River Severn to River Thames Transfer (STT)

Strategic regional water resource solution

Regulatory Assessment Report:

Habitats Regulation Assessment (HRA)

July 2021

SEVERN TRENT Thames Water United Utilities

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Severn Thames Transfer SRO

Evidence Report: Appendix 4.2: Habitat Regulations Assessment (HRA)

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Report for United Utilities on behalf of the Severn Thames Transfer Programme

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1	08/03/2021	Draft for STT review	[redacted]	[redacted]	[redacted]	[redacted]
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Figures

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Executive Summary

Water companies in England and Wales are required to produce a Water Resources Management Plan (WRMP) every five years. The Plan sets out how the company intends to maintain the balance between supply and demand for water over the selected planning horizon (minimum 25 years) in order to ensure security of supply in each of the water resource zones making up its supply area.

Following submission of WRMPs in 2019, Ofwat through the Price Review 2019 (PR19) Final Determination, has identified the potential for companies to jointly deliver strategic regional water resources. As part of the assessment of companies' PR19 business plans, Ofwat introduced proposals to support the delivery of Strategic Regional Water Resource Options (SROs) over the next 5 to 15 years. Ofwat's Final Determination in December 2019 set out a gated process for the co-ordination and development of a consistent set of SROs.

The Severn to Thames Transfer (STT) has been identified as an SRO in the PR19 Final Determination and includes eight key elements that may result in environmental impact. This Habitat Regulations Assessment (HRA) has been produced as part of the Gate 1, in accordance with the All Company Working Group (ACWG) current guidance for SRO Environmental Assessments. As the Gate 1 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 elements.

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.

As the Gate 1 submission does not form a statutory plan or project, UU has undertaken an assessment of the implications of the individual elements of the STT by adopting the *principles* of the HRA process to help identify risks to feasibility and deliverability of the elements as well as the additional monitoring and assessment work required to inform the formal HRA at Gate 2. While an in-combination assessment has been undertaken of the individual elements, 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 assessment has identified where there is a risk of Likely Significant Effects (LSE) as a result of each element and the STT SRO and, where a risk has been identified, whether adverse effects on site integrity could are predicted.

Screening concluded that the Vyrnwy Reservoir release (75 Ml/d), River Vyrnwy Mitigation release (80 Ml/d), River Vyrnwy Mitigation release (155 Ml/d), Minworth discharge diversion (115Ml/d), Deerhurst to Culham pipeline conveyance (300, 400 and 500 Ml/d) and Cotswold Canal conveyance including piping to Culham (300 Ml/d) would result in a risk of LSE on European designated sites alone and they were taken through to Appropriate Assessment. This was due to a clear risk of LSE on qualifying habitats and species of the Severn Estuary SAC and Ramsar site or where mitigation measures would be required. The 45Ml/d support release (Option 1a) refers to the current compensation releases from the Vyrnwy Reservoir and as this is the baseline, this option has not been considered for assessment in this report.

Table A: Summary of HRA Stage 1 Screening Assessment and Stage 2 Appropriate Assessment of Severn to Thames Transfer Elements.

Ref	Element ID	Stage 1 Screening Assessment - risk of likely significant effect on European site(s) alone?	Stage 2 Appropriate Assessment - predicted Adverse effect on integrity of European site?
1a	VyrnwyRelease_45	N/A	N/A
1b	VyrnwyRelease_75	Yes	No*
2a	MiddleVyrnwyBypass_80	Yes	No*
2b	MiddleVyrnwyBypass_155	Yes	No*
2c	VyrnwyBypass_180	No	No
3	ShrewsburyRedeployment_25	No	No
4	Mythe_15	No	No
5a	NetheridgePipelineDeerhurst_35	No	No
5b	NetheridgePipelineCotswold_35	No	No
6	Minworth_115	Yes	No*
7a	DeerhurstPipeline_300	Yes	No
7b	DeerhurstPipeline_400	Yes	No
7c	DeerhurstPipeline_500	Yes	No
8	CotswoldCanals_300	Yes	No

**Further monitoring and assessment required in Gate 2*

The Appropriate Assessment concluded that no adverse effects on site integrity of the Severn Estuary SAC and Ramsar site during construction and operation was predicted as a result of the implementation of the Deerhurst to Culham pipeline conveyance and Cotswold Canal conveyance are unlikely to result in adverse effects on the site integrity. This was due to consideration of the following embedded and additional mitigation measures: following best practice guidance for pollution prevention and biosecurity incidents, avoiding night-time works, using directional and/or baffled lighting when required, implementation of two stage screening and a hands-off flow (HoF) at the intake sites, to limit abstraction when flows at the gauging station are below 2,568 Ml/d. At flows greater than this HoF, up to 172 Ml/d is available for abstraction without support, and at flows greater than 3,333 Ml/d an additional 355 Ml/d is available for abstraction without support. These HoF limitations were also advised by the Environment Agency. Additional monitoring is required in order to determine whether suitable silt bed habitat for river lamprey and sea lamprey ammocoetes is present within close proximity of the intake sites for both elements. Water quality assessments confirmed that further study of water quality data, measured at NRW water quality monitoring sites is required, in order to fully determine the water quality and chemistry representation of the River Severn downstream of the Avon confluence prior to a detail assessment of impacts to water quality from STT options and schemes[1].

The Appropriate Assessment concluded that adverse effects on the site integrity of the Severn Estuary SAC and Ramsar site were not predicted as a result of construction and/or operation of the Vyrnwy Reservoir release (75 Ml/d), River Vyrnwy Mitigation (80 Ml/d) or the River Vyrnwy Mitigation release (155 Ml/d) . This in in view of existing data on the velocity, depth and water quality impacts associated with these elements and consideration of operational measures to mitigate against any impacts. The latter includes a review of the operational rules of the Severn Regulation to minimise the periods when support and regulation releases coincide. Further monitoring is required to understand the extent to which the River Vyrnwy provides supporting habitat to the fish populations of the Severn Estuary SAC and Ramsar site.

The Appropriate Assessment concluded that no adverse effects on site integrity of the Severn Estuary SAC and Ramsar, River Clun SAC, River Wye SAC and River Usk SAC is predicted as a result of the

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

implementation of the Minworth discharge diversion (115Ml/d) This includes the implementation of tertiary treatment of effluent prior to release in the River Avon and operational rules to avoid the upstream migration period of anadromous fish. There remains some uncertainty with regards to the potential impacts on migratory cues (chemical) and passability of barriers as a result of this element. The main concern relates to olfactory cues in species such as Atlantic salmon (*Salmo salar*), twait shad (*Alosa fallax*) sea lamprey (*Petromyzon marinus*), river lamprey (*Lampetra fluviatilis*) and European eel (*Anguilla anguilla*). European eel are also known to occur throughout the River Avon catchment and there is some uncertainty regarding the passability of barriers as a result of increased flow.

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 2 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.

1 Introduction

1.1 Background and purpose of report

Water companies in England and Wales are required to produce a Water Resources Management Plan (WRMP) every five years. The Plan sets out how the company intends to maintain the balance between supply and demand for water over the selected planning horizon (minimum 25 years) in order to ensure security of supply in each of the water resource zones making up its supply area.

Following submission of WRMPs in 2019, Ofwat through the Price Review 2019 (PR19) Final Determination, has identified the potential for companies to jointly deliver strategic regional water resources solutions to secure long-term resilience on behalf of customers while protecting the environment and benefiting wider society. As part of the assessment of companies' PR19 business plans, Ofwat introduced proposals to support the delivery of Strategic Regional Water Resource Options (SROs) over the next 5 to 15 years with solutions considered to be 'construction ready' for the 2025-2030 period. Ofwat's Final Determination[2] in December 2019 set out a gated process for the co-ordination and development of a consistent set of SROs.

This gated process provides a mechanism for the industry, regulators, stakeholders and customers to input into the development and scheduling of these strategic solutions, through a combined set of statutory and regulatory processes. These include the National Framework, Drinking Water Safety Plans, Business Plans and WRMPs. The strategic regional working group (consisting of Affinity Water, Anglian Water, Severn Trent Water, Southern Water, South West Water, Thames Water, United Utilities and Wessex Water) published a joint company statement reiterating a commitment to continue working with the Regulators' Alliance for Progressing Infrastructure Development (RAPID), the Environment Agency (EA), Natural Resources Wales (NRW), Ofwat and the Drinking Water Inspectorate (DWI) to make all of the planning processes and statutory timetables a success.

The Severn to Thames Transfer (STT) has been identified as an SRO in the PR19 Final Determination, with funding allocated equally between Thames Water (TW), United Utilities Water Limited (UU) and Severn Trent Water (ST). The STT SRO covers a wide geographical area that includes two regional plan areas across England, namely; Water Resources South East (WRSE) and Water Resources West (WRW). Whilst each regional plan area will develop their approach to environmental assessment and have their own timescales for development of these plans to meet statutory targets it is important that the environmental assessment of the STT SRO adopts a consistent approach.

In October 2020, the group of Water Companies involved in developing SROs (known as the All Company Working Group - ACWG), published guidance[3] 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 Habitat Regulation Assessment (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 Habitat Regulation Assessment (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, each SRO should meet the requirements of the Habitats Regulations before implementation.

[2] Ofwat (2019), PR19 Final Determinations, Strategic regional water resource solutions appendix
[3] Mott MacDonald Limited (2020). All Companies Working Group WRMP environmental assessment guidance and applicability with SROs. Published October 2020

The amended 2017 Habitats Regulations 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)[4] and Special Protected Areas (SPAs) [5]
- 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.

For ease of reference through this HRA report, these designations are collectively referred to as "European sites". As per Natural England (NE) guidance[6], 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 HRA report aims to establish whether elements included in the STT 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 that scheme.

1.2 Requirements for Habitat Regulations Assessments

As the Gate 1 submission does not form a statutory plan or project[7], the *principles* of the HRA process have been applied to help identify *risks* to feasibility and deliverability of the elements (alone and in-combination).

As such there is no competent authority undertaking the integrity test.

HRA Guidance for the appraisal of Plans[8], summarises the Habitats Regulations. Regulation 63 states that the Plan making authority (in this case the STT group comprising United Utilities, Thames Water and 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 or 105 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 —

[4] 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.
[5] 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).
[6] 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)
[7] Ofwat 3 April 2020 Strategic Regional Water Resource Solutions: Gate one assessment. Letter issued via email to Regulatory Directors of companies with strategic regional water resource solutions.

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

(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.

Regulation 105 of the Habitats Regulations states:

105. — (1) Where a land use plan —

(a) is likely to have a significant effect on a European site or a European offshore marine site (either alone or in combination with other plans or projects), and

(b) (b) is not directly connected with or necessary to the management of the site, the plan-making authority for that plan must, before the plan is given effect, make an appropriate assessment of the implications for the site in view of that site's conservation objectives.

(2) The plan-making authority must for the purposes of the assessment consult the appropriate nature conservation body and have regard to any representations made by that body within such reasonable time as the authority specify.

(3) They must also, if they consider it appropriate, take the opinion of the general public, and if they do so, they must take such steps for that purpose as they consider appropriate.

(4) In the light of the conclusions of the assessment, and subject to regulation 103 (considerations of overriding public interest), the plan-making authority or, in the case of a regional strategy, the Secretary of State must give effect to the land use plan only after having ascertained that it will not adversely affect the integrity of the European site or the European offshore marine site (as the case may be).

(5) A plan-making authority must provide such information as the appropriate authority may reasonably require for the purposes of the discharge of the obligations of the appropriate authority under this Chapter.

(6) This regulation does not apply in relation to a site which is —

(a) a European site by reason of regulation 8(1)(c), or

(b) a European offshore marine site by reason of regulation 15(c) of the 2007 Regulations (site protected in accordance with Article 5(4) of the Habitats Directive).

Best practice guidance[9] 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) 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 the element. As such, it is expected that elements 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 2.

1.3 Structure of the report

The report is divided into the following sections:

Section 1: This introduction

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

Section 2: Provides a background to the STT SRO

Section 3: Provides the methodology adopted for the HRA

Section 4: Provides the results of the screening of the individual STT elements

Section 5: Provides the Information to Inform the Appropriate Assessment of the individual STT elements

Section 7: Provides an assessment screening of the STT SRO (combined elements)

Section 7: Conclusions and Recommendations

2 Severn to Thames Transfer System

2.1 Introduction

A STT conveying raw water from the lower River Severn into the upper or middle River Thames via an interconnector would increase the catchment area from which water resources can be drawn to the south-east of England. In addition to any flows that may be available to be abstracted under licence from the River Severn, a range of raw water transfer supporting source options for the STT are under consideration to provide additional resource.

The STT SRO comprises 2 principal aspects:

1. Severn to Thames Conveyance – Deerhurst to Culham pipeline or canal conveyance, including piping to Culham.
2. Source rivers used to transport water associated with supported abstractions (rivers Vyrnwy, Severn, Avon and Thames).

In terms of the Interconnector there are two alternative options available. Firstly, a pipeline with a capacity of 300 Ml/d, 400 Ml/d and 500 Ml/d. This involves the abstraction of water from the lower River Severn at Deerhurst, its treatment at a new water treatment plant and then the transferring of the water for discharge to the middle River Thames at Culham. The alternative option to the pipeline conveyance is for the transfer of raw water to be undertaken via the Cotswold canals. This option would require the restoration of the canals and the transfer of raw water from the River Severn into the Gloucester & Sharpness Canal at Gloucester Docks, the transfer of raw water from the Gloucester & Sharpness Canal to the restored Cotswold canals, the transfer of water from the restored Cotswold canals near Lechlade to a water treatment works and then a pipeline for conveyance to the River Thames near Culham.

In order for all of the STT Source Support Elements to be able to deliver the water into the STT System there is a requirement for these water supplies to be replaced with other water sources (aspect 2 above). The provision of this additional water is covered under separate SROs that provide the facilities to enable supporting flows for the STT. These SROs are STW Sources SRO, STW Minworth SRO, UU Sources SRO and UU Lake Vyrnwy SRO.

The STT System comprises the STT SRO and the source SROs which would be required to work as a combined system to deliver the required outputs into the River Thames.

illustrates the scope of the STT system and the related UU and STW individual company, source-related elements.

