
[141] Jones, J.I., Douthwright, T.A., Arnold, A., Duerdoth, C.P., Murphy, J.F., Edwards, F.K. and Pretty, J.L. (2017) Diatoms as indicators of fine sediment stress. *Ecohydrology*, 10(5): e1832.
[142] APEM and Cascade Consulting (2009) *Riverine Plankton and Diatom Survey*. Report on behalf of Thames Water.

Reach	WFD (2015)	WFD (2019)	Data sources		Baseline Description
					expected values, indicating high nutrient conditions. TDI scores and the percentage of motile valves were higher than on average in the Thames. Taxa richness was also high. **East Hanney Ditch:** There were no available phytobenthos or phytoplankton data from East Hanney Ditch.
2.1	Good	Good	EA		**Lower River Ock and Nor Brook:** The only available data from Reach 2.1, are supplementary project data from Thames Water which are summarised under Reach 1.2.
			Supplementary	✔	
2.2	Good	Good	EA	✔	**Upper River Ock**:** There was only one post-2010 Environment Agency diatom survey from Reach 1.2 (taken in 2010). The biological metrics calculated for this survey are indicative of diatom assemblages that prefer nutrient enriched watercourses (TDI: 84.2). The TDI O:E ratio for this sample is indicative of Poor WFD class suggesting that high nutrients impair the diatom community. This survey found a relatively high percentage of motile taxa (36.6%) which may be indicative of high siltation within the channel. The percentage of pollution tolerant valves was low (14.9%), suggesting that the diatom community is not impaired by organic pollution.
			Supplementary		
2.3	Moderate	Moderate	EA		**Stutfield Brook**:** There were no available phytobenthos or phytoplankton data from Reach 2.3.
			Supplementary		
2.4	Mod erat	Mod erat	EA		**Upper Childrey Brook**:** The only available data from Reach 2.4, are supplementary project

Reach	WFD (2015)	WFD (2019)	Data sources		Baseline Description
			Supplementary	✔	data from Thames Water which are summarised under Reach 1.2.
2.5	Poor	Moderate	EA		**Letcombe Brook**:** There were no available phytobenthos or phytoplankton data from Reach 2.5.
			Supplementary		
2.6	Moderate	Moderate	EA		**Marcham Brook**:** There were no available phytobenthos or phytoplankton data from Reach 2.6.
			Supplementary		
2.7	Poor	Poor	EA		**Sandford Brook:** There were no available phytobenthos or phytoplankton data from Reach 2.7.
			Supplementary		
3	Not classified	Moderate	EA		**Ginge Brook and Mill Brook**:** There were no available phytobenthos or phytoplankton data from Reach 3.
			Supplementary		
4	Not classified	Not classified	EA	✔	**River Thames (Upstream of SESRO (Evenlode to Culham)):** Mean biological metrics (post-2010 surveys only) are indicative of diatom assemblages that prefer nutrient enriched watercourses (TDI: 69.5). Across the three Environment Agency sites and one SRO site, the TDI O:E ratio ranges from indicating Moderate to High WFD class. The mean percentage of motile taxa (18.9%) is moderate, which may be indicative of moderate siltation levels within the channel. The mean percentage of pollution tolerant valves is low (5.7%), suggesting that
			Supplementary	✔	

Reach	WFD (2015)	WFD (2019)	Data sources		Baseline Description
					the diatom community is not impaired by organic pollution. There were other phytoplankton data available for Reach 4 which are summarised under Reach 5.
5			EA		**River Thames (Immediately downstream of SESRO combined intake/discharge structure up to the River Thame confluence):** There are no available Environment Agency phytobenthos data from Reach 5. Raw TDI scores from two SRO monitoring sites were indicative of diatom assemblages that prefer nutrient enriched watercourses and were indicative of Moderate WFD class suggesting that nutrients impair the diatom community relative to reference condition. Phytoplankton monitoring by CEH in 2021 (Appendix A5.5 Water Quality and Phytoplankton Monitoring) (Reaches 4 to 13) and by Thames Water in 2005–2008 (Riverine Plankton and Diatom Survey, 2009)[143] (Reaches 4, 5 and 6) measured chlorophyll, as a proxy for phytoplankton biomass, and characterised the phytoplankton community into four groups: diatoms, nano-chlorophytes, pico-chlorophytes, and cyanobacteria. Chlorophyll concentration, and therefore phytoplankton biomass, is primarily driven by planktonic diatoms in the Thames. These studies found that there is a predictable sequence of phytoplankton succession in the Thames within the SESRO study area, which is consistent between sites. Chlorophyll tends to begin to increase in the spring and peaks in the Thames from the end of April to early May, with the size of the peak increasing with distance downstream. This is prompted by significant diatom growth, followed a few weeks later by nano-chlorophytes. However, by June, the diatoms and nano-chlorophytes have reduced in
			Supplementary	✔	

[143] APEM and Cascade Consulting (2009) *Riverine Plankton and Diatom Survey*. Report on behalf of Thames Water.

Reach	WFD (2015)	WFD (2019)	Data sources		Baseline Description
					number and pico-chlorophytes become dominant and continue to be so through to the autumn (October/November). All phytoplankton groups are at low quantities throughout the winter. Cyanobacteria make up only a small proportion of the total phytoplankton biomass, and their blooms tend to be sporadic and short-lived, but are most common in August, which the studies suggest is probably due to the higher water temperature at this time of year. High frequency monitoring by CEH (Bowes *et al.*, 2016)[144] has shown that the mid-Thames in late August/September sometimes experiences very large but short-lived (three to four days) peaks of chlorophyll, which mirrored diatom blooms. This occurred during CEH monitoring at the most upstream sites (Culham and Reading: Reaches 4/5 and 6) in 2021 (Appendix A5.5 Water Quality and Phytoplankton Monitoring) but did not occur in the lower Thames; the report suggests this could be due to dilution of the signal from other river inflows with low-chlorophyll levels, such as the River Kennet. The Riverine Plankton and Diatom Survey (2009)[145] also found that peaks in picoplankton (a size class of phytoplankton (<2 µm) that includes some cyanobacteria and chlorophytes) occurring in the latter half of the 2008 survey period were not reflected in the chlorophyll concentrations. The authors concluded that this was linked to the fact that although picoplankton were numerous, their smaller size results in a very low biomass relative to diatoms. Phytoplankton was also sampled fortnightly May to August 2007 at four sites in Reach 5

[144] Bowes, M.J., Loewenthal, M., Read, D.S., Hutchins, M.G., Prudhomme, C., Armstrong, L.K., Harman, S.A., Wickham, H.D., Gozzard, E. and Carvalho, L. (2016) Identifying multiple stressor controls on phytoplankton dynamics in the River Thames (UK) using high-frequency water quality data. *Science of the Total Environment*, 569-570: 1489-1499.
[145] APEM and Cascade Consulting (2009) *Riverine Plankton and Diatom Survey*. Report on behalf of Thames Water.

Reach	WFD (2015)	WFD (2019)	Data sources		Baseline Description
					specifically to compare on-river (Culham and Appleford) to off-river habitats (Abingdon Marina and Sutton Pools) (Larval Fish, Phytoplankton, Zooplankton and Water Quality monitoring at Selected Sites in the Thames, 2007)[146]. Similar to monitoring data from the main Thames, phytoplankton communities were dominated by diatoms and chlorophytes, followed by cryptophytes. Cyanobacteria were recorded in low quantities. Phytoplankton was more abundant in off-river habitats where the flow velocity was lower.
6	Good	Not classified	EA	✔	**River Thames (Between River Thame and Thames Water Datchet intake):** Mean biological metrics (post-2010 surveys only) are indicative of diatom assemblages that prefer nutrient enriched watercourses (TDI: 66.7). Across the two sites, the TDI O:E ratio ranges from indicating Good to High WFD class. The mean percentage of motile taxa (31.2%) is high, which may be indicative of high siltation levels within the channel. The mean percentage of pollution tolerant valves is also low (15.7%), suggesting that the diatom community is not impaired by organic pollution.
	Not classified	Not classified			
	Not classified	Not classified	Supplementary	✔	Phytoplankton data available for Reach 6 are summarised under Reach 5.
7			EA	✔	**River Thames (Between Thames Water Datchet intake and Affinity Water Sunnymeads intake):** There was only one post-2010 Environment Agency diatoms survey from Reach 7 (taken in 2012). The biological metrics calculated for this survey are indicative of diatom assemblages that prefer nutrient enriched watercourses (TDI: 60.7). The TDI O:E ratio for this sample is indicative of High WFD class suggesting that nutrients do not impair the diatom community. This survey found a moderate percentage of motile taxa (14.4%), which may be
			Supplementary	✔	

[146] APEM and Cascade Consulting (2007) *Larval and Juvenile Fish Populations of the upper River Thames – Survey results for 2007*. Report on behalf of Thames Water.

Reach	WFD (2015)	WFD (2019)	Data sources		Baseline Description
					indicative of moderate siltation levels within the channel. The percentage of pollution tolerant valves was low (5.6%), suggesting that the diatom community is not impaired by organic pollution. Phytoplankton data available for Reach 7 are summarised under Reach 5.
8			EA		**River Thames (Between Affinity Water Sunnymeads and Affinity Water Egham intake):** There were no available phytobenthos data from Reach 8. Phytoplankton data available for Reach 8 are summarised under Reach 5.
			Supplementary	✔	
9			EA	✔	**River Thames (Between Affinity Water Egham and Affinity Water Chertsey intake):** Mean biological metrics (post-2010 surveys only) are indicative of diatom assemblages that prefer nutrient enriched watercourses (TDI: 71.7), but there is a high range (51.2–88.6). The TDI O:E ranges from indicating Poor to High WFD class. The mean percentage of motile taxa (30.2%) is high, which may be indicative of high siltation levels within the channel. The mean percentage of pollution tolerant valves was low (20.0%), suggesting that the diatom community is not impaired by organic pollution. Phytoplankton data available for Reach 9 are summarised under Reach 5.
	Poor	Poor	Supplementary	✔	
10			EA		**River Thames (Between Affinity Water Chertsey intake and Affinity Water Walton (Desborough Island) intake):** There were no available Environment Agency phytobenthos data from Reach 10. Raw TDI scores from two SRO monitoring sites were indicative of diatom assemblages that prefer nutrient enriched watercourses and were indicative of Good and Bad WFD class respectively, i.e., spatial variation in community condition within this Reach. Phytoplankton data available for Reach 10 are summarised under Reach 5.
			Supplementary	✔	

Reach	WFD (2015)	WFD (2019)	Data sources		Baseline Description
11			EA		**River Thames (Between Affinity Water Walton and Thames Water Walton intake):** There were no available Environment Agency phytobenthos data from Reach 11. Raw TDI scores from two SRO monitoring sites were indicative of diatom assemblages that prefer nutrient enriched watercourses and were indicative of Moderate and Poor WFD class suggesting that nutrients impair the diatom community relative to reference condition. Phytoplankton data available for Reach 11 are summarised under Reach 5.
			Supplementary	✔	
12			EA		**River Thames (Between Thames Water Walton and Thames Water Hampton intake):** There were no available phytobenthos data from Reach 12. Phytoplankton data available for Reach 12 are summarised under Reach 5.
			Supplementary	✔	
13			EA	✔	**River Thames (Between Thames Water Hampton intake and Teddington Weir (tidal limit)):** There was only one post-2010 Environment Agency diatom survey from Reach 13 (taken in 2010). The biological metrics calculated for this survey are indicative of diatom assemblages that prefer nutrient enriched watercourses (TDI: 77.0). Across this Environment Agency site and three SRO sites, the TDI O:E ratio ranges from indicating Moderate to Poor WFD class suggesting that nutrients impair the diatom community relative to reference condition. This survey found a moderate percentage of motile taxa (15.8%), which may be indicative of moderate siltation levels within the channel. The percentage of pollution tolerant valves was low (1.3%), suggesting that the diatom community is not impaired by organic pollution. Phytoplankton data available for Reach 13 are summarised under Reach 5.
			Supplementary	✔	

*Notes: ** Indicates Reaches that have been included as reference Reaches only, i.e., there are no scheme interactions within these Reaches.*

5.3.7 Zooplankton community baseline

5.3.7.1 Overall study area summary

5.81 Zooplankton are not monitored for (and do not form part of) WFD river classification, but they are an important component of the aquatic ecosystem. They are a key food source for larval fish in the River Thames, with the timing and abundance of zooplankton peaks a major factor influencing the early growth rates of fish (Bass and May, 1996).[147] Additionally, zooplankton grazing is an important control of phytoplankton biomass in the Thames (Ruse and Love, 1997;[148] Freeman, 2019).[149] Zooplankton 'blooms' are also largely controlled by of the river discharge regime[150] and are therefore among those aquatic organisms that may be affected directly by any alterations to discharge regime, such as from reservoir operation.

5.82 There have been three main studies into the zooplankton community along the River Thames in the study area relevant to SESRO. These are:

- Bass *et al.* (1997)[151] collected zooplankton samples from the main channel of the middle Reaches of the River Thames at Inglesham (upstream of the area of interest), Radley College Boathouse (Reach 4), Abingdon Lock (Reach 4), Wallingford Bridge (Reach 6), and Caversham Lock (Reach 6) between April and October 1996.
- APEM and Cascade Consulting (2009)[152] sampled zooplankton and phytoplankton communities in the River Thames every two weeks in April to September and monthly between October to March in 2005 and 2006, and every two weeks March to November 2008. Sites include Nuneham and Culham (in Reach 4: upstream of the reservoir intake/outfall), Culham and Appleford (in Reach 5: downstream of the reservoir intake/outfall), and Shillingford (just downstream of the Thame confluence), Caversham Weir, and Romney Lock (in Reach 6).
- Freeman (2019) PhD thesis investigated river zooplankton-phytoplankton interactions in the River Thames in relation to the physical environment and water

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[147] Bass, J.A.B. and May, L. (1996) *Zooplankton interactions in the River Thames: literature review*. Final report to the Environment Agency.
[148] Ruse, L. and Love, A. (1997) Predicting phytoplankton composition in the River Thames, England. *Regulated Rivers, Research and Management,* 13: 171-183.
[149] Freeman, A. (2019) *River phytoplankton biological controls on a microscopic level.* Thesis submitted for the degree of Doctor of Philosophy. Department of Geography and Environmental Science, University of Reading
[150] Bass and May (1996) *Zooplankton interactions lit. rev.*.
[151] Bass, J.A.B., May, L., Esteban, G.F. and Collett, G.D. (1997) *Zooplankton interactions in the River Thames – Report to the Environment Agency (Thames Region),* IFE Report Ref. No T0403v7/1.
[152] APEM and Cascade Consulting (2009) *Riverine Plankton and Diatom Survey.* Report on behalf of Thames Water.

chemistry. As a part of this research, zooplankton were sampled weekly from five sites on the Thames (Hannington (upstream of the area of interest), Swinford (Reach 4), Wallingford (Reach 6), Goring (Reach 6), and Runnymede (Reach 8)) from March to September in 2015.

5.3.7.2 Zooplankton communities in the River Thames

5.83 Monitoring has shown that zooplankton communities in the Thames are typical of large eutrophic rivers, and that, although there are differences in zooplankton density between sites, the most abundant species are consistent throughout. Rotifers were the most abundant zooplankton group in monitoring conducted by Bass *et al.* (1997) and Freeman (2019) (noting that the former in particular applied methods specifically designed to avoid loss of rotifers from the samples – being comparatively smaller than cladocerans and copepods); rotifers made up 90% of the total zooplankton in Freeman (2019). The most abundant species across these studies were: *Keratella cochlearis, Keratella quadrata, Synchaeta oblonga*, and *Polyarthra dolichoptera*. Both studies also found that rotifer density, in parallel with chlorophyll concentrations increased with distance downstream, especially in late summer. Rotifer maximum density according to Freeman (2019) was highest at Runnymede (9,000 ind. l^{-1}), then Wallingford (4,500 ind. l^{-1}), and Goring (3,100 ind. l^{-1}), whereas at Swinford rotifer density was only 750 ind. l^{-1}. This positive correlation with chlorophyll (a proxy for phytoplankton biomass) suggests that rotifer abundance in the Thames is strongly linked to food availability.

5.84 Thames Water monitoring[153] in 2005, 2006, and 2008 found much lower numbers of rotifers. This could be due to changes in the community over time or, more likely, that the different sampling method used was not as effective at collecting rotifers relative to other zooplankton groups. Bass *et al.* (1997) demonstrated a significant difference in rotifer abundance estimates between different techniques for concentrating samples; between 500 ind. l^{-1} (63 µm mesh sampling) and 4000 ind. l^{-1} (sedimentation approach). Notably, the total zooplankton density in Thames Water samples was considerably lower than the other studies (up to a 9000 ind m^{-3}, which is equivalent to 9 ind. l^{-1}).

5.85 Copepods and cladocerans were found in relatively small numbers in the Thames by Bass *et al.* (1997) and Freeman (2009). Whilst cladocerans and copepods dominated (in relative terms) the Thames Water sampling, absolute abundance of both was comparable with other sources e.g., Bass *et al.* (1997), which noted that these groups may be more abundant in other (e.g., marginal, non-open water) areas that were not

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[153] APEM and Cascade Consulting (2009) *Riverine Plankton and Diatom Survey*. Report on behalf of Thames Water.

specifically targeted by any of the survey methods. For instance, locally elevated zooplankton density has been reported in and adjacent to off-river habitats such as Abingdon Marina (Bass *et al.*, 1997). The greater water retention time in off-river habitats relative to the main channel is conducive to phytoplankton and zooplankton productivity.[154]

5.3.7.3 Seasonal patterns in abundance and community composition

5.86 Zooplankton density in the Thames is highly seasonal. Monitoring[155,156,157] has shown that zooplankton biomass is typically highest in late spring and summer (June to August), with pronounced peaks later in the summer in some years, and low density over the winter. Seasonal patterns broadly correspond with patterns of phytoplankton growth, but there are significant differences in peak timings between years (Freeman, 2019). Spring zooplankton communities are associated with the spring/early summer diatom bloom, dominated by cold-adapted grazers like copepods and some rotifers. Then in mid-summer, when small chlorophytes, cryptophytes and cyanobacteria are more abundant, there are dense populations of some rotifer species. The timing and magnitude of peak densities for different zooplankton groups appears to be highly variable between studies and years.

5.4 Assessment outcomes

5.4.1 Source-pathway by Reach

5.87 Based on the source-pathway-receptor framework set out within Section 5.2.3, potential pathway occurrence has been 'mapped' to study Reaches, within which identified receptors could be affected (Table 5.8). The assessment of each identified pathway is then reported in subsequent sections, as identified in Table 5.8.

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[154] Bass, J.A.B. and May, L. (1996) *Zooplankton interactions in the River Thames: literature review*. Final report to the Environment Agency.
[155] Freeman, A. (2019) *River phytoplankton biological controls on a microscopic level.* Thesis submitted for the degree of Doctor of Philosophy. Department of Geography and Environmental Science, University of Reading.
[156] Bass, J.A.B., May, L., Esteban, G.F. and Collett, G.D. (1997) *Zooplankton interactions in the River Thames – Report to the Environment Agency (Thames Region),* IFE Report Ref. No T0403v7/1
[157] APEM and Cascade Consulting (2009) *Riverine Plankton and Diatom Survey*. Report on behalf of Thames Water.

Table 5.8 Potential for pathway occurrence by study Reach

Receptor	Potential change mechanism (Source: Pathway)				
	Construction	Operation			
	Footprint: Direct habitat loss, gain, or severance (Ock Catchment and Thames)	Regime: Changes in flow/level/habitat availability (Ock Catchment and Thames)	Regime: Changes in water quality (Ock Catchment and Thames)	Regime: Changes to barrier porosity (new structures and function of existing fish passes); and fish impingement/ entrainment at new and existing intake/ discharge structures (Ock Catchment and Thames)	Regime: Changes in community structure/ function mediated by primary productivity changes (Ock Catchment and Thames)
Watercourse habitats	*Mediator*	*Mediator*	-	-	-
Fish	Included	Included	Included	Included	Included
Invertebrates	Included	Included	Included	-	Included
Macrophytes	Included	Included	Included	-	Included
Phytoplankton/ Phytobenthos (Diatoms)	-	Included (reported in Section 5.4.6)	Included (reported in Section 5.4.6)	-	*Mediator*
Zooplankton	-	Included (reported in Section 5.4.6)	Included (reported in Section 5.4.6)	-	*Mediator*
Other aquatic habitats	Included	Included	Included	-	-
Reaches					
1.1 Cow Common Brook	✔ (Section 5.4.2)	✔ (Section 5.4.3)	✔ (Section 5.4.4)	*No existing fish passes or proposed new structures within the affected Reach*	✔ (Section 5.4.6)
1.2 Childrey Brook (lower)				✔ (Section 5.4.5)	
2.1 River Ock (lower)					
2.2 River Ock (upper)	*Watercourses adjacent to and upstream of the footprint within the Ock catchment – not included at Gate 1 but included for additional context and reference sites at Gate 2.*				
2.3 Stutfield Brook					
2.4 Childrey Brook (upper)					
2.5 Letcombe Brook					
2.6 Marcham Brook					
2.7 Sandford Brook	✔ (Section 5.4.2)	*Watercourse is upstream of operational regime pathways*			
3 Ginge Brook	*No footprint-mediated effects anticipated; no infrastructure proposed at Gate 2.*	*Watercourse is upstream of operational regime pathways*			
4 Thames – Upstream of SESRO (Evenlode to	✔ *(intake/discharge structure footprint*	✔ *(influence of Ock discharge only; Reach is upstream of SESRO*	✔ *(influence of Ock discharge only; Reach is upstream of SESRO*	✔ *(intake only – no existing fish passes within the affected Reach between Ock*	✔ *(influence of Ock discharge only; Reach is upstream of SESRO*

Receptor	Potential change mechanism (Source: Pathway) Construction Footprint: Direct habitat loss, gain, or severance (Ock Catchment and Thames)	Operation Regime: Changes in flow/level/habitat availability (Ock Catchment and Thames)	Regime: Changes in water quality (Ock Catchment and Thames)	Regime: Changes to barrier porosity (new structures and function of existing fish passes); and fish impingement/ entrainment at new and existing intake/ discharge structures (Ock Catchment and Thames)	Regime: Changes in community structure/ function mediated by primary productivity changes (Ock Catchment and Thames)
Culham): Reach length – 27.0 km	*only)* (Section 5.4.2)	*intake/discharge)* (Section 5.4.3)	*intake/discharge)* (Section 5.4.4)	*confluence and Reach 5)* (Section 5.4.5)	*intake/discharge)* (Section 5.4.6)
5 Thames – Immediately downstream of SESRO combined intake/ discharge structure up to the River Thame confluence: Reach length – 13.2 km	*No footprint-mediated effects anticipated; no infrastructure proposed at Gate 2.*	✔ (Section 5.4.3/Section 5.4.6)	✔ (Section 5.4.4/Section 5.4.6)	✔ (Section 5.4.5)	✔ (Section 5.4.6)
6 Thames – Between River Thame and Thames Water Datchet intake: Reach length – 87.3 km	*No footprint-mediated effects anticipated; no infrastructure proposed at Gate 2.*	✔ (Section 5.4.3/Section 5.4.6)	✔ (Section 5.4.4/Section 5.4.6)	✔ (Section 5.4.5)	✔ (Section 5.4.6)
7 Thames – Between Thames Water Datchet intake and Affinity Water Sunnymeads intake: Reach length – 2.8 km	*No footprint-mediated effects anticipated; no infrastructure proposed at Gate 2.*	✔ (Section 5.4.3/Section 5.4.6)	✔ (Section 5.4.4/Section 5.4.6)	✔ (Section 5.4.5)	✔ (Section 5.4.6)
8 Thames – Between Affinity Water Sunnymeads and Affinity Water Egham intake: Reach length – 6.4 km	*No footprint-mediated effects anticipated; no infrastructure proposed at Gate 2.*	✔ (Section 5.4.3/Section 5.4.6)	✔ (Section 5.4.4/Section 5.4.6)	✔ (Section 5.4.5)	✔ (Section 5.4.6)
9 Thames – Between Affinity Water Egham and Affinity Water Chertsey intake: Reach length – 6.9 km	*No footprint-mediated effects anticipated; no infrastructure proposed at Gate 2.*	✔ (Section 5.4.3/Section 5.4.6)	✔ (Section 5.4.4/Section 5.4.6)	✔ (Section 5.4.5)	✔ (Section 5.4.6)
10 Thames – Between Affinity Water Chertsey intake and Affinity Water Walton (Desborough Island) intake: Reach length – 7.3 km	*No footprint-mediated effects anticipated; no infrastructure proposed at Gate 2.*	✔ (Section 5.4.3/Section 5.4.6)	✔ (Section 5.4.4/Section 5.4.6)	✔ (Section 5.4.5)	✔ (Section 5.4.6)
11 Thames – Between Affinity Water Walton and Thames Water Walton intake: Reach length – 4.1 km	*No footprint-mediated effects anticipated; no infrastructure proposed at Gate 2.*	✔ (Section 5.4.3/Section 5.4.6)	✔ (Section 5.4.4/Section 5.4.6)	✔ (Section 5.4.5)	✔ (Section 5.4.6)
12 Thames – Between Thames Water Walton and Thames Water Hampton intake: Reach length – 2.2 km	*No footprint-mediated effects anticipated; no infrastructure proposed at Gate 2.*	✔ (Section 5.4.3/Section 5.4.6)	✔ (Section 5.4.4/Section 5.4.6)	✔ (Section 5.4.5)	✔ (Section 5.4.6)
13 Thames – Between Thames Water Hampton intake and Teddington Weir (tidal limit): Reach length – 9.5 km	*No footprint-mediated effects anticipated; no infrastructure proposed at Gate 2.*	✔ (Section 5.4.3/Section 5.4.6)	✔ (Section 5.4.4/Section 5.4.6)	✔ (Section 5.4.5)	✔ (Section 5.4.6)

Notes: Grey shaded boxes indicate reaches where there are no anticipated effects.

5.4.2 Footprint: direct habitat loss, gain or severance within the Ock[158] catchment and Thames[159]

5.88 Watercourse habitats within the proposed reservoir footprint are at risk of loss or severance in the absence of mitigation. Therefore in order to accommodate the reservoir and associated infrastructure, a number of watercourses will be diverted, thereby avoiding loss of watercourse habitat extent.

5.89 Study Reaches potentially affected by footprint are assessed in Table 5.9. The proposed scheme option(s) to which the assessment applies is also reported.

5.90 The proposed works for SESRO involve a 10-year construction programme, between 2029 and 2038. The environmental mitigation works would be undertaken as part of the initial site mobilisation from 2029 to 2030.

5.91 A core part of the environmental mitigation works for the proposed scheme includes the diversion of watercourses across the site to form both the Western Watercourse Diversion and the Eastern Watercourse Diversion. This will occur in the early part of the programme.

5.92 The Western Watercourse Diversion will have two main channels, the diverted and improved Cow Common Brook (i.e., Reach 1.1; part of the Cow Common Brook and Portobello Ditch WFD water body, currently at Poor Ecological Status) and improvements (by way of channel diversions and restoration) to the East Hanney Ditch (i.e., Reach 1.2; part of the Childrey Brook and Norbrook at Common Barn WFD water body, currently at Poor Ecological Status). These two watercourses will not be connected physically but together will form a mosaic of wetland habitats as the water rises and spreads out across the newly created floodplain which will form part of the floodplain compensation area. All the mitigation for the 'wetland' ditches will also be constructed at this stage.

5.93 The Eastern Watercourse Diversion will have a single main channel, the diverted and improved Mere Dyke (i.e., Reach 1.1; part of the Cow Common Brook and Portobello Ditch WFD water body, currently at Poor Ecological Status).

5.94 Technical Supporting Document B5 WFD shows the distribution of all design elements associated with the proposed scheme options that interact with watercourses within

[158] Ginge Brook and Mill Brook are not within the Ock hydrological catchment but form part of the Ock Environment Agency Operational Catchment.
[159] Restricted to footprint of combined intake/discharge structure. No other footprint mediated effects on the Thames are anticipated.

the study area, including the extents of the Western Watercourse Diversion and the Eastern Watercourse Diversion for all proposed scheme options.

5.95 The planned watercourse diversions and enhancements deliver between 15 and 35% net gain (Option dependent) in river biodiversity units relative to baseline (as reported in further detail within Technical Supporting Document B6 Biodiversity Net Gain Report). Overall, the proposed scheme aims to deliver a net gain of 10% across all habitats (terrestrial and aquatic). Whilst the existing baseline data suggest most of the watercourses affected are characterised by widespread and common species, further surveys are required to verify baseline conditions during subsequent Gates, notably due to access constraints at Gate 2 and in relation to the ditch networks in particular (see Section 5.6 on next steps). Should notable or protected species be identified within affected watercourses, further bespoke mitigation (for example specific habitat design measures or targeted habitat/species translocation) may be required.

5.96 The River Ock would be realigned locally as part of the overall enhancement plans and unlike watercourses within Reach 1.1 and Reach 1.2, is characterised by a diverse invertebrate, fish and macrophyte community, with several notable invertebrate species including fine-lined pea mussel and lithophilic and notable fish species such as brown trout and bullhead. The section of the Ock identified for enhancement exhibits a straightened planform relative to other sections immediately upstream of this location. Diversion of the Ock will deliver improved channel form (including low flow resilience through channel design) within the main channel itself and will retain the existing channel as a backwater feature, improving the overall ecological resilience of this Reach.

5.97 As discussed in Section 3.5, the new watercourses would be constructed in the dry, as much as possible, to keep the existing habitat functioning while the new channels are constructed. Flow will be directed into the Western Watercourse Diversion and the Eastern Watercourse Diversion once the channel construction is fully complete. This will be undertaken by connecting the new watercourses at the upstream ends to the existing flowing channels and then installing clay plugs at the upstream limits of the existing channels to divert the flows fully. Once the old channels are drained down, a clay plug would be installed at the downstream limit. It is envisaged, that following excavation of the watercourse additional mitigation could be undertaken upon them to increase the rate of establishment. This could include both selective marginal planting as well as invertebrate translocation, including any rare/notable species if discovered at a future date on site. Fish rescue and translocation would also be necessary after the channels have been fully plugged. These additional steps will aid establishment of these water bodies and help them move towards 'Good' ecological status at a quicker rate. Once all the additional mitigation has been completed the existing channels can be filled in with appropriate material and compacted.

5.98 Establishment time will vary between communities and species, but the overall trajectory of change will be positive relative to baseline conditions. It is envisaged that within two growing seasons the macrophytes and invertebrate communities will establish to a better condition than is present within the existing modified water bodies. As a result, it is envisaged that if construction is undertaken through 2029 and into early 2030 than by Autumn 2031 the habitats will be at a status that at is improved over baseline condition when compared to existing watercourse habitats within the scheme footprint and moving towards Good Ecological Status. A programme of monitoring and, if necessary, adaptive management would be implemented to ensure appropriate ecological objectives are realised.

5.99 Other footprint-mediated effects are largely restricted to individual watercourse crossings. The Gate 2 assessment assumes that the Western Watercourse Diversion and the Eastern Watercourse Diversion are in place and functional prior to the construction of other proposed scheme elements. Where an assessment of other proposed scheme elements on the Western Watercourse Diversion and the Eastern Watercourse Diversion has been undertaken, this is undertaken with reference to the trajectory of change in ecological baseline predicted for the watercourse diversions.

5.100 Each proposed scheme element with the potential to result in footprint-mediated effects is listed against the affected study Reach/receptor in Table 5.9. For each scheme element, the option(s) under which it applies is also reported. The scheme element names are consistent between the table and supporting figures (Figure 1.3 to Figure 1.8 in Appendix A1.1 Figures) where possible. One exception to this is “indicative footprint” which is used in the table but encompasses all the elements in the figures located within the perimeter access track (e.g., water extent, embankments, auxiliary discharge siphons, etc).

5.101 The overall effect of each item is indicated, which considers the likely embedded (i.e., design) mitigation (such as the conceptual design of river channel diversions (including planting), realignments and structures) and ‘standard’ mitigation (such as fish rescue and non-specific translocation of invertebrates through sediment transfer associated with channel diversions), prior to any further mitigation and/or compensation. Effects with multiple arrows highlight uncertainty in the current assessment conclusions at Gate 2.

Table 5.9 Footprint: direct habitat loss, gain or severance within the Ock Catchment and Thames

Reach/Receptor	Proposed scheme element	Applicable reservoir options	Description	Potential effects (inclusive of embedded (i.e., design) mitigation)	Overall predicted direction of change[160]
1.1 Cow Common Brook (including Portobello Ditch, Landmead Ditch, Mere Dyke, Oday Ditches[161] and feeder ditches)	Indicative footprint Settlement ponds Contractors site compound Auxiliary Drawdown Channel	All	To accommodate the reservoir footprint and other new infrastructure associated with the proposed scheme, it would be necessary to move a number of watercourses for all options. The extent of watercourse affected varies by proposed scheme option as follows, noting that some of the overall extents fall within Childrey Brook (lower) Reach (i.e., Reach 1.2): • 75 Mm³ Option: moving approximately 47 km of watercourse. • 100+30 Mm³ Option: moving approximately 58km of watercourse. • 125 Mm³ Option: moving approximately 58 km of watercourse. • 150 Mm³ Option: moving approximately 58 km of watercourse. • 80+42 Mm³ Option: moving approximately 58 km of watercourse. • 100 Mm³ Option: moving approximately 53 km of watercourse. Between 75 and 80% of the affected baseline watercourse extent for each option comprises ditch habitat (as defined by Environment Agency agreed methods documented within Technical Supporting Document B6 Biodiversity Net Gain Report). Key sections of habitat classed as river within the above watercourse extents (and associated with Reach 1.1) include: • 3 to 6 km (option dependent) of Portobello Ditch and Cow Common Brook which would be diverted to form part of the Western Watercourse Diversion. • 3.5 to 4.5 km (option dependent) of Mere Dyke which would be diverted to form part of the Eastern Watercourse Diversion. • 0.6 km (all options) of Oday Ditches. Detailed watercourse statistics associated with each option are provided in Technical Supporting Document B6 Biodiversity Net Gain Report.	The affected watercourses are characterised by relatively low-quality habitat and widespread and common macrophyte, macroinvertebrate and fish assemblages (where these occur) with limited intrinsic conservation value, as discussed within baseline sections of this report. Where assessed, the overall WFD biological status of this Reach is Poor. The planned Western Watercourse Diversion and Eastern Watercourse Diversion within Reach 1.1 will deliver morphological enhancements within diverted sections of Portobello Ditch, Cow Common Brook, and Mere Dyke, as well as enhancement of retained (realigned) sections of the existing Cow Common Brook/Landmead Ditch which would receive the diverted flows. New wetland ditches, the reservoir toe drain, and the Auxiliary Drawdown Channel (ADC) will also provide additional habitat creation. Overall, and based on the diversion, realignment and creation plans shown in Figure 1.3 to Figure 1.8 (in Appendix A1.1 Figures), the proposed scheme will deliver between 15 and 35% net gain (option dependent) in river biodiversity units relative to baseline (as reported in further detail within Technical Supporting Document B6 Biodiversity Net Gain Report). Following construction and diversion of water into the new Western Watercourse Diversion and Eastern Watercourse Diversion, ecological establishment will be enhanced through planting as well as non-specific translocation of invertebrates through sediment transfer. Fish rescue and translocation will also be undertaken at the same time as the channels are plugged. These activities will shorten establishment time. The habitat extent and condition-based approach adopted in Biodiversity Net Gain assessment is not specifically cognisant of notable or protected species. Whilst the existing baseline data suggests this Reach is characterised by widespread and common species, further surveys of are required to verify baseline conditions during subsequent Gates, notably due to access constraints at Gate 2 and in relation to the ditch networks in particular. Should notable or protected species be identified within affected watercourses, further bespoke mitigation (for example specific habitat design measures or targeted habitat/species translocation) may be required.	⇧

[160] As mediated by effect (neutral/beneficial/ adverse) based on understanding at Gate 2 and inclusive of current embedded (i.e. design) and standard mitigation.
[161] Oday ditches are included in Reach 1.1 (although technically the Thames water body) as they are within the reservoir footprint and they are most similar in character to Ock Reaches/ditches.

