ANNEX B4

Environmental Regulatory Assessments (HRA)

This document has been written in line with the requirements of the RAPID gate two guidance and to comply with the regulatory process pursuant to Severn Trent 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, Severn Trent 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.

STSources SRO
Severn Trent Water

SEVERN TRENT SOURCES STRATEGIC RESOURCE OPTION

B4 STS SRO Informal Habitat Regulation Assessment

Severn Trent Water Limited

Ricardo ref. ED16288 Issue: 3.1 11/08/2022

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1. INTRODUCTION

1.1 BACKGROUND AND PURPOSE OF REPORT

This report examines the Habitat Regulation Assessment (HRA) as part of the Severn Trent Sources (STS) Strategic Resource Option (SRO) ('the Scheme'). The Scheme was identified as an SRO in the PR19 Final Determination, with funding provided to Severn Trent Water (STW) as an individual company. The STS SRO is considered integral to the Severn Thames Transfer (STT) SRO. The central aspect of the STT is the interconnector which enables the transfer of raw water from the River Severn to the River Thames (Deerhurst to Culham pipeline). To support this transfer, additional sources of water are required to support baseline river flows. These additional sources of water will be supported by United Utilities and STW, which comprise of water resources that can be added, or not abstracted (redeployed), from the Rivers Vyrnwy, Severn, and Avon. This assessment only considers the STS SRO option, which comprises:

- A transfer of up to 35Ml/d of final effluent from Netheridge Wastewater Treatment Works (WwTW) to the River Severn at Haw Bridge.
- A 15Ml/d licence transfer from Mythe Water Treatment Works (WTW) to the Severn to Thames Transfer pipeline abstraction location at Deerhurst.

This report is a Technical Appendix to the STS SRO Interim Environmental Assessment (IEA), which provides further background information to the Scheme.

In October 2020, the group of Water Companies involved in developing SROs (known as the All Company Working Group - ACWG), published guidance[1] for environmental assessment methods for SROs which is aligned to the draft Water Resources Planning Guideline (WRPG): Working Version for Water Resource Management Plan 2024 (WRMP24) to increase the consistency of environmental assessment and the evaluation of impacts on environmental water quality in particular.

The ACWG guidance states that the HRA for each SRO should be undertaken in accordance with available guidance for England and Wales and should be based on a precautionary approach as required under the HRA process. The requirement for a HRA is established through the Conservation of Habitats and Species Regulations 2017 (as amended), commonly referred to as the Habitats Regulations. Under Regulations 63 and 105, any plan or project which is likely to have a significant effect on a European site (either alone or in-combination with other plans or projects) and is not directly connected with, or necessary for the management of the site, must be subject to a HRA to determine the implications for the site in view of its conservation objectives.

As such, the STS SRO should meet the requirements of the Habitats Regulations before implementation. The STS SRO was subject to an HRA during the Gate 1 assessments adopting the principals of HRA in 2021.

The amended Habitats Regulations[2] have created a national site network on land and at sea, including both the inshore and offshore marine areas, in the UK. The national site network includes:

- existing Special Areas of Conservation (SACs)[3] and Special Protected Areas (SPAs) [4]
- new SACs and SPAs designated under these Regulations

Designated Wetlands of International Importance (known as Ramsar sites) do not form part of the national site network. Many Ramsar sites overlap with SACs and SPAs, and may be designated for the same or different species and habitats. All Ramsar sites are protected in the same way as SACs and SPAs. A HRA is also required, as a matter of UK Government policy potential SPAs (pSPAs), possible

[1] Mott MacDonald Limited (2020). All Companies Working Group WRMP environmental assessment guidance and applicability with SROs. Published October 2020

[2] The Conservation of Habitats and Species (Amendment) (EU Exit) Regulations 2019

[3] SACs were designated under the Habitats Directive (92/43/EEC) and target particular habitats (Annex 1) and/or species (Annex II) identified as being of European importance.

[4] SPAs were classified under the European Council Directive 'on the conservation of wild birds' (2009/147/EC; 'Birds Directive') for the protection of wild birds and their habitats (including particularly rare and vulnerable species listed in Annex 1 of the Birds Directive, and migratory species).

SACs (pSAC) and listed or proposed Ramsar sites (pRamsar sites) for the purposes of considering plans and projects which may affect them.

For ease of reference through this report, these designations are collectively referred to as "European sites". As per Natural England (NE) guidance[5], any HRA should also consider any European Marine Protected Areas (MPAs) within England's inshore waters (out to 12 nautical miles) to support sites in achieving conservation objectives and to guide effective management. No MPAs of European importance or Marine Conservation Zones (MCZs) are associated with the study area and therefore, no further consideration is required to inform the Strategic Environmental Assessment (SEA).

This report aims to establish whether the Scheme included in the STS SRO are likely to have a significant effect on European sites, either alone or in-combination. This is judged in terms of the implications of the plan for a site's conservation objectives, which relate to its 'qualifying features' (i.e., those Annex I habitats, Annex II species, and Annex I bird populations for which it has been designated). Significantly, HRA is based on a rigorous application of the precautionary principle. Where uncertainty or doubt remains, an impact should be assumed, triggering the requirement for Appropriate Assessment of the Scheme.

1.2 REQUIREMENTS FOR HABITAT REGULATIONS ASSESSMENTS

As per the latest RAPID guidance a full HRA for a solution is not required until a planning and/or permit application (or its equivalent, for example a Development Consent Order), however the *principles* of the HRA process are applied during the gated process to identify risks to feasibility and deliverability of the schemes (alone and in-combination) as part of an informal HRA. As such there is no competent authority undertaking the integrity test.

HRA Guidance for the appraisal of projects[6], summarises the Habitats Regulations. Regulation 63 states that the competent authority (in this case Severn Trent Water) shall adopt, or otherwise give effect to, the Plan only after having ascertained that it will not adversely affect the integrity of a European site, subject to Regulation 64 of the Habitats Regulations.

Regulation 64 of the Habitats Regulations states:

64. — (1) If the competent authority is satisfied that, there being no alternative solutions, the plan or project must be carried out for imperative reasons of overriding public interest (which, subject to paragraph (2), may be of a social or economic nature), they may agree to the plan or project notwithstanding a negative assessment of the implications for the European site or the European offshore marine site (as the case may be).

(2) Where the site concerned hosts a priority natural habitat type or a priority species, the reasons referred to in paragraph (1) must be either —

(a) reasons relating to human health, public safety, or beneficial consequences of primary importance to the environment; or

(b) (b) any other reasons which the competent authority, having due regard to the opinion of the Appropriate Authority, consider to be imperative reasons of overriding public interest.

Best practice guidance[7], as well as RAPIDS's Gate 2 for the environmental assessments of SROs, recommends that if there are no alternative solutions and if, in exceptional circumstances, it is proposed that a Plan be adopted despite the fact that it may adversely affect the integrity of a European site, the HRA will need to address and explain the Imperative Reasons of Overriding Public Interest (IROPI)

[5] Help Note: Tips and advice on how to assess potential impacts of water company statutory plans on the marine environment1 – Focussing on Marine Conservation Zones (MCZ)

[6] Tyldesley, D. & Chapman, C. (2013) The Habitats Regulations Assessment Handbook, November 2020 edition UK: DTA Publications Limited.

[7] Tyldesley, D. & Chapman, C. (2013). The Habitats Regulations Assessment Handbook, February 2021 edition UK: DTA Publications Limited.

which the Plan making authority considers to be sufficient to outweigh the potentially adverse effects on the European site(s).

As noted above, the HRA process will be applied to help identify risks to feasibility and deliverability of each scheme. It is expected that the Schemes that are likely to result in adverse effects on site integrity will either be amended or will not be taken forward for consideration in Gate 3.

1.3 STRUCTURE OF THE REPORT

The report is divided into the following sections:

- Section 1: This introduction
- Section 2: Provides a background to the STS SRO
- Section 3: Provides the methodology adopted for the HRA
- Section 4: Provides the results of the screening of the individual STS Schemes
- Section 5: Provides the results of the Appropriate Assessment
- Section 6: Provides the in-combination assessment of the STS SRO
- Section 7: Conclusions and Recommendations

2. SCHEME DESCRIPTION

A summary of the two main STS SRO components is provided in Sections 2.1 and 2.2, and their joint operation in Section 2.3. A detailed overview of the scheme is presented within the main IEA report and a map of the STS SRO Scheme is available in Technical Appendix B3.2. The Scheme description provided at Gate 2 (on which Gate 2 assessments have been based) will be subject to further review in Gates 3 and 4.

2.1 MYTHE WTW ABSTRACTION LICENCE TRANSFER (15 ML/D)

This part of the Scheme provides support to the STT System from the Severn catchment by redeploying 15Ml/d of the existing STW abstraction licence at its Mythe WTW intake in the lower River Severn. This infrequently used licensed volume from Mythe would now remain in the River Severn for abstraction downstream at Deerhurst. STW has advised that no construction works would be required to redeploy the spare licence volume for abstraction. It is understood from STW that no specific additional resource to replace this current abstraction licence volume has been determined to date. The Mythe WTW abstraction licence Scheme will not operate alone and will operate in-combination with the Netheridge WwTW discharge diversion to Haw Bridge.

2.2 NETHERIDGE WWTW DISCHARGE DIVERSION TO HAW BRIDGE PIPELINE (35 ML/D)

Currently treated effluent from the Netheridge WwTW is discharged into the upper Severn Estuary. STS SRO proposes to divert a 35Ml/d portion of this treated discharge from Netheridge WwTW (approx. grid reference: SO 80891 15805) to a new outfall at Haw Bridge (just downstream from Deerhurst (approx. grid reference: SO 84595 27955)), on the freshwater River Severn to support STT abstraction at Deerhurst.

The outfall location to the River Severn will be located just upstream of the level gauge at Haw Bridge (see Scheme map in Technical Appendix B3.2). The discharge diversion from Netheridge WwTW would be pumped by a new pumping station, located at the WwTW via a 700 mm diameter pipeline approximately 15.5 km long with tunnelling under named watercourses, such as the River Severn.

The pipeline discharge to Haw Bridge will not be continuous. It will range from zero (when flows are high enough in the River Severn to support the STT transfer) to 35Ml/d when fully operational (during periods of lower flows in the River Severn). The pipeline will include nine drain-down points through which water in the pipeline will be discharged during maintenance activities (Technical Appendix B3.3). These drain-down points will be set back at least 10 m from water courses. The Netheridge WwTW final effluent would receive additional treatment to mitigate any water quality issues, which includes the removal of ammonia using a Multi-Bed Bio Reactor (MBBR), removal of phosphorus using ‘CoMag’®, and removal of selected organic compounds including phenols, Perfluorooctane sulfonic (PFOS) and some pesticides using Ozone, Biological Aerated Flooded Filter (BAFF) and Granulated Activated Carbon (GAC).

2.3 INDICATIVE OPERATION OF STS SRO

There are the following modes of operation. Please note the duration of the Scheme’s operation is indicative at this stage and could be refined based on further modelling or changes to river flow triggers.

- **Mode 1 -STT SRO sweetening flow provided by unsupported river abstraction:** STS SRO is not in operation and STT is also off. There is enough water in the River Severn at Deerhurst to provide the 20Ml/d STT sweetening flow between the River Severn to the Thames, with no undesirable effects on the River Severn.
- **Mode 2- STT SRO sweetening flow provided by STS Netheridge WwTW effluent transfer at 20Ml/d:** STS is ‘on’ but STT off. This means 20Ml/d is piped from Netheridge WwTW to Haw Bridge because STT is not working and thus only requires the sweetening flow, which the river

can't provide. This mode of operation would be expected to occur 12 % of the time (modelled over a 47-year period).

- **Mode 3- STT SRO water resources provided by the STS Netheridge WwTW effluent transfer at 35 Ml/d**: STS is 'on' and STT is 'on'. This means 35Ml/d is piped from Netheridge to Haw Bridge to allow a 35Ml/d STT abstraction. STT takes the additional 15 Ml/day from Mythe WTW abstraction licence transfer, so STT takes a 50Ml/d contribution from STS overall. This mode of operation would be expected to occur 16 % of the time (modelled over a 47-year period).

3. METHODOLOGY

3.1 INTRODUCTION

The ACWG guidelines indicate that a HRA should be undertaken in accordance with available guidance[8][9][10][11][12][13][14][15] and should be based on a precautionary approach as required under the Conservation of Habitats and Species Regulations 2017 (as amended).

The HRA required for Gate 2 has been carried out in line with the ACWG current guidance for SRO Environmental Assessment. The requirements and outputs of the assessment are consistent with those in the WRSE Regional Plan Environmental Assessment Methodology Guidance, as well as the WRPG guidance for WRMP24 and RAPID's guidance for Gate 2 assessments.

The objective of this HRA is to establish whether any of the Schemes for the STS SRO (i.e., Mythe WTW abstraction licence transfer and the Netheridge WwTW effluent transfer) is likely to have a significant effect on European sites (alone and in combination with each other when forming the STS SRO).

In-combination assessments with other SROs, non-SRO water resource options and other plans and projects in regional plans and WRMP24 will be undertaken as part of the relevant regional plan or WRMP24 assessment processes.

As the Gate 2 submission does not form a statutory plan or project, the principles of the HRA process were applied to help identify risks to feasibility and deliverability of the Schemes. A Stage 1 (screening) assessment was undertaken as part of the initial screening exercise for each of the Schemes, and the risk of failing the integrity test was reviewed for each Scheme, using the principles of the Stage 2 (Appropriate Assessment) assessment.

3.1.1 Stage 1 Screening

For Gate 1, each Scheme (either alone or in-combination) was considered to determine whether there were any risk of Likely Significant Effect (LSE) arising from construction or implementation activities and/or operation of the SRO on one or more European sites.

The gate-1 assessment of the risk of LSE associated with the STS HRA has been reviewed for gate-2 to ensure that any changes in SRO design, mitigation measures, operational regime, comments from regulator, etc have been considered.

GIS data was used to map the locations and boundaries of European sites in relation to the two different Schemes, i.e., the Mythe WTW abstraction licence transfer (operation) and the Netheridge WwTW treated effluent transfer (construction and operation). Sites within 10km of construction and operation works and 500m of rivers transferring the additional flow from Mythe and the transferred treated effluent were identified for screening of potential LSE. Where impact pathways were identified at greater distances (>10km) as a result of hydrological connectivity, for example the Severn Estuary, designated sites were screened in as appropriate.

The attributes of the European sites, which contribute to and define their integrity, current conservation status and the specific sensitivities of the site were considered with reference to:

[8] Court of Justice for the European Union's ruling on People Over Wind and Sweetman ('Sweetman II') vs Coillte Teoranta, Case C-323/17.

[9] UK Government (2019). Guidance on the use of Habitats Regulations Assessment.

[10] UK Government (2019). Conservation of Habitats and Species Regulations (Amendment) (EU Exit).

[11] Natural England (2020). Guidance on how to use Natural England's Conservation Advice Packages in Environmental Assessments.

[12] Tyldesley, D. & Chapman, C. (2013). The Habitats Regulations Assessment Handbook, February 2021 edition UK: DTA Publications Limited.

[13] Environment Agency and Natural Resources Wales (2017). Water resources planning guideline – April 2017

[14] European Commission (2018). Managing Natura 2000 sites - The provisions of Article 6 of the 'Habitats' Directive 92/43/EEC. European Union, 1-86.

[15] Defra (2012). The Habitats and Wild Birds Directives in England and its seas: Core guidance for developers, regulators & land/marine managers.

- Standard Data forms for SACs and SPAs and Information Sheets for Ramsar sites. An analysis of these information sources has enabled the identification of the site's qualifying features.
- Site conservation objectives,
- Supplementary Advice to the Conservation Objectives (SACO) where available,
- Site Improvement Plans,
- Core Management Plans (Wales),
- Article 12[16] and 17[17] reporting, and
- The supporting Site of Special Scientific Interest's favourable condition tables where relevant and no SACOs applicable to the features were available.

Analysis of how potential impacts of each scheme could affect a European site was undertaken using this information.

The qualifying habitats and species of European sites are vulnerable to a wide range of impacts such as physical loss or damage of habitat, disturbance from noise, light, human presence, changes in hydrology (e.g., changes in water levels/flow, flooding), changes in water or air quality and biological disturbance (e.g., direct mortality, introduction of disease or non-native species). The assessment considered the construction and operational effects.

In determining the likelihood of significant effects on European sites, particular consideration was given to the possible source-receptor pathways through which effects may be transmitted from activities associated with each Scheme, to features contributing to the integrity of the European sites (e.g., surface water catchments, air, etc.).

Where applicable, screening considered different types of impacts which can occur over different distances. The assumptions and distances used in the screening and a justification for their use are provided in **Table 3-1**.

Consideration was also given to the NE SSSI Impact Risk Zone (IRZ) datasets. The IRZs are reviewed regularly to ensure they reflect the current understanding of specific site sensitivities and potential risks posed to SSSIs. Where the notified features of a European site and SSSI are different, the SSSI IRZs have been set so that they reflect both. As such, these IRZs were used as part of a HRA to assist with determining whether there are likely to be significant effects from a particular development on the interest features of the European site.

Table 3-1: Potential impacts of the Scheme on European sites in general.

Broad categories of potential impacts on European sites, with examples	Examples of operations responsible for impacts
Physical loss: • Removal (including offsite effects, e.g., foraging habitat, and removal of supporting habitat within boundary of a SPA) • Smothering	Development of infrastructure associated with the scheme, e.g., new, or temporary pipelines, transport infrastructure, temporary weirs. Indirect effects from a reduction in flows e.g., drying out marginal habitat. Physical loss is most likely to be significant where the boundary of the scheme extends within the boundary of the European site, or within an offsite area of known foraging, roosting, breeding habitat (that supports species for which a European site is designated).
Physical damage: • Sedimentation / silting • Prevention of natural processes including coastal and fluvial bank stabilisation, prevention of long-shore drift etc. • Habitat degradation • Erosion	Reduction in river flow leading to permanent and/or temporary loss of available habitat, sedimentation/siltation, fragmentation, etc. Physical damage is likely to be significant where the boundary of the scheme extends within or is directly adjacent to the boundary of the European site, or within/adjacent to an offsite

[16] EU Member States are required to report on the implementation of the EU Birds Directive (under Article 12) every six years.

[17] All EU Member States are required to report on the implementation of the EU Habitats Directive (under Article 17) every six years. The report provides information on the conservation status of habitats and species listed in Annexes I, II, IV and V of the Directive.

Broad categories of potential impacts on European sites, with examples	Examples of operations responsible for impacts
• Fragmentation • Severance/barrier effect • Edge effects	area of known foraging, roosting, breeding habitat (that supports species for which a European site is designated, or where natural processes link the scheme to the site, such as through hydrological connectivity downstream of a scheme, long shore drift along the coast, or the scheme impacts the linking habitat).
Non-physical disturbance: • Noise (incl. underwater) • Visual presence • Human presence • Light pollution • Vibration (incl. underwater).	Noise from temporary construction or temporary pumping activities. Taking into consideration the noise level generated from general building activity (c. 122dB(A)) and considering the lowest noise level identified in appropriate guidance as likely to cause disturbance to bird species, it is concluded that noise impacts could be significant up to 1km from the boundary of the European site[18]. Noise from vehicular traffic during operation of a scheme. Noise from construction traffic is only likely to be significant where the transport route to and from the scheme is within 3-5km of the boundary of the European site. Plant and personnel involved in in operation of the scheme. These effects (noise, visual/human presence) are only likely to be significant where the boundary of the scheme extends within or is directly adjacent to the boundary of the European site, or within/adjacent to an offsite area of known foraging, roosting, breeding habitat (that supports species for which a European site is designated). Schemes which might include artificial lighting, e.g., for security around a temporary pumping station. Effects from light pollution are only likely to be significant where the boundary of the scheme is within 500m of the boundary of the European site. Vibration from temporary construction From a review of Environment Agency internal guidance on HRA and various websites/sources[19,20,21] it is considered that effects of vibration are more likely to be significant if development is within 500m of a European site.
Water table/availability: • Drying • Flooding / stormwater • Changes to surface water levels and flows including both increases and reductions. • Changes in groundwater levels and flows • Changes to coastal water movement	Changes to water levels and flows due to increased water abstraction, reduced storage, or reduced flow releases from reservoirs to river systems. These effects are only likely to be significant where the boundary of the scheme extends within the same ground or surface water catchment as the European site. However, these effects are dependent on hydrological continuity between the scheme and the European site, and sometimes, whether the scheme is up or down stream from the European site.
Toxic contamination: • Water pollution • Soil contamination • Air Pollution	Reduced dilution in downstream or receiving waterbodies due to changes in abstraction or reduced compensation flow releases to river systems.

[18] British Standards Institute (BSI) (2009) BS5228 - Noise and Vibration Control on Construction and Open Sites. BSI, London.

[19] Institute of Lighting Professionals (2011) Guidance Notes for the Reduction of Obtrusive Light GN01:2011

[20] Environment Agency (2013 Bird Disturbance from Flood and Coastal Risk Management Construction Activities. Overarching Interpretive Summary Report. Prepared by Cascade Consulting and Institute of Estuarine and Coastal Studies.

[21] Cutts N, Hemingway K and Spencer J (2013) The Waterbird Disturbance Mitigation Toolkit Informing Estuarine Planning and Construction Projects. Produced by the Institute of Estuarine and Coastal Studies (IECS). Version 3.2.

