South East Strategic Reservoir Option Gate 1 submission – Technical Annex B1

Appendix A11.1 Natural Capital Assessment: Full Report

Thames Water Utilities Ltd

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1. Introduction

1.1. The Strategic Resource Option

The South East Strategic Reservoir Option (SESRO) is a strategic regional reservoir in Thames Water's PR19 Final Determination, with funding allocated on a two-thirds to one-third basis between Thames Water and Affinity Water (the SESRO partners).

There are currently six different SESRO options (referred to collectively as "the options"), each in the same approximate location with the size and shape altering slightly depending on proposed capacity:

- 75 Mm^3
- 100 Mm^3
- 125 Mm^3
- 150 Mm^3
- Two phase development 30 + 100 Mm^3
- Two phase development 80 + 42 Mm^3

Each option includes the reservoir itself; a River Thames intake and outfall; intake pumping station; tunnel from river to pumping station to reservoir; shaft at intake; rail siding for construction and access road.

1.2. Rationale for Natural Capital Assessment

Natural Capital is an economic concept recognising that nature provides benefits and value to people. It considers natural capital (habitats, species, air, soil, water, oceans, minerals and natural processes) as a stock, from which ecosystem services flow, providing valuable benefits. The SESRO options have the potential to change existing natural capital stocks through land use change and therefore alter the flows of benefits they provide. Natural Capital has emerged as the framework of choice for gaining a better appreciation of the interlinkages between the economy and the environment, and has been promoted by the government in the 25-Year Environment Plan (HM Government, 2019).

As outlined in Section 3.3 of the Ofwat (2019) PR19 Determinations Report, it is envisaged that SROs will be delivered via the Regulators' Alliance for Progressing Infrastructure Development (RAPID) *Gated Process*. Atkins have been appointed by Thames Water to provide environmental support to SESRO at RAPID Gate 1: Initial concept design and decision making. The purpose of the environmental assessment at Gate 1 is to generate sufficient information for an initial assessment of identified strategic solutions. This stage of the RAPID process is focused on eliminating solutions that are demonstrated to be unsuitable, no longer require further development funding or will not benefit from the structured gate process, and the identification of alternative solutions. The environmental assessment for Gate 1 includes initial option-level Strategic Environmental Assessment (SEA), as well as initial environmental, social and economic valuations.

The Water Resource Planning Guidelines (WRPG) and Supplementary Guidance (SG) from the Environment Agency, Ofwat and Natural Resources Wales (2020) (currently in draft format while being updated following consultation) require environmental, social and economic valuations to be delivered through a Natural Capital Assessment (NCA). The All Companies Working Group (ACWG) reviewed the draft WRPG SG and the RAPID process to devise the "WRMP environmental assessment guidance and applicability with SROs" (Mott MacDonald, 2020a, referred to throughout this report as "ACWG guidance"). This ACWG guidance specifies that for RAPID Gate 1 an initial NCA based on the draft WRPG SG is required to help inform concept design and aid decision making by quantifying the relative cost, benefits and disbenefits of SRO schemes to aid the initial assessment of the identified strategic solutions. The Environment Agency has indicated that for Gate 1 it is expected that an NCA should follow at least the "minimum" methodologies listed in the WRPG SG. SESRO therefore requires an NCA to comply with WRPG SG and ACWG guidance, thereby contributing to the optioneering process in RAPID Gate 1.

1.3. Scope

As SESRO falls within the Water Resources South East (WRSE) region, an NCA has been undertaken at the regional level as part of the WRSE regional plan. The WRSE regional-level NCA was conducted using the earlier iterations of SESRO design data available at the time and a methodology appropriate for the regional scale. The results were released to the individual water companies in January 2021 (Mott MacDonald, 2021a)

for them to review and update with respect to their individual SROs. The approach provided a framework to be built upon within the individual water companies' WRMPs and SRO assessments.

This NCA has been undertaken for SESRO on behalf of Thames Water based on the latest option design data (Mott MacDonald, 2021b, SESRO WRMP24 Geopackage issued on 28/01/21 (six options)) and incorporating more detailed site-specific information where possible, as well as reviewing the results from the WRSE NCA. The scope includes the following components:

- Reviewing previous environmental assessment work for the site of the six SESRO options;
- Establishing a natural capital baseline for the six SESRO options' zone of influence (ZOI) and quantification of how natural capital assets will change with each option in place;
- Qualitative and quantitative assessment of the ecosystem services that would be provided by natural capital assets, including monetary valuation of these where possible;
- Translation of the above assessment results into a "Natural Capital Metric" and comparison with WRSE results.

This NCA forms part of Tasks 7 and 8 of the environmental work package for SESRO. This NCA report is included as an Appendix to Technical Annex B Environmental Assessment Report (EAR) to the RAPID Gate 1 submission report, providing additional detail on the assessment methodology and results. The assessment is focused on ecosystem services benefits and value arising from natural capital stocks and changes in those stocks, but not quantify those which are based on other capital e.g. built capital. Contributions of other capitals to options' benefits and disbenefits are being considered in the Wider Benefits study (see EAR Chapter 11).

2. Methodology

The methodology for the SESRO options' Gate 1 NCA consists of six steps as illustrated in Figure 2-1:

Figure 2-1 - Steps in the SESRO Gate 1 NCA

The methodology was developed to align with the following guidance and WRSE regional NCA methods as appropriate:

- All Companies Working Group (ACWG) WRMP environmental assessment guidance and applicability with SROs (Mott MacDonald, 2020a)
- Water Resources Planning Guidelines (WRPG) and Supplementary Guidance (SG) Environment and Society in Decision Making (consultation draft, September 2020) (at least according to the "minimum" requirements, and using "best practice" approaches where possible)
- WRSE Natural Capital & Biodiversity Net Gain Method Statement (Mott MacDonald, 2020b)
- WRSE Regional Plan Environmental Assessment Methodology Guidance (Mott MacDonald, 2020c)
- Natural England, (2020), Natural Capital Indicators: for defining and measuring change in natural capital.
- Defra's Enabling a Natural Capital Approach (ENCA) guidance (2020)

As well as describing the methodology used in the Gate 1 NCA for the SESRO options, this chapter specifies and explains the degree of alignment in approach with the WRPG SG, ACWG and the WRSE regional NCA methods (Mott MacDonald, 2020b) for each assessment step.

2.1. Step 1: Natural Capital baseline

The existing natural capital stocks within the SESRO options' Zone of Influence (ZOI) were identified and categorised to align with Natural England's (2020) National Natural Capital Atlas (NNCA) asset quantity indicators (based on habitat and land cover types). The ZOI is defined in accordance with the SEA study area as the maximum extent of all the six SESRO options' land acquisition boundaries (LABs) combined into a single boundary area, plus a 2 km buffer. This therefore excludes upstream and downstream impacts outside of this boundary.

The stocks were mapped using open-source data of the same or similar nature and quality as the NNCA approach. The different land cover or habitat classes within each open-source dataset were aligned with the NNCA asset types (Table 2-1). A single asset type was then assigned to individual land parcels identified from OS MasterMap data within the ZOI based on the dominant CORINE, Priority Habitat Inventory, CROME or OS land cover class in the land parcel. If more than one category was present in a land parcel, priority was given to Priority Habitat Inventory, OS, CROME and CORINE data in that order based on the level of detail and accuracy of the data. This was verified through use of satellite photography and checked against the WRSE environmental geodatabase. The Active Floodplain NNCA "abiotic" asset type was also assessed as part of baseline development to identify the provision of potential natural hazard regulation (flooding) by the assets. Asset quantities are reported by area (hectares) in an asset register for each of the six LABs.

In addition to land cover, the length of watercourses (rivers and ditches) identified from OS Surface Water lines were identified within each LAB, and the perimeter of surface water bodies such as ponds and reservoirs identified from OS MasterMap were calculated to reflect the water margin of these features. These factors contribute to the natural capital value of these assets and are required for valuation of specific services (see below).

Table 2-1 – Summary of the datasets used to determine each NNCA asset types in the Natural Capital baseline

NNCA asset type	Open-source datasets used to determine baseline Natural Capital
Arable and Horticulture	Land parcel dominated by crops (identified from the Crop Map of England, 2017) or as non-irrigated arable land or complex cultivation patterns by CORINE land cover map (2018).
Improved grassland	Land parcel dominated by pasture by CORINE land cover map (2018). Land parcels covered by solar panels were also included in the category as satellite imagery showed grass between panels suggesting an improved grassland habitat underneath the panels.
Other semi-natural grassland	Land parcel dominated by good quality semi-improved grassland and lowland dry acid grassland from Natural England's Priority Habitat Inventory.
Hay meadow	Land parcel dominated by lowland meadows from Natural England's Priority Habitat Inventory
Lowland fen	Land parcel dominated by lowland fen from Natural England's Priority Habitat Inventory
Broadleaved, mixed and yew woodland	Land parcel classified as deciduous woodland by OS MasterMap or dominated by broad-leaved or mixed forest by CORINE land cover map (2018).
Coniferous woodland	Land parcel classified as coniferous woodland by OS MasterMap or dominated by coniferous forest by CORINE land cover map (2018).
Woodland priority habitat	Land parcel dominated by deciduous woodland from Natural England's Priority Habitat Inventory
Orchards and top fruit	Land parcel dominated by traditional orchard from the Natural England's Priority Habitat Inventory or fruit trees and berry plantations from CORINE land cover map (2018).
Coastal and floodplain grazing marsh	Land parcel dominated by coastal and floodplain grazing marsh from Natural England's Priority Habitat Inventory
Rivers	Land parcels identified as rivers, ditches and drains identified from the OS MasterMap.
Ponds	Land parcels less than 2 ha in area identified as static water from the OS MasterMap or as waterbodies from the CORINE land cover map (2018).
Modified water	Land parcels identified as reservoirs and canals from the OS MasterMap data.
Sport and leisure	Land parcels dominated by sport and leisure facilities identified from the CORINE land cover map (2018).
Mineral extraction	Land parcels dominated by mineral extraction sites identified from the CORINE land cover map (2018).
Manmade	Land parcels identified as manmade from OS MasterMap data or as continuous or discontinuous urban fabric, airports or industrial/commercial units from the CORINE land cover map (2018).
Active floodplain	Land parcels dominated by high or medium risk of flooding identified from the Environment Agency's Risk of Flooding from Rivers and Seas dataset.