Reach/Receptor	Proposed scheme element	Applicable reservoir options	Description	Potential effects (inclusive of embedded (i.e., design) mitigation)	Overall predicted direction of change[160]
	Tunnel (crossings)	All	The proposed tunnel route crosses the Mere Dyke and the Eastern Watercourse Diversion in all six options. The proposed tunnel then crosses the Oday Ditches under all options. These ditches flow westwards and join the River Thames directly.	There are two potential options of method used for a tunnel crossing a watercourse. As it is not yet known what method is most likely, both are considered. One option is to bore under the channel. This should have minimal impact on the watercourse but might not always be feasible. This is the current preferred option. The other option is to cut a section into the channel, lay the tunnel down and then reinstate the channel on top. This will have temporary and localised effects but should not have permanent impacts, provided the channel is reinstated to a sufficient standard, either like for like or creating an improvement in morphology and habitat provision.	⇔
	Road Diversion (crossings)	All	For all options the proposed road diversion would cross watercourses. The 75, 100 and 125 Mm^3 options would cross seven watercourses including Cow Common Brook; Portobello Ditch; the Eastern Watercourse Diversion; and four unnamed ordinary watercourses. The 150, 80+42 and 100+30 Mm^3 options would cross six watercourses including Cow Common Brook; Portobello Ditch and four unnamed ordinary watercourses.	The potential effect of the crossings will depend on the type of structure used. A single, clear span crossing will have a lower impact than a box culvert. A Main River and/or WFD assessed watercourse will require a single-span bridge. A box culvert may be considered on smaller watercourses and ditches if the culvert is appropriately designed and mitigated. A box culvert may disrupt natural hydraulic and sediment transport processes; act as a barrier to the movement of fish and other wildlife; damage the bed and banks of the watercourse during construction; and reduce the extent of the riparian zone. A clear span bridge would shade the channel and riparian zone, locally reducing primary productivity. Depending on the constraints of each situation it may also impact on the morphology and hydrological regime. Regardless of the design option selected, structures will be designed to maintain flow and sediment continuity and species permeability which will maintain the overall function and integrity of the Reach, with only localised effects anticipated.	⇩
	Canal diversion (crossings)	All	The proposed canal diversion route has a varying number of crossings for the different options. All options include a crossing over the diverted Mere Dyke (which forms part of the new Eastern Watercourse Diversion).		⇩
	Auxiliary Drawdown Channel (crossing)	All	The proposed route for the ADC on all reservoir options include one crossing over the Eastern Watercourse Diversion. All other watercourses will be diverted to join this watercourse by the crossing point.		⇩
	Access Road (crossings)	All	The proposed access road route crosses eight watercourses. All routes cross the River Ock, the Eastern Watercourse Diversion and the ADC.		⇩
1.2 Childrey Brook (lower) (including East Hanney Ditch)	Western Watercourse Diversion	All	To accommodate the reservoir footprint and other new infrastructure associated with the proposed scheme, it would be necessary to move a number of watercourses for all options. The extent of watercourse affected varies by proposed scheme option as discussed in relation to Reach 1.1. Between 75–80% of the affected baseline watercourse extent for each option comprises ditch habitat (as defined by Environment Agency agreed methods documented within Technical Supporting Document B6 Biodiversity Net Gain Report). Key sections of habitat classed as river associated with Reach 1.2 include: 1.5 to 2 km (Option dependent) of East Hanney Ditch which	Broadly discussed in relation to Reach 1.1. The affected watercourses including East Hanney Ditch and associated feeder ditches are characterised by relatively low-quality habitat and widespread and common macrophyte, macroinvertebrate and fish assemblages (where these occur) with limited intrinsic conservation value as discussed within baseline sections of this report. Where assessed, the overall WFD biological status of this Reach is Poor (noting that invertebrate class is High). East Hanney Ditch will be realigned as part of the overall watercourse diversion, realignment and creation plans shown in Figure 4.25 in Appendix A1.1 Figures, contributing to the overall the proposed scheme delivery of between 15 and 35% net gain (option dependent) in river biodiversity units relative to baseline (as reported in further detail within Technical Supporting Document B6 Biodiversity Net Gain Report). The habitat extent and condition-based approach adopted in Biodiversity Net Gain assessment is not necessarily cognisant of notable or protected species. Whilst the existing baseline data suggests this Reach is characterised by widespread and common species, further surveys of are required to verify baseline	⇧

Reach/Receptor	Proposed scheme element	Applicable reservoir options	Description	Potential effects (inclusive of embedded (i.e., design) mitigation)	Overall predicted direction of change[160]
			would be realigned to accommodate the Western Watercourse Diversion. Detailed watercourse statistics associated with each option are provided in Technical Supporting Document B6 Biodiversity Net Gain Report.	conditions during subsequent Gates, notably due to access constraints at Gate 2 and in relation to the ditch networks in particular. Should such species be identified within affected watercourses, further bespoke mitigation (for example specific habitat design measures or targeted habitat/species translocation) may be required.	
	Road Diversion (crossings)	All	The proposed road diversion route crosses East Hanney Ditch in all options.	As per Reach 1.1 in relation to potential effects of crossings.	⇩
2.1 River Ock (lower)	Eastern and Western Watercourse Diversions	All	To accommodate the reservoir footprint and other new infrastructure associated with the proposed scheme, it would be necessary to move a number of watercourses for all options, as discussed in relation to Reach 1.1. No watercourses within Reach 2.1 fall within the reservoir footprint or associated infrastructure. However approximately 0.8 km (all options) of the River Ock will be enhanced as part of the wider watercourse diversion and realignment plans.	The River Ock is characterised by a diverse invertebrate, fish and macrophyte community, with several notable invertebrate species including fine-lined pea mussel and lithophilic and notable fish species such as brown trout and bullhead. The overall WFD biological status of the River Ock (lower) is Poor (driven by fish; noting that invertebrates and macrophytes/phytobenthos are high and good respectively). Approximately 0.8 km (all options) of the River Ock will already be realigned and enhanced as part of the existing wider watercourse diversion and realignment plans. Realignment of the Ock will deliver improved channel form within the main channel itself and will retain the existing channel (approximately 0.7 km) as a backwater feature, improving the overall ecological resilience of this Reach. The section of the Ock identified for enhancement exhibits a straightened planform relative to other sections immediately upstream of this location. The channel design will consider low flow resilience as well as habitat provision for notable species associated with the River Ock during subsequent project stages.	⇧
	Access Road	All	All options include a crossing of the River Ock, which is a Main River, and ditch MD7.	As per Reach 1.1 in relation to potential effects of crossings.	⇩
2.7 Sandford Brook	Access road	All	The proposed access road route for all options crosses the watercourse Sandford Brook (a Main River) twice and ditch SB1.	As per Reach 1.1 in relation to potential effects of crossings.	⇩
4. Thames – Upstream of SESRO (Evenlode to Culham)	Intake and outfall structure	All	New intake and outfall structure on the bank of the River Thames. May require some bank protection.	New structure on the bank of the River Thames would result in the loss of some riparian habitat and potentially marginal habitat. If bank protection were required there would be a localised impact on the geomorphology of the channel but it would be negligible at a water body scale and could be mitigated for elsewhere within the site.	⇩
The Cuttings and Hutchins Copse Local Wildlife Site	Reservoir footprint	All	The proposed scheme footprint association with all options has the potential to result in the loss of this LWS, which includes some aquatic features including ponds and sedge swamp.	There is potential that the Cuttings and Hutchins Copse LWS (which currently supports ponds alongside the railway, as well as a small area of sedge swamp and some wet woodland) may be lost. In the event it is not possible to retain this non-statutory and locally designated site, habitats represented within the LWS will be included within the baseline biodiversity unit calculations for site, against which the proposed scheme will deliver an overall net gain for biodiversity. The Biodiversity Net Gain (BNG) assessment of the proposed scheme is reported separately, within Technical Supporting Document B6 Biodiversity Net Gain Report.	⇩ ⇔

5.4.3 Operational regime: changes in flow/level/habitat availability within the Ock catchment and Thames

5.102 The flow regime of watercourses within the study area may be affected either by:

- the proposed scheme footprint (as described in Section 5.4.2) i.e., changes in the alignment of watercourses within the Ock catchment and the loss of catchment area associated with the footprint; and/or
- the operation of the proposed scheme abstraction from and discharge to the River Thames.

5.103 Study Reaches potentially affected by changes in flow regime associated with either (or both) of these proposed scheme elements are assessed in Table 5.10. The proposed scheme option(s) to which the assessment applies is also reported.

5.104 The overall potential effect of each mechanism is indicated by study Reach, based on current available modelling at Gate 2 (Chapter 2 Hydrology; Appendix A3.1 Weir Pool Sensitivity Screening and Chapter 4 Water Quality) which considers the likely embedded (i.e., design) mitigation (such as the conceptual design of river channel diversions and realignments within the Ock catchment), prior to any further mitigation and/or compensation. Effects with multiple arrows highlight uncertainty in the current assessment conclusions at Gate 2.

5.105 The potential for changes to flow to affect fish passage for resident and migratory species has been considered separately in Section 5.4.5.

Table 5.10 Regime: changes in flow/level/habitat availability within the Ock Catchment and Thames

Reach/Receptor	Proposed scheme element	Applicable reservoir options	Description	Potential effects (inclusive of embedded (i.e., design) mitigation)	Overall predicted direction of change[162]
1.1 Cow Common Brook (including Portobello Ditch, Landmead Ditch, Mere Dyke, Oday Ditches[163] and feeder ditches)	Scheme footprint	All*	Changes in flow in the Western Watercourse Diversion (the new Cow Common Brook) downstream of the reservoir relative to the existing Cow Common Brook, due to much of the water body catchment being within the proposed scheme footprint. Changes in flow in the Eastern Watercourse Diversion (the new Mere Dyke) downstream of the reservoir relative to the existing Mere Dyke, due to much of the water body catchment being within the proposed scheme footprint.	Preliminary modelling (see *Chapter 4 Water Quality*, in respect of SAGIS–SIMCAT flow modelling) shows that, as a result of the scheme footprint within the catchment area, there could be changes in flow in the new Western Watercourse Diversion relative to the existing Cow Common Brook. At broadly comparable points between the existing Cow Common Brook and the 'new' diverted Cow Common brook (i.e., the Western Watercourse Diversion; noting that no fixed-point comparison can be made as the watercourse is being diverted); a 4% increase in Q_{95} (1.47 to 1.53 Ml/d) and a 16% decrease in Q_{MEAN} (9.05 to 7.58 Ml/d) is predicted. The modelling does not consider potential localised contributions to baseflow that could emerge via superficial groundwater flows, based on the depth of the Western Watercourse Diversion which will be embedded in a floodplain compensation area. This would need to be assessed further during subsequent project stages. The new Western Watercourse Diversion and Eastern Watercourse Diversion will be designed to deliver morphological improvements against the baseline over their entire length. On balance, the morphological improvements secured through the new channel design (discussed in Section 5.4.2 in relation to footprint) are considered likely to deliver overall hydro-morphological and ecological benefits relative to baseline. The channels will be designed to accommodate modelled flows, with features (such as two-stage channels) incorporated to provide habitat resilience to low flows in particular. Modelling does not consider potential localised contributions in baseflow that could emerge via superficial groundwater flows, based on the depth of the realigned Western Watercourse Diversion and so the potential flow reduction (relative to broadly comparable baseline points) may not ultimately be realised. This would need to be assessed further during subsequent project stages. The potential changes in flow within the Western Watercourse Diversion and Eastern Watercourse Diversion relative to the existing are not considered likely to negate the overriding benefits of improved aquatic habitat condition delivered through the channel design.	⇔
		All*	There could be an increase in flow in a section (approximately 1 km) of the Landmead Ditch from the confluence of the Western Watercourse Diversion to its former confluence with the original Cow Common Brook.	The current channel may have capacity to accommodate the increase in flow by virtue of the Western Watercourse Diversion arrangement (with the Western Watercourse Diversion, i.e., new Cow Common Brook discharging to Landmead Ditch). However, preliminary modelling (see *Chapter 4 Water Quality*) shows that there may be a lower flow in the Western Watercourse Diversion so this could balance out. Should baseline capacity be exceeded, it would be more likely that localised floodplain	⇔

[162] As mediated by effect (neutral/beneficial/ adverse) based on understanding at Gate 2 and inclusive of current embedded (i.e. design) and standard mitigation.
[163] Oday ditches are included in Reach 1.1 (although technically within the Thames water body) as they are within the reservoir footprint and they are most similar in character to ditches associated with Reach 1.1 that are also affected by reservoir footprint.

Reach/Receptor	Proposed scheme element	Applicable reservoir options	Description	Potential effects (inclusive of embedded (i.e., design) mitigation)	Overall predicted direction of change[162]
				inundation frequency and duration would increase, that could have some additional benefits for biodiversity. Mitigation could include further local improvements to this Reach (in essence, extending further upstream the planned realignment of existing Cow Common Brook/Landmead Ditch around the confluence with the River Ock) should an impact be determined following further analysis. This would need to be assessed further during subsequent project stages.	
1.2 Childrey Brook (lower)	Scheme footprint	All*	Reduction in flow in the new East Hanney Ditch relative to the existing East Hanney Ditch, due to some of the water body catchment being within the reservoir footprint and the new Western Watercourse Diversion (i.e., flows now captured by the new Cow Common Brook). Reduction in flow in a section (approximately 2 km) of the existing Childrey Brook via flow reduction in the East Hanney Ditch and due to some of the water body catchment being within the reservoir footprint and the new Western Watercourse Diversion (i.e., flows now captured by the new Cow Common Brook).	Preliminary modelling (see *Chapter 4 Water Quality*, in respect of SAGIS–SIMCAT flow modelling) shows that, as a result of the scheme footprint within the catchment area, there could be a reduction in flow within the East Hanney Ditch and the Childrey Brook downstream of the existing confluence with the East Hanney Ditch. At the assessment point on the Childrey Brook immediately downstream of the existing confluence with East Hanney Ditch; an 8% decrease in Q_{95} (10.2 to 9.4 Ml/d) and a 9% decrease in Q_{MEAN} (33.3 to 30.2 Ml/d) is predicted. The modelling does not consider potential localised contributions in baseflow that could emerge via superficial groundwater flows, based on the depth of the realigned Western Watercourse Diversion. This would need to be assessed further in during subsequent project stages. The new realigned East Hanney Ditch will deliver morphological improvements against the baseline over its whole realigned length. On balance, the morphological improvements secured through the new channel design (discussed in Section 5.4.2 in relation to footprint) are considered likely to deliver overall benefits relative to baseline. The channel will be designed to accommodate modelled flows, with features (such as two-stage channels) incorporated to provide habitat resilience to low flows in particular. The potential changes in flow within East Hanney Ditch are not considered likely to negate the overriding benefits of improved aquatic habitat condition delivered through the channel design and the wider Western Watercourse Diversion. No morphological improvements to Childrey Brook are currently planned. Childrey Brook supports flow sensitive fish species including bullhead and brown trout and the invertebrate community is moderately sensitive to flow reductions, with evidence of historical flow stress apparent within the existing baseline. Recent Catchment Abstraction Management Strategy (CAMS) reporting[164] also identifies that '*Water bodies upstream of AP3* [the Ock assessment point prior to Thames confluence] *are impacted in part by public water supply abstractions. Thames Water Utilities Limited have carried out an investigation under the Restoring Sustainable Abstraction programme and identified their abstractions at Childrey Warren and Manor Road to be impacting these water bodies. Following this investigation, the Childrey Warren source is planned for closure, and habitat enhancement works will be carried out to reduce the impacts of*	⇩ ⇩

[164] Environment Agency (2019) *Kennet and Vale of White Horse Abstraction Licensing Strategy. A strategy to manage water resources sustainably* [online]. Available at https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/796172/Kennet-and-Vale-of-White-Horse-Abstraction-Licensing-Strategy.pdf [Accessed on: 17/06/22].

Reach/Receptor	Proposed scheme element	Applicable reservoir options	Description	Potential effects (inclusive of embedded (i.e., design) mitigation)	Overall predicted direction of change[162]
				abstraction'. However, the focus of this source closure appears to be on the protection of the Letcombe Brook[165] which is unaffected by the proposed scheme. Given the proportional extent of the Childrey Brook affected by the proposed scheme (2 km of the total 4 km WFD mainstem reportable water body length[166]), further work to understand the potential impact of this flow reduction will need to be undertaken during subsequent project stages. This is likely to involve further hydrological conceptualisation (including of potential superficial groundwater contributions) and screening based on the established Environmental Flow Indicator (EFI)[167] methodology. This would establish the degree of baseline hydrological change (through existing artificial influences) relative to naturalised hydrology, to place the potential flow reductions mediated by SESRO in further context. Additional hydroecological investigation may also be required in the event that predicted changes are non-compliant with the EFI. In the event that the flow reductions are considered likely to be adverse for the watercourse ecology and of a scale that may contribute to the water body failing to meet Good Ecological Status, further mitigation measures (for example, flow augmentation, or habitat improvements) may be required.	
2.1 River Ock (lower)	Scheme footprint	All*	Slight reduction in flow in a section (approximately 5 km) of the River Ock downstream of the confluences with the Childrey Brook and Cow Common Brook due to a reduction in flow in the Western Watercourse Diversion and Childrey Brook because much of the catchment is within the scheme footprint.	Preliminary modelling (see Section *Chapter 4 Water Quality*) shows that, as a result of the scheme footprint within the catchment area, there could be a reduction in flow within the River Ock downstream of the existing confluences with the Childrey Brook and Cow Common Brook. At the assessment point of the Ock immediately prior to the confluence with the Thames; a 2% decrease in Q_{95} (30.7 to 30 Ml/d) and a 3% decrease in Q_{MEAN} (142 to 138 Ml/d) is predicted. The modelling does not consider potential localised contributions in baseflow that could emerge via superficial groundwater flows, based on the depth of the realigned Western Watercourse Diversion. This would need to be assessed further during subsequent project stages. The watercourse supports flow sensitive fish species including bullhead and brown trout and the invertebrate community is moderately sensitive to flow reductions. No specific evidence of historical flow stress is apparent within the existing baseline review. However, recent Catchment Abstraction Management Strategy (CAMS) reporting[168] identifies that '*Water bodies upstream of AP3* [the Ock assessment point prior to Thames confluence] *are impacted in part by public water supply abstractions. Thames Water Utilities Limited have carried out an investigation under the Restoring Sustainable Abstraction programme and identified their abstractions at Childrey Warren and Manor Road to be impacting these water bodies. Following this investigation, the Childrey Warren source is planned for closure, and habitat enhancement works will be carried out*	⇔ ⇩

[165] Water Projects Online (2022) *Childrey Warren WTW Abstraction Closure (2019)* [online]. Available at: https://waterprojectsonline.com/custom_case_study/childrey-warren-wtw-abstraction-closure/ [Accessed on: 24/06/2022].
[166] Environment Agency (2022) *Catchment Data Explorer* [online]. Available at: https://environment.data.gov.uk/catchment-planning/ [Accessed on: 17/06/2022].
[167] Environment Agency (2013) Environmental Flow Indicator Guidance [internal]. January, 2013.
[168] Environment Agency (2019) *Kennet and Vale of White Horse Abstraction Licensing Strategy. A strategy to manage water resources sustainably* [online]. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/796172/Kennet-and-Vale-of-White-Horse-Abstraction-Licensing-Strategy.pdf [Accessed on: 17/06/22].

Reach/Receptor	Proposed scheme element	Applicable reservoir options	Description	Potential effects (inclusive of embedded (i.e., design) mitigation)	Overall predicted direction of change[162]
				to reduce the impacts of abstraction'. However, the focus of this source closure appears to be on the protection of the Letcombe Brook[169] which is unaffected by the proposed scheme. Whilst a relatively small reduction in flow is predicted for the River Ock, given the proportional extent of the water body affected by the change (5 km of the total 21 km WFD mainstem reportable water body length[170]), further work to understand the potential impact of this flow reduction will need to be undertaken during subsequent project stages. This is likely to involve further hydrological conceptualisation (including of potential superficial groundwater contributions) and screening based on the established Environmental Flow Indicator (EFI)[171] methodology. This would establish the degree of baseline hydrological change (through existing artificial influences) relative to naturalised hydrology, to place the potential flow reductions mediated by SESRO in further context. Additional hydroecological investigation may also be required in the event that predicted changes are non-compliant with the EFI. In the event that the flow reductions are considered likely to be adverse for the watercourse ecology and of a scale that may contribute to the water body failing to meet Good Ecological Status, further mitigation measures (for example, flow augmentation, or further habitat improvements) may be required. Approximately 0.8 km (all options) of the River Ock will already be realigned and enhanced as part of the existing wider watercourse diversion and realignment plans. Realignment of the Ock will deliver improved channel form within the main channel itself and will retain the existing channel as a backwater feature, improving the overall ecological resilience of this Reach. The Environment Agency[172] has also identified an existing issue with fish passage at New Cut Mill, downstream of SESRO which they are seeking to remediate. This may present an opportunity to align mitigation and enhancement measures on the River Ock through partnership working in this location.	
4. Thames – Upstream of SESRO (Evenlode to Culham)	Scheme footprint	All**	Ock ultimately joins the Thames within Reach 4 meaning any reduction in flow within the Ock as a consequence of scheme footprint ultimately propagates to the Thames.	Reach 4 sits immediately upstream of the influence of SESRO abstraction and discharge on the Thames. However, there could be changes in flow within this Reach, mediated by any change in flow within the River Ock which discharges to Reach 4. The potential flow reduction within the River Ock discussed in relation to Reach 2.1 has been benchmarked against the nearest appropriate gauging station (39046 – Thames at Sutton Courtenay;[173] located within the upstream extent of Reach 5). The potential flow reductions discussed in relation to Reach 2.1 (0.7 Ml/d at Q_{95} and 4 Ml/d at Q_{MEAN}) would constitute (assuming coincident low flows) less than 0.1% reduction at Q_{95} (220 Ml/d) and at Q_{MEAN} (2,357 Ml/d) respectively, based on data for the Sutton Courtenay gauging station (discussed in Chapter 2 Hydrology). These changes are considered to be negligible in the context of the	⇔

[169] Water Projects Online (2022) *Childrey Warren WTW Abstraction Closure (2019)* [online]. Available at https://waterprojectsonline.com/custom_case_study/childrey-warren-wtw-abstraction-closure/ [Accessed on: 24/06/2022].
[170] Environment Agency (2022) *Catchment Data Explorer* [online]. Available at: https://environment.data.gov.uk/catchment-planning/ [Accessed on: 17/06/2022].
[171] Environment Agency (2013) Environmental Flow Indicator Guidance [internal]. January, 2013.
[172] Pers. comm. Graham Scholey (Environment Agency) via email on 16/08/2022.
[173] UKCEH National River Flow Archive (2022) *39046 – Thames at Sutton Courtenay* [online]. https://nrfa.ceh.ac.uk/data/station/meanflow/39046 [Accessed on: 24/06/2022].

Reach/Receptor	Proposed scheme element	Applicable reservoir options	Description	Potential effects (inclusive of embedded (i.e., design) mitigation)	Overall predicted direction of change[162]
				ecological function and resilience of the River Thames and are not considered further within the assessment of Thames flow changes.	
5 Thames – Immediately downstream of SESRO combined intake/ discharge structure up to the River Thame confluence	Reservoir intake and discharge (Thames abstraction and discharge regime)	All**	Hydrological regime changes during years in which SESRO is operational, within periods during which SESRO abstracts water (typically winter months) from the Thames.	Based on the review of stochastic hydrological data (see *Chapter 2 Hydrology*) SESRO is likely to abstract water from the Thames at some stage in the year, and during approximately 60% of all hydrological years at the maximum rate of abstraction for the 150 Mm^3 option (and at lower rates ~34% of the total simulation occurring across most years). Abstraction typically occurs at points between the months of November and April (up to the maximum abstraction rate of 1000 Ml/d) but can occasionally occur during other periods (typically at a lower abstraction volume) where river flows allow (based on existing HoF constraints), as described in *Chapter 2 Hydrology*. The full stochastic dataset (see Figure 2.6 in Appendix A1.1 Figures and Table 2.9) indicates that SESRO will predominantly reduce baseline flows between Q_{20} to Q_{60}, with the greatest relative reduction at Q_{40}; an overall reduction in long term Q_{40} flow from 2,043 Ml/d to 1,933 Ml/d (a 5% reduction). Given SESRO would rarely affect flows above the long-term Q_{20}, it is unlikely to have a significant effect on channel/habitat forming flows or the overall inundation regime of the Thames floodplain (noting that no specific flood modelling has been undertaken). Consequently, SESRO abstraction is unlikely to significantly affect in-channel habitat condition or the in-channel and marginal wetland communities that may benefit from the current inundation regime. There remains a risk, given the reported relatively high frequency of out of bank flows (Lyons *et al.* (2021)[174] noted that the river was out of bank on ten occasions within this Reach during a study period of 1994–2018); the abstraction between Q_{20} and Q_{60} may have some influence on more moderate events in any given year around the boundary of out-of-bank conditions. This is considered unlikely to be significant in the context of the overall ecological integrity of the Reach and marginal wetland habitats but would benefit from further investigation during subsequent project stages. In terms of in-channel flow reduction, this is not considered likely to have any significant consequences for the ecology of the Thames during the periods and at the magnitude identified by the modelling undertaken. With climate change predicted to increase the frequency and magnitude of higher flow events, it may be that changes of the predicted magnitude are essentially ameliorated and balance out, relative to the existing hydrological baseline. This also merits further investigation during subsequent project stages.	⇔ ⇩

[174] Lyons, J., Hateley, J., Peirson, G., Eley, F., Manwaring, S. and Twine, K. (2021) An assessment of hydroacoustic and electric fishing data to evaluate long term spatial and temporal fish population change in the River Thames, UK. *Water*, 13: 2932.

Reach/Receptor	Proposed scheme element	Applicable reservoir options	Description	Potential effects (inclusive of embedded (i.e., design) mitigation)	Overall predicted direction of change[162]
		All**	Hydrological regime changes during years in which SESRO is operational, within periods during which SESRO discharges water (typically summer and autumn months) to the Thames.	Based on the review of stochastic hydrological data (see *Chapter 2 Hydrology*) SESRO is likely to augment flows (discharge to the River Thames) at some stage in the year during approximately 63% and 57% of all hydrological years for the 150 Mm^3 and 75 Mm^3 options respectively. Flow augmentation typically occurs between late June and November but can extend to early January during periods of more severe drought for both SESRO size options. Reviewing the pattern of release across the simulation it is also clear that when SESRO is triggered, it releases the maximum volume possible for the scheme, i.e., 315 Ml/d (including losses) for the 150 Mm^3 size scheme. This is important as it means that the variation in low flows within an individual year will be maintained but shifted by a consistent augmentation volume. An indicative representation of this dynamic is shown in Figure 2-7 in Appendix A1.1 Figures. The full stochastic dataset (see Figure 2.6 in Appendix A1.1 Figures and Table 2-9 within Chapter 2 Hydrology) shows the projected change in the long-term flow duration curve for the River Thames (based on the 150 Mm^3) immediately downstream of SESRO and indicates that SESRO will augment flows lower than Q_{60}, with the greatest relative change at Q_{95}. At this assessment location, an overall increase in long term Q_{95} flow from 361 Ml/d to 553 Ml/d is predicted (a 53% increase and equivalent of a baseline Q_{82}). The relative change reduces with increasing flow; by Q_{80} to a 25% increase; by Q_{70} to an 8% increase. The increase at Q_{95} is reflective of: • the modelling approach, where the stochastic series is 'stressed' relative to a historical period (i.e., assumes an increase in drought event frequency in the future over the stochastic analysis period) meaning that an 'all-years' Q_{95} stochastic baseline is typically lower than has been observed historically, i.e., the stochastically modelled relative (%) increase in Q_{95} resulting from the augmentation is likely to be (partly) an over estimation relative to the historical baseline; and • the reality that, with SESRO augmentation, low flows (including drought and very low flow events) will occur much less frequently, and some very low flows will effectively be removed from the hydrograph. Conceptually, the lower the baseline annual[175] Q_{95} of a given year, the greater the proportional change for that given year. This is summarised in Table 2.13 (*Chapter 2 Hydrology*) which ranks the baseline Q_{95} of the stochastic years selected for 1D modelling at Gate 2 (extreme drought, drought and moderately dry) and their equivalent Q_{95} (with SESRO augmentation), relative to the baseline stochastic Q_{95} return period (i.e. how frequently baseline Q_{95} is lower than the Q_{95} of the modelled hydrological year). As expected, the greatest proportional change is for the extreme drought scenario; from a baseline Q_{95} return period of 1-in-500 year (without SESRO) to a	⇩⇧

[175] Note that where exceedance values (e.g. Q_{95}) are used with reference to a defined stochastic hydrological year (e.g. extreme drought, drought or moderately dry); these represent the exceedance based on hydrology from that specific year alone and are distinct from long term average stochastic exceedance values, which are based on the long term stochastic dataset.

Reach/Receptor	Proposed scheme element	Applicable reservoir options	Description	Potential effects (inclusive of embedded (i.e., design) mitigation)	Overall predicted direction of change[162]
				scenario Q_{95} return period of 1-in-1.5 years (with SESRO). The lowest proportional change is associated with the moderately dry event which moves from a 1-in-4 year return to a 1-in-1.4 year return period. The relatively small difference between the end points (67% and 71%) for these hydrological years with significantly different baseline character, effectively underlines a key characteristic of SESRO augmentation: a 'flatter' lower end of the flow duration curve and a reduction in the range of flows at low flows (removing very low flows altogether and with greater proportional change for drought scenarios of increasing severity). Figure 2.3 and Figure 2.4 (in Appendix A1.1 Figures) show the three simulated years under the 150 Mm^3 scheme against the monthly mean ranking of observed data at Sutton Courtenay. Whilst the three years provide a snapshot of the patterns that may be experienced if SESRO was active, it suggests that immediately downstream of SESRO, flows that would have previously been considered as *exceptionally low*, *notably low,* and *potentially below normal* across the summer are not likely to occur and these years will be replaced with flows that have historically been considered as at the upper range of normal or even above normal. The 'dry' years selected for modelling represent stochastic years in which the River Thames would experience the greatest proportional changes (relative to baseline) in flow as a result of SESRO. With increasing baseline flow, the proportional influence of release from SESRO reduces. Similarly, with distance from SESRO, the proportional influence of augmentation reduces. Riverine ecology will respond to level and velocity change that is concomitant with changes to the discharge regime, meaning that stochastic discharge modelling can only tell part of the story. The 1D modelling undertaken for those selected years therefore facilitates greater understanding of the broad changes in magnitude and extent of those characteristics described more conceptually by the stochastic modelling. The below summarises the range (at the annual Q_{95}) for these different elements based on 1D modelling of the 150 Mm^3 option only for those periods when SESRO releases (see *Chapter 2 Hydrology*) to avoid 'diluting' the effect of the release through annual statistics (with the abstraction operational at other times of year). This focusses on relative change between baseline and SESRO scenarios rather than absolute predicted values, for reasons of model limitation as discussed in *Chapter 2 Hydrology* (see Table 2.14): • Flow – for the hydrological scenarios modelled and at Q_{95}, SESRO releases increase flow by between 80–120% (moderately dry-extreme scenario) at release; 50–70% after the Thame confluence, 35–50% after the Kennet confluence and 30–44% downstream of the Loddon inflow, diminishing further moving downstream to Datchet prior to re-abstraction. • Velocity – at Q_{95}, SESRO releases increase average channel velocity by between 33 and 103% at release; 16-25% after the Thame confluence and (broadly, noting caveats discussed in Chapter 2 Hydrology) thereafter prior to re-abstraction from Datchet downwards. In absolute terms, approximate changes range from 4 cm/s to 10 cm/s.	