Broad categories of potential impacts on European sites, with examples	Examples of operations responsible for impacts
	These effects are only likely to be significant where the boundary of the scheme extends within the same ground or surface water catchment as the European site. However, these effects are dependent on hydrological continuity between the scheme and the European site, and sometimes, whether the scheme is up or down stream from the European site. Air emissions associated with plant and vehicular traffic during construction and operation of schemes. The effect of dust is only likely to be significant where site is within or in proximity to the boundary of the European site[22,23]. Without mitigation, dust and dirt from the construction site may be transported onto the public road network and then deposited/spread by vehicles on roads up to 500m from large sites, 200m from medium sites, and 50m from small sites as measured from the site exit. Effects of road traffic emissions from the transport route to be taken by the project traffic are only likely to be significant where the protected site falls within 200 metres of the edge of a road affected[24].
Non-toxic contamination: • Nutrient enrichment (e.g., of soils and water) • Algal blooms • Changes in salinity • Changes in water chemistry (e.g., pH, calcium balance etc) • Changes in thermal regime • Changes in turbidity • Changes in sedimentation/silting	Changes to water salinity, nutrient levels, turbidity, thermal regime due to increased water abstraction, storage, or reduced compensation flow releases to river systems. These effects are only likely to be significant where the boundary of the scheme extends within the same ground or surface water catchment as the European Site. However, these effects are dependent on hydrological continuity between the scheme and the European site, and sometimes, whether the scheme is up or down stream from the European site.
Biological disturbance: • Direct mortality • Changes to habitat availability • Out-competition by non-native species • Selective extraction of species • Introduction of disease • Rapid population fluctuations • Natural succession	Potential for changes to habitat availability, for example reductions in wetted width of rivers leading to desiccation of macrophyte beds due to changes in abstraction or reduced compensation flow releases to river systems. In addition, via removal of vegetation (including hedgerows and trees) used by based as foraging, roosting and hibernation sites and birds as roosting and nesting sites. Creation of new pathway of non-native invasive species. This effect is only likely to be significant where the scheme is situated within the European site or an upstream tributary of the European site (or affects groundwater levels supporting these sites or tributaries) Entrapment during in-river or terrestrial construction works causing injury and/or mortality of mobile species Likely to be a risk of entrapment, injury and/or mortality where the boundary of the option extends within or is directly adjacent to the boundary of a European site or within/adjacent to offsite functionally linked habitat. Mobile species could include fish, bats, and European otters for example. Potential for changes to habitat availability via removal of vegetation (including hedgerows and trees) to facilitate construction activities and potential entrapment, injury and/or mortality of breeding birds and roosting/hibernating bats.

[22] Highways Agency (2003) Design Manual for Roads and Bridges (DMRB), Volume 11.
[23] Institute of Air Quality Management (2014) Guidance on the assessment of dust from demolition and construction v1.1.
[24] NE Internal Guidance – Approach to Advising Competent Authorities on Road Traffic Emissions and HRAs V1.4 Final - June 2018

Broad categories of potential impacts on European sites, with examples	Examples of operations responsible for impacts
	This effect is dependent on the requirement to remove vegetation (if it cannot be avoided), ecological surveys to determine species presence and timing of removal based on species specific ecological considerations.

3.1.2 Stage 2 Appropriate Assessment

Where an LSE was identified at the screening stage (noting the precautionary principle), the Scheme was subject to the *principles* of the Stage 2 Appropriate Assessment, noting again that the Gate 2 submission does not form a statutory plan or project and as such there is no competent authority undertaking the integrity test.

Further assessment has, therefore, been undertaken to identify where it is predicted that the integrity test cannot be met, and to identify further surveys, assessment, and mitigation requirements to provide greater certainty to any conclusions.

The Appropriate Assessment considered the potentially damaging aspects of the Schemes, both construction and operation, and the potential effects on the associated European site's qualifying features and achievement of the conservation objectives and characterised the impacts in terms of their likelihood, nature, scale, severity, and duration.

The potential for adverse effects on the integrity of a European site depends on the scale and magnitude of the action and its predicted impacts, taking into account the distribution of the qualifying features across the site in relation to the predicted impact and the location, timing and duration of the proposed activity and the level of understanding of the effect, such as whether it has been recorded before and, based on current ecological knowledge, whether it can be expected to operate at the site in question.

3.1.2.1 Impacts

To determine adverse effect on site integrity, the following parameters was used as appropriate to define the impact (i.e., mechanism by which effects are caused):

- Impact type - direct or indirect, positive, or negative
- Magnitude of impact – the 'amount' or intensity of an impact. This may sometimes (but not always) be synonymous with 'extent' (see below) for certain impacts, such as habitat loss.
- Extent of impact – the area over which the impact will be felt.
- Duration of impact – how long it will occur. The guidelines suggest that ecological impact durations should be described in terms of ecological characteristics (e.g., species lifecycles/longevity) rather than human timeframes. The definitions of duration based on this approach and using professional judgement are detailed in **Table 3-2**.
- Timing of impact – when it will occur, taking note of seasonality.
- Frequency of impact – how often it will occur.
- Reversibility of impact – whether recovery or reinstatement is possible.

Table 3-2: Definitions of impact duration

Duration	Habitats	Species
Short-term	The typical regrowth period for many submerged macrophytes, grass and herb communities – as a rough guide, up to two years	Impact is measurable up to one (breeding/wintering, migration, spawning etc.) season – as a rough guide, up to a year for fauna
Medium-term	The typical regrowth period for many shrub and hedge communities, slower growing macrophytes and reedbeds – as a rough guide, two to eight years	Impact is measurable up to one typical reproductive lifespan (in the wild). This varies depending on species, but generally anything from one year to 5 years as a rough guide for most fauna
Long-term	A period lasting longer than the typical scrub/hedge regrowth period – as a rough guide, more than 8 years	Impact is measurable over several (species) generations

Duration	Habitats	Species
Permanent	An impact where no reasonable chance of recovery/restoration is evident within the foreseeable future	

These impacts then need to be considered in terms of the effects to the qualifying habitats and species.

3.1.2.2 Adverse Effect

Where required, the possible impacts associated with each scheme was considered in the context of their effect on the qualifying features for the sites under consideration.

An Adverse Effect on the sites Integrity (AEoI) is likely to be one which undermines achievement of the sites conservation objectives and prevents the qualifying feature from progressing towards favourable conservation status.

Work commenced to inform the potential risks to the receiving environment associated with the schemes. This includes a monitoring programme for the freshwater communities and initial modelling of the potential physical environmental impacts. This data was used (where applicable) to inform the Appropriate Assessment for those schemes where LSEs were identified.

Any further data requirements, including the need for specific monitoring, will be identified in the Appropriate Assessment (if required) for consideration during Gate 3. As such, the data that was used in the more detailed assessments will be limited to that readily available.

3.1.3 Integrity Test

The integrity test is the conclusion of an Appropriate Assessment and requires the competent authority to ascertain whether the proposed scheme (either alone or in-combination with other plans or projects), will have no adverse effect on site integrity. The following definition of site integrity is provided by Defra: the integrity of the site is "*the coherence of its ecological structure and function, across its whole area, that enables it to sustain the habitat, complex of habitats and/or the level of populations of the species for which it was classified*"[25].

At gate-2, the potential for AEoI will be assessed against the conservation objectives as far as possible, and where it is predicted that the integrity test cannot be met, these will be identified for further consideration for the gate-3 assessments.

3.1.4 Mitigation measures and monitoring

The assessment considered measures that may be available to reduce the likelihood, magnitude, scale, and duration of the effect to a lower level, which can be applied at the Appropriate Assessment stage to inform the overall integrity test[26]. These measures will include both avoidance and reduction measures, with the former being the preferred option.

Where necessary, the report also recommends additional survey work that will be required to inform the Gate 3 HRA and any monitoring deemed necessary either for the purposes of validating the findings of the Appropriate Assessment (where required), or 'early warning' monitoring which would enable any actions to be stopped, paused, reduced in scale, or altered should an unexpected adverse effect be recorded when the SRO is being implemented.

The need for further investigation of potential mitigation measures that will be required as part of the gate-3 process will be defined as part of the Appropriate Assessment (if required).

[25]Defra Circular 01/2005.

[26] The "People over Wind" or "Sweetman" judgment ruled that Article 6(3) of the Habitats Directive must be interpreted as meaning that mitigation measures should be assessed within the framework of an Appropriate Assessment and that it is not permissible to take account of mitigation measures at the screening stage.

3.1.5 Limitations

Information provided by third parties, including publicly available information and databases, was considered correct at the time of submission. Due to the dynamic nature of the environment, conditions may change in the period between the preparation of this report, and the construction and operation of the proposed scheme.

The compilation of information to support an assessment has been undertaken in as detailed a way as possible, using all available open-source data where they exist. However, the conclusions drawn from this is necessarily limited by the age, type, coverage, and availability of data. Any uncertainties and the limitations of the assessment process are acknowledged and highlighted.

Recommendations for avoidance and mitigation measures to address the potential adverse effects on European Site integrity identified by this report are also based on the information available at the time of the assessment.

It is recognised that there are still a number of uncertainties and risks that need to be managed, with further iterations of the assessment required as more detailed engineering information and modelling work becomes available, prior to Gate 3. The in-combination assessments with other SROs, non-SRO options and other plans and projects has not been undertaken. It is understood that such assessments will be undertaken as part of the relevant regional plan or WRMP24 assessment processes.

As such, the conclusion on the risk of LSE and predictions regarding adverse effects will need to be reviewed and updated (where required) as more information becomes available during completion of the Gate 3 assessments. This includes consideration of any monitoring and modelling outputs made available between submission of this report and the end date if the Gate 2 assessments and any changes in the applicability and/or availability of mitigation measures.

4. HRA SCREENING OF STS SRO SCHEMES

4.1 RISK OF LIKELY SIGNIFICANT EFFECTS OF STS SRO

The STS SRO is associated with a number of European sites including SACs[27], SPAs[28] and Ramsar[29] sites, as identified in **Table 4-1** below.

As described in Section 3, this HRA has screened all of the European sites located within a 10km radius of any of the schemes in the study area and 500m of rivers transferring excess water. Sites that are hydrologically connected or which provide off-site functional habitat has also been considered. The SSSI IRZ has also been considered when selecting European Sites that require assessment. As indicated in Section 3.1.1, to further inform the likelihood of any impacts on European sites the NE SSSI IRZ datasets were also applied. The IRZs are reviewed regularly to ensure they reflect the current understanding of specific site sensitivities and potential risks posed to SSSIs. Where the notified features of a European site and SSSI are different, the SSSI IRZs have been set so that they reflect both. As such, these IRZs can be used as part of a HRA to assist with determining whether there are risks of likely to be significant effects from a particular development on the interest features of the European site.

Table 4-1 European designated sites associated with the STS SRO Schemes

European designated site	Associated Schemes	Screening Criteria
Cotswold Beechwoods SAC	Netheridge WwTW effluent transfer (35Ml/d)	The SAC is located 6.7km from the construction activities and has been for consideration of LSE as a result of construction activities.
Dixon Wood SAC	Mythe WTW abstraction licence transfer (15Ml/d)	The SAC is located 8.9km from the construction activities and has been for consideration of LSE as a result of construction activities.
Severn Estuary SAC	Netheridge WwTW effluent transfer (35 Ml/d) Mythe WTW abstraction licence transfer (15Ml/d)	Although the European site is 10.3km from the construction activities, the site is hydrologically connected (44.69km north-east via hydrological connectivity), and the associated reaches of the River Severn provides a migration route and off-site functional habitat for qualifying features of the site anadromous fish).
Severn Estuary SPA	Netheridge WwTW effluent transfer (35Ml/d) Mythe WTW abstraction licence transfer (15Ml/d)	Although the European site is 10.3km from the construction activities (44.69km north-east via hydrological connectivity), the site the reaches of the River Severn provides off-site functional habitat for qualifying features of the site and water quality and hydrological impacts could effect supporting habitats.
Severn Estuary Ramsar	Netheridge WwTW effluent transfer (35Ml/d) Mythe WTW abstraction licence transfer (15Ml/d)	Although the European site is 10.3km from the construction activities, the site is hydrologically connected (44.69km north-east via hydrological connectivity), and the associated reaches of the River Severn provides a migration route and off-site functional habitat for qualifying features of the site anadromous fish and water quality and hydrological impacts could effect supporting habitats.

[27] Special Areas of Conservation (SACs) are strictly protected sites designated under the EC Habitats Directive. Article 3 of the Habitats Directive requires the establishment of a European network of important high-quality conservation sites that will make a significant contribution to conserving the 189 habitat types and 788 species identified in Annexes I and II of the Directive (as amended). www.jncc.org.uk

[28] Special Protection Areas (SPAs) are strictly protected sites classified in accordance with Article 4 of the EC Directive on the conservation of wild birds (79/409/EEC), also known as the Birds Directive, which came into force in April 1979. They are classified for rare and vulnerable birds, listed in Annex I to the Birds Directive, and for regularly occurring migratory species. www.jncc.org.uk

[29] Ramsar sites are wetlands of international importance designated under the Ramsar Convention

European designated site	Associated Schemes	Screening Criteria
Walmore Common SPA	Netheridge WwTW effluent Transfer (35Ml/d)	The European site is located 6km from the proposed construction activities.
Walmore Common Ramsar	Netheridge WwTW effluent Transfer (35Ml/d)	The European site is located 6km from the proposed construction activities.

No pSACs, pSPAs, pRamsar sites, MPAs of European importance or MCZs are associated with the study area and therefore, no further consideration is required to inform the SEA.

4.2 SUMMARY OF RISK OF LIKELY SIGNIFICANT EFFECTS

The HRA screening assessments of the associated European sites for potential LSE is summarised Table 4-2with detailed assessments provided in **Annex 1.**

Where uncertainty has been identified, this uncertainty indicates that a confident conclusion of no risk of LSE is not yet possible, in most cases due to the very early stage of option development (meaning specific design and location information may not be available to allow a full appraisal of the risk of likely effects). Where uncertainty remains, an Appropriate Assessment is required to either confirm a risk of LSE related to a scheme or to confirm that no risk LSE are expected.

The gate-1 assessment concluded that no risk to LSE for any of the STS options. However, following consultation with NE and the EA, some uncertainty has been identified with regards to the risk to the Severn Estuary European site.

While no LSE has been identified for any of the European sites associated with the STS SRO, some uncertainty remains with regards to LSE on the Severn Estuary SAC and Ramsar site. As such, an Appropriate Assessment is required.

No construction activities are associated with the Mythe WTW abstraction licence transfer. The Scheme is located approximately 29.2km north-east of the Severn Estuary SAC and is approximately 49.6km north-east via hydrological connectivity. Construction activities will be required for the Netheridge WwTW effluent transfer. The footprint of the Scheme is outside of the boundary of the SAC and Ramsar site, however, the construction area potentially provides functionally linked habitat for the migratory species associated with the Severn Estuary. During proposed construction works for this Scheme potential impact pathways include localised increases in suspended sediment (siltation and deposition), potential invasive and non-native species introduction/spread, air pollution and potential water pollution incidents which could impact on supporting habitats. As such, mitigation measures should be considered in an Appropriate Assessment of the Scheme.

The Mythe WTW abstraction licence transfer scheme will not operate alone and will operate in-combination with the Netheridge WwTW effluent transfer when support is required. The potential impact pathway on hydrology is, therefore, the abstraction of 50Ml/d at Deerhurst and consequent augmentation of 35Ml/d at Haw Bridge, with net 15Ml/d reduction downstream of the discharge of treated effluent affecting the River Severn downstream of Haw Bridge and into the Severn Estuary.

Currently treated discharge from the Netheridge WwTW is input to the upper Severn Estuary. There is some uncertainty related to the potential changes in water quality due to the change in the discharge location of the portion of the effluent from the Netheridge WwTW.

Screening has, therefore, identified LSE on the migratory species associated with the Severn Estuary SAC and Ramsar site. This relates to the potential changes in flow and water quality and the risk to supporting habitats as well as migratory cues. LSE have also been identified for the qualifying habitats of the SAC and Ramsar site (e.g., Subtidal sandbanks which are covered by sea water all the time). Although the proportionate change in freshwater inflows into the estuary is not discernible (see Figure 5.1), there is a risk that changes in water quality could impact on the habitats which also support the designated fish and bird communities. Natural England has indicated that the proposed abstraction licence transfer of 15Ml/d represent a change in Recent Actual abstractions and that here is some uncertainty with regards to the potential impacts on flows and migratory fish of the SAC and Ramsar site.

The Netheridge WwTW effluent transfer pipeline/outfall construction could result in impacts on supporting habitats (floodplain and grazing marsh and neutral grassland) for the bird communities associated with the

Severn Estuary SPA. As such, LSE have been identified for the construction phase. LSE have also been identified during operation of the STS SRO on the estuarine habitats that provides supporting habitats to the bird communities. This is related to the potential changes in water quality during operation of the STS SRO.

Table 4-2 Summary of the outcomes of HRA Screening Assessment of the Schemes for STS SRO.

European designated site	Schemes	Risk of Likely significant effect?
Cotswold Beechwoods SAC	Netheridge WwTW effluent transfer (35Ml/d)	No
Dixon Wood SAC	Netheridge WwTW effluent transfer (35Ml/d)	No
	Mythe WTW abstraction licence transfer (15Ml/d)	No
Severn Estuary SAC	Netheridge WwTW effluent transfer (35Ml/d)	Yes
	Mythe WTW abstraction licence transfer (15Ml/d)	Yes
Severn Estuary SPA	Netheridge WwTW effluent transfer (35Ml/d)	Yes
	Mythe WTW abstraction licence transfer (15Ml/d)	No
Severn Estuary Ramsar	Netheridge WwTW effluent transfer (35Ml/d)	Yes
	Mythe WTW abstraction licence transfer (15Ml/d)	No
Walmore Common SPA	Netheridge WwTW effluent transfer (35Ml/d))	Yes
Walmore Common Ramsar	Netheridge WwTW effluent transfer (35Ml/d)	Yes

5. INFORMATION TO INFORM STAGE 2 APPROPRIATE ASSESSMENT

5.1 SCOPE OF THE APPROPRIATE ASSESSMENT

Screening of LSE (see Section 4.2) has identified the requirement for an Appropriate Assessment of the Severn Estuary SAC, SPA and Ramsar site and the Walmore Common SPA and Ramsar site. The scope of the Appropriate Assessment is summarised in Table 5-1.

Table 5-1 Scope of the Appropriate Assessment

European site	Qualifying Feature	Scope of Assessment
Walmore Common Ramsar SPA	A037 *Cygnus columbianus bewickii*, Bewick's swan	• Netheridge WwTW effluent transfer pipeline/outfall construction related impacts, including the impacts on supporting habitat for migratory fish and the designated bird communities. • Netheridge WwTW effluent transfer operation and impacts on water quality, d/s Haw Bridge. This includes impacts on supporting habitats for migratory fish, impacts on migratory cues and impacts on habitats within the Severn Estuary European Marine Site that support the designated birds and fish. • Joint Mythe WTW licence transfer and Netheridge WwTW effluent transfer operation and impacts on hydrology associated with the abstraction of 50Ml/d at Deerhurst and consequent augmentation of 35Ml/d at Haw Bridge, with net 15Ml/d reduction downstream of the discharge of treated effluent affecting the River Severn downstream and into the Severn Estuary. This includes impacts on supporting habitats for fish, migratory cues, and the designated bird communities.
Walmore Common Ramsar site	**Ramsar Criterion 6** Species/populations occurring at levels of international importance. Qualifying species/populations (as identified at designation): *Cygnus columbianus bewickii*, Bewick's swan – Wintering, NW Europe 43 individuals, representing an average of 0.5% of the GB population (5-year peak mean 1998/9-2002/3).	
Severn Estuary SAC	1095 *Petromyzon marinus*; Sea lamprey 1099 *Lampetra fluviatilis;* River lamprey 1103 *Alosa fallax*; Twaite shad	
Severn Estuary Ramsar site	**Ramsar criterion 1** Due to immense tidal range (second-largest in world), this affects both the physical environment and biological communities. **Ramsar criterion 3** Due to unusual estuarine communities, reduced diversity, and high productivity. **Ramsar criterion 4** This site is important for the run of migratory fish between sea and river via estuary. Species include Atlantic salmon (*Salmo salar*), sea trout (*S. trutta*), sea lamprey (*Petromyzon marinus*), river lamprey (*Lampetra fluviatilis*), allis shad (*Alosa alosa*), twaite shad (*A. fallax*) and European eel (*Anguilla anguilla*). It is also of particular importance for migratory birds during spring and autumn. **Ramsar criterion 5** Assemblages of international importance: Species with peak counts in winter: 70919 waterfowl (5-year peak mean 1998/99-2002/2003). **Ramsar criterion 6**	

European site	Qualifying Feature	Scope of Assessment
	Species/populations occurring at levels of international importance. Qualifying species/populations (as identified at designation): *Calidris alpina;* Dunlin – Passage/Wintering *Anas strepera;* Gadwall – Wintering *Tringa tetanus;* Common redshank – Passage/Wintering *Tadorna tadorna;* Common shelduck – Wintering *Anser albifrons albifrons;* Greater white-fronted geese – Wintering *Charadrius hiaticula;* Ringed plover – Passage *Numenius phaeopus*; Whimbrel – Passage Waterbird assemblage – Wintering Estuary with immense tidal range Unusual estuarine communities Run of migratory fish Possible future consideration under criterion 6: lesser black-backed gull (*Larus fuscus graellsii*), Eurasion teal (*Anas crecca*) and Northern pintail (*Anas acuta*) **Ramsar criterion 8** The fish of the whole estuarine and river system is one of the most diverse in Britain, with over 110 species recorded. Atlantic salmon, sea trout, sea lamprey, river lamprey, allis shad, twaite shad and European eel use the Severn Estuary as a key migration route to their spawning grounds in the many tributaries that flow into the estuary. The site is important as a feeding and nursery ground for many fish species particularly allis shad and twaite shad which feed on mysid shrimps in the salt wedge.	
Severn Estuary SPA	051 *Anas strepera;* Gadwall 394 *Anser albifrons albifrons;* Greater white-fronted geese 672 *Calidris alpina;* Dunlin 037 *Cygnus columbianus bewickii;* Bewick's swan 048 *Tadorna tadorna;* Common shelduck 162 *Tringa tetanus;* Common redshank WATR Internationally important assemblage of waterfowl (wildfowl and waders)	

5.2 CONSERVATION OBJECTIVES

The Appropriate Assessment has been completed in view of the relevant conservation objectives for the Severn Estuary European Marine Site.