Step 1 Inputs:

- SESRO WRMP24 LABs issued on 28/01/21 (six options)
- CORINE land cover map 2018
- Natural England's Priority Habitat Inventory
- Ordnance Survey (OS) MasterMap

- Ordnance Survey (OS) Surface Water line
- Crop Map of England (CROME) 2017
- Environment Agency's Risk of Flooding from Rivers and Seas
- WRSE SESRO geodatabase
- Google Earth satellite images

Step 1 Outputs:

- Map of Natural Capital stocks for the SESRO ZOI and within the LABs of each SESRO option
- Natural Capital asset register of each stock (in hectares) for each option

Step 1 Methodological alignment with relevant guidance and WRSE:

- Identifying existing natural capital stocks is a prerequisite for carrying out the assessment methodologies outlined in the WRPG SG and ACWG guidance, although in the latter this is specified as required at Gate 2 and not Gate 1. Compiling this asset register would nevertheless be a prerequisite for carrying out the assessment specified for Gate 1, hence its inclusion here.
- Asset quality and asset location and the use of quality and location indicators are not required for the Gate 1 NCA according to the WRPG SG and ACWG guidance, so this NCA is focused on asset quantity only (area in hectares). Quality and location should be considered in a Gate 2 NCA to comply with the ACWG guidance (see chapter 5).
- Prior to this assessment, WRSE also produced a natural capital baseline for the SESRO options using the NNCA approach. For the purposes of this NCA, a similar approach has been used using Priority Habitat Inventory and Risk of Flooding from Seas and Rivers, but also other open-source data that provide a greater level of detail and accuracy including CORINE, CROME and satellite imagery contributing to the baseline mapping process. These data enabled identification and mapping of assets at the field scale for individual land parcels delineated in OS MasterMap, thus providing an enhanced baseline resolution compared to the WRSE regional assessment.

2.2. Step 2: Change in Natural Capital assets

Natural Capital stock configurations were mapped and quantified for the alternative landcover arrangements that would be introduced by the six SESRO options. These changes in landcover have the potential to change asset quantities through introduction of reservoir features such as new water bodies, bunds, screening mounds, flood compensation areas and grey infrastructure as set out in the SESRO WRMP24 designs issued on 28/01/21 (Mott MacDonald, 2021b). This is a more recent design than used for the WRSE regional NCA. As no landscape design has been undertaken at Gate 1, habitat and landcover types were assigned to GIS polygons corresponding to these design features as informed by the Abingdon Reservoir Conceptual Design Report (CDR) (Mott MacDonald, 2021d), Biodiversity Net Gain assessment (Gate 1 Report, Annex B EAR, Chapter 11) and a review of corresponding assumptions made in the WRSE regional NCA for SESRO (see Table 2-2 for the NNCA type assigned to each design feature). Note: the feasibility of establishing these assets is outside the scope of this report, but uncertainty as to their potential future value is captured through sensitivity analysis in section 3.8.

Table 2-2 – NNCA asset type assigned to SESRO design features

SESRO design feature	Assigned NNCA asset type	Rationale
Embankment	Other semi-natural grassland	CDR appendix B shows conceptual plan to create biodiverse grassland areas on some embankments. Assumed intention to use some areas for grazing, arable farming or lowland heath not practical. Semi-natural grassland assumed for all embankment area.
Flood compensation area	Coastal and floodplain grazing marsh	CDR appendix B shows conceptual plan to create mix of ponds, scrapes and flushes, watercourses, ditches and unimproved grassland, and unimproved neutral grassland within flood compensation area. GIS design features provide area of flood compensation only, and this NNCA asset type is closest to including elements of all the intended

		features and was assumed as habitat type covering all of flood compensation area.
New roads, tracks, compounds and buildings	Manmade	Closest NNCA asset type available to design feature description.
Reservoir water extent	Modified water	Closest NNCA asset type available to design feature description.
Screening mounds	Broadleaved, mixed and yew woodland	CDR appendix B shows conceptual plan to create broadleaved woodland on screening mounds.
Settlement ponds	Ponds	Closest NNCA asset type available to design feature description.
Watercourse diversions and Auxiliary drawdown channel	Rivers	Closest NNCA asset type available to design feature description.

The coverage (area in hectares) of the various natural capital stocks were calculated for each option (in hectares) and presented in a natural capital asset register for comparison with the baseline. The length of new watercourses and the perimeter of new water bodies were also calculated for comparison with the baseline.

As no landcover changes are detailed outside of the options' LABs in the CDR or updated design issue (WRMP24 designs issued 28/01/21), assessment of change in natural capital stocks was focused only on assets inside the LABs for each option, with no change assumed for assets located in the wider ZOI. This is consistent with the WRPG SG which specifies option footprint as the minimum spatial extent of assessment and the WRSE regional NCA for the SESRO options. A static baseline was also assumed: no changes to existing asset quantities would occur within the LABs (e.g. due to climate, demographic or land use change) under a "do-nothing" scenario without the reservoir options or during the timeframe between the present day and a reservoir's construction. This is sufficient to comply with the WRPG SG and ACWG guidance for Gate 1. A dynamic baseline could be used in the Gate 2 NCA.

The following additional assumptions were made when assessing changes in natural capital stocks, and both are consistent with the assumptions used in the WRSE regional NCA for the SESRO options:

- Given that landscape design had not been undertaken for Gate 1 and the limited detail available in the CDR, assets or parts of assets located in areas within LABs that are not covered by design polygons (i.e. are outside of the design features mapped in the January 2021 design issue) were assumed to be restored post-construction to their original baseline asset type and were calculated as such.
- As location-specific construction mitigation plans were not available at Gate 1, all stocks within the LABs were assessed as if they would be lost during the construction period to provide a conservative estimate of their value given limited information.
- It will take time for new natural capital stocks to become established, so this assessment can be considered to be based on "best case" conditions, seeking to establish new habitats as early in the construction programme as possible.

Step 2 Inputs:

- Map of natural capital stocks (output from previous step)
- CDR report (Mott MacDonald, 2021d)
- SESRO WRMP24 designs issued on 28/01/21 including GIS data for each option comprising main design features

Step 2 Outputs:

- Natural Capital Asset register quantifying natural capital stocks for each option (area in hectares)

Step 2 Methodological alignment with relevant guidance and WRSE:

- Calculating changes in assets is a prerequisite for being able to carry out the assessment methodologies outlined in the WRPG SG and ACWG guidance, although in the latter this is specified as required at Gate 2 and not Gate 1. Compiling this asset register would nevertheless be a prerequisite for carrying out the assessment specified for Gate 1, hence its inclusion here.

- The approach and assumptions outlined above are consistent with that used in the WRSE regional NCA and are in accordance with the WRPG SG and ACWG guidance.
- The points of departure with the WRSE regional NCA for this assessment are that updated design data has been used in the mapping and quantification of assets at an enhanced resolution, and that determination of asset type for scheme design features was informed by the Biodiversity Net Gain assessment (Gate 1 Report, Annex B EAR, Chapter 11).

2.3. Step 3: Identification of ecosystem services

Natural Capital assets deliver valuable benefits to people through flows of ecosystem services. The ACWG guidance specifies that in a Gate 1 NCA the five ecosystem services set out in the WRPG SG should be assessed (definitions accord with WRPG SG usage):

- **Biodiversity and Habitat:** biodiversity acts as a supporting service, underlying the provisioning of many other ecosystem services;
- **Climate Regulation (carbon storage):** the capture and secure storage of carbon [by natural capital assets] that would otherwise be emitted to, or remain, in the atmosphere (in addition to construction and operational carbon);
- **Natural Hazard (flood and drought) regulation:** different habitat types have intrinsic flood risk management values by intercepting, storing and slowing water flows, and mitigate impacts of drought or improve drought resilience;
- **Water Purification:** the treatment service of natural capital assets, i.e. an asset that intercepts, removes or stores pollutants:
- **Water Regulation:** value of the benefit of the water to customers, current and future abstractors, as well as the value of leaving the water in the environment (note: this usage corresponds to description of the “water supply” as a provisioning service in ENCA (Defra, 2020), rather than the “water flow regulation” used in ENCA or National Ecosystem Assessment (NEA, 2011)).

Biodiversity and Habitat is being considered in the SESRO Gate 1 Biodiversity Net Gain assessment so it will not be repeated within the NCA. It is also not possible to assess drought regulation as part of the Natural Hazard Regulation service as there is no established methodology as detailed in the WRPG SG. As this methodology evolves the service could be assessed at a later RAPID Gate but will not be assessed in this Gate 1 NCA. Both of these exclusions align with the approach taken within the WRSE regional NCA.

The WRPG SG states that it should be considered whether an NCA should go beyond the minimum five services noted above. The WRSE regional NCA methodology (Mott MacDonald, 2020b) identified three additional ecosystem services could be relevant to the regional study area given its large rural coverage, potential for natural capital assets to influence air quality in nearby urban areas, and the potential for some SRO schemes to provide recreational opportunities. As described in ENCA, these are:

- **Food production:** food in its various forms is produced by a range of ecosystems;
- **Air pollutant removal:** by improving air quality, vegetation helps to lessen these impacts on health and wellbeing, resulting in lower health costs;
- **Recreation:** the recreational value of natural spaces reflects both the natural setting and the facilities on offer at the site and varies with the type of habitat, location, population density and the availability of substitute recreational opportunities.