Reach/Receptor	Proposed scheme element	Applicable reservoir options	Description	Potential effects (inclusive of embedded (i.e., design) mitigation)	Overall predicted direction of change[162]
				• Level – at Q_{95}, SESRO releases increase average river level between 5-20%. In absolute terms, approximate changes ranging from 7-23 cm, broadly (noting caveats discussed in Chapter 2 Hydrology) reducing with distance from SESRO. Broadly speaking, the modelling shows that the relative changes presented for the 150 Mm^3 are approximately halved with the 75 Mm^3 option (see *Chapter 2 Hydrology* for full results). Acknowledging that velocity changes are not evenly distributed across the channel cross-section and that marginal areas, in particular, will be critical for fish recruitment, Appendix A3.1 Weir Pool Sensitivity Screening has undertaken further cross-sectional sensitivity analysis to understand how changes in average cross-sectional velocity translate to changes in marginal velocities. Key observations based on all (198 no.) panels and all hydrological scenarios within the analysis and based on summer Q_{95} (when the highest proportional changes relative to baseline are predicted): • 71% (140) of panel results exhibit a relative change of less than 0.05 m/s (comprising 44% (87) with less than 0.03 m/s and 27% (53) between 0.03 m/s and 0.05 m/s); • 17% (33) of panel results exhibit a relative change of between 0.05 m/s and 0.1 m/s; and • 13% (25) of panel results exhibit a relative change of greater than 0.1 m/s (the highest of which is a 0.38 m/s predicted change). • Whilst some of the marginal values have a relatively high increase (in terms of % change), they remain slack water, suggesting overall resilience is high. The relative/proportional flow and velocity changes associated with SESRO discharge reduce with increasing baseline flow (i.e., with less dry years) and so these results (using baseline dry years) are broadly indicative of the largest proportional changes that may be anticipated under the proposed scheme. The direction of change with the dry scenarios underlines this effect, with the largest absolute changes (i.e., those 25 identified panel results with >0.1 m/s changes) disproportionately associated (40%) with the extreme drought scenario, and with the number of such panels reducing with less dry hydrological years (32% with drought; 28% with moderately dry). The largest absolute changes (i.e., within the 25 identified panel results with >0.1 m/s changes) are typically (though not exclusively) associated with deeper panels and/or those cross-sections that are symmetrical/homogenous 'U' rather than asymmetrical/heterogenous 'V' shaped, underlining: • the relatively higher impact of SESRO on homogenous channel cross-sections that are often also intrinsically of lower baseline ecological value based on their low cross-sectional heterogeneity;	

Reach/Receptor	Proposed scheme element	Applicable reservoir options	Description	Potential effects (inclusive of embedded (i.e., design) mitigation)	Overall predicted direction of change[162]
				• the relatively higher resilience of asymmetrical channel cross-sections that are also of intrinsically of higher baseline value; and • the opportunity presented by cross-sectional improvements as mitigation for residual risks associated with SESRO discharge, in the event this is considered necessary. Predicted changes within marginal areas specifically, are also considered likely to be worst-case/precautionary, for reasons discussed within Appendix A3.1 Weir Pool Sensitivity Screening. Overall, resilience in the marginal areas is likely to be quite high. Increased summer discharge (in general terms) has the potential for direct beneficial but also adverse effects, for example mortality of fish during a critical period in the life history of particular species. Increased discharge also has the potential for indirect effects such as changes in water quality (including temperature, which could also be beneficial or adverse) and food availability (such as changes in phytoplankton and zooplankton dynamics). Such indirect effects are considered in Section 5.4.4 and 5.4.6 respectively, though the relative influence of direct and indirect effects associated with discharge changes is not well understood[176] meaning disaggregating these effects is, and will remain a challenge. Considering direct effects; as a level-dependent system, velocity and depth on the River Thames are significantly influenced by how level control structures are operated at a given discharge. Therefore conceptually, with no change in existing level control operating procedures; velocity and depth during SESRO augmentation would simply reflect existing velocity and depth associated with the equivalent discharge under existing baseline conditions (to which the baseline ecology is adapted). The potential mechanisms of impact associated with flow augmentation are therefore a longer period of higher summer flow conditions relative to the stochastic baseline (and associated increases in both level and velocity during those periods, assuming no amendment to existing level-control operations), and a reduction in the frequency of low flow and drought year hydrology within the system. The adverse impacts of drought and low flow conditions for river ecology are well documented[177,178] such that water companies are required to manage the environmental impacts of their abstraction activities during drought events[179,180]. Flow augmentation can support rivers in which significant environmental and water resource pressures exist; and such measures already exist within the Thames region as part of the existing Water Resource Management	

[176] Frear, P.A. and Cowx, I.G. (2003) *Factors Affecting Coarse Fish Recruitment. Phase II – Examination and Analysis of Existing Environment Agency Data*. R&D Technical Report W2-048/TR. Swindon, UK: Environment Agency.
[177] Environment Agency (2017) *Drought response: our framework for England, June 2017*.
[178] Piniewski, M., Prudhomme, C., Acreman, M.C., Tylec, L., Oglecki, P. and Okruszko, T. (2016) Responses of fish and invertebrates to floods and droughts in Europe. *Ecohydrology*, 10(1): e1793.
[179] Environment Agency (2020) *Water Company Drought Plan guideline, December 2020* (Version 1.2) LIT UNASSIGNED
[180] Environment Agency (2020) *Environmental assessment for water company drought planning supplementary guidance*. LIT 55303

Reach/Receptor	Proposed scheme element	Applicable reservoir options	Description	Potential effects (inclusive of embedded (i.e., design) mitigation)	Overall predicted direction of change[162]
				Plan[181] and Drought Plan[182]. However, not all effects of drought and low flows are adverse for all species all of the time. A recent systematic review of literature investigating the impact of drought (and floods) on invertebrates and fish within European rivers[183] identified statistically significant adverse effects of drought for both invertebrates and fish. This was conclusive for invertebrates but some metrics for fish showed both positive and negative responses across the literature reviewed, and a comparative lack of literature on fish (as compared with invertebrates) was considered to reduce confidence in the conclusions. However, a reduction in drought and very low flow conditions in the River Thames, mediated by SESRO releases is likely to be beneficial for most of the River Thames ecology. Conversely, high summer flows have been correlated with a reduction in coarse fish recruitment/year class strength in UK rivers;[184] year class strength of roach in the River Ouse, for example, has been negatively correlated with increased discharge during the period from June to September inclusive. SESRO will release flow outside of drought and very low flow conditions (i.e., during years with a higher baseline summer range) and consequently, could have adverse consequences for certain fish species. However, this reported relationship can also be inconsistent and may depend on the specific characteristics of higher flow events. For example, Lyons *et al*. (2021)[185] examined the correlation between long term (1994–2018) fish population densities from Environment Agency hydroacoustic data, and river flow specifically within this Reach of the River Thames. The research sought to identify the presence of any statistically significant difference between years with peak hydroacoustic fish density estimates and flows that were statistically higher than the long-term average for the period. Two specific periods in which summer flows were higher than the long-term average were identified as 2007 and 2012. Following the 2007 peak, high mean hydroacoustic fish densities were recorded in 2008-2010. However, no such peak immediately followed the 2012 summer event. The authors tentatively hypothesise that the summer 2007 (which, unlike the 2012 event resulted in floodplain inundation) may have benefited cohorts of roach and bleak from preceding years by providing rich summer feeding areas in the floodplain environment, indicated by increases observed in acoustic abundance during subsequent years. Similarly, where studies[186] have identified negative correlations with increased discharge, it may be that these correlations are in part influenced by the contrast between 'flashy' periods of increased summer discharge (resulting in weaker recruitment) with more stable periods (resulting in better recruitment). SESRO releases provide a stable addition of flow during summer at a consistent rate (see *Chapter 2 Hydrology*), on top of	

[181] Thames Water (2019) *Water resource Management Plan 2019* [online]. Available at: https://www.thameswater.co.uk/about-us/regulation/water-resources [Accessed on: 28/06/22].
[182] Thames Water (2017) *Drought Plan 2017 –2022* [online]. Available at https://www.thameswater.co.uk/about-us/regulation/drought-plan#:~:text=What%20is%20a%20Drought%20Plan,while%20also%20protecting%20the%20environment [Accessed on: 28/06/22].
[183] Piniewski, M., Prudhomme, C., Acreman, M.C., Tylec, L., Oglecki, P. and Okruszko, T. (2016) Responses of fish and invertebrates to floods and droughts in Europe. *Ecohydrology*, 10(1): e1793.
[184] Frear, P.A. and Cowx, I.G. (2003) *Factors Affecting Coarse Fish Recruitment. Phase II – Examination and Analysis of Existing Environment Agency Data.* R&D Technical Report W2-048/TR. Swindon, UK: Environment Agency.
[185] Lyons, J., Hateley, J., Peirson, G., Eley, F., Manwaring, S. and Twine, K. (2021) An assessment of hydroacoustic and electric fishing data to evaluate long term spatial and temporal fish population change in the River Thames, UK. *Water*, 13: 2932.
[186] Frear, P.A. and Cowx, I.G. (2003) *Factors Affecting Coarse Fish Recruitment. Phase II – Examination and Analysis of Existing Environment Agency Data.* R&D Technical Report W2-048/TR. Swindon, UK: Environment Agency.

Reach/Receptor	Proposed scheme element	Applicable reservoir options	Description	Potential effects (inclusive of embedded (i.e., design) mitigation)	Overall predicted direction of change[162]
				the prevailing natural baseline variability. SESRO in itself would not impose a 'flashy' characteristic upon the hydrograph. The River Thames currently supports a diverse fish assemblage including eurytopic, rheophilic and limnophilic species occupying different ecological niches and with a preference for (and tolerance of) a range of velocity and environmental conditions. Roach and bleak dominate the community in terms of abundance within this Reach (a longer-term study of this Reach[187] found that roach contribute 61% and bleak 17% to the total catch in the river margins; and 29% and 61% in the mid-river). The only other species that contribute more than 2% of the captured population were chub and perch. As may be expected for a river of this type in a level-controlled Reach, the invertebrate community typically has a low sensitivity to reduced flow and has not historically been impaired by flow reduction (based on analysis from 2010 onwards and including periods of low flow (2010) and drought (2011) years). The absolute velocity values predicted by the 1D and panel modelling require caution in their interpretation (as discussed in *Chapter 2 Hydrology*) with further development and calibration planned during subsequent project stages; however, the relative changes are broadly indicative of the magnitude that may be expected between baseline and scenarios for the dry hydrological years modelled (with this proportional change reducing with increasing baseline flow). Different fish and life stages have different optimal flow and level preferences[188] and the magnitude of change predicted, whilst small in most instances, may well provide a competitive advantage and favour certain fish species over others. The timing of SESRO augmentation is likely to be a consideration given the baseline communities, in that some species may benefit (or receive proportionally less disbenefit) relative to other species. SESRO releases (typically) from late June to November after spawning and fry emergence of some of the coarse fish community and may favour chub and perch for example (as earlier spawners) over roach and bleak (later spawners). Reported bimodality of coarse fish populations[189] is a further consideration in this regard, in that prevailing conditions (with SESRO) may ultimately favour a particular cohort within a species that means that the cohort exhibiting a particular life-history strategy is favoured and becomes more dominant over a cohort that does not. Whilst this may reduce the overall ecological resilience of the population, it could mean that adverse impacts on for example, absolute abundance of a given species, are not as pronounced as may otherwise be expected. The overall characteristic of increased summer flows is also likely to directly benefit some species. For example, a local side channel known as the 'Harwell Lasher' was anecdotally of good habitat value to rheophilic fish species in the past being predominately composed of gravel	

[187] Lyons, J., Hateley, J., Peirson, G., Eley, F., Manwaring, S. and Twine, K. (2021) An assessment of hydroacoustic and electric fishing data to evaluate long term spatial and temporal fish population change in the River Thames, UK. *Water*, 13: 2932.
[188] Cowx, I.G., Noble, R.A., Nunn, A.D., Harvey, J.P., Welcomme, R.L. and Halls, A.S. (2004) *Flow and Level Criteria for Coarse Fish and Conservation Species*. Science Report SC020112/SR. Bristol, UK: Environment Agency.
[189] Frear, P.A. and Cowx, I.G. (2003) *Factors Affecting Coarse Fish Recruitment. Phase II – Examination and Analysis of Existing Environment Agency Data.* R&D Technical Report W2-048/TR. Swindon, UK: Environment Agency.

Reach/Receptor	Proposed scheme element	Applicable reservoir options	Description	Potential effects (inclusive of embedded (i.e., design) mitigation)	Overall predicted direction of change[162]
				glides, which in recent years has become covered by silt. Barbel used to feature much more regularly (anecdotally) in angler catches and chub would be seen spawning along this channel.[190] Additional summer flow (with control over how it is distributed between different side channels by virtue of the operation of existing structures) could therefore benefit rheophilic and lithophilic components of the fish community, increasing their relative abundance. Climate change is a further consideration, expected to increase the frequency and duration of low summer flows which, in part, SESRO would mitigate relative to the historical baseline. This would benefit from further investigation during subsequent project stages. Overall, flow changes within the River Thames as a result of SESRO have the potential to be both beneficial and adverse (at different times and for different species) for the existing baseline ecology and may affect the overall ecological integrity of the affected Reaches. Whilst flow augmentation that removes drought and very low flow years will conceptually provide overall benefits for ecological communities, the influence of SESRO (whilst proportionally smaller at higher baseline flow scenarios) would be to move average or typical lower flow (but non-drought) hydrological years into more average and above-average flow years. This aspect of change could realise more adverse than beneficial effects for the baseline ecological communities of the Reach, and requires further consideration (i.e., assessment of other such hydrological scenarios) as part of subsequent Gates. However, the additional velocity modelling undertaken as part of the hydrological scenarios modelled here (as dry scenarios, these are likely to be those with the highest proportional changes in velocity), suggest that marginal areas (particularly areas of better habitat diversity, i.e., those most likely to important in sustaining early life stages for recruitment) are more resilient to changes in discharge. Such areas were shown to have lower relative change in velocity compared to deeper areas. The relative magnitude of velocity change is also anticipated to reduce with increasing baseline flow scenarios (i.e., as SESRO represents a lower proportion of the overall discharge regime). Whilst the assessment in future Gates will seek to improve certainty on the trajectory of change that may be anticipated relative to baseline, a key challenge will be in the subjectivity and philosophy of whether a potential change (for example, changes in the relative abundance of different fish species) is considered to be adverse or beneficial, particularly in the context of the extensive existing anthropogenic modifications of the river and its flow regime which has shaped the baseline ecological communities. Proposed scheme mitigation is summarised in Section 5.5, including those elements of embedded mitigation (already considered in the context of identified potential effects) and potential further mitigation options that could support maintenance or improvement of the existing baseline ecology. These aspects of the scheme are to be developed and considered as part of subsequent Gates. For example, the level control structures and their operating regimes offer the	

[190] Pers. comm. Stuart Manwaring (Environment Agency) via email on 08/04/2022.

Reach/Receptor	Proposed scheme element	Applicable reservoir options	Description	Potential effects (inclusive of embedded (i.e., design) mitigation)	Overall predicted direction of change[162]
				opportunity to further mitigate and optimise the regime to reduce velocity changes relative to baseline conditions where desirable. Ramp-up flow release mitigation and other potential measures (such as marginal habitat improvements) are also identified in Section 5.5 and will be developed further as part during subsequent project stages. The overall extent of the influence is also an important consideration. Approximately 237 km of the River Thames sits outside of tidal influence (i.e., is above Teddington Weir) and the most significant hydraulic changes of SESRO are significantly ameliorated with distance from source and following the confluence with the Thame (i.e., some 13 km downstream of the release. Velocity effects thereafter (i.e., until flows are re-abstracted from Datchet onwards) are of significantly lower proportion (15% change for moderately dry as compared with 80% at the release). Similarly, the affected Reach forms part of a wider Thames (Evenlode to Thame) WFD Water Body (a total Water Body length of 64 km[191] excluding tributaries). Whilst there may be both adverse and beneficial effects for the ecology of the defined affected Reach (prior to the development of further mitigation), it seems unlikely that residual adverse effects post-mitigation would have the potential to affect the overall integrity of the River Thames, or the WFD water body of which this Reach forms part.	
Hayward's Eyot LWS **Clifton Hampden Meadows LWS** **Clifton Hampden Wood LWS** **Little Wittenham SSSI (No LSE predicted for the SAC – see Section 5.3.2)** **Dorchester Meadow LWS** **Dorchester Gravel Pits (Allen Pit) LWS**	Reservoir intake and discharge (Thames abstraction and discharge regime)	All**	Hydrological regime changes during years in which SESRO is operational, within periods during which SESRO abstracts water (typically winter months) from the Thames.	Potential risks and benefits remain as discussed in relation to Reach 5 – from potential changes in wetted river perimeter/frequency and duration of floodplain inundation. The primary mechanism of reduced inundation (on which some of these marginal habitats will depend) is considered unlikely to be significantly affected, given SESRO would rarely affect flows above the long-term Q_{20}. There remains a risk, given the reported relatively high frequency of out of bank flows (Lyons *et al.* (2021)[192] noted that the river was out of bank on ten occasions within this Reach during a study period of 1994–2018); the abstraction between Q_{20} and Q_{60} may have some influence on more moderate events in any given year around the boundary of out-of-bank conditions. This is considered unlikely to be significant in the context of the overall ecological integrity of the system and marginal wetland habitats but would benefit from further investigation during subsequent project stages. With climate change predicted to increase the frequency and magnitude of higher flow events, it may be that changes of the predicted magnitude are essentially ameliorated and balance out, relative to the existing hydrological baseline. This would benefit from further investigation during subsequent project stages.	⇔ ⇩

[191] Environment Agency (2022) *Catchment Data Explorer* [online]. Available at: https://environment.data.gov.uk/catchment-planning/ [Accessed on: 13/04/2022].
[192] Lyons, J., Hateley, J., Peirson, G., Eley, F., Manwaring, S. and Twine, K. (2021) An assessment of hydroacoustic and electric fishing data to evaluate long term spatial and temporal fish population change in the River Thames, UK. *Water*, 13: 2932.

Reach/Receptor	Proposed scheme element	Applicable reservoir options	Description	Potential effects (inclusive of embedded (i.e., design) mitigation)	Overall predicted direction of change[162]
6 Thames – Between River Thame and Thames Water Datchet intake	Reservoir intake and discharge (Thames abstraction and discharge regime)	All**	Hydrological regime changes during years in which SESRO abstracts water from (typically during winter months) and discharges water to (typically during summer and autumn months) the Thames.	Potential benefits and risks remain as discussed in relation to Reach 5, however, with the proportional reduction of these effects with distance from SESRO (as discussed in relation to Reach 5). It is considered unlikely that adverse residual effects (for example from increased velocity which dissipates following the confluence with the Thame as discussed in relation to Reach 5) are likely to affect the overall integrity of the Reach. Conversely, beneficial effects of flow support during periods of drought and very low flow are considered likely to be beneficial at a scale that could improve the overall ecological integrity of the Reach.	⇩ ⇧
7 to 12 River Thames **7 Thames – Between Thames Water Datchet intake and Affinity Water Sunnymeads intake** **To 12 Thames – Between Thames Water Walton and Thames Water Hampton intake**	Reservoir intake and discharge + Thames/Affinity abstractions (Thames abstraction and discharge regime)	All**	Hydrological regime changes during years in which SESRO abstracts water from (typically during winter months) and discharges water to (typically during summer and autumn months) the Thames.	Flow is re-abstracted throughout these Reaches steadily returning river flows to their equivalent baseline. Some beneficial effects of flow support during periods of drought and very low flow are considered likely to be beneficial but reduce throughout these Reaches and may not be significant for the overall ecological integrity of the Reaches.	⇧ ⇔
13 Thames – Between Thames Water Hampton intake and Teddington Weir (tidal limit)	Reservoir intake and discharge + Thames/Affinity abstractions (Thames abstraction and discharge regime)	All**	Hydrological regime changes during years in which SESRO abstracts water from (typically during winter months) and discharges water to (typically during summer and autumn months) the Thames.	No hydrological/hydraulic change anticipated within this Reach as SESRO release will have been fully re-abstracted.	⇔

*Notes: *All reservoir options are considered to be subject to the same potential effects with the direction of effect consistent between options, however, note that the detailed discussion of effect applies only to the 150 Mm^3 option which was modelled.*

*** All reservoir options are considered to be subject to the same potential effects with the direction of effect consistent between options, however, note that the detailed discussion of effect applies only to the 150 Mm^3 option and 75 Mm^3 options which were modelled.*

5.4.4 Operational regime: changes in water quality within the Ock catchment and Thames

5.106 The water quality of watercourses within the study area may be affected either by:

- the indicative footprint (as described in Section 5.4.2) i.e., changes in the alignment of watercourses within the Ock catchment and the loss of catchment area associated with the indicative footprint; and/or
- the operation of the proposed scheme abstraction from and discharge to the River Thames.

5.107 Study Reaches potentially affected by changes in water quality associated with either (or both) of these proposed scheme elements are assessed in Table 5.11. The proposed scheme option(s) to which the assessment applies is also reported.

5.108 The overall potential effect of each mechanism is indicated by study Reach, based on current available modelling at Gate 2 (*Chapter 4 Water Quality*) which considers the likely embedded (i.e., design) mitigation (such as reservoir aeration and the conceptual design of river channel diversions and realignments), prior to any further mitigation and/or compensation.

Table 5.11 Regime: changes in water quality within the Ock Catchment and Thames

Reach/Receptor	Proposed scheme element	Applicable reservoir options	Description	Potential effects (inclusive of embedded (i.e., design) mitigation)	Overall predicted direction of change[193]
1.1 Cow Common Brook (including Portobello Ditch, Landmead Ditch, Mere Dyke, Oday Ditches[194] and feeder ditches)	Scheme footprint	All*	Changes to water quality in the Western Watercourse Diversion (the new Cow Common Brook) downstream of the reservoir relative to the existing Cow Common Brook, as the diversion would redirect flow and chemical inputs to new channels and eliminate parts of the catchment. Changes to water quality in the Eastern Watercourse Diversion (the new Mere Dyke) downstream of the reservoir relative to the existing Mere Dyke, as the diversion would redirect flow and chemical inputs to new channels and eliminate parts of the catchment. There would be significant land use change (within those areas of the proposed scheme footprint which continue to form part of the catchment), which would no longer be agricultural land. As livestock and arable farming are two of the main sources of nutrients in the catchment (*Chapter 4 Water Quality*) this land use change is likely to be associated with a reduction in nutrient loading to the watercourses.	Preliminary modelling (see *Chapter 4 Water Quality*) shows that, as a result of the diversion of Cow Common Brook, there could be improvements in water quality in the new Western Watercourse Diversion relative to the existing Cow Common Brook baseline. At broadly comparable points (in terms of position in catchment; noting that no fixed point comparison can be made as the watercourse is being diverted) between the existing Cow Common Brook and the 'new' Cow Common brook (i.e. the Western Watercourse Diversion); a 15% decrease in mean nitrate (5.41 to 4.60 mg/l N), a 32% decrease in mean orthophosphate (0.47 to 0.32 mg/l P), and 51% decrease in 90^{th} percentile ammonia (0.10 to 0.05 mg/l N) is predicted. There is also a predicted 49% increase in DO 10^{th} percentile (4.63 to 6.92 mg/l), and 22% decrease in BOD 90^{th} percentile (1.02 to 0.80 mg/l). The baseline water quality in Cow Common Brook is poor (especially orthophosphate) and the aquatic community is adapted to high nutrient levels. The high nutrient concentrations mean that the macrophyte and invertebrate communities in particular are different to those which would be expected under reference conditions. A reduction in nitrate and orthophosphate could favour more nutrient-sensitive species and reduce the dominance of stress-tolerant species, thereby improving the species and functional richness of the community. A more diverse macrophyte flora could in turn create a more diverse physical habitat for invertebrates and small fish which live amongst the vegetation. However, note that the reduction in orthophosphate concentrations would not be enough to improve the WFD class. Given that class boundaries are set to reflect and support the ecological quality of the watercourse, a change in nutrient concentrations of this magnitude is unlikely to be significant within the context of the watercourse ecology as a whole. Additionally, there are often large spikes in ammonia and corresponding sharp drops in DO in the summer which might be an indication that the watercourse experiences low flows. Given that the new Western Watercourse Diversion will be designed to accommodate design flows and be more resilient to lower flows, there could be significant benefits to the aquatic ecology from a water quality perspective e.g., by reducing periods of deoxygenation. These potential water quality improvements fare mirrored in the retained section of Cow Common Brook, where orthophosphate and nitrate concentrations are predicted to improve (reduction in mean concentrations of 34% (0.47 to 0.31 mg/l P) and 0.05% (5.41 to 5.15 mg/l N) respectively) as the watercourse would be fed via run-off from the reservoir embankment rather than the old Cow Common Brook (which is affected by arable land use and septic tanks). However, ammonia (56% increase in the 90^{th} percentile (0.10 to 0.15 mg/l N)), DO (2% decrease in the 10^{th} percentile (4.63 to 4.56 mg/l)), and BOD (7% increase in the 90^{th} percentile (1.02 to 1.09 mg/l)) are affected due to the reduction in travel times in the now shorter watercourse. Although this is a large proportional increase in ammonia, the absolute values are still low and indicative of High WFD status, therefore it is unlikely to have any significant consequences	⇧

[193] As mediated by effect (neutral/beneficial/ adverse) based on understanding at Gate 2 and inclusive of current embedded (i.e. design) and standard mitigation.
[194] Oday ditches are included in Reach 1.1 (although technically the Thames water body) as they are within the reservoir footprint and they are most similar in character to ditches associated with Reach 1.1 also affected by reservoir footprint.

Reach/Receptor	Proposed scheme element	Applicable reservoir options	Description	Potential effects (inclusive of embedded (i.e., design) mitigation)	Overall predicted direction of change[193]
				for aquatic ecology. There is no baseline information for Mere Dyke, which will be diverted to form the Eastern Watercourse Diversion. However, preliminary modelling predicts that the water quality of the new channel would meet standards for High WFD class for ammonia (90th percentile is predicted to be 0.12 and 0.20 mg/l at the two assessment points) and BOD and would have lower orthophosphate concentrations than the old Cow Common Brook (mean orthophosphate predicted to be 0.35 and 0.32 mg/l P). Predicted mean nitrate is high, but comparable to the rest of the catchment (5.71 and 6.70 mg/l N). The predicted DO in the middle of the Eastern Watercourse Diversion represents a small improvement relative to the old Cow Common Brook (3% increase in 10th percentile) but DO is low in the headwaters (1.60 mg/l) due to the relatively low flows and limited opportunity for reaeration at this point.	
1.2 Childrey Brook (lower)	Scheme footprint	All*	The realignment of Western Watercourse Diversion would mean that some of the runoff which previously would have fed East Hanney Ditch would now flow into the Western Watercourse Diversion. This means that flow is predicted to decrease in East Hanney Ditch and thus the Childrey Brook downstream of its confluence, resulting in decreased dilution of pollutants in this Reach. There would be some land use change associated with the proposed scheme footprint which would no longer be agricultural land.	Preliminary modelling (see *Chapter 4 Water Quality*) shows that, as a result of the diversion of Cow Common Brook, reduction in flow in the realigned East Hanney Ditch (and therefore Childrey Brook downstream of the confluence), the water quality in the lower Childrey Brook may worsen slightly. At the assessment point on the Childrey Brook immediately downstream of the existing confluence with East Hanney Ditch; a 2% decrease in mean nitrate (9.39 to 9.18 mg/l N), but a 9% increase in mean orthophosphate (0.29 to 0.31 mg/l P), and 7% increase in 90th percentile ammonia (0.14 to 0.15 mg/l N) is predicted. There is also a predicted 3% increase in DO 10th percentile (7.96 to 8.23 mg/l) and 6% increase in BOD 90th percentile (3.20 to 3.38 mg/l). The predicted increase in ammonia is small in absolute values and would not prevent the watercourse achieving High WFD class for ammonia; the increase in orthophosphate is well within the existing (Moderate) class boundary associated with the baseline modelling. The aquatic ecology baseline of the lower Childrey Brook and East Hanney Ditch suggests that the ecology (especially the macrophyte community) is currently impacted by high nutrient levels (e.g., high RMNI, LEAFPACS2 O:E indicative of Poor WFD class). This accords with the water body RNAGs. The classification for the Phosphate element of WFD assessment has been Poor and Moderate for 2015 RBMP2 and 2019 dRBMP3 status respectively. Given that class boundaries are set to reflect and support the ecological quality of the watercourse, the within class (Moderate) change in nutrient concentrations predicted by the modelling at this assessment location, whilst adverse and undesirable, is unlikely to be significant within the context of the watercourse as a whole and could be further mitigated by addressing catchment and point-source pressures elsewhere within the catchment.	⇩
2.1 River Ock (lower)	Scheme footprint	All*	Modifications to the watercourses in and around the SESRO site would redirect flow and chemical inputs to different places. The River Ock is downstream of Childrey Brook, Cow Common Brook, and their feeder ditches, and so any changes in water quality in Reaches 1.1 and 1.2 would propagate to the River Ock. The predicted reduction in flow for the section of the River Ock downstream of the confluences with Childrey Brook and Cow Common Brook could reduce	Preliminary modelling (see *Chapter 4 Water Quality*) shows that the water quality in the lower River Ock is unlikely to change significantly, despite a small reduction in flow relating to the proposed watercourse modifications. Any changes anticipated are positive. At the assessment point of the Ock immediately prior to the confluence with the Thames; a 2% decrease in mean nitrate (7.86 to 7.69 mg/l N), a 2% decrease in mean orthophosphate (0.22 to 0.22 mg/l P), and no change in 90th percentile ammonia (0.03 to 0.03 mg/l N is predicted. There is also a predicted 1% increase in DO 10th percentile (10.37 to 10.48 mg/l) and no change in BOD 90th percentile (1.14 to 1.14 mg/l). Although there is a predicted slight reduction in river flows in the River Ock, which would affect dilution, this is balanced out by the reduced input of Cow Common Brook flow relative to the upstream River Ock. As	⇔

Reach/Receptor	Proposed scheme element	Applicable reservoir options	Description	Potential effects (inclusive of embedded (i.e., design) mitigation)	Overall predicted direction of change[193]
			dilution of pollutants within this section.	the existing Cow Common Brook water quality is worse than the upstream Ock catchment, this reduction in the 'new' Cow Common Brook benefits the water quality of the River Ock. As there is negligible or no change predicted for the water quality of the River Ock, there are unlikely to be any water quality related changes for the aquatic ecology.	
4. Thames – Upstream of SESRO (Evenlode to Culham)	Scheme footprint	All**	The River Ock discharges to the Thames within Reach 4 meaning any changes to water quality within the Ock catchment ultimately propagate to the Thames.	Given that the impacts of the Scheme on water quality in the River Ock are considered to be negligible, and the relative contribution of Ock to Thames is small (Section 5.4.3), no water quality impacts on the Thames are predicted.	⇔
5 Thames – Immediately downstream of SESRO combined intake/ discharge structure up to the River Thame confluence	Reservoir intake and discharge (Thames abstraction and discharge regime)	All**	Abstraction of water from the Thames could reduce dilution of pollutants in the River Thames as a result of the reduction in flows.	Immediately downstream of SESRO the impacts of abstraction on water quality are non-existent as at this point the abstraction simply removes a proportion of the flow rather than changing concentrations. Further downstream, this could influence the level of dilution for incoming flows (tributaries/point sources), however preliminary modelling (*Chapter 4 Water Quality*) suggests this is likely to be negligible.	⇧
			Discharge of water from SESRO would result in the mixing of reservoir and river water, altering the water quality of the river. Discharges from SESRO would increase the volume of water in the River Thames, increasing the dilution of tributaries and point sources.	Modelling indicates that the impacts of SESRO operational discharges are largely positive, in that it will reduce or make no change in river concentrations for both the 150 Mm^3 and the 75 Mm^3 options modelled. For an extreme drought and based on the 150 Mm^3 size option, the model predicts a 17% reduction in total P, and a 19% reduction in nitrate immediately downstream of SESRO. Reservoir attenuation, biological uptake, and sedimentation processes would improve the river quality in the reservoir relative to that in the Thames, meaning that discharges would improve water quality downstream and have a dilution effect on incoming tributaries or point discharges. The aquatic ecology baseline assessment shows that the Thames communities (especially macrophytes and phytobenthos) are dominated by species which prefer high nutrient concentrations. As such, the reduction in orthophosphate and nitrate during SESRO operation could favour more nutrient sensitive species, especially as these nutrients tend to be highest during low flows (when SESRO would be in operation). However, as the reduction in nutrients is predicted to be relatively low, and not enough to improve the WFD status for the orthophosphate element (to Good, from a baseline of Moderate), it is unlikely that the community change would be significant in the context of the Reach and the River Thames more widely. One exception to this is an increase (62% increase for an extreme drought scenario) in ammonia immediately downstream of the reservoir related to the increase in river velocities and consequent reduced travel time. However, this increase in concentration is predicted to only materialise for a relatively short distance in the context of the River Thames (it disappears by the Kennet confluence, i.e., 50 km downstream from SESRO) and whilst proportionally large, is very small in absolute terms and would not cause a change from High WFD status for ammonia as baseline River Thames concentrations are typically extremely low. The model predicts that SESRO would cause temperature to become more variable but that on average it could cause a slight decrease in water temperature (approximately 1% reduction for all scenarios, this equates to an average reduction of 0.2°C across the whole year for the extreme drought scenario). Temperature is an important control on biological activity (including the timing of key activities such as	

Reach/Receptor	Proposed scheme element	Applicable reservoir options	Description	Potential effects (inclusive of embedded (i.e., design) mitigation)	Overall predicted direction of change[193]
				spawning) and growth, and as aquatic species have preferred temperature ranges, a change in water temperature could be adverse or beneficial depending on the species requirements. In particular, strong year classes of cyprinids are often correlated with high water temperatures during the first summer of life (usually measured as the degree days above 12°C, i.e., the sum of the number of degrees above a threshold temperature each day within a period of time), although temperature alone is not a good predictor of year class strength.[195] Therefore, SESRO could indirectly affect fish through reducing temperature. This should, however, be considered within the context of future projected climate change, which is predicted to increase water temperature in the Thames with warming in recent decades already underway.[196] The overriding control on water temperature is likely to be climate rather than SESRO operation meaning SESRO could potentially function to partly mitigate for increasing river temperatures. Options to microsite the offtake level (if necessary) to further manage the temperature of discharge will be considered as part of additional mitigation options during subsequent project stages (see Section 5.5). Olfaction plays an important role in fish migration and spawning behaviour most notably for anadromous salmonids, lamprey, and juvenile eels (i.e., upstream migrating fish). Migratory salmonids and lamprey are not well represented within the Thames community in general and particularly not within the upper Thames. A small number of salmon are recorded each year within the lower Thames but are thought to be strays from nearby rivers and recent studies have found no evidence of successful salmon reproduction in the Thames.[197] Whilst angling reports of sea trout in the lower Thames exist, they are also considered to be uncommon within the Thames in general[198] and unlikely to form a significant component of the upper Thames community. Lamprey identified from with the study area are typically brook lamprey (which undertake more localised migrations than river or sea lamprey). The long-term ambition remains to restore migratory fish communities to the River Thames[199] and so the existing baseline may change in future. SESRO has the potential to contribute to further improvements in habitat (for rheophilic migratory species) and water quality in the Thames, complementing longer-term Environment Agency led initiatives (including fish passage and habitat improvements on tributaries of the Thames). Depending on the timing of an assumed future recovery, migratory populations may recover and establish within a River Thames that already includes the influence of SESRO on olfactory signals, and therefore would be adapted to this, rather than SESRO altering chemical signatures to which a baseline community is already adapted. However, considering the existing migratory fish component of the Thames and/or recovery of other migratory fish components prior to SESRO being commissioned, the mechanisms of effects from the proposed scheme relate primarily to the dilution or inhibition of olfactory signals. Conceptually, an alteration of the chemical signature of water within the Thames during periods of	

[195] Frear, P.A. and Cowx, I.G. (2003) *Factors Affecting Coarse Fish Recruitment. Phase II – Examination and Analysis of Existing Environment Agency Data.* R&D Technical Report W2-048/TR. Swindon, UK: Environment Agency.
[196] Hammond, D. and Pryce, A.R. (2007) *Climate change impacts and water temperature*. Science Report: SC060017/SR. Bristol, UK: Environment Agency.
[197] Griffiths, A.M., Ellis, J.S., Clifton-Dey, D., Machado-Schiaffino, G., Bright, D., Garcia-Vazquez, E. and Stevens, J.R. (2011) Restoration versus recolonisation: The origin of Atlantic salmon (*Salmo salar* L.) currently in the River Thames. *Biological Conservation*, 144(11): 2733–2738.
[198] Harris, G. (2004) A Review of the Statutory Regulations to Conserve Sea Trout Stocks in England and Wales. In: Harris, G. and Milner, N. (Eds) *Sea Trout Biology, Conservation and Management. Proceedings of the First International Sea Trout Symposium, Cardiff, July 2004.* Oxford: Blackwell Publishing, 441–456.
[199] Griffiths, A.M., Ellis, J.S., Clifton-Dey, D., Machado-Schiaffino, G., Bright, D., Garcia-Vazquez, E. and Stevens, J.R. (2011) Restoration versus recolonisation: The origin of Atlantic salmon (*Salmo salar* L.) currently in the River Thames. *Biological Conservation*, 144(11): 2733–2738.