The specific/relevant attributes and targets associated with the conservation objectives for each qualifying feature of the SAC, SPA and Ramsar site were identified in the Favourable Condition Tables (FCT) as provided

in the Regulation 33 advice for the site[30]. In particular, the assessments considered how the relevant attributes and targets associated with each feature:

- Attributes: particular characteristics of the features or sub-features which provide an indication of the condition of the feature (e.g., total population size, extent of a habitat type).
- Targets: These define the attribute values that equate to favourable condition.

If changes are observed that will result in 'significantly' changes in the target, this will likely result in adverse effects as the change will result in in the condition of the feature being classed as unfavourable or prevent the feature from attaining favourable condition.

NE have also provided a position statement regarding the condition assessment of the Severn Estuary[31]. NE have indicated that for the estuaries, mudflats and sandflats not covered by seawater at low tide, and Atlantic salt meadows features, the two factors contributing to unfavourable condition were: (i) coastal squeeze impacts; and (ii) water quality impacts. The Regulation 33 advice[32] for the site highlights the vulnerability of habitat and fish features to toxic contamination and nutrient loading; and identifies a number of relevant attributes that contribute to the favourable condition of these features. As such, these targets and attributes will require consideration in the Appropriate Assessment.

5.3 BASELINE

5.3.1 Severn Estuary SAC

The boundary of the Severn Estuary SAC (central location: Latitude 51.468611, Longitude -2.978055)[33] covers 737.14km² of the Severn Estuary; the largest coastal plain estuary in the UK[34] which supports a diversity of subtidal and intertidal habitats (approximately 2/3 subtidal and 1/3 intertidal)[35]. The hydrodynamic conditions created by the large 13m tidal range and consequent flow and flux of sediment within the estuary are particularly important abiotic processes, that contribute to the diversity and productivity of the SACs eight qualifying features. The habitat features are distributed throughout the SACs area, with some overlapping and others changing location based on physiological conditions; for example, the spatial extent of sandbanks will change due to their high mobility[34]. In addition, the Severn Estuary is of particular importance for three migratory anadromous fish species, that are rare in the UK and are the qualifying features of the SAC. These are river lamprey, sea lamprey and twaite shad. Lampreys (family Petromyzonidae) are part of a small group known as Agnatha, meaning jawless and twaite shad is part of the herring family (Clupeidae)[36].

5.3.1.1 Estuaries

The Estuary is an over-arching feature which incorporates all aspects of the physical, chemical, and biological attributes of the estuary as an ecosystem. The physical nature of the tidal regime determines not only the structure of the estuary and individual habitats but also the conditions affecting it and the biological communities it therefore supports. Estuaries are widespread throughout the Atlantic coasts of Europe. Approximately one-quarter of the area of estuaries in north-western Europe occurs in the UK. The UK has over 90 estuaries. The Severn Estuary SAC covers the extent of the tidal influence from an upstream limit between Frampton and Awre in Gloucestershire out seawards to a line drawn between Penarth Head in Wales and

[30] Natural England and Countryside Council for Wales (2009). Severn Estuary SAC, SPA and Ramsar Site: Regulation 33 Advice. Natural England and Countryside Council for Wales, 1 – 175.

[31] Natural England (2022). Position Statement: Indicative Condition Assessment of the Severn Estuary/Môr Hafren Special Area of Conservation (SAC). May 2022

[32] Natural England & the Countryside Council for Wales' advice given under Regulation 33(2)(a) of the Conservation (Natural Habitats, &c.) Regulations 1994, as amended.

[33] JNCC (2016). *Natura 2000 – Standard Data Form*. Natura 2000 Database, European Environment Agency.

[34] NRW (2018). *Severn Estuary / Môr Hafren Special Area of Conservation, Indicative site level feature condition assessments 2018*. NRW Evidence Report No: 235.

[35] Natural England and Countryside Council for Wales (2009). *Severn Estuary SAC, SPA and Ramsar Site: Regulation 33 Advice*. Natural England and Countryside Council for Wales, 1 – 175.

[36] Maitland, P. S and Hatton-Ellis, T. W (2003). *Ecology of the Allis and Twaite Shad*. Conserving Natura 2000 Rivers Ecology Series No. 3. English Nature, Peterborough.

Hinckley point in Somerset. It includes subtidal and intertidal areas landward to the line of high ground and flood defences (banks and walls) that provide the limit of tidal inundation. The Severn Estuary is the largest example of a coastal plain estuary in the UK, and one of the largest estuaries in Europe. It contributes approximately 30% of the UK Natura 2000 resource for estuaries, by area[37]. A complex pattern and combination of physical, chemical, and biological conditions and processes operates within estuaries, with many parameters varying temporally and spatially

5.3.1.2 Subtidal sandbanks

Sandbanks which are slightly covered by sea water all the time (subtidal sandbanks) consist of sandy sediments that are permanently covered by shallow sea water, typically at depths of less than 20 m below chart datum (but sometimes including channels or other areas greater than 20 m deep). The Severn Estuary subtidal sandbanks can be considered to contribute to the gravelly and clean sand sandbank resource. The Severn Estuary contributes approximately 3% of the UK Natura 2000 resource for subtidal sandbanks, by area. These subtidal areas play an important role in holding and supplying sediment for other habitats notably the intertidal mud and sandflats, saltmarshes and reef features and it is likely that subtidal invertebrate communities play a role as a food resource for some species of the fish assemblage feature of the SAC and Ramsar Site.

5.3.1.3 Intertidal mudflats and sandflats

Intertidal mudflats and sandflats are submerged at high tide and exposed at low tide. They form a major component of Estuaries and Large shallow inlets and bays in the UK but also occur extensively along the open coast and in lagoonal inlets. The intertidal part of the Severn Estuary supports extensive mudflats and sandflats. These cover an area of approximately 20,300 ha - the fourth largest area in a UK estuary and representing approximately 7 % of the total UK resource of this habitat type (approximately 10% of the UK Natura 2000 resource for Intertidal mudflats and sandflats, by area). Mudflats also provide a valuable feeding, roosting and resting area for a wide range of species of wading birds and waterfowl and are therefore important supporting habitats for the wintering and passage bird features of the SPA and Ramsar Site.

5.3.1.4 Atlantic salt meadow

This Annex I type is predominantly found on Atlantic coasts in western Europe. Atlantic salt meadows occur on North Sea, English Channel and Atlantic shores. There are more than 29,000 ha of the habitat type in the UK, mostly in the large, sheltered estuaries of south-east, south-west, and north-west England and in south Wales. Smaller areas of saltmarsh are found in Scotland. The Severn Estuary holds the largest aggregation of saltmarsh in the south and south-west of the UK. It covers approximately 1,400 ha, representing about 4% of the total area of saltmarsh in the UK. Saltmarshes also provide a valuable feeding and roosting and resting areas (particularly at high tide) for a wide range of species of waterfowl and are therefore very important supporting habitats for the wintering and passage bird features of the SPA and Ramsar Site. The habitats within the "Pills[38]" provide important shelter and feeding habitats for both fish and bird species. The Severn Estuary saltmarshes are generally grazed by sheep and/or cattle. Grazing is a significant factor in determining the plant communities found within them and their value for dependant species such as birds and rare plants.

5.3.1.5 Reef

Reefs are rocky marine habitats or biological concretions that rise from the seabed. They are generally subtidal but may extend as an unbroken transition into the intertidal zone, where they are exposed to the air at low tide. Reefs occur widely around the UK coast, and are found in both inshore and offshore waters. There is a far greater range and extent of rocky reefs than biogenic concretions. Only a few invertebrate species are able to develop biogenic reefs, and these have a restricted distribution and extent in the UK. The Severn Estuary has

[37] Based on Natura 2000 Standard data forms for all UK Natura 2000 sites which have estuaries as a feature- source: JNCC website http://www.jncc.gov.uk/ProtectedSites/SACselection/habitat.asp?FeatureIntCode=H1130

[38] Pills refers to a Welsh placename element. The name is defined as the tidal reach of a waterway, suitable as a harbour, and is common along the Bristol Channel and Severn Estuary

areas of biogenic reefs, formed by the tube-dwelling polychaete worm *Sabellaria alveolata*. *Sabellaria alveolata* reefs in the UK are predominantly an intertidal habitat but the Severn Estuary is one of the few places where *Sabellaria alveolata* reefs occur extensively in the subtidal, as well as the intertidal.

5.3.1.6 Other estuarine habitats: Hard substrate habitats (rocky shores) and eel grass beds

There is approximately 1,500 ha of hard substrate habitat within the Severn Estuary, consisting of boulders, rock, mussel/cobble scars, rocky pools, and shingle. The largest areas of hard substrate are located towards the outer estuary at Brean Down, Anchor Head and Sand Point together with rocky platforms and cliffs at Clevedon and Portishead. There are also extensive rock platforms at English stones, Aust and Beachley. Beds of eelgrass (*Zostera* spp.), the largest in Wales, occur on some of the more sheltered mixed hard substrate areas around the Welsh side of the Second Severn Crossing.

5.3.1.7 River lamprey

River lamprey occupy a large region from southern Norway to the western Mediterranean in coastal, transitional, and freshwater waterbodies[39]. They are a primitive species that is widespread in the UK, occurring in many rivers from the Great Glen in Scotland at the northern extent and continuing southwards[39]. They utilise the Severn Estuary as a migratory passage to and from their freshwater spawning and nursery sites present in the upper reaches of the River Usk, Wye and Severn. Adult river lamprey migrate upstream from October – December and spawn from March - April[39]. Access to these functional habitats is vital for the species to complete its lifecycle[35]. Relevant marine data for this feature has not been collected[34] and records within the Severn Estuary itself are lacking, with the most recent observation logged in 1939[40]. Supporting datasets from inflowing rivers have recorded river lamprey in the River Severn (close to Gloucester) in 2014[41]. NRW Monitoring programmes in the River Usk, and Wye have previously assessed ammocoete densities as failing in Usk and passable in the Wye from 2007 - 2012[44]. Water quality deterioration has been highlighted as a factor directly impacting on the condition of this feature in the Severn Estuary SAC such as fluctuating water temperature and dissolved oxygen[44]. Ammocoete habitat has been identified within the River Severn downstream of the River Avon confluence, but no spawning habitat is present in this reach.

5.3.1.8 Sea lamprey

Sea lamprey is the largest species of lamprey present in the UK, and it also occupies a larger region than river lamprey; from northern Norway to the western Mediterranean and eastern North America[42]. However, unlike river lamprey, it is absent from many northern and southern rivers in the UK due to pollution incidents and the construction of migratory barriers[42]. They utilise the Severn Estuary as a migratory passage to and from their freshwater spawning and nursery sites present in the upper reaches of the River Usk, Wye and Severn. Adult sea lamprey migrate upstream from April – May and spawn from late May – June[42]. Access to these functional habitats is vital for the species to complete its lifecycle[46]. Relevant marine data for this feature has not been collected and records within the Severn Estuary itself are lacking, with the most recent observation logged in 1933[43]. NRW Monitoring programmes in the River Usk and Wye have previously assessed ammocoete densities as failing from 2007 - 2012[44]. Water quality deterioration has been highlighted as a factor directly impacting on the condition of this feature in the Severn Estuary SAC such as changes in water temperature and dissolved oxygen[44]. Ammocoete habitat has been identified within the River Severn downstream of the River Avon confluence, but no spawning habitat is present in this reach.

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[39] Maitland, P. S (2003). *Ecology of the River, Brook and Sea Lamprey*. Conserving Natura 2000 Rivers Ecology Series No. 5. English Nature, Peterborough, 1 - 54.

[40] NBN (2019) *Human observation of Lampetra fluviatilis (Linnaeus, 1758), River Lamprey recorded on 1939-12-31*. Bristol Regional Environmental Records Centre.

[41] NBN (2017) *Human observation of Lampetra fluviatilis (Linnaeus, 1758), River Lamprey recorded on 2014-10-20.* Environment Agency.

[42] Maitland, P. S (2003). *Ecology of the River, Brook and Sea Lamprey*. Conserving Natura 2000 Rivers Ecology Series No. 5. English Nature, Peterborough, 1 - 54.

[43] NBN (2019). *Human observation of Petromyzon marinus (Linnaeus, 1758), Sea Lamprey recorded 1933-12-31.* Bristol Regional Environmental Records Centre.

[44] NRW (2018). *Severn Estuary / Môr Hafren Special Area of Conservation, Indicative site level feature condition assessments 2018*. NRW Evidence Report No: 235.

5.3.1.9 Twaite shad

Twaite shad is found along the western coastline of Europe, from southern Norway to Morocco and along the eastern Mediterranean, but the species has declined in numbers substantially throughout Europe[45]. Populations in the Severn Estuary utilise the River Seven, Usk and Wye as spawning grounds (freshwater phase around 3 months[44]) and the estuary itself as nursery habitat where juvenile shad feed on plankton[46]. Adult twaite shad migrate upstream to spawn from mid-May – mid July[45]. Access to these functional habitats is vital for the species to complete its lifecycle. There are several twaite shad records in the Severn Estuary from 1976 – 2002[47]. Monitoring conducted by NRW in the River Severn identified that the twaite shad population had declined from historic levels due to the presence of navigation weirs, that prevented access to 90% of rivers formerly accessible length[44]. Water quality deterioration has also been highlighted as a factor directly impacting on the condition of this feature in the Severn Estuary SAC[44].

5.3.2 Severn Estuary SPA

The Severn Estuary ranks amongst the top ten British estuaries for the size of visiting waterfowl populations that it supports over winter[48]. Outside of this period, it is of particular importance as a staging area in autumn and spring for migratory waterfowl species as it lies on the East Atlantic Flyway route. Bird communities are highly mobile and exhibit patterns of activity related to tidal water movements and many other factors. Different bird species exploit different parts of a marine area and different prey species

The migratory wintering and passage populations of birds in the Severn Estuary are designated features of the SPA and Ramsar Site which supports in excess of 70,000 birds in winter. These include internationally and nationally important populations of key bird species in winter for which the UK has particular importance in both Europe and the world. The bird assemblage is also part of the Estuaries feature of the SAC.

5.3.2.1 Internationally important populations of waterfowl

5.3.2.1.1 Annex 1 species of the SPA

The Severn Estuary SPA supports internationally important populations of one Annex I species, Bewick's swan *Cygnus columbianus bewickii*. This species is depended on the intertidal mudflats and sandflats as well as the salt marsh communities associated with the estuary. Bewick's swan graze on a range of 'soft' meadow grasses such as *Agrostis stolonifera* and *Alopecurus geniculatus* found in wet meadows which are out with the European Marine Site boundary.

5.3.2.1.2 Internationally important populations of regularly occurring migratory species of the SPA and internationally important populations of waterfowl of the Ramsar Site

The qualifying species of both the SPA and Ramsar are: European white-fronted goose (*Anser albifrons*), Dunlin (*Calidris alpina alpina*), Redshank (*Tringa totanus totanus*), Shelduck (*Tadorna tadorna*) and Gadwall (*Anas strepera*). These species are depended on the intertidal mudflats and sandflats, the saltmarshes, and the hard substrate habitats. These species are also dependent on the freshwater coastal grazing marsh, improved grassland, and open standing waters. These supporting habitats lie outside the European Marine Site boundary but within the SPA.

5.3.2.2 Internationally important assemblage of waterfowl

In addition to supporting internationally important populations of individual birds, the Severn Estuary also qualifies under Article 4.2 as a wetland of international importance by regularly supporting over 20,000

[45] Maitland, P. S and Hatton-Ellis, T. W (2003). *Ecology of the Allis and Twaite Shad*. Conserving Natura 2000 Rivers Ecology Series No. 3. English Nature, Peterborough.

[46] Natural England and Countryside Council for Wales (2009). *Severn Estuary SAC, SPA and Ramsar Site: Regulation 33 Advice*. Natural England and Countryside Council for Wales, 1 – 175.

[47] NBN (2020). Occurrence records. Weblink: here. Date accessed: 08/12/2020.

[48] Musgrove AJ, Pollitt MS, Hall C, Hearn RD, Holloway SJ, Marshall PE, Robinson JA and Cranswick PA (2001). The Wetland Bird Survey 1999-2000: Wildfowl and Wader Counts. Slimbridge: BTO/WWT/RSPB/JNCC.

waterfowl. A peak count of over 100,000 waterfowl was recorded in the winter season of 1992-93. The wintering waterfowl assemblage (consisting of over 68,000 birds) includes all regularly occurring waterfowl. These assemblages are dependent on the freshwater coastal grazing marsh, improved grassland, and open standing waters. These supporting habitats lie outside the European Marine Site boundary but within the SPA.

5.3.3 Severn Estuary Ramsar Site

The boundary of the Severn Estuary Ramsar site (central location: Latitude 51.2247222, Longitude -3.0491666) covers 246.63km² of the Severn Estuary which includes an extensive tidal zone consisting of Atlantic saltmarsh, mudflats, sandflats, and rocky shores[49]. The strong tidal regime and high turbidity have produced unique communities that are able to withstand the extreme conditions associated with unstable liquified mud and tide-swept sediment. The high densities of invertebrates provide feeding opportunities for passage and wintering waders and waterfowl. *Salicornia* spp. and annual sea blite (*Suaeda maritima*) colonise open mud on the lower shore and beds of *Zostera* species including eelgrass (*Zostera marina*), narrow-leaved eelgrass (*Zostera angustifolia*) and dwarf eelgrass (*Zostera noltei*). Species in the mid-upper saltmarsh include common cordgrass (*Spartina anglica*), common saltmarsh grass (*Puccinellia maritima*), red fescue (*Festuca rubra*) and saltmarsh rush (*Juncus gerardii*)[49]. Connectivity with multiple river systems also provides offsite functional spawning and nursery habitats for several fish species. Overlapping species with the Severn Estuary SAC and SPA have not been included. Additional baseline information provided in the River Avon confluence to tidal limit Environmental Assessment Report [50].

5.3.3.1 Allis shad

Allis shad are present along the western coastline of Europe, from southern Scandinavia to Spain but like Twaite shad, numbers of declined throughout Europe and they are caught only rarely in the River Severn and River Wye[51]. Adult Allis shad remain in marine habitats until they migrate upstream from April – June to spawn. The Severn Estuary is of importance for Allis shad as a feeding ground where they predominantly feed on *Mysida* species in the salt wedge and as a nursery ground[49].

5.3.3.2 Atlantic salmon

Atlantic salmon have a large distribution from Portugal to North America and are widespread in parts of the UK although, poor water quality and the presence of migratory barriers have driven a decline in salmon populations[52]. The Severn Estuary provides an important migratory route to freshwater spawning grounds in the upper reaches of the River Severn, Wye and Usk. They feed on a range of fish and crustaceans[54].

5.3.3.3 Sea trout

Sea trout is widely distributed from northern Scandinavia to northern Africa. Adult sea trout migrate upstream to spawn from September – December and smolts descend to the sea in spring, after up to 6 years in freshwater habitats[53]. The Severn Estuary provides an important migratory route to freshwater spawning grounds in the upper reaches of the River Severn, Wye and Usk. They also feed extensively in estuaries on a range of prey including fish and crustaceans[54].

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[49] JNCC (2008). *Information Sheet on Ramsar Wetlands (RIS), Severn Estuary*. JNCC, Version 3, 1 – 13.

[50] United Utilities (2021). Severn to Thames Transfer SRO downstream River Avon confluence to the tidal limit. Report by Ricardo Energy and Environment.

[51] Maitland, P. S and Hatton-Ellis, T. W (2003). *Ecology of the Allis and Twaite Shad*. Conserving Natura 2000 Rivers Ecology Series No. 3. English Nature, Peterborough.

[52] Hendry, K. & Cragg-Hine, D (2003). *Ecology of Atlantic Salmon*. Conserving Natura 2000 Rivers Ecology Series No. 7. English Nature, Peterborough.

[53] Miller, P. J and Loates, M. J (1997) Fish of Britain and Europe. *Harper Collins Publishers*, 1 – 288.

[54] Natural England and Countryside Council for Wales (2009). *Severn Estuary SAC, SPA and Ramsar Site: Regulation 33 Advice*. Natural England and Countryside Council for Wales, 1 – 175.

5.3.3.4 European eel

European eel is widely distributed from northern Scandinavia to northern Africa. Juvenile and yellow eels inhabit both coastal and freshwater habitats and descend to the sea as silver eels from September – December to spawn in the Sargasso Sea[53]. The Severn Estuary supports an important eel and elver fishery and has the largest eel run in Britain[54].

5.3.4 Walmore Common SPA

Walmore Common historically supported internationally important numbers of Bewick's swans during the winter months, and when the SPA was classified in 1991 it represented 3% of the total British wintering population and 1.5% of the European's population (104 birds). The population has since declined significantly from a five-year peak mean of 55 individuals in 2000/1-2004/05 (WeBS data from the BTO). Flight paths of the swans mainly follow the River Severn to access the wider Severn Vale. At Walmore Common, the swans from Slimbridge tend to fly on and off Walmore over Walmore Hill from the River Severn[55]. The Bewick's swans at Walmore Common use the fields surrounding areas which are inundated during high flow events and floods. For smaller floods the swans will largely be on the SPA fields but for bigger flood events they are mainly found off the SPA fields

5.3.5 Walmore Common Ramsar site

Walmore Common occupies a low-lying area in the Severn Vale, which is subject to winter flooding. The site is a wetland overlying peat providing a variety of habitats including improved neutral grassland, unimproved marshy grassland, and open water ditches. The common is part of a series of sites within the Severn Vale which, in winter, form an important refuge and feeding area for wildfowl. The highest bird numbers are seen during the harshest winters, when Walmore Common provides an essential feeding and roosting areas. He site qualifies under Ramsar criterion 6 (species/populations occurring at levels of international importance) with 43 individuals, representing an average of 0.5% of the GB population (5-year peak mean 1998/9- 2002/3) recorded at the site.