These three additional services were included in this NCA. The need to include them was determined by reviewing the results and scoping decisions in the WRSE regional NCA (Mott MacDonald, 2021a) for the SESRO options against the natural capital asset register generated in the earlier assessment step, in addition to reviewing the SESRO Gate 1 SEA report findings and relevant CDR information. Other additional ecosystem services could also be considered in a Gate 2 NCA. Other benefits that link Natural Capital to other forms of Capital are being considered in the Wider Benefits study at Gate 1.

Step 3 Inputs:

- Natural Capital Asset register
- WRSE regional NCA for SESRO options (Mott MacDonald, 2021a)
- SEA report findings
- CDR (Mott MacDonald, 2021d)

Step 3 Outputs:

- List of ecosystem services selected for assessment.

Step 3 Methodological alignment with relevant guidance and WRSE:

- Where any of the minimum five ecosystem services specified in the WRPG SG and ACWG guidance for Gate 1 will be excluded from this NCA, this is consistent with the WRSE regional NCA.
- Where any of the minimum five ecosystem services WRPG SG and ACWG guidance or additional three services identified for the WRSE regional study area are scoped in to depart from the WRSE regional NCA, the rationale is explained.

2.4. Step 4: Qualitative assessment

Each of the selected ecosystem services has been assessed qualitatively for each of the six SESRO options in accordance with the WRPG SG. This is based on the Gate 1 SEA results and the natural capital asset register developed in the first stage of the NCA. The purpose of the qualitative assessment is to support the quantitative assessment and interpret the results of monetisation. A qualitative assessment of significance has been assigned to help determine which selected services could be significantly improved or diminished under each option. Where considered inappropriate or not possible for services to be quantified or monetised at Gate 1, this qualitative score can be used.

Step 4 Inputs:

- Natural Capital Asset register
- WRMP24 SESRO options design data (Jan 2021)
- CDR (Mott MacDonald, 2021d)
- Results of the SEA assessment for topics corresponding to each ecosystem service

Step 4 Outputs:

- Narrative commentary describing the effect of each option for the delivery of each service
- Qualitative score for each service/option combination:
  - ✓✓ Potentially major positive change
  - ✓ Potential minor to moderate positive change
  - o No material change expected
  - x Potential minor to moderate adverse change
  - xx Potentially major negative change

Step 4 Methodological alignment with relevant guidance and WRSE:

- Qualitative assessments have been be carried out according to the specification of the WRPG SG.
- The need for qualitative assessments is specified in the ACWG guidance and has also been performed in the WRSE regional NCA to interpret quantitative outputs.

2.5. Step 5: Quantitative assessment and monetisation

The ecosystem services selected for assessment were quantified and (where possible) monetised for each SESRO option based on the asset quantity indicator (area in hectares) calculated in the asset register. Ecosystem services flow and value have therefore been quantified based on the change in area for each asset type within each option's LAB footprint. This aligns with the ACWG guidance and the approach used in the WRSE regional NCA.

The valuation tables listed in the WRSE NCA Method Statement (Mott MacDonald, 2020b) have been used to monetise these services, and these have been supplemented where appropriate in accordance with best practice using other valuation databases listed within the WRPG SG list of suitable datasets. The qualitative assessment results were used to inform the choice of values, and where appropriate supplementary datasets have been used these are explained. The sources of the monetary values are reported and it is highlighted and justified where these deviate from the WRPG SG, ACWG guidance and WRSE NCA Method Statement (Mott MacDonald, 2020b). Sensitivity analysis was completed using lower and upper transfer values for each ecosystem service where available and appropriate. Where relevant all values are based on 2019 prices to ensure comparability between the baseline and scenario and are calculated on a "per year £ value" rather than total across the scheme lifetime. To ensure values are representative against the most up-to-date prices, monetary values were converted using the most recent government GDP deflators (UK Government, 2020).

The detailed methods used in the quantitative assessment and valuation for each ecosystem service are discussed Table 2-3 below, including alignment with relevant guidance and the WRSE regional NCA.

Table 2-3 – Summary methodologies for each ecosystem service, and comparison with guidance and WRSE regional approach

Ecosystem service	Quantification and valuation approach*	Alignment with relevant guidance and WRSE
Climate Regulation (carbon storage and sequestration)	Quantification of carbon sequestration rates is based on asset quantities (area in hectares) within the LABs for baseline and option scenarios. The per hectare biophysical flow of this service was calculated using the sequestration values in WRPG SG Table 7 supplemented with datasets from the ENCA services databook. Monetisation is based on the Department for Business, Energy and Industrial Strategy (BEIS) Interim Non- Traded Carbon Values listed in the WRPG SG and WRSE NCA method statement (Mott MacDonald, 2020b) for broad habitat types. This is supplemented by data on carbon emissions associated with energy use on arable land from FARMSCOPER and for other asset types not covered in the BEIS database. Note: at the time of the assessment Natural England's 2021 updated review of the evidence of the impacts of management decisions and condition of carbon stores and sources had yet to be published. This could be utilised in future NCA at Gate 2.	The approach aligns with the WRPG SG and the WRSE regional NCA assessment as the same carbon sequestration rates are used for the majority of assets and the same sources of monetised values are used as referenced in the WRPG SG. These are supplemented where appropriate from published sources using established databases for landcover and habitat types that are not covered in the WRPG SG and WRSE assessment sources.
Natural Hazard (flooding) regulation	Natural hazard regulation (flooding) is based on asset quantities (woodland and grazing marsh extents) to calculate approximate annual average flood storage volumes of these habitat types. Whether these assets are providing this service is determined by presence of an active floodplain within the LABs. Monetisation was based on the Joint UK Land Environment Simulator model (JULES) output values specified in the WRPG SG. Note that this an approximation based on habitat type only and is NOT based on the Flood Hazard Research Centre's (FHRC) Multi-Coloured Manual.	This approach is fully aligned with the WRPG SG and WRSE regional NCA methodology.
Water Purification	Based predominantly on mapping of agricultural land cover for baseline and with option scenarios. FARMSCOPER estimates of water quality parameters relating to agricultural activity were used to give an indication of the ability of different assets to provide water purification services. This assessment	Differs from the suggestions of the WRPG SG which refers to use of the Natural Environment Valuation Online (NEVO) tool. However, this tool provides limited spatial resolution at a 2 km^2 grid scale. The predominantly agricultural nature of the SESRO LABs and need for resolution at the site level meant that use

Ecosystem service	Quantification and valuation approach*	Alignment with relevant guidance and WRSE
	included quantification and monetisation based on estimates of water quality parameters relating to agricultural activity, which were used to give an indication of reduction in water quality and thereby the ability of land cover to provide water purification services. These water quality parameters are predominantly phosphorus (P) and nitrate (N).	of well-established FARMSCOPER values in conjunction with field-resolution asset mapping data was therefore more appropriate for this service. WRPG SG specifies “You can use whichever tool you assess to be most appropriate as long as you justify your approach” so this method can be considered aligned with the WRPG SG. The WRSE regional NCA considers water purification qualitatively only and it was assessed quantitatively and monetised in this NCA by making use of other established data sources.
Air Pollutant Removal	Based on mapping of land cover for baseline and option scenarios, and calculation of air quality benefit provided by each asset. The value provided by natural capital assets is taken from the UK government’s air quality economic assessment methodology (Jones et al., 2019) using a health cost avoidance approach with quantitative estimates for air pollution removal of different habitats listed by Mott MacDonald (2020b).	A method is not specified for this service in the WRPG SG or ACWG. The approach used fully aligns with that devised for use in the WRSE regional NCA (Mott MacDonald, 2020b).
Food Production	Based on quantifying the extent (area in hectares) of agriculture and horticulture assets for baseline and option scenarios. Monetisation of food production (based on agricultural production only, excludes fisheries) was estimated using a simplified resource rent approach, defined as the value of agricultural production after all agriculture costs such as fertilisers, pesticides, machinery, fuel and labour have been removed. This is a common method of valuing provisioning services to distinguish natural from other capital inputs. Gross margins for each land use type are calculated using the Defra FARMSCOPER tool that uses average costs and output prices for the period between 2011 and 2017, and the Nix Farm Management Pocketbook (2000-2013).	A method is not specified for this service in the WRPG SG or ACWG. The WRSE regional NCA approach uses NEVO to provide values based on a structural model of agricultural land use and production for Great Britain estimated using the Farm Business Survey (2005-2011). The model predicts decisions made by profit maximising farmers about how to allocate use of their land and does not include food production from livestock. The approach devised for this NCA uses valuation data to 2017 and includes a variety of crop types including livestock types and is based on actual mapped land use rather than modelled. The well-established FARMSCOPER values have also been validated at the field scale on other recent NCA projects (Atkins, 2020).
Recreation	The SESRO Estimation of Potential Visitor Numbers analysis (Mott Macdonald, 2021c) was used as the basis for the quantification and monetisation of the recreation service. The study estimated current visitors to the site based on visits to public bridleways that route across land within the LABs and provided an estimated number of trips should a SESRO option be completed including trips from nearby	A method is not specified for this service in the WRPG SG or ACWG. The WRSE regional NCA uses ORVal which is a standardised and widely used tool for assessing recreation. One limitation of the tool is that it is unable to account for additional visitor numbers for some uses specific to the facilities to be offered by the SESRO e.g. sailing. Use of the Estimation of Potential Visitor Number analysis therefore provide a more