Reach/Receptor	Proposed scheme element	Applicable reservoir options	Description	Potential effects (inclusive of embedded (i.e., design) mitigation)	Overall predicted direction of change[193]
				discharge could affect fish behaviour with consequences for their reproductive success. Anadromous fish rely, in part, on following olfactory cues (e.g. migratory and alarm cues) in order to identify natal and/or suitable spawning streams, coordinate spawning behaviours and identify risks.[200,201] The array of key odorants utilised for olfactory navigation is not well understood but recent research suggests that the chemical array is likely to consist of a combination of amino acids, some steroids, bile acids and slats, prostaglandins and cations such as calcium and magnesium.[202] Similarly, the role of inhibitors is complex with recent studies [e.g.203] identifying that a range of substances including metals, pesticides and surfactants can inhibit olfactory receptors. Fundamentally, SESRO would store and release water from the same catchment. Whilst water abstracted (typically during winter), stored and released to the Thames is likely to have a different chemical signature to water flowing within the Thames during periods of discharge, the relative contribution of this water to the overall flow within the River Thames rapidly diminishes with distance from source (see Section 5.4.3) and a number of studies have indicated that salmonids are attracted to natal water diluted to very low proportions (as little as 0.1%).[204] Similar observations are reported for lamprey, i.e. that relevant signals are detected at low concentrations and larval odour elicits behavioural responses at the concentrations produced by a single larvae diluted several thousand fold.[205] SESRO is therefore unlikely to dilute signals from other tributaries of the Thames to the point at which signals driving migratory and/or behavioural cues are masked. Similarly, most elements of water quality improve with SESRO in the Thames and it is equally unlikely that SESRO would increase concentrations of olfactory inhibiting substances to the point this becomes ecologically meaningful. A residual risk, given the very low concentrations of olfactory substances required to elicit a behavioural response, is that SESRO stores components of olfactory signals based on winter abstraction and releases them back to the river at a point when they are not normally present, eliciting a mistiming or confusion of behavioural cues. Concentrations of substances arising from biological activity or from the unique chemistry of tributary streams, i.e., those likely to be involved in olfactory cues associated with identifying suitable streams for lamprey or natal streams for salmonids, are likely to be diluted during winter (abstraction) compared with summer (release). The relative contribution (even assuming no decay of these components during storage in SESRO) is therefore likely to be smaller than the prevailing signals dictating the olfactory response at this time of year. As the array of odorants involved in olfactory cues are not well understood (and therefore the decay, persistence, or accumulation of such substances during storage is unclear), this will remain a conceptual risk for SESRO but is considered very low in the context of the overriding controls on olfaction within the Thames catchment. The pattern of water quality changes is expected to be similar for all reservoir options, although as the	

[200] Buchinger, T.Y., Siefkes, M.J., Zielinski, B.S., Brant, B.O. and Li, W. (2015) Chemical cues and pheromones in the sea lamprey (*Petromyzon marinus*). *Frontiers in Zoology*, 12: 32.
[201] Bett, N.N., and Hinch, S.G. (2016) Olfactory navigation during spawning migrations: a review and introduction of the Hierarchical Navigation Hypothesis. *Biological Reviews*, 91(3): 728–759.
[202] Bett, N.N., and Hinch, S.G. (2016) Olfactory navigation during spawning migrations: a review and introduction of the Hierarchical Navigation Hypothesis. *Biological Reviews*, 91(3): 728–759
[203] Tierney, K. B., Singh, C. R, Ross, P. S. and Kennedy, C. J. (2007) Relating olfactory neurotoxicity to altered olfactory-mediated behaviors in rainbow trout exposed to three currently-used pesticides. *Aquatic Toxicology*, 81(1): 55–64.
[204] Sutterlin, A.M. and Gray, R. (1973) Chemical basis for homing of Atlantic salmon (*Salmo salar*) to a hatchery. *Journal of the Fisheries Research Board of Canada*, 30: 985–989.
[205] Buchinger, T.Y., Siefkes, M.J., Zielinski, B.S., Brant, B.O. and Li, W. (2015) Chemical cues and pheromones in the sea lamprey (*Petromyzon marinus*). *Frontiers in Zoology*, 12: 32.

Reach/Receptor	Proposed scheme element	Applicable reservoir options	Description	Potential effects (inclusive of embedded (i.e., design) mitigation)	Overall predicted direction of change[193]
				retention time would be lower in a smaller reservoir scheme, modelling for the 75 Mm^3 reservoir option predicts lower change to the Thames water quality relative to the baseline for this option. The influence of dilution and velocity changes would be similar between options as this is reliant on the volume of water released (which is similar across options). The reduction in nutrient concentrations could alter phytoplankton and phytobenthos growth and dynamics with implications on primary productivity and algal blooms (this is considered, including consequences for higher trophic groups, in Section 5.4.6).	
6 to 13 River Thames **6 Thames – Between River Thame and Thames Water Datchet intake** **to** **13 Thames – Between Thames Water Hampton intake and Teddington Weir (tidal limit)**	Reservoir intake and discharge (Thames abstraction and discharge regime)	All**	Abstraction of water from the Thames could reduce dilution of pollutants in the River Thames as a result of the reduction in flows	There is little evidence from the modelling that abstraction from the River Thames to fill SESRO would affect water quality as the model predicts only negligible differences between the baseline and SESRO scenarios. The only exception is a small increase in ammonia upstream of the Kennet confluence and upstream of Datchet, probably related to the reduction in dilution of point source inputs caused by the small reduction in flow and the slow decay of ammonia. This increase is not sufficient to change WFD class from High for ammonia.	⇧
			Discharge of water from the SESRO reservoir would result in the mixing of reservoir and river water, altering the water quality of the river.	The modelling predicts that the effects of SESRO on water quality would diminish with distance downstream, although small improvements remain relating to the dilution effect of SESRO discharge on incoming tributaries/point sources. Due to the increased flow velocity (and therefore reduced travel times) caused by SESRO discharge, there is a small (3%) increase in BOD predicted (against an existing baseline of very low BOD) at Datchet, whereas immediately downstream of SESRO BOD is predicted to be lower than the baseline.	
			Discharges from SESRO would increase the volume of water in the River Thames, increasing the dilution of tributaries and point sources.		
			Increased flow velocities caused by SESRO discharges would reduce travel times and thus could decrease within river losses of some chemicals relative to the baseline.		

*Notes: *All reservoir options are considered to be subject to the same potential effects with the direction of effect consistent between options, however, note that the detailed discussion of effect applies only to the 150 Mm^3 option which was modelled.*

*** All reservoir options are considered to be subject to the same potential effects with the direction of effect consistent between options, however, note that the detailed discussion of effect applies only to the 150 Mm^3 option and 75 Mm^3 options which were modelled.*

5.4.5 Operational regime: changes to existing barrier porosity (function of existing fish passes) within the Ock catchment and Thames; and fish impingement/entrainment at new and existing intake/discharge structures within the Thames

5.109 Existing barrier porosity (i.e., function of existing fish/eel passes) on watercourses within the study area may be affected by changes in flow (as described in Section 5.4.3) that move fish/eel passes outside of their optimal design range.

5.110 In addition, the operation of a new intake/outfall structure on the River Thames (as well as releases from SESRO enabling existing intakes to operate more frequently and/or for longer duration) may result in increased fish impingement/entrainment (and mortality) relative to existing baseline conditions, especially as this may form a backwater refuge.

5.111 Study Reaches potentially affected by these changes are assessed in Table 5.12. The proposed scheme option(s) to which the assessment applies is also reported.

5.112 The overall potential effect of each mechanism is indicated by study Reach, based on current available modelling at Gate 2 (Chapter 2 Hydrology and Chapter 4 Water Quality (in respect of SAGIS–SIMCAT flow modelling)) and design information (Technical Supporting Document A1 Concept Design Report) which considers the likely embedded (i.e., design) mitigation (such as the conceptual design of the new intake/outfall structure), prior to any further mitigation and/or compensation.

Table 5.12 Regime: changes to barrier porosity (function of existing fish passes) within the Ock Catchment and Thames; and fish impingement/entrainment at the new intake/discharge structure

<table>
<tr><th>Reach/Receptor</th><th>Proposed scheme element</th><th>Applicable reservoir options</th><th>Description</th><th>Potential effects (inclusive of embedded (i.e., design) mitigation)</th><th>Overall predicted direction of change[206]</th></tr>
<tr><td>1.2 Childrey Brook (lower)</td><td rowspan="2">Eastern and Western Watercourse Diversions</td><td rowspan="2">All</td><td>Reduction in flow in a section (approximately 2 km) of the existing Childrey Brook via flow reduction in the East Hanney Ditch and due to some of the water body catchment being within the reservoir footprint and the new Western Watercourse Diversion (i.e., flows now captured by the new Cow Common Brook).</td><td rowspan="2">Existing fish passes within Childrey Brook study area (1 No. upstream of East Hanney Ditch confluence; 1 No. downstream of East Hanney Ditch confluence, as shown in Figure 5.8 in Appendix A1.1 Figures) and an eel pass on the River Ock (1 No. downstream of Childrey Brook confluence, as shown in Figure 5.8 in Appendix A1.1 Figures) could be affected by slight reductions in flow predicted by modelling undertaken to date (discussed in Section 5.4.3).
The fish passes within the study area are designed to operate with a flow of between 5-10% of Average Daily Flow under Q_{95} flow conditions, and to operate efficiently at flows between Q_{95} and Q_{10}; eel passes within the study area are designed to function between Q_{99} to at least Q_{70} flow and levels (based on flows at the time the passes were designed).[207]
Whilst a relatively small change in flow is predicted within each Reach; this may serve to move the fish and eel passes outside of their effective range during certain low flow periods (relative to baseline) but move them within their effective range during certain higher flow periods (relative to baseline). Overall, the effect of the flow changes predicted on the effectiveness of existing fish and eel pass is considered likely to be negligible for the fish communities associated with these Reaches.</td><td rowspan="2">⇔</td></tr>
<tr><td>2.1 River Ock (lower)</td><td>Slight reduction in flow in a section (approximately 5 km) of the River Ock downstream of the confluence with the Childrey Brook and Cow Common Brook due to a reduction in flow in the Western Watercourse Diversion and Childrey Brook because much of the catchment is within the indicative footprint.</td></tr>
<tr><td>4. Thames – Upstream of SESRO (Evenlode to Culham)</td><td>Intake and outfall structure</td><td>All</td><td>New intake and outfall structure probably on the bank of the River Thames.</td><td>The consequences of water release (outfall) from the intake/outfall structure are assessed in the context of flow changes within the River Thames (see Section 5.4.3), as are the consequences of water intake on flow changes within the River Thames. However, the intake itself could also locally result in fish entrainment/impingement and mortality during periods of intake.
The intake design would consist of 24 No. Passive Wedge-Wire Cylinder (PWWC) screens with an air backwash system, in eight assemblies of three screens (see Technical Supporting Document A1 Concept Design Report). These would be located in a widening of the riverbank on the outside of the bend at the junction of the lock cut in the main river channel leading to the weirs. The detailed design of the intakes will be undertaken in line with Environment Agency good practice guidance[208,209] and in compliance with the Eel Regulations.[210]
However, by design, PWWC screens are the recommended and most widely used method for juvenile and larval fish protection (suitable for salmonids, lamprey, eels/elver, freshwater coarse fish, and benthic fish). They are much less prone to maintenance failures than other methods and are effective at preventing fish entry unless they are seriously damaged. They can also be designed with a narrow slot width meaning it is possible to prevent the entrainment of fish larvae</td><td>⇩</td></tr>
</table>

[206] As mediated by effect (neutral/beneficial/ adverse) based on understanding at Gate 2 and inclusive of current embedded (i.e. design) and standard mitigation.
[207] Pers. comm. Stuart Manwaring (Environment Agency) by return of data request via email on 25/11/2021.
[208] Environment Agency (2011) *Screening at intakes and outfalls: measures to protect eels 'The Eel Manual'*. LIT 5413.
[209] Environment Agency (2006) *Screening for Intake and Outfalls: a best practice guide*. Science Report SC030231.
[210] GOV.UK (2022). *The Eels (England and Wales) Regulations 2009*. Available at https://www.legislation.gov.uk/uksi/2009/3344/contents/made [accessed 29/06/2022]

Reach/Receptor	Proposed scheme element	Applicable reservoir options	Description	Potential effects (inclusive of embedded (i.e., design) mitigation)	Overall predicted direction of change[206]
				and eggs as well. The screens have a low through slot velocity, allowing fish to swim away (reducing risk of impingement), and have a relatively smooth external presentation, which reduces the risk of fish abrasion. The air-blast backwash system is a key part of the maintenance of the system, releasing explosive bursts of air to clear any debris which has been pinned to the outer surface of the screen that may otherwise reduce the effectiveness of the system by concentrating intake velocities over residual 'unblocked' area of the screens. It also prolongs the life of the system (limiting need for invasive maintenance). By design and when properly maintained, PWWC intake systems are highly effective at excluding fish and are recommended where 'near perfect screening'[211] is required. In addition to the effective design of the structure, the predominant timing of SESRO intake operation (winter) means that the risk of entrainment/impingement during critical life stages for eggs, fry, and juveniles (i.e., spring and summer) more likely to be at risk from intake structures, is also avoided by the proposed scheme. Whilst there inevitably remains a risk of some fish harm/mortality as a consequence of the intake, this is not considered likely to have a significant effect on the ecological function or integrity of the Reach or the River Thames.	
5 to 13 River Thames **5 Thames – Immediately downstream of SESRO combined intake/discharge structure up to the River Thame confluence** **to** **13 Thames – Between Thames Water Hampton intake and Teddington Weir (tidal limit)**	Reservoir intake and discharge (Thames abstraction and discharge regime)	All	Hydrological regime changes during years in which SESRO abstracts (typically during winter months) and discharges (typically during summer and autumn months) water from and to the Thames.	There are 59 No. existing fish passes within the Thames study area (Farmoor to Teddington; as shown in Figure 5.8 in Appendix A1.1 Figures) (32 No. fish passes; 18 No. eel passes; 9 No. both); ten of which are upstream of the SESRO intake/outfall. The fish passes within the study area are designed to operate with a flow of between 5-10% of Average Daily Flow under Q_{95} flow conditions, and to operate efficiently at flows between Q_{95} and Q_{10}; eel passes within the study area are designed to function between Q_{99} to at least Q_{70} flow and levels (based on flows at the time the passes were designed).[212] SESRO abstraction tends to reduce high flows and increase low flows meaning it is likely that fish and eel passes would be within their effective range for longer periods during years in which SESRO has an influence on the hydrology of the Thames, relative to the equivalent hydrological baseline without SESRO. Overall, the effect of the flow changes predicted on the effectiveness of existing fish and eel pass is considered likely to be positive for fish communities, but unlikely to have a significant effect on the ecological function or integrity of the River Thames.	⇧
				SESRO will provide additional water to the Thames during periods of release that allows existing intakes to function at higher intake volumes and/or longer durations than would otherwise be the case in equivalent hydrological years in the absence of the proposed scheme. Therefore, as a consequence of the proposed scheme, there could be a higher risk of fish entrainment/impingement at existing intake structures on the Thames. It is considered unlikely that this effect will be significant relative to the baseline risks already	⇩

[211] Environment Agency (2011) *Screening at intakes and outfalls: measures to protect eels 'The Eel Manual'*. LIT 5413.
[212] Pers. comm. Stuart Manwaring (Environment Agency) by return of data request via email on 25/11/2021.

Reach/Receptor	Proposed scheme element	Applicable reservoir options	Description	Potential effects (inclusive of embedded (i.e., design) mitigation)	Overall predicted direction of change[206]
				associated with the existing intake structures on the River Thames.	

5.4.6 Operational regime: changes in community structure/function mediated by primary productivity changes within the Ock catchment and Thames

5.113 The combined effects of habitat, flow, and water quality changes within the study area, as well as the operation of reservoir water storage and release, have the potential to change primary productivity and food-chain dynamics within affected watercourses. This could include direct effects on phytoplankton/phytobenthos communities, direct and indirect effects on zooplankton communities, and consequent indirect effects on higher trophic levels. Direct effects of habitat change, flow and water quality on macrophytes, as well as higher trophic levels (i.e. fish and invertebrates) are considered within Sections 5.4.2, 5.4.3 and 5.4.4 respectively.

5.114 Study Reaches potentially affected by these changes are assessed in Table 5.13. The proposed scheme option(s) to which the assessment applies is also reported.

5.115 The overall potential effect of each mechanism is indicated by study Reach, based on current available supporting modelling and assessments at Gate 2 (Chapter 4 Water Quality; Appendix A5.6 Phytoplankton Growth and Community Modelling; Appendix A5.7 Algal Growth Rate Studies) which consider the likely embedded (i.e., design) mitigation (such as reservoir aeration), prior to any further mitigation and/or compensation. Effects with multiple arrows highlight where there is uncertainty in the current assessment conclusions at Gate 2.

Table 5.13 Regime: changes in community structure/function mediated by primary productivity changes

Reach/Receptor	Proposed scheme element	Applicable reservoir options	Description	Potential effects (inclusive of embedded (i.e., design) mitigation)	Overall predicted direction of change[213]
1.1 Cow Common Brook (including Portobello Ditch, Landmead Ditch, Mere Dyke, Oday Ditches[214] and feeder ditches)	Indicative footprint	All	Changes in watercourse form and function based through new physical habitat structure.	Phytobenthos rather than phytoplankton is likely to be the important source of primary productivity (alongside macrophytes) within these Reaches, relative to the Thames Reaches (given important phytoplankton communities tend to develop in larger watercourses with greater retention times).[215] This is reflected in the fact that phytobenthos (rather than phytoplankton) underpins the ecological classification of river water bodies in the UK. Significant changes in the form and function of these Reaches (either locally or at a Reach scale) are predicted and the resulting ecological communities are likely to be different (as a consequence of changes in channel form, water quality and flow characteristics in the new channels). Whilst there may be 'winners' and 'losers' in terms of relative abundance of phytobenthos and macrophytes (and epiphytes), including responses to improvements and localised changes in nutrient conditions predicted in some of these Reaches (discussed in Section 5.4.4); overall it is not considered that changes in the nature of primary productivity within these Reaches are likely to significantly affect higher trophic levels relative to the existing baseline. On balance, the morphological improvements secured through the new channel design (discussed in Section 5.4.2 in relation to footprint) are considered likely to deliver overall benefits in habitat condition relative to baseline and any changes across those different elements driving primary productivity are not considered likely to negate (or significantly improve upon) the overriding benefits of improved aquatic habitat condition delivered through the channel design.	⇔
1.2 Childrey Brook (lower)			Reduction in flow in a section (approximately 2 km) of the Childrey Brook and some ditches (notably East Hanney Ditch) downstream of the proposed reservoir due to some of the water body catchment being within the indicative footprint and the new Western Watercourse Diversion (i.e., flows now captured by the new Cow Common Brook).		
2.1 River Ock (lower)			Slight reduction in flow in a section (approximately 5 km) of the River Ock downstream of the confluence with the Childrey Brook and Cow Common Brook due to a reduction in flow in the Western Watercourse Diversion and Childrey Brook because much of the catchment is within the indicative footprint.		
			Modifications to the river channels in and around the SESRO site will redirect flow and chemical inputs to new channels and eliminate part of the catchment (thereby reducing flows and accompanying chemical inputs to downstream Reaches).		
			There will be significant land use change to the catchment which will no longer be agricultural land (Livestock and Arable are two of the main sources of nutrients in the catchment: *Chapter 4 Water Quality*). This could reduce nutrient concentrations and potentially improve water quality by reducing the input of agricultural chemicals to the watercourse.		

[213] As mediated by effect (neutral/beneficial/ adverse) based on understanding at Gate 2 and inclusive of current embedded (i.e. design) and standard mitigation.
[214] Oday ditches are included in Reach 1.1 (although technically the Thames water body) as they are within the indicative footprint and they are most similar in character to ditches associated with Reach 1.1 also affected by indicative footprint.
[215] Dembowska, E. A. (2020) The Use of Phytoplankton in the Assessment of Water Quality in the Lower Section of Poland's Largest River. *Water* 2021(13): 3471.

Reach/Receptor	Proposed scheme element	Applicable reservoir options	Description	Potential effects (inclusive of embedded (i.e., design) mitigation)	Overall predicted direction of change[213]
4. Thames – Upstream of SESRO (Evenlode to Culham)	Indicative footprint	All	Ock ultimately joins the Thames within Reach 4 meaning any impacts of SESRO within the Ock ultimately propagates to the Thames.	Given that the impacts of the Scheme on water quality and flow in the River Ock are considered to be negligible, and the relative contribution of Ock to Thames is small (Section 5.4.3), no primary productivity impacts are predicted on this Reach of the River Thames.	⇔
5 Thames – Immediately downstream of SESRO combined intake/ discharge structure up to the River Thame confluence	Reservoir intake and discharge (Thames abstraction and discharge regime)	All*	Discharge from SESRO would reduce nutrient concentrations immediately downstream of the structure.	Conceptually, the predicted decrease in nutrients (especially orthophosphate) downstream of SESRO has the potential to limit phytoplankton growth during blooms. However, CEH monitoring (Appendix A5.5 Water Quality and Phytoplankton Monitoring) in 2021 and other published studies[216,217] have found that nutrient concentrations (including phosphorus, nitrogen, and silicon) in the River Thames are typically at high concentrations and are poorly correlated with chlorophyll a. These reports concluded that nutrients therefore do not affect the timing/magnitude of algal blooms in the River Thames or prevent the onset of blooms through limitation. During large blooms, SRP (Soluble Reactive Phosphorus; i.e., phosphorus immediately available for algal growth) and dissolved silicon have, however, been reduced to potentially limiting concentrations preceding a collapse in phytoplankton biomass (Appendix A5.6 Phytoplankton Growth and Community Modelling), suggesting that low nutrients can cause bloom collapse. However, as the reduction in nutrients is predicted to be relatively small, and not enough to improve the WFD status for the orthophosphate element (to Good, from a baseline of Moderate), it is unlikely that the change would cause a notable reduction in phytoplankton biomass. It is worth noting that SRP has been steadily decreasing in the Thames over the last 30 years (Thames Water, 2007),[218] and so it is possible that this may impose constraints on growth and therefore limit maximum phytoplankton peaks in the future. An additional strand of evidence comes from CEH (Appendix A5.7 Algal Growth Rate Studies), who used microcosm experiments to assess how Thames algae would respond to being exposed to a mixture of SESRO reservoir water (Farmoor reservoir water was used as a proxy) and River Thames water, as would occur downstream of SESRO during discharge. These experiments found that the growth rate of Thames algae was unaffected (or slightly reduced) by the addition of reservoir water, suggesting that the change in water quality would have negligible impact on Thames algae.	⇔
			Discharge would also change physical habitat conditions downstream, including increased flow and decreased water temperature. Low flows would be supplemented so	The Eutrophication Risk Modelling conducted by CEH (Appendix A5.6 Phytoplankton Growth and Community Modelling) investigated the effects of SESRO operation (in terms of increased flow and decreased temperature) on phytoplankton growth in the Thames. They predict relatively minor changes in the relative abundance of phytoplankton groups under SESRO scenarios (with	⇩ ⇩

[216] Waylett, A.J., Hutchins, M.G., Johnson, A.C., Bowes, M.J. and Loewenthal, M. (2013) Physico-chemical factors alone cannot simulate phytoplankton behaviour in a lowland river. *Journal of Hydrology*, 497: 223–233.
[217] Bowes, M.J., Ings, N.L., McCall, S.J., Warwick, A., Barrett, C., Wickham, H.D., Harman, S.A., Armstrong, L.K., Scarlett, P.M., Roberts, C., Lehmann, K. and Singer, A.C. (2012) Nutrient and light limitation of periphyton in the River Thames: implications for catchment management. *Science of the Total Environment*, 434: 201–212.
[218] Cascade Consultancy (2007) *Phytoplankton Baseline Report*. Report on behalf of Thames Water.

Reach/Receptor	Proposed scheme element	Applicable reservoir options	Description	Potential effects (inclusive of embedded (i.e., design) mitigation)	Overall predicted direction of change[213]
			that the lowest flows would no longer occur.	and without climate change), with virtually no change in chlorophyll concentration, and a reduction in the number of days of suitable cyanobacteria growth conditions. This is because cyanobacteria are more sensitive to temperature and flow than the other phytoplankton groups. Its blooms also tend to be later in the year (typically August) when SESRO is more likely to be operational. The report therefore suggests that SESRO is unlikely to affect most phytoplankton groups, but that it could partially mitigate the risk of problematic cyanobacteria blooms, which are predicted to increase under future climate change. This modelling is based on the River Thames at Runnymede (approximately 100 km downstream of SESRO where the effects of SESRO on flow velocity and temperature are likely to have been considerably ameliorated). Just downstream of SESRO, these effects will be proportionally greater, but precisely how that will affect local phytoplankton and zooplankton remains uncertain. Conceptually, it is understood that phytoplankton growth occurs within certain thresholds of flow, water temperature and solar radiation[219]. If SESRO increases flows above this threshold it could cause phytoplankton to wash out, or if it reduces temperature below this threshold, it could prevent growth. A previous study of phytoplankton growth across the Thames (including Culham) concluded that whilst phytoplankton population recruitment is depressed by high river flows and associated high turbidity; it is relatively insensitive to low and intermediate flows[220] (i.e., those SESRO proportionally most affected by SESRO). Conversely, below certain flow conditions, larger chlorophytes and diatoms settle out of the water column due to a lack of turbulence. [221] Similarly, very low levels of phytoplankton biomass through dry summers in the Thames have also been hypothesised to be attributable to efficient removal by benthic consumers, especially, large filtering mussels.[220] SESRO could lead to a reduction in phytoplankton growth immediately downstream of the release. During subsequent project stages investigations should further consider to what extent the findings (and thresholds) of Appendix A5.6 Phytoplankton Growth and Community Modelling can be applied and/or scaled further up the Thames, and how the existing CEH models may be adapted to these areas most significantly affected by hydraulic changes.	
			The addition of reservoir water to the Thames would transfer phytoplankton to the river.	CEH (Appendix A5.7 Algal Growth Rate Studies) conducted a series of experiments to assess how SESRO reservoir algae might respond to being introduced into the Thames. They found that the growth rates of Farmoor algae (a proxy for SESRO algae) were lower than the growth rate of local Thames algae, both when introduced directly into the Thames at Culham, and when introduced to a mix (45:55) of reservoir and Thames river water in the laboratory. This suggests that there is unlikely to be excessive growth of algae from SESRO upon addition to the Thames. CEH (Appendix A5.7 Algal Growth Rate Studies) also reported significant differences in the algal	⇩ ⇩

[219] Appendix A5.6 Phytoplankton Growth and Community Modelling.
[220] Cascade Consultancy (2007) *Phytoplankton Baseline Report*. Report on behalf of Thames Water.
[221] Appendix A5.6 Phytoplankton Growth and Community Modelling.

Reach/Receptor	Proposed scheme element	Applicable reservoir options	Description	Potential effects (inclusive of embedded (i.e., design) mitigation)	Overall predicted direction of change[213]
				communities of the River Thames and Farmoor reservoir; the reservoir had a lower proportion of diatoms and a higher proportion of cryptophytes and cyanobacteria. These cyanobacteria could be an issue as they were thought most likely to be the potentially toxin-producing genus *Microcystis,* and so discharges from SESRO could increase the abundance of this cyanobacteria in the Thames (assuming that Farmoor is an appropriate proxy for SESRO). Introducing this taxon to the Thames was not assessed by the CEH experiments as it was removed by pre-filtering (used to remove zooplankton and thus prevent grazing of the phytoplankton). Therefore, the implications of introducing this genus to the Thames should be investigated further at during subsequent project stages. However, the proportion of cyanobacteria (remaining after filtering) decreased relative to green algae when Farmoor reservoir algae was incubated in the Thames at Culham, leading the authors (Appendix A5.7 Algal Growth Rate Studies) to conclude that any cyanobacteria problem is likely to be localised to the transfer point. Importantly, Appendix A5.7 Algal Growth Rate Studies also found that the abundance of algae was much lower in Farmoor reservoir than in the River Thames (approximately 10 times lower in August). This means that discharges from SESRO would reduce the proportional abundance of phytoplankton, leading to an overall reduction in concentration. This is also reflected in the predictions from the 1-D model for the Thames just downstream of SESRO (Chapter 4 Water Quality). As such, SESRO could effectively ‘dilute’ phytoplankton biomass within the Reach relative to baseline.	
			Taken together, these evidence strands suggest that SESRO is unlikely to cause excessive algal growth or to encourage problematic blooms in the Thames.	The available evidence agrees that SESRO is therefore unlikely to increase the occurrence or magnitude of large phytoplankton blooms. Large blooms are associated with a host of negative effects on the whole ecosystem. They can suffocate aquatic life through causing oxygen depletion during the night (as the algae respires) or at the end of a bloom (as decomposition occurs). Additionally, some blooms may include potentially toxin-producing organisms, such as some cyanobacteria (which the modelling[222] suggests SESRO is likely to reduce). The toxins produced by these organisms can kill fish and other aquatic organisms and can affect the use of the river as a water resource. Filter feeding organisms (e.g., bivalve mussels, of which there are several notable species in the Thames) are particularly susceptible to these toxins because the way that they feed (taking up water and then filtering out non-ingestible material) accumulates toxins inside the organism. Some species of phytoplankton can also suffocate fish directly by clogging or irritating their gills. The reservoir releases could therefore benefit aquatic ecology by reducing the risk of large oxygen depleting or toxic phytoplankton blooms.	⇧

[222] Appendix A5.6 Phytoplankton Growth and Community Modelling

Reach/Receptor	Proposed scheme element	Applicable reservoir options	Description	Potential effects (inclusive of embedded (i.e., design) mitigation)	Overall predicted direction of change[213]
			Taken together, these evidence strands suggest that there may be a reduction in phytoplankton biomass/concentration, which would have implications for higher trophic levels as it represents a reduction and/or dilution of primary productivity.	Some of the available evidence suggests that SESRO may reduce phytoplankton growth and abundance in Thames through reducing the temperature, increasing flow, and introducing reservoir water which has a much lower concentration of algae. Flow augmentation by SESRO is expected to occur between the months of June and November but could extend to early January during periods of drought. Therefore, the main period during which phytoplankton may be affected is during the summer. This timing would mean that the main diatom bloom in the spring (between 1st February to 1st July of each year)[223] would not be affected by SESRO discharges. Phytoplankton growth is a major element of primary productivity in aquatic ecosystems. The Thames aquatic community is dependent on phytoplankton as it underpins the food web, therefore a decrease in its productivity could directly or indirectly reduce food resources for a wide range of organisms across the whole food chain. In particular, this could affect filter feeding invertebrates (e.g. *Anadonta* and *Unio* mussels but also zebra and quagga mussels), and larval/juvenile age classes of fish, which primarily feed on phytoplankton or zooplankton (whose population density closely follows patterns of phytoplankton biomass).[224] The timing, magnitude, and composition of phytoplankton and zooplankton communities are known to be major controls on the early growth rates (and thus long-term population success) of larval and juvenile cyprinid fish. Reduced primary productivity could benefit species or cohorts with certain feeding strategies (or those which can easily switch feeding strategies such as roach e.g., should a reduction in phytoplankton simply promote an increase in phytobenthos, macrophytes and epiphytes through reduced turbidity and increased free nutrients) or recruitment strategies (e.g., fish whose primary growth period occurs before SESRO discharge begins as the spring diatom bloom is less likely to be affected by SESRO). Therefore, reduced phytoplankton growth could indirectly lead to changes in the aquatic community structure. Scientific understanding of these complex interrelationships is low, and so there remains a high level of uncertainty as to what the effect of a change in primary productivity would be, and whether the predicted change would be enough to drive measurable responses in the community structure or function. Further assessment of the underlying mechanisms (i.e., predicted changes in phytoplankton) is proposed during subsequent project stages (see Section 5.6).	⇩ ⇩
6 to 13 River Thames **6 Thames – Between River Thame and**	Reservoir intake and discharge (Thames abstraction and discharge regime)	All*	SESRO is unlikely to cause excessive algal growth or to encourage problematic blooms in the Thames. There may be a reduction in phytoplankton density, which would have implications for higher trophic levels as it represents a reduction in primary productivity.	Broadly discussed in relation to Reach 5, although as the effects of SESRO on water quality and flow are predicted to diminish with distance downstream, it is likely that the influence of SESRO on phytoplankton and primary productivity would also reduce with distance downstream. No significant adverse effects are predicted at Runnymede under the CEH Eutrophication Risk Assessment Model assessment point. Some beneficial effects are predicted in relation to a	⇔ ⇧

[223] Appendix A5.6 Phytoplankton Growth and Community Modelling.
[224] Freeman, A. (2019) *River phytoplankton biological controls on a microscopic level*. Thesis submitted for the degree of Doctor of Philosophy. Department of Geography and Environmental Science, University of Reading.