The individual sources identified to date with indicative outputs under the separate SROs comprise:

1. Mythe abstraction reduction (15 Ml/d)
2. Minworth WwTW discharge diversion (115 Ml/d)
3. Netheridge WwTW discharge diversion, Deerhurst pipeline (35 Ml/d)
4. Netheridge WwTW discharge diversion, Cotswold canals (35 Ml/d)
5. Vyrnwy Reservoir release (75 Ml/d)

The two UU SROs provide additional capacity and facilities within the UU network to then enable Vyrnwy Reservoir support releases into the River Severn.

This HRA report considers the elements associated with the STT SRO only and separate assessments are being undertaken to inform the HRA of the other sources. 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 plans.

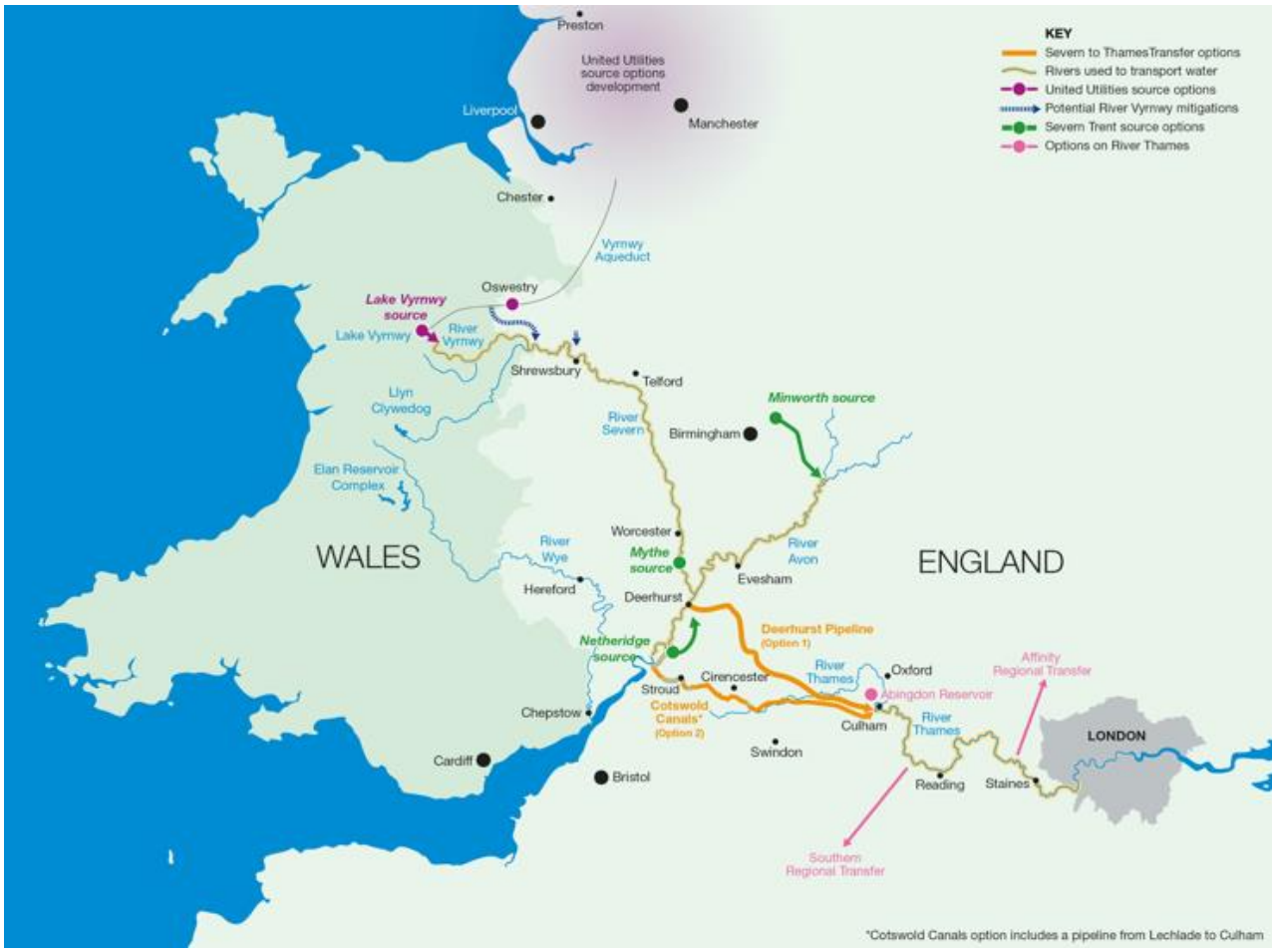

Figure 2.1*:* STT SRO key elements

Sustained releases from the Vyrnwy Reservoir into the River Vyrnwy in support of the STT has been identified as being of particular concern by NRW. These concerns relate to the potential unacceptable environmental impacts which may need to be mitigated. One such mitigation option to the Vyrnwy Reservoir source is the option to suspend the abstraction licence at Shrewsbury, which would have a commensurate reduction of up to 25Ml/d in supply from Vyrnwy Reservoir, as Shrewsbury would then be supplied from the Vyrnwy Reservoir. A further mitigation option to the Vyrnwy Reservoir source is the development of a River Vyrnwy Bypass pipeline that will be capable of transferring part of the Lake Vyrnwy Reservoir raw water releases from the Vyrnwy Aqueduct into the lower reaches of the River Vyrnwy or after its confluence with the River Severn.

As part of the Lake Vyrnwy Reservoir source, there are four potential mitigation options that could be used as environmental mitigation for Lake Vyrnwy Reservoir regulation releases directly into the River Vyrnwy. These being:

1. River Vyrnwy Mitigation - Shrewsbury redeployment (25 Ml/d)
2. River Vyrnwy Mitigation – Middle River Vyrnwy Bypass (80 Ml/d)
3. River Vyrnwy Mitigation – Middle River Vyrnwy Bypass (155 Ml/d)
4. River Vyrnwy Mitigation – River Vyrnwy Bypass (180 Ml/d)

In addition to the above sources the STT SRO also comprises two potential pipeline and canal conveyance options these being:

1. Pipeline conveyance, Deerhurst to Culham - 300, 400 and 500 Ml/d variants
2. Canal conveyance, including piping to Culham - 300 Ml/d

In total, there are eight different elements at a variety of different capacities that comprise the STT System (see **Table 2.1**). The current compensation release from the Vyrnwy Reservoir is 45Ml/d. As such, element 1a represents "business as usual" and will not be considered in the assessments.

A more detailed description of each element is provided in the sections below.

Table 2.1 Elements that from the STT SRO subject to assessment

Ref	Element ID	Name
1a	VyrnwyRelease_45	Vyrnwy Reservoir release (45Mld)
1b	VyrnwyRelease_75	Vyrnwy Reservoir release (75Mld)
2a	MiddleVyrnwyBypass_80	River Vyrnwy Mitigation - Vyrnwy release (100Mld) and Bypass (80Mld)
2b	MiddleVyrnwyBypass_155	River Vyrnwy Mitigation – Vyrnwy Bypass release (155Mld)
2c	VyrnwyBypass_180	River Vyrnwy Mitigation – Vyrnwy Bypass release (180Mld)
3	ShrewsburyRedeployment_25	River Vyrnwy Mitigation – Shrewsbury Redeployment (25Mld)
4	Mythe_15	Mythe abstraction reduction (15Mld)
5a	NetheridgePipelineDeerhurst_35	Netheridge WwTW discharge diversion (35Mld) - Deerhurst Pipeline
5b	NetheridgePipelineCotswold_35	Netheridge WwTW discharge diversion (35Mld) - Cotswold Canals
6	Minworth_115	Minworth WwTW discharge diversion (115Mld)
7a	DeerhurstPipeline_300	Pipeline conveyance, Deerhurst to Culham (300Mld)
7b	DeerhurstPipeline_400	Pipeline conveyance, Deerhurst to Culham (400Mld)
7c	DeerhurstPipeline_500	Pipeline conveyance, Deerhurst to Culham (500Mld)
8	CotswoldCanals_300	Canal conveyance, including piping to Culham (300Mld)

As part of the development of the STT Scheme, Jacobs undertook modelling of the STT Source Support Elements to determine the order in which the support elements would become operational for each of the Interconnector alternatives. This order was determined having regard to a number of factors including cost and resilience. The ordering of the support elements for both the Deerhurst to Culham pipeline conveyance and the Canal conveyance are set out in **Table 2.2**.

Table 2.2: STT Source Support Element Groupings

Pipeline conveyance		Canal conveyance	
Element Ref	Element ID	Element Ref	Element ID
7a	DeerhurstPipeline_300	8	CotswoldCanals_300
4	Mythe_15	4	Mythe_15
1b	VyrnwyRelease_75	5b	NetheridgePipelineCotswold_35
5a	NetheridgePipelineDeerhurst_35	1b	VyrnwyRelease_75
3	ShrewsburyRedeployment_25	3	ShrewsburyRedeployment_25
2a	MiddleVyrnwyBypass_80	2a	MiddleVyrnwyBypass_80
6	Minworth_115	6	Minworth_115

On the basis that the ordering of when the different STT Source Support Elements can become operational has been fixed through the work undertaken by Jacobs the environmental assessment of each of these support elements has had regard to the changing baseline position in terms of the receiving water environment. For example, when considering the introduction of the Shrewsbury Redeployment support element the assessment has regard that the water in the River Severn system

would include the additional water being made available / provided by the: Mythe (15 Ml/d); Vrynwy release (75 Ml/d); and Netheridge (35 Ml/d) source support elements.
A more detailed description of each element is provided in the sections below.

2.2 Pipeline conveyance, Deerhurst to Culham (300, 400 and 500 Ml/d) – element 7 a, b, and c

An unsupported or supported conveyance pipeline option from Deerhurst on the River Severn to Culham on the River Thames with a 300, 400 or 500Ml/d capacity Ml/d capacity and a total length [redacted]The element includes all engineering works required to transfer the flow to the River Thames. This includes: a river intake structure at Deerhurst including inlet screens and a twin pipeline to a low lift pump station, a raw water low lift pump station and a twin pipeline to the water treatment works, treatment works, a treated water high lift pump station, a rising main; a break pressure tank at the high point, a gravity main to discharge, an outfall at Culham with an actuated valve and an aeration cascade, washouts along the route provided with permanent discharge pipework to adjacent watercourses and a tee off the main pipeline for SWOX supply.

2.3 Canal conveyance, including piping to Culham (300 Ml/d) – element 8

The concept of canal conveyance is to utilise the historic infrastructure of the Cotswold Canals (Stroudwater Navigation and Thames and Severn Canals), in conjunction with the Gloucester and Sharpness Ship Canal and new pipeline transfer (either supported on unsupported) 300 Ml/d water from the River Severn to the River Thames. The engineering concept can be split into four broad segments:

1. River Severn (at Gloucester) to Summit Pound. The water will be abstracted from the River Severn at Gloucester via a low head pumping station and discharged into the Gloucester and Sharpness Ship Canal at the Gloucester Docks basin. Water will transfer by gravity along the operational Gloucester and Sharpness Ship Canal for abstraction at Saul Junction. At Saul Junction, water will be transferred by a series of [redacted] to Newtown Pound and via open channel transfer abstracted and transferred to [redacted] . Long pounds in the existing canal will be used for flow transfer between the discharge structure of one rising main and the intake to the next. The pipe which constitutes each rising main will be laid in the towpath or canal bed or along adjacent roads.
2. Summit Pound. In this section water will be transferred through the existing but currently damaged Sapperton Tunnel, then along the remainder of the summit pound. This will be rehabilitated, both for the water transfer and to allow navigation.
3. Summit Pound to Lechlade. In this section water will be transferred downhill along the canal by gravity, until it meets the River Thames at or near Inglesham. Locks are by-passed by abstracting the transfer water uphill of the lock and transferring it in a short length of pipe to a discharge point just downhill of the lock. This bypass arrangement is required to enable the locks to be used for navigation during the transfer.
4. Lechlade to Culham/ River Thames: Water will be processed at a new water treatment works and a pipeline will convey transfer flows to a discharge location at Culham. Pipeline diameters will be chosen to keep flow velocities below 2.5m/s, as required by Thames Water Asset Standard.

2.4 Mythe abstraction reduction (15 Ml/d) – element 4

This element provides support to STT abstraction from the Severn catchment by redeploying the 15 Ml/d infrequently used part of the existing STW abstraction licence at its Mythe intake in the lower River Severn. The currently infrequently used licensed volume would remain in the River Severn for abstraction downstream at Deerhurst by TW. The Mythe intake is located on the River Severn near Tewkesbury, [redacted]northeast of Deerhurst. STW has advised that only minor works would be required at Mythe and elsewhere to redeploy the spare licence volume for abstraction by TW.

To provide sufficient water to support the STT System from the Mythe intake, additional resource may be required. It is understood from STW that no specific additional resource to replace this current abstraction licence volume has been determined to date and would require consideration at Gate 2. This assessment would be undertaken as part of the STW Sources SRO.

2.5 Vyrnwy Reservoir release (75 Ml/d) – element 1b

Release of 75 Ml/d water from Lake Vyrnwy Reservoir, an existing reservoir in Mid Wales, into the River Vyrnwy (a tributary of the River Severn) for supporting flow in the River Severn for downstream re-abstraction from the River Severn at Deerhurst (and subsequent transfer into the River Thames to supply TW as well as potential other Water Companies). The reservoir is owned and operated by STW but predominately supplies water to UU who hold the abstraction rights for the reservoir and who have offered the water to TW when required.

This option would only become operational after the 15 Ml/d of the licensed River Severn abstraction at Mythe has been made available. In consequence, this assessment has had regard to the water environment that includes for this additional water being made available for abstraction. Furthermore, to provide for this release of water to support the STT System from the Vyrnwy Reservoir, additional resource will be required within the UU operational area. This additional resource is subject to separate assessments under the UU Sources SRO and UU Lake Vyrnwy SRO.