5.4 ASSESSMENT OF IMPACTS

5.4.1 Netheridge WwTW effluent transfer outfall construction related impacts

5.4.1.1 Construction impacts on supporting habitats for the designated bird communities

The construction of the pipeline to Haw Bridge will not result on direct impacts on any habitats that support the qualifying features of the Severn Estuary SPA and/or Ramsar site or the Walmore Common SPA and/or Ramsar site within the boundary of the designated sites.

However, the pipeline construction could result in direct impacts on functionally linked habitats. The Regulation 33 advice for the Severn Estuary European Marine Site indicates that freshwater grazing marsh, improved grassland and open waters also provide the structure and function to support many of the birds associated with the SPA and Ramsar Site[56]. Many of these habitats are present inside the boundaries of the European Marine Site, but are also present outside the boundaries of the SPA.

Similarly, the SACOs for the Walmore Common SPA[57] indicates that the principal habitat used by Bewick's Swans at this SPA are improved and semi-improved grassland, unimproved wet grassland and rush-pasture with these habitat types also providing off-site functionally linked habitat. The Bewick's swans congregate at Slimbridge, part of the Severn Estuary SPA. The swans have been recorded (Rees 1990) to use 10 key sites across Gloucestershire all situated within 3km from either the Severn or Avon rivers. These sites include Walmore Common SPA as well as Ashleworth Ham SSSI, Coombe Hill Canal SSSI. Other sites visited are non SSSIs as far north as Longdon Marsh in Worcestershire.

[55] ADAS (2008). Ecological Assessment to support a wind turbine proposal at Severn Smokery

[56] Natural England and Countryside Council for Wales (2009). Severn Estuary SAC, SPA and Ramsar Site: Regulation 33 Advice. Natural England and Countryside Council for Wales, 1 – 175.

[57]

The spatial dataset[58] which provides the location of Natural Environment and Rural Communities Act (NERC) (2006) Section 41 habitats of principal importance confirms that supporting habitats are *potentially* present outside the boundaries of the SPA and that the construction works could impact on these supporting habitats. This includes floodplain and grazing marsh and grasslands which will provide areas for feeding and roosting for all the migratory species particularly at high tide.

Natural England's Living Habitats data was also considered to provide an indication of the potential habitats that would be effected by the construction activities. Living England is a multi-year project which provides a habitat probability map for the whole of England, created using satellite imagery, field data records and other geospatial data in a machine learning framework. The data indicates that the habitat associated with the construction of the pipeline is mostly acid, calcareous and/or neutral grassland and arable and horticultural fields.

As noted in Section 2, the majority of the length of the pipeline will be installed via open trench. This will require the temporary stockpile of material which will be used to backfill and cover the trench to reinstate habitats.

The available data suggest that most of the habitat associated with the pipeline construction activities are improved grassland and arable fields. These habitats would potentially provide foraging habitats for wintering birds, especially during high tides when some of the saltmarsh and other supporting habitats in the Severn Estuary are covered by water.

More permanent impacts on habitat could occur where the subsurface drainage is altered as a result of the pipeline construction. This could result in a change in the dominant vegetation community and the structure of the habitat. This is only of concern where habitats are considered to be depended on sub-surface movement of groundwater such as wetland habitats (including floodplain and grazing marsh). There appears to be some floodplain and grazing marsh associated with the pipeline route on Alney Island. The banks of the River Severn in this area are highly modified so direct connectivity is likely to be limited and only approximately 150m of the pipeline route will effect the floodplain and grazing marsh.

Significant change in the structure and function of supporting habitat could undermine the conservation objectives of both the Severn Estuary and the Walmore Common European sites. It should, however, be considered that the extent of the construction activities is not considered significant in the context of the supporting habitats within the catchment. The impacts are also considered temporary and reversible. The potential impact pathways and the relevant mitigation measures are summarised below:

- Temporary loss of supporting habitat for birds due to topsoil stripping, trench creation for the installation of the pipeline and creation of a cofferdam.
- Changes in local hydrology could impact on habitat functionality.
    - Construction compounds will be sited sensitively and a buffer from designated habitats and sensitive receptors is to be maintained.
    - All habitats should be reinstated after constructions. A rehabilitation plan should be developed by a suitably qualified ecologist and should include the reinstatement of site draining in habitats that are depended on the movement of groundwater.
    - Spoil from pipeline construction should be distributed across the construction easement before topsoil replacement.
    - The approach to reinstatement of habitats should be included in the Construction Environmental Management Plan
- Excavations and movement of construction vehicles which could result in disturbance of birds.
    - No construction works will take place during the wintering season from November – March. If construction works must be conducted during the wintering season to avoid nesting birds, an Ecological Clerk of Works is recommended to undertake a bird survey prior to works to ensure no birds are present within 200m of the works. If present, works must stop until the qualifying species have exited the construction area.
    - Erect solid screens or barriers around site when directly adjacent to a sensitive receptor (in mitigation register.
    - Vehicles should be equipped with noise dampening equipment to minimise disturbances.
- The introduction and spread of Invasive Non-Native Species (INNS)

[58] https://data.gov.uk/dataset/4b6ddab7-6c0f-4407-946e-d6499f19fcde/priority-habitat-inventory-england

    - Best practice biosecurity measures should be followed, as recommended by the GB Non-Native Species Secretariat[59] to guard against any potential for spreading invasive and non-native species during construction.
- Exposure to pollution from accidental oil spills and run-off, localised increases in suspended sediment and noise/ vibration/ light disturbance.
    - Earthworks drainage should be controlled including use of temporary settlement ponds and measures will be taken to protect any temporarily exposed bare soil from runoff during heavy rainfall events.
    - Works will be conducted in adherence to EA Pollution Prevention Guidelines (now archived) and will required a Construction Environmental Management Plan with risk assessment for pollution incidents and a response plan if occurred.

Therefore, it is concluded that there is no risk of adverse effects on the bird communities of the SPA and Ramsar site. <u>This is in consideration of the proposed mitigation measures and construction methodology</u>. This also considers that any impacts will be temporary and fully reversible.

5.4.1.2 Construction impacts on supporting habitats for the designated fish communities

It is understood the construction of the outfall will adopt an approach of a subsurface outfall within the River Severn. This will require the installation of a temporary cofferdam to allow the construction of the outfall and associated pipeline. The construction works will be very localised and short term.

The construction work could impact on supporting habitat for lamprey ammocoete and could also disrupt the upstream and/or downstream migration of the anadromous and catadromous fish of the Severn Estuary.

- Adult shad will migrate from coastal waters into the Severn Estuary during mid to late spring (April – June) which would coincide with the construction work associated with the outfall for the Netheridge WwTW effluent transfer. Sea lamprey spawning migration also occurs in April and May with downstream migration of post metamorphic individuals occurring in July- September.
- The upstream migration of river lamprey occurs in October – January with downstream migration generally occurring in July-September. Atlantic salmon migrate upstream to spawn from November – December, but can enter the lower reaches of the River Severn in autumn with downstream migration occurring in April-May.
- Due to high river flows, construction <u>will not</u> occur in autumn/winter months. As such, the construction of the outfall will not coincide with the upstream migration of Atlantic salmon or river lamprey. The construction activities could, however, coincide with the upstream migration of sea lamprey and shad and the downstream migration of river and sea lamprey and Atlantic salmon.

Recent survey data is available for the reaches of the River Severn downstream of the Deerhurst abstraction and Haw Bridge. These data indicate that the River Severn in this reach is generally deep with the habitat dominated by glides[60]. The surveys concluded that lamprey nursery habitats were present in marginal areas of the left-hand bank throughout the reach, augmented by areas of cattle poaching. It is likely that a very small section of nursery habitat could be lost during the construction of the outfall.

The construction of the cofferdam could result in increase in suspended solids which could also impact on lamprey nursery habitat quality downstream. The impact is also considered to be temporary and reversible and high flows in autumn and winter will influence habitat distribution annually.

The surveys noted above found no suitable spawning habitat for shad and the likely risk to this species is related to the impacts on migration during construction of the cofferdam. Similarly, the construction of the cofferdam could coincide with the upstream of sea lamprey and downstream migration of river and sea lamprey as well as Atlantic salmon and sea trout. The construction activities are unlikely to impact on the downstream migration of any of the migratory species as the downstream migration is fairly passive and triggered by water

[59] Non-native species secretariat (2021). *Biosecurity and Prevention*. Accessed from: http://www.nonnativespecies.org/index.cfm?sectionid=58

[60] APEM (2021). UU STT Fisheries Surveys: Shad and Lamprey Habitat Walkovers. APEM Scientific Report P00006085. United Utilities, August 2021, v1.0 Final, 58 pp.

temperature and spate flows in late spring and early summer. The cofferdam and associated construction activities will not result in a barrier for downstream migration.

The cofferdam and associated construction activities will not result in a barrier for upstream migration. The construction activities could, however, impact on upstream migration as a result of increased noise and vibration. Noise levels of 140 to 160 dB transmitted from the ground to the water column would be perceptible to all fish species, at a peak frequency of 31.5Hz[61]. Behavioural responses by fish to this relate to the perceived loudness of the sound above typical hearing threshold of the species.

The construction method would, therefore, need to consider the potential impacts of noise and vibration. Mitigation measures could include timing of the activities to ensure that disturbance can also be minimised.

Significant change in the structure and function of supporting habitat could undermine the conservation objectives of the Severn Estuary European sites. The impacts are considered temporary and reversible. The potential impact pathways and the relevant mitigation measures are summarised below:

- Temporary loss of supporting habitat for lamprey ammocoete and changes in local hydrology which could impact on habitat functionality.
    - This impact is considered temporary and reversible, and habitat will remain available after the cofferdam is removed.
    - A phased construction of the cofferdam will also allow for lamprey to move out of the silt beds and, if required, lamprey ammocoetes should be relocated through electrofishing.
    - Directional/ baffled lighting during works on the riverbank will minimise light disturbance on the River Severn.
    - Avoid open-cut crossings of minor watercourses during upstream migration period for Atlantic salmon, European eel, and lamprey.
- Disruption of upstream and downstream migration, including impacts of noise and vibration
    - Consider the use of alternative piling rigs required and/or soft starts during the construction to reduce noise and vibration.
    - Avoiding any night-time working within the channel and scheduling construction works to avoid continuous work with the main river channel.
    - Where possible, it is proposed that lighting should be directional/baffled for works on the riverbank to minimise light disturbance in the River Severn.
    - Avoid and/or minimise construction works between October-May.
    - Directional/ baffled lighting during works on the riverbank will minimise light disturbance on the River Severn.
- The introduction and spread of Invasive Non-Native Species (INNS).
    - Best practice biosecurity measures should be followed, as recommended by the GB Non-Native Species Secretariat[62] to guard against any potential for spreading invasive and non-native species during construction.
- Exposure to pollution from accidental oil spills and run-off, localised increases in suspended sediment and noise/ vibration/ light disturbance
    - Earthworks drainage should be controlled including use of temporary settlement ponds and measures will be taken to protect any temporarily exposed bare soil from runoff during heavy rainfall events.
    - Works will be conducted in adherence to EA Pollution Prevention Guidelines (now archived) and will required a Construction Environmental Management Plan with risk assessment for pollution incidents and a response plan if occurred
    - Works should be conducted in adherence to EA Pollution Prevention Guidelines; now archived.
    - Construction Environmental Management Plan with risk assessment for pollution incidents and introduction/ spread of INNS and a response plan if occurred should be developed.

[61] https://assets.gov.ie/85787/a1ce38e5-51b7-4c89-96ca-5886a82968bb.pdf

[62] Non-native species secretariat (2021). *Biosecurity and Prevention*. Accessed from: http://www.nonnativespecies.org/index.cfm?sectionid=58

It is concluded that there is no risk of adverse effects on the fish community of the SAC and Ramsar site. This is in consideration of the proposed mitigation measures and construction methodology. This also considers that any impacts will be temporary and fully reversible.

5.4.2 Netheridge WwTW effluent transfer operation and impacts on water quality associated, d/s Haw Bridge.

5.4.2.1 Context

To attain favourable condition, water quality within the Severn estuary and supporting habitats needs to be sufficient to support migratory passage. Levels (for temperature, salinity, turbidity, pH, and dissolved oxygen) should comply with targets established under the Water Framework Directive. Toxic contaminants in the water column and sediment should also be below levels which would pose a risk to the ecological objectives of the site.

Natural England have note that[63], for the estuaries, mudflats and sandflats not covered by seawater at low tide, and Atlantic salt meadows features, the two factors contributing to unfavourable condition were: (i) coastal squeeze impacts; and (ii) water quality impacts (based upon Water Framework Directive reporting for the relevant Welsh waterbodies). The assessment for sea lamprey, river lamprey and Twaite shad was based on data from the inflowing rivers (Rivers Usk and Wye) as relevant marine data on the populations had not been collected. Sea lamprey and river lamprey were deemed to be in unfavourable condition due to water quality issues. Twaite shad was deemed to be in unfavourable condition due to water quality issues and artificial barriers to migration

The conservation advice for the Severn Estuary European Marine Site also highlights the vulnerability of habitat to changes in water quality. Changes in any of the physico-chemical parameters in the water column can impact on the quality of the estuary habitat and hence could lead to changes in the presence and distribution of species (along with recruitment processes and spawning behaviour) and those at the edge of their geographic ranges and non-natives. In particular this relates to:

- Toxic contamination through the introduction of synthetic and/or non-synthetic compounds
- Changes in nutrient loading
- Changes in the thermal regime
- Changes in salinity
- Changes in oxygenation

Changes in any of the physico-chemical parameters in the water column can impact on the quality of the estuary habitat and hence could lead to changes in the presence and distribution of species (along with recruitment processes and spawning behaviour) and those at the edge of their geographic ranges and non-natives.

Of particular concern is significant increases in Dissolved Absorbable Inorganic Nitrogen (DAIN) which can change the species composition of the plants on the saltmarsh and thus the structure of the sward. Increases in nutrients can cause excessive algal growth on the mudflats, denying the birds access to their invertebrate prey and changing the invertebrate species composition in the sediment. However, high nutrient loads can also be beneficial to some species of birds by increasing the density and size of prey items. Though the water quality has been improved in recent years there are still local areas of concern

5.4.2.2 Proposed treatment

The Netheridge WwTW currently discharges into the Severn Estuary near Gloucester (downstream of the weir at Maismore (i.e., below the normal tidal limit). A change in discharge location could therefore impact on water quality with a consequent direct impact on lamprey ammocoete and juvenile shad and/or an indirect impact on migratory ques (olfaction). Olfactory cues play an important role in the behavioural ecology of many fish species governing their navigation, predator avoidance, social dynamics, prey detection and homing in

[63] Natural England (2022). Position Statement: Indicative Condition Assessment of the Severn Estuary/Môr Hafren Special Area of Conservation (SAC). May 2022

migratory species. The ability of fish species to migrate and navigate towards freshwater during anadromous migrations has stimulated a large volume of research.

The assessment of any potential impacts needs to consider the proposed treatment that will be implemented as part of the ST Source SRO. The portion of the treated effluent from the Netheridge WwTW that will be diverted to the River Severn at Haw Bridge will be subject to tertiary treatment.

As a result, the quality of the effluent that will be discharged at Haw Bridge will be significantly better than the effluent currently being discharged near Gloucester during operation of the STS SRO. It is also noted that the majority of the treatment process will remain in place during periods when the STS is not operational resulting in improvements in effluent quality in general.

The tertiary treatment will consist of the following:

- Moving Bed Biofilm Reactor (MBBR) for the further treatment of ammonia,
- Ferrous sulphate dosing into the Activated Sludge Process and CoMag treatment for further treatment of total phosphorus,
- Biological Aerated Flooded Filter (BAFF) technology for the further treatment of Biological Oxygen Demand 9BOD) and Total Suspended Solids (TSS)
- Tertiary solids removal to reduce iron concentrations from the treatment process
- Ozone contactor to remove organic substances such as Chlorothalonil
- Granular Activated Carbon (GAC) for the removal of organics such as 2,4-dichlorophenol, nonylphenols, octylphenols, perfluorooctane sulfonic acid (PFOS) and its derivatives

5.4.2.3 Impacts on general water chemistry

An extensive suite of water quality monitoring has been undertaken since 2020 in the study area, particularly at a monitoring site at Deerhurst. In the absence of water quality pressures between Deerhurst and Haw Bridge, Deerhurst water quality data are considered to also represent Haw Bridge. There is also a monitoring site in Netheridge WwTW final effluent to characterise the water quality of the source water for the advanced treatment process that would be included for the SRO. There are typically 16 data points available at these two locations with reported water quality for: all WFD priority hazardous substances , all WFD priority substances, all WFD specific pollutants; all WFD physico-chemical water quality determinands; all other chemicals listed by the EA as with Environmental Quality Standards that are subject to environmental permitting; a suite of chemicals relevant to Drinking Water Safety Planning as required by the Drinking Water Inspectorate; a range of chemicals linked to disruption of olfaction in fish. Continuous monitoring data are also available for water temperature, dissolved oxygen and conductivity for the same period and sites.

Downstream of the tidal limit at Gloucester some changes in water quality are expected from operation of the full STT according to 1D time series deterministic hydraulic and water quality modelling undertaken for STT SRO. This is in consideration of the STS SRO being operational to support the fully supported STT SRO. The changes in the general physical-chemical characteristics are summarised as follows:

- In the River Severn at the tidal limit, the scheme is predicted to reduce water temperature by 0.2°C and 0.3°C.
- Dissolved oxygen concentrations are predicted to be reduced by about 0.1 mg/l.
- Ammoniacal nitrogen concentrations are predicted to be increased by about 0.02 mg/l.
- Oxidised nitrogen is increased by about 0.8 mg/l during the scheme (~10% increase on baseline). DAIN concentrations are increased by a similar amount.

The magnitude of flow change associated with the Netheridge WwTW effluent transfer is low: 20 or 35Ml/d discharged into River Severn flows of 1,300Ml/d or more; and as such the extent of potential difference is low compared to the full STT SRO. Furthermore, the planned advanced treatment processes at Netheridge WwTW are specifically designed to avoid water quality effects. This particularly holds true for chemicals, where analysis of the full suite of WFD chemicals has identified none would increase in concentration in the River Severn and the Netheridge WwTW effluent transfer would not impede any chemicals currently failing environmental quality standards (EQS) in the River Severn at point of discharge from achieving EQS. In terms of the load of chemicals entering the Severn Estuary, as the SRO's advanced treatment processes at

Netheridge WwTW would remove these to treatment sludges there would be an overall reduction in chemical input into the estuary.

Specific additional analysis has been undertaken in relation to DAIN using the EA long term water quality monitoring point at Haw Bridge[64] for the 10-year period 2013-2022. The 117 data points identify DAIN concentration as 5.65 mg-N/l with a standard deviation of 1.14 mg-N/l. Allowing for the expected removal rates of the SRO's advanced treatment processes at Netheridge WwTW, discharged concentration at Haw Bridge could be 15.8 mg-N/l. Modelled assessment identifies that for two representative scenarios:

- Using the operating pattern of STS SRO, once every twenty years this could lead to an annual increase in DAIN contribution from the freshwater River Severn to the Severn Estuary of 46 tonnes from a baseline of 14,804 tonnes – an increase of 0.31%. It is noted that under these circumstances at least 90 tonnes/year less DAIN would be input into the Severn Estuary from Netheridge WwTW at the current outfall.
- Using the operating pattern of STS SRO, once every twenty years this could lead to an annual increase in DAIN contribution from the freshwater River Severn to the Severn Estuary of 35 tonnes from a baseline of 15,369 tonnes – an increase of 0.23%. It is noted that under these circumstances at least 67 tonnes/year less DAIN would be input into the Severn Estuary from Netheridge WwTW at the current outfall.

As such there would be an overall reduction in DAIN input from the freshwater River Severn and Netheridge WwTW combined into the Severn Estuary as result of STS SRO.

5.4.2.4 Impacts on chemicals including determinants that would impact on olfaction

This category includes contamination from synthetic compounds (including pesticides and herbicides), non-synthetic compounds (including heavy metals) and hydrocarbons (oil related products). The estuary feature is currently considered to have moderate sensitivity and high exposure and therefore high vulnerability to toxic contamination.

Toxic contaminants may act as a barrier to migration. The sensitivity of fish olfaction is odorant-dependent. As such, changes in water quality could impact on the migratory cues of the migratory species associated with the Severn Estuary. In general, fish can detect natural chemical cues in aquatic environments at concentrations ranging down to the parts per billion (10^{-9} M) or trillion (10^{-12} M)[65]. This level coincides with concentrations of natural odorants, such as amino acids[66] and bile salts[67], in surface waters.

For those chemicals with an EQS, there would be no change in concentration that changes from EQS pass to EQS fail; no reduction in quality where there is EQS pass; no further reduction in quality where there is currently EQS fail; and for chemicals with current EQS fail, no impediments to achieving EQS pass. The review has been undertaken using River Severn at Deerhurst chemical concentrations and post-removal treatment efficacy from STS engineers, and is without recourse to the minimum 1:37 dilution rate of the River Severn at the Netheridge WwTW effluent transfer outfall.

Selected endocrine disruptors which may act as olfactory inhibitors in the context of SROs have only recently been identified[68]. These chemicals require specific analysis which has only recently commenced and has a smaller evidence base at present that will be kept under review in Gate 3.

