South East Strategic Reservoir Option (SESRO)

Supporting Document A-1:

Concept Design 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.

Contents

Figures and Tables

1. Introduction

1.1 Background

1.1 The South East Strategic Reservoir Option (SESRO) provides an opportunity to deliver a resilient water supply to the South East for generations to come. The project would deliver a new reservoir to store water abstracted during periods of high flow in the River Thames for use during periods of low river flow or high demand for water. The reservoir could be used by the customers of multiple water companies across the South East of England. The scale of the development provides an opportunity to deliver new spaces for nature and recreation, providing a net environmental gain and socioeconomic benefits for the local area and wider region.

1.2 In the final determination of the 2019 water industry price review (PR19) Ofwat set out a formal gated process and allocated funds to develop integrated strategic regional water resource solutions (SROs) during the 2020-2025 planning period (AMP7). The South East Strategic Reservoir Option (SESRO) / Abingdon Reservoir Option has been included in successive Water Resource Management Plans (WRMPs) developed by Thames Water and was selected in the Thames Water and Affinity Water WRMP19 preferred plans; therefore, the PR19 final determination allocated funds to these two water companies to develop SESRO through the Ofwat gated process. This report sets out an indicative concept design for the scheme to support the Gate 2 submission to the Regulators' Alliance for Progressing Infrastructure Development (RAPID), which includes Ofwat, the Environment Agency (EA) and the Drinking Water Inspectorate (DWI). The gates set out by Ofwat are as follows:

- Gate 1 – Initial feasibility, design and multi-solution decision making
- Gate 2 – Detailed feasibility, design and multi-solution decision making
- Gate 3 – Finalised feasibility, pre-planning investigations and planning applications
- Gate 4 – Planning applications, procurement strategy and land purchase

1.3 SESRO forms a set of options within the Water Resources South East (WRSE) regional water resources plan. SESRO information has been provided to WRSE to inform the option screening process and investment modelling. An 'emerging regional plan' was issued for public consultation in early 2022 and a 'draft regional plan' has been issued for further consultation in November 2022.

1.4 SESRO includes several size variants that are included in the Thames Water WRMP24 Constrained List of options, having passed through the Thames Water screening process (see Thames Water WRMP24 Reservoir Feasibility Report Addendum). The screening process has been undertaken by Thames Water with support from the SRO team where necessary and is consistent with guidance in the National Framework for regional planning, issued by Defra, and the Water Resources Planning Guidelines (WRPG) issued by the Environment Agency.

1.5 The following six reservoir sizes are under consideration for SESRO and are discussed in this Gate 2 Concept Design Report (CDR):

- 150 Mm^3 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

1.2 Scheme Overview and Location

1.6 It is anticipated that SESRO would provide additional resource during drought conditions. Water would be abstracted from the River Thames during periods of high flow and stored in a reservoir, only to be released back to the River Thames when there is a need to augment the flows. SESRO would release water into the River Thames which could subsequently be re-abstracted by existing / new infrastructure further downstream to maintain supply to customers of Thames Water, Affinity Water, and potentially other water companies in the South East.

1.7 This report sets out the Gate 2 indicative conceptual design for SESRO, the key components of which can be summarised as:

- Provision of a fully bunded reservoir in Oxfordshire, 5km south-west of Abingdon (with total storage capacity between 75 Mm^3 and 150 Mm^3) within the area bounded by the A34 and Steventon to the east; the Great Western Main Line (London to Bristol) to the south; the A338 and East Hanney to the west; and the River Ock to the north.
- Pumping station at the toe of the embankment (on the north-east side of the reservoir) containing pumps for filling the reservoir and turbines for energy recovery during periods when the reservoir releases water to the River Thames.
- 3.3 km long conveyance tunnel to transfer flows via the pumping station to and from an intake / outfall structure on the right bank of the River Thames near Culham.
- Raw water would be abstracted from the river when water levels are high, using pumps to fill the reservoir. The maximum quantity abstracted in any day would not exceed 1,000 Ml.
- Flows would be discharged into the river when the reservoir is releasing water via the energy recovery turbines (working assumption maximum rate of 600 Ml/d, but typical release rate between ~165 Ml/d and ~320 Ml/d depending on the size of the reservoir selected).
- Auxiliary drawdown channel which would also form a rehabilitated, navigable section of the Wilts & Berks Canal, available to allow release of additional water from the reservoir in emergency scenarios. The Wilts & Berks Canal was taken out of operation ~100 years ago but may be reinstated in the future.

- Main access road (from A415) and diversion of the East Hanney to Steventon Road.
- Temporary rail siding to facilitate delivery of construction materials by freight train.
- Recreation facilities, public education facilities, landscaping and creation of aquatic / grassland habitats.
- Channel and floodplain construction as required to mitigate the impact of the reservoir on local watercourses and floodplains.

1.8 An overview of the SESRO site for the 150 Mm^3 variant is provided in Figure 1.1. A more detailed site layout plan is included in Appendix A.

1.3 Sizing and Phasing

1.9 The Draft WRSE regional resilience plan and the draft WRMP24 for both Affinity Water and Thames Water include the 100 Mm^3 SESRO scheme within the preferred plan, providing water into supply by 2040. There are, however, four single phase variants (150 Mm^3, 125 Mm^3, 100 Mm^3 and 75 Mm^3) and two dual phase variants (30+100 Mm^3 and 80+42 Mm^3) under consideration.

1.10 The dual phase variants are being considered to investigate whether it is appropriate to bring smaller reservoirs online to fill the anticipated shorter-term deficit, with the remainder of the site then reserved for development at a later date.

1.11 All six size variants have been input in the WRSE investment modelling as mutually exclusive options and the water resources planning process will determine which option is selected in the long term regional and water companies plans.

1.12 Many of the scheme details presented in the following sections are associated with the 150 Mm^3 variant, as this was selected in WRMP19 and would have the greatest impact, giving a worst case assessment. However, this remains indicative and is presented to support the Gate 2 submission, it is expected to develop and change if SESRO progresses to later gates and development stages. All key scheme elements would also be required for the smaller sized reservoirs (although some at a reduced scale) and the alternative details and design would be developed during subsequent project phases should the 100 Mm^3 (or any of the other variants) be included within the preferred plan in the Final WRMP24.

Figure 1.1: Schematic Representation of 150 Mm³ SESRO Variant

1.4 Links with Other Options, Schemes and Elements

1.13 The SESRO site has sufficient space to allow water from the reservoir to be treated on site and then transferred either to the south to serve Southern Water (via the Thames to Southern Transfer SRO) or else north, to support either the ‘Swindon and Oxfordshire’ (SWOX) or the 'Slough, Wycombe and Aylesbury’ (SWA) Water Resource Zones (WRZs). The additional transfer conduits and associated water treatment facilities are not included within the SESRO core scheme, although a land allocation within the scheme boundary is identified for such future use. The timing and precise need for these additional elements is still uncertain, but they are options that would continue to be explored as the SESRO scheme is developed.

1.4.1 Dependencies

1.14 SESRO is not dependent on any other SROs or other company options. However, in order for SESRO to deliver a benefit to customers the water that is released into the River Thames would need to be re-abstracted, treated and distributed which may require the provision of additional infrastructure.

1.15 There are other water resource options considered in the WRSE regional planning that would either benefit from, or be dependent on, water supply from SESRO, these include:

- Thames Water options to supply the LON (London), SWOX (Swindon and Oxfordshire) or SWA (Slough, Wycombe and Aylesbury) Water Resource Zones.
- Thames to Affinity Transfer (T2AT) SRO: The T2AT SRO is considering options to transfer water into the Affinity Water area. Some of these would depend on the development of SESRO or the Severn Thames Transfer (STT) for water resource; however they would not require any works at the SESRO site.
- Thames to Southern Transfer (T2ST) SRO: The T2ST SRO is considering options to transfer water from the River Thames into the Southern Water area. The preferred intake location at Gate 2 stage is at Culham which could be supplied by the Severn-Thames Transfer (STT) SRO, or by taking water from SESRO. Potable and non-potable water transfers are being considered; a potable transfer could include a new Water Treatment Works (WTW) at the SESRO site.
- Abstraction at South East Water’s existing surface water intake on the River Thames at Bray.

1.4.2 Mutual Exclusivities

1.16 All SESRO variants assessed in this report are mutually exclusive, including all phased variants. No other options included in the WRSE regional planning are mutually exclusive with SESRO variants. However, there is a limit on discharge to the River Thames which would limit the total capacity of new water resource options discharging into the River Thames at this location.

2. Conceptual Design

2.1 Design Principles

2.1 All of the design elements of the SESRO scheme (engineering, landscape and architecture) can be considered under a framework built around the National Infrastructure Commission's (NIC) Design Principles for National Infrastructure[1], which considers design under four headings: Climate, People, Places and Value.

2.2 The All Company Working Group (ACWG) of water companies involved in the SRO programme commissioned development of a design framework and Design Principles for the whole SRO programme that provided high level Design Principles for Gate 2.

2.3 During Gate 2 development the multidisciplinary SESRO project team (including environmental, planning and engineering specialists) held workshops framed around the design principles to develop an indicative masterplan for the scheme.

2.4 The following bullet points describe how the Gate 2 concept design responds to the ACWG design principles (the full titles and descriptions of the ACWG design principles are not given here and cn be found in the 'All Company Working Group (ACWG) Design Principles, Process and Gate 2 Guidance':

- **Nature knows no boundaries**: This principle talks of working across water company boundaries and developing sustainable solutions for the wider benefit of society. SESRO has potential to provide water to multiple water companies and links to a number of other SROs. WRSE is developing a best value long-term plan for the region that includes consideration of environmental and resilience metrics, and SESRO is selected in the emerging and draft plans. The project team engaged across organisational boundaries with companies and stakeholders during Gate 2 through the All Company Working Group, meetings with regulators and stakeholder meetings for specific work packages.
- **Resource and carbon efficient throughout:** Carbon footprint and hotspots have been assessed and opportunities to reduce carbon have been identified. Focus on this will continue as the design develops in Gate 3 and beyond. SESRO has been designed to use all excavated material on site and the use of rail freight to import construction material is incorporated into the Gate 2 concept design as described later in this report.
- **Resilient and adaptable:** Flood risk and mitigation has been a key consideration in development of the SESRO masterplan. Rainwater falling on the water surface would be captured within the reservoir, while a replacement floodplain storage area has also been integrated into the scheme. The replacement floodplain storage area would be integrated with watercourse diversions and would provide

[1] Climate, People, Places, Value, Design Principles for National Infrastructure, published by the National Infrastructure Commission Design Group

wetland habitat in a nature based solution. Water resources and flooding assessments have considered climate change.

- **Understand and respond to your Community's needs:** The SESRO scheme would store a very large volume of water (up to 150 Mm^3) for use when water is not available directly from the natural environment. This would provide a reliable supply of water to customers as part of the wider water supply system in the South-East of England. The Gate 2 masterplan workshops and assessments of the scheme considered the impact and potential benefits to local communities and public engagement has been undertaken through the regional and company water resources planning processes. In Gate 3 further SESRO specific consultation would be undertaken to ensure that a wide spectrum of local views are considered as the scheme develops.
- **Engage widely, early and meaningfully:** Public engagement has been undertaken through water resource planning process during Gate 2 (WRSE and WRMP). There has also been stakeholder engagement focussed on specific workstreams to understand constraints and preferences of local and national bodies and regulators to facilitate creation of the initial masterplan. Wider consultation would be undertaken during Gate 3 on various aspects of the SESRO site.
- **Improve access and inclusion:** The Gate 2 masterplan and concept design were developed with consideration of local communities. Stakeholder engagement was undertaken with local councils on specific aspects, particularly access and a provisional access strategy was developed. The reservoir site has potential to provide space for walking, sailing and other recreational activities with access by public transport, sustainable transport (such as cycling) and road access. The extent of public access and recreational facilities will need to be balanced with space for nature and impact on local communities, and wider consultation and engagement will be undertaken in Gate 3.
- **Take care:** Environmental net gain has been an integral part of work undertaken during Gate 2. The masterplanning specifically considered how different aspects of the scheme could achieve more than one outcome. For example, integration of the replacement floodplain storage area with watercourse diversions and wetland creation.
- **Protect and promote the recovery of nature:** The landscape design for the scheme has been updated during Gate 2 and specifically considered in the masterplanning exercise alongside biodiversity net gain and public access to nature.
- **Design all features beautifully, with honesty and creativity:** Landscape design has been considered during Gate 2 and the locations of buildings and structures has been reviewed. Architectural concepts will be developed as the project moves into Gate 3 work.
- **Maximise embedded value:** A multi-disciplinary masterplanning exercise has been undertaken to inform the Gate 2 design concept, which considered construction, operation / public access and potential future uses of the site (e.g. by other SROs).

- **Understand how you could provide additional value:** WRSE is developing a long-term multi-sector regional plan for water resources and if selected SESRO would form an integral part of this plan, securing resilient water supplies for the future. The opportunity to provide increased resilience to flooding for local communities has been explored in Gate 2 and will continue to be considered and discussed with regulators and other stakeholders in Gate 3.
- **Capture and measure embedded and additional value:** SESRO-specific Design Principles have been developed during Gate 2 and the indicators associated with these would be identified and assessed in Gate 3 to provide a baseline for further design stages. It is likely that the UN Sustainable Development Goals would form part of this process. The SESRO scheme would deliver a robust and sustainable source of water, environmental and biodiversity net gain, opportunities for recreation and other social benefits for the local area.

2.2 Operating Philosophy and Scheme Components

2.5 The main aspects of the operating philosophy for the concept design of SESRO are considered under three different scenarios: abstraction, storage, and release. An overview is provided in Section 2.2.1, with further details provided as part of the description of the scheme components in Section 2.2.2 through to Section 2.2.15. Layout plans are provided in Appendix A.

2.2.1 Overview of Operating Philosophy

2.6 For abstraction of water from the River Thames:

- Water would be abstracted at the river intake / outfall structure on the riverbank of the River Thames at Culham.
- The river intake / outfall structure would be connected via a shaft and conveyance tunnel to a pumping station at the toe of the reservoir embankment.
- Water would be pumped from the pumping station into a pipeline housed within a further conveyance tunnel underneath the reservoir embankment. The pipeline would connect to the main intake / outlet tower where water would be discharged into the reservoir.
- Key assumptions on abstraction are as follows:
  - No abstraction would take place into SESRO when the river flow as measured at Culham is less than 1,450 Ml/d on the previous day.
  - The maximum pumping capacity would not exceed 1,200 Ml/d.
  - The maximum quantity abstracted in any day would not exceed 1,000 Ml (and 150,000 Ml/yr).
  - Abstraction would increase progressively at a rate of no more than 300 Ml/d.

2.7 For storage of water in the reservoir:

- The maximum storage volume varies depending on the size variant. Reservoir storage volume would be partially below existing ground level (created by excavation of the borrow pit) and partially above existing ground level (created by construction of the reservoir embankment). In addition to the 'live' (useable) water, a zone of 'dead' (unused) water would be retained at the base of the reservoir to help maintain water quality within the entire live storage zone.
- The inner face of the reservoir embankment would be protected against wave erosion. This is currently planned to largely consist of a layer of rip rap (loose angular stones), which would be underlain by sand filter and gravel bedding layers placed on the clay embankment.
- It would be necessary to circulate water to maintain good water quality. A network of air diffusers on the bed of the reservoir would be included to release streams of bubbles to disturb any stratification forming in the reservoir.

2.8 For release of water from the reservoir to the River Thames at the river intake / outfall structure:

- In addition to the, above mentioned, main inlet / outlet tower there would be secondary outlet towers in the reservoir connected via a culvert on the bed of the reservoir to the main inlet/outlet tower (and from there to the conveyance tunnel). These provide alternative abstraction locations to manage water quality of discharges.
- The same conveyance tunnel as outlined above for abstraction would be used to convey water from the reservoir back to the River Thames.
- When the reservoir water level is high enough, the transfer of water back to the River Thames would provide an opportunity for energy recovery. Energy recovery hydropower turbines would be incorporated into the pumping station to enable this.

2.2.2 Reservoir

2.9 The concept design of the reservoir differs for the alternative SESRO size variants. In all cases, the reservoir has an embankment all the way around the perimeter which would be highest along the northern side where the ground is lowest, and lowest along the southern side. For the largest variant (with a live storage volume of 150 Mm^3), the perimeter embankment height would be between 15 and 25m above ground level, with a crest elevation of 80m above sea level. The embankment would have a crest length of around 10km, enclosing a reservoir with a surface area of around 6.5km^2 (similar to Grafham Water in Cambridgeshire, and around half the area of Rutland Water). Smaller single-phase variants (with live volumes of 75 Mm^3, 100 Mm^3 and 125 Mm^3) would have lower embankments and smaller surface areas. For example, the initial concept design developed for the 75 Mm^3 variant has an embankment around 4m lower, and a surface area of 4.1km^2.

2.10 There are two ‘dual phase’ variants under consideration, each of which consists of a Phase 1 reservoir and a Phase 2 reservoir separated by a dividing embankment. The perimeter embankment for these options would follow the same alignment as the 150 Mm^3 option, though the embankments would be 3-4m lower (to balance cut and fill on the site).

2.2.2.1 Reservoir Safety

2.11 The reservoir would be designed and constructed in compliance with the applicable reservoir safety legislation (The Reservoirs Act 1975, as amended). In accordance with this Act, the design and construction of the reservoir would be supervised by a Construction Engineer, namely a competent and highly experienced dam engineer already appointed to the ‘All Reservoirs Panel’ by the Secretary of State. It would also be overseen by an independent expert engineering panel for additional scrutiny appropriate for a large reservoir such as SESRO.