2.6 Netheridge WwTW discharge diversion

2.6.1 Deerhurst Pipeline (35 Ml/d) – element 5a

Currently water from STW's Netheridge WwTW is discharged into the upper Severn Estuary. It is proposed to divert a 35 Ml/d portion to a new outfall on the freshwater River Severn to support STT abstraction from the River Severn at Deerhurst. The optimal outfall location to the River Severn is being designed during Gate 1 through review of environmental constraints. The outfall study area is locally downstream of the proposed intake from the River Severn at Deerhurst. The diversion from Netheridge WwTW would be pumped by a new pumping station, located at the WwTW land via a 700mm diameter pipeline approximately [redacted] long.

The transfer of WwTW discharge for STT support would not be continuous, only discharging to the freshwater river outfall according to an operating regime when support is required to enable abstraction from the River Severn. The discharge would be a flow replacement for river water abstracted locally upstream. The element will result in a relocation of up to 35 Ml/d.

This option would only become operational after the both the Mythe abstraction reduction (15 Ml/d) support element and the Vyrnwy Reservoir Release (75 Ml/d) support element have been made available. In consequence, this assessment has had regard to the water environment that includes for this additional water being made available for abstraction.

2.6.2 Netheridge WwTW discharge diversion, Cotswold Canals (35 Ml/d) – element 5b

Currently water from STW's Netheridge WwTW is discharged into the upper Severn Estuary. It is proposed to divert a 35 Ml/d portion to a new outfall on the freshwater River Severn to support STT abstraction from the River Severn at Gloucester and Sharpness Canal. The optimal outfall location to the River Severn is being designed during Gate 1 through review of environmental constraints. The outfall study area is located downstream of the proposed abstraction discharging to Gloucester and Sharpness Canal. The discharge diversion from Netheridge WwTW would be pumped by a new pumping station, located at the WwTW land via a 700mm diameter pipeline approximately [redacted] long.

The transfer of WwTW discharge for STT support would not be continuous, only discharging to the freshwater river outfall according to an operating regime when support is required to enable abstraction from the River Severn. The discharge would be a flow replacement for river water abstracted locally upstream. The element will result in a relocation of up to 35 Ml/d.

This option would only become operational after the Mythe abstraction reduction (15 Ml/d) support element has been made available. In consequence, this assessment has had regard to the water environment that includes for this additional water being made available for abstraction.

2.7 River Vyrnwy Mitigation

Sustained releases from the Vyrnwy Reservoir into the River Vyrnwy in support of the STT has been identified as being of particular concern by NRW. These concerns relate to the potential unacceptable environmental impacts which may need to be mitigated. One such mitigation option to the Vyrnwy Reservoir source is the option to suspend the abstraction licence at Shrewsbury, which would have a commensurate reduction of up to 25Ml/d in supply from Vyrnwy Reservoir, as Shrewsbury would then be supplied from the Vyrnwy Reservoir. This will require construction of additional infrastructure, including a new pipeline. A further mitigation option to the Vyrnwy Reservoir source is the development of a River Vyrnwy Bypass pipeline that will be capable of transferring part of the Lake Vyrnwy Reservoir raw water releases from the Vyrnwy Aqueduct into the lower reaches of the River Vyrnwy or after its confluence with the River Severn. The transfer of water from the aqueduct to the lower River Vyrnwy or the River Severn will require the construction of a new pipeline.

As part of the Lake Vyrnwy Reservoir source, there are four potential mitigation options that could be used as environmental mitigation for Lake Vyrnwy Reservoir regulation releases directly into the River Vyrnwy. These being:

1. River Vyrnwy Mitigation - Shrewsbury redeployment (25 Ml/d)
2. River Vyrnwy Mitigation – Middle River Vyrnwy Bypass (80 Ml/d)
3. River Vyrnwy Mitigation – Middle River Vyrnwy Bypass (155 Ml/d)
4. River Vyrnwy Mitigation – River Vyrnwy Bypass (180 Ml/d)

To provide sufficient water to support the STT System from these mitigation options, additional resource will be required within the UU operational area. This additional resource is subject to separate assessments under the UU Sources SRO and UU Lake Vyrnwy SRO.

2.7.1 Shrewsbury redeployment (25 Ml/d) – element 3

This element comprises additional redeployment of the existing River Severn abstraction at Shrewsbury, which will require the construction of a number of booster and pumping stations and process enhancements at Shelton water treatment works (WTW). Abstraction at Shrewsbury currently serves STW customers in Shrewsbury and Oswestry. UU and WwTW have offered to provide a supply to both Shrewsbury and Oswestry from Lake Vyrnwy Reservoir using the existing aqueduct and a new pipeline to Shrewsbury. This would reduce abstraction from the upper River Severn by 25 Ml/d at Shrewsbury and leave water in the river for abstraction at Deerhurst or Gloucester Docks (and subsequent transfer into the River Thames to supply TW as well as potential other Water Companies).

This option would only become operational after the 75 Ml/d Vyrnwy Reservoir Release support element, the 35Ml/d Netheridge WwTW discharge diversion support element and the 15 Ml/d Mythe support element have been made available for abstraction at Deerhurst, or Gloucester Docks. In consequence, this assessment has had regard to the water environment that includes for this additional water being in the River Severn.

2.7.2 Middle River Vyrnwy Bypass (80 Ml/d) - element 2a

This element comprises a raw water pipeline which will transport 80 Ml/d from the Vyrnwy Aqueduct, (which feeds Oswestry WTW) to the River Vyrnwy. The pipeline is a mitigation measure for the impact of a support release the Vyrnwy Reservoir element on the reaches of the River Vyrnwy between the Reservoir and the confluence with the River Banwy.

Operationally, this element also includes a contribution of 25 Ml/d from the abstraction reduction at Shrewsbury (element 3) and 75 Ml/d from the Vyrnwy Reservoir release (element 1a), to contribute a total of 180 Ml/d to the STT scheme. In addition to the above support elements this option would only become operational after the 35Ml/d Netheridge WwTW discharge diversion support element and the 15 Ml/d Mythe support element have been made available for abstraction at Deerhurst, or Gloucester Docks. In consequence, this assessment has had regard to the water environment that includes for all this additional water being in the River Severn.

2.7.3 Vyrnwy Bypass release (155 Ml/d) – Element 2b

This element comprises a raw water pipeline which will transport 155 Ml/d from the Vyrnwy Aqueduct, (which feeds Oswestry WTW) to the River Vyrnwy. The pipeline is a mitigation measure for the impact

of a support release the Vyrnwy Reservoir element on the reaches of the River Vyrnwy between the Reservoir and the confluence with the River Banwy.

Operationally, this element also includes a contribution of 25 Ml/d from the abstraction reduction at Shrewsbury (element 3) to contribute a total of 180 Ml/d to the STT scheme. In addition to the above support elements this option would only become operational after the 35Ml/d Netheridge WwTW discharge diversion support element and the 15 Ml/d Mythe support element have been made available for abstraction at Deerhurst, or Gloucester Docks. In consequence, this assessment has had regard to the water environment that includes for all this additional water being in the River Severn.

2.7.4 Vyrnwy Bypass release (180 Ml/d) – Element 2c

This element comprises a raw water pipeline which will transport 180 Ml/d from the Vyrnwy Aqueduct, (which feeds Oswestry WTW) to the River Severn. The pipeline is a mitigation measure for the impact of a support release the Vyrnwy Reservoir element on the reaches of the River Vyrnwy between the Reservoir and the confluence with the River Banwy.

This option would only become operational after the 35Ml/d Netheridge WwTW discharge diversion support element and the 15 Ml/d Mythe support element have been made available for abstraction at Deerhurst, or Gloucester Docks. In consequence, this assessment has had regard to the water environment that includes for all this additional water being in the River Severn.

2.8 Shrewsbury redeployment (25 Ml/d) – Element 3

This element comprises additional redeployment of the existing River Severn abstraction at Shrewsbury, which will require the construction of a number of booster and pumping stations and process enhancements at Shelton water treatment works (WTW). Abstraction at Shrewsbury currently serves STW customers in Shrewsbury and Oswestry. UU and WwTW have offered to provide a supply to both Shrewsbury and Oswestry from Lake Vyrnwy Reservoir using the existing aqueduct and a new pipeline to Shrewsbury. This would reduce abstraction from the upper River Severn by 25 Ml/d at Shrewsbury and leave water in the river for abstraction at Deerhurst.

To provide sufficient water to support the STT from the Shrewsbury WTW, additional resource will be required within the UU operational area. This additional resource is subject to separate assessments under the UU Sources SRO and UU Lake Vyrnwy SRO UU Sources SRO and UU Lake Vyrnwy SRO.

2.9 Minworth WwTW discharge diversion (115 Ml/d) – Element 6

Currently, water from STW's Minworth WwTW is discharged into the River Tame, a tributary of the River Trent. It is proposed to divert a 115 Ml/d portion to a new outfall on the River Avon and hence into the River Severn catchment to support STT abstraction from the River Severn at Deerhurst.

There would be a new extended treatment facility and pumping station at Minworth WwTW. The pipeline from Minworth WwTW to the River Avon outfall would involve construction of a [redacted] rising main and gravity main of up to[redacted] The optimal outfall location on the River Avon locally around Warwick is being designed during Gate 1 through review of environmental constraints. The pipeline route from Minworth WwTW is in a south-east direction and will include several river, highway and other road crossings.

The transfer of WwTW discharge for STT support would not be continuous – only discharging to the River Avon according to an operating regime when support is required to enable abstraction from the River Severn. The discharge would be a regulating release augmenting flows in the downstream Rivers Avon and Severn to the STT abstraction location at Deerhurst.

The element will have result in a transfer of up to 115 Ml/d into the River Avon and is also subject of a separate assessment under the STW Minworth SRO.

3 Methodology

3.1 Introduction

The ACWG guidelines indicate that a HRA should be undertaken in accordance with available guidance[1011121314151617] 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 1 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.

The objective of this HRA is to establish whether any of the elements for the STT SRO is likely to have a significant effect on European sites (alone and in combination with each other when forming the STT SRO). In-combination assessments with other SROs, non-SRO 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 1 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 elements. A Stage 1 (screening) assessment was undertaken as part of the initial screening exercise for each of the elements, and the *risk* of failing the integrity test was reviewed for each element, using the principles of the Stage 2 (Appropriate Assessment) assessment.

3.1.1 Stage 1 Screening

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

GIS data was used to map the locations and boundaries of European sites in relation to the different elements; within 10km of construction and operation works and 500m of rivers transferring excess water. 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:

- 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.
- Article 12 and 17 reporting,
- Site conservation objectives,
- Supplementary advice to the conservation objectives (SACO) where available
- Site Improvement Plans
- Core Management Plans (Wales), and
- the supporting Site of Special Scientific Interest's favourable condition tables where relevant and no SACOs applicable to the features were available.

[10] Court of Justice for the European Union's ruling on People Over Wind and Sweetman ('Sweetman II') vs Coillte Teoranta, Case C-323/17.
[11] UK Government (2019). Guidance on the use of Habitats Regulations Assessment.
[12] UK Government (2019). Conservation of Habitats and Species Regulations (Amendment) (EU Exit).
[13] Natural England (2020). Guidance on how to use Natural England's Conservation Advice Packages in Environmental Assessments.
[14] Tyldesley, D. & Chapman, C. (2013). The Habitats Regulations Assessment Handbook, February 2021 edition UK: DTA Publications Limited.
[15] Environment Agency and Natural Resources Wales (2017). Water resources planning guideline – April 2017
[16] European Commission (2018). Managing Natura 2000 sites - The provisions of Article 6 of the 'Habitats' Directive 92/43/EEC. European Union, 1-86.
[17] Defra (2012). The Habitats and Wild Birds Directives in England and its seas: Core guidance for developers, regulators & land/marine managers.

Analysis of how potential impacts of each element 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 element, to features contributing to the integrity of the European sites (e.g. surface water catchments, air, etc.).

Screening for LSEs was determined on a proximity basis for many of the types of impacts, based on the proximity of the potential location of the elements, to each European site. Where impact pathways were identified at greater distances (>10km) as a result of hydrological connectivity for example, designated sites were screened in as appropriate. Different types of impacts can occur over different distances, and as such the assumptions and distances used in the HRA 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 scheme on European sites.

Broad categories of potential impacts on European sites, with examples	*Examples of operations responsible for impacts* (distance assumptions in italics)
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 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 • Fragmentation • Severance/barrier effect • Edge effects	*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 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	*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

Broad categories of potential impacts on European sites, with examples	*Examples of operations responsible for impacts* (distance assumptions in italics)
• Light pollution • Vibration (incl. underwater).	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.* 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

[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 Too kit Informing Estuarine Planning and Construction Projects. Produced by the Institute of Estuarine and Coastal Studies (IECS). Version 3.2.
[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.

Broad categories of potential impacts on European sites, with examples	*Examples of operations responsible for impacts* (distance assumptions in italics)
	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.* 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 for an element at the screening stage (noting the precautionary principle), the element was subject to the *principles* of the Stage 2 Appropriate Assessment, noting again that the Gate 1 submission does not form a statutory plan or project and as such there is no competent authority undertaking the integrity test.

Further assessment was, therefore, undertaken to identify where there are *risks* 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 elements, both construction and operation, and the potential effects on the associated European site's qualifying

[24] NE Internal Guidance – Approach to Advising Competent Authorities on Road Traffic Emissions and HRAs V1.4 Final - June 2018

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.

Impacts

To determine adverse effect on site integrity, the following parameters were 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*
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.

Adverse Effect

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

An Adverse Effect on the site's 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 has commenced to inform the potential risks to the receiving environment associated with many of the elements. This includes a monitoring programme for the freshwater communities and initial modelling of the potential physical environmental impacts. These data were used (where applicable) to inform the Appropriate Assessment for those elements where LSEs were identified.

Any further data requirements, including the need for specific monitoring, were identified in the Appropriate Assessment for consideration during Gate 2 and Gate 3. As such, the data that was used in the more detailed assessments was limited to that readily available. The scope of the monitoring programme is subject to a separate report[25].

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*"[26].

At Gate 1, the potential for AEoI will be assessed against the conservation objectives as far as possible, and where there are *risks* that the integrity test cannot be met, these were identified for further consideration for the Gate 2 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[27]. These measures included both avoidance and reduction measures, with the former being the preferred option.