Reach/Receptor	Proposed scheme element	Applicable reservoir options	Description	Potential effects (inclusive of embedded (i.e., design) mitigation)	Overall predicted direction of change[213]
Thames Water Datchet intake to 13 Thames – Between Thames Water Hampton intake and Teddington Weir (tidal limit)				reduction in harmful cyanobacteria growth.	

*Notes: *All reservoir options are considered to be subject to the same potential effects with the direction of effect consistent between options, however, note that evidence from the UKCEH Eutrophication Risk Modelling applies only to the 150 Mm^3 option which was modelled in this supporting assessment.*

5.4.7 Overall summary of potential effects

5.116 An overall summary of potential effects by source-pathway and receptor is presented in Table 5.14, based on current proposed scheme understanding and supporting assessments and modelling available at Gate 2.

5.117 Based on currently available information, the majority of identified effects are considered likely to be either negligible or result in minor adverse or minor beneficial effects that are unlikely to affect the overall ecological integrity of affected Reaches.

5.118 Some effects have the potential to result in benefits that are considered likely to improve the overall ecological integrity of affected Reaches; notably the planned diversion, realignment, and creation of watercourse habitats within the Ock Catchment associated with Cow Common Brook, Childrey Brook and the River Ock.

5.119 Effects with multiple arrows in Table 5.14 highlight residual uncertainty in the current assessment conclusions at Gate 2. A particular focus for subsequent Gates will be on reducing uncertainty for those elements with the potential to result in adverse effects that may reduce the overall ecological integrity of affected Reaches.

5.120 Identified adverse effects with risks to the overall ecological integrity of affected Reaches include potential flow reduction on the Childrey Brook and primary productivity/food-chain effects within the River Thames (Reach 5 and Reach 6).

5.121 Flow changes within the River Thames as a result of SESRO have the potential to be both beneficial and adverse (at different times and for different species) for the existing baseline ecology and may affect the overall ecological integrity of the affected Reaches, as discussed in Section 5.4.3. Whilst the assessment in future Gates will seek to improve certainty around the trajectory of change that may be anticipated relative to baseline; a key challenge will be resolving the subjectivity and philosophy of whether a potential change (for example, changes in the relative abundance of different fish species) is considered to be adverse or beneficial, particularly in the context of the extensive existing anthropogenic modifications of the river and its flow regime which has shaped the baseline ecological communities. Also, in terms of changes already under way including lowering of phosphate over time and the effects of climate change on the current baseline.

5.122 Proposed scheme mitigation is summarised in Section 5.5, including those elements of embedded mitigation (already considered in the context of identified potential effects) and a brief summary of potential further mitigation options that could support maintenance or improvement of the existing baseline – to be developed and considered as part of subsequent Gates. Next steps towards reducing uncertainty in the assessment as part of subsequent Gates are also discussed in Section 5.6.

Table 5.14 Summary of direction and magnitude of impacts by study Reach. Double arrows indicate residual uncertainty.

<u>**Receptor**</u>	<u>**Potential change mechanism (Source: Pathway)**</u>				
	Construction	***Operation***			
	Footprint: Direct habitat loss, gain, or severance (Ock Catchment and Thames)	**Regime: Changes in flow/level/habitat availability (Ock Catchment and Thames)**	**Regime: Changes in water quality (Ock Catchment and Thames)**	**Regime: Changes to barrier porosity (new structures and function of existing fish passes); and fish impingement/ entrainment at new and existing intake/ discharge structures (Ock Catchment and Thames)**	**Regime: Changes in community structure/ function mediated by primary productivity changes (Ock Catchment and Thames)**
Watercourse habitats	*Mediator*	*Mediator*	-	-	-
Fish	Included	Included	Included	Included	Included
Invertebrates	Included	Included	Included	-	Included
Macrophytes	Included	Included	Included	-	Included
Phytoplankton/ Phytobenthos (Diatoms)	-	*Included (reported in Section 5.4.6)*	*Included (reported in Section 5.4.6)*	-	Mediator
Zooplankton	-	*Included (reported in Section 5.4.6)*	*Included (reported in Section 5.4.6)*	-	*Mediator*
Other aquatic habitats	Included	Included	Included	-	-
		<u>**Reaches**</u>			
1.1 Cow Common Brook	⇧	⇔	⇧	*No existing fish passes or proposed new structures within the affected Reach*	⇔
1.2 Childrey Brook (lower)	⇧	⇩ ⇩	⇩	⇔	⇔
2.1 River Ock (lower)	⇧	⇔ ⇩	⇔	⇔	⇔
2.2 River Ock (upper)	*Watercourses adjacent to and upstream of the indicative footprint within the Ock catchment – not included at Gate 1 but included for additional context and reference sites at Gate 2.*				
2.3 Stutfield Brook					
2.4 Childrey Brook (upper)					
2.5 Letcombe Brook					

Receptor	Potential change mechanism (Source: Pathway) *Construction* Footprint: Direct habitat loss, gain, or severance (Ock Catchment and Thames)	*Operation* Regime: Changes in flow/level/habitat availability (Ock Catchment and Thames)	Regime: Changes in water quality (Ock Catchment and Thames)	Regime: Changes to barrier porosity (new structures and function of existing fish passes); and fish impingement/ entrainment at new and existing intake/ discharge structures (Ock Catchment and Thames)	Regime: Changes in community structure/ function mediated by primary productivity changes (Ock Catchment and Thames)
2.6 Marcham Brook					
2.7 Sandford Brook	⇩ (amber)	*Watercourse is upstream of operational regime pathways*			
3 Ginge Brook	*No footprint-mediated effects anticipated; no infrastructure proposed at Gate 2.*	*Watercourse is upstream of operational regime pathways*			
4 Thames – Upstream of SESRO (Evenlode to Culham): Reach length – 27.0 km	⇩ (amber)	⇔ (grey)	⇔ (grey)	⇩ (amber)	⇔ (grey)
5 Thames – Immediately downstream of SESRO combined intake/ discharge structure up to the River Thame confluence: Reach length – 13.2 km	*No footprint-mediated effects anticipated; no infrastructure proposed at Gate 2.*	⇩ (red) ⇧ (blue)	⇧ (green)	⇧ (green)	⇩ (amber) ⇩ (red)
6 Thames – Between River Thame and Thames Water Datchet intake: Reach length – 87.3 km		⇩ (amber) ⇧ (blue)	⇧ (green)	⇧ (green)	⇧ (green) ⇔ (grey)
7 Thames – Between Thames Water Datchet intake and Affinity Water Sunnymeads intake: Reach length – 2.8 km		⇧ (green) ⇔ (grey)	⇧ (green)	⇧ (green)	⇧ (green) ⇔ (grey)
8 Thames – Between Affinity Water Sunnymeads and Affinity Water Egham intake: Reach length – 6.4 km		⇧ (green) ⇔ (grey)	⇧ (green)	⇧ (green)	⇧ (green) ⇔ (grey)
9 Thames – Between Affinity Water Egham and Affinity Water Chertsey intake: Reach length – 6.9 km		⇧ (green) ⇔ (grey)	⇧ (green)	⇧ (green)	⇧ (green) ⇔ (grey)
10 Thames – Between Affinity Water Chertsey intake and Affinity Water Walton (Desborough Island) intake: Reach length – 7.3 km		⇧ (green) ⇔ (grey)	⇧ (green)	⇧ (green)	⇧ (green) ⇔ (grey)
11 Thames – Between Affinity Water Walton and Thames Water Walton intake: Reach length – 4.1 km		⇧ (green) ⇔ (grey)	⇧ (green)	⇧ (green)	⇧ (green) ⇔ (grey)
12 Thames – Between Thames Water Walton and Thames Water Hampton intake: Reach length – 2.2 km		⇧ (green) ⇔ (grey)	⇧ (green)	⇧ (green)	⇧ (green) ⇔ (grey)

Receptor	Potential change mechanism (Source: Pathway)				
	Construction	*Operation*			
	Footprint: Direct habitat loss, gain, or severance (Ock Catchment and Thames)	Regime: Changes in flow/level/habitat availability (Ock Catchment and Thames)	Regime: Changes in water quality (Ock Catchment and Thames)	Regime: Changes to barrier porosity (new structures and function of existing fish passes); and fish impingement/ entrainment at new and existing intake/ discharge structures (Ock Catchment and Thames)	Regime: Changes in community structure/ function mediated by primary productivity changes (Ock Catchment and Thames)
13 Thames – Between Thames Water Hampton intake and Teddington Weir (tidal limit): Reach length – 9.5 km		⇔	⇧	⇧	⇔

5.5 Potential options for mitigation considered

5.123 The assessments presented within this Chapter have considered the likely embedded (i.e., design) mitigation and 'standard' mitigation (such as fish rescue associated with channel diversions), prior to any further mitigation and/or compensation.

5.124 The assessment of construction-mediated effects at Gate 2 is restricted to those effects relating to the indicative footprint of the proposed scheme only (i.e., watercourse diversions, realignments etc). Mechanisms of effect associated with proposed scheme construction activities (such as accidental pollution incidents) will be controlled through good practice construction methodologies and supplementary construction mitigation as required. These types of effects will be assessed as part of formal approvals for the construction of the proposed scheme should it progress.

5.125 Embedded and standard mitigation already included within the assessment presented here broadly comprises:

- the conceptual design of river channel diversions and realignments including improvements to their morphology relative to poor quality existing habitats;
- fish rescue and translocation associated with channel diversions;
- the design and operation of the reservoir that underpins modelling outputs (for example reservoir aeration for water quality and existing HoF constraints on abstraction within the River Thames); and
- the design of other aspects of the reservoir infrastructure (such as watercourse crossing structures and the PWWC intake/discharge structure which will need to be compliant with the Eel Regulations).

5.126 A core part of the environmental mitigation works for the proposed scheme includes the diversion of watercourses across the site to form both the Western Watercourse Diversion and the Eastern Watercourse Diversion.

5.127 The Western Watercourse Diversion will have two main channels, the diverted and improved Cow Common Brook (i.e., Reach 1.1; part of the Cow Common Brook and Portobello Ditch WFD water body) and improvements (by way of channel diversions and restoration) to the East Hanney Ditch (i.e., Reach 1.2; part of the Childrey Brook and Norbrook at Common Barn WFD water body). These two watercourses will not be connected physically but together will form a mosaic of wetland habitats as the water rises and spreads out across the newly created floodplain which will form part of the floodplain compensation area. The Eastern Watercourse Diversion will have a single main channel, the diverted and improved Mere Dyke (i.e., Reach 1.1; part of the Cow Common Brook and Portobello Ditch WFD water body).

5.128 The planned watercourse diversions and enhancements deliver between 15 and 35% net gain (Option dependent) in river biodiversity units relative to baseline (as reported in further detail within Technical Supporting Document B6 Biodiversity Net Gain Report). Overall, the proposed scheme aims to deliver a net gain of 10% across all habitats (terrestrial and aquatic).

5.129 In addition to those measures already considered within the assessment, a number of further mitigation measures are potentially available and may be required to manage residual risks to ecology during construction and operational phases. These will be further developed as part of subsequent Gates as the understanding of potential proposed scheme effects further develops (for example with model refinements and/or the assessment of additional hydrological years – see Section 5.6) and confidence in the likely extent and magnitude of effects improves. Such measures may broadly comprise (subject to need/feasibility):

- further constraints on the timing and/or magnitude of abstraction and release (beyond those dictated by operational constraints/capacity and existing licencing constraints on the River Thames), perhaps including 'planned' low flow years should these be considered necessary for the maintenance of ecology;
- 'optimisation' of a ramp up flow release sequence for the reservoir;
- 'optimisation' of level control structures within affected Reaches – velocity and level are counteracting forces within the Thames (as a level dependent system managed for navigation) and undesirable effects in velocity could be partly offset by increasing level, and vice-versa;
- 'optimisation' of temperature changes through design of the reservoir offtake level;
- habitat improvements to provide increased ecological resilience of affected Thames Reaches to predicted hydraulic changes – for example, localised grading of banks to increase the extent of areas in which important baseline habitats (such as marginal slacks) can 'migrate' up the riverbank, creation of additional backwater habitats;
- bespoke habitat design, monitoring and (if necessary) adaptive management for watercourse diversions and realignments for specific target invertebrate, macrophyte and/or fish species and communities, subject to further baseline surveys of the affected watercourses;
- species translocations of specific invertebrates or macrophytes if required (subject to further baseline surveys of the affected watercourses); and

- catchment or point source measures to offset any residual effects on water quality within the Ock Catchment and Thames.

5.6 Considerations for subsequent project stages

5.130 Next steps for the aquatic ecology assessment of SESRO relate to:

- improving confidence in the existing baseline, including:
  - ongoing SRO monitoring at existing Thames monitoring locations for fish, invertebrates, macrophytes and INNS to update and maintain baseline understanding;
  - full suites (including seasonal replicates) of ecological surveys within areas that were access constrained at Gate 2 (i.e., watercourses including ditches associated with and affected by the indicative footprint). This is likely to include walkover Modular River Survey (MoRPh)[225] method surveys, as well as fish, macroinvertebrate and macrophyte surveys and eDNA sampling of rivers and streams such as Cow Common Brook, Childrey Brook and the River Ock. In addition, ditch condition surveys[226] and ditch biodiversity surveys[227] will be required for the ditch networks affected by the footprint, likely undertaken within a stratified sampling approach. Collectively these surveys will support the update of BNG and aquatic ecology baselines. Bespoke methodologies may need to be developed and agreed to target certain species/assemblages, notably for invertebrates.
  - Phytoplankton, zooplankton and fish fry surveys in the main River Thames within the reach between Culham and the River Thame to understand within-year and between-year variability in blooms and peak occurrence.
- improving confidence in the current supporting modelling and assessments of direction and magnitude of change predicted for the various scheme elements and Reaches including:
  - repeated and refined CEH algae experiments and modelling, including translation of predictions/update of the existing modelling assessment point (Runnymede) to areas closer to the intake/discharge point;

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[225] Walkover Modular River Survey (MoRPh) methodology. The Biodiversity Metric 3.0 auditing and accounting for biodiversity: User Guide.
[226] The Biodiversity Metric 3.0 auditing and accounting for biodiversity Technical Supplement.
[227] Palmer, M., Drake, M. and Stewart, N. (2013) *A manual for the survey and evaluation of the aquatic plant and invertebrate assemblages of grazing marsh ditch systems*. (version 6, May 2013). Buglife.

- refined and/or validated Ock catchment modelling through extension of the 1D model to encompass this area, including an improved understanding of the likely contributions from superficial groundwater to the future channel flow;
- refined Thames hydraulic modelling to include additional 'less dry' hydrological years, climate change scenarios, and additional cross-sectional survey information for panelled velocity assessment. Also, inclusion of more detailed level-control structure representation to assist with level/velocity optimisation studies. Importantly, this will rely on an improved understanding of the options available to manage water levels via existing structures (for example, should refined modelling suggest it is advisable to reduce flow velocities for ecological maintenance) without compromising the navigation maintenance policies of the Thames;
- sensitivity analysis of potential interaction between the Thames abstraction periods and out of bank flows.

- improving definitions of adverse and beneficial effects in relation to Thames ecology, in liaison with the Environment Agency. Whilst the assessment in future Gates will seek to improve certainty on the trajectory of change that may be anticipated relative to baseline, a key challenge will be whether a potential change (for example, in the relative abundance of different fish species) is considered to be adverse or beneficial, particularly in the context of the extensive existing anthropogenic modifications of the river and its flow regime which has shaped baseline ecological communities. A degree of 'stress-testing' WFD fisheries classifications based on potential changes in relative abundance could be undertaken, for example. However, this may be complicated by the fact that the Thames water bodies have relatively few WFD fish data classifications. The survey methodology typically used to characterise the River Thames is bespoke and non-compliant with WFD standard methods. Further liaison with the Environment Agency will help refine definitions of adverse and beneficial effects in the context of the existing baseline, to inform subsequent Gates.
- developing mitigation for any anticipated residual adverse effects, through iteration of the above confidence changes (in both baseline and assessment) and in line with those items identified in Section 5.5.

6. Invasive Non-Native Species (INNS) risk assessment

6.1 Introduction

6.1 This chapter examines the potential risks of INNS introduction and spread to and from SESRO, via transfer pathways that may become active once the reservoir is operational. Excluded are risks associated with the construction of SESRO itself which will be controlled through good practice construction methodologies and supplementary construction mitigation as required – to be outlined and agreed as part of formal approvals for the construction of the Scheme during subsequent Gates.

6.2 An INNS is any "non-native animal or plant that has the ability to spread causing damage to the environment, the economy, our health and the way we live".[228] Whilst this definition does not include pathogens, it is widely acknowledged that INNS can also carry (non-native) pathogens which can affect native populations more than they do the INNS themselves, for example crayfish plague (*Aphanomyces astaci*). Invasive species are considered the second biggest threat, after habitat loss and destruction, to biodiversity worldwide and carry a significant cost burden for UK water companies annually, both through the cost of their direct control and from damage to infrastructure and operational disruption.[229] Understanding the risk presented by INNS is an essential stage in the process of developing mitigation measures for SESRO to reduce the risk of their introduction and spread as a consequence of the Scheme.

6.3 Since the Gate 1 INNS assessment, the National Appraisal Unit (NAU) has issued a standardised risk assessment approach for all SROs[230] at Gate 2, in the form of a risk assessment tool (hereafter the SRO Aquatic INNS Risk Assessment Tool; SAI–RAT). Broadly this followed the same principles as those applied to the risk assessment of SESRO at Gate 1.

6.4 INNS transfer pathways are mediated via activities undertaken within the asset itself (for example maintenance and recreational activities) and through the raw water transfer (RWT) to and from the asset. In this case, the asset is described as the proposed raw water storage reservoir. The risk assessment approach therefore

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[228] Great Britain Non Native Species Secretariat (GB NNSS). Definition of terms: Invasive Non Native Species. [online]. Available at: http://www.nonnativespecies.org/index.cfm?pageid=64 [Accessed on: 22/03/2022]
[229] UKWIR. (2016). Invasive Non-Native Species (INNS) Implications on the Water Industry. [online]. Available at: https://ukwir.org/Invasive-and-Non-Native-Species-(INNS)-Implications-on-the-Water-Industry [Accessed on: 27/07/2021]
[230] EA Asset tool 6610_ Final user version and EA SRO assessment tool handbook v1- Final – issued 30 November 2022.

considers both asset and raw water transfer INNS risks. Further details of the method are summarised in sections below, with full details provided in the user guide.[231]

6.5 The final maintenance, recreation, and public access plans for SESRO are in development, to be finalised as part of subsequent Gates. Therefore, a number of hypothetical scenarios have been assessed to understand potential INNS risks and mitigation requirements at Gate 2. These are broadly aligned with the scenarios applied during the Gate 1 INNS risk assessment, updated where required based on additional tool functionality and/or developing understanding from allied SESRO workstreams (such as developing design and recreational access plans), to ensure they remain applicable at Gate 2. The potential maintenance, recreation, and public access plans for SESRO are assumed to be independent of SESRO size options at this stage, within the functionality and sensitivity of the SAI–RAT (for example, boating is considered possible for any given SESRO size option). Therefore, all asset scenarios relate to permutations of maintenance, recreation, and public access rather than a SESRO size option.

6.6 Similarly, the raw water transfer risk assessment is based on a series of scenarios relating to the raw water transfer design, operation, and maintenance. In some instances (for example the transfer of raw water from SESRO to the River Thames) the operation is dependent on SESRO size option and therefore where relevant, scenarios relate specifically to SESRO size options.

6.7 The Gate 1 risk assessment concluded that all scenarios applied to both the asset and raw water transfers were 'medium risk' for INNS transfer, with the exception of two asset scenarios which included the removal of recreation from the reservoir. These were both classified as 'low risk' for INNS transfer.

6.8 The Environment Agency has stated that there are no plans at this stage to set thresholds or a figure on acceptable risk as the objective of the tool is to provide a comparative analysis of INNS risk across SROs.[232] A key challenge of INNS risk management for the SRO programme, including SESRO, is balancing the risk of INNS transfer and spread with providing high quality multi-purpose and accessible public assets. It is therefore highly unlikely that recreational access to SESRO in all its forms would be excluded purely on the basis of INNS risk. Therefore, some INNS risks will inevitably remain within the final plans for SESRO, balanced against wider aspirations

[231] EA Asset tool 6610_ Final user version and EA SRO assessment tool handbook v1- Final – issued 30 November 2022.
[232] EA Asset tool 6610_ Responses to Feedback from Industry – issued 30 November 2022.

for the use of the asset, and mitigated where possible based on available biosecurity measures.

6.9 Full details of the SAI–RAT risk assessment method is provided by the Environment Agency.[233] A summary is provided below, noting where supplementary analysis has been undertaken specifically for SESRO. The remainder of the chapter then reports on the application of the SAI–RAT, the results from the asset and raw water transfer risk assessments during Gate 2, and the options appraisal of potential biosecurity measures that could help mitigate risks identified. Full SAI–RAT risk assessments for each option assessed (as outlined in subsequent sections) is provided in Appendix 6.1 INNS EA Asset tool 6610 Iterations.

6.2 Methodology

6.2.1 Risk assessment tool

6.10 In addition to the INNS risk assessment being undertaken within the Environment Agency mandated tool for Gate 2 submission, wider Environment Agency feedback on Gate 1 submissions has also informed the methodology described above, notably in relation to:

- the INNS search areas being extended to include Farmoor; and
- inclusion of comparison of SESRO with the Thames Water AMP7 Water Industry National Environment Programme (WINEP) [234] INNS risk assessments, within the same tool.

6.11 The SAI–RAT has been developed to standardise risk assessments across all SROs. The SAI–RAT was constructed based on common working methodologies from previously developed tools, such as the Wessex Water Asset Risk Assessment Tool, and the Northumbrian Water Group (NWG) Raw Water Transfer Risk Assessment Tool – the latter developed to meet the requirements of Environment Agency PR19 guidance for the assessment of raw water transfers.[235] A high-level overview of the SAI–RAT process is provided in Insert 6.1.

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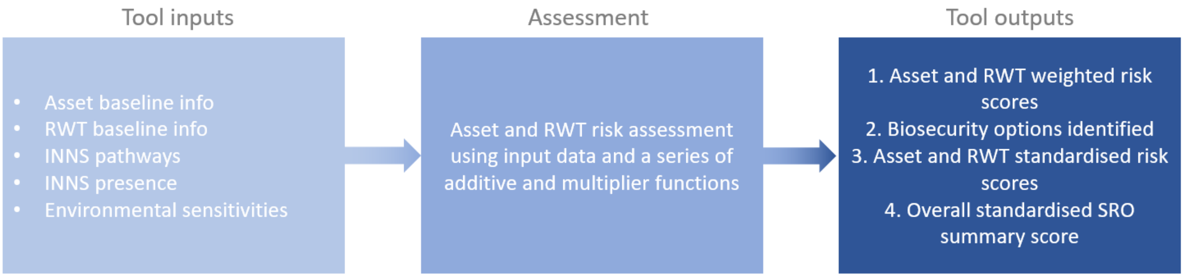
[233] EA Asset tool 6610_ Final user version and EA SRO assessment tool handbook v1- Final – issued 30 November 2022

[234] The AMP7 WINEP contains an obligation for all water companies to investigate INNS risk on their estates, including their assets and raw water transfers. As part of this, water companies will need to understand the key pathways of spread of INNS and how the risk of spread through those pathways can be mitigated.

[235] Environment Agency (2017). PR19 – Assessing the risks of spread of Invasive non-native species posed by existing water transfers – OFFICIAL

6.12 Stakeholder workshops supporting the review and update of the mandated INNS assessment tool (whilst it was in development) were also attended by SESRO project representatives on 3 August 2021 and 22 September 2021, with feedback provided to the Environment Agency on the functionality of the tool.

Insert 6.1 High-level overview of the SAI–RAT process



6.13 The SAI–RAT retains discrete modules for the assessment and (relative) quantification of asset and raw water transfer risk. Similar to its predecessor tools, the SAI–RAT uses an INNS functional group approach rather than a species-based approach, thereby future-proofing against pathway risks from INNS that are not yet recorded within the SRO environs (or indeed the United Kingdom). Baseline INNS presence is also broadly considered within the tool. Where INNS are known to be present at baseline (one or more confirmed high impact[236] INNS species) this is also accounted for within the risk assessment scoring.

6.14 Alongside baseline sensitivities of the SRO environs (such as the presence of protected and priority habitats), and the characteristics of the asset and raw water transfer (such as whether water is transferred within or between catchments), the presence and frequency of INNS transfer pathways drives the quantitative output of SAI–RAT. Based on these input criteria, a total risk score for any given SRO and scenario is provided as an output, supporting an assessment of the relative risk of different scenarios for SESRO and comparative assessment across SROs.

6.15 Within the SAI–RAT, the risk of any given scenario is standardised and expressed as a percentage of the highest potential risk score that can be calculated within the SAI–RAT. This produces a final risk score of between 1 and 100 percent (from low to high risk) for each scenario. The SAI–RAT guidance does not provide an interpretation of the risk scores; instead, this is an indicative risk categorisation to facilitate

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[236] WFD TAG high impact species, any species on the WCA Schedule 9 and any species on the European List of Concern.

comparison between SROs. The assessment of risk must always be considered on a case-by-case basis with professional judgement to support the findings of the tool.

6.2.2 Datasets reviewed

6.16 Along with the scenarios and findings from the Gate 1 INNS risk assessment, a number of datasets were used within the Gate 2 assessment process, to identify INNS, environmental designations, and priority habitats in the vicinity of the Scheme. This exercise was undertaken in tandem with the aquatic ecology assessment (Chapter 5 Aquatic Ecology and Appendix A5.1 Ecological Data Baseline).

6.17 Design reports and other data sources were also used to understand design, as well as the public access and recreational requirements of the reservoir and associated raw water transfers. The following datasets and sources were used for the assessments in this report:

- 2020 and 2021 SRO Monitoring data; including fish, macroinvertebrate, macrophyte, multi-purpose eDNA monitoring and bespoke INNS surveys within the study area;
- Environment Agency Ecology and Fish Data Explorer data;[237]
- Thames Valley Environmental Record Centre (TVERC) data;[238]
- DEFRA MAGIC website;[239]
- Natural England Habitat Networks GIS layers;[240]
- Supplementary data from Thames Water AMP7 WINEP investigations into INNS;
- Gate 2 Technical Supporting Document A1 – Concept Design Report; and

[237] Environment Agency (2022). EA Ecology & Fish Data Explorer. [online]. Available at: https://environment.data.gov.uk/ecology/explorer/ [Accessed on: 07/03/2022]
[238] TVERC (2022). Thames Valley Environmental Records Centre Data Request: Available at: https://www.tverc.org/cms/content/data-searches [Accessed on: 23/03/2022].
[239] DEFRA (2022). MAGIC website. [online]. Available at: https://magic.defra.gov.uk/MagicMap.aspx [Accessed on: 23/03/2022]
[240] Data.gov.uk. (2022). Habitat Networks (England). [online] Available at: https://data.gov.uk/dataset/0ef2ed26-2f04-4e0f-9493-ffbdbfaeb159/habitat-networks-england [Accessed on: 07/03/2022]

- Gate 2 Technical Supporting Document B3 – Conservation, Access and Recreation Strategy[241].

6.2.3 INNS data searches

6.18 The SAI–RAT considers baseline presence of 'high-priority' INNS only. The pathway approach for INNS risk assessments and management takes account of life cycle strategies through the use of functional groups, meaning the mitigation measures appraisal considers INNS transfer risk and mitigation on a group-by-group basis. This helps ensure that any horizon species not yet established will be accounted for within their respective functional group (26 such groups are defined in the guidance).

6.19 High priority INNS are defined as any:

- species categorised as "high impact" on the Water Framework Directive UKTAG aquatic alien species list;[242]
- species on the list of Invasive Alien Species of Union Concern (Regulation (EU) 1143/2014);[243] and/or
- species listed on Schedule 9 of the Wildlife and Countryside Act (as amended) 1981.[244]

6.20 The full list of INNS within the three lists are provided in Appendix A6.2 (INNS List).

6.21 Three additional INNS lists were also considered for SESRO, collating a supplementary baseline list of all INNS that do not sit within legislation but are named on INNS lists from high-profile, credible sources. These sources include:

- Great Britain Non-Native Species Secretariat Alert Species;[245]

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[241] The scenarios applied to the asset risk assessment are aligned to the low, medium and high risk scenarios provided in the Conservation, Access and Recreation Strategy, with the lowest-risk asset scenario (no.1), noted as having lower levels of recreation occurring than the Conservation, Access and Recreation Strategy details. Similarly, the highest-risk asset scenario (no.9), is noted as having higher levels of recreation occurring than the Conservation, Access and Recreation Strategy details.

[242] Gov.UK (2015). The Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015. [online]. Available at: https://www.legislation.gov.uk/uksi/2015/1623/pdfs/uksiod_20151623_en_auto.pdf [Accessed on: 07/03/2022]

[243] European Commission (2015). EU Regulation 1143/2014 on Invasive Alien Species. [online]. Available at: https://ec.europa.eu/environment/nature/invasivealien/list/index_en.htm [Accessed on: 07/03/2022]

[244] Gov.UK (2021). Wildlife and Countryside Act 1981 – Schedule 9. [online]. Available at: https://www.legislation.gov.uk/ukpga/1981/69/schedule/9 [Accessed on: 07/03/2022]

[245] GB Non-Native Species Secretariat. 2022. Species alerts – GB non-native species secretariat. [online] Available at: http://www.nonnativespecies.org/alerts/index.cfm [Accessed on: 07/03/2022]

- species identified by the Cross-Party Working Group;[246] and
- species included in the UKWIR study of 'INNS Implications on The Water Industry'.[247]

6.22 Whilst these supplementary records are not considered within the SAI–RAT itself, they are reported here for additional baseline context.

6.23 The guidance requires that aquatic and riparian species records within a 1 km buffer from the asset and the source are included within respective asset and raw water transfer risk assessments. Due to subjectivity in distinguishing riparian from terrestrial plants (with even archetypal 'riparian' plants such as Japanese knotweed, Himalayan balsam and giant hogweed being terrestrial in the strictest sense but associated with waterways through which they spread),[248] all plants within the above lists are included.

6.24 The guidance outlines processes to support this search through desk-based analysis of open-source data. Here, open-source data has been supplemented with SRO-specific monitoring data and TVERC biological records data sources as identified in Section 6.2.2.

6.25 In addition to the 1 km search area, hydrological connectivity to the source has been considered and the search area extended upstream. Based on the limited influence of baseline species records on the SAI–RAT, a pragmatic approach to extending this search area was taken, aligned to a request from the Environment Agency at Gate 1 to extend the baseline search area to Farmoor Reservoir. For consistency, the hydrological distance to Farmoor Reservoir had been applied to all hydrological connectivity the equivalent distance upstream from the source.

6.26 Existing datasets for INNS were therefore reviewed against the following Reaches and reported separately below:

- a 1 km radius from the indicative location for the largest SESRO size option (as required in the SAI–RAT guidance),[249] including upstream and downstream of the river intake (on the River Thames); and,

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[246] Water Company INNS cross-party working group (2020) – INNS taxa list.
[247] UKWIR (2022). Invasive and Non-Native Species (INNS) Implications on the Water Industry. [online] Available at: https://ukwir.org/Invasive-and-Non-Native-Species-(INNS)-Implications-on-the-Water-Industry [Accessed on: 07/03/2022]
[248] Environment Agency (2014). Aquatic and riparian plant management: controls for vegetation in watercourses. Project: SC120008/R1.
[249] Defined as the indicative extent of SESRO 150 Mm^3 option.

- a 30.7 km[250] upstream Reach (hydrologically connected) from the SESRO river intake.

6.2.4 Design considerations and transfer pathways

6.27 Based on the concept designs of the reservoir, pathways which may result in the introduction/spread of INNS to or out of the reservoir were identified, based on potential design elements as they are understood at Gate 2. The full list of potential design elements (noting that not all elements may be carried forward to final design) include:

- Car Park;
- Boat Park;
- Water sports clubhouse;
- Visitor centre;
- Equestrian centre;
- Outdoor educational centre;
- Heritage centre;
- Footpaths;
- Bridleways;
- Jetty;
- Pier;
- Slipway;
- Beach promenade;
- Cove;
- Road access;
- Angling pond;
- Water treatment works;
- Pumping station;
- Fully bunded reservoir;
- River intake/discharge structure;
- Pipe from river to pumping station;
- Pipe from pumping station to the main tower in the reservoir;
- Formal sports area e.g., tennis;
- Wetland and woodland;
- Emergency Drawdown Siphon; and
- Auxiliary Discharge Channel (Reservoir emergency discharge to River Thames).

6.28 For all reservoir options, the intake/discharge structure, pipelines and pumping station are considered as a single raw water transfer associated with the primary transfer of water to and from the reservoir. The combined intake/discharge structure is planned on the right bank of the River Thames near Culham (approx. grid reference:

[250] Based on the upstream hydrological connection distance to Farmoor Reservoir, and in line with Environment Agency feedback received on Gate 1 submissions. It is noted that this goes over and above the SAI–RAT requirements.

SU 49745 94930), in which abstraction will occur through fine screens – which would be compliant with the Eels Regulations (2009).[251] Water is taken to and from the reservoir through the reservoir using dual pipes, and discharges will be through a stepped gravity weir. Whilst the route of the pipeline and the pumping station will be the same for transfers to and from the reservoir, the pipelines will differ in their operation. Water will be transferred via gravity flow from the river to the pumping station located close to the reservoir before it is pumped into the reservoir. Water will then be released back to the river via a rehabilitated section of the Wilts & Berks Canal (the auxiliary discharge channel; ADC) through gravity.

6.29 During periods where there will be no abstraction from the River Thames to the reservoir, there will be a continuous sweetening flow to prevent stagnation in the water transfer system, which circulates its volume every four days (equates to an 18 Ml/d pumping requirement). The sweetening flow will take water from the intake on the River Thames, and pump it via a pipeline to the ADC, from where it will discharge back to the River Thames without interacting with the reservoir. This low-volume Thames to Thames transfer has not been investigated as part of the INNS risk assessment, due to the absence of INNS dispersal risk associated with this closed-loop system.

6.30 Further information on the design and operation of the transfer system is provided in the Gate 2 Technical Supporting Document A1 – Concept Design Report.