2.12 The design of SESRO would continue to follow international best practice for the design of embankment dams, to ensure the highest possible standard of dam safety is met. Some of the key design features are:

- Internal filtering and drainage – to safely manage dam seepage flows whilst preventing these eroding the dam internally.
- No buried engineered fill / structure interfaces. Instead, all water conveyance would be via a tunnel excavated through the foundation clay, or via siphon pipes over the dam crest.
- Provision of pipework to enable an emergency drawdown at an initial rate of 1m/day – this is the maximum recommended installed rate within current UK guidance for reservoirs and matches that adopted at all other major Thames Water reservoirs.
- A wide embankment crest and measures to prevent uncontrolled vehicular access to limit the risks of damage induced by persons.
- Provision of a comprehensive control system to prevent overfilling.
- Wave erosion protection – the inner face of the embankment would be protected from wave erosion capable of protecting against extreme storm winds.
- Sufficient freeboard (difference in level between maximum operating level and top of wave wall / dam crest) to take account of long-term settlement of the dam, and the risk of large waves breaking over the dam.
- Monitoring and surveillance – A comprehensive, automated system of instruments would be installed within the dam. Such readings would supplement on-site monitoring by operatives trained in reservoir safety surveillance.

2.13 The Construction (Design and Management) Regulations 2015 and other safety legislation would also apply to the entire SESRO scheme, and the design would continue to comply with all relevant requirements.

2.2.2.2 Reservoir Embankment

2.14 The reservoir embankment would be constructed primarily using Kimmeridge and Gault clay sourced from the site (see Section 2.2.2.3).

2.15 Figure 2.1 provides an indicative cross section of the reservoir embankment and shows that:

- The embankment would be formed of structural fill and landscape fill, won from excavations at the site. These would be split into zones, as is common in large modern dam design, reflecting differing watertightness and strength requirements depending on location within the embankment.
- The dam would also include sand and gravel filter and drainage zones which are typical for embankment dams and help manage seepage through the embankment (see Section 2.2.2.6)
- The inner face of the embankment would be protected with riprap (see Section 2.2.2.5).

2.2.2.3 Reservoir Borrow Pit

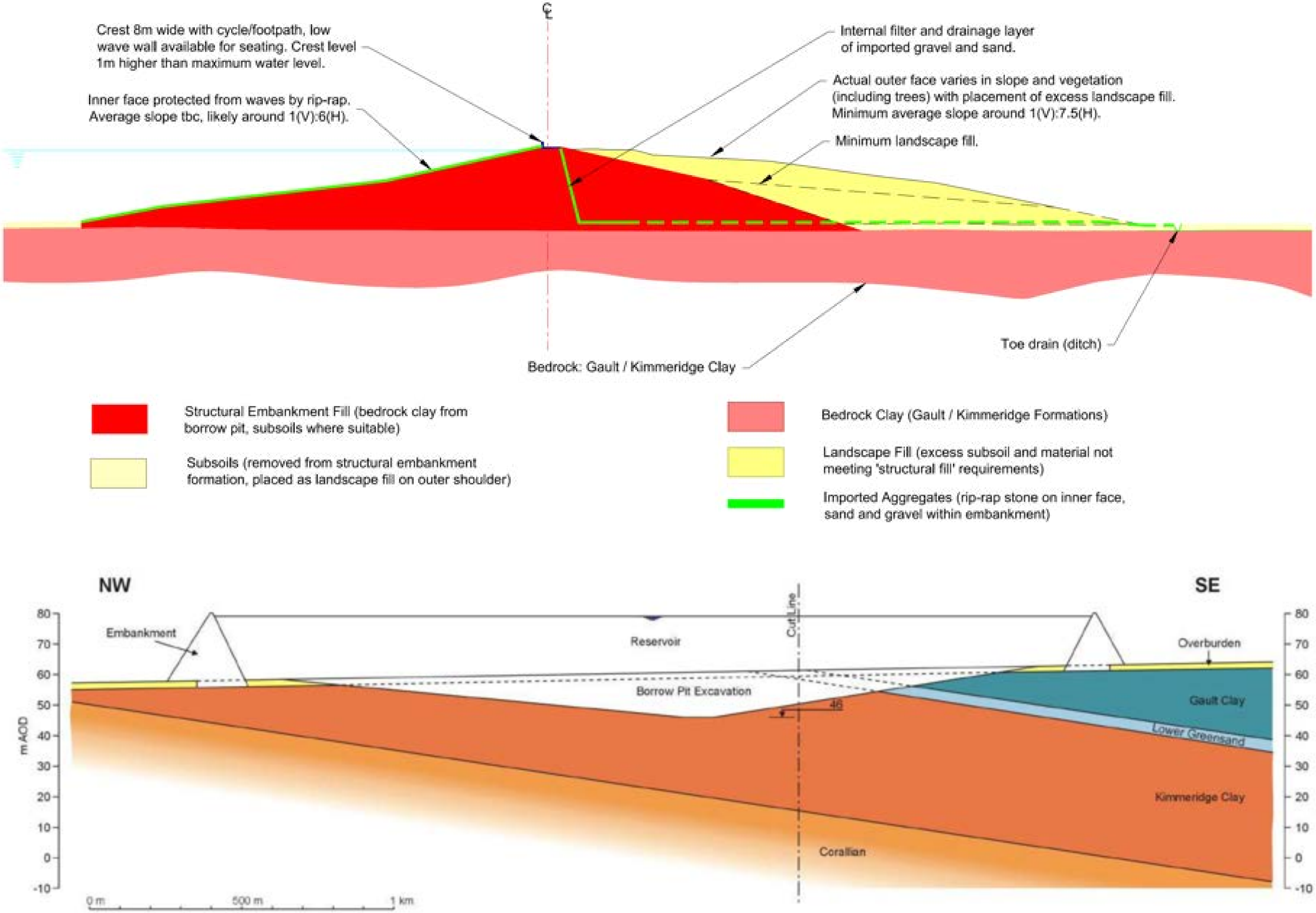
2.16 The Kimmeridge and Gault clay present as bedrock at the site would be used to form the dam embankment, excavated from a borrow pit forming the 'bowl' of the SESRO reservoir. To access this clay, other materials would also need to be excavated, namely the overlying subsoil above the bedrock clay, and a thin layer of Lower Greensand, a sandy stratum which lies between the Kimmeridge and Gault Clays. These other materials are unsuitable for inclusion within the structural / watertight zones of the embankment and would therefore be placed as landscape fill to create a coherent landscape design and avoid their haulage from site.

2.17 The reservoir borrow pit shape (as shown indicatively on Figure 2.1) has been selected to suit geological constraints whilst maintaining good water quality. Features include:

- Provision of a 100m wide trench at the base of the borrow pit, running south-west to north-east.
- Provision of a wide 'buffer' between the upstream toe of the embankment and the upper edge of the borrow pit excavation.
- The borrow pit has a 'V' shape profile when viewed from NW to SE, which aligns with the dip of the geological strata whilst also being suitable for maintaining water quality.

2.18 The borrow pit design would continue to be assessed in response to the findings of future ground investigations. The current balance between the volumes required for the embankment and the volume obtained from borrow pit excavation is outlined in Section 2.2.2.4.

Figure 2.1: Indicative Cross-Section of Reservoir Embankment (above) and Borrow Pit (below)



2.2.2.4 Borrow Pit Excavation to Embankment Fill Balance

2.19 The concept design maintains a balance of the volume of material excavated from the borrow pit and the volume of material required to form the embankment, to avoid the need to import material to site (other than materials that are not available on the site such as aggregates for rip rap, filter, and drainage zones) or to export bulk excavated material from site.

2.20 It is necessary to balance the total volume from excavation and fill, but also important to excavate sufficient clay which is suitable to use for the structural zones within the embankment. The total volume of excavation (and therefore total fill) varies from around 26Mm^3 (for the 75 Mm^3 live reservoir volume option) to around 46Mm^3 for the 150 Mm^3 option. During further design development, further study of the ground variability and modelling of the embankment design will allow the shape of both borrow pit and embankment to be optimised to reduce the earthworks as much as possible.

2.2.2.5 Erosion Protection

2.21 For the design of any embankment dam, it is essential to protect the dam from the potential erosive impact of waves which would break against the inner face of the embankment. SESRO would include a layer of riprap stone to protect the inner face, and sufficient freeboard to prevent wave spray and slop from eroding the dam crest and downstream shoulder during storms.

2.22 The riprap would consist of large, angular blocks of natural rock, which would interlock and dissipate the wave energy. The riprap would be laid on a sand filter layer and a gravel bedding layer to prevent washout of the embankment clay from between the riprap stones.

2.23 This solution is a common type of wave protection for embankment dams in the UK, with many established precedents. For the SESRO 150 Mm^3 variant, the rock sizes and the thickness of the gravel / sand layers have been selected based on established formulae relating to maximum wave heights. As the design develops more detailed modelling would be undertaken to enable the riprap rock size to be optimised. The required volume of riprap ranges from approximately 300,000m^3 for the 75 Mm^3 variant to approximately 545,000m^3 for the 150 Mm^3 variant. The required volume of sand filter and gravel bedding ranges from approximately 270,000m^3 for the 75 Mm^3 variant to approximately 490,000m^3 for the 150 Mm^3 variant.

2.24 These materials are not available at the site and would therefore need to be imported. Studies have been undertaken to investigate how import of this material could be achieved by freight trains and at Gate 2 this is considered feasible based on current timetables (see Section 2.2.15.3 and Section 3.1.2.2 for further details).

2.2.2.6 Internal Filters and Drainage

2.25 The embankment includes internal drainage layers formed with sand and gravel. As shown in Figure 2.1 there is a 'chimney drain' under the outer crest edge, a drainage 'blanket' at the base of this, and a series of internal drains connecting this to the downstream toe of the embankment. These internal drains then connect to an external toe drainage ditch, at discrete locations where the drainage flow can be measured. This drainage ditch would continue around the entire outer perimeter of the reservoir embankment.

2.26 This type of drainage network is typical for embankment dams. It is required to safely intercept and manage seepage which may pass through the dam and/or foundation, whilst also preventing the migration of clay particles. The arrangement also has the effect of draining the outer shoulder of the embankment (enhancing stability) and allows for monitoring of seepage.

2.27 The estimate of the quantities for filter and drainage material (clean sands and gravels) ranges from approximately 240,000m^3 for the 75 Mm^3 variant to 315,000m^3 for the 150 Mm^3 variant. This material is not available at the SESRO site in the quantities required and would therefore need to be imported. Studies have been undertaken to investigate how import of this material could be achieved by freight trains and at Gate 2 this is considered feasible (see Section 2.2.15.3 and Section 3.1.2.2 for further details).

2.2.3 Conveyance Tunnels

2.28 For all SESRO variants, the operational transfer of water between the reservoir and the River Thames would be via a conveyance tunnel, as shown in the layout plan in Appendix A. The selected maximum conveyance capacity (between river and reservoir) is the same irrespective of reservoir size or phasing, and therefore the design and alignment of the conveyance tunnel is the same for all SESRO variants.

2.29 The eastern-most end of the conveyance tunnel would be at the bank of the River Thames near Culham where a shaft would be constructed to form the connection between tunnel and the river intake / outfall structure (see Section 2.2.4). The first (main) section of the conveyance tunnel would link the river intake / outfall shaft to the pumping station at the outer reservoir embankment toe (see Section 2.2.5). Water would be pumped from here into the reservoir via a pipeline housed within a second section of the conveyance tunnel which would pass below the dam embankment and into the main reservoir inlet / outlet tower (see Section 2.2.6.1). Water would flow back to the River Thames under gravity using the driving head of the reservoir and the same conveyance pipework and tunnel.

2.30 The concept design therefore requires two main conveyance tunnel sections:

- Section 1 – connecting the river intake / outfall structure with the pumping station. Indicatively, this would be 3.5 – 4 km long, 4 – 4.5 m diameter, lined with reinforced concrete and constructed using a Tunnel Boring Machine (TBM). This section of the conveyance tunnel would be filled with water at all times.

- Section 2 – connecting the pumping station with the main inlet / outlet tower. Indicatively, this would be 0.5 km long, 4.5 – 5 m diameter and also with a concrete lining. The tunnel would be dry, would pass underneath the perimeter embankment of the reservoir and would contain the pipeline conveying flows between reservoir and pumping station.

2.31 For either of the two dual-phase SESRO variants there would be an additional (indicatively 0.5 km long, 4.5 – 5 m diameter) tunnel required below the embankment that divides the first and second phase reservoirs. This connecting tunnel would need to be constructed within Phase 1 to allow the Phase 1 reservoir to remain operational during construction and commissioning of the Phase 2 reservoir.

2.32 All tunnels would be constructed entirely in Kimmeridge Clay, which is not expected to raise significant difficulties in relation to tunnel construction. However, as with all tunnels, some limited ground settlement along the line of the tunnel can be expected and must be mitigated. The tunnel alignment at this stage has been selected to avoid the need to pass under existing housing developments.

2.33 The conveyance tunnel would also be used as part of the auxiliary drawdown measures for the reservoir (see Section 2.2.10).

2.2.4 River Intake / Outfall Structure and Shaft

2.34 For all SESRO variants, the same river intake / outfall structure design applies, because the abstraction, discharge, and conveyance capacity (between reservoir and river) are the same irrespective of reservoir size or phasing.

2.35 The combined river intake / outfall structure would be located on the right bank of the River Thames near Culham. The intake arrangement would allow water to be abstracted from the river through an array of screens sited on a slab submerged on the bed of the river. The length of the intake structure would be approximately 30-35 m along the riverbank. A buried connecting culvert would link the intake screens / manifold to a vertical, circular shaft (indicatively 15-20 m deep with an internal diameter of 12-15 m) to form the connection with the conveyance tunnel (the portal of which would pass through the wall of the shaft at its base). Gates would be included within the connecting culvert to enable isolation of the shaft from the River Thames and to facilitate maintenance activities.

2.36 Discharge of water from the reservoir to the River Thames would be via the same conveyance tunnel and shaft as would be used for abstraction. From the shaft the water would be passed back to the River Thames, via a separate connecting culvert and an open, stepped cascade structure. This would aerate the flow whilst avoiding scour over the full operational range of the river. Gates would be included within the connecting culvert to isolate the shaft from the River Thames and to facilitate maintenance activities.

2.37 The intake/outfall structure would be secure, preventing unauthorised access into the tunnel and minimising risk to river users posed by the abstraction and discharge flows.

2.2.5 Pumping Station

2.38 The concept design of the pumping station has been based on the abstraction and release rates outlined in Section 2.2.1. All size variants have the same maximum abstraction and release values and therefore the concept design of the pumping station is the same for all size variants.

2.2.5.1 Civil Works

2.39 The pumping station would be situated at the outer toe of the reservoir embankment along the alignment of the conveyance tunnel. The footprint of the pumping station would be approximately 70–80 m by 30–50 m and the structure would be located within a 15–20 m deep excavation to allow for connection with the conveyance tunnel (described in Section 2.2.3). This would also enable all large plant to be situated underground and therefore limit the size of the building above ground and the noise caused by pump operation.

2.40 The pumping station would house intake pumps that would be used to transfer water into the reservoir from the River Thames (see Section 2.2.5.2) as well as energy recovery turbines and pressure dissipation valves which would be utilised when water is released from the reservoir (see Section 2.2.5.3).

2.41 The part of the pumping station above ground level would provide space for ancillary equipment, electrical transformers/switchgear and operation/maintenance facilities. The current conceptual design estimates the height of the pumping station building to be between 15 m and 20 m above existing ground level.

2.2.5.2 Intake Pumps

2.42 The maximum allowable abstraction of 1,000 Ml/d is equivalent to 11.6 m^3/s. The intake pumps in the concept design have been selected to have a combined maximum pumping rate of 14 m^3/s to allow for standby capacity as well as to give some flexibility to pump to the full daily allowance while avoiding peak electricity tariff periods. To provide the capacity required, five pumps have been incorporated into the concept design.

2.43 The pumping head required would be dependent on the maximum reservoir operating level, which varies for the different reservoir size variants. The gross pumping head would range from ~29m for the 150 Mm^3 variant to ~25m for the 75 Mm^3 variant.

2.44 Estimates of energy requirements for pumping water into the reservoir are provided in Section 2.3.1.

2.2.5.3 Energy Recovery Turbines

2.45 Water stored in the reservoir would be at a higher elevation than the water in the River Thames when the reservoir is full. This means there is a potential for energy recovery when water is released from the reservoir back to the River Thames. The design therefore includes energy recovery turbines.

2.46 The reservoir release rate for the 150 Mm^3 scheme is 321 Ml/d. The energy recovery turbines have therefore been sized such that 321 Ml/d can pass through one turbine, with the other turbine providing redundancy. Therefore, the rated discharge for each energy recovery turbines is set at 3.7 m^3/s.

2.47 Estimates of energy generated from release of water from the reservoir are provided in Section 2.3.1.

2.2.5.4 Sweetening Flow Pumping

2.48 During periods of the year when there is no transfer of water between the reservoir and River Thames there is a risk that water within the conveyance tunnels and associated pipework becomes stagnant. To avoid this, pumping would be required to maintain a sweetening flow through the system.

2.49 The sweetening flow pump would pump water from the tunnel, into a pipeline for discharge into the Auxiliary Drawdown Channel (ADC) (see Section 2.2.10) through which it would be returned to the River Thames. Discharge via the ADC has the added advantage that this water can be used to replenish losses due to leakage and lockage during canal navigation. To replenish the water pumped from the tunnel there would be an equivalent abstraction of water from the River Thames at the river intake / outfall structure.

2.50 Estimates of energy required for the sweetening flow are provided in Section 2.3.2.

2.2.5.5 Pressure Dissipation Valves

2.51 There may be situations where the energy recovery turbines are not operational (e.g., for maintenance) during periods where water needs to be released from the reservoir to the River Thames. The concept design therefore allows for water to be released instead via pressure reducing valves.

2.52 The conveyance tunnel has been designed to be part of the solution for drawdown of the reservoir in an emergency situation. The discharge required during an emergency event is to be as high as possible without causing flooding of the pumping station. Therefore, the pumping station concept design also includes submerged discharge valves to provide additional discharge capacity. See Section 2.2.10 for further details on emergency drawdown.