Ecosystem service	Quantification and valuation approach*	Alignment with relevant guidance and WRSE
	urban areas and tourists. These visitor numbers were monetised using the Defra Environmental Value Look-Up Tool based on a lower bound (conservative) value for recreation and tourism (Sen et al., 2014; Hanley et al., 2001). The lower bound value is used to ensure the value of the service is not overestimated. These values were cross-checked against with outputs from the Outdoor Recreation Valuation (ORVal) tool. As all visitor numbers were assumed to be the same across all SESRO options in the Visitor Numbers analysis (assumed equivalent recreation facilities would be provided for all options), the recreation value was calculated for the maximum capacity reservoir only and applied to all options.	accurate estimate of recreational value compared to ORVal. The transfer value used to monetise recreation follows standardised approach using the Environmental Value Look-Up Tool which is referred to in the WRPG SG. A sense check was completed using the visitor numbers and welfare values from ORVal and comparing approximate £/visit values.
Water Regulation	To quantify the importance of the SESRO options' potential contribution to this ecosystem service to customers, their deployable outputs are calculated as a proportion of the baseline supply forecast (critical period) for the Swindon and Oxfordshire (SWOX) water resource zone. At Gate 1 it has not been quantified how SESRO will influence water abstraction elsewhere, although the hydrological assessment (Gate 1 Report, Annex B EAR, Chapter 4) does quantify changes in flows for the River Thames downstream of the proposed discharge point at Sutton Courtenay relative to baseline flow as part of the environmental assessment. It does not provide information about changes in abstraction supply and demand elsewhere following operation of a SESRO option. Quantifying the potential economic value of water left in the environment for other existing and future users and businesses is therefore not possible at this stage in the Gated RAPID process, but could be considered at Gate 2, such as for calculating potential benefits to chalk streams whose abstractions could be reduced through introduction of SESRO. This service is not quantified further in this Gate 1 NCA and is not monetised.	The WRPG SG stipulates that this service should be qualitatively and quantitatively assessed as a minimum, and this will be performed with available data in this Gate 1 NCA. The WRPG SG section on monetisation for this service states it should not be used for decision making purposes. Given the purpose of the Gate 1 NCA for informing choices on options is was therefore not considered appropriate to monetise this service. It would be assessed in monetary terms as the methodology is developed in a later assessment stage such as Gate 2. Water regulation is not assessed as part of the WRSE regional NCA but is included in the WRSE Environmental Destination workstream currently in progress.

* Note all values are in 2019 prices using the most recent government GDP deflators (UK Government, 2020).

Step 5 Inputs:

- Natural Capital Asset register: quantities (hectares) for baseline and option configurations

- Reference values and tool outputs specific to each ecosystem service

Step 5 Outputs:

- Natural Capital account: table of values for each ecosystem service summarising the value delivered across for each SESRO option during operation and comparison to the baseline (construction value assumed zero)

Step 5 Methodological alignment with relevant guidance and WRSE:

- The methods used to quantify and monetise each of the ecosystem services broadly align with the WRPG SG, ACWG guidance, and the WRSE regional NCA, and where alternative data sources, tools, or reference values have been used these align with approaches referenced in the WRPG SG and are explained above in Table 2-3.
- Where the techniques used within this NCA do depart from those used in the WRSE regional NCA, this provides an updated assessment using the latest design data for each option, enabling comparison with a more granular asset data and site-specific information, and draw on a wider range of established values databases for monetisation.

2.6. Step 6: Translation to Natural Capital metrics

In translating the results of this study into Gate 1 NC metrics, it is important to recognise that there are both benefits and disbenefits associated with each option due to differences in the direction of change for individual ecosystem services. It is important to recognise this in decision making and informing choice of options because trading off benefits against disbenefits or one service against another might not be appropriate in all circumstances. For each option three metrics have therefore been generated by this assessment:

- Total disbenefit: sum of services with negative change values (baseline versus option);
- Total benefit: sum of services with positive change values (baseline versus option);
- Net benefit: overall change in value across all services.

It is recommended that both the disbenefits and benefits are recognised in investment decision making. Note that these values are for the operational period of the reservoir only, with the natural capital value during construction assumed to be zero. This because of a lack of data showing projections for land use change over the construction period. For a qualitative assessment of construction impacts the SEA should be consulted.

Step 6 Inputs:

- Change (£/year) output values from the quantification and monetisation step (section 2.5) for all services.

Step 6 Outputs:

- Three NC metrics as defined above.

Step 6 Methodological alignment with relevant guidance and WRSE:

- This approach aligns with the WRSE regional NCA in that a net benefit based only on operational value on a £/year basis was calculated, summed across all services – this corresponds to the net benefit metric defined above.
- The approach differs from the WRSE regional NCA in that additional services are accounted for, and two additional metrics are reported to distinguish total disbenefits and total benefits for the reasons outlined above.

3. Results

3.1. Step 1: Natural Capital baseline

The majority of land within the ZOI is categorised as Arable and Horticulture: this is the largest stock by land area. The second largest area consists of built assets named as “Manmade” in the NNCA. There are also large areas of Improved Grassland and Coastal and Floodplain Grazing Marsh assets. The full breakdown of assets for the ZOI is detailed in Table 3-1 by NNCA classification.

Table 3-1 – Natural Capital Assets within the ZOI

Natural Capital Asset (landcover by NNCA type)	Area (ha) within the ZOI
Arable and Horticulture	4760.25
Broadleaved, mixed and yew woodland	142.58
Coastal and floodplain grazing marsh	355.24
Coniferous woodland	96.41
Hay meadows	11.09
Improved grassland (includes Pastures)	778.54
Lowland fens	0.60
Manmade	1142.36
Mineral extraction	0.25
Modified waters	5.81
Orchards and top fruit	20.91
Other semi-natural grassland	75.36
Ponds	54.97
Rivers and ditches (length in km)	74.75 km
Sport and leisure	36.52
Woodland priority habitat	168.71

Some areas of solar farms were also detected within the ZOI. For the purposes of this NCA they were classified as Improved grassland rather than Manmade due to the presence of vegetation cover interspersed with the solar panels on these sites visible in satellite photography. Although not considered at Gate 1, the renewable energy generation value of these sites (abiotic service) could be considered in an NCA at a later Gate.

Step 1 comparison with WRSE results:

- Corresponding asset types were compared between this NCA ZOI baseline and the WRSE regional NCA, and their relative quantities were sufficiently similar given the updates to the LAB boundaries in the latest design issue.
- The WRSE regional NCA uses the whole surface water operational catchment to define the ZOI meaning that the reported asset quantities are larger as a different spatial extent is used.
- In the Asset Register (see section 3.2) assets are presented only within the SESRO options’ footprints (i.e. LAB) and baseline values correspond in relative values and are broadly comparable in absolute terms. Differences in baseline values are likely due to use of updated design data (included update LAB extents) and the field-scale mapping of assets by this NCA.
- Manmade surfaces and impermeable surfaces are not considered within the WRSE asset register.

3.2. Step 2: Change in Natural Capital assets

As no landcover changes are detailed outside of the options' LABs in the option design data, assessment of changes in natural capital stocks only accounted for assets inside the LAB for each option, with no change assumed for assets located in the wider ZOI. Table 3-2 below provides an asset register, detailing changes in asset quantities (area in hectares) for each options' LAB compared to the baseline of existing assets. Only asset types present within the LABs are reported. Changes in assets are only reported for options once operational: for the purposes of the NCA all assets are assumed to be lost during construction (see section 2.2).

The changes in assets between baseline and option scenarios are broadly similar across the six options: net losses of Arable and Horticulture, Improved Grassland and Watercourses, with net increases in the areas of Modified Water (the reservoir water body), smaller increases in Broadleaved, mixed and yew woodland, Other semi natural grassland and Ponds. The changes are more pronounced for the larger capacity options because of their larger footprints, and differences between options on the basis of individual assets are due to alternative configurations of option design features.

Table 3-2 – Natural Capital Asset register (operation only, construction excluded)

Natural Capital asset (by NNCA classification)	150 Mm^3 (ha)			125 Mm^3 (ha)			100 Mm^3 (ha)			75 Mm^3 (ha)			30/100 Mm^3 (ha)			80/42 Mm^3 (ha)		
	Baseline	With scheme	Change	Baseline	With scheme	Change	Baseline	With scheme	Change	Baseline	With scheme	Change	Baseline	With scheme	Change	Baseline	With scheme	Change
Arable and Horticulture	1400	486	−914	1387	537	−850	1283	516	−767	1215	546	−669	1400	483	−916	1400	501	−899
Broadleaved, mixed and yew woodland or Woodland priority habitat	48	81	32	48	82	34	45	75	30	42	65	24	48	81	32	48	81	33
Coastal and floodplain grazing marsh	67	147	81	67	160	94	67	159	92	67	131	65	67	147	80	67	148	81
Coniferous woodland	0.2	0.2	0	0.2	0.2	0	0.2	0.2	0	0.2	0.2	0	0.2	0.2	0	0.2	0.2	0
Improved grassland*	148	31	−117	148	49	−99	148	71	−77	148	80	−69	148	31	−117	148	34	−114
Pastures	44	22	−22	44	23	−21	44	24	−20	44	22	−22	44	22	−22	44	22	−22
Manmade	51	65	14	51	66	16	50	68	18	49	70	21	51	66	15	51	55	4
Modified Water	3	664	662	3	585	583	2	497	495	2	394	392	3	654	651	3	650	647
Other semi natural grassland	0	229	229	0	210	210	0	195	195	0	223	223	0	238	238	0	243	243
Ponds	5	13	8	5	13	8	5	13	8	4	12	8	5	13	8	5	14	9
Rivers and ditches (length km)	67	30	−28	67	40	−27	62	40	−22	59	40	−19	67	38	−30	67	42	−25

Step 2 comparison with WRSE results:

- Changes in asset quantities and differences between options broadly correspond with the WRSE regional NCA results, allowing for slight differences in and updates to the LABs in the latest design issue.
- The WRSE regional NCA asset register also includes habitats outside of the option boundary within the wider ZOI, but changes are only assessed for assets within the LABs for the ecosystem services valuation which aligns with this NCA.
- All assets categories within the WRSE register that are not present within the LABs have not been included within the register, for example 'lowland fens' are not included.

3.3. Step 3: Identification of ecosystem services

In addition to the four ecosystem services identified for assessment in section 2.3, to comply with relevant guidance, the additional three services considered in the WRSE regional NCA were also identified for assessment in this NCA on the following grounds:

- **Food Production:** largest asset within the LABs is Arable and Horticulture land;
- **Air Pollutant Removal:** nearby Air Quality Management Areas (AQMAs) Marcham and Abingdon are less than 0.5 and 2 km from the LABs respectively, while option LABs are adjacent to main roads;
- **Recreation:** CDR includes mention of potential to provide visitor amenities and recreational features.