It is important to note that the Netheridge WwTW already discharges into the Severn Estuary and the proposed STS SRO will only result in a change in discharge location with an improved treatment process which is designed to lead to no change in chemical concentration in migratory pathways and functionally linked habitats

[64] https://environment.data.gov.uk/water-quality/view/sampling-point/MD-00025085

[65] Belanger, R.M., Corkum, L.D., Li, W., Zielinski, B.S., 2006. Olfactory sensory input increases gill ventilation in male round gobies (Neogobius melanostomus) during exposure to steroids. Comparative Biochemistry and Physiology-Part A: Molecular & Integrative Physiology 144, 196–202.

[66] Shoji, T., Yamamoto, Y., Nishikawa, D., Kurihara, K., Ueda, H., 2003. Amino acids in stream water are essential for salmon homing migration. Fish Physiology and Biochemistry 28, 249–251.

[67] Zhang, C., Brown, S.B., Hara, T.J., 2001. Biochemical and physiological evidence that bile acids produced and released by lake char (*Salvelinus namaycush*) function as chemical signals. Journal of Comparative Physiology B 171, 161–171.

[68] Ricardo Energy & Environment (2021). Technical Note. Severn Thames Transfer SRO – Impact of determinands on olfaction and fish populations in the Severn Estuary. United Utilities on behalf of the Severn Thames Transfer Programme. December 2021.

within the freshwater River Severn itself; and a consequent reduction in load input to the Severn Estuary SAC itself from .the freshwater River Severn and Netheridge WwTW combined.

Therefore, it is concluded that there is no risk of adverse effects on the Severn Estuary SAC, SPA and Ramsar site (or supporting habitats for the Walmore Common European site). This is in consideration of the treatment.

5.4.3 Joint Mythe WTW licence transfer and Netheridge WwTW effluent diversion operation

The Mythe WTW abstraction licence Scheme will not operate alone and will operate in-combination with the Netheridge WwTW effluent transfer when support is required.

The potential impact pathway on hydrology is, therefore:

- The abstraction of 50Ml/d at Deerhurst up to Haw Bridge (effecting approximately 3.9 km of the River Severn), and
- The augmentation of 35Ml/d at Haw Bridge, with net 15Ml/d reduction downstream of the discharge of treated effluent (effecting the River Severn downstream of Haw Bridge and into the Severn Estuary.

The likely operational pattern (as used in this assessment) is presented in Section 2.3.

Table 5-2 provides a summary representation of the potential changes in flow within the ~3.9km reach of the River Severn between the Deerhurst intake and the Haw Bridge outfall. It is evident that in both a moderate-low flow year (A82 scenario) and a very low flow year (M96 scenario) the proportionate change in flow is between 1.3 and 2.1% in summer months. The most notable change in flows in this ~3.9km reach of the River Severn in both modelled scenarios is a decrease of ~7% in flow in November in the A82 scenario. The decrease in flow should be considered in the context of the average flows during these autumn months which can exceed 10,00Ml/d in November. The significance of these flow changes on the habitat quality and quality for the relevant features (including migratory fish) in this ~3.9 km reach of the River Severn is discussed in the sections below (see Section 5.4.3.1).

After the Netheridge discharge point, flows in the River Severn will be augmented by the discharge of 35Ml/d of tertiary treated effluent at Haw Bridge with the fully supported STT scheme. Table 5 4 provides a summary representation of the potential changes in flow downstream of Haw Bridge. From the results it is evident that that maximum reduction in flow is ~0.4% in summer with the most notable change of ~6% in autumn when flows are ~10,000Ml/d.

The potential changes in past forward flow have also been considered for a 47-year representative period comparing reference conditions to a fully operation STT (supported abstraction) in Figure 5.1 Flow duration curve of a 47-year representative period showing the changes in flow at the tidal limit of the Severn Estuary.

Overall, the changes in freshwater inflows into the Severn Estuary is not discernible.

Table 5-2: Summary of flow changes in the River Severn downstream of the Haw Bridge discharge location.

	% flow reduction, downstream Deerhurst compared with upstream Deerhurst	% flow reduction, downstream Haw Bridge compared with upstream Deerhurst
Minimum flows	1.3%	0%
Q99 Exceptionally low flows	2.1%	0.4%
Q95 Very low flows	1.9%	0.4%
Q90 low flows	1.6%	0.4%

While not all estuarine habitats are directly depended on freshwater inflows, some habitats that support the bird and fish communities of the Severn Estuary will be dependent on freshwater inflows for maintaining the required salinity and sediment regime as well as water quality. For example, the intertidal mudflats and sandflats largely dependent on the salinity which limits the penetration of marine species upstream where freshwater influences are strongest. The Atlantic salt meadows of the estuary is also dependent on freshwater

inputs for maintaining the sediment and nutrient regime. The available data suggests that the only habitats associated with the upper estuary which will provide some supporting habitat to the relevant estuarine species (birds and fish) are some mudflats.

Significant changes in freshwater inflows could impact on the process that are important for the structure and function of some of the estuarine habitats with a consequent impact on the ability to support and maintain the qualifying features of the Severn Estuary European Marine Site.

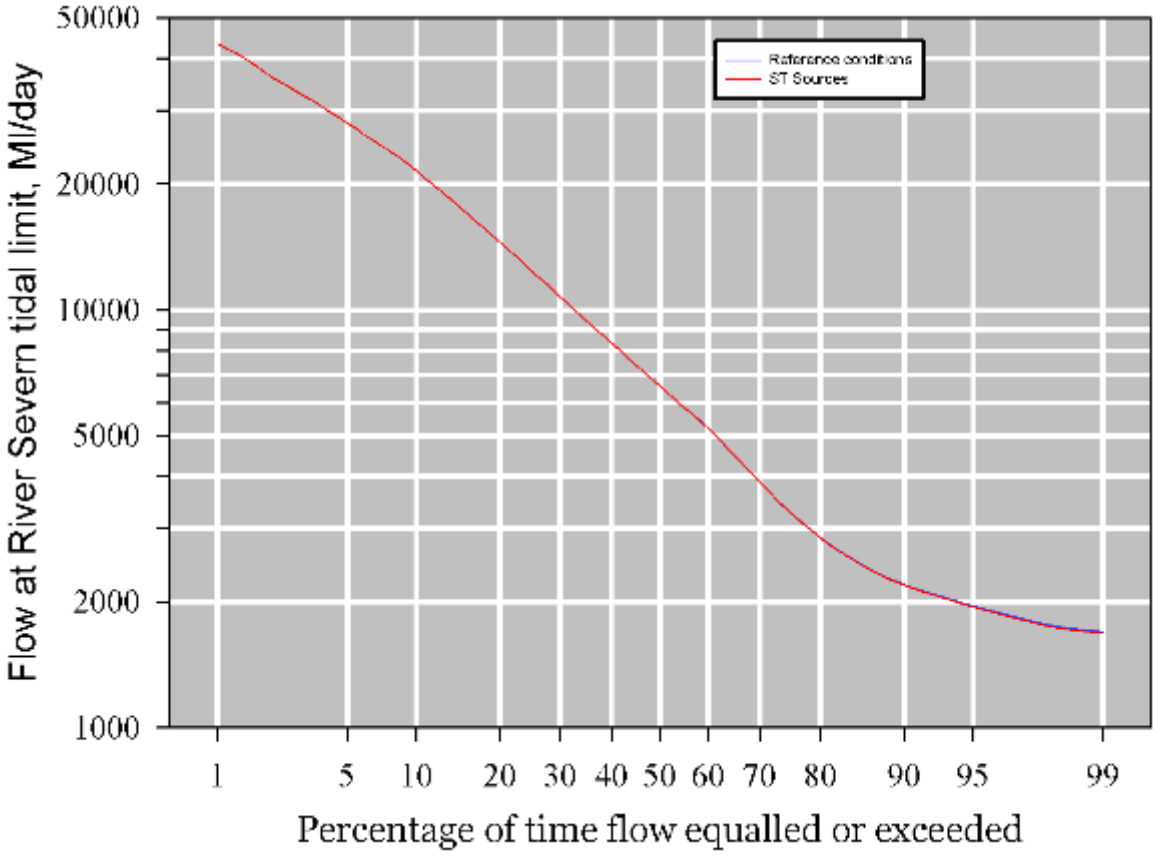


Figure 5.1 Flow duration curve of a 47-year representative period showing the changes in flow at the tidal limit of the Severn Estuary

As noted above, flow in the River Severn will be augmented by the discharge of 35Ml/d of tertiary treated effluent at Haw Bridge which will reduce the magnitude of any flow impacts on the reaches of the River Severn downstream of the outfall and into the Severn Estuary. As such, the hydrological impacts downstream of the Haw Bridge outfall will be limited to a loss of 15Ml/d (due to the transfer of the infrequently used abstraction licence).

There are no flow targets for the Severn Estuary.

- The Regulation 33 advice does, however, indicate that that the target for the tidal regime and flows (conservation objective; maintaining the characteristic physical form and flow) is for riverine flows (Rivers Wye, Usk and Severn) and estuarine flows to be sufficient to ensure Water Framework Directive target of Good Ecological Status (GES) is met.
- Research in 1992 recommended maintaining a Mean Residual Flow of 1,200-1,500Ml/d during neap tides and 1,800-2,400Ml/d during spring tides[69]. These regulation 'freshet' releases were tested but terminated in 2006 due to the assessments that concluded that this was as an inefficient use of resources with no reported benefits.

[69] Environment Agency (2013). River Severn Drought Order Environmental Report.

Table 5-3 provides a summary of the residual flow requirements for the Severn Estuary (as adapted from Wade, 1996)[70].

Table 5-3 Set or suggested residual flows for the River Severn: reasons for flow and comparison to observed Q95 values.

River	Environmental Residual Flow (Ml/d)	Q95 (Ml/d)	Residual Flow / Q95	Reason*
Severn				
- Neap Tides	1,200	1,780	0.67	D
- Spring Tides	1,800			F S Q

*D = Dilution, F = Fisheries, S = Saline Intrusion, Q = Quality.

It is noted that the HoF of 2,568Ml/d which is well above the flow required to prevent saline intrusion above Maisemore Weir of 1,800 and 1,200Ml/d on spring and neap tides respectively. This is mostly because flows from around Q96 onwards are elevated towards what would naturally have occurred[71]. However, the flow regime met the EA's Environmental Flow Indicator (EFI) requirements at all times, at the time of writing the Severn Drought Order[72].

From the assessment of hydrological impacts, it is evident that the proportionate reduction in flow is not of a magnitude to result in changes in salinity with the associated habitats continued to be influenced by the large tidal regime and the associated estuarine processes.

Therefore, it is concluded that there is no risk of adverse effects on site integrity of the Severn SAC, SPA and Ramsar site (or supporting habitats for the Walmore Common European site) when considering the changes freshwater inflow.

This is because the freshwater inflows will still be sufficient to support any habitat processes and will remain above the residual flow requirements. Particularly in summer, flow will generally be higher when compared to naturalised flow conditions and the changes will be within the natural annual variations that would be observed under baseline conditions.

The significance of these flow changes on the habitat quality and quality for the relevant features in River Severn downstream of Haw Bridge are discussed in the sections below.

5.4.3.1 Impacts on habitat quality and quality

The impacts on habitat quality and quantity will be limited to the short reach (~3.9km) between the abstraction for the STT at Deerhurst and the diversion outfall at Haw Bridge. Downstream of Haw Bridge the impact will be limited to a reduction in flow of 15Ml/d which will be non-discernible.

It is noted that most of the migratory fish associated with the Severn Estuary will migrate to the middle and upstream reaches as well as some tributaries of the River Severn to existing spawning sites/habitats. The main risk associated with the reduction in flow between the Deerhurst the Severn Estuary is considered to include:

- the potential impact on lamprey ammocoete habitat.
- the potential impact on downstream migration of migratory species.
- the potential impact on habitat availability for juvenile shad.

The marginal silt beds downstream of the confluence with the River Avon to the tidal limit are considered important nursery habitats for sea and river lamprey. Such nursery habitats consist of open-structured, aerated, silty and sandy substrates between 2 and 40cm depth generally in shallow (<0.5m) slack-water channel margins with some shade. Any reduction in the density and/or abundance in lamprey ammocoete could impact on the condition status of the qualifying feature. A loss of habitat and the resulting impact on abundances of

[70] Wade RJ (1996). Flow requirements to estuaries. In *Water Environment '96 "Supply and Demand – A Fragile Balance"*.
[71] Environment Agency (2013). River Severn Drought Order Environmental Report. Appendix H.
[72] Environment Agency (2013). River Severn Drought Order Environmental Report.

post metamorphic individual could also impact on the number of returning adults which would undermine the conservation objectives of the site.

In addition to the risk of changes in the quality and quantity of lamprey ammocoete habitat, the modelled operational regime indicates that the operation of a fully STT (i.e., with the ST SRO operational), would potentially coincide with the downstream migration of smolt, juvenile shad and/or post metamorphic lamprey individuals. Significant changes in velocity could impact on this life stages as juvenile shad and post metamorphic lamprey are generally poor swimmers and depend on drift to successfully reach the estuary.

As noted above, the potential impacts on habitat quality and quality have been subject to modelling and the results are provided in Figure 5.3 and Figure 5.4.

The results of the modelling completed for the STT operational impacts indicates that the changes in depth and velocity, within the ~3.9km reach of the River Severn between the Deerhurst abstraction and Haw Bridge outfall location, will be non-discernible for most of the operation period in a moderate-low flow year (A82 scenario) and the very low flow year (M96 scenario). Overall, the average change in velocity and depth will be <2% in all months. The potential changes in velocity and depth are not considered to be of a magnitude to result in impacts on habitat availability for the fish community (including lamprey ammocoete) with the velocity and depths remaining similar to baseline conditions and within the preferred and optimum requirements for the baseline fish community.

This is evident when comparing photographs that were taken on different days when the change in depth/level much higher than would be experienced as a result of the STS SRO. Figure 5.2 shows the River Severn downstream of the Deerhurst on the two separate dates in 2021. This includes the 21st of July 2021 when water levels (as measured at Deerhurst) was at 0.584m and the 13th of August 2021 (when flows were at 0.692m). This represents a difference in level of ~10cm, far more than would be observed as a result of the operation of the STS SRO and there is no perceptible change in habitat availability for fish in at this location.

The most noticeable change in velocity is likely to be in October where modelling shows a potential change of ~ 5% in velocity, however, velocity will still be within the optimum range for lamprey ammocoete habitat (0.01-0.05 m/s) and will not impact on the downstream drift of either ammocoete on shad juveniles.

As noted in the sections above, the impact of the fully supported STT (i.e., with the ST SRO operational) will be limited to the 3.9km reach downstream of the Deerhurst abstraction. The results of the modelling for the reach of the River Severn downstream of Haw Bridge also shows no discernible change in velocity and depth.

The most noticeable change in depth and velocity in October where modelling shows a potential change of ~ 5%. However, velocity will still be within the optimum range for lamprey ammocoete habitat (0.01-0.5 m/s) and will not impact on the downstream drift of either ammocoete on shad juveniles. Similarly, depth will still be within the optimum range for lamprey juveniles (0 – 2m with shallow margins preferred). As a result, there will be no impact on the quality and quality of habitat availability to support lamprey ammocoete or juvenile shad.

Based on the available data there will be no impact on the key attributes and targets for attaining favourable condition. It is recommended that the start-up and shut down of the discharge of treated effluent is undertaken in a phased approach over a 5-day period.

Therefore, it is concluded that there is no risk of adverse effects on site integrity of the Severn Estuary SAC and Ramsar site when considering the changes in habitat quality and quantity.

Figure 5.2 Photographs showing the River Severn downstream of the Deerhurst on the 21st of July 20210 (top) and 13th of August 2021 (bottom) when levels were at 0.584m and 0.692m respectively (as measured at Deerhurst)

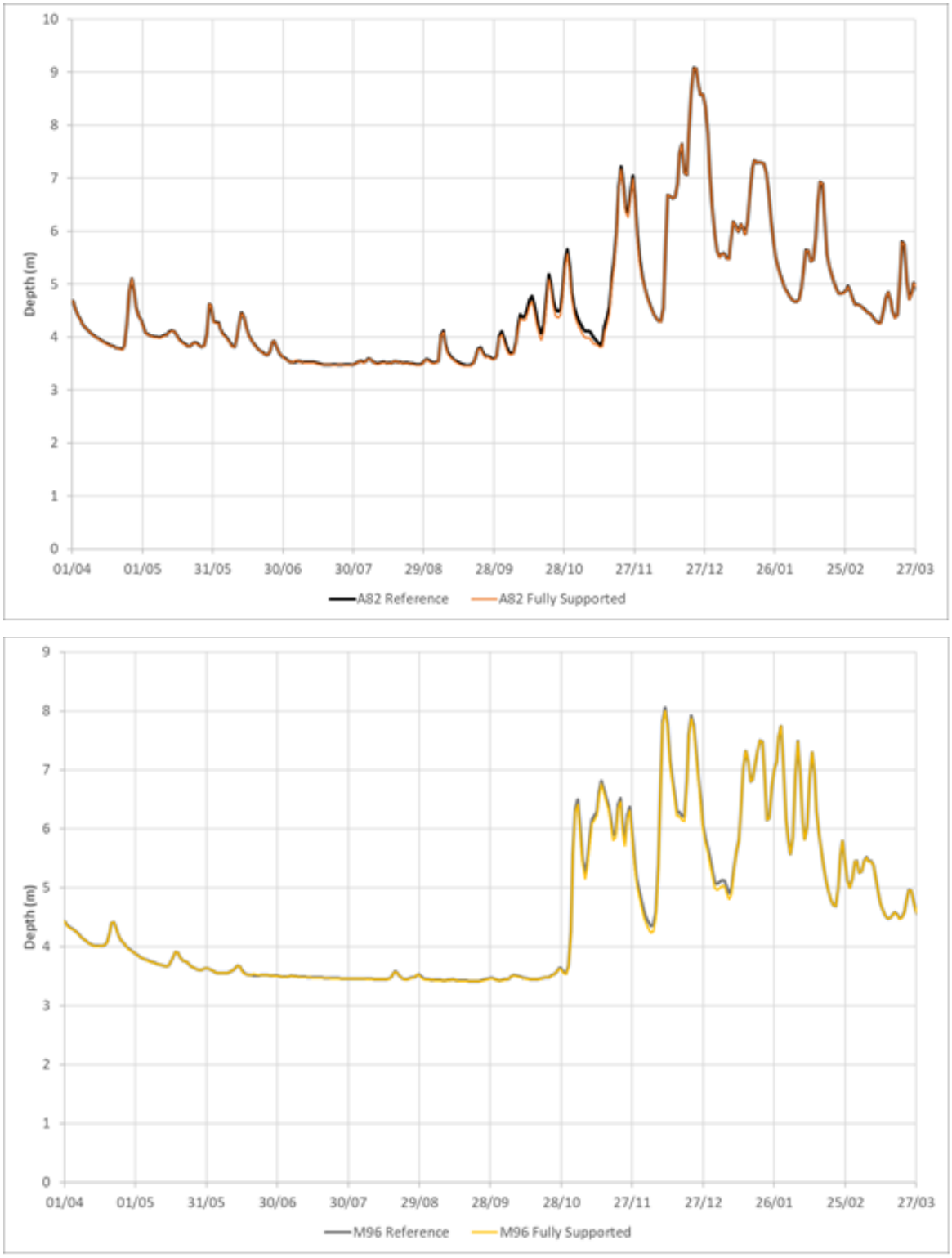
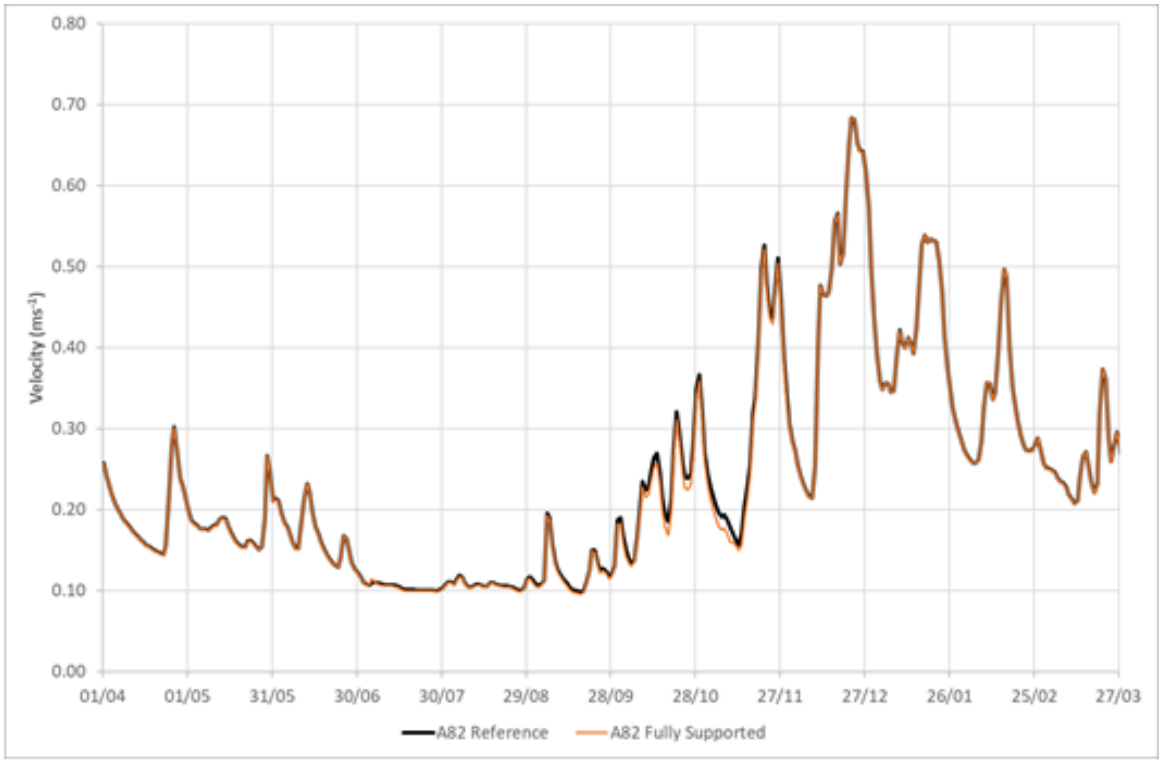