2.2.6 Reservoir Inlet and Outlet Towers

2.2.6.1 Main Inlet / Outlet Towers and Associated Pipework

2.53 Water would be discharged into, and out of, the reservoir at a main inlet / outlet tower. As shown on the layout plan in Appendix A, the tower would be located between the inner toe of the reservoir embankment and the top of the borrow pit excavation. Below ground level, the main inlet / outlet tower structure would be formed by a 15-18 m deep circular concrete shaft (similar to that at the intake/outfall structure) to connect with the upstream end of the conveyance tunnel (described in Section 2.2.3). The diameter of the tower above ground level is likely to be between 13-15 m.

2.54 The connection that would be formed with the conveyance tunnel would allow for the raw water pipeline to extend from the pumping station into the base of the main intake / outlet tower. This pipe connection would allow water abstracted from the river to be pumped, via the pumping station, to the base of the main inlet / outlet tower where it would be jetted into the reservoir through 2 - 3 jet nozzles. The motion caused by jetting of the water in this way would augment the natural circulation of reservoir water driven by the effect of the prevailing wind and the Coriolis force, thereby contributing to efforts to prevent stratification (see Section 2.2.7 for further details).

2.55 From the natural ground level, the main inlet / outlet tower for the 150 Mm^3 variant would have a height of approximately 27 m to extend above the top water level by 2-5 m. In addition, a ~7m high building to house gate lifting equipment would be required on top of the tower.

2.56 The tower would include off-take pipes to allow water to be drawn out of the reservoir at several different levels. This would allow for flexibility to further help manage any variation of water quality with water depth.

2.57 The draw-off pipework at the different levels would each have isolation valves and would connect to a vertical pipe at the centre of the tower. This in turn, would connect to the (aforementioned) 2.5 m diameter raw water pipe housed in the conveyance tunnel. This arrangement would therefore facilitate discharge from the reservoir (via the energy recovery turbines in the pumping station) into the conveyance tunnel for release to the River Thames at the river intake / outfall structure.

2.58 All SESRO variants would have one main inlet / outlet tower which, in combination with the conveyance tunnel, would allow flow to and from the pumping station as described above. However, the dual phase reservoir variants would require a further two ‘main’ (i.e. internally dry) inlet / outlet towers; one is within the Phase 1 reservoir another is within the Phase 2 reservoir. These two additional main inlet / outlet towers would allow the reservoirs to be connected via a tunnel below the dividing embankment (see Section 2.2.3).

2.2.6.2 Secondary Outlet Towers and Associated Connection Culvert

2.59 To provide flexibility in the locations within the reservoir where water can be abstracted, the concept design incorporates secondary outlet towers. As shown in the layout plan in Appendix A the single phase options have two secondary outlet towers located away from the dam crest and towards the centre of the reservoir. These towers are only provided for abstraction from the reservoir and therefore do not contain pipework and nozzles for jetting water into the reservoir.

2.60 The secondary outlet towers would be located within the central trench of the borrow pit. For the 150 Mm^3 option, they would be ~35m high so that they would extend ~1m above the top water level of the reservoir. The towers would have an internal diameter of ~6-8 m and would be internally wet (i.e., water level inside equals that of the reservoir outside). In a similar way as for the main inlet / outlet tower, the secondary outlet towers would allow water to be released from the reservoir at various levels (with openings in the tower walls controlled by penstocks).

2.61 A culvert running along the central trench of the borrow pit, would convey flows from the secondary outlet towers to the main inlet / outlet tower.

2.62 As shown in the layout plan provided in Appendix A, all reservoir variants (once all phases are constructed) have two secondary outlet towers, apart from the 80 Mm^3 P1 + 42 Mm^3 P2 variant which has only one secondary outlet tower due to the relatively smaller area of the Phase 2 reservoir. Further water quality modelling could lead to changes in positions of towers, or change the number required.

2.2.7 Reservoir Mixing

2.63 The temperature of water within a reservoir naturally varies with depth. Water at the reservoir surface tends to be warm and oxygenated, while water at greater depths (which receives less sunlight) is likely to remain colder and de-oxygenated. These conditions can encourage algae growth at the reservoir surface which can adversely affect water quality and make temperature differences worse by blocking sunlight. It is therefore important to ensure there are systems in place to encourage sufficient re-circulation and mixing of reservoir water.

2.64 Some natural circulation of reservoir water would be caused by the effects of wind shear and the Coriolis force. Furthermore, the jetting of water into the reservoir at the base of the main intake / outfall structure (as described in Section 2.2.6.1) would help augment this natural circulation. However, to account for periods of the year when water is not being jetted into the reservoir there is a need for a separate system for reservoir mixing.

2.65 The concept design therefore includes for a network of air diffusers in the bed of the reservoir, which would release bubbles of air into the reservoir. This air would be fed to the diffusers from air compressors in the pumping station using a network of pipes buried in the perimeter embankment and reservoir bed. The stream of bubbles from each diffuser would encourage cold water at the base of the reservoir to rise to the surface, allowing warmer water at the surface to move to lower levels.

2.66 It is expected that diffuser operation would be required during the six-month period between April and September when higher temperatures would increase the risk of stratification. The associated estimated energy requirements are discussed in Section 2.3.3.

2.2.8 Watercourses

2.67 As shown on the layout plan in Appendix A the reservoir would cut across some existing watercourses and surface drainage channels. Therefore, an East Watercourse Diversion (Section 2.2.8.1) and a West Watercourse Diversion (Section 2.2.8.2) would be required to maintain waterway connectivity.

2.68 The indicative alignment of the watercourse was developed through engagement between the engineering team and aquatic environment specialists. The diversion channels would incorporate a low flow channel set within a wider high flow channel. Further design of the form of the channels would be carried out in future stages in accordance with best practice and naturalised design principles to attain the required ecological status as determined by the Water Framework Directive (WFD), see Supporting Document B1, Environmental Appraisal Report (aquatic) for further information.

2.2.8.1 East Watercourse Diversion

2.69 The East Watercourse Diversion has a total length of approximately 6km for all reservoir size variants. As shown in the layout plan in Appendix A, the channel would start south of the reservoir and flow east then north, passing through culverts below the Auxiliary Drawdown Channel (ADC), and discharging into the River Ock. This would allow for connectivity for Orchard Farm Ditch, Goose Willow Ditch, Steventon Ditch West, Steventon Ditch East, Mere Dyke East, Mere Dyke West and Mere Dyke.

2.2.8.2 West Watercourse Diversion

2.70 The required length of the West Watercourse Diversion would differ depending on the size of the reservoir from approximately 6.7 km for the 150 Mm^3 and dual phase variants to approximately 3.5 km for the 75 Mm^3 variant.

2.71 The watercourse diversion would start south of the reservoir, north of the railway, and flow west then north. Cow Common Brook and Portobello Ditch would be realigned such that they converge. Continuing north, the West Watercourse Diversion would discharge into Landmead Ditch which would convey flows to the River Ock.

2.72 A Replacement Floodplain Storage (RFS) area (see Section 2.2.11) would be incorporated along the majority of the length of the West Watercourse Diversion.

2.73 Approximately 1.3 km of the existing East Hanney Ditch would also need to be realigned within the RFS. The realignment would run alongside the West Watercourse Diversion and would also require a culvert below the road from East Hanney. The realigned East Hanney Ditch would drain into Childrey Brook which is a tributary of the River Ock.

2.2.9 Wilts and Berks Canal Corridor

2.74 The Wilts & Berks Canal (W&BC) connected the Kennet and Avon Canal to the River Thames at Abingdon in 1810 but was abandoned in 1914. However, the Wilts & Berks Canal Trust (W&BCT) aim to achieve full restoration of the canal with a primary aim for recreational use. The design of SESRO therefore allows for a 'safeguarded' corridor around the west and north side of the reservoir which could be used for construction of the W&BC in the future by the W&BCT.

2.75 The SESRO project team have had discussions with the W&BCT throughout all phases of development of the SESRO design. Any restoration of the W&BC is proposed to have a 5.3 m wide, 1.5 m deep cross-section which would allow for traditional canal narrow boats.

2.76 Construction of the final section of the proposed W&BC as part of the SESRO project has also been considered for a variety of potential secondary benefits, namely:

- Recreational use by passenger boats (other than narrow boats) such as those used on the Thames, or for use by barges bringing construction materials to site – however, this would require a larger 12 m wide, 2 m deep cross section. The use of barges to bring construction materials to the SESRO site was rejected following a logistics study, primarily due to the number of locks and gates to be navigated along the Thames (and hence journey times).
- Flood mitigation – an opportunity to route a portion of the flood flows from the River Ock to the River Thames, and therefore reduce flood risk in Abingdon (still under consideration, see Section 2.5.2).
- Auxiliary Drawdown of SESRO – due to the proximity of the proposed restored W&BC there is an opportunity for the final stretch to be designed to accept flows from the reservoir during emergency drawdown (part of the core scheme for all SESRO size variants, see Section 2.2.10).

2.2.10 Auxiliary Drawdown

2.77 Guidance from the Environment Agency (EA) / Department for Rural Affairs (DEFRA)[2]

[2] Guide to drawdown capacity for reservoir safety and emergency planning, DEFRA Doc ref: SC130001, 017

advises that reservoirs should incorporate facilities to enable a sufficiently rapid drawdown in an emergency in proportion to the level of hazard posed. For a large reservoir such as the SESRO (of any of the sizes being considered), a maximum installed drawdown capacity of 1m depth per day is recommended.

2.78 Section 2.2.10.1 and Section 2.2.10.2 describe how the required drawdown rate of 1m/day could be achieved by the drawdown arrangement for the 150 Mm^3 variant.

2.2.10.1 Drawdown via Pumping Station and Conveyance Tunnel

2.79 The reservoir surface area for the 150 Mm^3 variant would be 6.5 km^2. To draw down by 1m within a day therefore requires a discharge capacity of 76 m^3/s. As noted in Section 2.2.5.5, the concept design of the pumping station includes some valves that allow the conveyance tunnel to discharge part of this auxiliary drawdown flow:

- Four in-line pressure reducing valves in the pumping station each with a discharge capacity of 2.5 m^3/s and therefore a combined capacity of 10 m^3/s,
- Three submerged discharge valves in the pumping station each with a discharge capacity of 6.8 m^3/s and therefore a combined capacity of 20.4 m^3/s.

2.80 These valves would provide a total capacity for auxiliary drawdown through the conveyance tunnel for the 150 Mm^3 variant of 30.4 m^3/s, which is sufficient to reduce the level of the 150 Mm^3 reservoir by ~400mm/day.

2.2.10.2 Drawdown via Auxiliary Drawdown Siphons and Auxiliary Drawdown Channel

2.81 Above the discharge that can be provided through the pumping station, an additional 45.6 m^3/s is necessary to satisfy the 1 m/day requirement. As shown in the layout plan for the 150 Mm^3 variant in Appendix A this would be achieved by:

- Four auxiliary drawdown siphons (metal pipes), which are buried under the surface of the reservoir embankment, that discharge via valves into a buried concrete chamber at the outer toe of the embankment.
- From the concrete chamber the emergency discharge would flow along an ~900 m long open channel which then connects to the main Auxiliary Drawdown Channel (ADC).
- The ~4 km long ADC would be an open channel used to convey flows from the SESRO site, below the A34 and to the River Thames.

2.82 In normal circumstances the ADC could be used as a navigable section of the Wilts & Berks Canal (as discussed in Section 2.2.9). However, it would also need to be designed so that there would be sufficient capacity to accept up to 48 m^3/s in an emergency reservoir drawdown scenario. The concept design therefore incorporates levees along both sides of the ADC to provide the capacity needed during an emergency drawdown scenario. These levees would be set back from the channel edge so there is room for towpaths for use by pedestrians and cyclists.

2.83 For the ADC to be navigable, the design includes two navigation locks at Oday Hill, each of which includes a bypass weir and channel to convey the emergency drawdown flows around the lock structure. A third lock would be located close to the reservoir; this would provide an area for day-mooring and boat turning, as well as a refuge in case of emergency drawdown.

2.84 The ADC would pass under the A34 using a box culvert which would be ~60 m long to pass below the A34 and the associated cut slope on either side. Initial discussions have been held with Highways England on this aspect of the project.

2.2.10.3 Auxiliary Drawdown Concept Design Differences for Other Variants

2.85 The above describes the arrangement for auxiliary drawdown for the 150 Mm^3 variant. For the other single-phase SESRO size variants the arrangement would be similar but with a reduced capacity in line with the reservoir surface areas. For example, for the 75 Mm^3 option the reservoir area would be 4.1km^2 and this would therefore require a total emergency drawdown capacity of 47.3m^3/s.

2.86 For the dual-phase variants, siphons would be required at two locations in order to draw down both reservoirs independently, in turn requiring the canal to be extended westwards along the northern side of the reservoir.

2.2.11 Replacement Floodplain Storage

2.2.11.1 Introduction

2.87 A hydraulic model has been developed to understand how the construction of SESRO may impact fluvial flooding in the River Ock catchment and to investigate the volume of floodplain that might be considered to be displaced. The hydraulic model has been used to develop an indicative design of Replacement Floodplain Storage (RFS).

2.88 The following three hydraulic modelling scenarios have been used to assess a 1 in 100 year return period flood event with a 70% increase in flow as an allowance for future climate change:

- Baseline (the River Ock without construction of SESRO)
- With construction of the 150 Mm^3 SESRO variant, but without Replacement Flood Storage
- With construction of the 150 Mm^3 SESRO variant, with Replacement Flood Storage

2.2.11.2 Comparison of Baseline to With Scheme (no RFS)

2.89 To investigate the impact that the construction of SESRO may have on fluvial flooding, peak flood flows from the three main modelling scenarios have been compared where the River Ock passes under the A34. At this location, during the 1 in 100 year return period flood event (with 70% addition to account for climate change), the peak flow reduces from 42.5 m^3/s in the Baseline model to 37.2 m^3/s in the With Scheme (no RFS) model. This reduction in peak flow is considered to be due to 6.5 km^2 surface area of the reservoir being removed from the overall River Ock catchment (as precipitation that would fall onto the surface of the reservoir would no longer be passed into the River Ock). This finding indicates that, even prior to inclusion of replacement floodplain storage, the construction of the 150 Mm^3 reservoir would not increase fluvial flood risk to Abingdon from the River Ock.

2.2.11.3 Comparison of Baseline to With Scheme (including RFS)

2.90 The Environment Agency stipulate that for any loss of floodplain storage as a result of development (or change in landscape) compensation storage must be provided to minimise catchment floodplain loss. Level-for-level compensation is the lowering of ground levels to ensure that the same volume of flood storage is available at the same elevation as the flooding that has been displaced. Compensation areas should also be located as near as possible to where the floodplain storage is being removed. This is commonly referred to as Replacement Floodplain Storage (RFS).

2.91 The current SESRO RFS design reflects the standard approach for developments on floodplain areas; however, it is noted that typically developments do not store the rainwater that falls onto their surface, and they would generally cause flood water within their catchment to be displaced to another area within the same catchment. SESRO does not exhibit this behaviour across the whole development because rainfall falling on the ~6.5 km^2 reservoir surface can only then be discharged via the conveyance tunnel into the River Thames (thereby bypassing the River Ock catchment). The current RFS design assumes the existing floodplain that is lost is to be replaced, so is considered conservative.

2.92 The RFS would help deliver biodiversity net gain requirements as it would be developed to provide valuable wetland habitats. The indicative design would include meanders, vegetation, constrictions, and bunds to beneficially slow flow. Further details may be found in Supporting Document B1, Environmental Appraisal Report (aquatic) and Supporting Document B6, Biodiversity Net Gain.

2.93 The RFS areas identified for the 150 Mm^3 reservoir variant are shown on the layout plan in Appendix A. Low bunds have been included within the RFS to help slow the flow and build up sufficient storage during the 1 in 100 year return period flood event (with 70% addition to account for climate change) to achieve the required level-for-level compensation. The current concept design for this largest variant RFS requires an approximate excavation of 850,000m^3. This material would be used for the construction of screening / noise bunds and for other landscaping requirements.

2.94 The outputs of the hydraulic models indicate that construction of the RFS would further reduce peak flood flows when measured at the A34 crossing. For the 1 in 100 year return period flood event (with 70% addition to account for climate change), the modelled peak flow at the A34 crossing reduces further to 36.8 m^3/s. As well as the impacts of the reservoir and main RFS area, there are some other structures proposed around the SESRO site which would potentially impact flood flows, for example road embankments and the watercourse diversions. These relatively small areas of changed flood extent would be resolved with refinement of the design of watercourse diversions and culverts during the next stage of design development.

2.95 The ADC and access road to the intake/outfall structure both require embankments to be constructed across part of the River Thames floodplain which could impact on the natural flows along the floodplain. These structures are to be subject to further design development to minimise their size and enable natural fluvial floods to traverse without raising flood risk.

2.2.12 Groundwater Drain

2.96 The construction of the reservoir would block groundwater flows that currently occur within the superficial deposits which reside above the (largely impermeable) Kimmeridge and Gault clay formations. The groundwater has been assessed to flow from south to north in the layer of superficial deposits, and the design of all reservoir sizes includes a groundwater drain that would be installed below the perimeter embankment toe drainage ditch, on the southern side of the reservoir. The purpose of the drain is to convey these natural groundwater flows around the reservoir (which blocks their path) to avoid groundwater flooding to the south side of the reservoir. The following sub-sections provide an overview of preliminary groundwater modelling that has been undertaken to better understand the potential impact of the reservoir on groundwater flow in the superficial deposits aquifer with a particular focus on the potential impact on nearby villages.

2.2.12.1 Conceptual Understanding of Existing Groundwater Flows

2.97 The top layers of geology at the SESRO site are described as superficial deposits, which are up to 10m thick and include Alluvium, River Terrace Deposits (sands and gravels) and Head Deposits. These are permeable and contain groundwater. The bedrock in the area consists largely of clay formations, which form a low permeability base to the superficial deposits and produce an aquifer. Groundwater is reported to flow in a north to north-easterly direction through the superficial deposits, and groundwater levels are estimated to be between surface and 2.5m below ground level.