The full list of ecosystem services identified for assessment within this NCA were therefore:

1. Climate Regulation (carbon storage and sequestration)
2. Natural Hazard (flooding) regulation
3. Water Purification
4. Food production
5. Air Pollutant Removal
6. Recreation
7. Water regulation

Step 3 comparison with WRSE results:

- The WRSE regional NCA for the SESRO options had scoped out **Natural Hazard (flooding) regulation** despite the presence of an active floodplain within the LABs based on the assumption that the impact of the construction of the reservoir (built capital) would supersede the effect of the removal of trees (natural capital) within the LABs. The service was scoped in for this NCA to incorporate changes in Coastal and floodplain grazing marsh assets as well as woodlands which also contribute to this service.
- The WRSE regional NCA for the SESRO options had scoped out **Air Pollutant Removal** on the grounds that the AQMAs are not within the options' LABs. This NCA has identified this service for assessment on the grounds that the AQMAs are within the SEA ZOI and option LABs are adjacent to main roads.
- The WRSE regional NCA scoped out **Water Regulation** as this is considered in the WRSE Environmental Destination workstream. It has been included as part of this NCA for SESRO options (no monetisation).
- There were no differences in the rationale for inclusion of all the other services.

3.4. Step 4: Qualitative assessment

Table 3-3 presents the results of a qualitative assessment of the SESRO options by each individual ecosystem service. The options were expected to differ slightly only in terms of their magnitude due to their differences in spatial extents and consequences for changes in natural capital assets. The changes are assessed for once the new assets have had time to become fully established. A key for the qualitative score is shown in Table 3-4.

Table 3-3 – Qualitative assessment results by service

Service	Commentary	Score
Climate Regulation (carbon storage and sequestration)	Conversion of arable land to woodland, wetland and other habitats may provide benefits in terms of carbon sequestration due to the higher sequestration potential of the latter assets. There is an increase in deciduous woodland for all scenarios. Caution is advised in interpreting results as there may be significant carbon losses during land use change and it will take time for new landcover to become established before net sequestration rates increase. Results should be compared with	✓

Service	Commentary	Score
	assessments of construction and operational carbon emissions to provide a full lifecycle carbon assessment.	
Natural Hazard (flooding) regulation	Based on an overall increase in woodland and grazing marsh asset types (habitat-based assessment only), all scenarios have the potential to improve the flood regulation service compared to the predominantly arable landscape.	✓
Water Purification	Conversion of arable land to a variety of higher quality habitats is likely to reduce inputs of nutrients and pesticides to local watercourses, as well as providing filtration of surface water runoff from surrounding agricultural land. Increase of woodland cover and wetland habitats could also enhance this service.	✓
Air Pollutant Removal	Conversion of arable land to a variety of other habitat types, in particular woodland, will provide increased capacity for air pollutant removal with potential benefit to local air quality. This is expected to be minor for all six scenarios given that AQMAs are not present within the LABs but are less than 0.5 km away.	✓
Food Production	All options will result in loss of Arable and horticulture assets, reducing food production potential. There is potential for some food production to continue to occur within the site according to the CDR although the area will be much reduced.	xx
Recreation	Designs for all six scenarios include new recreational facilities such sailing, angling, new footpaths and car parking. Furthermore, the land use change away from agricultural land to freshwater habitats and woodland will increase the biodiversity and aesthetic attraction value of land within the LABs compared to its existing agricultural usage and this is expected to increase visitors.	✓✓
Water Regulation	All options will deliver an additional deployable output in water supply with the magnitude of increase varying depending on the capacity of each option, representing a positive change in provision of this service for customers. Considering the provision of this service for other abstractors (current and future), water will be abstracted from the River Thames to fill the reservoir and then released back into the river to be re-abstracted further downstream. The hydrological assessment (EAR, Chapter 4) outlines that abstraction would usually take place during times of higher flows and discharge in the drier parts of the year, so the value of water in left in the environment will be maintained while enabling provision of this service to other abstractors. One of the benefits that has been proposed for the SESRO options is in creating a surplus to facilitate a reduction in abstractions in other locations such as vulnerable chalk streams. This potential benefit is likely to vary depending on the capacity of the reservoir and is proposed for analysis in Gate 2.	✓✓ (but change is not due to changes in the natural capital assets as indicated by landcover change)

Table 3-4 – Qualitative assessment key

Score	Outcome
xx	Potentially major negative change
x	Potential minor to moderate negative change
o	No material change expected
✓	Potential minor to moderate positive change
✓✓	Potentially significant positive change

Step 4 comparison with WRSE results:

- Results correspond to the quantitative outputs of **Climate regulation, Food production, Water Purification** and **Recreation**. Qualitative results are not reported in the WRSE regional NCA.
- The other services assessed here were scoped out in the WRSE regional NCA.

3.5. Step 5: Quantitative assessment and monetisation

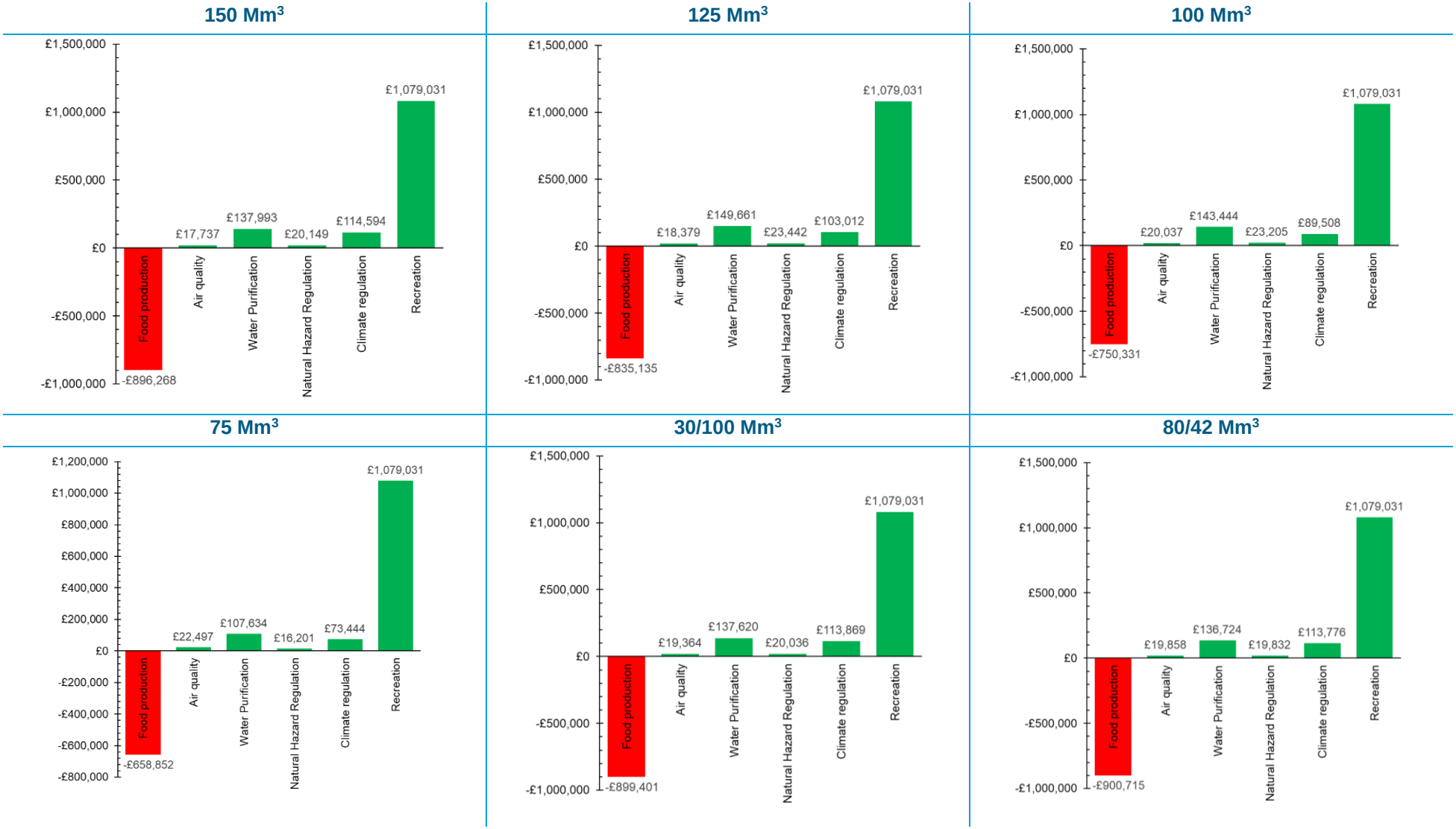
The following ecosystem services were quantified and monetised:

- **Climate Regulation (carbon storage and sequestration)**
- **Natural Hazard (flooding) regulation**
- **Water Purification**
- **Air Pollutant Removal**
- **Food Production**
- **Recreation**

As described above, **Water Regulation** was quantified in limited terms but not monetised.

The results are summarised for each ecosystem service in section 3.5.1 to section 3.5.7 below. For ease of interpretation, a visual breakdown for each option is illustrated in Figure 3-1 with corresponding numerical values in Table 3-5 to Table 3-10. Note that the Figures exclude water regulation which was not monetised and was assessed separately in section 3.5.7.