Where necessary, the report also recommended additional survey work that will be required to inform the Gate 2 HRA and any monitoring deemed necessary either for the purposes of validating the findings of the Appropriate Assessment, 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 2 process were also defined as part of the Appropriate Assessment.

3.1.5 Limitations

Information provided by third parties, including publicly available information and databases, is 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 configuration.

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 2. While an in-combination assessment has been undertaken of the individual elements, the in-combination assessments with other SROs, non-SRO options and

[25] Ricardo Energy & Environment (2020). Severn to Thames Transfer: Environmental Assessment Methodologies. Report prepared for United Utilities. 29 October 2020.
[26] Defra Circular 01/2005.
[27] 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.

other plans and projects has not been undertaken, It is understood that such assessments will be 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 2 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 STT Elements

4.1 Risk of Likely Significant Effects of Severn to Thames Transfer

The STT SRO is associated with a number of European and Internationally designated sites including SACs[28], SPAs[29] and Ramsar[30] sites as identified in **Table 4.1** below.

Table 4.1 European designated sites potentially affected by Severn to Thames Transfer Elements

European designated site	Associated Element
Berwyn and South Clywd Mountains SAC	Vyrnwy Reservoir release (75 Ml/d) River Vyrnwy Mitigation – Vyrnwy release (100 Ml/d) and Bypass (80 Ml/d)
Berwyn SPA	Vyrnwy Reservoir release (75 Ml/d) River Vyrnwy Mitigation – Vyrnwy release (100 Ml/d) and Bypass (80 Ml/d)
Bredon Hill SAC	Pipeline conveyance, Deerhurst to Culham (300, 400 and 500 Ml/d) Mythe abstraction reduction (15 Ml/d)
Chilterns Beechwoods SAC	Pipeline conveyance, Deerhurst to Culham (300, 400 and 500 Ml/d) Canal conveyance, including piping to Culham (300 Ml/d)
Cothill Fen SAC	Pipeline conveyance, Deerhurst to Culham (300, 400 and 500 Ml/d) Canal conveyance, including piping to Culham (300 Ml/d)
Cotswold Beechwoods SAC	Netheridge WwTW discharge diversion, Deerhurst pipeline (35 Ml/d) Netheridge WwTW discharge diversion, Cotswold canal (35 Ml/d) Canal conveyance, including piping to Culham (300 Ml/d)
Dixton Wood SAC	Pipeline conveyance, Deerhurst to Culham (300, 400 and 500 Ml/d) Mythe abstraction reduction (15 Ml/d)
Hartslock Wood SAC	Pipeline conveyance, Deerhurst to Culham (300, 400 and 500 Ml/d) Canal conveyance, including piping to Culham (300 Ml/d)
Little Wittenham SAC	Pipeline conveyance, Deerhurst to Culham (300, 400 and 500 Ml/d) Canal conveyance, including piping to Culham (300 Ml/d)
Montgomery Canal SAC	River Vyrnwy Mitigation – Vyrnwy release (100 Ml/d) and Bypass (80 Ml/d) River Vyrnwy Mitigation – Vyrnwy Bypass release (155Mld) River Vyrnwy Mitigation – Vyrnwy Bypass release (180Mld)
Midland Meres and Mosses Phase 1 Ramsar	River Vyrnwy Mitigation - Vyrnwy release (100Mld) and Bypass (80Mld) River Vyrnwy Mitigation – Vyrnwy Bypass release (155Mld) River Vyrnwy Mitigation – Vyrnwy Bypass release (180Mld) River Vyrnwy Mitigation – Shrewsbury Redeployment (25Mld)
Midland Meres and Mosses Phase 2 Ramsar	River Vyrnwy Mitigation – Vyrnwy release (100 Ml/d) and Bypass (80 Ml/d) River Vyrnwy Mitigation – Vyrnwy Bypass release (155Mld) River Vyrnwy Mitigation – Vyrnwy Bypass release (180Mld)
North Meadow and Clattinger Farm SAC	Canal conveyance, including piping to Culham (300 Ml/d)
River Clun SAC	Minworth WwTW discharge diversion – 115 Ml/d
River Dee and Bala Lake SAC	River Vyrnwy Mitigation – Vyrnwy release (100 Ml/d) and Bypass (80 Ml/d) River Vyrnwy Mitigation – Vyrnwy Bypass release (155Mld) River Vyrnwy Mitigation – Vyrnwy Bypass release (180Mld)
River Usk SAC	Minworth WwTW discharge diversion – 115 Ml/d
River Wye SAC	Minworth WwTW discharge diversion – 115 Ml/d
Rodborough Common SAC	Canal conveyance, including piping to Culham (300 Ml/d)
Severn Estuary SAC	Netheridge WwTW discharge diversion, Deerhurst pipeline (35 Ml/d) Netheridge WwTW discharge diversion, Cotswold canal (35 Ml/d)

[28] 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

[29] 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

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

European designated site	Associated Element
	Pipeline conveyance, Deerhurst to Culham (300, 400 and 500 Ml/d) Vyrnwy Reservoir release (75 Ml/d) River Vyrnwy Mitigation – Vyrnwy release (100 Ml/d) and Bypass (80 Ml/d) River Vyrnwy Mitigation – Vyrnwy Bypass release (155Mld) River Vyrnwy Mitigation – Vyrnwy Bypass release (180Mld) River Vyrnwy Mitigation – Shrewsbury Redeployment (25Mld) Canal conveyance, including piping to Culham (300 Ml/d) Mythe abstraction reduction (15 Ml/d) Minworth WwTW discharge diversion – 115 Ml/d
Severn Estuary SPA	Netheridge WwTW discharge diversion, Deerhurst pipeline (35 Ml/d) Netheridge WwTW discharge diversion, Cotswold canal (35 Ml/d) Pipeline conveyance, Deerhurst to Culham (300, 400 and 500 Ml/d) Vyrnwy Reservoir release (75 Ml/d) River Vyrnwy Mitigation – Vyrnwy release (100 Ml/d) and Bypass (80 Ml/d) River Vyrnwy Mitigation – Vyrnwy Bypass release (155Mld) River Vyrnwy Mitigation – Vyrnwy Bypass release (180Mld) River Vyrnwy Mitigation – Shrewsbury Redeployment (25Mld) Canal conveyance, including piping to Culham (300 Ml/d) Mythe abstraction reduction (15 Ml/d) Minworth WwTW discharge diversion – 115 Ml/d
Severn Estuary Ramsar	Netheridge WwTW discharge diversion, Deerhurst pipeline (35 Ml/d) Netheridge WwTW discharge diversion, Cotswold canal (35 Ml/d) Pipeline conveyance, Deerhurst to Culham (300, 400 and 500 Ml/d) Vyrnwy Reservoir release (75 Ml/d) River Vyrnwy Mitigation – Vyrnwy release (100 Ml/d) and Bypass (80 Ml/d) River Vyrnwy Mitigation – Vyrnwy Bypass release (155Mld) River Vyrnwy Mitigation – Vyrnwy Bypass release (180Mld) River Vyrnwy Mitigation – Shrewsbury Redeployment (25Mld) Canal conveyance, including piping to Culham (300 Ml/d) Mythe abstraction reduction (15 Ml/d) Minworth WwTW discharge diversion – 115 Ml/d
Tanat and Vyrnwy Bat sites SAC	River Vyrnwy Mitigation – Vyrnwy release (100 Ml/d) and Bypass (80 Ml/d) River Vyrnwy Mitigation – Vyrnwy Bypass release (155Mld) River Vyrnwy Mitigation – Vyrnwy Bypass release (180Mld)
Walmore Common SPA	Netheridge WwTW discharge diversion, Deerhurst pipeline (35 Ml/d) Netheridge WwTW discharge diversion, Cotswold canal (35 Ml/d) Canal conveyance, including piping to Culham (300 Ml/d)
Walmore Common Ramsar	Netheridge WwTW discharge diversion, Deerhurst pipeline (35 Ml/d) Netheridge WwTW discharge diversion, Cotswold canal (35 Ml/d) Canal conveyance, including piping to Culham (300 Ml/d)

As described in Sections 2, this HRA has screened all of the elements located within a 10km radius of any of the European sites in the study area and 500m of rivers transferring excess water. The SSSI IRZ has also been considered when selecting European Sites that require assessment. As indicated in Section 2.1.1, 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.

The HRA screening assessments of identified European sites within 10km radius of the elements for potential effects is provided in **Table 4.2.** 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.

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

Table 4.2: Screening assessments of identified European sites within 10km radius of the proposed Severn to Thames Transfer Elements for potential effects.

Designated site name:	**Berwyn and South Clwyd Mountains (UK0012926)**	
Designation type: (SAC, SPA, Ramsar):	**SAC**	
Qualifying features:	4030 European dry heaths 7130 Blanket bogs (* if active bog) 6210 Semi-natural dry grasslands and scrubland facies on calcareous substrates (*Festuco-Brometalia*) (* important orchid sites) 7140 Transition mires and quaking bogs 8120 Calcareous and calcshist screes of the montane to alpine levels (*Thlaspietea rotundifolii*) 8210 Calcareous rocky slopes with chasmophytic vegetation	**Water Dependency** Habitats identified as water dependent[31]: • 4030 European dry heaths • 7130 Blanket bogs • 7140 Transition mires and quaking bogs • 8120 Calcareous and calcshist screes of the montane to alpine levels (*Thlaspietea rotundifolii*) • 8210 Calcareous rocky slopes with chasmophytic vegetation
Current conservation status:	**4030 European dry heaths: Bad and deteriorating** (range: favourable, area: favourable, structure and function: bad and deteriorating, future prospects: bad but improving). Main pressures: grazing, abandonment of pastoral systems, burning, urbanised areas, human habitation, continuous urbanisation, discontinuous urbanisation, communication networks, energy transport, other forms of transportation and communication, air pollution, invasion by a species. Main threats: grazing, abandonment of pastoral systems, burning, discontinuous urbanisation, other pollution or human impacts/activities and invasion by a species. **7130 Blanket bogs (* if active bog): Bad but improving** (range: favourable, area: inadequate and deteriorating, structure and function: bad but improving, future prospects: bad but improving. Main pressures: problematic native species, grazing; drainage for agriculture, air pollution, conversion to other land uses, modification of hydrological conditions, renewable energy infrastructure and human disturbance. Main threats: problematic native species, grazing, drainage for agriculture and air pollution. **6210 Semi-natural dry grasslands and scrubland facies on calcareous substrates (Festuco-Brometalia): Bad but improving** (range: favourable, area: inadequate and deteriorating, structure and function: bad but improving, future prospects: favourable. Main pressures: grazing, air pollution, air-borne pollutants, modification of cultivation practices, livestock farming and animal breeding (without grazing), fertilisation, forest planting on open ground, mining and quarrying, urbanised areas, human habitation, deer grazing/ browsing/ trampling, outdoor sports and leisure activities, recreational activities, other human intrusions and disturbances, soil pollution and solid waste (excluding discharges), invasive non-native species, problematic native species, fire and fire suppression, other ecosystem modifications, biocenotic evolution, succession, changes in abiotic conditions and changes in biotic conditions. Main threats: As stated in pressures. **7140 Transition mires and quaking bogs; Very wet mires often identified by an unstable `quaking` surface: Bad and deteriorating** – Main pressures: water abstraction, grazing, fragmentation, absence of or inappropriate management, pollution, air pollution – Main threats: water abstraction, grazing, fragmentation, absence of or inappropriate management, pollution, air pollution and climate change. **8120 Calcareous and calcshist screes of the montane to alpine levels: Bad but improving** (range: favourable, area: favourable, structure and function: bad but improving, future prospects: favourable). Main pressures: grazing, air pollution, sports, tourism and leisure activities, problematic native species and natural succession. Main threat: invasive species, climate change, grazing, air pollution, sports, tourism and leisure activities, problematic native species and natural succession. **8210 Calcareous rocky slopes with chasmophytic vegetation: Bad but improving** (range: favourable, area: favourable, structure and function: bad but improving, future prospects: bad but improving. Main pressures: grazing, air pollution, sports, tourism and leisure activities and problematic native species. Main threats: grazing, air pollution, sports, tourism and leisure activities, invasive species, natural succession and climate change.	
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. • The distribution of qualifying species within the site.	
SSSI Condition assessment:	Information not currently available	
Site Improvement Plan:	Information not currently available	
Potential Effects		
Element:		Risk of Likely Significant Effects?
Vyrnwy Reservoir release (75 Ml/d)	This element is located approximately [redacted] to the east of Berwyn and South Clwyd Mountains SAC. Relevant threats and pressures of the qualifying features that could be affected include modification of hydrological conditions and water abstraction (listed in current conservation status). No construction activity is required at Lake Vyrnwy Reservoir. Although all of the qualifying features have been identified as water dependant, the SAC is not hydrologically connected downstream of the proposed regulation release. UU currently abstracts water from Vyrnwy Reservoir for treatment at the Oswestry WTWs. The abstraction volume is limited by an abstraction licence. In addition, regulation releases and flood drawdown releases are often made from the Vyrnwy Reservoir. At times of operation of this element, the Oswestry WTWs will be (part) supplied by the UU Sources SRO and regulation and flood drawdown releases will remain unchanged or potentially reduced). As such, baseline water levels will remain unchanged. . No additional impact pathways during the operation of this element have been identified on qualifying features of the SAC. Therefore, no likely significant effects (LSE) are anticipated from this element.	**No**
River Vyrnwy Mitigation – Vyrnwy release (100 Ml/d) and Bypass (80 Ml/d)	This element is located approximately [redacted] (at its closest point) to the east of Berwyn and South Clwyd Mountains SAC. Relevant threats and pressures of the qualifying features to this element include air pollution, air borne-pollutants, modification of hydrological conditions, human disturbance, soil pollution and solid waste, water abstraction and other ecosystem modifications. No construction activity is required at Lake Vyrnwy Reservoir and construction works on the proposed bypass are a sufficient distance away [redacted] eliminating soil pollution and solid waste, human disturbance and other ecosystem modifications from further consideration. Although all of the qualifying features have been identified as water dependant, the SAC is not hydrologically connected downstream of the proposed regulation releases. . UU currently abstracts water from Vyrnwy Reservoir for treatment at the Oswestry WTWs. The abstraction volume is limited by an abstraction licence. In addition, regulation releases and flood drawdown releases are often made from the Vyrnwy Reservoir. At times of operation of this element, the Oswestry WTWs will be (part) supplied by the UU Sources SRO and regulation and flood drawdown releases will remain unchanged or potentially reduced). As such, baseline water levels will remain unchanged. Therefore, no LSE are anticipated from this element.	**No**