Figure 5.3 Graphical representation of the modelled changes in depth (in meters) between the Deerhurst abstraction and the Haw Bridge discharge location in a A82 (moderate low flow year) and M96 scenario (very low flow year)



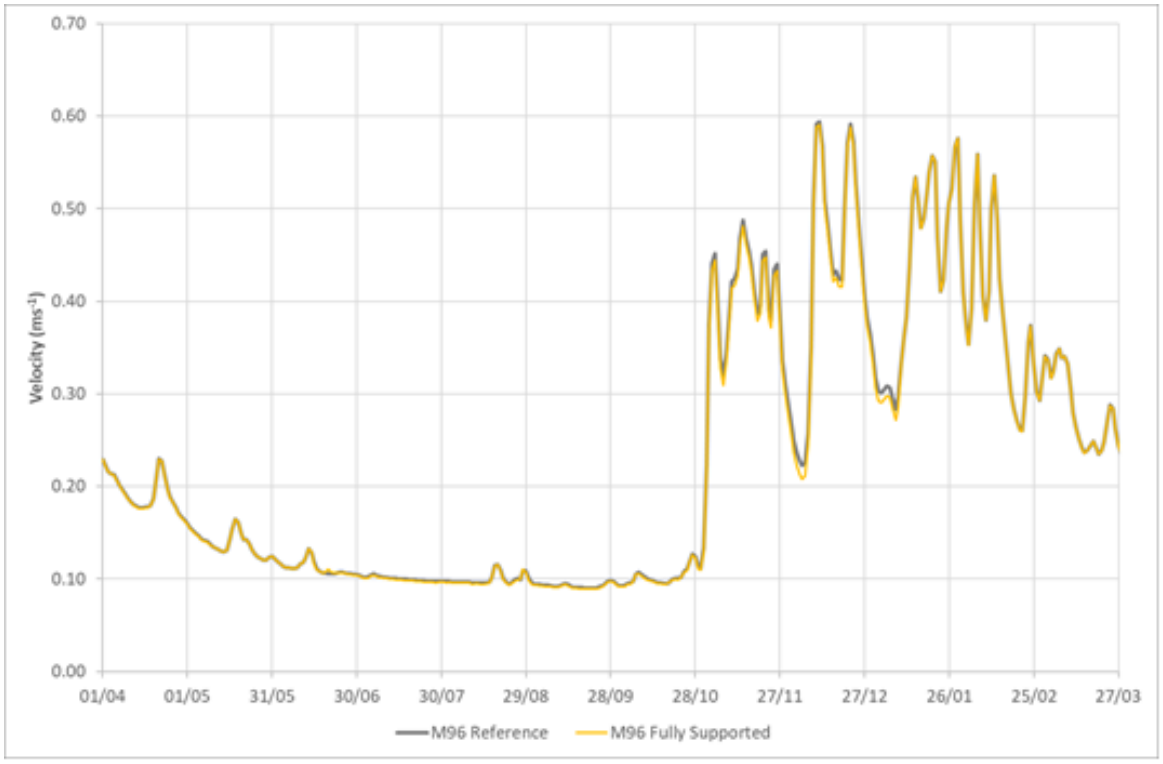


Figure 5.4 Graphical representation of the modelled changes in velocity (m/s) between the Deerhurst abstraction and the Haw Bridge discharge location in a A82 (moderate low flow year) and M96 scenario (very low flow year)

5.4.3.2 Impacts on migration and barriers

As note in Section 5.2, favourable condition status for the qualifying features is depended on flows from the rivers Wye, Usk and Severn into the estuary being sufficient to allow migration and that physical barriers do not impede upstream migration. It is evident that the STS SRO will potentially be operational during the migration period for all of the migratory fish associated with the Severn Estuary European site.

It is noted that the only barrier downstream of the Deerhurst intake is the Maisemore Weir. The weir is considered passable to all migratory species, although passability is influenced by tidal state, particularly for shad which require spring tides. The main risk to migratory species, as related to hydrology, is change in migratory cues.

The natural flow regime is critical to all aspects of lamprey life cycle. It shapes the characteristic biotope mosaic, maintains water in critical biotopes (including marginal silt beds), and provides adequate flows for migratory passage. The main upstream migration period for river lamprey is October to March. The spawning season of this species in British rivers starts when the water temperatures reach 10–11ºC[73]. The upstream spawning migration for sea lamprey in Europe usually takes place in April and May when the adults start to migrate back into fresh water.

The result of the modelling indicates the total change in flow during the upstream migration period for river lamprey is ~ 6% and ~0.2% during the upstream migration period for sea lamprey in a moderate-low flow scenario (A82). In a very low flow year (M96 scenario) total change in flow during the upstream migration period for river lamprey is between 1.7 and 4.2% and 0.1% during the upstream migration period for sea lamprey.

Olfaction may play an important role at several stages of the lamprey life history and studies suggest that spawning migrations are initiated by a range of environmental cues including, flow, temperature, tidal and dial phases as well as chemical olfactory cues. However, unlike the 'alevins' of salmonid species which undergo a period of imprinting shortly after hatching, during which the chemical nature of the natal watercourse is learned using olfactory senses allowing individuals to return accurately, lampreys use conspecific odours to identify suitable spawning habitat, search for mates, and avoid risk[74]. Larvae excrete lamprey-specific bile acids[75] into the water at rates sufficient to create a detectable concentration in a river (~10 ng/h)[76]. Three bile acids, petromyzonol sulphate (PZS), petromyzonamine disulfate (PADS), and petromyzosterol disulfate (PSDS) are released into the water[28] and elicit strong electrophysiological responses from the olfactory epithelium and influence the behaviour of migratory lamprey in laboratory mazes[77].

The proportionate change in flow should be considered in the context of the average flow during this period which will be ~ 5,444 – 9,339Ml/d. The proportionate change will be within the expected naturally variation and due to the extremely low concentrations that are detectable by migrating adults, olfaction will not be impacted by the operation of the STS SRO.

The literature review completed by APEM[78] identified that twaite shad spawning activity on the lower main stem River Severn is well documented in the scientific literature, although the spatial extent of spawning activity appears to be quite restricted compared to historical accounts. On the River Severn, twaite shad spawning activity has been observed in the lower catchment, downstream of Upper Lode weir. It was previously believed that a lack of observed spawning activity upstream of the weir may have been attributable to the weir posing a physical barrier to upstream migration. It is unclear to what extend the twaite shad population of the lower River Severn contributes to the twaite shad population of the Severn Estuary.

The role and mechanisms of olfaction in twaite and allis shad has not been subject to extensive research. Previous work using otolith chemistry has shown that elemental signatures in juvenile American shad from

[73] Hardisty MW & Potter IC (eds) (1971). *The biology of lampreys*. Academic Press, London.

[74] Wagner CM, Stroud EM, Meckley TD, Kraft C. (2011). A deathly odour suggests a new sustainable tool for controlling a costly invasive species. Can J Fish Aquat Sci.; 68: 1157–60

[75] Haslewood GAD, Tökés L. (1969). Comparative studies of bile salts. Bile salts of the lamprey Petromyzon marinus L. Biochem J. 114:179.

[76] Fine JM, Sorensen PW. (2010). Production and fate of the sea lamprey migratory pheromone. Fish Physiol Biochem. 36:1013–20

[77] Sorensen PW, Fine JM, Dvornikovs V, Jeffrey CS, Shao F, Wang J, *et al*. (2005). Mixture of new sulfated steroids functions as a migratory pheromone in the sea lamprey. Nat Chem Biol. 1:324–8.

[78] APEM (2020). STT Ecological Literature Review. APEM Scientific Report P00004288. Severn Thames Transfer Partnership, September 2020, v2.0 Final, 480 pp

three large rivers along the northeast Atlantic coast of the United States were highly distinct[79]. Strontium (Sr) isotopes in otoliths provided a particularly powerful addition to the suite of variables used to determine the natal origins of juvenile American shad. The composition of rocks within a watershed determines the ratio of different isotopes of dissolved inorganic Sr in river water. Otolith Sr is, in turn, isotopically equilibrated with the ambient water[80].

Adult shad will migrate from coastal waters into the Severn Estuary during mid to late spring (April – June) which would coincide with the operation of the STS SRO. The total flow change in the impacted reach during this period is expected to be <1% in either a moderate-low or a very low flow year (A82 and M96 scenario). The STS SRO will not impact on the passability of any barriers to shad migration and the proportionate change will not impact on migratory ques (physical or chemical).

Atlantic salmon migrate upstream to spawn from November – December, but can enter the lower reaches of the River Severn in autumn. The spawning habitat for Atlantic salmon is widely distributed in the upper reaches of the River Severn and the numerous tributaries of the River Severn. The total flow change in the impacted reach during this period is expected to be between ~6% in either a moderate-low or a very low flow year (A82 and M96 scenario) during the upstream migration period and will be within the interannual variations that would be expected in this reach. the migratory behaviours and the role of olfaction in Atlantic salmon are well understood. Olfaction plays an important role at several stages of the Atlantic salmon life history and numerous studies suggest that spawning migrations are initiated by a range of environmental cues including, flow[6], temperature[6], tidal[8] and dial phases[6] as well as chemical olfactory[5] cues.

The proportionate change in flow should be considered in the context of baseline flows within the modelled scenarios. The flow during the months of November and December has been modelled as ranging between 9,799Ml/d to 21,263Ml/d. As such the proportionate change in flow in this reach as a result of the operation of the STS SRO will not impact on the passability of any barriers to Atlantic migration and the proportionate change will not impact on migratory ques (physical or chemical).

Therefore, it is concluded that there is no risk of adverse effects on site integrity of the Severn SAC and Ramsar site when considering the impacts on migration and barriers.

This also considers the change in location of the discharge location of the Netheridge WwTW which could be considered part of the “baseline” in terms of olfactory ques. It is recommended that the start-up and shut down of the discharge of treated effluent is undertaken in a phased approach over a 5-day period.

[79] Thorrold, S. R., C. M. Jones, S. E. Campana, J. W. McLaren, and J. W. H. Lam. 1998. Trace element signatures in otoliths record natal river of juvenile American shad (*Alosa sapidissima*). Limnology and Oceanography 43:1826–1835

[80] Kennedy, B. P., J. D. Blum, C. L. Folt, and K. H. Nislow. 2000. Using natural strontium isotopic signatures as fish markers: methodology and application. Canadian Journal of Fisheries and Aquatic Sciences 57:2280–2292.

6. IN-COMBINATION ASSESSMENT

6.1 IN-COMBINATION EFFECTS ASSESSMENT WITH OTHER PLANS AND DEVELOPMENTS

The in-combinations assessment draw on the proposed approach outlined in Section 3. As described, this HRA report considers the schemes associated with the STS SRO only and separate assessments are being undertaken to inform the HRA of the other sources and the STT SRO. In-combination assessments of the various SROs that form the STT System is not subject to this report and will be considered in the relevant regional plan.

As such this HRA only considered in-combination effects in terms of local and site-specific information including large development allocations within Local Plans and larger planning applications.

The Mythe WTW abstraction licence transfer scheme is located within the area of the Tewkesbury Borough Council. The Netheridge WwTW effluent discharge diversion and Haw Bridge pipeline scheme crosses through both the Tewkesbury Borough Council and Gloucester City Council authorities. The following information sources have been used to identify the list of other developments and plans that could be included in the cumulative effects assessment with other plans and developments.

The list of other developments and plans within the ZOI of the STS are shown below

6.1.1 Gloucester City Council Website - Planning applications

Great Western Yard is a proposed residential development scheme of up to 330 dwellings with associated landscaping, parking, and ancillary works on land at Great Western Yard, Great Western Road, Gloucester. Planning permission is not yet confirmed, but the construction activities will occur within an existing build up areas and no supporting habitat will be impacts. As such, no in-combination impacts are expected.

6.1.2 Gloucester City 2019 Plan

Screening it was found that both Cotswolds Beechwoods SAC and Walmore Common SPA were identified as being the closest sites to the plan Area. The Cotswolds Beechwoods SAC site is located only 2.4km from the Plan area and the Walmore Common SPA is 4km from the plan area. Screening determined that the policies in the plan should prevent significant impacts occurring. These policies include the creation of open spaces in the plan boundary for recreational use and the protection of playing fields from any potential loss. The policies also ensure noise and light pollution is restricted especially when near sensitive zones such as a European designation. As such, no in-combination impacts are expected.

6.1.3 Planning Inspectorate's Programme of Projects

The M5 Junction 10 improvements involves upgrading the existing junction with a grade separated roundabout centred on the existing junction. The improvements will not result in a direct loss of supporting habitats and will involve the upgrade of an existing road and major junction. As such, impacts on the bird communities are unlikely. The HRA for the M5 Junction 10 improvement concluded that in the absence of mitigation, pollution impacts to the River Chelt during construction and operation, and disturbance impacts to qualifying European eel and river lamprey using the River Chelt during construction may have an LSE on these qualifying species of the Severn Estuary SAC and Ramsar site. An appropriate assessment however concluded that, with mitigation measures in place, no adverse effects on site integrity will be expected.

While planning permission has not yet been granted, it is possible that the construction activities associated with the STS SRO and the M5 Junction 10 improvements could coincide. The in-combination impacts (in the absence of mitigation measures) could result in adverse effects on European eel and river lamprey that will use the River Chelt as functionally lined habitat.

No in-combination impacts are, however, expected should the mitigation measures listed in this report and the HRA for the M5 Junction 10[81] improvements be implemented.

[81] Gloucestershire County Council (2021). M5 Junction 10 improvements scheme. Preliminary Environmental Information Report (PEIR) Biodiversity chapter. November 2021. Prepared by Atkins.

6.1.4 Tewkesbury Borough Council Website - Planning application advanced search (Major dwellings, mineral, Major retail)

Two projects have been identified from the Tewkesbury Borough Council Website. This includes the following:

- Twigworth Strategic Allocation: A mixed use development comprising demolition of existing buildings; up to 725 dwellings and a local centre of 0.33ha; primary school, open space, landscaping, parking, and supporting infrastructure and utilities; and the creation of a new vehicular access from the A38 Tewkesbury Road.
- Innsworth Strategic Allocation: A mixed use development comprising demolition of existing buildings, up to 1,300 dwellings and 8.31 hectares of land for employment generating uses comprising a neighbourhood centre of 4.23ha, office park of 1.31ha and business park of 2.77ha, primary school, open space, landscaping, parking, and supporting infrastructure and utilities, and the creation of new vehicular accesses from the A40 Gloucester Northern Bypass, Innsworth Lane and Frogfurlong Lane.

The development is located approximately 300m from the Netheridge WwTW effluent transfer pipeline. The available information indicates that the proposed development area will mostly impact arable fields and impacts on supporting habitats will not be significant. The development on both projects have commenced and the construction timelines are unlikely to overlap. As such, no-in-combination effects are likely.

6.1.5 Joint Core Strategy (JCS) which includes Cheltenham, Gloucester, and Tewkesbury.

In addition to the Innsworth and Twigworth Strategic Allocation, the Joint Core Strategy (JCS) which includes Cheltenham, Gloucester and Tewkesbury also includes the potential development of the Churchdown strategic allocation. The available information indicates that the proposed development area will mostly impact arable fields and impacts on supporting habitats will not be significant. As such, no-in-combination effects are likely.

6.1.6 Transport and Works Act (TWA) applications and decisions

There are currently no transport and Works Act (TWA) applications and decisions associated with the zone of influence, hence no-combination impacts are expected

6.1.7 Gloucester County Council Website – Planning application advanced search

Tewkesbury Major Mineral Application, Tewkesbury Major Waste Application, Gloucester Major Mineral Application and Gloucester Major Waste Application. All applications are sufficiently distanced the STS to avoid in-combination effects or are dated 2015 or older (i.e., will not be in-combination with the STS SRO). As such, no in-combination impacts are expected.

7. CONCLUSION AND RECOMMENDATIONS

7.1 SUMMARY OF ADVERSE EFFECTS

As per the latest RAPID guidance a full HRA for a solution is not required until a planning and/or permit application (or its equivalent, for example a Development Consent Order), however the *principles* of the HRA process are applied during the gated process to identify risks to feasibility and deliverability of the Schemes (alone and in-combination) as part of an informal HRA. As such there is no competent authority undertaking the integrity test.

As such, this HRA has only determined the *risk* of LSE and the *risk* of adverse effects on site integrity. Screening identified a risk of LSE for the Severn Estuary SAC, SPA and Ramsar site as well as the Walmore Common SPA and Ramsar site and the need for an appropriate assessment based on the following pathways:

- Netheridge WwTW effluent transfer pipeline/outfall construction related impacts, including the impacts on supporting habitat for migratory fish and the designated bird communities.
- Netheridge WwTW effluent transfer operation and impacts on water quality, downstream of Haw Bridge. This includes impacts on supporting habitats for migratory fish, impacts on migratory cues and impacts on habitats within the Severn Estuary European Marine Site that support the designated birds and fish.
- Joint Mythe WTW licence transfer and Netheridge WwTW effluent transfer operation and impacts on hydrology associated with the abstraction of 50Ml/d at Deerhurst and consequent augmentation of 35Ml/d at Haw Bridge, with net 15Ml/d reduction downstream of the discharge of treated effluent affecting the River Severn downstream and into the Severn Estuary. This includes impacts on supporting habitats for fish, migratory cues, and the designated bird communities.

The informal appropriate assessment concluded that, based on the current information and the proposed mitigation measures, there would be no adverse effects on site integrity of the Severn Estuary SAC, SPA and Ramsar site or the Walmore SPA and Ramsar site.

7.2 UNCERTAINTY

Selected endocrine disruptors which may act as olfactory inhibitors in the context of SROs have only recently been identified. These chemicals require specific analysis which has only recently commenced and has a smaller evidence base at present that should be kept under review in Gate 3. Further assessment of the risk to olfactory cues needs to be considered in Gate 3 when data becomes available and further modelling is completed. The results of any further monitoring and modelling needs to be considered in the review of the appropriate assessment

7.3 RECOMMENDATIONS

The conclusion on the risk of LSE and predictions regarding adverse effects on site integrity will need to be reviewed and updated (where required) as more information becomes available during completion of the Gate 3 assessments. This also includes the in-combination assessment with other plans and projects.

This includes consideration of any further monitoring and modelling outputs made available between submission of this report and the end date of the Gate 2 assessments and any changes in the applicability and/or availability of mitigation measures.

ANNEXES

Annex 1 Detailed Screening Tables

Designated site name:	**Cotswold Beechwoods (UK0013658)**		
Designation type: (SAC, SPA, Ramsar):	**SAC**		
Qualifying features:	9130 *Asperulo-Fagetum* Beech forests 6210 Semi-natural dry grasslands and scrubland facies on calcareous substrates (*Festuco-Brometalia*) (*important orchid sites)	**Water Dependency** Habitat and species not identified as water dependent, but it will be important to protect the rooting structure of the beech tree features[82].	
Current conservation status:	**9130 *Asperulo-Fagetum* Beech forests: Unfavourable recovering.** (range: favourable, area: unfavourable - inadequate, structure and function: unfavourable – bad, future prospects: unfavourable - bad). **6210 Semi-natural dry grasslands and scrubland facies on calcareous substrates (*Festuco-Brometalia*) (*important orchid sites): Favourable.** (range: favourable, area: favourable, structure and function: unfavourable – bad, future prospects: unfavourable - bad).		
Conservation objectives:	Ensure that the integrity of the site is maintained or restored as appropriate, and ensure that the site contributes to achieving the Favourable Conservation Status of its Qualifying Features, by maintaining or restoring; • The extent and distribution of qualifying natural habitats • The structure and function (including typical species) of qualifying natural habitats, and • The supporting processes on which qualifying natural habitats rely		
SSSI Condition assessment:	Cotswold Commons and Beechwoods SSSI: 55.83% Unfavourable – recovering and 44.17% Favourable.		
Site Improvement Plan:	1. Invasive species – Threat – 9130 Beech forests - Reduce invasive sycamore especially in the canopy; Reduce squirrel damage to trees. 2. Deer – Threat – 9130 Beech forests - Reduce deer browsing pressure. 3. Disease – Threat – 9130 Beech forests - Produce a strategy to deal with potential ash dieback. 4. Public access/disturbance – Threat – 9130 Beech forests - Minimise impact of recreational use, especially mountain biking, horse riding and dog walking. 5. Changes in species distributions – Threat – 9130 Beech forests - Monitor the effects of drought on beech trees. 6. Air pollution: impact of atmospheric nitrogen deposition – Pressure – 6210 Semi-natural dry grasslands and scrubland facies on calcareous substrates – Control, reduce and ameliorate atmospheric nitrogen impacts.		
Potential Effects			
Scheme:		Risk of Likely Significant Effects Alone?	Risk of Likely Significant Effects In-combination with other schemes
Netheridge WwTW effluent transfer (35 Ml/d)	This scheme is located approximately 6.7km north-west of Cotswold Beechwoods SAC. A SIP pressure of potential relevance during construction is the impact of air pollution and atmospheric nitrogen deposition. The empirical critical load for atmospheric nitrogen deposition of the beech forests is 10 – 20 kg N/ha/yr and for the semi natural dry grasslands is 15 – 25 kg N/ha/yr. Current trends (data collected in 2017) at the designated site suggest that nitrogen deposition for the beech forests is above the critical load by 9 kg N/ha/yr. However, due to the distance between the designated site and the proposed construction works, no additional nitrogen deposition at the designated site is anticipated. No impact pathways during the operation of this scheme have been identified as Cotswold Beechwoods SAC is not hydrologically connected downstream of the Netheridge discharge location. Beech forests are also not classified as water dependent species. Therefore, no LSE are anticipated on the qualifying features of the SAC.	**No**	**No**

[82] UKTAG (2003). *Guidance on the Identification of Natura Protected Areas [Final]*. UK Technical Advisory Group on the Water Framework Directive. TAG Work Programme Task 4.a, 1 – 20.