2.98 Groundwater levels change with the seasons and interact with the surface water system. Average annual recharge of the superficial deposits aquifer is estimated to be 182mm/year (37.5Ml/d), although there is considerable spatial variability across the study area. Recharge is seasonal being concentrated between October and January. Mean runoff is estimated to be 54mm/year, contributing around 11Ml/d to surface water flow.

2.99 Surface water flows in minor watercourses towards the River Ock and the River Thames in the north and east. Both recharge and runoff are expected to discharge to the surface watercourses across the study area and extensive field drains and ditches currently control groundwater levels.

2.2.12.2 Preliminary Groundwater Model Scenarios

2.100 A preliminary groundwater model has been built to simulate four predictive scenarios:

- Baseline historical model (1961-2019).
- Reservoir constructed without planned drainage.
- Reservoir constructed including toe drain, flood storage area and watercourse diversions only.
- Reservoir constructed including toe drain, flood storage area, watercourse diversion and additional groundwater drain.

2.2.12.3 Preliminary Groundwater Model Results

2.101 There is considerable uncertainty in the model, which should be refined based on observation data to be collected during future ground investigations and surveys at the site, such as groundwater levels and spot flow gauging data. Results from the model scenarios indicate that:

- Baseline groundwater levels are controlled by surface and near surface drainage.
- Introduction of the reservoir footprint to the model leads to an increase in groundwater levels generally across the study area, with areas to the east most affected by the increase in groundwater levels. Groundwater levels are widely still controlled by existing surface and subsurface drainage.
- Groundwater levels are reduced by the presence of the proposed toe drain, flood storage area and watercourse diversions.
- When the additional groundwater drain is introduced further reductions in groundwater levels occur; however, the impacts are local to the groundwater drain.
- With the proposed toe drain, flood storage area and watercourse diversions, the increased risk of groundwater flooding is low; this can be further mitigated with the additional groundwater drain.
- Limited impacts on groundwater levels are expected at Steventon, East Hanney and West Hanney; however, the preliminary modelling indicates that the presence of the reservoir may lead to an increase in groundwater levels around Drayton. Further model development and investigation into the impacts to the east of the reservoir will be undertaken at Gate 3 as more data is collected and becomes available to inform the modelling.

2.2.13 Recreational Facilities

2.102 A range of recreational activities have been proposed for the core scheme. These were derived for the 150 Mm^3 SESRO variant and would be scaled back accordingly should the smaller options be selected by the WRMP24 strategic planning process. Further details can be found in Supporting Document B4, Conservation, Access, and Recreation Strategy.

2.103 The recreational activities included in the core scheme, as shown on the layout plan in Appendix A, include:

- A main visitor centre, located beside the lagoons, at the north-east corner of the site. The exact make-up and design of this building is yet to be determined, and it is assigned an indicative footprint of 30 m x 30 m (two-storey building) to enable flexibility for future consultation and design on its form and function.
- Facilities for a sailing club including internal / external boat storage, a clubhouse, and access to the reservoir for controlled water-based activity. The exact details of the associated building have yet to be developed and would be subject to future consultation. A single story building with an indicative footprint of 30 m x 30 m has currently been included. There may need to be a raised gallery lookout on the roof of the sailing club for supervision of sailing activities.
- A café, located in a prime viewpoint location on the embankment crest. This would be in the north-east corner of the reservoir with views south across to the North Wessex Downs AONB and the Ridgeway. An indicative footprint of 30 m x 15 m has been assumed for this single-storey building; however the exact form and function of this building would be subject to future consultation.
- An extensive network of walking, cycling, and riding routes around the site.
- A dedicated nature conservation zone, along the western side of the reservoir, combining the replacement flood storage area, diverted watercourses and wetland creation. It is envisaged that walking routes in this area would be more limited to reduce footfall and combined with features such as boardwalks and bird hides to facilitate unintrusive visitor interaction with this part of the site.
- A single storey education centre would be located at the northern end of the wetland area (western side of the site), linked to the main access and car park via a controlled access road, enabling limited provision for car and coach access. An indicative footprint of 30 m x 15 m is currently assumed, however, as with the other buildings on site the exact form and function of this building would be subject to future consultation.

2.104 These recreational activities in the core scheme have been selected on the basis of the capacity of the SESRO site to accommodate them alongside other environmental constraints, current use of Thames Water's existing reservoir sites, recreational obligations for water undertakers under the Water Industry Act and operational and safety advice from Thames Water's Dam and Reservoir Safety team. The choice of final scheme recreational use would be further refined and adjusted to reflect feedback from future public consultation events and further technical analysis.

2.105 The layout plan for the 150 Mm^3 variant in Appendix A shows the proposed footpath and cycle paths that would connect into existing public rights of way (PROW) that surround and cross the SESRO site. These changes are designed to maximise the amenity value of the retained, diverted and proposed new routes, enable access for all and to encourage a wide range of non-vehicular routes into and around the SESRO site.

2.106 The recreational activities in the core scheme have been selected on the basis of best practice, maximising the amenity value of the routes and the connectivity of the existing and new network. The choice of final scheme PROW routes and access would be further refined and adjusted to reflect ongoing liaison with Oxfordshire County Council, engagement with local recreational groups, feedback from future public consultation events and further technical analysis.

2.2.14 Roads and Access

2.2.14.1 A415 to SESRO Access Road

2.107 As shown on the layout plans in Appendix A, for all SESRO variants the main access route into site for both construction and operation would be from the A415 (Marcham Road). The currently proposed route would be ~4 km long and would initially route east (parallel to the A415) and then south (parallel to the A34) to reach the main construction compound (which would subsequently become the main car park) and the pumping station. It is envisaged that this access road would be a rural two-lane carriageway with a width of 7.3m. It has been proposed that a 3m wide shared cycle / footpath would be provided on both the east and west sides of the road. The road design could be integrated with local highways expansion plans or adapted as appropriate in response to local development pressures and plans.

2.108 To reduce the impact on traffic using the Marcham Interchange (where the A415 joins the A34), the proposed junction has been situated ~1.2 km away from it. At this stage of design development a roundabout, rather than a priority T-junction, has also been proposed for the new junction to increase its capacity. Initial junction capacity modelling has been undertaken, as summarised in Section 2.2.14.4.

2.109 The A415 to SESRO access road would be raised above the River Ock floodplain on an embankment and would cross over the River Ock, the Auxiliary Drawdown Channel and the West Watercourse Diversion on bridges. Bridges or culverts would also be required for the road to pass over three smaller watercourses. There is an opportunity for the design of SESRO access road embankment to be adapted so that it would act as a part of a flood alleviation scheme that has previously been investigated by the Environment Agency (Abingdon FAS). See Section 2.5.2 for further information.

2.2.14.2 Steventon to East Hanney Road Diversion

2.110 For any of the reservoir capacities under consideration there would be a requirement to relocate the road that currently connects East Hanney to Steventon. Outside of Steventon the road would be diverted to the south from its current alignment and then route west along the southern extent of the reservoir embankment. The route has been provisionally determined so that it would junction with the A338 to the south of East Hanney. Such an alignment would reduce the impact on traffic within East Hanney and could also help better serve a proposed new Wantage and Grove Railway station if this were also to be constructed in the future (see Section 2.5.3).

2.111 The layout plan in Appendix A shows that the Steventon to East Hanney road diversion would have a roundabout junction with the A338 and the total length of the realigned East Hanney to Steventon Road would be ~5km for all reservoir variants. It is envisaged that the road would consist of a rural two-lane carriageway with a width of 7.3 m. It has been proposed that a 2m wide footway would be provided on the north side of the road and that a 3m wide shared cycle / footway would be provided on the south side of the road, separated from the road with a hedgerow.

2.112 The Steventon to East Hanney road would be slightly raised above existing ground level but would require a higher embankment on the approaches to its crossing of the West Watercourse Diversion and the potential future Wilts and Berks Canal.

2.113 The alignment and usage restriction for this road will be further refined as the project continues towards Gate 3, following further engagement with Oxfordshire County Council and local communities.

2.2.14.3 Visitor Trip Generation Estimate

2.114 An initial analysis of visitor trip generation has been undertaken for SESRO to provide indicative information for Gate 2 environmental and social assessments. The methodology was as follows:

- Calculate the number of residents within 15-, 30-, 60- and 90-minute drive-time catchment of the proposed reservoir.
- Use the methodology from the planning application for a new reservoir at Havant Thicket, Hampshire to estimate the likely percentage of visitors from residents within each drive-time catchment.
- Estimate the number of tourists who would likely visit the proposed reservoir as well as with estimates for passing traffic, education, and events.
- Estimate the mode split of trips that would be made by car and non-car modes.
- Estimate the annual and weekly distribution of trips based on data from existing sites and use this to establish the approximate visitors on a monthly and daily basis.
- Estimate the trip distribution across the day using specialist software.

2.115 As the scheme is developed for Gate 3 and DCO submission, and further work is undertaken on recreational scenarios the estimate will be reviewed and updated.

2.2.14.4 Initial Junction Modelling

2.116 To investigate how additional traffic generated by the SESRO scheme may impact the existing road network, initial junction modelling has been undertaken. The modelling was carried out for: the A415 junction with the SESRO access road; the A338 junction with the Steventon to East Hanney road diversion; and the A415 junction with the A34 Marcham Interchange. At this stage no public transport or active travel modes have been considered in assessment of junctions.

2.117 Junction traffic was modelled using baseline traffic, estimates of peak travel during construction and estimates of peak travel from visitors during operation. Traffic growth factors were applied to existing traffic data to approximate baseline traffic conditions in 2030 (when construction of SESRO may be underway) and in 2040 (when construction of SESRO may have been completed and operation may have begun).

2.118 The results indicate that the roundabout concept designs for the A415 junction with the SESRO access road and the A338 junction with the Steventon to East Hanney road diversion would provide sufficient capacity in the future scenarios.

2.119 For the A415 junction with the A34 Marcham Interchange the initial junction modelling indicates that, during certain times of the day in August (where higher numbers of visitors may be anticipated) there could be capacity issues. To investigate this further at the next stage of design development it will be important to engage further with project teams considering other nearby potential road developments (see Section 2.2.14.6) as well as to review how inclusion of public transport and active travel modes could reduce the estimated number of vehicles.

2.2.14.5 Car Parking

2.120 The Gate 2 concept design includes two main car parking areas:

- Main visitor car park – located at the end of the A415 to SESRO Access Road and close to the Visitor Centre.
- Reservoir embankment car park – located on the reservoir embankment shoulder.

2.121 There are also some smaller car parking areas envisaged at the following locations:

- Reservoir crest café car park – located on the reservoir crest with limited spaces to be used for staff, deliveries and disabled access to café; controlled access at toe of the reservoir embankment.
- Pumping station car park – for operational and maintenance vehicle use only.
- Education centre car park – for staff and visitors to the education centre only with space for limited car and coach parking; controlled access at the main visitor car park.
- East Hanney and Steventon car parks – provision of limited spaces at the ‘stub’ roads would be left following construction of the Steventon to East Hanney road

diversion; intended to be for local use only to enable parking and pedestrian access to the site.

2.122 This concept design will be challenged and developed with further stakeholder and community engagement during Gate 3.

2.2.14.6 Potential Developments to the Surrounding Road Network

2.123 There are potential developments to the road network proposed by other parties, which would need further consideration during future design development and consultation. These include:

- National Highway's project for 'A34 improvements north and south of Oxford'.
- Potential bypasses along the A415 to the south of Marcham and to the South of Abingdon.
- Several housing developments are proposed in the area, including a significant development on the Dalton Barracks site which would require a new road heading north from the A415 close to the proposed A415 to SESRO access road junction.

2.2.15 Other Enabling Infrastructure

2.2.15.1 Contractors Compounds

2.124 The main site compound would be located in the north-east corner of the reservoir, close to the pumping station and main intake outfall tower. An area of approximately 400 m by 300 m has been identified for this main compound. This allows for offices, welfare facilities, plant yard, stores, laboratory, accommodation, and car parking.

2.125 Smaller satellite compounds would also be required at other locations across the site.

2.2.15.2 Services

2.126 A number of existing services have been identified at the site, and the concept design would require diversion of these in advance of construction. These include power cables, a gas main, telecommunications cabling, and water / sewerage pipework.

2.2.15.3 Rail Siding and Materials Handling Area

2.127 As outlined in Section 2.2.2.4, the reservoir embankment and borrow pit would be designed to ensure volumes of cut and fill are balanced, to avoid the need to import or export clay from the site. There are, however, some significant quantities of sands, gravels, and rip rap required for the embankment inner slope protection (Section 2.2.2.5) and for filter and drainage layers within the embankment (Section 2.2.2.6). To avoid having to transport this material by road haulage the SESRO scheme would include a new rail siding, so this material could be transported to the site via rail.

2.128 This rail siding would be temporary, constructed on the existing Great Western Main Line (London to Bristol) along with an adjacent materials handling / stockpiling area. The quantities of aggregates required for all reservoir size options are significant and therefore the same rail siding has been assumed for all SESRO variants.

2.129 An important consideration for the siding design is the existing reduction from a four-track railway to a two-track railway just to the east of the Wantage Road (A338) crossing. Connecting the rail siding to the two-track railway is possible but could bring about operational constrains associated with slow speed access to the facility, so extending the northern track of the four-track railway directly into a rail siding could be preferrable as it would not restrict the passage of faster running passenger services. Further design during the next stage of design development should confirm the siding position and arrangement.

2.3 Scheme Operation Energy Estimates

2.3.1 Pumping Energy Required and Renewable Energy Generation

2.130 The energy that is required to refill the reservoir and the energy that can be generated when releasing water from the reservoir would vary from year to year, depending on utilisation of the scheme. Outputs from Deployable Output (DO) modelling (daily inflows, outflows, and reservoir storage volumes) have been used to estimate the average annual energy requirements for:

- Energy required to pump water from the River Thames to the reservoir via the intake pumps (see Section 2.2.5.2).
- Energy generated by the energy recovery turbines (see Section 2.2.5.3) during periods when water is released from the reservoir back to the River Thames.

2.131 The estimates demonstrate that the pumping energy required, and turbine energy generated vary across the modelled years. Where the modelled year is representing a drought the DO model draws more water out of the reservoir, resulting in higher energy generation. Then in the subsequent modelled year, the DO model shows longer periods of reservoir refilling and therefore higher pumping energy requirements.

2.132 Given this range in energy estimates, it is beneficial to consider an average energy requirement across all the modelled years, as shown in Table 2.1. This shows that for the 150 Mm^3 scheme (on average) 4,110 MWh of energy would be required annually to pump water into the reservoir, and (on average) 2,444 MWh of this could be recovered from the energy recovery turbines.

2.133 It is also beneficial to estimate the annual maximum pumping energy required and the associated annual maximum turbine energy generated. This is referred to as 100% utilisation and is required to inform operational cost estimates and inputs into water resource management plans. The annual 100% utilisation scenario for the

150 Mm^3 variant requires a release of 321Ml/d for 365 days, for which it is estimated the turbines would generate 4,751MWh. However, there would be a subsequent pumping energy requirement of 8,713MWh for the reservoir to be refilled. The estimates for all variants are presented in Table 2.1.

Table 2.1: Estimated Pump and Turbine Energy – Annual Average and Maximum Utilisation

Variant	Turbine Energy for Full Release (MWh)	Pumping Energy for Full Refill (MWh)	Estimated Average Annual Turbine Energy (MWh)	Estimated Average Annual Pumping Energy (MWh)
150 Mm^3	4,751	-8,713	2,444	-4,110
125 Mm^3	3,728	-6,958	1,918	-3,282
100 Mm^3	2,748	-5,308	1,414	-2,504
75 Mm^3	1,713	-3,697	1,015	-1,873
30 + 100 Mm^3, P1	631	-1,488	374	-754
30 + 100 Mm^3, P1 + P2 *	3,033	-7,904	1,561	-3,728
80 + 42 Mm^3, P1	2,007	-4,034	1,189	-2,044
80 + 42 Mm^3, P1 + P2 *	2,895	-6,959	1,489	-3,283

* Provides combined energy estimates for P1 and P2 schemes

2.3.2 Sweetening Flow Pump Energy Estimate

2.134 The need for a sweetening flow pump within the pumping station is discussed in Section 2.2.5.4. This would operate continuously at 160 l/s during periods of the year when water would neither be abstracted from the River Thames, nor released from the reservoir. The required pump capacity has been set based on a need to replace the total volume of water within the conveyance tunnel every 4 days.

2.135 It is proposed that the water would be pumped from the tunnel to the Auxiliary Drawdown Channel using a 50 kW – 60 kW pump. It is estimated that, on average, the pump would operate approximately 3,200 to 3,900 hours a year, resulting in an estimated average annual energy requirement of 234 MWh. The conveyance tunnel is the same for all variants, therefore this energy estimate is considered applicable for all variants.

2.3.3 Air Diffuser Network Energy Estimate

2.136 As discussed in Section 2.2.7, to reduce the risk of deteriorating water quality, the concept design for the 150 Mm^3 variant includes for a network of air diffusers connected to two 200 kW air compressors in the pumping station.

2.137 Computational Fluid Dynamics modelling completed for Gate 2 on the 150 Mm^3 variant indicates that these would need to operate during the six-month period between April and September when higher temperatures would increase the risk of stratification. The modelling outputs, presented in Supporting Document B1, Environmental Appraisal Report (aquatic), indicate that 1.92 MWh/ day would be required during this period. Assuming an efficiency of 60% the daily energy requirement is therefore 3.2 MWh, corresponding to an annual energy requirement of ~585 MWh. The energy required for the other SESRO variants has been estimated by scaling based on reservoir surface area.

2.3.4 Summary of Energy Estimate

2.138 Table 2.2 provides a summary of the annual energy estimate for all SESRO variants based on the Gate 2 concept design. At the next stage of design development these estimates will be discussed with the Distribution Network Operator (DNO) to establish the steps required to ensure sufficient network capacity for scheme operation.