[31] 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:	**Berwyn (UK9013111)**	
Designation type: (SAC, SPA, Ramsar):	**SPA**	
Qualifying features:	082 *Circus cyaneus;* Hen harrier 098 *Falco columbarius;* Merlin 103 *Falco peregrinus;* Peregrine falcon 074 *Milvus milvus;* Red kite	**Water Dependency** Species identified as water dependent[32]: • 082 *Circus cyaneus;* Hen harrier (breeding and wintering). • 098 *Falco columbarius;* Merlin (breeding and wintering). • 103 *Falco peregrinus;* Peregrine falcon (breeding). • 074 *Milvus milvus;* Red kite (breeding).
Current conservation status:	**082 *Circus cyaneus;* Hen harrier: Unfavourable** (type: reproducing, size: minimum 14; maximum 14 (2.2% of the British breeding population 5-year mean, 1991 – 1995), unit: pairs, data quality: good, population: 2 – 15%, isolation: population not isolated, but on margins of area of distribution). **098 *Falco columbarius;* Merlin: Unfavourable** (type: reproducing, size: minimum 14; maximum 14 (1.1% of the British breeding population 5-year mean, 1991 – 1995) unit: pairs, data quality: good, population: <2%, isolation: population not isolated within extended distribution range) **103 *Falco peregrinus;* Peregrine falcon: Unfavourable** (type: reproducing, size: minimum 18, maximum 18 (1.5% of the British breeding population 5-year mean, 1991 – 1995), unit: pairs, data quality: good, population: <2%, isolation: population not isolated within extended distribution range) **074 *Milvus milvus;* Red kite: Unknown** (type: reproducing, size: minimum 2; maximum 3 (1.2% of the British breeding population 5-year mean, 1991 – 1995), unit: pairs, data quality: good, population: <2%, isolation: Population not isolated, but on margins of area of distribution) Main threats and pressures: High – fire and fire suppression; problematic native species; outdoor sports and leisure activities, recreational activities; invasive non-native species; grazing. Medium – hunting and collection of wild animals; biocenotic evolution, succession.	
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:	Information not currently available.	
Site Improvement Plan:	Information not currently available.	
Potential Effects		
Element:		Risk of Likely Significant Effects?
Vyrnwy Reservoir release (75 Ml/d)	This element is located approximately 525 m south-west of Berwyn SPA. None of the main threats and pressures are relevant to this element (listed in current conservation status) and no construction works will be required. Although all the qualifying species of the SPA have been identified as water dependent, the operation of regulation releases from Lake Vyrnwy Reservoir will not lead to any changes to the baseline water environment in the vicinity of the SPA. UU currently abstracts water from Vyrnwy Reservoir for treatment at the Oswestry WTWs. The abstraction volume is limited by an abstraction licence. In addition, regulation releases and flood drawdown releases are often made from the Vyrnwy Reservoir. At times of operation of this element, the Oswestry WTWs will be (part) supplied by the UU Sources SRO and regulation and flood drawdown releases will remain unchanged or potentially reduced). As such, baseline water levels will remain unchanged. No additional impact pathways have been identified for the proposed element; therefore, no LSE are anticipated.	**No**
River Vyrnwy Mitigation – Vyrnwy release (100 Ml/d) and Bypass (80 Ml/d)	This element is located approximately 525 m south-west of Berwyn SPA (at closest point). None of the main threats and pressures are relevant to this element (listed in current conservation status). Due to distance between the proposed bypass and Berwyn SPA ([redacted]), the impact of noise, vibration and light disturbance plus the potential for air pollution during construction is considered negligible on qualifying features of the SPA. Although all the qualifying species of the SPA have been identified as water dependent, the operation of regulation releases from Lake Vyrnwy Reservoir, the bypass (option 5) and Shrewsbury redeployment will not lead to any changes to the baseline water environment in the vicinity of the SPA. UU currently abstracts water from Vyrnwy Reservoir for treatment at the Oswestry WTWs. The abstraction volume is limited by an abstraction licence. In addition, regulation releases and flood drawdown releases are often made from the Vyrnwy Reservoir. At times of operation of this element, the Oswestry WTWs will be (part) supplied by the UU Sources SRO and regulation and flood drawdown releases will remain unchanged or potentially reduced). As such, baseline water levels will remain unchanged. No additional impact pathways have been identified for the proposed element; therefore, no LSE are anticipated.	**No**

[32] 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:	**Bredon Hill (UK0012587)**	
Designation type: (SAC, SPA, Ramsar):	**SAC**	
Qualifying features:	1079. *Limoniscus violaceus*; Violet click beetle	**Water Dependency** Species not identified as water dependent[33].
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:	Bredon Hill SSSI: 95.45% Favourable and 4.55% Unfavourable recovering.	
Site Improvement Plan:	1. Forestry and woodland management – Pressure/Threat - 1079 Violet click beetle - Formulate and implement a wood mould continuity strategy for the Violet click beetle population. 2. Feature location/ extent/ condition unknown – Pressure/Threat - 1079 Violet click beetle - Survey of Violet click beetle, to identify site distribution. 3. Disease – Threat - S1079 Violet click beetle - Monitor for the impact of Ash dieback and investigate the effect of tree death on the wood mould persistence and continuity. 4. Air Pollution: impact of atmospheric nitrogen deposition – Pressure - 1079 Violet click beetle - Reduce the impact of atmospheric nitrogen deposition. 5. Climate Change – Threat - 1079 Violet click beetle - Monitor and plan for the effect of increased losses due to storms and changed environment.	
Potential Effects		
Element:		Risk of Likely Significant Effects?
Pipeline conveyance, Deerhurst to Culham (300, 400 and 500 Ml/d)	This element is located approximately [redacted] south-east of Bredon Hill SAC. The only SIP pressure of potential relevance to this element is (4) air pollution, that could occur during construction. Given the distance of the element to the SAC, significant air quality impacts on qualifying features can be excluded. The operation of water abstraction and transfer from Deerhurst to Culham is not anticipated to have a LSE on the violet click beetle, as it has not been identified as water dependent and the Bredon Hill SAC is not hydrologically connected downstream of the proposed intake site.	**No**
Mythe abstraction reduction (15 Ml/d)	This element is located approximately [redacted] south of Bredon Hill SAC. The only SIP pressure of potential relevance to this proposed element is (4) air pollution, that could occur during construction. Given the distance of the element to the SAC, significant air quality impacts on qualifying features can be excluded. The operation of abstraction reductions at the Mythe intake is not anticipated to have a LSE on the violet click beetle, as it has not been identified as water dependent and the Bredon Hill SAC is not hydrologically connected downstream of the proposed abstraction site.	**No**

[33] 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:	**Chilterns Beechwoods (UK0012724)**	
Designation type: (SAC, SPA, Ramsar):	**SAC**	
Qualifying features:	1083 *Lucanus cervus;* Stag beetle 6210 Semi-natural dry grasslands and scrubland facies: on calcareous substrates (*Festuco-Brometalia*) 9130 *Asperulo-Fagetum* Beech forests	**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[33].
Current conservation status:	**6210 Semi-natural dry grasslands and scrubland facies: on calcareous substrates (*Festuco-Brometalia*): Bad but improving** (range: favourable area: inadequate but improving, structure and function: Bad but improving, Future prospects: favourable). **9130 *Asperulo-Fagetum* Beech forests: Bad but improving** (range: favourable area: inadequate but improving, structure and function: Bad but improving, Future prospects: favourable) **1083 *Lucanus cervus;* Stag beetle: Favourable** (range: favourable, population: favourable, habitat: unknown, future prospects: favourable)	
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:	Naphill Common SSSI: 100% Favourable; Bisham Woods SSSI: 97.37% Favourable and 2.63% Unfavourable recovering; Windsor Hill SSSI: 26.56% Favourable and 73.44% Unfavourable recovering; Tring Woodlands SSSI: 100% Unfavourable recovering; Hollowhill & Pullingshill Woods SSSI: 100% Favourable; Ellesborough & Kimble Warrens SSSI: 10.75% Favourable and 89.25% Unfavourable recovering; Bradenham Woods, Park Wood & The Coppice SSSI: 94.52% Favourable and 5.48% Unfavourable recovering; Ashridge Commons & Woods SSSI: 86.33% Favourable and 13.67% Unfavourable recovering; and Aston Rowant Woods SSSI: 100% Favourable.	
Site Improvement Plan:	1. Forestry and woodland management – Pressure/Threat – 9130 Beech forests - Secure appropriate woodland management. 2. Deer – Pressure/Threat - 9130 Beech forests - Improve deer management. 3. Changes in species distributions – Threat - 1083 Stag beetle - Monitor stag beetle population. 4. Invasive species – Pressure/Threat - 9130 Beech forests - Investigate the impacts of grey squirrel. 5. Disease – Threat – 9130 Beech forests - Address box blight and other diseases. 6. Public Access/disturbance – Threat – 1083 Stag beetle - Reduce visitor impact on dead wood. 7. Air Pollution: impact of atmospheric nitrogen deposition – Pressure - 6210 Semi-natural dry grasslands and scrubland facies, 9130 Beech forests, 1083 Stag beetle - Establish a Site Nitrogen Action Plan.	
Potential Effects		
Element:		Risk of Likely Significant Effects?
Pipeline conveyance, Deerhurst to Culham (300, 400 and 500 Ml/d)	Chilterns Beechwoods SAC is 0.14 km east of the River Thames (Reading to Cookham). Downstream of the proposed outfall in Culham, the River Thames will experience higher discharge volumes and water dependent habitats within the immediate vicinity of the River Thames may be impacted. The only SIP pressure of potential relevance to this element is (7) air pollution, that could occur during construction. However, given the distance between the proposed outfall in Culham and Chiltern Beechwoods SAC [redacted] significant air quality impacts can be excluded. In addition, none of the SACs qualifying features have been identified as water dependent and therefore, LSE from higher discharge volumes down the River Thames are not anticipated.	**No**
Canal conveyance, including piping to Culham (300 Ml/d)	Chilterns Beechwoods SAC is 0.14 km east of the River Thames (Reading to Cookham). Downstream of the proposed outfall in Culham, the River Thames will experience higher discharge volumes and water dependent habitats within the immediate vicinity of the River Thames may be impacted. The only SIP pressure of potential relevance to this element is (7) air pollution, however, given the distance between the proposed outfall in Culham and Chiltern Beechwoods SAC [redacted] significant air quality impacts can be excluded. In addition, none of the SACs qualifying features have been identified as water dependent and therefore, LSE from higher discharge volumes down the River Thames are not anticipated.	**No**

Designated site name:	**Cothill Fen (UK0012889)**	
Designation type: (SAC, SPA, Ramsar):	**SAC**	
Qualifying features:	7230 Alkaline fens 91E0 Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (*Alno-Padion, Alnion incanae, Salicion albae*)	**Water Dependency** Habitat identified as water dependent[34]: • 7230 Alkaline fens. • 91E0 Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (*Alno-Padion, Alnion incanae, Salicion albae*).
Current conservation status:	**7230 Alkaline Fens: Bad** (range: favourable, area: unknown, structure and function: bad, future prospects: bad but improving) **91E0 Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior*: Bad but improving** (range: favourable, area: inadequate, structure and function: bad but improving, future prospects: inadequate but improving).	
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:	Cothill Fen SSSI: 65.22% Favourable and 34.78% Unfavourable recovering	
Site Improvement Plan:	1. Water Pollution – Pressure - 7230 Alkaline fens - Investigate the impact, pathways and sources of water pollution. Draw up and implement a Diffuse Water Pollution Plan (DWPP). 2. Hydrological Changes – Pressure/Threat - 7230 Alkaline fens - Investigate the hydrology of the site. 3. Air Pollution: impact of atmospheric nitrogen deposition – Pressure - 7230 Alkaline fens - Reduce the impacts of atmospheric nitrogen.	
Potential Effects		
Element:		Risk of Likely Significant Effects?
Pipeline conveyance, Deerhurst to Culham (300, 400 and 500 Ml/d)	The element is located approximately [redacted] south-west of Cothill Fen SAC. All of the SIP threats and pressures for this SAC are considered potentially relevant to this element: (1) water pollution, (2) hydrological changes and (3) air pollution. Construction of the pipeline is unlikely to affect groundwater levels in the unconfined Corallian aquifer in the vicinity of the SAC, as the pipeline is on different geological strata and no water or air pollution impacts are anticipated, due to the distance between the proposed works and designated site. In addition, no impact pathways including hydrological changes have been identified during operation of this element, as the Cothill Fen SAC is not located downstream of the intake or outfall sites and therefore, no LSE are anticipated.	**No**
Canal conveyance, including piping to Culham (300 Ml/d)	The element is located approximately [redacted] south-west of Cothill Fen SAC. All of the SIP threats and pressures for this SAC are considered potentially relevant to this element: (1) water pollution, (2) hydrological changes and (3) air pollution. Construction of the pipeline is unlikely to affect groundwater levels in the unconfined Corallian aquifer in the vicinity of the SAC, as the pipeline is on different geological strata and no water or air pollution impacts are anticipated, due to the distance between the proposed works and designated site. In addition, no impact pathways including hydrological changes have been identified during operation of this element, as the Cothill Fen SAC is not located downstream of the intake or outfall sites and therefore, no LSE are anticipated.	**No**

[34] 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:	**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[35].
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		
Element:		Risk of Likely Significant Effects?
Netheridge WwTW discharge diversion, Deerhurst pipeline (35 Ml/d)	This element is located approximately [redacted] 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 element 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**
Netheridge WwTW discharge diversion, Cotswold Canals (35 Ml/d)	This element is located approximately [redacted] 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 element 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**
Canal conveyance, including piping to Culham (300 Ml/d)	This element is located approximately [redacted] south-west of Cotswold Beechwoods SAC. The only SIP pressure of potential relevance to this proposed element is (6) air pollution, that could occur during construction. No significant air quality impacts are anticipated during construction as the element is sufficiently distant from the designated sites. In addition, no impact pathways duration the operation of this element has been identified as none of the qualifying features are water dependent and Cotswold Beechwoods SAC is not hydrologically connected downstream of the intake or outfall sites associated with the Canal conveyance. Therefore, no LSE are anticipated.	**No**