6.31 A separate raw water transfer – an emergency drawdown (EDD) – will also be required in the form of a four-pipe siphon, which will have the capacity to take large flows from the reservoir into the ADC. Discharge will be conveyed through the ADC before discharging into the River Thames adjacent to the SESRO intake/outlet structure at Culham. The EDD, to meet regulatory standards, is designed to allow for a minimum drawdown rate of either five percent of reservoir capacity per day, or one metre of reservoir depth per day. Whilst an EDD is typically designed for use during emergency situations on a very rare basis, they must also be tested for a short period of time on a bi-annual basis, for regulatory compliance purposes. Despite operating on a regular, but infrequent basis, an EDD is designed to convey large flows in the case of an emergency and has been assessed accordingly. Further information on the design and operation of the EDD is provided in the Gate 2 Technical Supporting Document A1 – Concept Design Report.

[251] Environment Agency. (2009). Screening at intakes and outfalls: measures to protect eel.

6.32 Of these two raw water transfers, the following criteria underpin the inherent risk of each transfer operation:

- Volume of water to be transferred
- Frequency of transfer operation
- Physical transfer distance
- Transfer relative to WFD water bodies and catchments
- Source, pathway and receptor type
- Any existing connections
- Number of RWT inputs
- Number of washout points

6.33 The pathways of INNS transfer that have been identified within the raw water transfer risk assessment, based on the identified design elements were the following:

- Navigation at source
- Navigation on pathway
- Angling at source
- Angling on pathway
- Watersports at source
- Watersports on pathway

6.34 The pathways of INNS transfer that have been identified and used within the asset risk assessment, based on the identified design elements were the following:

- Staff site visit (not entering water)
- Staff site visit entering or in contact with raw water
- Road vehicle site visit
- Maintenance not entering water
- Maintenance in water
- Angling equipment
- Live bait
- Fish stocking
- Large vessels (over 28ft)
- Small vessels (under 28ft)
- Water Sports Equipment (Stand up paddle-boarding (SUP), Canoe, Kayaks)
- Water Safety Equipment (Temporary Moorings, jetties, inflatables, buoys)
- Mammals/waterfowl on site
- Transfer of waste sludge to land
- Recreational walker/jogger/ runner

6.2.5 Risk assessment of asset

6.35 The INNS pathway frequency scores underpin the relative quantification of risks within the asset module of SAI–RAT and are categorised on a five-point scale of 0.5-

point increments between 0 and 2; with 0 indicating that the pathway is not applicable and 2 indicating that the pathway is present and occurs very frequently. Further details on the methodology are available in the guidance.[252]

6.36 A total of ten asset scenarios were run in the SAI–RAT for the SESRO asset. These included a likely baseline of the SESRO reservoir site, as understood at Gate 2; multiple variations of the baseline, exploring the effects of changes in pathway use frequency; and a worst-case scenario building on the baseline scenario. Further information on the proposed recreational use of SESRO and its associated infrastructure is provided in the Gate 2 Technical Supporting Document B3 – Conservation, Access and Recreation Strategy.

6.37 The scenarios used within the risk assessment were the same broad scenarios of those applied during the Gate 1 assessment, amended where the pathways were not directly transferable to the SAI–RAT. The potential maintenance, recreation and public access plans for SESRO are assumed to be independent of SESRO size option at this stage, within the functionality and sensitivity of the SAI–RAT (for example, boating is considered possible for any given SESRO size option). Therefore, all asset scenarios relate to permutations of maintenance, recreation and public access rather than a SESRO size option.

6.38 Table 6.1 provides descriptions of the scenarios (including baseline) which have been further developed from the Gate 1 assessment. Full details of input parameters for each scenario (specific occurrence and frequency scores for all pathways) are provided as part of the results within Section 6.4, alongside resultant risk scores for each scenario. The pathways that have been amended within the SAI–RAT include:

- Large vessels (over 28 ft) – the "berthed boat if brought onto site" pathway from the Gate 1 scenarios has been translated into the Gate 2 scenarios;
- Small vessels (under 28 ft) – the "Small/inflatable boat if brought onto site" pathway from the Gate 1 scenarios has been translated into the Gate 2 scenarios;
- Water Sports Equipment (SUPs, Canoe, Kayaks) – the "Water sports equipment if brought onto site" pathway from the Gate 1 scenarios has been translated into the Gate 2 scenarios; and
- Mammals/waterfowl on site – the "wildfowl not entering water" pathway from the Gate 1 scenarios has been translated into the Gate 2 scenarios.

[252] EA Asset tool 6610_ Final user version and EA SRO assessment tool handbook v1- Final – issued 30 November 2022.

6.39 One pathway from the Gate 2 SAI–RAT tool was not included within the Gate 1 scenarios; the "Water Safety Equipment (Temporary Moorings, jetties, inflatables, buoys)" pathway.

Table 6.1 Asset risk assessment scenario descriptions

Scenario	Description
Baseline	The most realistic scenario for the reservoir, based on current understanding at Gate 2, including a combination of occasional fish stocking[253] and a high-frequency of water sports and terrestrial-based recreation (e.g., walking). All other scenarios are variations of this scenario.
1	No terrestrial or aquatic recreational activities on site.
2	No aquatic recreational activities on site. Terrestrial recreational activities such as walkers continue.
3	No vehicles on site. All people and recreational activities frequencies reduced by one step/increment (0.5 reduction) compared to the baseline scenario to account for the reduction in transport to site.
4	Bankside angling in the reservoir, no water sports or boating.
5	Just boating on the reservoir, no angling or water sports.
6	Just water sports in the reservoir, no angling or boating.
7	No vehicles on site, all other activities at anticipated level of frequency.
8	Angling, water sports and boating in the reservoir.
9	'Worst-case scenario', with all anticipated activities at maximum frequency.

[253] It is noted that fish stocking and angling (which may include coarse and/or salmonid species) are typically linked activities in reservoirs. There has been no final decision on stocking but we have assumed that low-level fish stocking (without angling) may take place for biodiversity purposes as part of the baseline scenario to start the ecosystem..

6.2.6 Risk assessment of primary raw water transfers

6.40 The intrinsic characteristics of the raw water transfer underpins the relative quantification of risks within the raw water module of SAI–RAT; type, distance, volume and frequency of transfer – as well as the activities likely to be present on the transfer (e.g., recreation and maintenance). Further details on the methodology are available in the guidance.[254]

6.41 As with the asset risk assessment, scenarios have been developed for the transfer of water from the reservoir to the Thames, and vice versa. These are the broadly the same scenarios applied within the Gate 1 assessment. These scenarios account for the different variations within the plans for the different options, to account for how these may alter the risk of INNS being transferred to and from the reservoir via raw water transfers.

6.42 For the transfer of raw water from the River Thames to the reservoir, two scenarios were run in the SAI–RAT; a realistic baseline of the raw water transfer from the River Thames to the reservoir and a variation of the baseline, exploring the effects that changes in the raw water transfer might have on the overall risk of INNS transfer to the SESRO site. These are the same scenarios applied during the Gate 1 INNS risk assessment and have been re-run using the SAI–RAT. Table 6.2 provides a brief description of each of the raw water transfer scenarios, with full details of input parameters that underpin these scenarios and their associated risk scores outlined within the results section (Section 6.4), alongside resultant risk scores for each scenario. It is assumed that SESRO will not influence activities that occur within the River Thames (the source of this transfer) and therefore no permutations of the source (River Thames) baseline are considered within this aspect of the risk assessment. Further information on the design and operation of the intake/discharge structure and its associated infrastructure is provided in the Gate 2 Technical Supporting Document A1 – Concept Design Report.

[254] EA Asset tool 6610_ Final user version and EA SRO assessment tool handbook v1- Final – issued 30 November 2022.

Table 6.2 Raw water transfer risk assessment scenario descriptions (River Thames to reservoir)

Raw Water Transfer	Scenario	Description
River Thames to Reservoir	Baseline	The most realistic scenario for raw water transfer from the River Thames to the reservoir based on Gate 2 design. Scenario 1 is based on this baseline.
	1	>3 washout/ maintenance points in the raw water transfer, everything else the same as the baseline.

6.43 Unlike the transfer from the River Thames to the reservoir (where the daily maximum intake capacity is fixed regardless of the SESRO size selected), certain SESRO size options for the transfer of raw water from the reservoir to the River Thames have different discharge capacities, which directly affects risk weighting within the SAI–RAT. Details of the abstraction and discharge regimes (including volume and frequency of operation) of the different SESRO size options are provided in Chapter 2 Hydrology.

6.44 For this reason, all six SESRO size options were run through the SAI–RAT for the transfer from the reservoir to River Thames. The discharge associated with each size option is shown in Table 6.3, alongside the applicable discharge category within the SAI–RAT.

Table 6.3 Raw water transfer risk assessment scenario descriptions (reservoir to the River Thames)

Size Option (Mm^3)	Maximum Release Rate (Ml/d)	Volumetric Discharge Category in SAI–RAT (Ml/d)
75	165	151–200
100	219	201–250
125	270	251–300
150	321	301–400
130 (100 + 30)	280	251–300
122 (80 + 42)	264	251–300

6.45 Similarly, there are various permutations of activities that may occur within the reservoir, subject to agreed maintenance, recreation and public access plans for SESRO. These could have a material influence on the risk of raw water transfer from the reservoir to Thames. A total of six scenarios have therefore been run for each of the six size options (as shown in Table 6.4; i.e., a total of 36 discrete scenarios), with full details of input parameters that underpin these scenarios and their associated risk scores outlined within the results section. However, the range of options within the discharge category field of the SAI–RAT (as shown in Table 6.3) is sufficiently broad that the 125, 130 and 122 Mm^3 options fall within the same discharge category and are therefore indistinguishable within the SAI–RAT. Therefore, for the purpose of reporting the risk assessment, and due the similarity in risk scores, only the smallest option (75 Mm^3) and largest (150 Mm^3) options have been reported, with the impact of permutations of source (i.e., reservoir) activities reported for each of these.

Table 6.4 Raw water transfer risk assessment scenario descriptions (reservoir to River Thames)

Raw Water Transfer	Scenario	Description
Reservoir to River Thames	Baseline	The most realistic scenario for raw water transfer from the reservoir to the River Thames based on Gate 2 design. All other scenarios are based upon this baseline.
	1	No angling or water sports in the reservoir.
	2	International angling events, but no water sports in the reservoir.
	3	International water sports events, but no angling in the reservoir.
	4	>3 washout/ maintenance points in the raw water transfer.
	5	International angling and water sports events in the reservoir.

6.2.7 Risk assessment of emergency drawdown

6.46 During the Gate 1 risk assessment, an emergency discharge scenario was applied as a permutation of the identified raw water transfer scenarios above. Due to the status of the EDD/ADC as a raw water transfer in its own right, this has been further assessed under its own risk assessment at Gate 2. This enables the assessment to account for different scenarios that may apply (e.g., considering recreation requirements at the source and along its pathway).

6.47 As with the main outlet transfer, the different SESRO size options have an impact on the potential release rate of the emergency drawdown. Despite this, in both the 75 Mm^3 option (smallest) and 150 Mm^3 option (largest), the EDD will be designed to discharge flows of >500 Ml/d (the largest option selectable in the SAI–RAT), at 4,113 Ml/d and 6,774 Ml/d, respectively. In essence the SAI–RAT is not sensitive to permutations at this scale and so size option is irrelevant for understanding the INNS risk of the EDD/ADC.

6.48 A total of three scenarios were therefore developed for the EDD/ADC, accounting for a low, medium and high-use scenario, with varying levels of activity occurring on its pathway. In all three scenarios, the source (i.e., reservoir) recreational pathways were identical, allowing an assessment of how different operations and recreational requirements on the EDD/ADC pathway may impact the overall risk. The source recreational pathways were formed from the 'baseline' scenario from the raw water transfer from reservoir to River Thames assessment, which accounts for no angling within the reservoir itself, but regular watersports activities and national events. A description of these scenarios is provided in Table 6.5, with full details of input parameters that underpin these scenarios and their associated risk scores outlined within the results section (Section 6.4-), alongside resultant risk scores for each scenario.

Table 6.5 Emergency drawdown risk assessment scenarios

Raw Water Transfer	Scenario	Description
Emergency Drawdown	Low-use	Baseline activities at the reservoir (source) with no navigation, angling or watersports on the pathway of the EDD/ADC
	Medium-use	Baseline activities at the reservoir (source) with navigation, but no angling or watersports on the pathway of the EDD/ADC
	High-use	Baseline activities at the reservoir (source) with navigation, angling and watersports on the pathway of the EDD/ADC

6.2.8 Mitigation measures options appraisal

6.49 A generalised biosecurity module included within the SAI–RAT identifies potential biosecurity measure types from a defined list of 30 options that may be considered by the user. This is an automated process taking account of the INNS transfer pathways identified to be present. Should a specific INNS pathway (e.g., angling, watersports etc.) be 'activated' within the assessment, this high-level options identification is completed automatically by the tool, highlighting which options may be broadly applicable for targeting that specific pathway.

6.50 The SAI–RAT does not consider mitigation measures within, or revise risk scores in the context of, mitigation measures being 'selected'. Therefore, all risks and scores reported should be considered as a worst-case prior to any mitigation (within the context of the scenario to which they apply). The quantitative risk assessment scoring approach facilitates comparison of scenarios based on their intrinsic relative risk. The qualitative biosecurity module is effectively a bolt-on which helps identify which types of mitigation measures may help further reduce risk for any given scenario. Further details on the methodology are available in the guidance.[255]

6.51 Acknowledging that the biosecurity module cannot take account of the specific context of a given pathway, or the feasibility of implementation of a given measure, in the context of SESRO; a supplementary mitigations options appraisal has been undertaken. This is reported in Appendix A6.3 INNS Mitigation Measures Appraisal with outcomes summarised within this report.

6.52 The mitigation measures options appraisal involved reviewing known biosecurity approaches (e.g., boat wash down facilities, biosecurity strategies, targeted species management, screens etc.) and assessing their appropriateness of use in each scenario, in relation to the key identified pathways.

6.53 A simple scoring system was applied for each mitigation measure to help assess its suitability for application against the identified transfer pathways. All options were scored from 1 to 3 for efficacy and feasibility and given a Red-Amber-Green (RAG) colour code from which a cumulative score has been generated, which was also colour coded on a RAG scale (Table 6.6). This cumulative score (e.g., between 2 and 6) has been used to assess the potential applicability of each option to SESRO, from an efficacy and feasibility perspective. The cumulative nine-point scoring matrix is shown in Table 6.7.

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[255] EA Asset tool 6610_ Final user version and EA SRO assessment tool handbook v1- Final – issued 30 November 2022.

6.54 The options identification focusses on those measures which mitigate the risk of INNS transfer via, or remove INNS from, transfer pathways identified by SAI–RAT. It does not focus on eradication measures for INNS following their establishment. Acknowledging that there is a degree of overlap in this respect within some of the measures identified (i.e., measures that can be both preventative and used in efforts to eradicate INNS following establishment); efficacy scores are assigned on the basis of the measure's effectiveness in managing transfer/introduction risks via transfer pathways. Feasibility scores are assigned based on the applicability of the measure considering operational, environmental, and social costs and factors. These scores are derived from professional judgement and are used as an indication only of which methods are best recommended for consideration as part of future project stages. Following the selection of any measure for SESRO in future, a more detailed appraisal would be required to explore all possible implications of the proposed measure.

Table 6.6 Three-point scoring for efficacy and feasibility of mitigation measures

Score and Colour Code	Efficacy	Feasibility
1	Not effective at preventing or removing INNS	Significant negative operational, environmental or social cost
2	Moderately effective at preventing or removing INNS	Moderate operational, environmental or social cost
3	Highly effective at preventing or removing INNS	Minimal operational, environmental or social cost

Table 6.7 Cumulative scoring matrix for mitigation measures

	Not effective at preventing or removing INNS	Moderately effective at preventing or removing INNS	Highly effective at preventing or removing INNS
Significant negative operational, environmental or social cost	2	3	4*
Moderate operational, environmental or social cost	3	4	5
Minimal operational, environmental or social cost	4*	5	6

**Where a score of 4 is formulated from a score of 1 for either efficacy or feasibility, the cumulative score of 4 is coloured red.*

6.2.9 Comparison to other assets

6.55 Under the AMP7 WINEP, all water companies are undertaking an INNS risk assessment of their existing assets and transfers, using a range of risk assessment tools and methods. Drawing existing assets and transfers into the standardised SAI–RAT approach therefore represents a valuable opportunity in understanding how the proposed and hypothetical risk from SESRO compares against the risk from assets and transfers already in operation.

6.56 For the purpose of this comparative analysis, Farmoor Reservoir No. 2, Queen Mother Reservoir and High Maynard Reservoir were selected based on their similarities to the proposed SESRO Scheme. These reservoirs are similar due their status of being publicly accessible and supporting recreational activities. Each reservoir also receives its water directly from a river intake. Specifically, both Farmoor Reservoir No. 2 and Queen Mother Reservoir receive water from the River Thames. Public access and recreation at each reservoir includes:

- Farmoor Reservoir No. 2 – Sailing, angling, walking
- Queen Mother Reservoir – Sailing
- High Maynard Reservoir – Angling, walking

6.57 Based on completion of the SAI–RAT with the actual operation, maintenance and recreational use of these assets, a comparison against the risk profile of SESRO using the SAI–RAT has been undertaken. An existing options appraisals of mitigation measures for existing Thames Water assets (including these identified sites) is also underway as part of Thames Water’s AMP7 WINEP obligations; and initial findings have been integrated when considering the feasibility of measures within the mitigation measures options appraisal of SESRO.

6.3 Understanding of the baseline

6.3.1 INNS records

6.3.1.1 Overview

6.58 Following a review of available data, INNS recorded within 1 km of the indicative location for SESRO and the River Thames source near Culham, and within 30.7 km upstream of (and hydrologically connected to) the source were identified. The 30.7 km has been selected as this covers the upstream hydrological distance to Farmoor Reservoir system which is identified as a key potential upstream source of

INNS (see Section 6.2.3). For consistency this hydrological distance was extended in all upstream directions from the source (i.e., including tributaries in addition to the River Thames itself).

6.59 INNS reported include those species which are classified as 'high priority', as per the SAI–RAT guidance and, separately, those species which are listed in other lists as outlined within the methodology (see Section 6.2.3) but not included within the SAI–RAT. Whilst these 'other' INNS are not a high priority and not included within the risk assessment itself, they provide further context as to the risks associated with the Scheme from the existing baseline. Locations within these search areas at which INNS records were identified are shown in Figure 6.1 and 6.2 in Appendix A1.1 Figures.

6.3.1.2 1 km search area

6.60 High priority INNS located within a 1 km radius of the indicative location for SESRO are shown in Table 6.8. This search area was used to inform baseline INNS presence criteria within the tool as per the SAI–RAT guidance.

6.61 The INNS search identified nine high priority species, along with five 'other' species. These other species included high profile INNS, such as the Asian clam (*Corbicula fluminea*) and quagga mussel (*Dreissena rostriformis bugensis*).

Table 6.8 Recorded presence of high priority and 'other' invasive species within 1 km of SESRO indicative scheme location

Status	Scientific name	Common name
High Priority INNS	*Elodea canadensis*	Canadian waterweed
	Elodea nuttallii	Nuttall's waterweed
	Heracleum mantegazzianum	Giant hogweed
	Rhododendron ponticum	Rhododendron
	Impatiens glandulifera	Himalayan balsam
	Dikerogammarus haemobaphes	Demon shrimp
	Dreissena polymorpha	Zebra mussel
	Hemimysis anomala	Bloody red shrimp
	Pacifastacus leniusculus	American signal crayfish
'Other' INNS	*Chelicorophium curvispinum*	Caspian mud shrimp

Status	Scientific name	Common name
	Corbicula fluminea	Asian clam
	Crangonyx pseudogracilis/floridanus	Freshwater amphipod
	Dreissena rostriformis bugensis	Quagga mussel
	Potamopyrgus antipodarum	New Zealand mud snail

Colour coding correlates with the overarching functional group category:
Yellow = Aquatic Plants;
Green = Terrestrial/riparian Plants;
Blue = Aquatic Animals.

6.3.1.3 30.7 km search area

6.62 High priority INNS located within 30.7 km upstream of the source are shown in Table 6.9. Those that are also located within the 1 km buffer are identified.

6.63 The INNS search identified a list of 25 high priority species within a 30.7 km upstream hydrological connection. This included 15 additional high priority species than recorded in the 1 km search area, along with the same five 'other' species as identified within the 1 km search area. These other species included high profile INNS, such as the Asian clam (*Corbicula fluminea*) and quagga mussel (*Dreissena rostriformis bugensis*).

Table 6.9 Recorded presence of high priority and 'other' invasive species within 30.7 km distance upstream from the SESRO intake on the River Thames

Status	Scientific name	Common name	Also, in 1 km buffer
High Priority INNS	*Azolla filiculoides*	Water fern	
	Crassula helmsii	New Zealand pygmyweed	
	Elodea callitrichoides	South American waterweed	
	Elodea canadensis	Canadian waterweed	✓
	Elodea nuttallii	Nuttall's waterweed	✓
	Hydrocotyle ranunculoides	Floating pennywort	
	Lagarosiphon major	Curly waterweed	
	Myriophyllum aquaticum	Parrot's-feather	
	Ailanthus altissima	Tree-of-heaven	
	Allium triquetrum	Three-cornered garlic	
	Fallopia japonica	Japanese knotweed	
	Fallopia japonica × sachalinensis	Knotweed	
	Gunnera tinctoria	Giant-rhubarb	
	Heracleum mantegazzianum	Giant hogweed	✓
	Impatiens glandulifera	Himalayan balsam	✓
	Lysichiton americanus	American skunk-cabbage	
	Rhododendron ponticum	Rhododendron	✓
	Carassius auratus	Goldfish	
	Cyprinus carpio	Common carp	
	Dikerogammarus haemobaphes	Demon shrimp	✓
	Dreissena polymorpha	Zebra mussel	✓
	Hemimysis anomala	Bloody red shrimp	✓
	Pacifastacus leniusculus	American signal crayfish	✓
	Sander lucioperca	Zander	

Status	Scientific name	Common name	Also, in 1 km buffer
'Other' INNS	*Chelicorophium curvispinum*	Caspian mud shrimp	✓
	Corbicula fluminea	Asian clam	✓
	Crangonyx pseudogracilis/floridanus	Freshwater amphipod	✓
	Dreissena rostriformis bugensis	Quagga mussel	✓
	Potamopyrgus antipodarum	New Zealand mud snail	✓

Colour coding correlates with the overarching functional group category:
Yellow = Aquatic Plants;
Green = Terrestrial/riparian Plants;
Blue = Aquatic Animals.

6.3.2 Site designations and priority habitats

6.64 A review of the MAGIC website for statutory designations identified a single SSSI (Barrow Farm Fen), located 400 m north-east of the indicative location for the largest SESRO option (150 Mm^3). Barrow Farm Fen is characterised as a dense wet and dry carr woodland.[256] Due to the presence of this SSSI, the 'Highest order site designation of asset: National' variable was activated within the asset risk assessment, to account for its presence within 1 km of the indicative location for SESRO. For further information on environmental designations, see Chapter 5 Aquatic Ecology and Appendix A5.1 Ecological Data Baseline.

6.65 Within the raw water transfer risk assessment, this SSSI was noted as present at the reservoir (the receptor of the transfer from river to reservoir). However, due to the distance between the SSSI and the discharge location on the River Thames (the receptor of the transfer from reservoir to river), this site was not within the prescribed search area. For this reason, the 'Highest order site designation receptor: none' input was activated on the assessment of transfer from reservoir to river.

6.66 A review of Natural England's Priority Habitat Inventory (PHI) identified 51 individual priority habitat units within a 1 km buffer of the indicative location of the largest SESRO option (150 Mm^3), excluding network enhancement and expansion zones (i.e., opportunity areas not yet recognised as containing priority habitat). These priority

[256] Natural England. 2022. Designated Sites View: Barrow Farm Fen SSSI. [online]. Available at: https://designatedsites.naturalengland.org.uk/SiteDetail.aspx?SiteCode=S1001521&SiteName=Barrow%20farm&countyCode=&responsiblePerson=&SeaArea=&IFCAArea= [Accessed on: 23/03/2022].

habitats include lowland fens and meadows, traditional orchards and wood pasture and parkland, and are located in the vicinity of the reservoir, raw water transfer pathway and intake/discharge point on the River Thames. For this reason, 'Known to be present' was activated for priority habitats in all assessments, including for the asset itself, as well as for the raw water transfers from river to reservoir, and vice versa.

6.4 Assessment outcomes and potential options for mitigation considered

6.4.1 Asset risk assessment

6.67 Within the asset risk assessment, all scenarios had the same scoring applied in relation to the presence of high priority INNS, priority habitats and national site designations (i.e., Barrow Farm Fen SSSI) within 1 km of the proposed reservoir.

6.68 A range of occurrence multipliers were selected for INNS transfer pathways (e.g., staff site visits, recreation), to account for the different scenarios identified within Table 6.1. Table 6.10 provides details of the pathway-frequency scores for each scenario. Full SAI–RAT risk assessments for each option assessed is provided in Appendix 6.1 INNS EA Asset tool 6610 Iterations. These different scenarios produced a range of scores as follows:

- 21.27% – scenario 1 (accounting for no recreation at the reservoir); to,
- 88.46% – for scenario 9 (accounting for a 'worst-case scenario', with anticipated activities at maximum frequency).
- The baseline scenario for the reservoir, considered most likely to be representative, sits within this range at 57.90%.

6.69 The full range of risk scores for the asset under each scenario are provided at the bottom of Table 6.10

6.70 Table 6.11 indicates which mitigation measures may be suitable for reducing the risk associated with each scenario. The SAI–RAT risk assessment scores do not consider mitigation measures or revise risk scores in the context of mitigation measures being 'selected'. Therefore, all risks and scores reported here should be considered as worst-case prior to any mitigation (within the context of the scenario to which they apply).

6.71 Within the SAI–RAT mitigation module, mitigation options are broadly identified which may be applicable based on INNS pathways present within each scenario. Many of the mitigation options identified by the SAI–RAT are applicable to an asset irrespective of recreational requirements or asset operation and therefore presented as options for each scenario applied. For example, it is always recommended that the asset, regardless of recreation or operation, would benefit from a biosecurity strategy and check, clean, dry protocols for anyone visiting the area.

6.72 Alternatively, some mitigation options may be applicable only where recreation (e.g., sailing or angling) takes place. Whilst not all pathways are identified in each scenario, and whilst different scenarios may have varying levels of pathway occurrence frequency, similar mitigation options may be applied to target a range of INNS pathways. For example, whilst different processes are required for different activities, the overall mitigation measures of event management and equipment washing facilities may be applied to both angling or sailing activities at the reservoir.

6.73 Further information on identified mitigation measures, including measures supplementary to those identified within the SAI–RAT module (as indicated in Table 6.11), are detailed in Appendix A6.3 INNS Mitigation Measures Appraisal. Whilst all potentially suitable mitigation measures have been identified (denoted by ticks), the appraisal identifies that feasibility and efficacy varies between measures (represented by their respective scores within Table 6.11).

6.74 The most effective measures to mitigate risks of the most likely (i.e., baseline) scenario are those which are both potentially applicable to the scenario and score highly considering the feasibility and effectiveness of the measure (i.e., cumulative score of 5 or greater). Broadly, such measures for asset biosecurity include:

- a general biosecurity strategy and management plan and stringent check, clean, dry protocols;
- recreational event management and policies relating to fish stocking and angling restrictions (e.g., live bait policy), as well as site-supplied equipment;
- general cleaning options, including boot-brushing stations, dip stations, as well as washing stations for boats and other equipment being used at the reservoir;
- effective waste management protocols; and,
- INNS monitoring.

*Table 6.10 Asset risk assessment scenarios**

Activity/Pathway	Scenario									
	Baseline	1	2	3	4	5	6	7	8	9
Same INNS, priority habitats and site designations factors applied for all scenarios	Existing high priority INNS on site: Known to be present. Carries a weighting of +20 risk points. Existing Priority Habitats on site: Known to be present. Carries a weighting of +20 risk points. Highest order site designation of asset: National. Carries a weighting of +15 risk points.									
Staff site visit (not entering water) frequency	2	1.5	2	1.5	2	2	2	2	2	2
Staff site visit entering or in contact with raw water frequency	1.5	1	1	1	1	1.5	2	1.5	1.5	2
Road vehicle site visit frequency	2	1.5	2	0	2	2	2	0	2	2
Maintenance not entering water frequency	1.5	1	1.5	1	1.5	1.5	1.5	1.5	1.5	2
Maintenance in water frequency	1	0.5	0.5	0.5	0.5	1	1	1	1	2
Angling equipment frequency	0	0	0	0	2	0	0	0	2	2
Live bait frequency	0	0	0	0	2	0	0	0	2	2
Fish stocking frequency	0.5	0	0.5	0.5	2	0	0	0.5	2	2
Large vessels (over 28 ft) frequency	0	0	0	0	0	0	0	0	0	0

Activity/Pathway	Scenario									
	Baseline	1	2	3	4	5	6	7	8	9
Small vessels (under 28 ft) frequency	1.5	0	0.5	1	0	2	0	1.5	1.5	2
Water Sports Equipment (SUPs, Canoe, Kayaks) frequency	2	0	0	1.5	0	0	2	2	2	2
Water Safety Equipment (Temporary Moorings, jetties, inflatables, buoys) frequency	1.5	0	0	1	1	1	1	1.5	1.5	2
Mammals/waterfowl on site frequency	2	1	2	2	2	2	2	2	2	2
Transfer of waste sludge to land frequency	0	0	0	0	0	0	0	0	0	0
Recreational walker/jogger/ runner frequency	2	0	2	1.5	2	2	2	2	2	2
Overall risk score (total score)	481.75	177	280	346.5	469	387	404	451.75	651.25	736
Final Asset Risk Score (% out of 100)	57.90%	21.27%	33.65%	41.65%	56.37%	46.51%	48.56%	54.30%	78.28%	88.46%

** Scenarios are defined in Table 6.1.*

*Table 6.11 Mitigation methods potentially suitable for each asset scenario**

Mitigation option	Efficacy Score	Feasibility score	Cumulative score	Scenario									
				Base-line	1	2	3	4	5	6	7	8	9
General site biosecurity													
Biosecurity strategy and management	N/A	N/A	N/A	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Check, clean, dry protocols	N/A	N/A	N/A	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
INNS monitoring**	N/A	N/A	N/A	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Aquatic recreational activities													
Event management	3	2	5	✓		✓	✓	✓	✓	✓	✓	✓	✓
Site-supplied equipment (watersports)	3	2	5	✓		✓	✓		✓	✓	✓	✓	✓
Site-supplied equipment (angling)	3	2	5					✓				✓	✓
Fish stocking policy	2	3	5	✓		✓	✓	✓			✓	✓	✓
Live bait policy	2	3	5					✓				✓	✓
Access points**	2	2	4	✓		✓	✓	✓	✓	✓	✓	✓	✓
Physical nets (inc. booms and skimmers)**	2	2	4	✓		✓	✓		✓	✓	✓	✓	✓
CO_2 bubble curtain**	1	1	2	✓		✓	✓		✓	✓	✓	✓	✓
Cleaning options													

Mitigation option	Efficacy Score	Feasibility score	Cumulative score	Scenario									
				Base -line	1	2	3	4	5	6	7	8	9
Sticky mats	1	3	4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Boot-brushing stations	2	3	5	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Personal disinfectant	3	1	4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Dip stations	3	2	5	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Tyre troughs	2	2	4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Carbonated water	2	1	3	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Wash-down wet room	3	2	5	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Pressure washing hoses	2	3	5	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Boat wash station	3	2	5	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Drying room	3	2	5	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Wastewater treatment works**	3	1	4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Main sewers connection**	2	2	4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Terrestrial drainage area**	1	2	3	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Septic tank**	2	2	4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Disposal of solid waste**	2	3	5	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Mitigation option	Efficacy Score	Feasibility score	Cumulative score	Scenario									
				Base -line	1	2	3	4	5	6	7	8	9
Raw water transfers													
Active filtration (screen filters)	-	-	-										
Active filtration (deep bed filters)	-	-	-										
Active filtration (other)	-	-	-										
Passive filtration (fish screens)	-	-	-										
Passive filtration (conveyor screens)	-	-	-										
Passive filtration (rundown screens)	-	-	-										
Biocidal paint	-	-	-										
Silicone-based coating**	-	-	-										
Stop water flow	-	-	-										
Coincide with reproductive season**	-	-	-										
High velocity flow**	-	-	-										
Manual cleaning**	-	-	-										
Water treatment													
Chlorination	-	-	-										

Mitigation option	Efficacy Score	Feasibility score	Cumulative score	Scenario									
				Base -line	1	2	3	4	5	6	7	8	9
Coagulation and flocculation**	-	-	-										
Biochemical**	-	-	-										
UV lighting	-	-	-										
Integrated treatment systems	-	-	-										
Site Development and maintenance**													
Hard surfaces**	2	1	3	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Perimeter fencing and grids**	3	1	4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Bird deterrents**	2	1	3	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Root barrier fabric**	1	2	3	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Aeration**	2	1	3	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Site-supplied operational equipment	3	2	5	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

**See detailed description of each mitigation option in Appendix A6.3 INNS Mitigation Measures Appraisal.*

***Mitigation measures identified in addition to those suggested through the SAI–RAT.*

6.4.2 Raw water transfer (primary raw water transfers) risk assessment

6.4.2.1 Thames to Reservoir

6.75 Within the raw water transfer (River Thames to reservoir) risk assessment, the same input scoring criteria was applied to both scenarios (identified in Table 6.2), with the exception of the number of washout/maintenance points in the transfer. This included a known presence of high priority INNS at the source and pathway, national site designations (i.e., Barrow Farm Fen SSSI) at the receptor, and a known presence of priority habitats on the pathway and at the receptor.

6.76 The full range of inputs and risk assessment scores for each scenario is shown in Table 6.12. Full SAI–RAT risk assessments for each option assessed is provided in Appendix 6.1 INNS EA Asset tool 6610 Iterations. These different scenarios produced a range of scores as follows:

- 61.63% (baseline scenario) – the most likely scenario, accounting for watersports at source; to,
- 63.13% (scenario 1) – same as the baseline scenario, except for additional washouts from the transfer.

6.77 The risk scores are summarised at the bottom of Table 6.12, and include the raw risk scores before they are adjusted to a weighting out of 100%.

6.78 As per the asset risk assessment approach, Table 6.13 indicates which mitigation measures may be suitable for reducing the risk associated with each scenario.