Table 2.2: Estimated Average Annual Energy – All Variants

Variant	Turbine Energy (MWh)	Pumping Energy (MWh)	Sweetening Pump Energy (MWh)	Air Diffuser Energy (MWh)	Miscellaneous Energy (MWh)
150 Mm^3	2,444	-4,110	-234	-584	-715
125 Mm^3	1,918	-3,282	-234	-520	-578
100 Mm^3	1,414	-2,504	-234	-450	-450
75 Mm^3	1,015	-1,873	-234	-365	-322
30 Mm^3 (P1)	374	-754	-234	-139	-140
30 Mm^3 (P1) + 100 Mm^3 (P2)	1,561	-3,728	-234	-597	-655
80 Mm^3 (P1)	1,189	-2,044	-234	-375	-348
80 Mm^3 (P1) + 42 Mm^3 (P2)	1,489	-3,283	-234	-596	-584

2.4 Interaction with other SROs / WRMP24 Options

2.4.1 Severn to Thames Transfer

2.139 The Severn to Thames Transfer (STT) is a Strategic Resource Option that would connect the River Severn to the River Thames via a pipeline or a combination of pipeline and canal. The proposed River Thames outfall structure for the STT is near Culham at approximately the same location as the SESRO river intake / outfall structure. Therefore, if both SESRO and STT were to progress planning would be required to ensure that the designs are aligned to maximise possible benefit whilst avoiding unacceptable cumulative adverse effects.

2.140 There would be benefit in aligning the last section of STT pipeline (which extends just north of the SESRO site, below the A34, to an outfall structure at the River Thames) with the SESRO Auxiliary Drawdown Channel (ADC). In this way, should both SESRO and STT be selected for construction then this section of the STT pipeline could be constructed along the towpath of the ADC and connected into the SESRO river intake / outfall structure (rather than having a separate outfall structure). This has the potential to provide efficiencies in the A34 crossing, minimise construction disturbance, ease access for pipeline maintenance and avoid the need for two separate outflow structures discharging to the River Thames.

2.141 At Gate 2, the concept designs of both SESRO and STT have been developed independently of each other. At later design stages, if it has been confirmed that both SROs are required, there could be an opportunity for the STT pipeline to connect directly into the SESRO reservoir, enhancing the combined benefit of the two schemes.

2.4.2 Thames to Southern Transfer

2.142 The Thames to Southern Transfer (T2ST) is a Strategic Resource Option which would facilitate transfer of water from the Thames Water region into the Southern Water region. Various source locations are under consideration, including STT and / or SESRO at Culham. A connection to SESRO would require additional pipework and equipment within the SESRO pumping station, and a Water Treatment Works (WTWs) located at the SESRO site. Therefore, if both SESRO and T2ST were to progress planning would be required to ensure that the designs are aligned.

2.143 Discussions have been held between the two SRO design teams, during which it was confirmed that the space requirement at the SESRO site for Water Treatment Works (WTW) would need to be approximately 300 m x 150 m for a T2ST 120 Ml/d capacity option. A suitable area for this potential WTWs on the SESRO site has been identified. A T2ST WTW would also require a 200 mm diameter piped connection to the existing Abingdon Sewage Treatment Works located on the right (west) bank of the River Thames just upstream of Culham. It has been proposed that this would be constructed in the tow path of the SESRO Auxiliary Drawdown Channel.

2.144 A T2ST option starting at Culham would require STT or SESRO to be constructed, with the T2ST being constructed either at the same time or at a later date. If it is determined that SESRO and this T2ST option should be constructed, even with significantly differing delivery dates, it is proposed that the pipework associated with the T2ST that is within the SESRO site would be constructed at the same time as SESRO to avoid construction disturbance at a later date. The SESRO concept design would include a safeguarded area for the T2ST treatment site to be development when T2ST is needed.

2.4.3 Thames to Affinity Transfer

2.145 The Thames to Affinity Transfer (T2AT) is a Strategic Resource Option which would facilitate transfer from Thames Water region to Affinity Water region. To allow for this transfer the natural flow of water in the River Thames will need to be supported, especially during drought years. Therefore, for some of the options being considered for T2AT, SESRO is a pre-requisite because without SESRO the transfer would leave Thames Water with a reduced volume of strategic storage.

2.4.4 SWOX / SWA Water Treatment Works

2.146 Options for treated water transfers from SESRO into Thames Water's Swindon and Oxfordshire (SWOX) and Slough, Wycombe and Aylesbury (SWA) Water Resource Zones are included in Thames Water's Water Resource Management Plan 2024 Constrained List of options. These options would require additional pipework and equipment within the SESRO pumping station, a Water Treatment Works (WTW) located at the SESRO site, and treated water pipelines from SESRO to connect into the existing network. The new WTWs could also potentially be supplied from STT, in which case additional pipeline connections to the STT interconnector would be required.

2.147 The draft WRMP24 Best Value Plan includes 48 Ml/d of new WTW at the SESRO site and space for this has been identified within the SESRO masterplan.

2.4.5 SESRO to Farmoor Raw Water Transfer

2.148 Thames Water WRMP24 Constrained List also includes an option for a 24 Ml/d raw water transfer from SESRO to the existing Farmoor Reservoir. This would allow water from SESRO to be treated at the existing Farmoor WTW. The SESRO masterplan includes consideration of this transfer pipeline route within the SESRO site.

2.149 There is also a potential opportunity for a larger capacity raw water transfer to Farmoor, which could allow for reduced abstraction from the River Thames into Farmoor Reservoir, thereby maintaining a higher flow in the river as it passes through Oxford. This could have a positive impact on the environmental conditions of the Oxford watercourses but is not currently part of the core SESRO scheme.

2.5 Opportunities / Future Benefits Realisation

2.150 Section 2.2 outlines the key components of the current concept design. There are opportunities which, while not currently incorporated into the concept design, could provide other benefits and which therefore should continue to be considered in later stages of design development. These include:

- Generating energy using floating solar panels on part of the reservoir.
- Generating energy using wind turbines sited within the reservoir.
- Use of the main access road embankment to impound a flood storage reservoir on the River Ock.
- Connecting with a potential new railway station at Wantage and Grove.

2.5.1 Alternative Renewable Energy Generation

2.5.1.1 Solar Energy

2.151 There may be an opportunity for a floating solar farm on the surface of the reservoir to replace some of the existing solar energy generating capacity which would be lost. The technology for floating solar is proven, with solar farms being installed at existing reservoir sites. There are, however, several aspects which would need to be taken into consideration to establish if floating solar were suitable for the SESRO reservoir and, if so, the appropriate surface area / design of the floating solar farm. This includes the potential that a floating solar farm may impact water quality, and the need to provide clear separation of areas for floating solar farm and areas for recreational use (e.g. sailing).

2.5.1.2 Wind Energy

2.152 Wind turbines could be sited within the 100m wide corridor between the inner toe of the reservoir embankment and the top of the borrow pit (meaning they would be approximately 150m from the crest of the reservoir). This has not been included within the core SESRO scheme at this stage due to concerns about their visual impact. There are several areas of further study required if wind turbines are to be further considered for incorporation into the scheme, including detailed visual and noise impact assessments.

2.5.2 Flood Storage Reservoir

2.153 The Environment Agency has previously carried out a feasibility study for construction of a flood alleviation scheme for Abingdon. This included a flood embankment constructed across the River Ock upstream (east) of the A34, to impound a Flood Storage Reservoir (FSR) which would fill during floods by holding back a proportion of the flood flow and thereby reduce flooding in Abingdon. The Abingdon Flood Alleviation Scheme has not progressed to construction, however the Environment Agency continues to consider options for flood mitigation in this area.

2.154 The proposed A415 to SESRO access road would be built on an embankment along a similar alignment as the flood embankment previously considered by the

Environment Agency study. Therefore, there is an opportunity for one embankment to provide both access to the SESRO site and flood storage. While this dual-purpose functionality has not been incorporated into the current conceptual design, flood modelling has been undertaken to investigate the opportunity and to help inform future discussions with the Environment Agency.

2.5.3 Wantage and Grove Station

2.155 The viability of a new passenger railway station along the Great Western Main Line has been, and continues to be, assessed under a separate project. Seven potential sites have previously been considered: two located just to the east of the A338, and five within the 1.7 km stretch of rail to the west of the A338.

2.156 Possible synergies with a potential Wantage and Grove Station would continue to be considered as SESRO progresses towards Gate 3. For instance: location of the temporary SESRO rail sidings; opportunities for public transport access to the SESRO site for recreation; and potential for inclusion in the SESRO workforce travel plan (if the station were to be operational prior to SESRO construction).

2.5.4 Alternative Operation for Downstream Flood Management

2.157 As SESRO would abstract water from the River Thames during periods of higher flow, there is a potential that it could be used to help reduce peak flood flows in the River Thames, essentially operating as an off-line flood storage reservoir. The operation of the reservoir would need to be adjusted such that it has storage available to be filled during periods of the year where flood flows could be anticipated.

2.158 This opportunity would be assessed further in the next stages of design development. This would need to consider whether additional controls are required to manage intake water quality during flood periods. It would also be necessary to quantify the increase in pumping energy required for this alternative operating regime as well as the benefits to downstream areas in the River Thames catchment.

3. Scheme Delivery

3.1 This Chapter presents an initial assessment of key aspects of the construction phase of SESRO. The construction phase activities would continue to be reviewed if SESRO were to progress to the next stage of design development.

3.1 Construction Materials Delivery

3.1.1 Main Construction Materials Required

3.1.1.1 Reservoir Earthworks and Internal Filters / Drainage

3.2 The vast majority of material excavated on site would be from the reservoir borrow pit, with other volumes associated with the ADC, tunnel, pumping station, and the flood replacement storage area excavations. As outlined in Section 2.2.2.4, all excavated material would be used on site to avoid the need for export and disposal off site.

3.3 As outlined in Section 2.2.2.2, the excavated fill would be placed in either ‘structural’ or ‘landscape’ zones within the reservoir embankment, depending on their engineering characteristics. Excavation and placement would be planned so as to minimise haulage distances and avoid double handing (using temporary stockpiles).

3.4 The reservoir embankments also include filtering and drainage layers consisting of clean filter sand and drainage gravel. These materials are not available for excavation at the site and would be imported to the site by freight train (see Section 3.1.2.2).

3.1.1.2 Reservoir Embankment Erosion Protection – Riprap and Bedding Layer

3.5 Due to the need for the inner face of the embankment to be protected against erosion by waves the design includes a layer of hard, durable graded rock (riprap) overlaying a gravel bedding layer, and a sand filter layer. These materials are not present at the site or in its vicinity in the quantities required. Preliminary investigations have concluded that these materials can be sourced in the UK and brought to the SESRO site by rail in the quantities required.

3.1.1.3 Concrete

3.6 Most of the concrete that would be required for construction of SESRO would need to be poured in-situ. However, some (particularly for tunnel lining and shaft segments and wave wall units) could be precast off site and imported.

3.7 In-situ concrete constituents (primarily cement, fine aggregate, coarse aggregate, and water) could be imported to the site separately and mixed at an on-site batching plant. Alternatively, concrete would be batched off-site at existing batching plant facilities and delivered by road in standard mixer trucks. Studies undertaken have indicated that local batching facilities could provide sufficient capacity if required. This will be kept under review as the design is developed.

3.1.1.4 Road Sub-base / Capping Layers and Asphalt

3.8 All new permanent roads and cycle paths would require materials to be imported to the site. Temporary haul roads around the site could be constructed of the same materials or alternatively from roller compacted concrete.

3.9 Most road construction would need to be completed during the initial stages of construction before the rail siding and associated materials handling area would be operational. Therefore, most of the materials for road construction would need to be imported by road rather than by rail.

3.1.1.5 Fuel

3.10 Significant imports of fuel would be required for construction of the reservoir, if using diesel-fuelled earthmoving plant. It is anticipated that fuel would be delivered to site in tankers. However, there may be opportunities to use alternatives to diesel powered earthmoving plant, such as electric, hydrogen or HVO (Hydrotreated Vegetable Oil) fuel. This is being considered as part of a separate All Company Working Group (ACWG) project to investigate low carbon opportunities across SROs. The outputs of this would be reviewed in the next stage of design development.

3.1.2 Delivery of Construction Materials

3.11 Based on initial quantity estimates and the indicative construction programme (described in Section 3.3) it has been estimated that approximately 70% of the construction materials could be imported by rail, with 30% imported by road.

3.1.2.1 Road

3.12 Initial imports by road will be mainly for construction of roads within the site, later imports will be mainly of concrete for construction of structures and tunnels.

3.13 It has been estimated that, across the construction period for the 150 Mm^3 variant, approximately 65,000 – 70,000 delivery vehicles would be required to deliver material to site via the A415 to SESRO access road. It is recommended that the programme and assumptions used to develop this initial estimate be revisited at the next stage of project development in consultation with a contractor.

3.1.2.2 Rail

3.14 Large quantities of sands, gravels, and rip rap would need to be transported to the site by freight train, requiring the construction of a rail siding and an adjacent materials handling area, as discussed in Section 2.2.15.3. Based on construction material estimates for the 150 Mm^3 variant and the indicative construction programme (outlined in Section 3.3) it has been estimated that a total of approximately 2,500 freight train deliveries, each with a carrying capacity of approximately 1,320 tonnes. This would require one to two trains to enter the site daily across a five year period of the construction programme.

3.15 The capacity available for two freight train deliveries a day within the current train timetable has been assessed. For the purposes of this assessment, it has been assumed that all materials would be loaded onto freight trains at the Portbury Docks in Avonmouth. The Great Western Main Line (London to Bristol) December 2019 timetable was used for this preliminary assessment. Two unique inbound/outbound path combinations were identified:

- 1st train arriving at 05:17, with indicative unloading time between 06:00 to 11:30 to allow for departure at 11:59
- 2nd train arriving at 12:38 with indicative unloading time between 12:45 to 18:15 to allow for departure at 20:32

3.16 The impact of needing to add additional services, particularly in the intra-peak period, needs to be further considered, and performance modelling on the additional services would need to be undertaken at the next stage of design development to highlight any impacts they may cause. Freight train paths that are currently timetabled, but not used, should also be considered for SESRO deliveries as this could eliminate or reduce any adverse impact on railway network performance.

3.2 Construction Process

3.2.1 River Intake / Outfall Structure and Shaft

3.17 The river intake / outfall structure (see Section 2.2.4) would primarily be a buried reinforced concrete structure on the right bank of the River Thames, with an above-ground building for control equipment and plant.

3.18 The works would be within the flood plain and measures would therefore be required to protect against fluvial flooding inundating the site. It would be necessary to isolate the works from the river through a cofferdam, which would likely be constructed from sheet piles.

3.19 The buried circular shaft behind the river intake / outfall structure which connects to the conveyance tunnel would be formed of a precast concrete segmental wall and in-situ concrete base. The Tunnel Boring Machine (TBM) would be lifted out of the shaft on completion of its excavation of the conveyance tunnel.

3.2.2 Conveyance Tunnels

3.2.2.1 Pumping Station to River Intake / Outfall Structure

3.20 This section of the conveyance tunnel would be excavated by a Tunnel Boring Machine (TBM). The TBM would be installed within the pumping station box and driven towards the shaft at the river intake / outfall structure.

3.21 The excavated clay material from the conveyance tunnel would be from the same formation as that encountered in the reservoir's borrow pit, and it would be directly transported within the site for placement in the embankments as landscape fill.

3.22 As is normal for tunnelling operations, the underground work would be expected to progress on a 24-hour, 7 day working pattern. As the TBM advances, pre-cast concrete tunnel lining segments would be installed around the tunnel perimeter and bolted together. A secondary lining formed of concrete may be required within the tunnel to enhance durability. This would be poured in-situ in rings after the tunnelling is complete.

3.2.2.2 Main Inlet / Outlet Tower to Pumping Station

3.23 This section of the conveyance tunnel links the pumping station that sits just outside the toe of the embankment to the tower within the footprint of the reservoir storage. Due to the need for internal pipework to be installed within it, this tunnel requires a larger cross section than the tunnel between the pumping station and the river intake / outfall structure. This would prevent the use of the same TBM for construction, and instead the tunnel would be constructed by excavation of the clay while a concrete lining would be sprayed onto the excavated barrel surface to form an in-situ concrete lining.

3.24 The tunnel could be driven in either direction, with the excavated clay placed within the reservoir embankment.

3.2.3 Pumping Station

3.25 The pumping station would be housed in a large buried rectangular box, which can also be used as the starting point for the TBM drive. The box would be constructed by installing a concrete diaphragm wall around the perimeter and excavating down with standard excavating plant, removing the spoil by cranes. The excavated material would then be used on site as embankment or landscape fill. A thick concrete base slab would be poured at the base, and the reinforced concrete frame of the pumping station building would be built within the box, which would also act to permanently prop the box walls.

3.26 The pumping station box poses one of the largest requirements for in-situ concrete for the project, with a required volume of approximately 16,000 m^3.

3.27 The construction process for the box is complex, and the main box structure must be largely formed before the tunnelling can start. The internal civil structure can then be built and would need to be complete prior to installation of pumps, valves, and pipework.

3.2.4 Reservoir Earthworks

3.28 The excavation of the borrow pit and subsequent placement of the excavated material to form the reservoir embankments is the most considerable construction activity and would require a large fleet of excavators, rollers, and dumper trucks.

3.29 The works would be carried out across four main summer working seasons to avoid the risk of poor winter weather affecting clay handling. It is likely that the embankment construction would focus initially along the northern side of the reservoir where the dam is highest and where there is an important interface with the conveyance tunnel.

3.30 The current concept design assumes that working hours for earthworks would be from 07:00 to 18:00 on weekdays with work between 07:00 to 13:00 on Saturday largely limited to enabling works and plant repairs.

3.2.4.1 Borrow pit excavation

3.31 The stripping of topsoil and vegetation from the borrow pit would be carried out alongside requirements for archaeological investigations.

3.32 The superficial deposits (overburden) encountered within the top of the borrow pit excavation are expected to only be suitable as landscaping fill, whilst the clay strata below would be used for structural fill. A deep working face would be established to allow both to be excavated concurrently as required to suit the embankment construction and reduce the need for double handling.