[35] 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[36].
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		
Element:		Risk of Likely Significant Effects?
Pipeline conveyance, Deerhurst to Culham (300, 400 and 500 Ml/d)	The element is located [redacted] south of Dixton Wood SAC, based on a 40 m working width during construction. Changes in species distribution is a relevant SIP threat of the violet click beetle due to noise and vibration disturbance and potential presence within the footprint of the works. As construction works are not required within Dixton Woods boundary and there is a lack of suitable habitat within and surrounding the footprint of the proposed works (largely heavily managed agricultural land), no LSE are anticipated on violet click beetle distribution. Short term air quality impacts (dust and vehicle emissions) on supporting habitat of violet click beetle (broadleaved deciduous woodland) could potentially occur during construction, given the close proximity of the designated site. However, no significant air quality impacts are anticipated as the number of vehicle movements will come under the commonly applied threshold for potential air quality impacts of 1000 AADT or 200 HGV movements per day (within 200m of a designated site). In addition, air quality has not been identified as a SIP threat or pressure to the qualifying species of the site. As the violet click beetle is not water dependent and Dixton Wood is not hydrologically connected to the operation of the water abstraction and transfer from Deerhurst to Culham, LSE on the qualifying feature of the SAC is not anticipated.	**No**
Mythe abstraction reduction (15 Ml/d)	The element is located [redacted] north-west of Dixton Wood SAC. None of the SIP threats and pressures for this SAC are considered relevant to an abstraction reduction at the Mythe intake. The proposed element will not require land take from within the SAC boundaries and construction activities are at a sufficient distance from the SAC, that 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**

[36] 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:	**Hartslock Wood (UK0030164)**	
Designation type: (SAC, SPA, Ramsar):	**SAC**	
Qualifying features:	91J0 *Taxus baccata* woods of the British Isles 6210 Semi-natural dry grasslands and scrubland facies: on calcareous substrates (*Festuco-Brometalia*)	**Water Dependency** Habitats not identified as water dependent, but it will be important to protect the rooting structure of the qualifying features[37].
Current conservation status:	**6210 Semi-natural dry grasslands and scrubland facies: on calcareous substrates (*Festuco-Brometalia*): Bad but improving** (range: favourable area: inadequate but improving, structure and function: bad but improving, future prospects: favourable). **91J0 *Taxus baccata* woods of the British Isles: Bad but improving** (range: favourable area: favourable, structure and function: bad but improving, future prospects: inadequate but improving).	
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 qualifying natural habitats • The structure and function (including typical species) of the qualifying natural habitats; and • The supporting processes on which the qualifying natural habitats rely	
SSSI Condition assessment:	Hartslock SSSI: 88.08% Favourable and 11.92% Unfavourable recovering.	
Site Improvement Plan:	1. Air Pollution: risk of atmospheric nitrogen deposition – Threat - 6210 Semi-natural dry grasslands and scrubland facies, 91J0 *Taxus baccata* woods of the British Isles - Further investigate impacts of atmospheric nitrogen deposition.	
Potential Effects		
Element:		Risk of Likely Significant Effects?
Pipeline conveyance, Deerhurst to Culham (300, 400 and 500 Ml/d)	Hartslock Wood SAC is immediately adjacent to the River Thames on the eastern bank between Wallingford to Caversham. Downstream of the proposed outfall in Culham, the River Thames will experience higher discharge volumes and habitats within the immediate vicinity of the River Thames may be impacted. The threat of (1) air pollution is of potential relevance to this element during construction, however, given the distance between the proposed outfall in Culham and Hartslock Wood SAC [redacted] significant air quality impacts can be excluded. In addition, as none of the qualifying features have been identified as water dependent, no LSE are anticipated from operation of this element.	**No**
Canal conveyance, including piping to Culham (300 Ml/d)	Hartslock Wood SAC is immediately adjacent to the River Thames on the eastern bank between Wallingford to Caversham. Downstream of the proposed outfall in Culham, the River Thames will experience higher discharge volumes and water dependent habitats within the immediate vicinity of the River Thames may be impacted. The threat of (1) air pollution is of potential relevance to this element during construction, however, given the distance between the proposed outfall in Culham and Hartslock Wood SAC [redacted] significant air quality impacts can be excluded. In addition, as none of the qualifying features have been identified as water dependent, no LSE are anticipated from operation of this element.	**No**

[37] 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:	**Little Wittenham (UK0030184)**	
Designation type: (SAC, SPA, Ramsar):	**SAC**	
Qualifying features:	1166 *Triturus cristatus*; Great crested newt	**Water Dependency** Species identified as water dependent: • 1166 *Triturus cristatus*; Great crested newt[37].
Current conservation status:	**1166 *Triturus cristatus*, Great crested newt: Inadequate** (range: Favourable, population: Inadequate and deteriorating, Habitat: unknown, future prospects: favourable).	
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:	Little Wittenham SSSI: 100% Favourable.	
Site Improvement Plan:	1. Invasive Species – Pressures/Threat - 1166 Great crested newt - Remove fish from breeding ponds; Construct further ponds in the SAC to provide additional fish-free breeding habitat. 2. Public Access/Disturbance – Threat - 1166 Great crested newt - Conduct audits to determine the best locations for signed access routes and construct new access routes.	
Potential Effects		
Element:		Risk of Likely Significant Effects?
Pipeline conveyance, Deerhurst to Culham (300, 400 and 500 Ml/d)	Little Wittenham SAC is immediately adjacent to the River Thames on the eastern bank between Evenlode to Thame and [redacted] west of the proposed outfall located at Culham. The proposed scheme will not require land take from within the SAC boundaries and construction activities are at a sufficient distance that no significant impacts on the qualifying features are anticipated. The pressure/threat of introducing invasive and non-native species from the River Severn to the River Thames has been identified as an impact pathway associated with this element, however, as the breeding ponds of the Little Wittenham SAC are not hydrologically connected to the River Thames. Therefore, LSE on the qualifying feature of the SAC are anticipated.	**No**
Canal conveyance, including piping to Culham (300 Ml/d)	Little Wittenham SAC is immediately adjacent to the River Thames on the eastern bank between Evenlode to Thame and [redacted] west of the proposed outfall located at Culham. The proposed scheme will not require land take from within the SAC boundaries and construction activities are at a sufficient distance that no significant impacts on the qualifying features are anticipated. The pressure/threat of (1) introducing invasive species from the River Severn to the River Thames has been identified as an impact pathway associated with this element, however, as the breeding ponds of the Little Wittenham SAC are not hydrologically connected to the River Thames, the risk of spreading invasive species to waterbodies of Little Wittenham SAC is negligible. Therefore, LSE on the qualifying feature of the SAC are anticipated.	**No**

Designated site name:	**Midland Meres and Mosses Phase 1 (UK11043)**	
Designation type: (SAC, SPA, Ramsar):	**Ramsar**	
Qualifying features:	The Meres & Mosses form a geographically discrete series of lowland open water and peatland sites in the north-west Midlands of England. These have developed in natural depressions in the glacial drift left by receding ice sheets which formerly covered the Cheshire/Shropshire Plain. The 16 element sites include open water bodies (meres), the majority of which are nutrient-rich with associated fringing habitats; reed swamps, fen, carr & damp pasture. Peat accumulation has resulted in nutrient poor peat bogs (mosses) forming in some sites in the fringes of meres or completely infilling basins. In a few cases the result is a floating quaking bog or schwingmoor. The wide range of resulting habitats support nationally important flora & fauna. **Ramsar Criterion 1:** The site comprises a diverse range of habitats from open water to raised bog. **Ramsar Criterion 2:** Supports a number of rare species of plants associated with wetlands, including five nationally scarce species six stamened water wort *Elatine hexandra*, least spike rush *Eleocharis acicularis*, cowbane *Cicuta virosa*, marsh fern *Thelypteris palustris*, and elongated sedge *Carex elongate*. It also supports an assemblage of rare wetland invertebrates including three endangered insects and five other British Red Data Book species of invertebrates).	**Water Dependency:** The Ramsar Site and its various qualifying criteria (by definition) are all water dependent.
Current conservation status:	N/A	
Conservation objectives:	Not available	
SSSI Condition assessment:	Bomere, Shomere and Betton Pools SSSI: 100% Unfavourable - recovering	
Site Improvement Plan:	Information not currently available	
Potential Effects		
		Risk of Likely Significant Effects?
River Vyrnwy Mitigation - Vyrnwy release (100Mld) and Bypass (80Mld)	The Bomere, Shomere and Betton Pools SSSI is the only element of the Midland Meres and Mosses phase 1 Ramsar site within [redacted] of the element. It is located [redacted] south-east of Shrewsbury intake and [redacted] south of the River Severn at the closest section (downstream of the intake). The Ramsar site is located over [redacted] from the proposed bypass pipeline route and the Vyrnwy release and is therefore, highly unlikely to be significantly affected by the construction of these elements. The SSSI citation identifies that this constituent SSSI of the Ramsar site is of interest due to water chemistry, aquatic and wetland vegetation and invertebrate communities. The site also includes a small basin mire, a more extensive area of peat around Shomere and an area of woodland. Given the distance of the elements that require construction (>[redacted] to the Ramsar site), the risk of construction related impacts such as dust, habitat loss, pollution or biosecurity are highly unlikely. Bomere Pool, Shomere Pool and Betton Pool are located over 3.66 km from the River Severn and are not hydrologically dependent on the river for maintenance of the water level in the meres or the condition of adjacent wetland habitats. Therefore, the site would not be affected by changes in water level or flow within the waterbodies receiving the discharge (River Vyrnwy) or reduction in abstraction (River Severn). No significant air quality impacts are anticipated as the option element is sufficiently distant from the designated sites. Therefore, no LSE on the qualifying feature is anticipated.	**No**
River Vyrnwy Mitigation – Vyrnwy Bypass release (155Mld)	The Bomere, Shomere and Betton Pools SSSI is the only element of the Midland Meres and Mosses phase 1 Ramsar site within [redacted] of the option. It is located [redacted] south east of Shrewsbury intake and [redacted] south of the River Severn at the closest section (downstream of the Shrewsbury intake). The Ramsar site is located over [redacted] from the proposed bypass pipeline route and is therefore highly unlikely to be adversely affected by the construction of these elements. The SSSI citation identifies that this constituent SSSI of the Ramsar site is of interest due to water chemistry, aquatic and wetland vegetation and invertebrate communities. The site also includes a small basin mire, a more extensive area of peat around Shomere and an area of woodland. Given the distance of the elements that require construction [redacted] to the Ramsar site the risk of construction related impacts such as, dust, habitat loss, pollution or biosecurity are highly unlikely. The Bomere Pool, Shomere Pool, and Betton Pool located over 3.66 km from the River Severn and are not hydrologically dependent on the river for maintenance of the water level in the meres or the condition of adjacent wetland habitats. Therefore, the site would not be affected by changes in water level or flow within the waterbodies receiving the discharge (River Vyrnwy) or reduction in abstraction (River Severn). No significant air quality impacts are anticipated as the option element is sufficiently distant from the designated sites. Therefore, no LSE on the qualifying feature is anticipated.	**No**
River Vyrnwy Mitigation – Vyrnwy Bypass release (180Mld)	The Bomere, Shomere and Betton Pools SSSI is the only element of the Midland Meres and Mosses phase 1 Ramsar site within [redacted] of the option. It is located [redacted] km south east of Shrewsbury intake and [redacted] south of the River Severn at the closest section (downstream of the Shrewsbury intake). The Ramsar site is located over [redacted] from the proposed bypass pipeline route and is therefore highly unlikely to be adversely affected by the construction of these elements. The SSSI citation identifies that this constituent SSSI of the Ramsar site is of interest due to water chemistry, aquatic and wetland vegetation and invertebrate communities. The site also includes a small basin mire, a more extensive area of peat around Shomere and an area of woodland. Given the distance of the elements that require construction [redacted] to the Ramsar site the risk of construction related impacts such as, dust, habitat loss, pollution or biosecurity are highly unlikely. The Bomere Pool, Shomere Pool, and Betton Pool located over [redacted] from the River Severn and are not hydrologically dependent on the river for maintenance of the water level in the meres or the condition of adjacent wetland habitats. Therefore, the site would not be affected by changes in water level or flow within the waterbodies receiving the discharge (River Vyrnwy) or reduction in abstraction (River Severn). No significant air quality impacts are anticipated as the option element is sufficiently distant from the designated sites. Therefore, no LSE on the qualifying feature is anticipated.	**No**
Vyrnwy Mitigation – Shrewsbury redeployment (25 Ml/d)	This element includes the enhancement of infrastructure at Shelton wastewater treatment works (WTW), which is located [redacted] south-east of Midland Meres and Mosses Phase 1 (Bomere, Shomere and Betton Pools SSSI) at its closest point and [redacted] south of the River Severn at the closest section; downstream of the Shrewsbury intake. The proposed process enhancements consist of hypochlorite dosing, rapid gravity filters, hypochlorite dosing pre-contact tank, BH pumps M&E and a contact tank. In addition, the Ford PS upgrade is proposed [redacted] north-west of the Ramsar site. The Fenemere SSSI (a element of Midland Meres and Mosses Phase 1 Ramsar site) is also [redacted] north of Shelton WTW and [redacted] east of a proposed pumping station for Ruyton PSR. Potential impact pathways from construction works at Shelton WTW, Ford PS upgrade and pumping station include air pollution, pollution incidents and introduction/ spread of invasive and non-native species while using construction vehicles. Due to the distance between this element and the Ramsar site, impacts from pollution incidents and invasive species are considered unlikely. No significant air quality impacts are anticipated as the option element is sufficiently distant from the designated sites. Hydrological changes during operation of this element must also be considered. However, the habitats at Bomere, Shomere and Betton Pools and Fenemere are not hydrologically dependent on the River Vyrnwy or River Severn for maintenance of the water level or condition of adjacent wetland habitats. Therefore, no LSE on the qualifying feature is anticipated.	**No**