6.79 Whilst the SAI–RAT identifies mitigation measures that are potentially appropriate for INNS transfer through recreation (in this case, known watersports); in this situation, recreation only occurs at the source of the transfer from the River Thames to the reservoir, and not along its pathway. Mitigation measures identified for watersports and (potential) angling at the source (River Thames) have been excluded from recommendations as controls on recreation within the River Thames itself falls outside of scope of SESRO. Instead, only those measures that can be implemented on the transfer itself (e.g., the use of screens to reduce the chance of transfer through the pipeline) have been considered at this stage.

6.80 Further information on identified mitigation measures, including measures supplementary to those identified within the SAI–RAT module are detailed in Appendix A6.3 INNS Mitigation Measures Appraisal. Whilst all potentially suitable mitigation measures have been identified (denoted by ticks), the appraisal identifies that feasibility and efficacy varies between measures (represented by their respective scores within Table 6.13).

6.81 The most effective measures to mitigate risks of the most likely (i.e., baseline) scenario are those which are both potentially applicable to the scenario and score highly considering the feasibility and effectiveness of the measure (i.e., cumulative score of 5 or greater). In addition to the measures identified for asset biosecurity, such measures specific to transfer biosecurity include:

- inclusion of the transfer operation and maintenance in a general biosecurity strategy and management plan and stringent check, clean, dry protocol;
- passive transfer filtration measures such as fish and eel screens and conveyor screens which are likely to be highly effective against certain INNS/life stages. These will be less effective against INNS with smaller life stages that are likely to be present during periods of water transfer from Thames to reservoir;
- site-supplied operational maintenance equipment; and,
- inclusion of the transfer inlet and outlet within INNS monitoring supporting early detection of new INNS.

*Table 6.12 Raw water transfer risk assessment scenarios applied for the River Thames to the reservoir**

Raw Water Transfer Risk Assessment Options	River Thames → Reservoir Scenario Baseline	1
Source type	River intake	River intake
Number of raw water transfer inputs to source	Unknown	Unknown
Pathway type	Pipe	Pipe
Receptor type**	Online water body (reservoir)	Online water body (reservoir)
Volume of water	>500 Ml/d	>500 Ml/d
Frequency of operation	Year round – intermittent	Year round – intermittent
Transfer distance (km)	1.1–5	1.1–5
Number of washout/maintenance points	1	>3
Source navigable	Yes	Yes
Pathway navigable	No	No
Angling at source	Unknown	Unknown
Angling on pathway	No	No
Water sports at source	Casual use by individuals/clubs	Casual use by individuals/clubs

Raw Water Transfer Risk Assessment Options	River Thames → Reservoir	
	Scenario	
	Baseline	1
Water sports on pathway	No	No
Presence of high priority INNS – source	Known to be present	Known to be present
Presence of high priority INNS – pathway	Known to be present	Known to be present
Highest order site designation receptor	National	National
Presence of priority habitat – pathway	Known to be present	Known to be present
Presence of priority habitat – receptor	Known to be present	Known to be present
Other existing connections	None	None
Overall risk score (total score)	831.9375	852.1875
Final RWT risk score (% out of 100)	61.63%	63.13%

** Scenarios are defined in Table 6.2.*

*** SAI–RAT guidance is ambiguous on the definition of 'offline' vs. 'online' water body. On a precautionary basis, the assessment of SESRO has defined the receptor as being online (on the basis this is a higher risk receptor type) – as the configuration of the Scheme (transferring water directly from and to the River Thames) is more aligned with the definition of 'online' water body (example provided being an impounding reservoir) than 'offline' water body (examples provided being gravel pits and quarries).*

*Table 6.13 Mitigation methods potentially suitable for each raw water transfer scenario from the River Thames to the reservoir**

Mitigation option	Efficacy Score	Feasibility score	Cumulative score	Scenario Baseline	 1
			General site biosecurity		
Biosecurity strategy and management	N/A	N/A	N/A	✓	✓
Check, clean, dry protocols	N/A	N/A	N/A	✓	✓
INNS monitoring**	N/A	N/A	N/A	✓	✓
			Aquatic recreational activities		
Event management	-	-	-		
Site-supplied equipment (watersports)	-	-	-		
Site-supplied equipment (angling)	-	-	-		
Fish stocking policy	-	-	-		
Live bait policy	-	-	-		
Access points**	-	-	-		
Physical nets (inc. booms and skimmers)**	-	-	-		
CO_2 bubble curtain**	-	-	-		
			Cleaning options		
Sticky mats	-	-	-		
Boot-brushing	-	-	-		

Mitigation option	Efficacy Score	Feasibility score	Cumulative score	Scenario Baseline	 1
stations					
Personal disinfectant	-	-	-		
Dip stations	-	-	-		
Tyre troughs	-	-	-		
Carbonated water	-	-	-		
Wash-down wet room	-	-	-		
Pressure washing hoses	-	-	-		
Boat wash station	-	-	-		
Drying room	-	-	-		
Wastewater treatment works**	-	-	-		
Main sewers connection**	-	-	-		
Terrestrial drainage area**	-	-	-		
Septic tank**	-	-	-		
Disposal of solid waste**	-	-	-		
Raw water transfers					
Active filtration (screen filters)	3	1	4	✓	✓
Active filtration (deep bed filters)	3	1	4	✓	✓
Active filtration	3	1	4	✓	✓

Mitigation option	Efficacy Score	Feasibility score	Cumulative score	Scenario Baseline	 1
(other)					
Passive filtration (fish screens)	2	3	5	✓	✓
Passive filtration (conveyor screens)	2	3	5	✓	✓
Passive filtration (rundown screens)	2	1	3	✓	✓
Biocidal paint	2	1	3	✓	✓
Silicone-based coating**	2	1	3	✓	✓
Stop water flow	1	3	4	✓	✓
Coincide with reproductive season**	1	1	2	✓	✓
High velocity flow**	1	2	3	✓	✓
Manual cleaning**	1	2	3	✓	✓
Water treatment					
Chlorination	3	1	4	✓	✓
Coagulation and flocculation**	2	1	3	✓	✓
Biochemical**	2	1	3	✓	✓
UV lighting	3	1	4	✓	✓
Integrated treatment	3	1	4	✓	✓

Mitigation option	Efficacy Score	Feasibility score	Cumulative score	Scenario Baseline	 1
systems					
Site Development and maintenance**					
Hard surfaces**	-	-	-		
Perimeter fencing and grids**	-	-	-		
Bird deterrents**	-	-	-		
Root barrier fabric**	-	-	-		
Aeration**	-	-	-		
Site-supplied operational equipment	3	2	5	✓	✓

**Detailed descriptions of each mitigation option are provided in Appendix A6.3 INNS Mitigation Measures Appraisal.*
***Mitigation measures identified in addition to those suggested through the SAI–RAT.*

6.4.2.2 Reservoir to River Thames

6.82 Within the raw water transfer (reservoir to the River Thames) risk assessment, the same input scoring criteria was applied to all scenarios (identified in Table 6.4) in relation to the presence of high priority INNS at the source and on the pathway, the presence of priority habitat on the pathway and at the receptor, and the absence of site designations at the receptor.

6.83 Similarly, operational parameters of the raw water transfer remained the same for all scenarios, with the exception of discharge. However, the range of options within the discharge category field of the SAI–RAT (as shown in Table 6.14) is sufficiently broad that 125, 130 and 122 Mm^3 options fall within the same discharge category and are therefore indistinguishable within the SAI–RAT (as shown by raw score range column).

6.84 Risk scores (Table 6.14) for all options and scenarios fall within a relatively narrow range (47.88% to 56.88%). Acknowledging this and the fact that the 125, 130 and 122 Mm^3 options are indistinguishable by the SAI–RAT, detailed results are presented for only the smallest and lowest potential risk option (75 Mm^3) and largest and highest potential risk option (150 Mm^3).

Table 6.14 Raw water transfer risk assessment scenario descriptions (Reservoir to Thames)

Size Option (Mm^3)	Maximum Release Rate (Ml/d)	Volumetric Discharge Category in SAI–RAT (Ml/d)	Raw Score Range (column AN in SAI–RAT)
75	165	151–200	646.31–727.31 (47.88–53.88%)
100	219	201–250	659.81–740.81 (48.88–54.88%)
125	270	251–300	673.31–754.31 (49.88–55.88%)
150	321	301–400	686.81–767.81 (50.88–56.88%)
130 (100 + 30)	280	251–300	673.31–754.31 (49.88–55.88%)

Size Option (Mm^3)	Maximum Release Rate (Ml/d)	Volumetric Discharge Category in SAI–RAT (Ml/d)	Raw Score Range (column AN in SAI–RAT)
122 (80 + 42)	264	251–300	673.31–754.31 (49.88–55.88%)

6.85 The full range of inputs and risk assessment scores for the 75 Mm^3 option and the 150 Mm^3 option under each scenario are provided in Table 6.15 and Table 6.16, respectively. The baseline scenario for the 75 Mm^3 option is reported as 50.13%. The baseline scenario for SESRO 150 Mm^3 option is reported at 53.13%.

6.86 Table 6.17 indicates which mitigation measures may be suitable for reducing the risk associated with each scenario (unchanged between reservoir size options).

6.87 Whilst the SAI–RAT identifies mitigation measures that are potentially appropriate for INNS transfer through recreation (in this case, angling and watersports); in this situation, recreation only occurs at the source of the transfer from the reservoir to the River Thames and not on the transfer itself. Recreation also occurs on the River Thames but recreation at the receptor is not considered within the raw water transfer risk assessment. Those mitigation measures identified for recreation at the source (the reservoir itself) have therefore been excluded from recommendations as the asset risk assessment and options appraisal already considers mitigation for recreation on the reservoir itself. Instead, only those measures that can be implemented on the transfer itself (e.g., the use of screens to reduce the chance of transfer through the pipeline) are considered in Table 6.17.

6.88 Further information on identified mitigation measures, including measures supplementary to those identified within the SAI–RAT module are detailed in Appendix A6.3 INNS Mitigation Measures Appraisal. Whilst all potentially suitable mitigation measures have been identified (denoted by ticks), the appraisal identifies that feasibility and efficacy varies between measures (represented by their respective scores within Table 6.17).

6.89 The most effective measures to mitigate risks of the most likely (i.e., baseline) scenario are those which are both potentially applicable to the scenario and score highly considering the feasibility and effectiveness of the measure (i.e., cumulative score of 5 or greater). In addition to the measures identified for asset biosecurity, such measures specific to transfer biosecurity are those already discussed in Section 6.4.2.1 (River Thames to reservoir transfer). In addition to measures on the transfer itself, INNS mitigation measures may be implemented at the source of the transfer, to reduce the likelihood of INNS being transferred from the reservoir to the River Thames. These mitigation measures are summarised in Section 6.4.1 (Asset Risk Assessment).

*Table 6.15 Raw water transfer risk assessment scenarios applied for the reservoir to River Thames (75 Mm^3 option)**

Raw Water Transfer Risk Assessment Options	Reservoir → River Thames					
	Scenario					
	Baseline	1	2	3	4	5
Source type**	Online water body (reservoir)	Online water body (reservoir)	Online water body (reservoir)	Online water body (reservoir)	Online water body (reservoir)	Online water body (reservoir)
Number of raw water transfer inputs to source	1	1	1	1	1	1
Pathway type	Pipe	Pipe	Pipe	Pipe	Pipe	Pipe
Receptor type	River	River	River	River	River	River
Volume of water	151–200 Ml/d	151–200 Ml/d	151–200 Ml/d	151–200 Ml/d	151–200 Ml/d	151–200 Ml/d
Frequency of operation	Year round – intermittent	Year round – intermittent	Year round – intermittent	Year round – intermittent	Year round – intermittent	Year round – intermittent
Transfer distance (km)	1.1–5	1.1–5	1.1–5	1.1–5	1.1–5	1.1–5

Raw Water Transfer Risk Assessment Options	Reservoir → River Thames Scenario Baseline	1	2	3	4	5
Number of washout/ maintenance points	1	1	1	1	>3	1
Source navigable	No	No	No	No	No	No
Pathway navigable	No	No	No	No	No	No
Angling at source	No	No	Members and day ticket holders, international events	No	No	Members and day ticket holders, international events
Angling on pathway	No	No	No	No	No	No
Water sports at source	National events	No	No	International events	National events	International events

Raw Water Transfer Risk Assessment Options	Reservoir → River Thames Scenario Baseline	1	2	3	4	5
Water sports on pathway	No	No	No	No	No	No
Presence of high priority INNS – source	Known to be present	Known to be present	Known to be present	Known to be present	Known to be present	Known to be present
Presence of high priority INNS – pathway	Known to be present	Known to be present	Known to be present	Known to be present	Known to be present	Known to be present
Highest order site designation receptor	None	None	None	None	None	None
Presence of priority habitat – pathway	Known to be present	Known to be present	Known to be present	Known to be present	Known to be present	Known to be present

Raw Water Transfer Risk Assessment Options	Reservoir → River Thames Scenario Baseline	1	2	3	4	5
Presence of priority habitat – receptor	Known to be present	Known to be present	Known to be present	Known to be present	Known to be present	Known to be present
Other existing connections	None	None	None	None	None	None
Overall risk score (total score)	676.6875	646.3125	686.8125	686.8125	696.9375	727.3125
Final RWT risk score (% out of 100)	50.13%	47.88%	50.88%	50.88%	51.63%	53.88%

**Scenarios are defined in Table 6.4.*

***SAI–RAT guidance is ambiguous on the definition of 'offline' vs. 'online' water body. On a precautionary basis, the assessment of SESRO has defined the source as being online (on the basis this is a higher risk receptor type) – as the configuration of the Scheme (transferring water directly from and to the River Thames) is more aligned with the definition of 'online' water body (example provided being an impounding reservoir) than 'offline' water body (examples provided being gravel pits and quarries).*

*Table 6.16 Raw water transfer risk assessment scenarios applied for the reservoir to River Thames (150 Mm^3)**

Raw Water Transfer Risk Assessment Options	Reservoir → River Thames Scenario Baseline	1	2	3	4	5
Source type**	Online water body (reservoir)	Online water body (reservoir)	Online water body (reservoir)	Online water body (reservoir)	Online water body (reservoir)	Online water body (reservoir)
Number of raw water transfer inputs to source	1	1	1	1	1	1
Pathway type	Pipe	Pipe	Pipe	Pipe	Pipe	Pipe
Receptor type	River	River	River	River	River	River
Volume of water	301–400 Ml/d	301–400 Ml/d	301–400 Ml/d	301–400 Ml/d	301–400 Ml/d	301–400 Ml/d
Frequency of operation	Year round – intermittent	Year round – intermittent	Year round – intermittent	Year round – intermittent	Year round – intermittent	Year round – intermittent
Transfer distance (km)	1.1–5	1.1–5	1.1–5	1.1–5	1.1–5	1.1–5

Raw Water Transfer Risk Assessment Options	Reservoir → River Thames Scenario					
	Baseline	1	2	3	4	5
Number of washout/ maintenance points	1	1	1	1	>3	1
Source navigable	No	No	No	No	No	No
Pathway navigable	No	No	No	No	No	No
Angling at source	No	No	Members and day ticket holders, international events	No	No	Members and day ticket holders, international events
Angling on pathway	No	No	No	No	No	No
Water sports at source	National events	No	No	International events	National events	International events

Raw Water Transfer Risk Assessment Options	Reservoir → River Thames Scenario Baseline	1	2	3	4	5
Water sports on pathway	No	No	No	No	No	No
Presence of high priority INNS – source	Known to be present	Known to be present	Known to be present	Known to be present	Known to be present	Known to be present
Presence of high priority INNS – pathway	Known to be present	Known to be present	Known to be present	Known to be present	Known to be present	Known to be present
Highest order site designation receptor	None	None	None	None	None	None
Presence of priority habitat – pathway	Known to be present	Known to be present	Known to be present	Known to be present	Known to be present	Known to be present

Raw Water Transfer Risk Assessment Options	Reservoir → River Thames Scenario Baseline	1	2	3	4	5
Presence of priority habitat – receptor	Known to be present	Known to be present	Known to be present	Known to be present	Known to be present	Known to be present
Other existing connections	None	None	None	None	None	None
Overall risk score (total score)	717.1875	686.8125	727.3125	727.3125	737.4375	767.8125
Final RWT risk score (% out of 100)	53.13%	50.88%	53.88%	53.88%	54.63%	56.88%

**Scenarios are defined in Table 6.4.*

***SAI–RAT guidance is ambiguous on the definition of 'offline' vs. 'online' water body. On a precautionary basis, the assessment of SESRO has defined the source as being online (on the basis this is a higher risk receptor type) – as the configuration of the Scheme (transferring water directly from and to the River Thames) is more aligned with the definition of 'online' water body (example provided being an impounding reservoir) than 'offline' water body (examples provided being gravel pits and quarries).*

*Table 6.17 Mitigation methods potentially suitable for each raw water transfer scenario from the reservoir to the River Thames**

Mitigation option	Efficacy Score	Feasibility score	Cumulative score	Scenario					
				Baseline	1	2	3	4	5
General site biosecurity									
Biosecurity strategy and management	N/A	N/A	N/A	✓	✓	✓	✓	✓	✓
Check, clean, dry protocols	N/A	N/A	N/A	✓	✓	✓	✓	✓	✓
INNS monitoring**	N/A	N/A	N/A	✓	✓	✓	✓	✓	✓
Aquatic recreational activities									
Event management	-	-	-						
Site-supplied equipment (watersports)	-	-	-						
Site-supplied equipment	-	-	-						

Mitigation option	Efficacy Score	Feasibility score	Cumulative score	Scenario					
				Baseline	1	2	3	4	5
(angling)									
Fish stocking policy	-	-	-						
Live bait policy	-	-	-						
Access points**	-	-	-						
Physical nets (inc. booms and skimmers)**	-	-	-						
CO_2 bubble curtain*	-	-	-						
Cleaning options									
Sticky mats	-	-	-						
Boot-brushing stations	-	-	-						
Personal disinfectant	-	-	-						

Mitigation option	Efficacy Score	Feasibility score	Cumulative score	Scenario					
				Baseline	1	2	3	4	5
Dip stations	-	-	-						
Tyre troughs	-	-	-						
Carbonated water	-	-	-						
Wash-down wet room	-	-	-						
Pressure washing hoses	-	-	-						
Boat wash station	-	-	-						
Drying room	-	-	-						
Wastewater treatment works**	-	-	-						
Main sewers connection**	-	-	-						
Terrestrial drainage area**	-	-	-						

Mitigation option	Efficacy Score	Feasibility score	Cumulative score	Scenario					
				Baseline	1	2	3	4	5
Septic tank**	-	-	-						
Disposal of solid waste**	-	-	-						
				Raw water transfers					
Active filtration (screen filters)	3	1	4	✓	✓	✓	✓	✓	✓
Active filtration (deep bed filters)	3	1	4	✓	✓	✓	✓	✓	✓
Active filtration (other)	3	1	4	✓	✓	✓	✓	✓	✓
Passive filtration (fish screens)	2	3	5	✓	✓	✓	✓	✓	✓
Passive filtration (conveyor	2	3	5	✓	✓	✓	✓	✓	✓

Mitigation option	Efficacy Score	Feasibility score	Cumulative score	Scenario					
				Baseline	1	2	3	4	5
screens)									
Passive filtration (rundown screens)	2	1	3	✓	✓	✓	✓	✓	✓
Biocidal paint	2	1	3	✓	✓	✓	✓	✓	✓
Silicone-based coating**	2	1	3	✓	✓	✓	✓	✓	✓
Stop water flow	1	3	4	✓	✓	✓	✓	✓	✓
Coincide with reproductive season**	1	1	2	✓	✓	✓	✓	✓	✓
High velocity flow**	1	2	3	✓	✓	✓	✓	✓	✓
Manual cleaning**	1	2	3	✓	✓	✓	✓	✓	✓
Water treatment									
Chlorination	3	1	4	✓	✓	✓	✓	✓	✓

Mitigation option	Efficacy Score	Feasibility score	Cumulative score	Scenario					
				Baseline	1	2	3	4	5
Coagulation and flocculation**	2	1	3	✓	✓	✓	✓	✓	✓
Biochemical**	2	1	3	✓	✓	✓	✓	✓	✓
UV lighting	3	1	4	✓	✓	✓	✓	✓	✓
Integrated treatment systems	3	1	4	✓	✓	✓	✓	✓	✓
Site Development and maintenance**									
Hard surfaces**	-	-	-						
Perimeter fencing and grids**	-	-	-						
Bird deterrents**	-	-	-						
Root barrier fabric**	-	-	-						
Aeration**	-	-	-						

Mitigation option	Efficacy Score	Feasibility score	Cumulative score	Scenario					
				Baseline	1	2	3	4	5
Site-supplied operational equipment	3	2	5	✓	✓	✓	✓	✓	✓

**Detailed descriptions of each are provided in Appendix A6.3 INNS Mitigation Measures Appraisal.*

***Mitigation measures identified in addition to those suggested through the SAI–RAT.*

6.4.3 Emergency drawdown (raw water transfer) risk assessment

6.90 Within the raw water transfer (emergency drawdown) risk assessment, the same input scoring criteria was applied to all scenarios (identified in Table 6.5) in relation to the presence of high priority INNS at the source and on the pathway, the presence of priority habitat on the pathway and at the receptor, and the absence of site designations at the receptor. Similarly, operational parameters of the EDD/ADC remained the same for all scenarios, including discharge category (as discussed in the Risk assessment of emergency drawdown Section 6.2.7).

6.91 The full range of inputs and risk assessment scores for each scenario is shown in Table 6.18. Full SAI–RAT risk assessments for each option assessed is provided in Appendix 6.1 INNS EA Asset tool 6610 Iterations. These different scenarios produced a range of scores as follows:

- 57.13% (low-use scenario);
- 60.13% (medium-use scenario); and
- 61.25% (high-use scenario)

6.92 Whilst each scenario varies in overall risk, the risk scores are all greater than the main outlet transfer from the reservoir to River Thames, with the highest risk scenario scoring 56.88% (the baseline scoring 53.13%).

6.93 In comparison to the primary raw water transfer from the reservoir to the River Thames, all EDD scenarios score higher risk than the primary raw water transfer scenarios, which range from 50.88% to 56.88%, whilst the EDD scenarios range from 57.13% to 61.25%. The higher risk scores reported for the EDD are a product of large potential releases (all scenarios), as well as the open channel nature of the ADC, which is assessed as facilitating navigation (medium-use scenario) and both navigation and recreation (high-use scenario) on the pathway. Both the raw water transfer from the reservoir to the River Thames and the emergency drawdown have the same source inputs included within the SAI–RAT, allowing for a direct comparison between their pathways.

6.94 Whilst the SAI–RAT identifies mitigation measures that are potentially appropriate for INNS transfer through navigation and recreation (in this case, angling and watersports); in this situation, only the medium and high-use scenarios include navigation/recreation on the pathway, whilst all scenarios include recreation at the source (the reservoir). Those mitigation measures identified for recreation at the source (the reservoir itself) have therefore been excluded from recommendations as the asset risk assessment and options appraisal already considers mitigation for recreation on the reservoir itself. Instead, only those measures that can be implemented on the transfer itself (e.g., the use of screens to reduce the chance of transfer through the pipeline) are considered in Table 6.19.

6.95 Further information on identified mitigation measures, including measures supplementary to those identified within the SAI–RAT module are detailed Appendix A6.3 INNS Mitigation Measures Appraisal. Whilst all potentially suitable mitigation measures have been identified (denoted by ticks), the appraisal identifies that feasibility and efficacy varies between measures (represented by their combined score within Table 6.19).

6.96 The most effective measures to mitigate risks of the most likely (i.e., baseline) scenario are those which are both potentially applicable to the scenario and score highly considering the feasibility and effectiveness of the measure (i.e., cumulative score of 5 or greater). In addition to the measures identified for asset biosecurity, such measures specific to EDD transfer biosecurity are consistent with those identified for the main raw water transfer in Section 6.4.2. Should the high-use scenario for the emergency drawdown be selected, this is likely to contain recreation on the transfer (i.e., the ADC). In this case, those mitigation measures stipulated for the asset in Section 6.2.5 are also likely to be applicable to the transfer here.

*Table 6.18 Emergency drawdown risk assessment scenarios applied**

Emergency Drawdown Risk Assessment Options	Scenario Low-use	Medium-use	High-use
Source type**	Online water body (reservoir)	Online water body (reservoir)	Online water body (reservoir)
Number of raw water transfer inputs to source	1	1	1
Pathway type	Partial open water, partial pipeline	Partial open water, partial pipeline	Partial open water, partial pipeline
Receptor type	River	River	River
Volume of water	>500 Ml/d	>500 Ml/d	>500 Ml/d
Frequency of operation	Occasional, i.e., infrequent, regulatory compliance	Occasional, i.e., infrequent, regulatory compliance	Occasional, i.e., infrequent, regulatory compliance
Transfer distance (km)	1.1–5	1.1–5	1.1–5
Number of washout/ maintenance points	1	1	1
Source navigable	No	No	No
Pathway navigable	No	Yes	Yes
Angling at source	No	No	No
Angling on pathway	No	No	Members only, no matches
Water sports at source	National events	National events	National events
Water sports on pathway	No	No	Casual use by individuals/clubs
Presence of high priority INNS – source	Known to be present	Known to be present	Known to be present
Presence of high priority INNS – pathway	Known to be present	Known to be present	Known to be present
Highest order site designation receptor	None	None	None
Presence of priority	Known to be present	Known to be present	Known to be present

Emergency Drawdown Risk Assessment Options	Scenario Low-use	Medium-use	High-use
habitat – pathway			
Presence of priority habitat – receptor	Known to be present	Known to be present	Known to be present
Other existing connections	None	None	None
Overall risk score (total score)	771.1875	881.6875	826.875
Final RWT risk score (% out of 100)	57.13%	60.13%	61.25%

**Scenarios are defined in Table 6.5.*

***SAI–RAT guidance is ambiguous on the definition of 'offline' vs. 'online' water body. On a precautionary basis, the assessment of SESRO has defined the source as being online (on the basis this is a higher risk receptor type) – as the configuration of the Scheme (transferring water directly from and to the River Thames) is more aligned with the definition of 'online' water body (example provided being an impounding reservoir) than 'offline' water body (examples provided being gravel pits and quarries).*

*Table 6.19 Mitigation methods potentially suitable for each emergency drawdown scenario**

Mitigation option	Efficacy Score	Feasibility score	Cumulative score	Scenario		
				Low-use	Medium-use	High-use
General site biosecurity						
Biosecurity strategy and management	N/A	N/A	N/A	✓	✓	✓
Check, clean, dry protocols	N/A	N/A	N/A	✓	✓	✓
INNS monitoring**	N/A	N/A	N/A	✓	✓	✓
Aquatic recreational activities						
Event management	3	2	5			✓
Site-supplied equipment (watersports)	3	2	5			✓
Site-supplied equipment (angling)	3	2	5			✓
Fish stocking policy	-	-	-			
Live bait policy	2	3	5			✓
Access points**	2	2	4		✓	✓
Physical nets (inc. booms and skimmers)**	2	2	4		✓	✓
CO_2 bubble curtain**	1	1	2		✓	✓
Cleaning options						
Sticky mats	1	3	4			✓
Boot-brushing stations	2	3	5			✓
Personal disinfectant	3	1	4			✓

Mitigation option	Efficacy Score	Feasibility score	Cumulative score	Scenario		
				Low-use	Medium-use	High-use
Dip stations	3	2	5			✓
Tyre troughs	2	2	4			✓
Carbonated water	2	1	3			✓
Wash-down wet room	3	2	5			✓
Pressure washing hoses	2	3	5			✓
Boat wash station	3	2	5			✓
Drying room	3	2	5			✓
Wastewater treatment works**	3	1	4			✓
Main sewers connection**	2	2	4			✓
Terrestrial drainage area**	1	2	3			✓
Septic tank**	2	2	4			✓
Disposal of solid waste**	2	3	5			✓
Raw water transfers						
Active filtration (screen filters)	3	1	4	✓	✓	✓
Active filtration (deep bed filters)	3	1	4	✓	✓	✓
Active filtration (other)	3	1	4	✓	✓	✓
Passive filtration (fish screens)	2	3	5	✓	✓	✓
Passive filtration (conveyor screens)	2	3	5	✓	✓	✓

Mitigation option	Efficacy Score	Feasibility score	Cumulative score	Scenario		
				Low-use	Medium-use	High-use
Passive filtration (rundown screens)	2	1	3	✓	✓	✓
Biocidal paint	2	1	3	✓	✓	✓
Silicone-based coating**	2	1	3	✓	✓	✓
Stop water flow	1	3	4	✓	✓	✓
Coincide with reproductive season**	1	1	2	✓	✓	✓
High velocity flow**	1	2	3	✓	✓	✓
Manual cleaning**	1	2	3	✓	✓	✓
Water Treatment						
Chlorination	3	1	4	✓	✓	✓
Coagulation and flocculation**	2	1	3	✓	✓	✓
Biochemical**	2	1	3	✓	✓	✓
UV lighting	3	1	4	✓	✓	✓
Integrated treatment systems	3	1	4	✓	✓	✓
Site Development and maintenance**						
Hard surfaces**	2	1	3		✓	✓
Perimeter fencing and grids**	-	-	-			
Bird deterrents**	-	-	-			
Root barrier fabric**	-	-	-			
Aeration**	2	1	3	✓	✓	✓
Site-supplied	3	2	5	✓	✓	✓

Mitigation option	Efficacy Score	Feasibility score	Cumulative score	Scenario		
				Low-use	Medium-use	High-use
operational equipment						

**Detailed descriptions of each are provided in Appendix A6.3 INNS Mitigation Measures Appraisal.*

***Mitigation measures identified in addition to those suggested through the SAI–RAT.*

6.4.4 Asset risk assessment – comparison with existing assets

6.97 Risk assessments have been completed for Farmoor Reservoir No. 2, Queen Mother Reservoir and High Maynard Reservoir. The assessment of these assets was completed using the SAI–RAT. Full SAI–RAT risk assessments for each option assessed is provided in Appendix 6.1 INNS EA Asset tool 6610 Iterations. However, unlike the SESRO asset risk assessment, activity/pathway inputs and scores are based on the known operation of the reservoirs, rather than hypothetical scenarios. Scoring therefore reflects current arrangements for public access and recreational activities and provides a useful comparator for SESRO. The inputs provided within the assessment for each reservoir, including pathway-frequency scores are shown in Table 6.20-. The final risk scores generated for comparison are also provided.

6.98 When comparing these sites, all three fall within the risk scores associated with the SESRO risk assessment scenarios, which range from 21.27% to 88.46%. These comparison asset risk assessments produced a range of scores as follows:

- 62.56% (Farmoor Reservoir);
- 46.21% (Queen Mother Reservoir); and
- 41.56% (High Maynard Reservoir).

6.99 The SESRO reservoir baseline scenario scored 57.90%. Based on the recreational activities occurring at Farmoor, this is considered to be the most similar to the SESRO asset baseline scenario, with Farmoor scoring only 4.66% points higher in terms of relative risk.

6.100 Farmoor Reservoir (unlike SESRO baseline) is not associated with priority habitats or environmental designations on site, which intrinsically lowers its risk profile (and therefore scoring) within the context of the SAI–RAT. The fact that Farmoor is still considered a higher risk asset than SESRO by the SAI–RAT despite this relatively lower baseline risk profile, is a product of the occurrence of angling and the higher frequency of fish stocking activities taking place at the site.

6.101 Queen Mother Reservoir (as per SESRO baseline) has no provision for angling activities at the asset but has high-frequency of sailing activities. The lower risk profile of this asset relative to SESRO is driven by the absence of environmental designations and priority habitats at the site, lower frequency of recreation and maintenance visits by staff and road vehicles.

6.102 High Maynard Reservoir also scores lower than the SESRO baseline scenario, with the absence of sailing activities being a key factor. Whilst High Maynard is associated with high frequencies of angling, the lower levels of staff site activity and maintenance in the water (relative to the SESRO baseline) also drives this relative reduction in risk.

6.103 Collectively, the comparison assets therefore demonstrate the heightened INNS transfer risk associated with the occurrence and frequency of higher risk activities such as recreation and staff site visits. Such activities are key drivers in determining the overall INNS risk profile of a given asset.

Table 6.20 Asset risk assessment inputs and scores for comparison assets

Activity/Pathway	Assets		
	Farmoor	Queen Mother	High Maynard
Existing high priority INNS on site	Known to be present	Known to be present	Known to be present
Existing priority habitats on site	Not known to be present	Not known to be present	Not known to be present
Highest order site designation of asset	None	None	International
Staff site visit (not entering water) frequency	2	1.5	2
Staff site visit entering or in contact with raw water frequency	0.5	1.5	0.5
Road vehicle site visit	1.5	1.5	1.5

frequency			
Maintenance not entering water frequency	1	1	1.5
Maintenance in water frequency	0.5	0.5	0.5
Angling equipment frequency	2	0	2
Live bait frequency	1.5	0	1
Fish stocking frequency	1	0	0.5
Large vessels (over28ft) frequency	0	0	0
Small vessels (under 28ft) frequency	2	2	0
Water Sports Equipment (SUPs, Canoe, Kayaks) frequency	2	2	0
Water Safety Equipment (Temporary Moorings, jetties, inflatables, buoys) frequency	1	1	0.5
Mammals/waterfowl on site frequency	2	2	2
Transfer of waste sludge to land frequency	0	0	0
Recreational walker/jogger/ runner frequency	2	1	2
Overall risk score (total score)	520.5	384.5	345.75
Final Asset Risk Score	62.56%	46.21%	41.56%

(% out of 100)			

6.4.5 Raw water transfer risk assessment – comparison with existing transfers

6.104 Risk assessments have been completed for the raw water transfers associated with Farmoor Reservoir No. 2, Queen Mother Reservoir and High Maynard Reservoir. The assessment of these transfers was completed using the SAI–RAT, however, unlike the SESRO raw water transfer risk assessment, scenarios have not been generated as the transfers are existing (and not hypothetical). Scoring therefore reflects current transfer operation at these sites and provides a useful comparator for SESRO. The inputs provided within the assessment for each transfer, including pathway-frequency scores are provided in Table 6.21. The final risk scores generated for comparison are also provided.

6.105 None of the comparison sites discharge to a river, as the SESRO outlet does. However, the SAI–RAT applies the same multipliers for discharge to a river or 'online water body' (i.e. reservoir). With regard to the comparison transfers, with the exception of Farmoor Reservoir outlet to Swinford Water Treatment Works, all other transfers discharge to an 'online water body', making them directly comparable to the SESRO outlet to the River Thames, in terms of multipliers applied.