Figure 3-1 – Annual change in ecosystem services for each scenario (comparing to operation to baseline)



3.5.1. Climate Regulation (carbon storage and sequestration)

As shown in Table 3-5 all scenarios had a negative baseline value and a positive value with a SESRO option in place for climate regulation. The negative baseline for all scenarios is associated with carbon emissions from energy use associated with the management of agricultural land and reflects the poor carbon sequestration potential of arable land under prevailing management techniques. The change to a positive value with SESRO relates to an increase in quantities of assets with a higher carbon sequestration potential (woodland, grazing marsh, semi-natural grassland) as well as a reduction in emissions associated with agricultural energy use. Note that these results only include net change in emissions associated with land use change and do not include construction or operational carbon. These results should be considered together to understand the whole lifecycle carbon value of the scheme. Furthermore, the sequestration reference values used from the WRPG SG do not account for habitat maturity: it is likely sequestration rates will change over time as habitats establish and mature, and it is unlikely that these sequestration rates and their annual value will therefore remain constant. Caution should therefore be applied in using the absolute values generated in this study and can be considered for comparison between options only and not to provide an overall indication of natural capital value.

Comparing the options, the 150 Mm^3 option exhibits the largest increase in value of this service. This is predominantly due to the large extent of arable land in the baseline and its replacement with other assets that sequester more carbon.

Table 3-5 – Results: Climate regulation (carbon storage and sequestration)

Option	Baseline Value (£/year)	With SESRO Value (£/year)	Change in Value (£/year)
150 Mm^3	−£43,851	£70,743	£114,594
125 Mm^3	−£40,581	£62,760	£103,341
100 Mm^3	−£36,950	£52,963	£89,913
75 Mm^3	−£34,342	£39,334	£73,676
30/100 Mm^3	−£42,005	£72,137	£114,142
80/42 Mm^3	−£42,005	£72,043	£114,048

Note all values are in 2019 prices using the most recent government GDP deflators (UK Government, 2020).

Step 5 comparison with WRSE results – climate regulation:

- These results differ from the WRSE regional NCA outputs in terms of the absolute values for the baseline and option scenarios as carbon emissions from arable land management were not taken into account in the WRSE assessment. For this reason the WRSE results show a net decrease in carbon sequestration value rather than an increase. Furthermore, this assessment supplemented the WRSE regional NCA carbon sequestration value database for a wider range of asset types with values from other sources: for example, Natural England's value for wetland from Carbon storage by habitat: Review of the evidence of the impacts of management decisions and condition of carbon stores and sources (Natural England, 2012).

3.5.2. Natural Hazard (flooding) regulation

As shown in Table 3-6 there is an increase in the natural hazard regulation (flooding) value for all options (as provided by natural capital assets), ranging from approximately £20k to £40k per year. This increase relates to the increase in woodland landcover which provides greater flood storage volumes via canopy interception and soil water storage compared to the predominantly arable and horticulture landcover without the scheme. Changes in wetland type habitats, in particular Coastal and floodplain grazing marsh, also provide some flood storage capacity.

Overall, the 125 Mm^3 size option provides the largest increase in natural hazard regulation value due to this scenario having the largest quantity of woodland asset.

It is important to note that this assessment only shows the contribution of natural capital stocks, such as woodland and grazing marsh, to flood storage potential, and does not provide a comprehensive assessment of overall flood risk and protection of properties provided by the scheme as a whole. There will need to be a detailed flood risk assessment including economic valuation in a subsequent Gate assessment for this specific purpose.

Table 3-6 – Results: Natural Hazard (flooding) regulation

Option	Baseline Value (£/year)	With SESRO Value (£/year)	Change in Value (£/year)
150 Mm^3	£20,505	£40,655	£20,150
125 Mm^3	£20,496	£43,938	£23,442
100 Mm^3	£20,157	£43,363	£23,206
75 Mm^3	£19,826	£36,027	£16,201
30/100 Mm^3	£20,505	£40,542	£20,037
80/42 Mm^3	£20,505	£40,337	£19,832

Note all values are in 2019 prices using the most recent government GDP deflators (UK Government, 2020).

Step 5 comparison with WRSE results – natural hazard regulation (flooding):

- The WRSE regional NCA scoped out Natural hazard regulation (flooding) on the basis that the effect of the reservoir's construction would outweigh any change in the provision of flood storage potential due to woodland cover changes (see section 3.3). This assessment has quantified and monetised the contribution of these habitats in accordance with the WRPG SG for natural capital stocks only and not the overall contribution of the reservoir to flood risk.

3.5.3. Water Purification

As shown in Table 3-7 all options had a slightly positive baseline value and a more significant positive value with a SESRO option in place. The minor positive baseline for all scenarios is due to the poor water quality parameters associated with agricultural land, and the increase to a more significant positive value with options in place relates to the reduction in arable land and conversion to wetland type habitats (such as grazing marsh assets) which provide enhanced water purification services.

Overall the 125 Mm^3 option sees the largest increase in water purification value. This is predominantly due to the larger extent of arable land in the baseline for the site and the conversion to alternative habitats, in particular the flood compensation storage area which is largest of all the options in the 125 Mm^3 scenario.

Table 3-7 – Results: Water Purification

Option	Baseline Value (£/year)	With SESRO Value (£/year)	Change in Value (£/year)
150 Mm^3	£5,820	£143,813	£137,993
125 Mm^3	£7,742	£157,402	£149,660
100 Mm^3	£13,317	£156,761	£143,444

Option	Baseline Value (£/year)	With SESRO Value (£/year)	Change in Value (£/year)
75 Mm^3	£17,403	£125,038	£107,635
30/100 Mm^3	£5,820	£143,440	£137,620
80/42 Mm^3	£5,820	£142,544	£136,724

Note all values are in 2019 prices using the most recent government GDP deflators (UK Government, 2020).

Step 5 comparison with WRSE results – water purification:

- In the WRSE regional NCA water purification was only assessed qualitatively. This assessment included quantification and monetisation based on estimates of water quality parameters (P and N) relating to agricultural activity, which are used to give an indication of reduction in water quality and ability of land cover to provide water purification services.
- The qualitative assessment conducted as part of the WRSE regional NCA suggested that there would be a net loss in this service during construction with a net improvement in this service post-construction across the options.

3.5.4. Air Pollutant Removal

As shown in Table 3-8 all options show an increase in air pollutant removal potential from approximately £70k to £90k per year across the options. The expected improvement relates to the increase in woodland and grassland habitats in particular as they provide the largest air pollutant removal service, and the quantities of these assets will replace agricultural land which is less effective in providing this service.

Overall, there are only slight differences between options with changes in value ranging from £17,737 to £22,497 per year. The 75 Mm^3 option shows the largest increase in air pollutant removal value. This due to the scenario maintaining the largest extent of grassland compared to the other options, as well increasing woodland across the LAB. Although grassland provides air pollutant removal benefits on a less significant scale than woodland by collecting air pollutants on the plant surface, the area of grassland retained is behind the largest change in value for this option.

Table 3-8 – Results: Air Pollutant removal

Option	Baseline Value (£/year)	With SESRO Value (£/year)	Change in Value (£/year)
150 Mm^3	£73,626	£91,363	£17,737
125 Mm^3	£73,074	£91,453	£18,379
100 Mm^3	£69,701	£89,738	£20,037
75 Mm^3	£66,775	£89,272	£22,497
30/100 Mm^3	£73,626	£92,991	£19,365
80/42 Mm^3	£73,626	£93,485	£19,859

Note all values are in 2019 prices using the most recent government GDP deflators (UK Government, 2020).

Step 5 comparison with WRSE results – air pollutant removal:

- In the WRSE regional NCA as air pollutant removal is scoped out (see section 3.3). However, this assessment included air pollutant removal due to the nearby Marcham and Abingdon AQMAs that are situated <0.5 and <2 km from the LABs respectively.

3.5.5. Food Production

As shown in Table 3-9 all scenarios have a significant positive baseline value and a negative value with SESRO options in place. The significant negative change is associated with the loss of a large extent of arable land which is dedicated to producing food. Overall the 75 Mm^3 option sees the least disbenefit associated with food production because the option will entail the loss of arable land area compared with in the baseline.

Table 3-9 – Results: Food Production

Option	Baseline Value (£/year)	With SESRO Value (£/year)	Change in Value (£/year)
150 Mm^3	£1,360,691	£464,423	−£896,268
125 Mm^3	£1,322,788	£487,654	−£835,134
100 Mm^3	£1,213,135	£462,804	−£750,331
75 Mm^3	£1,132,384	£473,531	−£658,853
30/100 Mm^3	£1,360,691	£461,289	−£899,402
80/42 Mm^3	£1,360,691	£459,975	−£900,716

Note all values are in 2019 prices using the most recent government GDP deflators (UK Government, 2020).

Step 5 comparison with WRSE results – food production:

- Aligning with the WRSE regional NCA, this assessment estimates a loss in food production value across all SESRO options with greater losses for larger capacity options with larger LAB extents.
- Baseline values in the WRSE regional NCA are uniform across options (£1.7million per year) and these NCA values are approximately 25% lower in comparison. Service values for SESRO options are noticeably around five times lower than those in the WRSE regional NCA, and consequently the change in this service against the baseline is more pronounced.
- These differences could be because in the WRSE regional NCA NEVO modelling was used which does not consider food production value for livestock as well as crops. This assessment used FARMSCOPER values that contains estimates for a range of agricultural activities including crop and livestock, and the values were applied based on land cover at each site assessed at the field-scale rather than model predictions.

3.5.6. Recreation

As described in section 2.5, the same visitor number estimates have been used across all six SESRO options. As shown in Table 3-10, a comparison of the baseline and SESRO scenarios predicts an increase in recreation value due to a predicted rise in visitors to the site associated with expansion of natural capital assets of interest such as woodland and wetland, increased access from footpaths and car parks, the construction of a visitor centre and facilities for specific activities such as sailing and fishing.

Table 3-10 – Results: Recreation

Option	Baseline Value (£/year)	With SESRO Value (£/year)	Change in Value (£/year)
150 Mm^3	£141,910	£1,220,941	£1,079,031
125 Mm^3			
100 Mm^3			
75 Mm^3			
30/100 Mm^3			
80/42 Mm^3			

Note all values are in 2019 prices using the most recent government GDP deflators (UK Government, 2020).