Designated site name:	**Midland Meres and Mosses Phase 2 (UK11080)**	
Designation type: (SAC, SPA, Ramsar):	**Ramsar**	
Qualifying features:	The Meres and Mosses form a geographically diverse series of lowland open water and peatland sites in the north-west Midlands of England and north-east Wales. These have developed in natural depressions in the glacial drift left by receding ice sheets which formerly covered the Cheshire/ Shropshire Plain. The 18 element sites include open water bodies (meres), the majority of which are nutrient-rich with associated fringing habitats, reed swamp, fen, carr and damp pasture. Peat accumulation has resulted in the nutrient-poor peat bogs (mosses) forming in some sites on the fringes of the meres or completely infilling basins. In a few cases the result is a floating quaking bog or schwingmoor. The wide range of resulting habitats support nationally important flora and fauna. Nationally important species occurring on the site. Higher Plants. *Calamagrostis stricta, Carex elongata, Cicuta virosa, Thelypteris palustris* Lower Plants. *Sphagnum pulchrum, Dicranum undulatum* **Ramsar Criterion 1:** The site comprises a diverse range of habitats from open water to raised bog. **Ramsar Criterion 2:** Supports a number of rare species of plants associated with wetlands, including the nationally scarce cowbane *Cicuta virosa* and, elongated sedge *Carex elongata*. Also present are the nationally scarce bryophytes *Dicranum affine* and *Sphagnum pulchrum*. Also supports an assemblage of invertebrates including several rare species. There are 16 species of British Red Data Book insect listed for this site including the following endangered species: the moth *Glyphipteryx lathamella*, the caddisfly *Hagenella clathrata* and the sawfly *Trichiosoma vitellinae*. **Species currently occurring at levels of national importance:** Species with peak counts in spring/autumn: Northern shoveler, *Anas clypeata*, NW & C Europe 171 individuals, representing an average of 1.1% of the GB population (5-year peak mean 1998/92002/3) Species with peak counts in winter: Great cormorant, *Phalacrocorax carbo carbo*, - NW Europe 323 individuals, representing an average of 1.4% of the GB population (5-year peak mean 1998/92002/3) Great bittern, *Botaurus stellaris stellaris*, - W Europe, NW Africa 1 individuals, representing an average of 1% of the GB population (5 year peak mean 1998/92002/3) Water rail, *Rallus aquaticus*, - Europe 7 individuals, representing an average of 1.5% of the GB population (5-year peak mean 1998/92002/3)	**Water Dependency:** The Ramsar Site and its various qualifying criteria (by definition) are all water dependent.
Current conservation status:	N/A	
Conservation objectives:	Not available	
SSSI Condition assessment:	Morton Pool and Pasture SSSI: 100% Favourable Hencott pools SSSI: 59.53% unfavourable recovering, 44.07% unfavourable – No change.	
Site Improvement Plan:	Information not currently available	
Potential Effects		
Element:		Risk of Likely Significant Effects?
River Vyrnwy Mitigation - Vyrnwy release (100Mld) and Bypass (80Mld)	The Morton pool and pasture SSSI is the only element of the Midland Meres and Mosses phase 2 Ramsar site within [redacted] of proposed bypass pipeline. It is located [redacted] east of the proposed route. One other element of the Ramsar site is located [redacted] north of the Shrewsbury intake but over [redacted] from the other option elements (Vyrnwy bypass pipeline and Vyrnwy release). The SSSI citation for Morton Pool identifies that this site is of interest for the mere, Morton Pool, the surrounding fen and carr vegetation, and the damp peaty pasture to the west of Morton Pool; which is identified as being one of the best examples of damp grassland in Shropshire. Hencott pool SSSI which form the only unit of the Ramsar site within [redacted] of the Shrewsbury intake comprises a peat-filled basin supporting fen and carr vegetation and represents a stage in the succession from open water to carr woodland and peat bog. Morton Pool and Hencott Pool are not identified as supporting the populations of waterfowl of national importance, for which other units of the Midland Meres and Mosses Ramsar site are designated. Due to the low use of the site by waterfowl populations and distance to the site boundary (over 1 km), disturbance of significant bird populations of the Ramsar site during construction or operation of this element is highly unlikely. The relevant potential impacts are hydrological changes, invasive species and air pollution during construction. Given the distance of the option element to the Ramsar site and absence of works within or adjacent, introduction or spread of invasive species at the site is highly unlikely. The meres at Morton Pool and Hencott Pool are not hydrologically dependent on the River Vyrnwy or River Severn for maintenance of the water level or condition of adjacent wetland habitats. Therefore, the sites would not be affected by changes in water level or flow within the waterbodies receiving the discharge (River Vyrnwy) or reduction in abstraction (River Severn). No significant air quality impacts are anticipated as the option element is sufficiently distant from the designated sites and the anticipated number of vehicle movements comes under the commonly applied threshold for potential air quality impacts of 1000 AADT or 200 HGV movements per day (within 200m of a designated site). Therefore, no LSE on the qualifying feature is anticipated.	**No**
River Vyrnwy Mitigation – Vyrnwy Bypass release (155Mld)	The Morton pool and pasture SSSI is the only element of the Midland Meres and Mosses phase 2 Ramsar site within [redacted] of proposed bypass pipeline. It is located [redacted] east of the proposed route. One other element of the Ramsar site is located [redacted] north of the Shrewsbury intake but over [redacted] from the other option elements (Vyrnwy bypass pipeline and Vyrnwy release). The SSSI citation for Morton Pool identifies that this site is of interest for the mere, Morton Pool, the surrounding fen and carr vegetation, and the damp peaty pasture to the west of Morton Pool; which is identified as being one of the best examples of damp grassland in Shropshire. Hencott pool SSSI which form the only unit of the Ramsar site within [redacted] of the Shrewsbury intake comprises a peat-filled basin supporting fen and carr vegetation and represents a stage in the succession from open water to carr woodland and peat bog. Morton Pool and Hencott Pool are not identified as supporting the populations of waterfowl of national importance, for which other units of the Midland Meres and Mosses Ramsar site are designated. Due to the low use of the site by waterfowl populations and distance to the site boundary (over 1 km), disturbance of significant bird populations of the Ramsar site during construction or operation of this element is highly unlikely. The relevant potential impacts are hydrological changes, invasive species and air pollution during construction. Given the distance of the option element to the Ramsar site and absence of works within or adjacent, introduction or spread of invasive species at the site is highly unlikely. The meres at Morton Pool and Hencott Pool are not hydrologically dependent on the River Vyrnwy or River Severn for maintenance of the water level or condition of adjacent wetland habitats. Therefore, the sites would not be affected by changes in water level or flow within the waterbodies receiving the discharge (River Vyrnwy) or reduction in abstraction (River Severn). No significant air quality impacts are anticipated as the option element is sufficiently distant from the designated sites and the anticipated number of vehicle movements comes under the commonly applied threshold for potential air quality impacts of 1000 AADT or 200 HGV movements per day (within 200m of a designated site). Therefore, no LSE on the qualifying feature is anticipated.	**No**

Designated site name:	Midland Meres and Mosses Phase 2 (UK11080)	
River Vyrnwy Mitigation – Vyrnwy Bypass release (180Mld)	The Morton pool and pasture SSSI is the only element of the Midland Meres and Mosses phase 2 Ramsar site within [redacted] of proposed bypass pipeline. It is located [redacted] east of the proposed route. One other element of the Ramsar site is located [redacted] north of the Shrewsbury intake but over [redacted] from the other option elements (Vyrnwy bypass pipeline and Vyrnwy release). The SSSI citation for Morton Pool identifies that this site is of interest for the mere, Morton Pool, the surrounding fen and carr vegetation, and the damp peaty pasture to the west of Morton Pool; which is identified as being one of the best examples of damp grassland in Shropshire. Hencott pool SSSI which form the only unit of the Ramsar site within [redacted] of the Shrewsbury intake comprises a peat-filled basin supporting fen and carr vegetation and represents a stage in the succession from open water to carr woodland and peat bog. Morton Pool and Hencott Pool are not identified as supporting the populations of waterfowl of national importance, for which other units of the Midland Meres and Mosses Ramsar site are designated. Due to the low use of the site by waterfowl populations and distance to the site boundary (over 1 km), disturbance of significant bird populations of the Ramsar site during construction or operation of this element is highly unlikely. The relevant potential impacts are hydrological changes, invasive species and air pollution during construction. Given the distance of the option element to the Ramsar site and absence of works within or adjacent, introduction or spread of invasive species at the site is highly unlikely. The meres at Morton Pool and Hencott Pool are not hydrologically dependent on the River Vyrnwy or River Severn for maintenance of the water level or condition of adjacent wetland habitats. Therefore, the sites would not be affected by changes in water level or flow within the waterbodies receiving the discharge (River Vyrnwy) or reduction in abstraction (River Severn). No significant air quality impacts are anticipated as the option element is sufficiently distant from the designated sites and the anticipated number of vehicle movements comes under the commonly applied threshold for potential air quality impacts of 1000 AADT or 200 HGV movements per day (within 200m of a designated site). Therefore, no LSE on the qualifying feature is anticipated.	**No**
Vyrnwy Mitigation – Shrewsbury redeployment (25 Ml/d)	There are multiple construction sites proposed as part of delivering this element within 10km of the Midland Meres and Mosses Phase 2. The proposed pumping station for Pant DSR is located [redacted] west of Midland Meres and Mosses Phase 2 (Morton Pool and Pasture SSSI). Other elements of the Shrewsbury redeployment within 10km of Midland Meres and Mosses Phase 2 (Morton Pool and Pasture SSSI) include the booster station to Shelton ([redacted] south-east) and pumping station for Ruyton DSR ([redacted] south-east). Infrastructure enhancements at Shelton wastewater treatment works (WTW) are located [redacted] south-west of Midland Meres and Mosses Phase 2 (Hencott Pool SSSI) and [redacted] north-east of the River Severn at the closest section; downstream of the Shrewsbury intake. The proposed process enhancements consist of hypochlorite dosing, rapid gravity filters, hypochlorite dosing pre-contact tank, BH pumps M&E and a contact tank. In addition, the Ford PS upgrade is proposed [redacted] south-west of the Ramsar site. Potential impact pathways from these construction works include air pollution, pollution incidents and introduction/ spread of invasive and non-native species while using construction vehicles. Due to the distance between this element and the Ramsar site, impacts from pollution incidents and invasive species are considered unlikely. No significant air quality impacts are anticipated as the option element is sufficiently distant from the designated sites. Hydrological changes during operation of this element must also be considered. However, the habitats at Morton Pool and Pasture and Hencott Pool are not hydrologically dependent on the River Vyrnwy or River Severn for maintenance of the water level or condition of adjacent wetland habitats. Therefore, no LSE on the qualifying feature is anticipated.	**No**

Designated site name:	**North Meadow and Clattinger Farm (UK0016372)**	
Designation type: (SAC, SPA, Ramsar):	**SAC**	
Qualifying features:	6510 Lowland hay meadows (*Alopecurus pratensis*, *Sanguisorba officinalis*)	**Water Dependency** Habitat identified as water dependent[38]: • 6510 Lowland hay meadows (*Alopecurus pratensis*, *Sanguisorba officinalis*).
Current conservation status:	**6510 Lowland hay meadows** (*Alopecurus pratensis*, *Sanguisorba officinalis*)**: Bad but improving** (range: favourable, area: inadequate and deteriorating, structure and function: bad but improving, future prospects: bad but improving).	
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:	Clattinger Farm SSSI: 100% Favourable; and North Meadow, Cricklade SSSI: 100% Favourable.	
Site Improvement Plan:	1. Inappropriate water levels – Pressure/Threat - 6510 Lowland hay meadows - Review and update Water Level Management Plan. 2. Habitat fragmentation – Pressure/Threat - 6510 Lowland hay meadows - Habitat restoration to improve the site's resilience. 3. Commons management – Pressure/Threat - 6510 Lowland hay meadows - Landowner agreement for livestock fencing. 4. Public access/disturbance – Pressure/Threat - 6510 Lowland hay meadows - Manage and mitigate the effects of public access. 5. Water Pollution – Threat - 6510 Lowland hay meadows - Investigate the risks from diffuse pollution carried in floodwaters.	
Potential Effects		
Element:		Risk of Likely Significant Effects?
Canal conveyance, including piping to Culham (300 Ml/d)	The element (proposed pipeline) is located approximately [redacted] north-east of North Meadow and Clattinger Farm SAC. The element will not require any land take within the boundaries of the SAC. The most relevant SIP pressures and threats on the qualifying feature of the SAC are (1) inappropriate water levels and (5) water pollution. Based on the assumption that a 30 m working area will be required during the pipeline installation, all of the proposed works will be restricted by linear features already present between North Meadow and Clattinger Farm and the proposed pipeline, which include: a dual carriageway (A419), single track road (High Street) and the River Churn. Additionally, no surface water hydrological connectivity has been identified. Construction works within proximity of the SAC will be relatively short term and based on the number of linear features between the proposed pipeline and the SAC, impacts from water pollution incidents and on water level management are unlikely. As the proposed works are within [redacted] of the designated site, air pollution during construction has also been identified as a potential impact pathway. Atmospheric nitrogen deposition, ammonia and oxides of nitrogen concentrations are not currently above critical loads or levels for lowland hay meadows[39]. On the basis that construction works will be short term and the number of linear features between the proposed pipeline and the SAC will provide a buffer from dust created during construction, no LSE are anticipated. In addition, the anticipated number of vehicle movements comes under the commonly applied threshold for potential air quality impacts of 1000 AADT or 200 HGV movements per day (within [redacted] of a designated site). During operation, no impact pathways have been identified and therefore, no LSE are anticipated from this element.	**No**

[38] 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.
[39] Air Pollution Information System (2017). North Meadow and Clattinger Farm SAC. Accessed from: http://www.apis.ac.uk/srcl/select-a-feature?site=UK0016372&SiteType=SAC&submit=Next