6.106 All three transfers from rivers to the comparison sites are characterised by lower risk scores than the SESRO raw water transfer risk assessment scenarios which score 61.63% and 63.13%. These comparison transfers produced a range of scores as follows:

- 50.25% (Farmoor Reservoir intake);
- 59.63% (Queen Mother intake); and
- 51.38% (High Maynard intake).

6.107 Despite the comparison intake pathways having higher inherent risk (e.g., partial open water and river types), the piped SESRO intake will convey a larger intake volume than the existing reservoirs – which is a key driver of its risk scoring within the SAI–RAT. This, alongside the presence of a national designation in proximity of the receptor, and priority habitats and INNS along its pathway are key drivers of the relatively higher risk of SESRO. Therefore, the inherent characteristics of the SESRO transfer and the baseline environmental conditions are the key drivers of the slightly increased risk relative to existing comparators – and are not factors which are controlled specifically through further mitigation.

6.108 Transfers from the reservoirs to other receptors are also broadly characterised by lower risk scores than SESRO. All three transfers from the comparison sites to rivers achieve lower risk scores than the SESRO raw water transfer risk assessment scenarios, with the exception of the Queen Mother Reservoir outlet. These comparison transfers produced a range of scores as follows:

- 43.23% (Farmoor Reservoir outlet);
- 48.88% (Queen Mother Reservoir outlet); and
- 41.50% (High Maynard Reservoir outlet).

6.109 In comparison, the SESRO outlet scenarios scored between 47.88% and 53.88% for the smallest SESRO size option (Table 6.15) and between 50.88 % and 56.88 % for the largest SESRO size option (Table 6.16). The baseline scores were 50.13 % and 53.13 % for the smallest and largest SESRO size options, respectively. The Queen Mother Reservoir outlet (the highest risk of the comparison sites) scored 48.88 % in comparison.

6.110 The key driver of higher risk associated with the outlet scenarios for SESRO relative to the comparator sites is the higher volume of discharge associated with SESRO. This is partly offset by other factors across the comparison sites including additional raw water inputs to source, for example. However, the inherent characteristics of the SESRO transfer remain the key drivers of the slightly increased risk relative to existing comparators – and are not factors which are controlled specifically through further mitigation. Unlike SESRO transfer from the Thames to reservoir, the inherent risks associated with transfer to the Thames could be further reduced through alteration of the activities that take place at the reservoir.

6.111 Through the ongoing development of Thames Water's AMP7 WINEP Company-Wide INNS Plan, it us understood that some mitigation measures are already present at each of Farmoor Reservoir No. 2, Queen Mother Reservoir and High Maynard Reservoir, as well as on their associated raw water transfers. For example, both Farmoor and Queen Mother reservoirs have existing washdown stations for the sailing activities that take place there, as well as signage to educate visitors of the Check Clean Dry campaign (signage is also present at High Maynard Reservoir). The inlets for all three reservoirs are also provisioned with eel screens with 1.75 mm apertures (with the exception of High Maynard with a 10 mm Klawa screen),[257] which are suitable for preventing the transfer of larger INNS. The effectiveness of these

[257] Klawa-gmbh.de. (2022). Eel bypass. [online]. Available at: https://www.klawa-gmbh.de/en/our-business-areas/ecological-hydropower-technology/eel-bypass/ [Accessed 4 May 2022].

measures in a site context is not known and the remainder of the AMP7 WINEP programme will involve further investigations into suitable INNS mitigation measures that are deemed effective and feasible to install across Thames Water assets. Thames Water is also undertaking its own trials of some INNS mitigation measures, in which results will be obtained during the remainder of AMP7. The measures already implemented at these comparison sites have been identified as part of a range of measures to be considered and further developed for SESRO during future project design stages. As per SAI–RAT functionality and consistent with SESRO, the existing mitigation measures installed are not factored into the risk assessment scores.

Table 6.21 Raw water transfer risk assessment inputs and scores for comparison transfers

Raw water transfer risk assessment options	Raw water transfer					
	Farmoor Intake	Farmoor Outlet	Queen Mother Intake	Queen Mother Outlet	High Maynard Intake (Chingford Aqueduct)	High Maynard Outlet (Transfer to Walthamstow 4)
Source type*	River	Online water body (reservoir)	River	Online water body (reservoir)	River	Online water body (reservoir)
Number of raw water transfer inputs to source	Unknown	2	Unknown	1	Unknown	2
Pathway type	Partial open water, partial pipe	Partial tunnel, partial pipeline	Partial open water, partial pipe	Partial tunnel, partial pipeline	River	Pipeline
Receptor type*	Online water body (reservoir)	Water treatment works	Online water body (reservoir)	Online water body (reservoir)	Online water body (reservoir)	Online water body (reservoir)
Volume of water	301–400 Ml/d	301–400 Ml/d	301–400 Ml/d	301–400 Ml/d	101–150 Ml/d	51–100 Ml/d
Frequency of operation	Year round – intermittent	Year round – intermittent	Year round – intermittent	Year round – intermittent	Year round – continuous variable flow	Year round – intermittent
Transfer distance (km)	<1	1.1–5	1.1–5	1.1–5	1.1–5	<1

Raw water transfer risk assessment options	Raw water transfer Farmoor Intake	Farmoor Outlet	Queen Mother Intake	Queen Mother Outlet	High Maynard Intake (Chingford Aqueduct)	High Maynard Outlet (Transfer to Walthamstow 4)
Number of washout/ maintenance points	1	1	1	1	None	None
Source navigable	Yes	No	Yes	No	No	No
Pathway navigable	No	No	No	No	No	No
Angling at source	Unknown	Members and day ticket holders, national events	Unknown	No	No	Members and day ticket holders, local matches
Angling on pathway	No	No	No	No	No	No
Water sports at source	Casual use by individuals/clubs	International events	Casual use by individuals/clubs	International events	No	No
Water sports on pathway	No	No	No	No	No	No
Presence of	Known to be	Known to be	Known to be	Known to be	Known to be present	Known to be present

Raw water transfer risk assessment options	Raw water transfer Farmoor Intake	Farmoor Outlet	Queen Mother Intake	Queen Mother Outlet	High Maynard Intake (Chingford Aqueduct)	High Maynard Outlet (Transfer to Walthamstow 4)
high priority INNS – source	present	present	present	present		
Presence of high priority INNS – pathway	Not recorded	Not recorded	Not recorded	Not recorded	Not recorded	Not recorded
Highest order site designation receptor	Local	None	Local	None	International	International
Presence of priority habitat – pathway	Not known to be present	Not known to be present	Not known to be present	Not known to be present	Not known to be present	Not known to be present
Presence of priority habitat – receptor	Not known to be present	Not known to be present	Not known to be present	Not known to be present	Known to be present	Known to be present
Other existing connections	1	None	None	None	None	2

Raw water transfer risk assessment options	Raw water transfer Farmoor Intake	Farmoor Outlet	Queen Mother Intake	Queen Mother Outlet	High Maynard Intake (Chingford Aqueduct)	High Maynard Outlet (Transfer to Walthamstow 4)
Overall risk score (total score)	678.375	583.5375	804.9375	659.9475	693.5625	560.25
Final RWT risk score (% out of 100)	50.25%	43.23%	59.63%	48.88%	51.38%	41.50%

**SAI–RAT guidance is ambiguous on the definition of 'offline' vs. 'online' water body. On a precautionary basis, the assessment of these comparison sites has defined the source and receptor (where applicable depending on the direction of transfer) as being online (on the basis this is a higher risk receptor type) – as the comparison sites are more aligned with the definition of 'online' water body (example provided being an impounding reservoir) than 'offline' water body (examples provided being gravel pits and quarries). This also maintains consistency for the purpose of comparative assessment of risk against SESRO.*

6.4.6 Risk assessment overall scores

6.112 The range of risk scores produced by SAI–RAT for each asset and raw water transfer option assessed are summarised in Table 6.22 to support a high-level comparison between the options.

6.113 The SAI–RAT also produces an overall summary score for each option (which combines both the asset and raw water transfer modules of the tool), presented in -Table 6.23. These overall summary scores are calculated by taking an average of all elements of the site, for the *baseline scenario only* (i.e., the most likely scenario) for the asset, raw water transfer and emergency drawdown. This provides an overall comparison between options and comparator sites including Farmoor Reservoir No.2, Queen Mother Reservoir and High Maynard Reservoir. As emergency drawdown arrangements were not included for the comparator sites, two overall risk scores are presented for all SESRO options: summary scores which exclude the emergency drawdown (and can therefore be directly compared to other sites); and summary scores which include the emergency drawdown (and can therefore only be directly compared against other SESRO options).

6.114 Some variation in risk scores is identified by the SAI–RAT, which ranks the SESRO options as slightly higher risk (but with minor differences between size options), followed by Farmoor Reservoir No.2, Queen Mother Reservoir and then High Maynard Reservoir. As discussed in Section 6.4.5, primary drivers behind these higher SESRO risk scores, relative to comparison sites, are inherent to SESRO (such as release to river and the higher volumetric transfer of water associated with SESRO as compared with the other sites).

Table 6.22 Summary risk scores for the SESRO asset and raw water transfer risk assessments, including all SESRO scenarios and different size options

SRO Element	Minimum Risk Score	Maximum Risk Score	Average Risk Score
Asset	21.27%	88.46%	52.70%
Raw Water Transfer (75 Mm^3 option)	47.88%	63.13%	53.76%
Raw Water Transfer (100 Mm^3 option)	48.88%	63.13%	54.51%
Raw Water Transfer (125, 130 and 122 Mm^3 options)	49.88%	63.13%	55.26%
Raw Water Transfer (150 Mm^3 option)	50.88%	63.13%	56.01%
Emergency drawdown	57.13%	61.25%	59.50%

Table 6.23 Overall summary scores for each SESRO option (baseline scores only), including comparison sites

Site	Average Risk Score*	Average Risk Score (inc. EDD)**
SESRO 75 Mm³ option	56.55%	57.45%
SESRO 100 Mm³ option	56.87%	57.70%
SESRO 125, 130 and 122 Mm³ options	57.22%	57.95%
SESRO 150 Mm³ option	57.55%	58.20%
Farmoor Reservoir (comparison)	52.01%	N/A
Queen Mother Reservoir (comparison)	51.57%	N/A
High Maynard Reservoir (comparison)	44.81%	N/A

**This is the average score of all asset and raw water transfer risk assessment baseline scenarios excluding the emergency discharge on the basis this is not included with risk assessments for the comparator sites.*

***This is the average score of all asset and raw water transfer risk assessment baseline scenarios including the emergency discharge*

6.4.7 Conclusions

6.115 A detailed analysis has been undertaken to assess the risk of INNS being introduced and spread to and from SESRO, via transfer pathways that may become active once the reservoir is operational. This assessment has been based on an Environment Agency standardised risk assessment tool for use by all SROs at Gate 2 (the SAI–RAT). This allowed for a consistent approach to assessing different SESRO size options and relevant scenarios, developed to account for uncertainties around the final use of the reservoir and raw water transfers. Scenarios have taken into consideration different variations of INNS pathway-frequency to understand how this will alter risk. This included most likely (baseline) scenarios and a range of other scenarios; from no recreational activities at the site to 'worst-case scenarios' in which all INNS pathways are identified as present at maximum frequency.

6.116 In relation to the risk assessment of the asset (the proposed SESRO reservoir), under 'baseline' conditions, the site was assessed to have a final asset risk score of 57.90%. The full removal of recreation (terrestrial and aquatic), as well as the removal of aquatic recreation only, would result in the reservoir having a final asset risk score of 21.27% or 33.65%, respectively. Conversely, should all recreational activities (e.g., angling, watersports, boating and walking) occur, or all pathways be set to maximum frequency of occurrence; the final asset risk score would become 78.28% or 88.46%, respectively.

6.117 The results highlight the risk of unmitigated recreational activities for INNS transfer, especially activities within water body. The size of the reservoir has no specific bearing on the viability of the identified activities and so was not considered within the asset assessment; option size is essentially irrelevant as a differentiator of asset risk. A key challenge of INNS risk management for the SRO programme, including SESRO, is balancing the risk of INNS transfer and spread with providing high quality multi-purpose and accessible public assets. It is highly unlikely that recreational access to SESRO, in all its forms, would be excluded purely on the basis of INNS risk management requirements. Therefore, some INNS risks will inevitably remain within the final plans for SESRO, balanced against wider aspirations for the use of the asset, and mitigated where possible based on available biosecurity measures.

6.118 Similarly, all raw water transfer scenarios from river to reservoir (and vice versa) were assessed to have a narrower range of potential risk. Whilst there is little variation between risk scores for the raw water transfers, the different scenarios applied accounted for differences of INNS pathway-frequency (including recreation requirements at the source and on the pathway itself). Whilst a degree of variation in the risk score was apparent between the scenarios as a result; the lack of significant change in risk highlights that the inherent risk of unmitigated movements of large water volumes is the key factor in driving the risk score for raw water transfers. This is further supported by the similarities in risk scores between the options, with both the smallest transfer option (165 Ml/d, i.e., 151–200 Ml/d category in SAI–RAT) and largest transfer option (321 Ml/d, i.e., 301–400 Ml/d category in SAI–RAT) producing similar risk scores. The scenarios (occurrence and frequency of activities etc.) and the option size therefore account for little variation in the overall risk scores. The activity of transferring water from river to reservoir (and vice versa) is intrinsic to SESRO and thus further design mitigation is likely to be the key to reducing INNS transfer risk.

6.119 The provision of an emergency drawdown from the reservoir has been assessed as a separate element of SESRO due to the difference in operation to the main intake/outlet transfer. The emergency drawdown was assessed to be higher risk than the main raw water transfers to and from the reservoir, with a medium-use final risk score of 60.13%. For comparison, the final risk scores for the main outlet transfer (baseline) for the largest size option was 53.13%. As with the main raw water transfer risk assessment, the activity of transferring water from a reservoir to a river is inherently risky and therefore, design mitigation is again likely to be the key to reducing INNS transfer risk.

6.120 A generalised biosecurity module included within the SAI–RAT, identifies potential biosecurity measure types from a defined list of 30 options that may be considered by the user. This is an automated process taking account of the INNS transfer pathways identified to be present. Should a specific INNS pathway (e.g., angling, watersports etc.) be 'activated' within the assessment, this high-level options identification is completed by the tool, highlighting which options may be broadly applicable for the targeting that specific pathway. These measures, alongside measures supplementary to those identified by SAI–RAT, have been further evaluated for both the management of the asset and raw water transfers. The selection of suitable biosecurity measures for further consideration as part of subsequent design stages is based on an initial assessment of the efficacy and feasibility of implementing the measures. Full mitigation recommendations are provided in Appendix A6.3 INNS Mitigation Measures Appraisal and the outcomes are summarised in Table 6.24 and Table 6.25.

Table 6.24 Transfer pathway measures recommended for inclusion in future design/site use optioneering

Mitigation Method	Pathway targeted	Cumulative Score
Recreational		
Event management	Recreation	5
Site-supplied equipment (watersports)	Watersports	5
Site-supplied equipment (angling)	Angling	5
Fish stocking policy	Angling	5
Live bait policy	Angling	5
Manual cleaning (dry)		
Boot-brushing stations	Walkers and site staff	5
Manual cleaning (static water)		
Dip stations	Watersports and angling	5
Manual cleaning (running water)		
Wash-down wet room	Watersports and angling	5
Manual cleaning (pressurised water)		
Pressure washing hoses	Watersports and angling	5
Boat wash station	Watersports	5
Drying		

Mitigation Method	Pathway targeted	Cumulative Score
Drying room	Watersports and angling	5
Waste disposal*		
Disposal of solid waste*	General INNS waste	5
Preventative measures – passive filtration		
Passive filtration (fish screens) (or)	Raw water transfer	5
Passive filtration (conveyor screens)	Raw water transfer	5
Site development and maintenance		
Site-supplied operational equipment	Entire site	5

**Mitigation measures identified in addition to those suggested through the SAI–RAT*

Table 6.25 Transfer pathway measures that may be considered for inclusion in future design/site use optioneering

Mitigation Method	Pathway targeted	Cumulative Score
Recreational		
Access points*	Recreation	4
Physical nets (inc. booms and skimmers)*	Water sports	4
Manual cleaning (static water)		
Tyre troughs	Vehicle access	4
Waste disposal*		
Main sewers connection*	General INNS waste	4
Septic tank*	General INNS waste	4

**Mitigation measures identified in addition to those suggested through the SAI–RAT*

6.121 Thames Water is currently undertaking a set of AMP7 WINEP investigations for INNS for assets with public access (including, but not limited to, Farmoor Reservoir, Queen Mother Reservoir and High Maynard Reservoir) as well as raw water transfers, which includes specifying and (where feasible) installing biosecurity measures at assets with public access. The SESRO SRO has taken account of the findings of this study as the WINEP has progressed and will continue to benefit from lessons learned through this ongoing programme, for example, through trials being undertaken for INNS mitigation measures.

6.122 A comparison of results between the SESRO scenarios and the comparison sites demonstrate that the SESRO asset risk scores are broadly comparable with those of Farmoor, Queen Mother and High Maynard reservoirs, with Farmoor scoring 4.66% higher in relative risk score, than the SESRO baseline scenario. With the raw water transfer risk assessment comparisons, most comparison transfers (to and from the reservoirs noted above) score lower in INNS transfer risk. This is due to the large volumetric transfer requirements for the SESRO intake and outlet, the discharge of SESRO to river, and the presence of INNS under the footprint of the pathway and the presence of priority habitats under the footprint of the asset. Overall, after assessing the average risk score of the baseline scenarios for each SESRO size option (including the asset, raw water transfer and emergency drawdown assessments), all achieve a slightly greater INNS risk score than the respective comparison sites.

6.5 Considerations for subsequent project stages

6.123 The findings of the Gate 2 INNS risk assessments will continue to inform future SESRO design iterations, including design mitigation for the raw water transfers and plans for the recreational use of the asset including appropriate biosecurity measures.

6.124 During subsequent project stages, option refinement would result in fewer scenarios, and more focus on developing and embedding design mitigation and broader mitigation measures most likely to be feasible and effective for the control of INNS.

6.125 By this point, Thames Water's AMP7 WINEP Company-Wide INNS Plan is likely to have been fully developed, which may provide further evidence on measures that are most likely to be viable for implementation. Further evidence may be available through the trials of INNS mitigation measures, being undertaken by Thames Water during their AMP7 WINEP investigations.

7. Summary of main findings and considerations for subsequent project stages

7.1 Summary of main findings

7.1 Table 7.1 shows a summary of findings from the Environmental Appraisal (aquatic) of SESRO.

Table 7.1 Environmental Appraisal Report (aquatic) – Summary

Assessment/ Topic	Environmental Appraisal Report (aquatic) – Summary
Hydrology	The results of the modelling undertaken for Gate 2 indicate that flows in the River Thames currently considered as being notably or exceptionally low would not occur as frequently if SESRO was developed. The impact of abstraction at the higher flows to refill SESRO is having a lesser impact over a longer dataset. Increases in velocity as a result of SESRO releases being triggered at their highest (maximum) discharge rate will be managed through the development of a release regime with incremental increases and/or decreases in flow. This assessment has focussed on the impact of augmenting drought years however further assessment of releases that occur on flows that may currently be considered as within the normal range is recommended as they may require mitigation. This could be achieved by reviewing the triggers that initiate and cease SESRO augmentation. It is expected that increases (during augmentation) or decreases (during abstraction) in water levels and velocities along the River Thames will be mitigated through the operation of level management structures. It is recommended that this potential option for mitigation is revisited as the modelled representations of the structures are reviewed in subsequent stages. For the River Ock, modelling has shown a flow reduction in the lowermost Childrey Brook (8%) due to these flows being diverted further downstream. Overall, there is a slight (2%) flow reduction at the bottom-most part of the catchment as a result of rainfall falling into the reservoir rather than the river itself.

Assessment/ Topic	Environmental Appraisal Report (aquatic) – Summary
Fluvial Geomorphology	At this Gate 2 stage, it can be concluded that because the newly designed river diversions and interconnecting wetland ditches will be (a) of significantly better quality than the baseline watercourses that will be diverted/replaced as part of the proposed scheme and (b) greater in quantity (i.e. watercourse length) than the baseline watercourses that will be diverted/replaced as part of the proposed scheme, the quality of the fluvial geomorphology within the study area will experience an improvement relative to the status quo. A net total of 57.57 km of watercourse would be diverted/replaced as part of the proposed scheme. The BNG assessment provides further details of how the condition of the habitat of these watercourses has been classified. However, a brief summary is as follows: 43.67 km of this length is made up of ditch habitat, with over 83% of total ditches within the study area being diverted/replaced. Based on the data available, but in absence of detailed field studies, many of these ditches are assumed to be of poor condition. 13.90 km of riverine habitat would also be diverted/replaced as part of the development, which is over 85% of the total river length within the study area. Most of these rivers have been artificially modified to at least some extent and have been classified as being in moderate condition. As above, in some locations, watercourses displayed more variability and a natural planform with diverse habitat and therefore achieve a good condition. To achieve the required 10% Biodiversity Net Gain, the scheme is required to enhance 17.41 km of watercourse (16.44 km of river and 0.97 km of ditch) and create 31.05 km of new watercourse (25.65 km ditch and 5.40 km of canals and culverts). To the west of the site, in particular, habitat gains are expected to be large as a result of a large area of interconnecting aquatic habitats including wet woodland, wetlands and running watercourses. This is, in turn, expected to provide significant opportunity for Biodiversity Net Gains for both aquatic and terrestrial flora and fauna.

Assessment/ Topic	Environmental Appraisal Report (aquatic) – Summary
Water Quality	In general, the analysis indicates that the impacts of SESRO on water quality in the River Thames are largely positive: improving or making no change in river concentrations compared to the WFD thresholds. This is primarily the result of SESRO 'improving' concentrations during the long period of storage (the average retention based on modelled (Pywr) outputs is greater than 7 years) compared to the influent water from the River Thames, because of normal reservoir attenuation, biological uptake, and sedimentation processes. In addition, the released water provides greater dilution of downstream inputs from tributaries and discharges. One exception to this is an increase in ammoniacal nitrogen immediately downstream of the reservoir. However, this needs to be caveated by the high degree of uncertainty in predicting reservoir ammonia concentrations since this chemical is highly dynamic in nature and can show a high degree of temporal variability. Ammoniacal nitrogen levels are also very low in the River Thames at the moment, indicative of WFD 'High Status' and no change to status is predicted. A marginal increase in BOD is also simulated further downstream for some scenarios at some times of the year, which is likely to be the result of increased velocities and reduced loss (decay) within the river. It is noted that BOD does not contribute to WFD status and that this does not appear to affect dissolved oxygen levels. It is also noted that this is against very low BOD concentrations in the River Thames at this point in time. In the River Ock, again generally water quality effects are expected to be positive notably in the diverted Cow Common Brook, which will become the Western Watercourse Diversion. The only exception is an increase for ammonia and orthophosphate in the lowermost Childrey Brook, related to loss of flow from the catchment as a result of moving the diverted Cow Common Brook westwards (to become the Western Watercourse Diversion) and routing of rainfall and Western Watercourse Diversion flows to the River Ock downstream of Marcham Mill (i.e., downstream of Childrey Brook confluence). This results in a reduced dilution of upstream point source inputs. It is anticipated that this can be mitigated by changes to Sewage Works discharges in the Childrey Brook catchment.

Aquatic Ecology	Based on currently available information, the majority of identified effects are considered likely to be either negligible or result in minor adverse or minor beneficial effects that are unlikely to affect the overall ecological integrity of affected Reaches. Some effects have the potential to result in benefits that are considered likely to improve the overall ecological integrity of affected Reaches; notably the planned diversion, realignment and creation of watercourse habitats within the Ock Catchment associated with Cow Common Brook, Childrey Brook and the River Ock. This is in the context of a current baseline which is affected by poor aquatic habitats and (at times) poor water quality with very few records of aquatic species with conservation interest. Ecological data in the Ock catchment is, however, limited to historic, SESRO, and Environment Agency surveys which are spatially discrete. Whilst some additional eDNA surveys were undertaken in Gate 2, the assessment should be updated in future gates as more information becomes available. Identified adverse effects with risks to the overall ecological integrity of affected Reaches include potential flow reduction on the lowermost part of the Childrey Brook and primary productivity/food-chain effects within the River Thames (Reach 5 and Reach 6). Flow changes within the River Thames as a result of SESRO have the potential to be both beneficial and adverse (at different times and for different species) for the existing baseline ecology and may affect the overall ecological integrity of the affected Reaches. The modelling assessment presented has focused on lower flow years, which makes the assessment conservative, and more typical ‘average’ years should be considered in future gates. The change in hydrology where historical flow periods will no longer occur is broadly seen as a positive. The velocity work also suggests that there remain areas of refuge in the margins as flows increase. Eutrophication risk assessment and phytoplankton bloom assessment work undertaken by the Centre for Ecology and Hydrology have not identified any areas of concern and some of the water quality changes, notably temperature, are again considered beneficial. Key areas of future assessment/uncertainty relate to direct and indirect velocity effects on phytoplankton, zooplankton and fish fry. The timing of releases in relation to ‘peak occurrence’ (i.e., blooms for plankton, presence of ichthyoplankton) require more detailed analysis of historic data as well as collection of more data. The assessments presented considered the likely embedded (i.e., design) mitigation and ‘standard’ mitigation (such as fish rescue associated with channel diversions), prior to any further mitigation and/or compensation. In addition to those measures already considered within the assessment, a number of further mitigation measures are potentially

Assessment/ Topic	Environmental Appraisal Report (aquatic) – Summary
	available and may be required to manage residual risks to ecology during construction and operational phases.
INNS	The Invasive and Non-Native Species (INNS) risk assessment results highlight the risk of unmitigated recreational activities for INNS transfer, especially activities within water body. The size of the reservoir has no specific bearing on the viability of the identified activities and so was not considered within the asset assessment; meaning option size is essentially irrelevant as a differentiator of asset risk. A key challenge of INNS risk management for the SRO programme, including SESRO, is balancing the risk of INNS transfer and spread with providing high quality multi-purpose and accessible public assets. It is highly unlikely that recreational access to SESRO, in all its forms, would be excluded purely on the basis of INNS risk management requirements. Therefore, some INNS risks will inevitably remain within the final plans for SESRO, balanced against wider aspirations for the use of the asset, and mitigated where possible based on available biosecurity measures. Similarly, all raw water transfer size scenarios from river to reservoir (and vice versa) were assessed to have a narrower range of potential risk. Whilst there is little variation between risk scores for the raw water transfers, the different scenarios applied accounted for differences of INNS pathway-frequency (including recreation requirements at the source and on the pathway itself). Whilst a degree of variation in the risk score was apparent between the scenarios as a result; the lack of significant change in risk highlights that the inherent risk of unmitigated movements of large water volumes is the key factor in driving the risk score for raw water transfers. This is further supported by the similarities in risk scores between the options, with both the smallest and largest transfer options producing similar risk scores. The scenarios (occurrence and frequency of activities etc.) and the option size therefore account for little variation in the overall risk scores. A generalised biosecurity module included within the SAI–RAT, identifies potential biosecurity measure types from a defined list of 30 options that may be considered by the user. In addition, on request from the Environment Agency, selected measures from Thames Water’s Water Industry National Environment Programme (WINEP) were also presented, together resulting in a list of INNS mitigation measures to be considered as part of Gate 2 and subsequent design stages. The efficacy and feasibility of implementing the measures should remain under review as the scheme, including the proposed recreational activities, develops over time.

7.2 Considerations for subsequent project stages

7.2.1 Hydrology

7.2 Collection of additional hydrometric data in with a focus on smaller watercourses within and upstream of the indicative location for SESRO within the River Ock catchment.

7.3 Collection of groundwater/surface water interaction monitoring via in-situ piezometers within the River Ock catchment.

7.4 Refinement of the integrated hydrology and water quality modelling approach recognising that both the RSS Pywr model and the Infoworks ICM model were developed for different primary purposes at Gate 2, i.e., DO Assessment and flow/level/water quality simulations respectively.

7.5 Refinement of the representation of the intake structures including minimum operating flows and future license limits, in addition to the representation of the T2AT transfer into Wraysbury reservoir as the scheme details are developed going forward.

7.6 Assessment of a wider range of years during subsequent project stages during which SESRO may be releasing to capture impacts of augmentation at less extreme flows.

7.7 It is recommended that future assessments also incorporate climate change which was not feasible for this assessment within the timescales of Gate 2.

7.8 Refinement and/or validation of Ock catchment modelling through extension of the 1D model to encompass this area, including an improved understanding of the likely contributions from superficial groundwater to the future channel flow.

7.9 Refinement of Thames hydraulic modelling to include additional ‘less dry’ hydrological years, climate change scenarios, and additional cross-sectional survey information for panelled velocity assessment. Also, inclusion of more detailed level-control structure representation to assist with level/velocity optimisation studies. Importantly, this will rely on an improved understanding of the options available to manage water levels via existing structures (for example, should refined modelling suggest it is advisable to reduce flow velocities for ecological maintenance) without compromising the navigation maintenance policies of the Thames.

7.2.2 Fluvial geomorphology

7.10 Site walkovers of all of the watercourses within the indicative location for SESRO.

7.11 MoRPh surveys for 20% of the watercourses.

7.12 Furthered hydraulic understanding of the watercourses within the indicative location for SESRO, such that stream power characterisation can be ascertained more accurately.

7.13 Continued development of the design principles for the newly designed (mitigation) river diversions and interconnecting wetland ditches.

7.2.3 Water quality

7.14 Several refinements would be beneficial in the Infoworks and Pywr hydrological, and water quality models in relation to the hydrology, hydraulics and operation of the River Thames control structures during abstraction and discharge (Appendix A2.1 SESRO River Thames calibration report). These may have a 'knock on' change on water quality so, if taken forward, water quality outputs will need to be compared once the modifications have taken place. Note the River Thames ICM modelling calibration report (Appendix A2.1 SESRO River Thames calibration report) includes a section on future refinements to the model.

7.15 The ammonia and BOD aspects of the reservoir modelling have a level of uncertainty because these determinands were not modelled in PROTECH; so, it was not possible to condition the Intermediate Reservoir Water Quality model against PROTECH. In subsequent project stages, they should either be included in PROTECH or another approach to ground truthing should be considered such as comparison with observed data from other reservoirs.

7.16 Orthophosphate cannot be modelled in Infoworks ICM and total phosphorus was not modelled in PROTECH. To improve model interaction these inconsistencies should be addressed to improve the model linkages.

7.17 Dissolved oxygen was not modelled in any of the reservoir models so the assumption was that the water released from SESRO will be at 100% saturation. Ideally, this assumption needs to be tested through explicit reservoir modelling of dissolved oxygen and/or the engineering options to ensure 100% saturation assessed in more detail.

7.18 Noting that the intention is to develop a 1D hydrodynamic model for the River Ock. Any repeat SAGIS-SIMCAT modelling of the River Ock, the flow and chemical inputs and sources would ideally be 'ground truthed' by site investigations and additional monitoring of water quality sampling and flow (the existing data are over 5 years old). The development of a hydrodynamic model for the River Ock (to allow flow and water quality modelling) should also be continued.

7.2.4 Aquatic ecology

7.19 Improving confidence in the existing baseline, including:

- ongoing SRO monitoring at existing River Thames monitoring locations for fish, invertebrates, macrophytes and INNS to update and maintain baseline understanding;
- full suites (including replicates) of ecological surveys within areas that were access constrained at Gate 2 (i.e., watercourses including ditches associated with and affected by the indicative footprint). This is likely to include walkover Modular River Survey (MoRPh)[258] method surveys, as well as fish, macroinvertebrate and macrophyte surveys and eDNA sampling of rivers and streams such as Cow Common Brook, Childrey Brook and the River Ock. In addition, ditch condition surveys[259] and ditch biodiversity surveys[260] will be required for the ditch networks affected by the footprint, likely undertaken within a stratified sampling approach. Collectively these surveys will support the update of BNG and aquatic ecology baselines.
- Phytoplankton, zooplankton and fish fry surveys in the main River Thames within the reach between Culham and the River Thame to understand within-year and between-year variability in blooms and peak occurrence.

7.20 Improving confidence in the current supporting modelling and assessments of direction and magnitude of change predicted for the various scheme elements and reaches including:

- Repeat and refined UKCEH algae experiments and modelling, including translation of predictions/update of the existing modelling assessment point (Runnymede) to areas closer to the intake/discharge point.
- Sensitivity analysis of potential interaction between the Thames abstraction periods and out of bank flows.

7.21 Improving definitions of adverse and beneficial effects in relation to Thames ecology, in liaison with the Environment Agency. Whilst the assessment in subsequent project stages will seek to improve certainty on the trajectory of change that may be anticipated relative to baseline, a key challenge will be whether a potential change (for example, in the relative abundance of different fish species) is considered to be

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[258] Walkover Modular River Survey (MoRPh) methodology. The Biodiversity Metric 3.0 auditing and accounting for biodiversity: User Guide.
[259] The Biodiversity Metric 3.0 auditing and accounting for biodiversity Technical Supplement.
[260] Palmer, Drake and Stewart (2013) A manual for the survey and evaluation of the aquatic plant and invertebrate assemblages of grazing marsh ditch systems.

adverse or beneficial, particularly in the context of the extensive existing anthropogenic modifications of the river and its flow regime which has shaped baseline ecological communities. A degree of ‘stress-testing’ WFD fisheries classifications based on potential changes in relative abundance could be undertaken, for example. However, this may be complicated by the fact that the Thames water bodies have relatively few WFD fish data classifications. The survey methodology typically used to characterise the River Thames is bespoke and non-compliant with WFD standard methods. Further liaison with the Environment Agency will help refine definitions of adverse and beneficial effects in the context of the existing baseline, to inform subsequent Gates.

7.22 Developing mitigation for any anticipated residual adverse effects, through iteration of the above confidence changes (in both baseline and assessment).

7.2.5 INNS

7.23 The findings of the Gate 2 INNS risk assessments will continue to inform future SESRO design iterations, including design mitigation for the raw water transfers and plans for the recreational use of the asset including appropriate biosecurity measures.

7.24 During subsequent project stages, option refinement would result in fewer scenarios, and more focus on developing and embedding design mitigation and broader mitigation measures most likely to be feasible and effective for the control of INNS. By this point, Thames Water’s AMP7 WINEP Company-Wide INNS Plan is likely to have been fully developed, which may provide further evidence on measures that are most likely to be viable for implementation. Further evidence may be available through the trials of INNS mitigation measures, being undertaken by Thames Water during their AMP7 WINEP investigations.

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