Designated site name:	**Dixton Wood (UK0030135)**		
Designation type: (SAC, SPA, Ramsar):	**SAC**		
Qualifying features:	1079. *Limoniscus violaceus*; Violet click beetle	**Water Dependency**: Species not identified as water dependent[83].	
Current conservation status:	**1079 *Limoniscus violaceus*; Violet click beetle: Bad and deteriorating** (range: favourable, population: bad and deteriorating, habitat: inadequate and deteriorating, future prospects: bad).		
Conservation objectives:	Ensure that the integrity of the site is maintained or restored as appropriate, and ensure that the site contributes to achieving the Favourable Conservation Status of its Qualifying Features, by maintaining or restoring; • The extent and distribution of the habitats of qualifying species • The structure and function of the habitats of qualifying species • The supporting processes on which the habitats of qualifying species rely • The populations of qualifying species, and, • The distribution of qualifying species within the site		
SSSI Condition assessment:	Dixton Wood SSSI: 100% Unfavourable recovering		
Site Improvement Plan:	1. Changes in species distributions – Threat - 1079 Violet click beetle - Carry out survey and monitoring work to inform advice to landowner. 2. Forestry and woodland management – Pressure/Threat - 1079 Violet click beetle - Formulate and implement a wood mould continuity strategy for the Violet click beetle population. 3. Disease – Threat - 1079 Violet click beetle - Monitor for Chalara and take appropriate action.		
Potential Effects			
Scheme:		Risk of Likely Significant Effects Alone?	Risk of Likely Significant Effects In-combination with other schemes
Mythe WTW abstraction licence transfer (15 Ml/d)	The scheme is located 8.9 km north-west of Dixton Wood SAC. None of the SIP threats and pressures for this SAC are considered relevant to an abstraction licence transfer at the Mythe intake. The proposed scheme will not require land take from within the SAC boundaries and as no construction activities are required, no LSE are anticipated. As the violet click beetle is not water dependent and Dixton Wood is not hydrologically connected downstream of the Mythe intake, LSE on the qualifying feature of the SAC is not anticipated.	**No**	**No**

[83] UKTAG (2003). *Guidance on the Identification of Natura Protected Areas [Final]*. UK Technical Advisory Group on the Water Framework Directive. TAG Work Programme Task 4.a, 1 – 20.

Designated site name:	**Severn Estuary SAC (UK0013030)**	
Designation type: (SAC, SPA, Ramsar):	**SAC**	
Qualifying features:	1130 Estuaries 1140 Mudflats and sandflats not covered by seawater at low tide 1330 Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*) 1110 Sandbanks which are slightly covered by sea water all the time 1170 Reefs 1095 *Petromyzon marinus*; Sea lamprey 1099 *Lampetra fluviatilis;* River lamprey 1103 *Alosa fallax*; Twaite shad	**Water Dependency:** Habitat and species identified as water dependent**Error! Bookmark not defined.**: • 1130 Estuaries • 1140 Mudflats and sandflats not covered by seawater at low tide • 1330 Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*) • 1110 Sandbanks which are slightly covered by sea water all the time • 1170 Reefs • 1095 *Petromyzon marinus*; Sea lamprey • 1099 *Lampetra fluviatilis;* River lamprey • 1103 *Alosa fallax*; Twaite shad
Current conservation status:	**1130 Estuaries: Unfavourable – Bad** (range: favourable area: unknown, structure and function: unfavourable - bad, future prospects: unfavourable - bad). **1140 Mudflats and sandflats not covered by seawater at low tide: Unfavourable – Bad** (range: favourable, area: unknown, structure and function: unfavourable – bad, future prospects: unfavourable – bad). **1330 Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*): Unfavourable - Bad** **1110 Sandbanks which are slightly covered by sea water all the time: Favourable - Deteriorating** (range: favourable area: unfavourable - inadequate, structure and function: unfavourable - bad, future prospects: unfavourable - bad). **1170 Reefs: Unknown** (range: unknown, area: unknown, structure and function: unfavourable - inadequate, future prospects: unfavourable - inadequate). **1095 *Petromyzon marinus*; Sea lamprey: Unfavourable** (range: favourable, population: unknown, habitats for the species: unknown, future prospects: unknown). **1099 *Lampetra fluviatilis;* River lamprey: Unfavourable** (range: favourable, population: favourable, habitats for the species: unknown, future prospects: favourable). **1103 *Alosa fallax*; Twaite shad: Unfavourable** (range: unfavourable - inadequate, population: unfavourable - inadequate, habitats for the species: unfavourable - inadequate, future prospects: unfavourable – inadequate).	
Conservation objectives:	Ensure that the integrity of the site is maintained or restored as appropriate, and ensure that the site contributes to achieving the Favourable Conservation Status of its Qualifying Features, by maintaining or restoring; • The extent and distribution of qualifying natural habitats and habitats of qualifying species • The structure and function (including typical species) of qualifying natural habitats • The structure and function of the habitats of qualifying species • The supporting processes on which qualifying natural habitats and the habitats of qualifying species rely • The populations of qualifying species, and, • The distribution of qualifying species within the site.	
SSSI Condition assessment:	Severn Estuary SSSI: 95.80% Favourable, 0.08% Unfavourable - recovering and 2.43% Unfavourable - no change. Bridgwater Bay SSSI: 88.42% Favourable, 11.28% Unfavourable – Recovering and 0.29% Unfavourable – No change. Upper Severn Estuary SSSI: 85.85% Favourable and 3.31% Unfavourable – Recovering.	
Site Improvement Plan:	1. Public access/disturbance – Pressure/Threat - 1130 Estuaries, 1170 Reefs, 1330 Atlantic salt meadows – Identify/reduce impacts of disturbance to birds and damage to habitats. 2. Physical modification – Threat - 1095 Sea lamprey, 1099 River lamprey and 1103 Twaite shad – Reduce, remove (where possible), and prevent barriers to migratory species. 3. Impacts of development – Pressure/Threat - 1130 Estuaries, 1170 Reefs, 1330 Atlantic salt meadows, 1140 Intertidal mudflats and sandflats, 1095 Sea lamprey, 1099 River lamprey and 1103 Twaite shad – Inform strategic planning decisions to minimise impact of development. 4. Coastal squeeze – Pressure/Threat - 1130 Estuaries, 1170 Reefs, 1330 Atlantic salt meadows, 1140 Intertidal mudflats and sandflats – Limit coastal squeeze, provide sustainable coastal defences, improve existing structures, deliver compensatory habitat. 5. Change in land management – Pressure/Threat - 1130 Estuaries, 1330 Atlantic salt meadows – Maintain appropriate levels and timing of grazing and management of intertidal saltmarsh habitat. 6. Changes in species distributions – Threat – 1095 Sea lamprey, 1099 River lamprey and 1103 Twaite shad – Understand/prepare for changes in species distribution (caused by climate change/other events). 7. Water pollution – Pressure/Threat - 1110 Subtidal sandbanks, 1130 Estuaries, 1170 Reefs, 1330 Atlantic salt meadows, 1140 Intertidal mudflats and sandflats, 1095 Sea lamprey, 1099 River lamprey and 1103 Twaite shad – Identify any existing issues and prevent/reduce decline in water and sediment quality (applying relevant measures to all relevant tributaries in England and Wales). 8. Air Pollution: impact of atmospheric nitrogen deposition – Pressure - 1130 Estuaries, 1330 Atlantic salt meadows, 1095 Sea lamprey, 1099 River lamprey, 1103 Twaite shad and waterbird assemblage – Develop a Site Nitrogen Action Plan. 9. Marine consents and permits minerals and waste – Pressure/Threat - 1110 Subtidal sandbanks, 1140 Intertidal mudflats and sandflats, 1170 Reefs, 1330 Atlantic salt meadows, 1095 Sea lamprey, 1099 River lamprey, 1103 Twaite shad – Ensure in-combination/cumulative impacts from aggregate extraction, maintenance dredging and disposal are fully considered. 10. Fisheries: recreational marine and estuarine – Pressure – 1095 Sea lamprey, 1099 River lamprey and 1103 Twaite shad, 1140 Intertidal mudflats and sandflats, 1170 Reefs and 1330 Atlantic salt meadows – Establish levels and location 11. Fisheries: commercial marine and estuarine – Threat - 1095 Sea lamprey, 1099 River lamprey and 1103 Twaite shad, 1140 Intertidal mudflats and sandflats, 1170 Reefs and 1330 Atlantic salt meadows - Identify any threats to site features and habitats from commercial fisheries activity and establish and ensure compliance with any necessary management measures. 12. Invasive species – Threat - 1130 Estuaries, 1170 Reefs, 1330 Atlantic salt meadows, 1140 Intertidal mudflats and sandflats – Assess the risks from and control the spread of invasive non-native species. 13. Marine litter – Pressure/Threat - 1130 Estuaries, 1170 Reefs, 1330 Atlantic salt meadows, 1140 Intertidal mudflats and sandflats, 1095 Sea lamprey, 1099 River lamprey and 1103 Twaite shad – Investigate sources of marine litter and implement actions for removal/shoreline clean up. 14. Marine pollution incidents – Threat - 1110 Subtidal sandbanks, 1130 Estuaries, 1170 Reefs, 1330 Atlantic salt meadows, 1140 Intertidal mudflats and sandflats, 1095 Sea lamprey, 1099 River lamprey and 1103 Twaite shad – Minimise impact from marine pollution incidents and clean up response.	
Potential Effects		
Scheme:		Risk of Likely Significant Effects Alone? / Risk of Likely Significant Effects In-combination with other schemes
	This scheme is located approximately 10.3 km north-east of the Severn Estuary SAC and is approximately 44.69 km north-east via hydrological connectivity. The most relevant SIP threats and pressures of this scheme during construction are (2) physical modification, (3) impacts of development, (6) changes in species distribution, (7) water pollution, (8) air pollution and (12) invasive species. The most relevant SIP threat of this scheme during operation is (2) physical modification.	**Yes** / **Yes**

Designated site name:	**Severn Estuary SAC (UK0013030)**		
Netheridge WwTW effluent transfer (35 Ml/d)	**River lamprey, sea lamprey, twaite shad, allis shad, Atlantic salmon, sea trout and European eel** Off-site functional habitat downstream of the proposed outfall could potentially be affected during construction works as a result of localised increases in suspended sediment (siltation and deposition), potential invasive and non-native species introduction/ spread from construction vehicles and unclean PPE, noise and vibration disturbance, entrapment and impingement and potential water pollution incidents. Although temporary in nature and the relatively small footprint, mitigation measures may be required during the construction of the outfall near Haw Bridge. Potential impact pathways of this scheme during operation include exposure to localised changes in nutrient loading, turbidity, salinity regime and dissolved oxygen surrounding the outfall during migration upstream, as a result of a change in the location of effluent released from Netheridge WwTW. The proportionate change in flow is <1.5% in summer months. The most notable change in flows in the River Severn in into the Severn Estuary is a decrease of 4.2-6.9% in flow in the autumn when flows are >10,000Ml/d. Overall, the changes in freshwater inflows into the Severn Estuary is not discernible. However, LSE have been identified as the change in flow could impact on supporting habitat for the lamprey species. There is also some uncertainty with regards to the impacts on olfactory cues for the migratory species. The treated effluent will be subject to further treatment prior to discharge into the River Severn. However, some uncertainty has been identified with regards to the potential impacts of water quality changes on supporting habitats for the migratory species. As such, LSE have been identified on a precautionary basis.		
	Estuaries, mudflats and sandflats, Atlantic salt meadows, sandbanks, and reefs The footprint of this scheme is outside of the boundary of the SAC. During proposed construction works for this scheme potential impact pathways include localised increases in suspended sediment (siltation and deposition), potential invasive and non-native species introduction/ spread from construction vehicles and unclean PPE, air pollution and potential water pollution incidents. Although temporary in nature and the relatively small footprint, mitigation measures may be required during the construction of the outfall near Haw Bridge. Localised changes in water flow may expose a larger area of intertidal mudflats (A2.3 – littoral mud) and cause fluctuations in nutrient loading, turbidity, salinity, and oxygenation surrounding the outfall during operation. The proportionate change in flow is <1.5% in summer months. The most notable change in flows in the River Severn in into the Severn Estuary is a decrease of 4.2-6.9% in flow in the autumn when flows are >10,000Ml/d. Overall, the changes in freshwater inflows into the Severn Estuary is not discernible. Estuaries, Mudflats, and sandflats not covered by seawater at low tide, and Atlantic salt meadows features are currently in an unfavourable condition with the two factors contributing to unfavourable condition were: (i) coastal squeeze impacts; and (ii) water quality impacts. Further changes in water quality of the River Severn as a result of operation of the STS SRO could therefore prevent the Conservation Objectives of these features being met.	**Yes**	**Yes**
Mythe WTW abstraction licence transfer (15 Ml/d)	**River lamprey, sea lamprey, twaite shad, allis shad, Atlantic salmon, sea trout and European eel** The scheme is located approximately 29.2 km north-east of the Severn Estuary SAC and is approximately 49.6 km north-east via hydrological connectivity. The SIP threats and pressures of potential relevance to this scheme is (2) physical modification threat and (7) water pollution. The proposed scheme will not require land take from within the designated site however, the scheme is hydrologically linked to the designated site. No construction works are required and due to the distance from the designated site and the fact that no change in abstraction is proposed, no LSE are anticipated on any of the designated sites. However, Natural England has indicated that the proposed abstraction of 15Ml/d represent a change in Recent Actual abstractions and that here is some uncertainty with regards to the potential impacts on flows and migratory fish.	**Yes**	**Yes**
	Estuaries, mudflats and sandflats, Atlantic salt meadows, sandbanks, and reefs The scheme is located approximately 29.2 km north-east of the Severn Estuary SAC and is approximately 49.6 km north-east via hydrological connectivity. The SIP threats and pressures of potential relevance to this scheme is (2) physical modification threat and (7) water pollution. The proposed scheme will not require land take from within the designated site however, the scheme is hydrologically linked to the designated site. No construction works are required and due to the distance from the designated site and the fact that no change in abstraction is proposed, no LSE are anticipated on any of the designated sites. Localised changes in water flow may expose a larger area of intertidal mudflats (A2.3 – littoral mud) and cause fluctuations in nutrient loading, turbidity, salinity, and oxygenation surrounding the outfall during operation. Due to the large tidal range of the Severn Estuary and small volume of change in total flow negligible amendments to water flow within the river reach during operation are anticipated. Therefore, no LSE on qualifying habitat features of the SAC are anticipated.	**No**	**No**

Designated site name:	**Severn Estuary SPA (UK9015022)**	
Designation type: (SAC, SPA, Ramsar):	**SPA**	
Qualifying features:	Severn Estuary SPA 051 *Anas strepera;* Gadwall 394 *Anser albifrons albifrons;* Greater white-fronted geese 672 *Calidris alpina;* Dunlin 037 *Cygnus columbianus bewickii;* Bewick's swan 048 *Tadorna tadorna;* Common shelduck 162 *Tringa tetanus;* Common redshank WATR Internationally important assemblage of waterfowl (wildfowl and waders)	**Water Dependency:** Species identified as water dependent[84]. • 051 *Anas strepera;* Gadwall. • 394 *Anser albifrons albifrons;* Greater white-fronted geese. • 672 *Calidris alpina;* Dunlin. • 037 *Cygnus columbianus bewickii;* Bewick's swan. • 048 *Tadorna tadorna;* Common shelduck. • 162 *Tringa tetanus;* Common redshank. • WATR Internationally important assemblage of waterfowl (wildfowl and waders).
Current conservation status:	**051 *Anas strepera;* Gadwall:** (type: wintering, size: minimum 282; maximum 282 (0.9% of the population 5 year peak mean 1991/92 – 1995/96), unit: individuals, data quality: good, population: 2 – 15%, isolation: population not isolated within extended distribution range). **394 *Anser albifrons albifrons;* Greater white-fronted geese** (type: wintering, size: minimum 2664; maximum 2664 (0.4% of the population 5 year peak mean 1991/92 – 1995/96), unit: individuals, data quality: good, population: 15 - 100%, isolation: population not isolated, but on margins of area of distribution). **672 *Calidris alpina alpina;* Dunlin** (type: wintering, size: minimum 44624; maximum 44624 (3.3% of the population 5 year peak mean 1991/92 – 1995/96), unit: individuals, data quality: good, population: 2 - 15%, isolation: population not isolated within extended distribution range). **037 *Cygnus columbianus bewickii;* Bewick's swan** (type: wintering, size: minimum 280; maximum 280 (3.9% of the population 5 year peak mean 1991/92 – 1995/96), unit: individuals, data quality: good, population: 2 - 15%, isolation: population not isolated within extended distribution range). **048 *Tadorna tadorna;* Common shelduck** (type: wintering, size: minimum 3330; maximum 3330 (1.1% of the population 5 year peak mean 1991/92 – 1995/96), unit: individuals, data quality: good, population: 2 - 15%, isolation: population not isolated within extended distribution range). **162 *Tringa tetanus;* Common redshank** (type: wintering, size: minimum 2330; maximum 2330 (1.3% of the population 5 year peak mean 1991/92 – 1995/96), unit: individuals, data quality: good, population: 2 - 15%, isolation: population not isolated within extended distribution range). **WATR Waterfowl assemblage** (size: minimum 84317; maximum 84317. Unit: individuals; motivation: International conventions).	
Conservation objectives:	Ensure that the integrity of the site is maintained or restored as appropriate, and ensure that the site contributes to achieving the aims of the Wild Birds Directive, by maintaining or restoring; • The extent and distribution of the habitats of the qualifying features • The structure and function of the habitats of the qualifying features • The supporting processes on which the habitats of the qualifying features rely • The population of each of the qualifying features, and, • The distribution of the qualifying features within the site.	
SSSI Condition assessment:	Severn Estuary SSSI: 95.80% Favourable, 0.08% Unfavourable - recovering and 2.43% Unfavourable - no change. Aust Cliff SSSI: 100% Favourable. Blue Anchor to Lilstock Coast SSSI: 100% Favourable. Bridgewater Bay SSSI: 88.42% Favourable, 11.28% Unfavourable – Recovering and 0.29% Unfavourable – no change. Clevedon Shore SSSI: 100% Favourable. Lydney Cliff SSSI: 100% Favourable. Middle Hope SSSI: 80.40% Favourable and 19.60% Unfavourable – Recovering. Portishead Pier to Black Nore SSSI: 100% Favourable. Purton Passage SSSI: 100% Favourable. Spring Cove Cliffs SSSI: 100% Favourable. Steep Holm SSSI: 100% Favourable. Upper Severn Estuary SSSI: 85.85% Favourable, 10.84% Unfavourable – Declining and 3.31% Unfavourable – Recovering.	
Site Improvement Plan:	1. Public access/disturbance – Pressure/Threat - 037(NB) Bewick's swan, 048(NB) Common shelduck, 051(NB) Gadwall, 149(NB) Dunlin, 162(NB) Common shelduck, 394(NB) Greater white-fronted goose and waterbird assemblage – Identify/reduce impacts of disturbance to birds and damage to habitats. 2. Impacts of development – Pressure/Threat - 037(NB) Bewick's swan, 048(NB) Common shelduck, 051(NB) Gadwall, 149(NB) Dunlin, 162(NB) Common shelduck, 394(NB) Greater white-fronted goose and waterbird assemblage - Inform strategic planning decisions to minimise impact of development. 3. Coastal squeeze – Pressure/Threat - 037(NB) Bewick's swan, 048(NB) Common shelduck, 051(NB) Gadwall, 149(NB) Dunlin, 162(NB) Common shelduck, 394(NB) Greater white-fronted goose and waterbird assemblage – Limit coastal squeeze, provide sustainable coastal defences, improve existing structures, deliver compensatory habitat. 4. Change in land management – Pressure/Threat - 037(NB) Bewick's swan, 048(NB) Common shelduck, 051(NB) Gadwall, 149(NB) Dunlin, 162(NB) Common shelduck, 394(NB) Greater white-fronted goose and waterbird assemblage – Maintain appropriate levels and timing of grazing and management of intertidal saltmarsh habitat. 5. Changes in species distributions – Threat – 037(NB) Bewick's swan, 048(NB) Common shelduck, 051(NB) Gadwall, 149(NB) Dunlin, 162(NB) Common shelduck, 394(NB) Greater white-fronted goose, waterbird assemblage - Understand/prepare for changes in species distribution (caused by climate change/other events). 6. Water pollution – Pressure/Threat - 037(NB) Bewick's swan, 048(NB) Common shelduck, 051(NB) Gadwall, 149(NB) Dunlin, 162(NB) Common shelduck, 394(NB) Greater white-fronted goose and waterbird assemblage – Identify any existing issues and prevent/reduce decline in water and sediment quality (applying relevant measures to all relevant tributaries in England and Wales). 7. Air Pollution: impact of atmospheric nitrogen deposition – Pressure - 051 Gadwall and waterbird assemblage – Develop a Site Nitrogen Action Plan. 8. Fisheries: recreational marine and estuarine – Pressure – 037(NB) Bewick's swan, 048(NB) Common shelduck, 051(NB) Gadwall, 149(NB) Dunlin, 162(NB) Common shelduck, 394(NB) Greater white-fronted goose and waterbird assemblage – Establish levels and location 9. Fisheries: commercial marine and estuarine – Threat - 037(NB) Bewick's swan, 048(NB) Common shelduck, 051(NB) Gadwall, 149(NB) Dunlin, 162(NB) Common shelduck, 394(NB) Greater white-fronted goose and waterbird assemblage - Identify any threats to site features and habitats from commercial fisheries activity and establish and ensure compliance with any necessary management measures. 10. Marine litter – Pressure/Threat - 037(NB) Bewick's swan, 048(NB) Common shelduck, 051(NB) Gadwall, 149(NB) Dunlin, 162(NB) Common shelduck, 394(NB) Greater white-fronted goose and waterbird assemblage – Investigate sources of marine litter and implement actions for removal/shoreline clean up. 11. Marine pollution incidents – Threat - 037(NB) Bewick's swan, 048(NB) Common shelduck, 051(NB) Gadwall, 149(NB) Dunlin, 162(NB) Common shelduck, 394(NB) Greater white-fronted goose and waterbird assemblage – Minimise impact from marine pollution incidents and clean up response.	
Potential Effects		

[84]UKTAG (2003). *Guidance on the Identification of Natura Protected Areas [Final]*. UK Technical Advisory Group on the Water Framework Directive. TAG Work Programme Task 4.a, 1 – 20.