Step 5 comparison with WRSE results – recreation:

- These results align with the WRSE regional NCA to the extent that both assessments estimate an increase in recreation value for SESRO options compared to the baseline due to the provision of recreational features and amenities.
- These results differ from the WRSE regional NCA in that the WRSE assessment was based on the outputs of the ORVal model, whereas this assessment included the visitor number results from the site-specific analysis: SESRO Options Estimation of Potential Visitor Numbers analysis (Mott MacDonald, 2021b). The ORVal analysis is considered likely to underestimate the recreation value as it does not account for the specific recreational activities that could take place at the site, such as sailing and fishing and additional attractions such as the visitor centre.
- These results also differ from the WRSE regional NCA in that this assessment provides a uniform value across options, because the latest design assumes the same provision of recreational features for all options,

3.5.7. Water regulation

To quantify the importance of the SESRO options' potential contribution to this ecosystem service to customers, their deployable outputs are calculated as a proportion of the baseline supply forecast (critical period) for the Swindon and Oxfordshire (SWOX) water resource zone in Table 3-11. The WRMP19 baseline supply forecast (critical period) value of 385.38Ml/d is used (Thames Water, 2019). The results illustrate that the larger capacity options can make a larger contribution to supply relative to baseline supply. Note that these figures are illustrative to quantify how important each source is as required by the WRPG SG, and that the largest capacity SESRO option is included within the final plan's total supply forecast value. As noted in the qualitative assessment, any potential positive benefit in this service is not due to changes in natural capital stocks, but effectively changing the location where the ecosystem service benefit will be experienced, rather than actually increasing the its provision in absolute terms.

Table 3-11 – Deployable output of options as a proportion of baseline forecast supply

	75 Mm^3	100 Mm^3	125 Mm^3	150 Mm^3	Two phase development 30 + 100 Mm^3	Two phase development 80 + 42 Mm^3
Deployable output (Ml/d)	161.0	210.0	253.0	294.0	69.0	170.0
As a proportion of baseline supply forecast (%)	41.8	54.5	65.6	76.3	17.9	44.1

The hydrological assessment (Gate 1 Report, Annex B EAR, Chapter 4) quantifies the changes in flows for the River Thames downstream of the proposed discharge point at Sutton Courtenay relative to baseline flow. The magnitudes of these changes in flows have been calculated as part of the environmental assessment and not for the purpose of assessing potential change in abstraction supply and demand elsewhere following operation of a SESRO option. Quantifying the potential economic value of water left in the environment for other existing and future users and businesses is therefore not possible at this stage in the Gated RAPID process, but could be considered at Gate 2; for example, calculating potential benefits to chalk streams whose abstractions could be reduced through introduction of SESRO. This service is not quantified further in this Gate 1 NCA and is not monetised (see section 2.5).

Step 5 comparison with WRSE results – recreation:

- Water regulation was not assessed in the WRSE regional NCA and the results the Environmental Destination is in progress.

3.5.8. Summary across ecosystem services

Table 3-12 below presents the overall balance of ecosystem value provided by natural capital assets across each of the six SESRO options comparing the baseline with the operational value (post-construction). This is for all the services assessed, except water regulation which was not monetised.

All six options show an increase in overall ecosystem services value and have a positive total net value. This is primarily due to the significant increase in recreation value expected for the site, which outweighs the decrease in ecosystem value of food production. Improvements in all the other services also exhibit an improvement in value compared to the baseline scenario, but as illustrated in Figure 3-1, without the increase in recreation value they are insufficient both alone and in combination to outweigh the change in Food production value.

Overall, options 75 and 100 exhibit the largest net positive change in value at £640k and £605k per year respectively. This is due to the combination of changes in different ecosystem service values, in particular:

- Food production: with a range in values due to the various arable land extents in the baseline and how much land is converted into other land uses in the scenario;
- Climate regulation: with variation based on woodland extent in the scenario and the associated carbon sequestration.
- Water purification: sees a range in values with the greatest benefits seen for scenarios with more wetland type habitats and less arable land.

Table 3-12 Summary results table for each SESRO option across all ecosystem services from NCA undertaken within this study

Option	Baseline Value (£/year)	With SESRO Option Value (£/year)	Change in Value (£/year)
150 Mm^3	£1,558,701	£2,031,938	£473,237
125 Mm^3	£1,525,429	£2,064,148	£538,719
100 Mm^3	£1,421,270	£2,026,570	£605,300
75 Mm^3	£1,343,956	£1,984,143	£640,187
30/100 Mm^3	£1,560,547	£2,031,340	£470,793
80/42 Mm^3	£1,560,547	£2,029,325	£468,778

Note all values are in 2019 prices using the most recent government GDP deflators (UK Government, 2020).

Sensitivity analysis was completed using lower and upper transfer values for each ecosystem service where available and appropriate. The analysis compared the figures for change in value between options for the different scenarios. As shown in Figure 3-2, the results demonstrated that in terms of options comparison the lower and upper values provide an overall consistent result for comparing between options. For three of the options the lower values result in a net negative rather than net positive change between baseline and option scenarios. These results suggest that caution should be applied in using the absolute values generated in this study (as well as the WRSE regional NCA) as the outputs are contingent on the transfer values used. It will take time for new assets to become established, which means that these benefits are unlikely to be realised immediately on scheme opening. In combination with the fact that the assessment was based on a limited set

of ecosystem services means that the results of this study (and the WRSE regional NCA) should therefore be used only for comparison between options and not to provide an overall indication of natural capital value for the SESRO options or the existing site. As the negative change values were small in magnitude for the lower bound values relative to the larger positive values for the mid and upper values, this suggests that - subject to the foregoing caveats - some confidence can be placed in the overall conclusion that the SESRO options could offer an overall improvement in natural capital value for the ecosystem services assessed, and that comparison between options on this basis is sufficiently robust. See Appendix A for further detail on the sensitivity analysis.

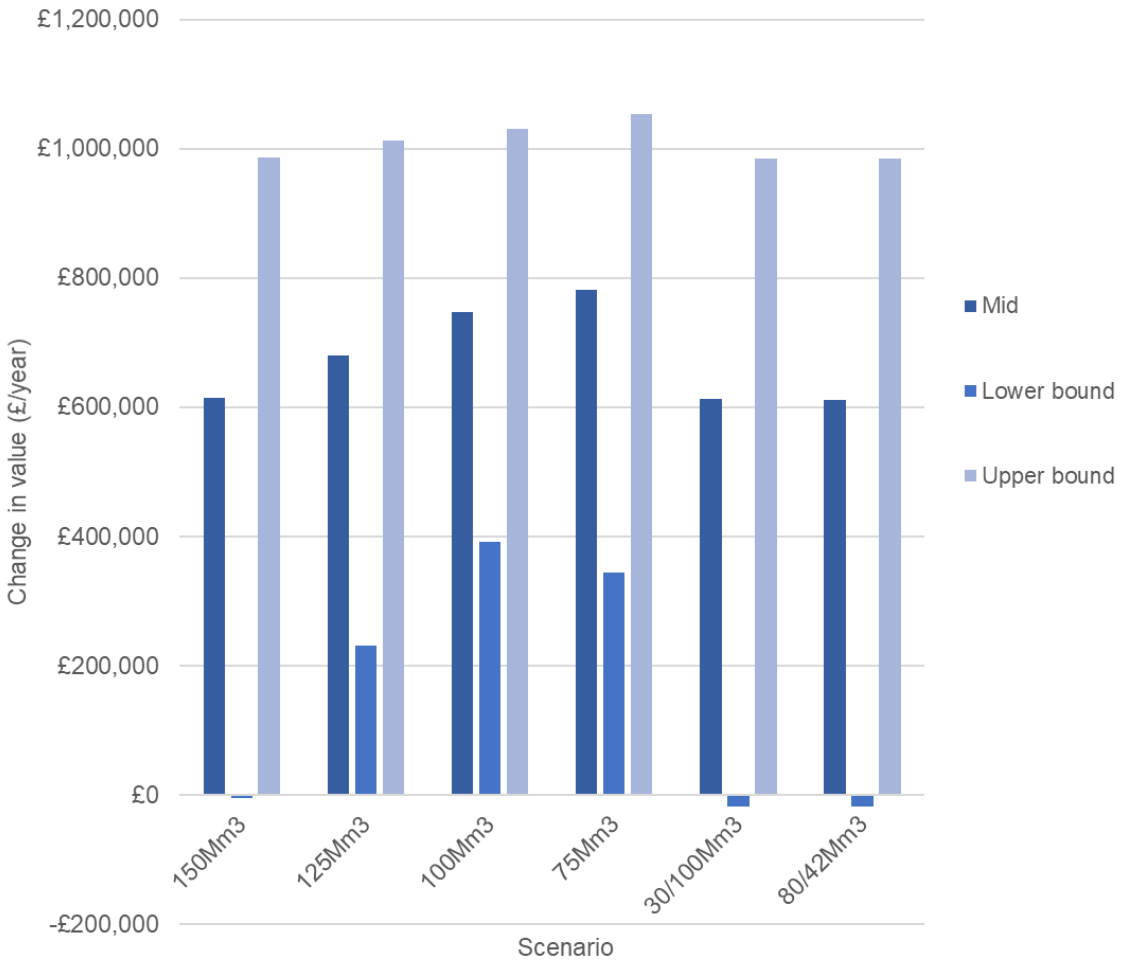


Figure 3-2 – Sensitivity analysis: change in value (£/year) – comparison of upper, lower and mid values

Step 5 comparison with WRSE results – overall change in value across services:

- As shown in Table 3-13, the figures representing the change in natural capital value are higher in this study than the WRSE regional NCA. For options 100, 75, 30/100 and 80/42 Mm^3 capacities this is within one order of magnitude difference, which in the emerging practice of natural capital accounting is not considered significant. For options 150 and 125 Mm^3 the values in this study are 20 and 43 times higher respectively. The higher values are likely to originate from the methodological differences between the two studies, most significantly accounting for additional visitor numbers for specific recreational activities, and inclusion of three additional services in the valuation for this study.
- The results show differences in the relative rank of options between this study and the WRSE regional NCA. This could be due to use of the updated design data within this study, including different LAB extents and new configurations of screening bunds and flood compensation areas.
- Sensitivity analysis was not conducted as part of the WRSE regional NCA. The results from the sensitivity analyses carried out here suggest that caution should be applied in citing absolute values from both studies and the results should only be used for comparison between options at Gate 1, and not for an overall indication of change in natural capital value.