3.33 The borrow pit excavation would need extensive temporary works to control water (keeping it away from working faces and haulage routes) and store it in lagoons for settlement of fines prior to discharge into adjacent watercourses (or use as dust suppressant during construction and if necessary, for earthworks compaction). The lagoons / settlement ponds would be constructed at the northeast corner of the reservoir and be retained after construction as permanent water features for landscape and biodiversity improvement.

3.2.4.2 Embankment construction

3.34 It is envisaged that the embankment would be constructed with multiple work faces on either side of the start point progressing towards each other. The embankments would typically be constructed from the outside face towards the inside face. This enables the outer landscape fill to be placed first (thereby providing visual and noise barrier benefits, as well as reducing the need for double handling of superficial deposits).

3.35 All fill forming the embankment would be laid in thin (~150 mm) horizontal layers and compacted by appropriate roller plant.

3.36 There are two aspects of the embankment which must be constructed of imported material. One of these is the thin drainage / filter layer against the outer face of the highly impermeable 'core' and underneath the downstream shoulder. This must be constructed of suitable sand and gravel, which is not available on site. The other is rip-rap, which consists of stone blocks placed on the upstream face of the dam to prevent wave erosion.

3.37 It is envisaged that these materials would be imported to site by rail and then transported to the embankment working face via dumper trucks on haul roads. Stockpiling of these materials at the rail siding materials handling area would be necessary given expected difference between delivery timing (all year) and placement timing (summer only). Most drainage material would be required towards the start of the embankment construction, with more rip rap needed towards the end.

3.2.5 Reservoir Inlet / Outlet Towers

3.38 The towers would each be around 36-45 m high, including for a superstructure at the top to house equipment.

3.39 The towers would be formed of reinforced concrete, cast in-situ using either slip forming or jump forming techniques. The volume of concrete and steel in the tower is the same irrespective of construction method. It is likely that the towers would be constructed in sequence, so formwork can be re-used, and peak batching rates minimised.

3.2.6 Auxiliary Drawdown Channel

3.40 One of the most significant components of the construction of the Auxiliary Drawdown Channel is the culvert to allow the canal to cross below the A34, as mentioned in Section 2.2.10.

3.41 Three methods of construction have been considered:

- Option 1: Total diversion of the A34 to the east and / or west of current alignment and construction of canal crossing structure in open cut
- Option 2: Diversion of all A34 traffic to east side of the carriageway; installation of piles to form the walls of the canal crossing for the west side; construction of roof and road reinstatement on west side; repeat for similar construction on east side; when both sides constructed, let traffic run on top whilst excavating underneath and then forming the base of the canal crossing structure.
- Option 3: Construction of the complete canal structure and a jacking pit on one side of the A34; and steadily jacking (pushing) the structure under the carriageway whilst excavating the spoil from inside.

3.42 Option 1 or 2 are currently recommended for further consideration and continued consultation with National Highways and other stakeholders. Option 3 is now considered unfeasible given the shallow depth between carriageway level the top of the canal crossing structure.

3.3 Indicative Construction Programme

3.43 An indicative construction programme for the 150 Mm^3 variant is presented in Appendix B. For details on the pre-construction programme refer to the SESRO Gate 2 Report.

3.44 The main activities covered in the indicative construction programme are: road construction; compound construction; rail sidings / material handling area; delivery of material to material handling area; RFS / watercourse diversion; ADC channel and siphons; embankment construction (excavation, fill, drains and riprap); pumping station; tunnel construction; river intake / outfall structure; intake / outlet towers; finishing works (including landscaping and planting); reservoir impounding and project commissioning.

3.45 The following provides an overview of some of the above activities that the indicative programme has identified as on the critical path. These are provided to show the basis for the assumed 9 – 10 year construction programme:

- Mobilisation to site – April Year 1
- Completion of road access from A415 to the SESRO main compound and to the area where the rail siding is to be constructed – mid Year 2
- Completion of rail sidings and materials handling area – mid Year 3
- Initial delivery of gravel and sand for drainage material – late Year 3 / early Year 4
- Earthworks seasons 1 and 2 to take place during summer months – March to November Year 4 and March to November Year 5
- Initial delivery of riprap with sand / gravel bedding material – mid Year 4
- Earthworks seasons 3 and 4 (including riprap placement) – March to November Year 6 and March to November Year 7
- Completion works for the reservoir, including final riprap placement and wave wall – mid Year 8
- Impounding and commissioning – November Year 7 – April Year 10

3.46 Using the programme developed for the 150 Mm^3 variant as a basis, construction durations for the other variants have been considered. Many of the scheme components are the same regardless of the size of the reservoir, there is unlikely therefore to be a substantial difference in the overall construction programme. However, for reservoir sizes 100 Mm^3 and below, it is estimated that fewer earthworks seasons would be required and therefore these are estimated to have an 8 year construction period.

4. Future Scheme Development

4.1 This CDR describes the status of SESRO design development at Gate 2. Two further gates were described by Ofwat in the PR19 determination:

- Gate 3 – Developed design, finalised feasibility pre-planning investigations and planning applications
- Gate 4 – Planning applications, procurement, and land purchase

4.2 Ofwat also indicated that a Gate 5 may be required to allow regulators to review progress towards planning consents.

4.3 SESRO is a large scheme that would qualify as a Nationally Significant Infrastructure Project (NSIP), as explained in the SESRO Gate 2 Report. SESRO would therefore follow the Development Control Order (DCO) process to gain planning permission. This process (and other associated requirements such as Environmental Impact Assessment (EIA) regulations, compulsory land purchase rules etc.) has specific requirements around consultation and documentation for submission to DCO Examination. Gate 3 would not include planning applications for SESRO but would see the start of project specific informal consultations and preparation for a DCO submission as the project moves beyond long term water resources planning and progresses towards delivery.

4.4 The scheme would also qualify for the Direct Procurement for Customers (DPC) delivery process set out by Ofwat, which requires reporting at specified Control Points as a project moves towards construction. DPC would set up contracts to design (i.e. design detailing within the agreed planning envelope), build, finance and operate the scheme.

4.5 The SRO gates, DCO process and DPC procurement would progress in parallel after Gate 2 and design development would need to: provide an appropriate level of detail to satisfy RAPID that the project should progress through the gates; deliver data to the wider project team for planning and environmental assessment; and create sufficient project definition to inform DPC tender documentation. There would be a continued drive to reduce uncertainty and understand risk in cost estimates, and to ensure that safety (during the lifecycle of the scheme) is considered at every stage of design development.

4.6 The following sections outline key activities for future scheme development. Refer to the main Gate 2 report for further information about the timeline for the remaining gates and associated activities.

4.1 Design Principles

4.7 A series of measures would be developed to track how the design of the scheme responds to the ACWG and SESRO Design Principles. Design decisions that affect key considerations described by the Design Principles would be captured.

4.2 Design Development

4.8 Some elements of the SESRO design already go beyond the typical level of detail required for water resources planning; however, it is a large engineering scheme and there are still many elements of the design that require further development to give improved confidence in the planning envelope and cost estimates. The following sub-sections describe key future activities.

4.2.1 Ground Investigations

4.9 Information from historic Ground Investigation (GI) surveys is available for the SESRO site; however, additional information is now required to inform design development to Gates 3 and 4. GI would be particularly important for design of the roads, pumping station, river intake / outfall structure, reservoir towers, Auxiliary Drawdown Channel, conveyance tunnel and rail sidings. At a number of locations it is also recommended to carry out groundwater monitoring to inform future groundwater modelling.

4.10 Proposed locations for boreholes have been identified alongside recommendations for the tests and monitoring required. In particular, the boreholes required for groundwater monitoring should be prioritised so that monitoring can be carried out over a duration of 1-2 years.

4.2.2 Reservoir Borrow Pit and Embankment Design

4.11 The reservoir embankment is the most significant component of the scheme and therefore requires continuous design development throughout the gated process. Key areas for consideration in the next stage are as follows:

- Refinement of the shape of the borrow pit based on the results of further GI, to optimise for the best available clay quality.
- Embankment design development would include: Finite Element model calibration; analysis of the potential interaction between the embankment and the conveyance tunnel; confirmation of fill requirements for the proposed landscape strategy; and crest road detailing including desiccation cracking control measures and instrumentation / monitoring strategy.
- The above refinements to borrow pit and embankment design would need to account for the need to retain a balance between borrow pit excavation and

embankment fill. This would involve updates to the digital 3D modelling to review earthworks volumes required.

- Refinement of the design of the riprap for protection of the inner face of the embankment against wave erosion should be carried out. Physical wave modelling in a laboratory could be carried out to verify and optimise the design.

4.12 Future design developments associated with the reservoir will be carried out in consultation with the 'Reservoir Advisory Panel' (an independent expert engineering panel) as an auditing process to ensure best practice relating to reservoir safety is continually adopted.

4.2.3 Conveyance Tunnel Design

4.13 The conveyance tunnel design should be reviewed alongside any new GI information obtained along the revised tunnel alignment.

4.14 One of the main activities for conveyance tunnel design relates to the potential interaction between the tunnel and the reservoir embankment, and whether this results in a need for additional design elements to limit settlement and tunnel deformation.

4.15 The internal pressure that could be expected within the tunnel may require a secondary lining, or some alternative solution, to be incorporated into the design. This should also be considered at the next stage of design development.

4.16 A safe system of work should be developed for the operational phase which would consider access into the tunnel for inspection and maintenance alongside development of a methodology for periodically removing any accumulation of silt.

4.2.4 Structure Design

4.17 The design of the pumping station, river intake / outfall structure and the reservoir towers would need to be updated based on a review of outputs from the GI as well as aspects identified through the Gate 2 review.

4.18 Digital 3D models of the structures would be updated and used to improve material quantity estimates and cost estimates. These models would also be used within visualisations for public consultations as well as in visual impact assessment studies.

4.19 It is envisaged that architects and landscape architects would be engaged to allow structures to be developed in alignment with the SESRO Design Principles. As well as the structures mentioned above, the architects would also consider the visitor centre, café, education centre and sailing clubhouse.

4.20 A high-level options appraisal for alternative locations of the river intake / outfall structure should be carried out. There may be a potential to shift the structure away from the River Thames floodplain.

4.2.5 Auxiliary Drawdown Channel

4.21 Construction of the Auxiliary Drawdown Channel across the River Thames floodplain has a potential to impact River Thames flooding as raised levees are required. A River Thames flood model should therefore be used to consider the floodplain impact of the ADC. This model could subsequently be used to investigate solutions, which may include provision of siphons below the ADC.

4.22 Discussions with the Wilts and Berks Canal Trust should continue, which would include development of initial plans for how boats could be evacuated from the ADC in an emergency drawdown scenario. This may highlight whether any additional refuge locations would be required.

4.23 The design of the channel, locks, and road crossings (e.g. A34 and B4017) should be developed, considering outputs from the GI and further engagement with highways stakeholders.

4.2.6 Road and Access

4.24 Road junction modelling should continue to be refined with updated vehicle number estimates for construction material delivery, workforce commuting, and visitors. The review of the modelling should consider any new census data and traffic count surveys which could inform the baseline traffic conditions.

4.25 Inputs to the modelling should also consider other proposed / potential developments, including the National Highway's A34 improvement project, Marcham bypass, South Abingdon bypass, Wantage and Grove Station and housing developments.

4.26 Opportunities to provide improved public transport and walking / cycling links to the site should continue to be developed.

4.27 There are some variations to the route of the A415 to SESRO access road and the Steventon to East Hanney road diversion which should be considered in an options appraisal.

4.2.7 Cost and Carbon Estimates

4.28 As noted above, it is envisaged that digital 3D models would be used to develop more accurate quantity estimates which would feed into updated capital cost and embodied carbon assessments.

4.29 Opportunities for reduction in embodied carbon should be taken into consideration as the design develops.

4.3 Flood Review

4.3.1 Fluvial Flood Review

4.30 To allow updates to the fluvial flood modelling in Gate 3 it is recommended that a topographic survey along the main watercourses is carried out. This would include sections of the River Ock and key tributaries that are within the model extent. River gauge flow monitoring at selected locations across the model extent is also recommended.

4.31 A range of flood return periods and durations would need to be considered in the Gate 3 modelling. Therefore, the basis for the hydrology should be agreed with the Environment Agency. This would also include for potential future changes to climate change uplifts.

4.32 The Gate 2 model outputs show some areas where there is a relatively small increase in flood risk which would need to be addressed through updates to the design. This may include adjustments to watercourse diversion channel widths, Replacement Floodplain Storage levels, culvert sizes and / or road alignments.

4.33 As listed in the ADC section above, a River Thames flood model should be developed and used to investigate the potential impact of levees along the Auxiliary Drawdown Channel. If it is decided that the FSR is to be incorporated into the core SESRO scheme, it is recommended that this River Thames model is also linked to the River Ock model to investigate the joint probability of flood events.

4.34 Further assessment of opportunities for fluvial flood mitigation should continue. This includes: the possibility of using the A415 to SESRO access road as a flood embankment for a flood storage reservoir; and the potential for altering the abstraction regime to provide storage for downstream flood management.

4.3.2 Groundwater Flood Review

4.35 There is considerable uncertainty in the conceptual understanding of groundwater flows and hence the modelling that has been undertaken to date, which is not informed by observation data. Future GI plans would be designed to reduce this uncertainty for future model refinement.

4.36 It is recommended that:

- Observation boreholes are installed or recommissioned to monitor groundwater levels in the superficial deposits and Lower Greensand aquifers.
- Spot flow gauging is undertaken to improve the understanding of surface water flow across the study area and contributions from Chalk springs.
- New observation data are used to refine and update the model.
- Sensitivity testing is undertaken to understand the impact of assumptions made in the groundwater modelling, particularly to investigate the potential connectivity between the superficial deposits aquifer and the Lower Greensand and the conductance of the drain and river cells.

4.4 Construction Methodology Review

4.37 During Gate 3 the project would progress with EIA Scoping, which would require a good understanding of proposed construction activities including (but not limited to): access and on-site accommodation provision for the construction workforce; compound locations; construction and material delivery programme; materials handling and soil / earth movements; activities that could affect noise and air quality; and construction plant energy requirements. Further details of key aspects for this construction methodology review are discussed in the following sub-sections.

4.4.1 Site Layout

4.38 Site layout plans would be developed for different stages of construction based on the proposed construction programme. These would include, for example: size and location of construction compounds; size and location of rail siding materials handling area; the locations for noise bunding; areas for temporary soil storage; and haul roads.

4.4.2 Material Delivery

4.39 The main materials that are currently envisaged to be delivered by road are asphalt, road sub-base, road capping, concrete and fuel. The review of construction methodology should consider updates to material quantities for the Gate 3 design, potential source locations and the assumptions on capacity of HGV delivery vehicles.

4.40 The main materials to be delivered by rail include riprap, gravel and sand, therefore identifying a suitable programme for delivery of this material is an important aspect of confirming the overall construction programme. The work to date has identified potential paths for freight train delivery, however it is important that these continue to be discussed with Network Rail.

4.41 A more detailed options appraisal for the location and design of the rail siding and materials handling area should be carried out.

4.42 Network Rail has industry performance targets which would need to be maintained as a minimum, meaning that the current level of route safety performance and measured train accident risk cannot be degraded. These aspects would need to be taken into consideration in developing more detailed layouts of the rail siding and materials handling area.

4.4.3 Workforce Travel Plan

4.43 The size of the workforce would vary throughout the construction period, with higher numbers likely to be required during the summer months when earthworks are underway. It is recommended to review assumptions on the size of workforce and aspects which would impact how they would travel to the site. For example:

- Provision for accommodation on site could be increased to reduce the number of daily vehicle movements.
- Working hours (or shifts) could be set to reduce workforce travel during peak hours for other road users.
- Shuttle bus arrangements from nearby rail stations could be included.

4.5 Operating Strategy

4.5.1 Safety and Security

4.44 Key operation, inspection and maintenance activities across the site should be identified to ensure safety and security is incorporated into the design.

4.5.2 Visitor Travel Plan

4.45 Further work should be undertaken to refine estimates of the number of visitors that would visit the site for recreation. This would allow for refinement of junction designs as well as car park sizing. This would require further engagement on the masterplan and approach to recreational facilities.

4.46 Public transport routes and links into existing public rights of way are a key component of the design to encourage more sustainable access for visitors. These should be taken into consideration when estimating the likely number of cars entering the site.

4.5.3 Energy Requirements

4.47 Energy required for the operation of SESRO and energy generation from the hydropower turbines have been estimated. These estimates should continue to be reviewed and discussed with the Distribution Network Operator (DNO) to establish whether there would be sufficient network capacity.