Designated site name:	**Severn Estuary SPA (UK9015022)**		
Scheme:		Risk of Likely Significant Effects Alone?	Risk of Likely Significant Effects In-combination with other schemes
Netheridge WwTW effluent transfer (35 Ml/d)	This scheme is located approximately 10.3 km north-east of the Severn Estuary SPA and is approximately 44.69 km north-east via hydrological connectivity. The SIP threats and pressures of potential relevance to this scheme during construction are (2) impacts of development, (5) changes in species distributions, (6) water pollution and (7) air pollution. The footprint of this scheme is outside of the boundary of the SPA. Due to the distance between the proposed construction works of the pipeline and outfall and designated site, no impacts from disturbance and therefore, species distribution are anticipated. In addition, the distance via hydrological connectivity is also sufficient to conclude no LSE from water pollution incidents or increased suspended sediment that could impact on supporting habitats of bird species associated with the SPA. The empirical critical load for atmospheric nitrogen deposition is 20 – 30 kg N/ha/yr for Atlantic saltmarsh and is currently not being exceeded within the designated site (in 2017, nitrogen deposition on short vegetation was 12 kg N/ha/yr. Considering that nitrogen deposition is below the critical load and also the distance between the proposed construction works and designated site, no LSE are anticipated. The construction of the pipeline to Haw Bridge will not result on direct impacts on any habitats that support the qualifying features of the SPA. However, the pipeline construction could result in direct impacts on floodplain grazing marsh habitat and grasslands. The Regulation 33 advice for the Severn Estuary European Marine Site indicates that freshwater grazing marsh / Neutral grassland are considered supporting habitat to designated bird interests within SPA. Impacts on supporting habitats could result in LSE. The most relevant SIP threat and pressure to this scheme during operation are (2) impacts of development and (5) changes in species distributions. No direct impact pathways on qualifying species have been identified for this scheme during operational works, due to the proposed timing of discharging treated effluent (outside of overwintering season) and distance from the designated site. Due to the large tidal range of the Severn Estuary and small volume of effluent proposed for diversion and discharge in the freshwater River Severn, negligible amendments to water flow within the river reach during operation are anticipated. The proportionate change in flow is <1.5% in summer months. The most notable change in flows in the River Severn in into the Severn Estuary in both modelled scenarios is a decrease of 4.2-6.9% in flow in the autumn. Overall, the changes in freshwater inflows into the Severn Estuary is not discernible. However, Natural England has indicated that the proposed abstraction of 15Ml/d represent a change in Recent Actual abstractions and that here is some uncertainty with regards to the potential impacts on flows and migratory fish. Estuaries, Mudflats and sandflats not covered by seawater at low tide, and Atlantic salt meadows features are currently in an unfavourable condition with the two factors contributing to unfavourable condition were: (i) coastal squeeze impacts; and (ii) water quality impacts. Changes in water quality as a result of operation of the STS SRO could therefore prevent the Conservation Objectives of these features being met.	**Yes**	**Yes**
Mythe WTW abstraction licence transfer (15 Ml/d)	The scheme is located approximately 29.2 km north-east of the Severn Estuary SPA and is approximately 49.6 km north-east via hydrological connectivity. The SIP threats and pressures of potential relevance to this scheme is (5) changes in species distribution and (6) water pollution. The proposed scheme will not require land take from within the designated site however, the scheme is hydrologically linked to the designated site. No construction works are required. Due to the large tidal range of the Severn Estuary and small volume of change in total flow negligible amendments to water flow within the river reach during operation are anticipated. Therefore, no LSE on qualifying habitat features of the SAC are anticipated.	**No**	**No**

Designated site name:	**Severn Estuary Ramsar (UK11081)**	
Designation type: (SAC, SPA, Ramsar):	**Ramsar site**	
Qualifying features:	**Ramsar criterion 1** Due to immense tidal range (second-largest in world), this affects both the physical environment and biological communities. **Ramsar criterion 3** Due to unusual estuarine communities, reduced diversity, and high productivity. **Ramsar criterion 4** This site is important for the run of migratory fish between sea and river via estuary. Species include Atlantic salmon (*Salmo salar*), sea trout (*S. trutta*), sea lamprey (*Petromyzon marinus*), river lamprey (*Lampetra fluviatilis*), allis shad (*Alosa alosa*), twaite shad (*A. fallax*) and European eel (*Anguilla anguilla*). It is also of particular importance for migratory birds during spring and autumn. **Ramsar criterion 5** Assemblages of international importance: Species with peak counts in winter: 70919 waterfowl (5 year peak mean 1998/99-2002/2003). **Ramsar criterion 6** Species/populations occurring at levels of international importance. Qualifying species/populations (as identified at designation): *Calidris alpina;* Dunlin – Passage/Wintering *Anas strepera;* Gadwall – Wintering *Tringa tetanus;* Common redshank – Passage/Wintering *Tadorna tadorna;* Common shelduck – Wintering *Anser albifrons albifrons;* Greater white-fronted geese – Wintering *Charadrius hiaticula;* Ringed plover – Passage *Numenius phaeopus*; Whimbrel – Passage Waterbird assemblage – Wintering Estuary with immense tidal range Unusual estuarine communities Run of migratory fish Possible future consideration under criterion 6: lesser black-backed gull (*Larus fuscus graellsii*), Eurasion teal (*Anas crecca*) and Northern pintail (*Anas acuta*) **Ramsar criterion 8** The fish of the whole estuarine and river system is one of the most diverse in Britain, with over 110 species recorded. Atlantic salmon, sea trout, sea lamprey, river lamprey, allis shad, twaite shad and European eel use the Severn Estuary as a key migration route to their spawning grounds in the many tributaries that flow into the estuary. The site is important as a feeding and nursery ground for many fish species particularly allis shad and twaite shad which feed on mysid shrimps in the salt wedge.	**Water Dependency:** The Ramsar Site and its qualifying criteria (by definition) are all water dependent.
Current conservation status:	N/A	
Conservation objectives:	Not available.	
SSSI Condition assessment:	Severn Estuary SSSI: 95.80% Favourable, 0.08% Unfavourable - recovering and 2.43% Unfavourable - no change. Aust Cliff SSSI: 100% Favourable. Blue Anchor to Lilstock Coast SSSI: 100% Favourable. Clevedon Shore SSSI: 100% Favourable. Lydney Cliff SSSI: 100% Favourable. Middle Hope SSSI: 80.40% Favourable and 19.60% Unfavourable – Recovering. Portishead Pier to Black Nore SSSI: 100% Favourable. Purton Passage SSSI: 100% Favourable. Spring Cove Cliffs SSSI: 100% Favourable. Steep Holm SSSI: 100% Favourable. Upper Severn Estuary SSSI: 85.85% Favourable, 10.84% Unfavourable – Declining and 3.31% Unfavourable – Recovering.	
Site Improvement Plan:	See threats and pressures listed in Severn Estuary SAC and SPA screening table.	

Potential Effects

Scheme:		Risk of Likely Significant Effects Alone?	Risk of Likely Significant Effects In-combination with other schemes
Netheridge WwTW effluent transfer (35 Ml/d)	This scheme is located approximately 10.3km north-east of the Severn Estuary Ramsar site and is approximately 44.69km north-east via hydrological connectivity. **Ramsar Criterion 4 and 8** The scheme is located approximately 29.2 km north-east of the Severn Estuary SAC and is approximately 49.6 km north-east via hydrological connectivity. The SIP threats and pressures of potential relevance to this scheme is (2) physical modification threat and (7) water pollution. The proposed scheme will not require land take from within the designated site however, the scheme is hydrologically linked to the designated site. Potential impact pathways of this scheme during operation include exposure to localised changes in nutrient loading, turbidity, salinity regime and dissolved oxygen surrounding the outfall during migration upstream, as a result of a change in the location of effluent released from Netheridge WwTW. The proportionate change in flow is <1.5% in summer months. The most notable change in flows in the River Severn in into the Severn Estuary is a decrease of 4.2-6.9% in flow in the autumn when flows are >10 000Ml/d. Overall, the changes in freshwater inflows into the Severn Estuary is not discernible. However, LSE have been identified as the change in flow could impact on supporting habitat for the lamprey species. There is also some uncertainty with regards to the impacts on olfactory cues for the migratory species. The treated effluent will be subject to further treatment prior to discharge into the River Severn. However, some uncertainty has been identified with regards to the potential impacts of water quality changes on supporting habitats for the migratory species. As such, LSE have been identified on a precautionary basis	**Yes**	**Yes**
	Ramsar Criterion 5 and 6 The footprint of this scheme is outside of the boundary of the Ramsar site. Due to the distance between the proposed construction works of the pipeline and outfall and designated site, no impacts from disturbance and therefore, species distribution are anticipated. In addition, the distance via hydrological connectivity is also sufficient to conclude no LSE from water pollution incidents or increased suspended sediment that could impact on supporting habitats of bird species associated with the Ramsar site. The empirical critical load for atmospheric nitrogen deposition is 20 – 30 kg N/ha/yr for Atlantic saltmarsh and is currently not being exceeded within the designated site (in 2017, nitrogen deposition on short vegetation was 12 kg N/ha/yr. Considering that nitrogen deposition is below the critical load and also the distance between the proposed construction works and designated site, no LSE are anticipated. The most relevant SIP threat and pressure to this scheme during operation are (2) impacts of development and (5) changes in species distributions. No direct impact pathways on qualifying species have been identified for this scheme during operational works, due to the proposed timing of discharging treated effluent (outside of overwintering season) and distance from the designated site.	**Yes**	**Yes**

Designated site name:	**Severn Estuary Ramsar (UK11081)**		
	The proportionate change in flow is <1.5% in summer months. The most notable change in flows in the River Severn in into the Severn Estuary in both modelled scenarios is a decrease of 4.2-6.9% in flow in the autumn. Overall, the changes in freshwater inflows into the Severn Estuary is not discernible. However, Natural England has indicated that the proposed abstraction of 15Ml/d represent a change in Recent Actual abstractions and that here is some uncertainty with regards to the potential impacts on flows and migratory fish. Estuaries, Mudflats, and sandflats not covered by seawater at low tide, and Atlantic salt meadows features are currently in an unfavourable condition with the two factors contributing to unfavourable condition were: (i) coastal squeeze impacts; and (ii) water quality impacts. Changes in water quality as a result of operation of the STS SRO could therefore prevent the Conservation Objectives of these features being met.		
	Ramsar Criterion 1 and 3 The footprint of this scheme is outside of the boundary of the Ramsar site. During proposed construction works for this scheme potential impact pathways include localised increases in suspended sediment (siltation and deposition), potential invasive and non-native species introduction/ spread from construction vehicles and unclean PPE, air pollution and potential water pollution incidents. Due to the distance between the proposed works and the designated site via hydrological connectivity and directly, and temporary nature of constructing the outfall, no LSE are anticipated on qualifying habitats of the Ramsar site during construction. Localised changes in water flow may expose a larger area of intertidal mudflats (A2.3 – littoral mud) and cause fluctuations in nutrient loading, turbidity, salinity, and oxygenation surrounding the outfall during operation. The most notable change in flows in the River Severn in into the Severn Estuary is a decrease of 4.2-6.9% in flow in the autumn when flows are >10,000Ml/d. Overall, the changes in freshwater inflows into the Severn Estuary is not discernible. The treated effluent will be subject to further treatment prior to discharge into the River Severn. However, some uncertainty has been identified with regards to the potential impacts of water quality changes on supporting habitats for the migratory species. As such, LSE have been identified on a precautionary basis.	**Yes**	**Yes**
Mythe WTW abstraction licence transfer (15 Ml/d)	This scheme is located approximately 10.3 km north-east of the Severn Estuary SPA and is approximately 44.69 km north-east via hydrological connectivity. **Ramsar Criterion 4 and 8** Off-site functional habitat downstream of the proposed outfall could potentially be affected during construction works as a result of localised increases in suspended sediment (siltation and deposition), potential invasive and non-native species introduction/ spread from construction vehicles and unclean PPE, noise and vibration disturbance, entrapment and impingement and potential water pollution incidents. Although temporary in nature and the relatively small footprint, mitigation measures may be required during the construction of the outfall near Haw Bridge. Potential impact pathways of this scheme during operation include exposure to localised changes in nutrient loading, turbidity, salinity regime and dissolved oxygen surrounding the outfall during migration upstream, as a result of a reduction in freshwater effluent released from Netheridge WwTW. Due to the large tidal range of the Severn Estuary and small volume of effluent proposed for diversion and discharge in the freshwater River Severn, negligible amendments to water flow within the river reach during operation are anticipated. Furthermore, the treated effluent will be subject to further treatment prior to discharge into the River Severn and water quality impacts have been identified as negligible[85]. However, some uncertainty has been identified with regards to the potential impacts of water quality changes. As such, LSE have been identified on a precautionary basis.	**Yes**	**Yes**
	Ramsar Criterion 5 and 6 No construction activities are required. The most relevant SIP threat and pressure to this scheme during operation are (2) impacts of development and (5) changes in species distributions. No direct impact pathways on qualifying species have been identified for this scheme during operational works, due to the proposed timing of discharging treated effluent (outside of overwintering season) and distance from the designated site. In addition, due to the large tidal range of the Severn Estuary and small volume of the abstraction no discernible changes are anticipated. Furthermore, the treated effluent will be subject to further treatment prior to discharge into the River Severn and water quality impacts have been identified as negligible. Therefore, no LSE on supporting habitat of the Ramsar site are anticipated.	**No**	**No**
	Ramsar Criterion 1 and 3 The scheme is located approximately 29.2 km north-east of the Severn Estuary SAC and is approximately 49.6 km north-east via hydrological connectivity. The SIP threats and pressures of potential relevance to this scheme is (2) physical modification threat and (7) water pollution. The proposed scheme will not require land take from within the designated site however, the scheme is hydrologically linked to the designated site. No construction works are required and due to the distance from the designated site and the fact that no change in abstraction is proposed, no LSE are anticipated on any of the designated sites. Localised changes in water flow may expose a larger area of intertidal mudflats (A2.3 – littoral mud) and cause fluctuations in nutrient loading, turbidity, salinity, and oxygenation surrounding the outfall during operation. Due to the large tidal range of the Severn Estuary and small volume of effluent proposed for diversion and discharge in the freshwater River Severn, negligible amendments to water flow within the river reach during operation are anticipated. Therefore, no LSE on qualifying habitat features of the SAC are anticipated.	**No**	**No**

[85] Ricardo Energy & environment (2021). Severn to Thames Transfer SRO. Assessment Report: Appendix B3.2 Water Quality. Report for United Utilities on behalf of the Severn to Thames Transfer Programme. March 2021

Designated site name:	**Walmore Common SPA (UK9007051)**		
Designation type: (SAC, SPA, Ramsar):	**SPA**		
Qualifying features:	A037 *Cygnus columbianus bewickii*, Bewick's swan	**Water Dependency** Species identified as water dependent[86]: • *Cygnus columbianus bewickii*, Bewick's swan.	
Current conservation status:	**A037 *Cygnus columbianus bewickii*, Bewick's swan: Unknown.** Type: Wintering. Size: minimum 104, maximum 104. Unit: Individuals. Data quality: Good. Population: <2%. Isolation: Population not-isolated within extended distribution range.		
Conservation objectives:	Ensure that the integrity of the site is maintained or restored as appropriate, and ensure that the site contributes to achieving the Favourable Conservation Status of its Qualifying Features, by maintaining or restoring; • The extent and distribution of habitats of qualifying species • The structure and function of the habitats of qualifying species • The supporting processes on which the habitats of qualifying species rely • The populations of qualifying species, and, The distribution of qualifying species within the site.		
SSSI Condition assessment:	Walmore Common SSSI: 100% Unfavourable – no change.		
Site Improvement Plan:	1. Hydrological changes – Threat – 037(NB) Bewick's swan - Water level management plan. 2. Changes in species distributions – Threat – 037(NB) Bewick's swan - Research into Bewick's swan distribution. 3. Change in land management – Threat – 037(NB) Bewick's swan - Improve habitat connectivity. 4. Offsite habitat availability/management – Pressure/Threat – 037(NB) Bewick's swan - Review designation boundaries to include critical grazing areas. 5. Public access/disturbance – Threat – 037(NB) Bewick's swan - Access strategy 6. Energy production – Threat – 037(NB) Bewick's swan - Appropriate ecological information available to inform development control.		
Potential Effects			
Scheme:		Risk of Likely Significant Effects Alone?	Risk of Likely Significant Effects In-combination with other schemes
Netheridge WwTW discharge diversion, Deerhurst pipeline (35 Ml/d)	This scheme is located 6 km south-east of Walmore Common SPA. The SIP threats and pressures of potential relevance to this scheme are (1) hydrological changes, (2) changes in species distribution and (4) offsite habitat availability/management. Due to the distance between the designated site and the proposed works, no disturbance or air pollution impacts during construction are anticipated, that could cause changes in species distribution. However, the pipeline construction could result in direct impacts on floodplain grazing marsh habitat and grasslands. Bewick's swans overwinter at Walmore Common from October – March. The most notable change in flows in the River Severn in into the Severn Estuary is a decrease of 4.2-6.9% in flow in the autumn when flows are >10,000Ml/d. Overall, the changes in freshwater inflows into the Severn Estuary is not discernible. The treated effluent will be subject to further treatment prior to discharge into the River Severn. However, some uncertainty has been identified with regards to the potential impacts of water quality changes on supporting habitats for the migratory species. As such, LSE have been identified on a precautionary basis.	**Yes**	**Yes**

[86] UKTAG (2003). *Guidance on the Identification of Natura Protected Areas [Final]*. UK Technical Advisory Group on the Water Framework Directive. TAG Work Programme Task 4.a, 1 – 20.

Designated site name:	**Walmore Common Ramsar (UK11076)**		
Designation type: (SAC, SPA, Ramsar):	**Ramsar**		
Qualifying features:	**Ramsar Criterion 6** Species/populations occurring at levels of international importance. Qualifying species/populations (as identified at designation): *Cygnus columbianus bewickii*, Bewick's swan – Wintering, NW Europe 43 individuals, representing an average of 0.5% of the GB population (5 year peak mean 1998/9-2002/3).	**Water Dependency** Species identified as water dependent[87]: • *Cygnus columbianus bewickii*, Bewick's swan	
Current conservation status:	N/A		
Conservation objectives:	Information not available.		
SSSI Condition assessment:	Walmore Common SSSI: 100% Unfavourable – no change.		
Site Improvement Plan:	1. Hydrological changes – Threat – Bewick's swan - Water level management plan. 2. Changes in species distributions – Threat – Bewick's swan - Research into Bewick's swan distribution. 3. Change in land management – Threat – Bewick's swan - Improve habitat connectivity. 4. Offsite habitat availability/management – Pressure/Threat – Bewick's swan - Review designation boundaries to include critical grazing areas. 5. Public access/disturbance – Threat – Bewick's swan - Access strategy 6. Energy production – Threat – Bewick's swan - Appropriate ecological information available to inform development control.		
Potential Effects			
Scheme:		Risk of Likely Significant Effects Alone?	Risk of Likely Significant Effects In-combination with other schemes
Netheridge WwTW discharge diversion, Deerhurst pipeline (35 Ml/d)	This scheme is located 6 km south-east of Walmore Common Ramsar site. Due to the distance between the designated site and the proposed works, no disturbance or air pollution impacts during construction are anticipated, that could cause changes in specie distribution. The construction of the pipeline to Haw Bridge will not result on direct impacts on any habitats that support the qualifying features of the Ramsar site. However, the pipeline construction could result in direct impacts on floodplain grazing marsh habitat and grasslands. Bewick's swans overwinter at Walmore Common from October – March. The most notable change in flows in the River Severn in into the Severn Estuary is a decrease of 4.2-6.9% in flow in the autumn when flows are >10,000Ml/d. Overall, the changes in freshwater inflows into the Severn Estuary is not discernible. The treated effluent will be subject to further treatment prior to discharge into the River Severn. However, some uncertainty has been identified with regards to the potential impacts of water quality changes on supporting habitats for the migratory species. As such, LSE have been identified on a precautionary basis.	**Yes**	**Yes**

[87] UKTAG (2003). *Guidance on the Identification of Natura Protected Areas [Final]*. UK Technical Advisory Group on the Water Framework Directive. TAG Work Programme Task 4.a, 1 – 20.

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