Table 3-13 – Comparison of change in value between this study and the WRSE regional NCA

	This study		WRSE regional NCA	
Option	Change in Value (£/year)	Relative rank*	Change in Value (£/year)	Relative rank*
150 Mm^3	£473,237	4	£23,943	5
125 Mm^3	£538,719	3	£12,580	6
100 Mm^3	£605,300	2	£102,217	1
75 Mm^3	£640,187	1	£93,259	2
30/100 Mm^3	£470,793	5	£52,107	4
80/42 Mm^3	£468,778	6	£62,454	3

* Note: relative rank is based only on relative differences between options based on comparison of overall net change in value for each option and does not suggest or prescribe option preferences.

3.6. Step 6: Translation to Gate 1 Natural Capital metrics

In translating the results of this study into Gate 1 NC metrics, it is important to recognise that there are both benefits and disbenefits associated with each option due to differences in the direction of change for individual ecosystem services. In the case of SESRO, negative changes are estimated for the food production service, while the other services are expected to increase in value across the options. The metric excludes the water regulation service which was not valued. Table 3-14 reports the total disbenefit (negative change) and total benefit (positive change) in ecosystem services value, compared to the baseline value. A net value is calculated to demonstrate the overall balance in changes to the values across all services. It is recommended that both the disbenefits and benefits are recognised in investment decision making to ensure they are not traded off against each other. Note that these values are for the operational period of the reservoir only, with the natural capital value during construction assumed to be zero due to data limitations only. It should also be noted that these changes in value will not be immediately realised on opening of the scheme and will take time for services such as carbon sequestration and water purification to become positive.

Table 3-14 – SESRO Gate 1 NC metrics

	Option					
Metric	150 Mm^3	125 Mm^3	100 Mm^3	75 Mm^3	30/100 Mm^3	80/42 Mm^3
Total disbenefit (£/year)	−£896,268	−£835,134	−£750,331	−£658,853	−£899,402	−£900,716
Total benefit (£/year)	£1,369,505	£1,373,853	£1,355,631	£1,299,040	£1,370,195	£1,369,494
Net value (£/year)	£473,237	£538,719	£605,300	£640,187	£470,793	£468,778

Step 6 comparison with WRSE results:

- Comparison with the NC metrics delivered by the WRSE regional NCA are provided in section 3.5.8.

4. Conclusions

The main conclusions of the SESRO Gate 1 NCA were:

- All options demonstrate an overall positive change in natural capital value compared to the baseline on a £/year basis, although it should be noted that this improvement in natural capital value is unlikely to be realised immediately after scheme completion as it will take time for assets to become established;
- The reported positive change in natural capital value is primarily due to the significant increase in recreation value expected for the site, which outweighs the decrease in ecosystem value of food production – although improvements in all the other services are also reported in comparison to the baseline, without recreation they are insufficient both alone and in combination to outweigh the loss in food production value;
- Sensitivity analysis concluded that the results were sufficiently robust to allow comparison between options on the basis of their natural capital values, but caution should be used when citing the absolute values as these are contingent which transfer values are used in calculations;
- Options 75 Mm^3 and 100 Mm^3 exhibited the largest net positive change in value at £640k and £605k per year respectively due to the combination of changes in specific ecosystem service values, in particular their lower losses in food production due to their smaller footprint relative to the other options;
- The results were compared with the findings of the WRSE regional NCA at each stage in the assessment and for each ecosystem service. It is proposed that the NC metrics developed in this assessment can be used to update the WRSE values for the SESRO options given the enhancement in natural capital asset mapping resolution, extended valuation of additional ecosystem services and use of supplementary valuation databases.

5. Further assessment: Gate 2 NCA scope

According to the ACWG guidance, the purpose of the Gate 2 NCA is to support detailed feasibility, concept design and multi-solution decision making, producing metrics suitable for use in cost-benefit analysis (CBA). The ACWG guidance states that it should be informed by and compliant with both the WRPG SG and ENCA guidance.

The Gate 2 NCA should therefore provide an NCA with an expanded scope in comparison to Gate 1. This could include:

- Use of the “best practice” techniques referred to in the WRPG SG methodologies for the minimum five ecosystem services;
- Consideration of a broader range of ecosystem services based on stakeholder consultation and more detailed uses of the existing options sites; e.g. consideration of the renewable energy (solar power) value;
- Drawing on ENCA approaches such as the HMT Green Book four step approach and Natural Capital Accounting methodologies;
- Accounting for construction phase changes in value, the total lifecycle of the scheme, and ecosystem dynamics to determine if and when a tipping point in the balance of benefits (such as carbon sequestration) might occur;
- Use of NNCA quality and location indicators, as well as quantity indicators to provide more refined total benefit valuation figures for scheme lifecycle which are more appropriate for stakeholder consultation and design;
- Assessment of potential abstraction reductions in chalk streams and associated natural capital benefits.

The Gate 2 NCA should also be informed by use of field surveys, such as the UKHab survey which will inform the BNG assessment, as well as Gate 2 scheme designs.

To maximise the value of the Gate 2 NCA it is proposed that it should be incorporated into the iterative design process, both informing and utilising outputs of aspects such as option landscape designs. This will enable the scheme design to maximise the natural capital value of options with a view to achieve environmental net gain through Biodiversity Net Gain, and support flood risk and carbon assessments to account for the contribution of natural capital assets. This will enable the NCA to deliver greater value, not only as part of the design and assessment process, but also in supporting delivery of greater natural capital value to benefit customers, stakeholders, society and the environment. This will support the development of best value plans for Thames Water and Affinity Water.

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Appendices

Appendix A. Sensitivity Analysis

Sensitivity analysis was undertaken using lower and upper transfer values for each ecosystem service where available and appropriate. The monetisation results for each scenario and ecosystem service with low, mid and upper values are outlined below. Overall, it is clear that the 150 Mm^3, 30/100 Mm^3 and 84/42 Mm^3 options provide a lower ecosystem services value compared to the current baseline than the 125 Mm^3, 100 Mm^3 and 75 Mm^3 options.

Table A-1 – Lower bound sensitivity analysis

Ecosystem service	150 Mm^3	125 Mm^3	100 Mm^3	75 Mm^3	30/100 Mm^3	80/42 Mm^3
Food production	−£328,491	−£306,356	−£274,036	−£241,434	−£329,674	−£329,674
Air quality regulation	£12,112	£11,307	£11,246	£10,561	£12,024	£12,024
Water purification	£61,413	£63,716	£50,064	£47,058	£61,362	£61,362
Natural hazard regulation	£20,150	£23,442	£23,206	£16,201	£20,037	£20,037
Climate regulation	£0	£0	£0	£0	£0	£0
Recreation	£1,220,941	£1,220,941	£1,220,941	£1,220,941	£1,220,941	£1,220,941
Total	**£986,125**	**£1,013,050**	**£1,031,421**	**£1,053,327**	**£984,690**	**£984,690**

Note that all values are in 2019 prices using the most recent government GDP deflators (UK Government, 2020).

Table A-2 – Upper bound sensitivity analysis

Ecosystem service	150 Mm^3	125 Mm^3	100 Mm^3	75 Mm^3	30/100 Mm^3	80/42 Mm^3
Food production	−£2,378,994	−£2,215,734	−£1,995,161	−£1,748,968	−£2,387,187	−£2,387,187
Air quality regulation	£49,295	£49,013	£50,208	£53,067	£52,125	£52,125
Water purification	£367,181	£412,827	£400,771	£290,668	£365,603	£365,603
Natural hazard regulation	£392,763	£456,492	£448,918	£315,358	£390,499	£390,499
Climate regulation	£343,901	£308,517	£266,710	£213,604	£340,868	£340,868
Recreation	£1,220,941	£1,220,941	£1,220,941	£1,220,941	£1,220,941	£1,220,941
Total	**−£4,913**	**£232,056**	**£392,387**	**£344,670**	**−£17,151**	**−£17,151**

Note that all values are in 2019 prices using the most recent government GDP deflators (UK Government, 2020).

Table A-3 – Mid values used in assessment

Ecosystem service	150 Mm^3	125 Mm^3	100 Mm^3	75 Mm^3	30/100 Mm^3	80/42 Mm^3
Food production	−£896,268	−£835,134	−£750,331	−£658,853	−£899,402	−£900,716
Air quality regulation	£17,737	£18,379	£20,037	£22,497	£19,365	£19,859
Water purification	£137,993	£149,660	£143,444	£107,635	£137,620	£136,724
Natural hazard regulation	£20,150	£23,442	£23,206	£16,201	£20,037	£19,832
Climate regulation	£114,594	£103,341	£89,913	£73,676	£114,142	£114,048
Recreation	£1,220,941	£1,220,941	£1,220,941	£1,220,941	£1,220,941	£1,220,941

Ecosystem service	150 Mm^3	125 Mm^3	100 Mm^3	75 Mm^3	30/100 Mm^3	80/42 Mm^3
Total	**£615,147**	**£680,629**	**£747,210**	**£782,097**	**£612,703**	**£610,688**

Note that all values are in 2019 prices using the most recent government GDP deflators (UK Government, 2020).

Peter Mulder
Atkins Limited
Woodcote Grove
Ashley Road
Epsom
KT18 5BWWoodcote Grove
Ashley Road
Epsom
KT18 5BW

Tel: +44 (0)1372 726140
Fax: +44 (0)1372 740055
Tel: +44 (0)1372 726140
Fax: +44 (0)1372 740055
peter.mulder@atkinsglobal.com