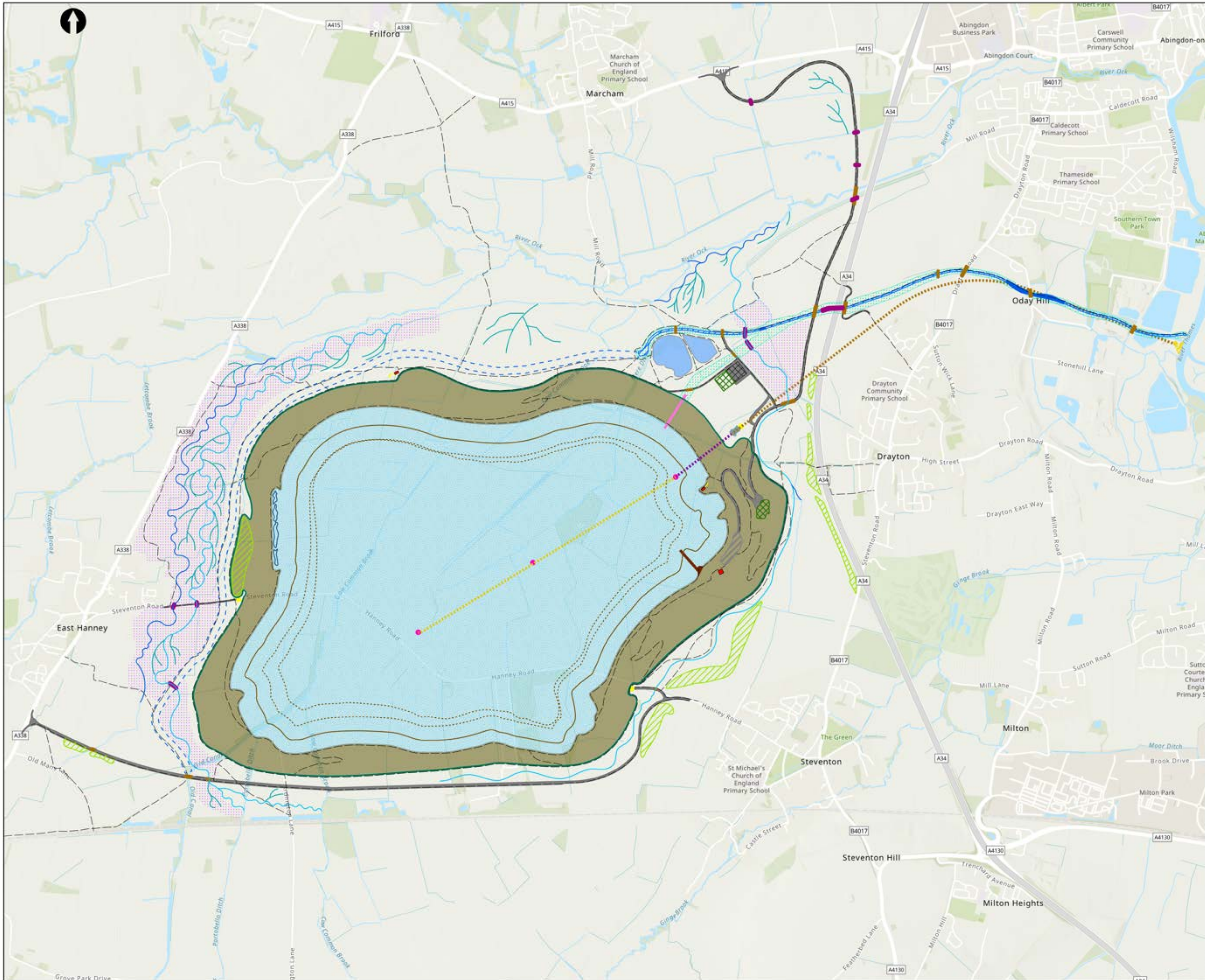
4.48 The energy required for alternative scheme operating principles should also be considered. For example, keeping reservoir water level low to provide storage for downstream flood mitigation.

4.49 Annual energy required for operation of SESRO would, on average, exceed annual energy generated by the hydropower turbines. Furthermore, SESRO energy requirements vary throughout the year. Therefore, additional renewable energy options should continue to be considered in the next stages of design development.

Appendix A SESRO Variant Indicative Layout Plans

A-1: SESRO Concept Design Report

A.1 Indicative layout plan - 150 Mm^3 capacity reservoir



Legend

Reservoir Items:
- Reservoir Embankment
- Reservoir Water Surface
- Reservoir Toe Drain
- Reservoir Lagoons
- Reservoir Inner Embankment Toe
- Reservoir Borrow Pit
- Auxiliary Drawdown Channel - Siphons
- Auxiliary Drawdown Channel - Locks
- Auxiliary Drawdown Channel - Water Surface
- Auxiliary Drawdown Channel - Extent of Cutting / Levees
- Outlet Tower Connecting Culvert
- Conveyance Tunnel - Section 1
- Conveyance Tunnel - Section 2

Watercourse Items:
- Watercourse Proposed Ditches
- Watercourse Proposed Diversions
- Watercourse Proposed Alignments
- Culverts
- Wilts & Berks Canal Corridor (for potential future development)

Access Items:
- Access roads
- Car Park - Grasscrete
- Car Park - Hardstanding
- Car Park - Small Hardstanding Area
- Bridges
- Footpaths / Cycleway/ Bridleway
- Boat Facilities Hardstanding (Indicative Extent)

Landscaping Items:
- Screening Bunds
- Settlement Ponds
- Replacement Floodplain Storage (indicative extent)

Structures:
- Pumping Station
- Reservoir Inlet and Outlet Towers
- River Intake / Outfall structure
- Promenade / Jetty
- Buildings for Recreation

0 500 1,000 Meters

Rev	Date	Description	Drawn	Ch'k'd	App'd
P2	29/06/22	Conceptual Design - June 22 (Gate 2)	BW	LB	RM
P1	22/02/22	Conceptual Design - July 21	LJ	DT	RM

MOTT MACDONALD
22 Station Road
Cambridge, CB1 2JD
T +44 (0)1223 463 500
F +44 (0)1223 461 007
W www.mottmac.com

Client

Affinity Water / Thames Water

Project Title

South East Strategic Reservoir Option (SESRO) Conceptual Design

Drawing Title

Site Overview 150Mm3 Option

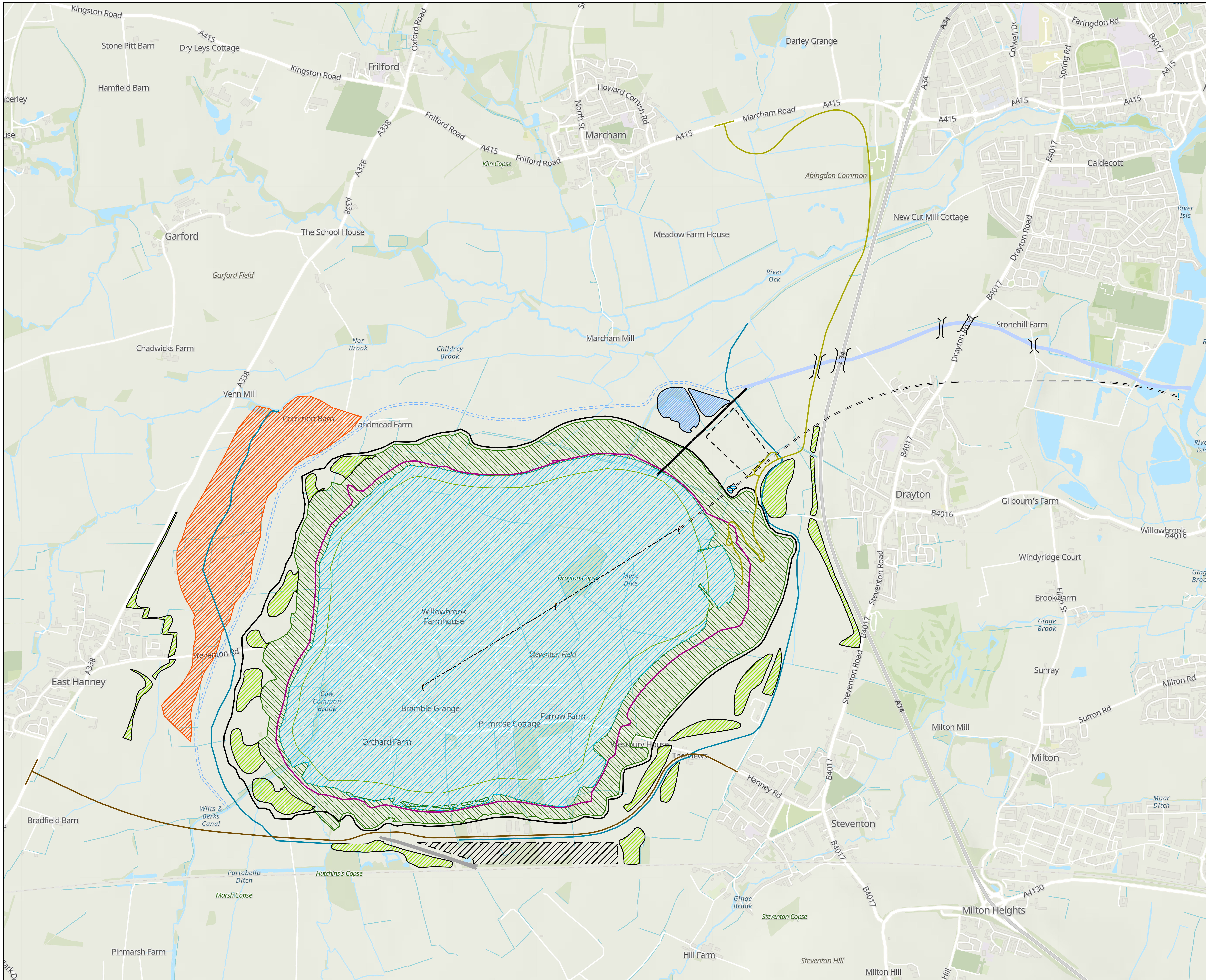
Scale at A2	MM Project No.	Status
1:17,500	405335	INF

GIS File TW South East Strategic Reservoir/Do/GIS/04 Map Composition/ArcGIS Online/SESRO_Conceptual_Design.aprx

Drawing No. MMD-405335-SESRO-010-OPT150-0001 Rev P2

Credits World Topographic Map: Esri Community Maps Contributors, Esri UK, Esri, HERE, Garmin, GeoTechnologies, Inc, METI/NASA, USGS
World Hillshade: Esri, Intermap, NASA, NGA, USGS

A.2 Indicative layout plan - 125 Mm^3 capacity reservoir



Legend

- Intake Outfall Structure
- Main Inlet-Outlet Tower
- Secondary Outlet Tower
- Access Road (A415 to SESRO)
- Auxiliary Discharge Siphons
- Auxiliary Drawdown Channel
- Bridges
- Connecting Culvert
- Conveyance Tunnel
- Crest of Embankment
- East Hanney to Steventon Road Diversion
- Inner Toe of Embankment
- Perimeter Access Track
- Railway Sidings
- Watercourse Diversion
- Wilts & Berks Canal - Indicative Route (Restoration W&BC and SESRO)
- Contractors Site Compound
- Embankment
- Materials Handling Area
- Pumping Station
- Replacement Flood Storage
- Screening Mounds
- Settlement Ponds
- Water Extent

Meters: 0 – 500 – 1,000

Rev	Date	Description	Drawn	Ch'k'd	App'd
1	18/06/21	Conceptual Design - July 21	LJ	DT	RM

MOTT MACDONALD
22 Station Road
Cambridge, CB1 2JD
T +44 (0)1223 463 500
F +44 (0)1223 461 007
W www.mottmac.com

Client: Affinity Water; Thames Water

Project Title

South East Strategic Reservoir Option (SESRO) Conceptual Design

Drawing Title

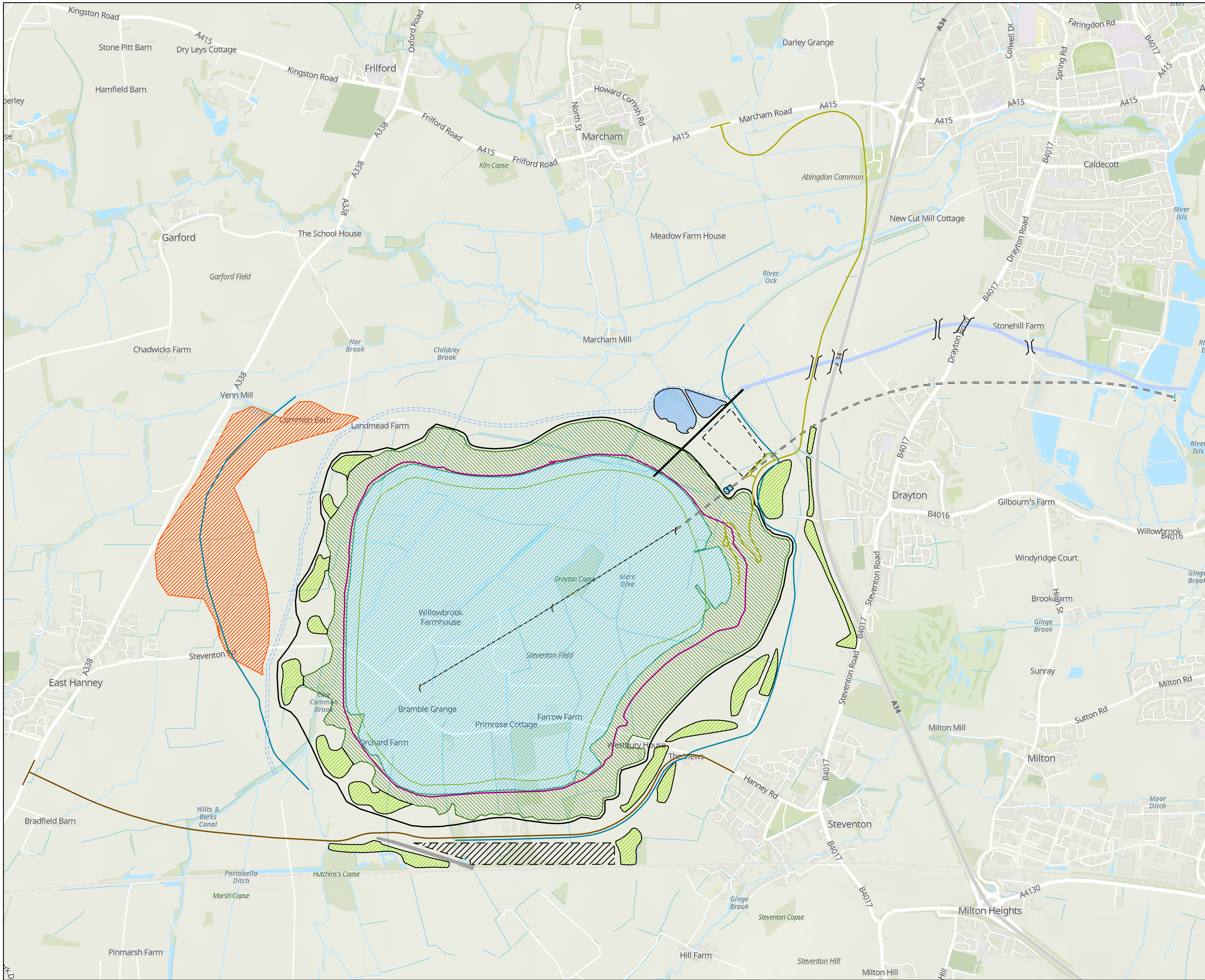
Site Overview 125Mm^3 Option

Scale at A2	MM Project No.	Status
1:17,500	405335	INF

GIS File: TW South East Strategic Reservoir/Do/GIS/04 Map Composition/ArcGIS Online/SESRO_Conceptual_Design.aprx

Drawing No.: MMD-405335-SESRO-010-OPT125-0001 — Rev 1

A.3 Indicative layout plan - 100 Mm^3 capacity reservoir



Legend

- Intake Outfall Structure
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0 500 1,000 Meters

Rev	Date	Description	Drawn	Ch'k'd	App'd
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MOTT MACDONALD
22 Station Road
Cambridge, CB1 2JD
T +44 (0)1223 463 500
F +44 (0)1223 461 007
W www.mottmac.com

Client

Affinity Water

Thames Water

Project Title

South East Strategic Reservoir Option (SESRO) Conceptual Design

Drawing Title

Site Overview 100Mm^3 Option

Scale at A2	MM Project No.	Status
1:17,500	405335	INF

GIS File TW South East Strategic Reservoir\Do\GIS\04 Map Composition\ArcGIS Online\SESRO_Conceptual_Design.aprx

Drawing No. MMD-405335-SESRO-010-OPT100-0001 Rev 1

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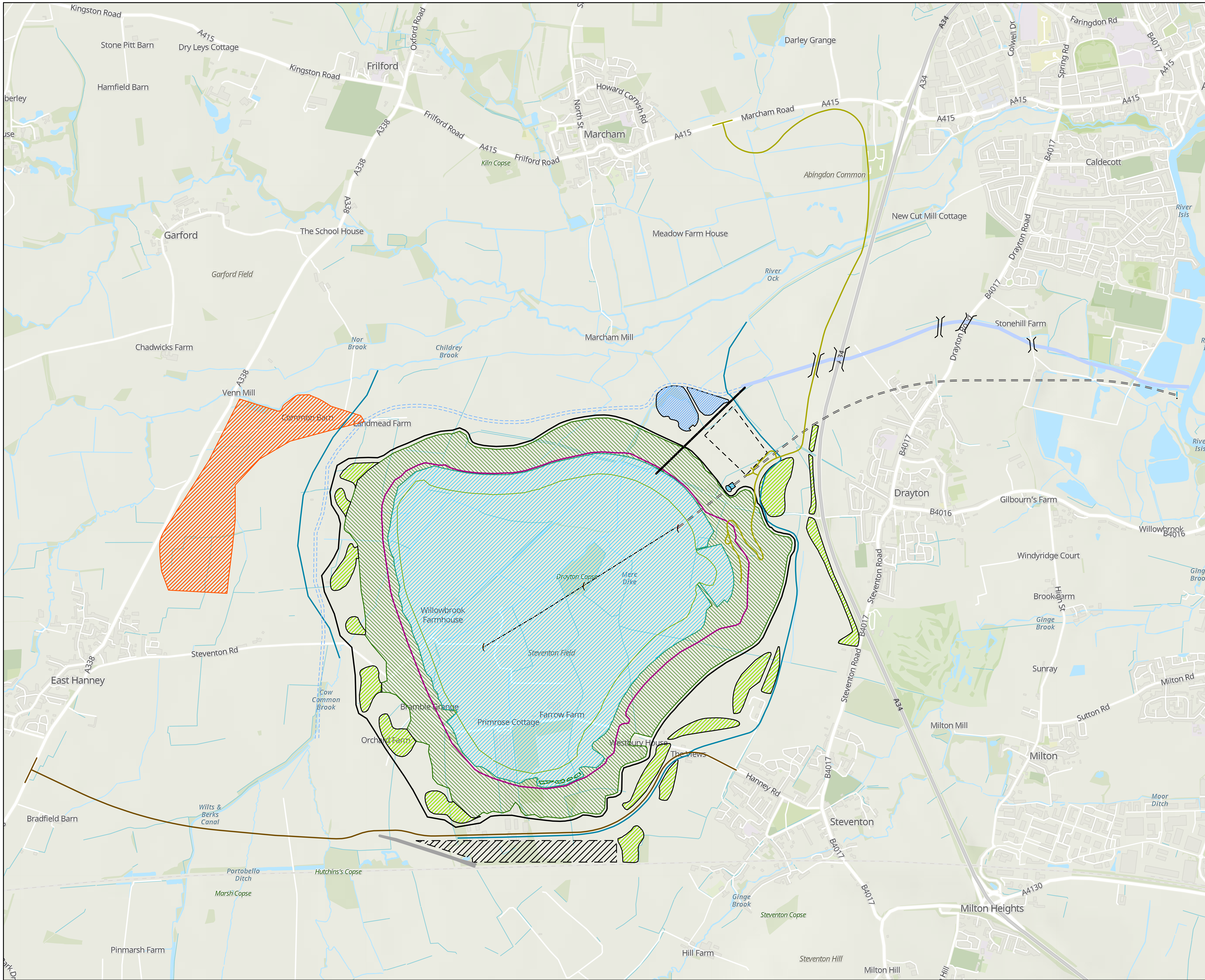
Contains data from OS Zoomstack
GB_Hillshade: Contains OS data © Crown Copyright and database right 2019

A.4 Indicative layout plan - 75 Mm^3 capacity reservoir



Legend

- Intake Outfall Structure
- Main Inlet-Outlet Tower
- Secondary Outlet Tower
- Access Road (A415 to SESRO)
- Auxiliary Discharge Siphons
- Auxiliary Drawdown Channel
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- Settlement Ponds
- Water Extent

0 500 1,000 Meters

Rev	Date	Description	Drawn	Ch'k'd	App'd
1	18/06/21	Conceptual Design - July 21	LJ	DT	RM

MOTT MACDONALD

22 Station Road
Cambridge, CB1 2JD
T +44 (0)1223 463 500
F +44 (0)1223 461 007
W www.mottmac.com

Client

Affinity Water
Thames Water

Project Title

South East Strategic Reservoir Option (SESRO) Conceptual Design

Drawing Title

Site Overview 75Mm^3 Option

Scale at A2	MM Project No.	Status
1:17,500	405335	INF

GIS File TW South East Strategic Reservoir/Do/GIS/04 Map Composition/ArcGIS Online/SESRO_Conceptual_Design.aprx

Drawing No. MMD-405335-SESRO-010-OPT075-0001 Rev 1

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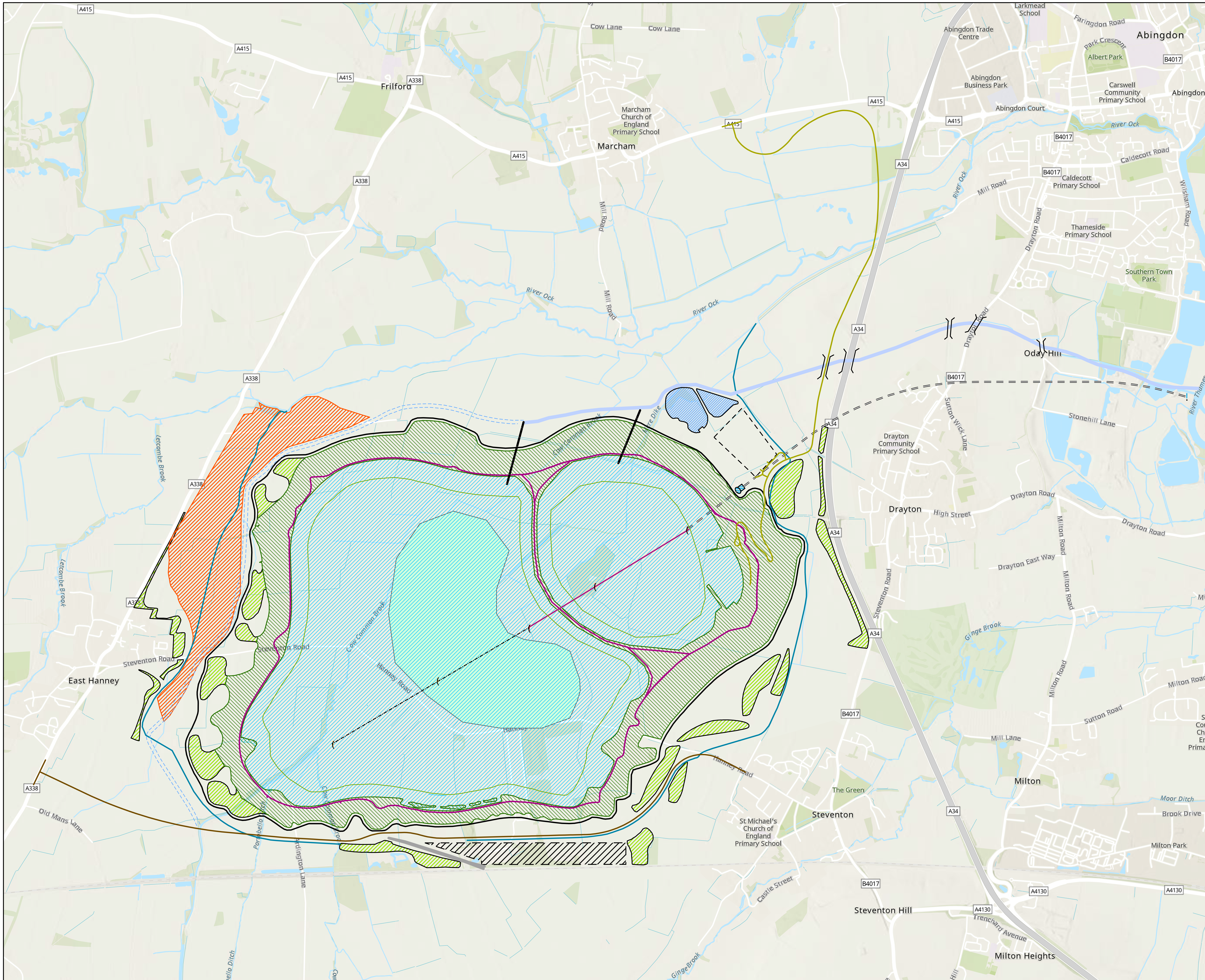
GB_Hillshade: Contains OS data © Crown Copyright and database right 2019

A.5 Indicative layout plan - 30 + 100 Mm^3 capacity reservoir



Legend

- Intake Outfall Structure
- Main Inlet-Outlet Tower
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- Auxiliary Discharge Siphons
- Auxiliary Drawdown Channel
- Bridges
- Connecting Culvert
- Conveyance Tunnel
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- East Hanney to Steventon Road Diversion
- Inner Toe of Embankment
- Perimeter Access Track
- Pressurised Steel Pipe
- Railway Sidings
- Watercourse Diversion
- Wilts & Berks Canal - Indicative Route (Restoration W&BC and SESRO)
- Contractors Site Compound
- Embankment
- Materials Handling Area
- Pumping Station
- Replacement Flood Storage
- Screening Mounds
- Settlement Ponds
- Water Extent
- Spoil Area

0 500 1,000 Meters

Rev	Date	Description	Drawn	Ch'k'd	App'd
1	18/06/21	Conceptual Design - July 21	LJ	DT	RM

MOTT MACDONALD
22 Station Road
Cambridge, CB1 2JD
T +44 (0)1223 463 500
F +44 (0)1223 461 007
W www.mottmac.com

Client

Affinity Water
Thames Water

Project Title

South East Strategic Reservoir Option (SESRO) Conceptual Design

Drawing Title

Site Overview 30Mm^3 + 100Mm^3 Option

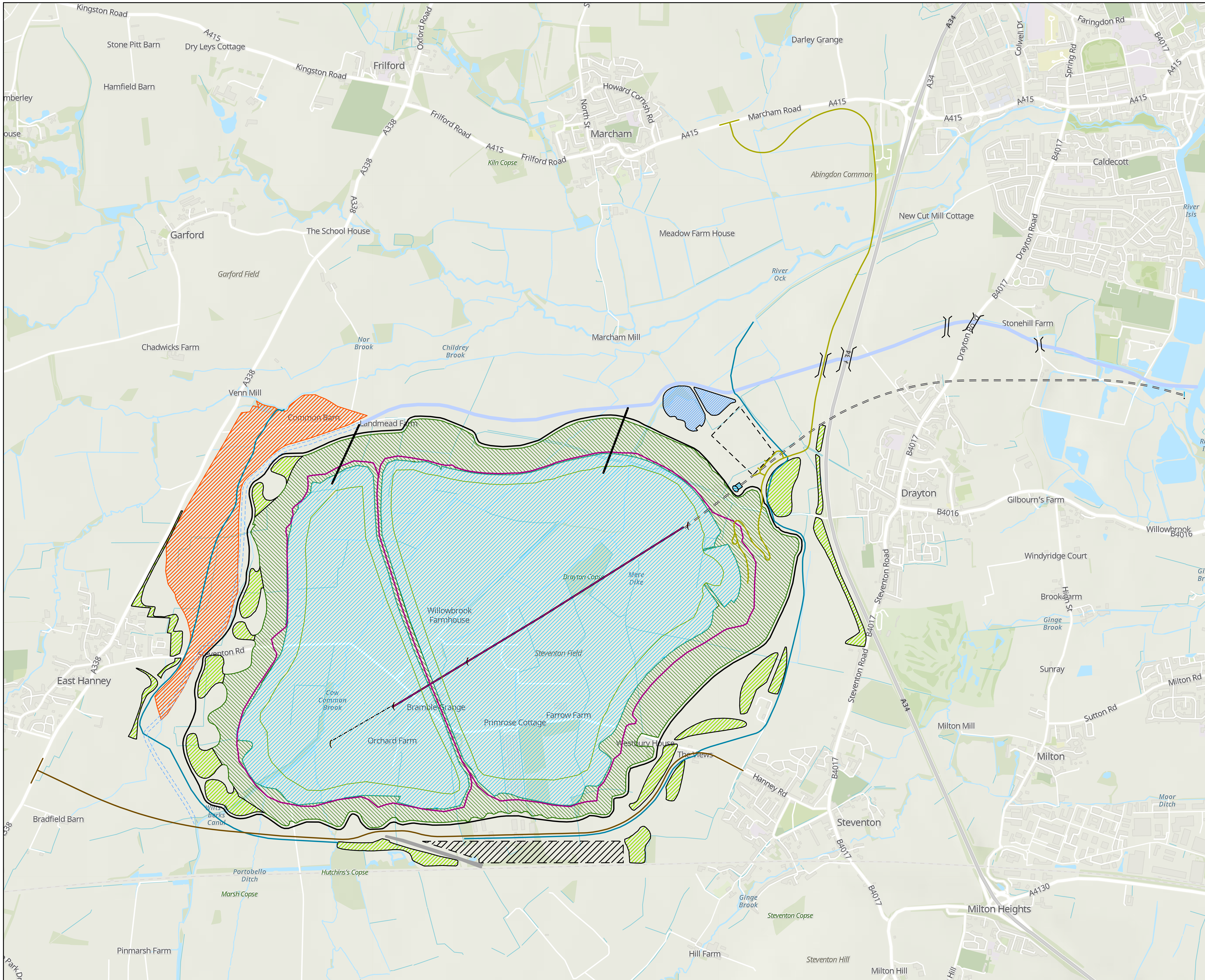
Scale at A2	MM Project No.	Status
1:17,500	405335	INF

GIS File: TW South East Strategic Reservoir/Do/GIS/04 Map Composition/ArcGIS Online/SESRO_Conceptual_Design.aprx

Drawing No.	Rev
MMD-405335-SESRO-010-OPT30+100-0001	1

Credits: World Topographic Map: Esri Community Maps Contributors, Esri UK, Esri, HERE, Garmin, Foursquare, GeoTechnologies, Inc, METI/NASA, USGS
World Hillshade: Esri, Intermap, NASA, NGA, USGS

A.6 Indicative layout plan - 80 + 42 Mm^3 capacity reservoir



Legend

- Intake Outfall Structure
- Main Inlet-Outlet Tower
- Secondary Outlet Tower
- Access Road (A415 to SESRO)
- Auxiliary Discharge Siphons
- Auxiliary Drawdown Channel
- Bridges
- Connecting Culvert
- Conveyance Tunnel
- Crest of Embankment
- East Hanney to Steventon Road Diversion
- Inner Toe of Embankment
- Perimeter Access Track
- Pressurised Steel Pipe
- Railway Sidings
- Watercourse Diversion
- Wilts & Berks Canal - Indicative Route (Restoration W&BC and SESRO)
- Contractors Site Compound
- Embankment
- Materials Handling Area
- Pumping Station
- Replacement Flood Storage
- Screening Mounds
- Settlement Ponds
- Water Extent

0 500 1,000 Meters

Rev	Date	Description	Drawn	Ch'k'd	App'd
1	18/06/21	Conceptual Design - July 21	LJ	DT	RM

MOTT MACDONALD

22 Station Road
Cambridge, CB1 2JD
T +44 (0)1223 463 500
F +44 (0)1223 461 007
W www.mottmac.com

Client

Affinity Water
Thames Water

Project Title

South East Strategic Reservoir Option (SESRO) Conceptual Design

Drawing Title

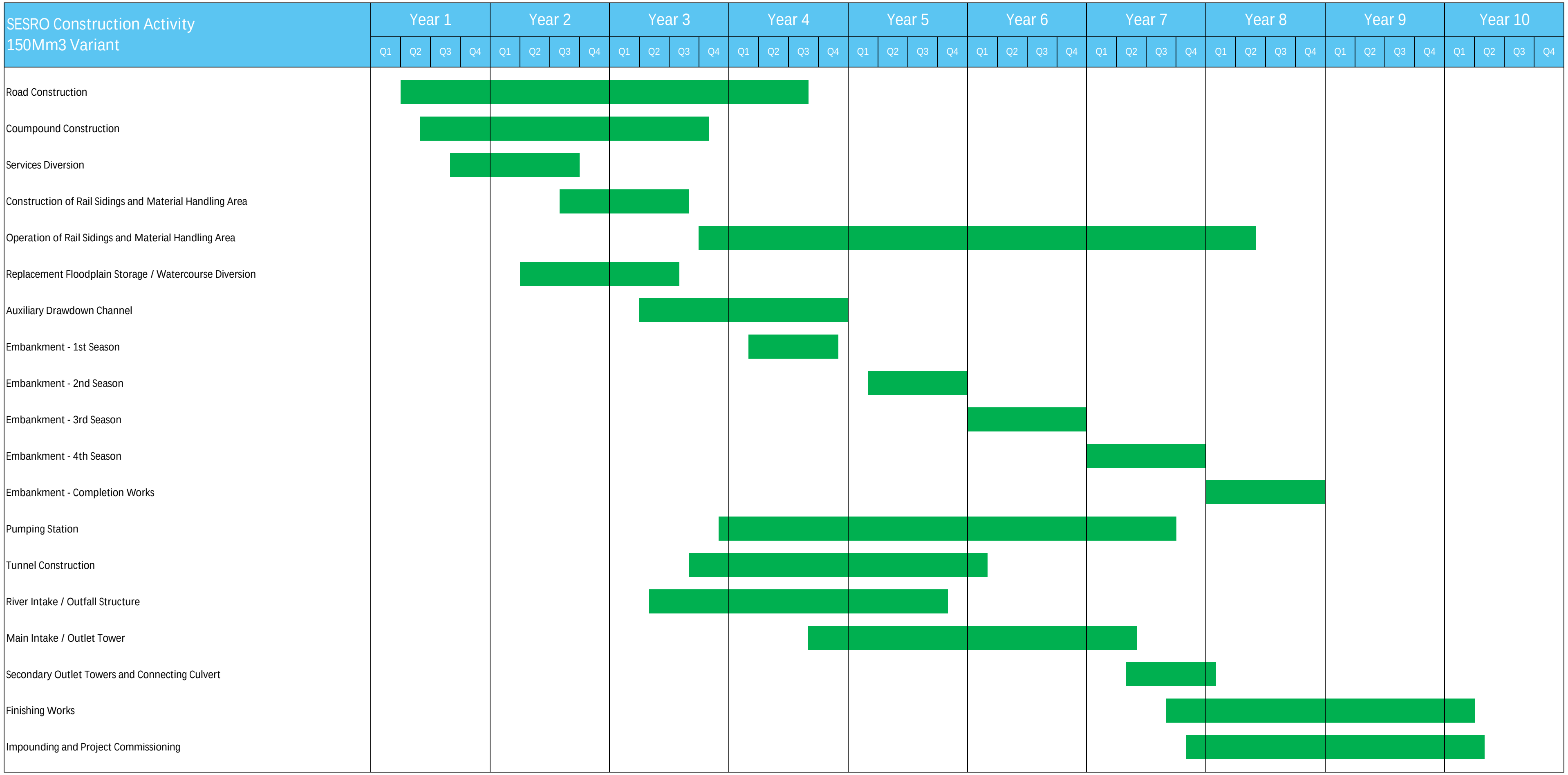
Site Overview 80Mm^3 + 42Mm^3 Option

Scale at A2	MM Project No.	Status
1:17,500	405335	INF

GIS File TW South East Strategic Reservoir/Do/GIS/04 Map Composition/ArcGIS Online/SESRO_Conceptual_Design.aprx

Drawing No. MMD-405335-SESRO-010-OPT80+42-0001 Rev 1

Appendix B Indicative Construction Programme


SESRO Construction Activity
150Mm3 Variant
Year 1
Year 2
Year 3
Year 4
Year 5
Year 6
Year 7
Year 8
Year 9
Year 10
Q1 Q2 Q3 Q4
Road Construction
Coumpound Construction
Services Diversion
Construction of Rail Sidings and Material Handling Area
Operation of Rail Sidings and Material Handling Area
Replacement Floodplain Storage / Watercourse Diversion
Auxiliary Drawdown Channel
Embankment - 1st Season
Embankment - 2nd Season
Embankment - 3rd Season
Embankment - 4th Season
Embankment - Completion Works
Pumping Station
Tunnel Construction
River Intake / Outfall Structure
Main Intake / Outlet Tower
Secondary Outlet Towers and Connecting Culvert
Finishing Works
Impounding and Project Commissioning

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