Designated site name:	**Montgomery Canal (UK0030213)**	
Designation type: (SAC, SPA, Ramsar):	**SAC**	
Qualifying features:	1831 Floating water-plantain *Luronium natans*	**Water Dependency:** Habitat and species identified as water dependent[38]: • 1831 Floating water-plantain *Luronium natans*.
Current conservation status:	**1831 Floating water-plantain *Luronium* natans: Deteriorating** (range: unfavourable - inadequate, population: unfavourable – inadequate, habitat for the species: unknown, future prospects: unfavourable – inadequate). Main pressures: agricultural activities point source water pollution, agricultural diffuse water pollution, invasive alien species, problematic native species, development and operation of dams, modification of hydrological flow and natural succession. Main threats: agricultural diffuse water pollution, air pollution, management of fishing stocks and game, invasive alien species, problematic native species (I04), mixed source water pollution, flow modification and natural succession.	
Conservation objectives:	Maintain the extent and distribution of floating water-plantain *Luronium natans* within the Montgomery Canal at favourable conservation status, where all of the following conditions are satisfied: • The *L. natans* population in favourable condition will reflect the natural carrying capacity of the canal habitat and will be limited principally by species ability to spread or be relocated (vegetative or otherwise), the suitability of the rooting medium and competition between species as part of habitat succession. • Recreation pressure, principally through boat movements and fisheries management, will not significantly affect the maintenance of the species, or its ability to disperse throughout the canal network and any associated off-line reserves. • The ecological status of the water environment, including elements of water quality and physical habitat quality, will be sufficient to support the population of *L. natans* in favourable condition. • All factors affecting the achievement of the above conditions are under control. Maintain the extent, distribution and quality of the floating, submerged, emergent and marginal vegetation that constitutes the canal vegetation habitat feature within the Montgomery Canal at favourable conservation status, where all of the following conditions are satisfied: • The canal vegetation in favourable condition will reflect the natural carrying capacity of the canal habitat and will be limited principally by species ability to spread or be relocated (vegetative or otherwise), the suitability of the rooting medium and competition between species as part of habitat succession. • The ecological status of the water environment, including elements of water quality, depth and clarity, will be sufficient to support species-rich canal vegetation with a variety of submerged, floating and marginal species and the populations of locally rare or uncommon species in favourable condition. • Recreation pressure, principally through boat movements and fisheries management, will not significantly affect the maintenance of the canal vegetation, or its ability to disperse throughout the canal network and any associated off-line reserves. • All factors affecting the achievement of the above conditions are under control.	
SSSI Condition assessment:	Montgomery Canal, Aston Locks - Keeper's Bridge SSSI: 100% Unfavourable – no change.	
Site Improvement Plan:	Information not currently available.	
Potential Effects		
Element:		Risk of Likely Significant Effects?
River Vyrnwy Mitigation - Vyrnwy release (100Mld) and Bypass (80Mld)	The closest part of the Montgomery Canal SAC to Bypass Option 5 is located [redacted] west the proposed bypass pipeline route. The Montgomery Canal crosses the affected reach of the River Vyrnwy via an aqueduct but is not hydrologically dependent on the river flow for maintenance of the aquatic habitats within the SAC. The SAC is designated for populations of floating water plantain; this species requires slow flowing or still aquatic habitats, and the maintenance of the SAC population is not dependent of habitats located outside of the SAC boundary. There is no direct hydrological connectivity between the proposed bypass pipeline route or from the reservoir release and the Montgomery Canal. The SAC is located over [redacted] (upstream) of the Shrewsbury intake. Therefore, due to the distance to the SAC boundary and absence of hydrological connectivity between the pipeline route, there will be no direct impacts on habitat availability as a result of construction or operation Bypass Option 5. Floating water plantain requires periodic disturbance for maintenance of the population. The construction of the Vyrnwy Bypass and operation of bypass pipeline or Vyrnwy release have no potential to alter the level of recreation (boat) activity in the canal which currently provides the periodic disturbance. Construction activity adjacent to the canal has potential to reduce habitat suitability for floating water plantain, due to introduction of dust/sediments which could reduce water clarity or increase nutrient content of the water. However, this is unlikely to be significant due the distance from the proposed route. Increased traffic emissions or construction access routes adjacent to the canal have potential to affect nutrient and sediment loads through deposition of emissions, dust or road run off if access routes cross or are adjacent to the canal. No significant air quality impacts are anticipated as the option element is sufficiently distant from the designated sites. Due to the absence of hydrological connectivity with the canal, there is no potential to change the water depth or extent through operation of the Bypass pipeline, Vyrnwy release or change in the abstraction volume at the Shrewsbury intake. Therefore, operation of this element is highly unlikely to significantly affect the qualifying features of the SAC.	**No**
River Vyrnwy Mitigation – Vyrnwy Bypass release (155Mld)	The closest part of the Montgomery Canal SAC to Bypass Option 5 is located [redacted] west the proposed bypass pipeline route, the Montgomery Canal crosses the River Vyrnwy upstream of the discharge location via an aqueduct but is not hydrologically dependent on the river flow for maintenance of the aquatic habitats within the SAC. The SAC is designated for populations of floating water plantain; this species requires slow flowing or still aquatic habitats, and the maintenance of the SAC population is not dependent of habitats located outside of the SAC boundary. There is no direct hydrological connectivity between the proposed bypass pipeline route or from the reservoir release and the Montgomery Canal. The SAC is located over [redacted] (upstream) of the Shrewsbury intake. Therefore, due to the distance to the SAC boundary and absence of hydrological connectivity between the pipeline route, there will be no direct impacts on habitat availability as a result of construction or operation Bypass Option 5. Floating water plantain requires periodic disturbance for maintenance of the population. The construction of the Vyrnwy Bypass and operation of bypass pipeline or Vyrnwy release have no potential to alter the level of recreation (boat) activity in the canal which currently provides the periodic disturbance. Construction activity adjacent to the canal has potential to reduce habitat suitability for floating water plantain, due to introduction of dust/sediments which could reduce water clarity or increase nutrient content of the water. However, this is unlikely to be significant due the distance from the proposed route. Increased traffic emissions or construction access routes adjacent to the canal have potential to affect nutrient and sediment loads through deposition of emissions, dust or road run off if access routes cross or are adjacent to the canal. No significant air quality impacts are anticipated as the option element is sufficiently distant from the designated sites. Due to the absence of hydrological connectivity with the canal, there is no potential to change the water depth or extent through operation of the Bypass pipeline, Vyrnwy release or change in the abstraction volume at the Shrewsbury intake. Therefore, operation of this element is highly unlikely to significantly affect the qualifying features of the SAC.	**No**

Designated site name:	**Montgomery Canal (UK0030213)**	
River Vyrnwy Mitigation – Vyrnwy Bypass release (180Mld)	The closest part of the Montgomery Canal SAC to Bypass Option 7 is located [redacted] west the proposed bypass pipeline route, the Montgomery Canal crosses the affected reach of the River Vyrnwy via an aqueduct but is not hydrologically dependent on the river flow for maintenance of the aquatic habitats within the SAC. The SAC is designated for populations of floating water plantain this species required slow flowing or still aquatic habitats and the maintenance of the SAC population is not dependent of habitats located outside of the SAC boundary. There is no direct hydrological connectivity between the proposed bypass pipeline route or from the reservoir release and the Montgomery Canal. The SAC is located over [redacted] (upstream) of the Shrewsbury intake. Due to the distance to the SAC boundary and absence of hydrological connectivity between the pipeline route there will be no direct impacts on habitat availability, as a result of construction or operation Bypass Option 7. Floating water plantain requires periodic disturbance for maintenance of the population. The construction of the Vyrnwy Bypass and operation of bypass pipeline or Vyrnwy release have no potential to alter the level of recreation (boat) activity in the canal which currently provides the periodic disturbance. Construction activity adjacent to the canal has potential to reduce habitat suitability for floating water plantain, due to introduction of dust/sediments which could reduce water clarity or increase nutrient content of the water. However, this is unlikely to be significant due the distance from the proposed route. Increased traffic emissions or construction access routes adjacent to the canal have potential to affect nutrient and sediment loads through deposition of emissions, dust or road run off if access routes cross or are adjacent to the canal. No significant air quality impacts are anticipated as the option element is sufficiently distant from the designated sites. Due to the absence of hydrological connectivity with the canal there is no potential to change the water depth or extent through operation of the Bypass pipeline Vyrnwy release or change in the abstraction volume at the Shrewsbury intake. Therefore, operation of this element is highly unlikely to significantly affect the qualifying features of the SAC.	**No**

Designated site name:	**River Clun SAC (UK0030250)**	
Designation type: (SAC, SPA, Ramsar):	**SAC**	
Qualifying features:	1029 Freshwater pearl mussel *Margaritifera margaritifera*	**Water Dependency** Habitat and species identified as water dependent[38]: 1029 Freshwater pearl mussel *Margaritifera margaritifera*
Current conservation status:	1029 Freshwater pearl mussel *Margaritifera margaritifera*: **Deteriorating** (range: unfavourable - bad, population: unfavourable – bad, habitat for the species: unfavourable - bad, future prospects: unfavourable – bad). Main pressures: Agricultural activities generating diffuse pollution to surface or ground waters, forestry activities generating pollution to surface or ground waters, physical alteration of water bodies, illegal harvesting, collecting and taking. Main threats: Agricultural activities generating diffuse pollution to surface or ground waters, forestry activities generating pollution to surface or ground waters, Illegal harvesting, collecting and taking	
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. • The distribution of qualifying species within the site.	
SSSI Condition assessment:	River Teme SSSI (Unit 6) – Unfavourable - declining	
Site Improvement Plan:	3 Low breeding success/ Pressure poor recruitment- Pressure/threat -1029 Freshwater pearl mussel *Margaritifera margaritifera*- Intensive programme to safeguard and increase through breeding the vulnerable mussel population	
Potential Effects		
Element:		Risk of Likely Significant Effects?
Minworth WwTW discharge diversion (115 Ml/d)	The River Clun is a tributary of the River Teme, which is the second largest tributary of the River Severn. The site includes only the lower reaches of the river and extends upstream from the confluence with the Teme to Broadward Bridge near Marlow. This section of the river holds a population of the freshwater pearl mussel, one of the few lowland populations left in the UK. The freshwater pearl mussel larvae attach to the gills of salmon and trout before eventually detaching and settling in the riverbed gravels where they grow to adulthood. The operation of the Minworth WwTW discharge diversion will result in the transfer of water which is currently discharged into the River Tame to the River Avon. The Environment Agency and Natural England have identified that there is uncertainty regarding the potential impact on migratory cues (chemical) for Atlantic salmon which may impact on the number of juveniles salmonids in the watercourse which contribute to the lifecycle of the species.	**Yes**

Designated site name:	**River Dee and Bala Lake (UK0030252)**	
Designation type: (SAC, SPA, Ramsar):	**SAC**	
Qualifying features:	3260 Water courses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation.1106 Atlantic salmon *Salmo salar* 1831 Floating water-plantain *Luronium natans* 1095 Sea lamprey *Petromyzon marinus* 1096 Brook lamprey *Lampetra planeri* 1099 River lamprey *Lampetra fluviatilis* 1163 Bullhead *Cottus gobio* 1355 Otter *Lutra lutra*	**Water Dependency:** Habitats and species identified as water dependent[40]: • 3260 Water courses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation. • 1106 Atlantic salmon *Salmo salar.* • 1831 Floating water-plantain *Luronium natans.* • 1095 Sea lamprey *Petromyzon marinus.* • 1096 Brook lamprey *Lampetra planeri.* • 1099 River lamprey *Lampetra fluviatilis.* • 1163 Bullhead *Cottus gobio.* 1355 Otter *Lutra lutra.*
Current conservation status:	**3260 Water courses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation: Bad and deteriorating –** (range: favourable, area: inadequate, structure and function: bad and deteriorating, future prospects: bad and deteriorating). Main pressures: pollution, hydrological interventions, physical interventions and biological interventions. Main threats: pollution, hydrological interventions, physical interventions, biological interventions and climate change. **1106 Atlantic salmon *Salmo salar:* Unfavourable - inadequate (**Range: favourable, Population: unfavourable – inadequate, habitat for the species: favourable, Future prospects: unfavourable – inadequate). Main pressures: modification of hydrological flow or physical alteration of water bodies for agriculture (excluding development and operation of dams), roads, paths, railroads and related infrastructure (e.g. bridges, viaducts, tunnels), illegal shooting/killing, bycatch and incidental killing (due to fishing and hunting activities), mixed source pollution to surface and ground waters (limnic and terrestrial) and mixed source marine water pollution (marine and coastal). Main threats: use of plant protection chemicals in agriculture, modification of hydrological flow or physical alteration of water bodies for agriculture (excluding development and operation of dams), roads, paths, railroads and related infrastructure (e.g. bridges, viaducts, tunnels), illegal shooting/killing, bycatch and incidental killing (due to fishing and hunting activities), mixed source pollution to surface and ground waters (limnic and terrestrial), mixed source marine water pollution (marine and coastal), and abstraction from groundwater and surface water or mixed water. **1831 Floating water-plantain *Luronium* natans: Deteriorating (**Range: unfavourable - inadequate, Population: unfavourable – inadequate, habitat for the species: unknown, Future prospects: unfavourable – inadequate). Main pressures: agricultural activities point source water pollution, agricultural diffuse water pollution, invasive alien species, problematic native species, development and operation of dams, modification of hydrological flow and natural succession. Main threats: agricultural diffuse water pollution, air pollution, management of fishing stocks and game, invasive alien species, problematic native species (I04), mixed source water pollution, flow modification and natural succession. **1095 Sea lamprey *Petromyzon marinus*: Unknown** (Range: unknown, Population: unknown, habitat for the species: unknown, Future prospects: unknown). Main pressures: agricultural activities generating point source pollution to surface or ground waters, agricultural activities generating diffuse pollution to surface or ground waters, forestry activities generating pollution to surface or ground waters, hydropower (dams, weirs, run-off-the-river), including infrastructure and discharge of urban waste water (excluding storm overflows and/or urban run-offs) generating pollution to surface or ground water. Main threats: same as main pressures. **S1096 Brook lamprey *Lampetra planeri*: Inadequate but improving –** (range: favourable, population: unknown, habitat: inadequate but improving, future prospects: favourable). Main pressures: bait digging, sand and gravel extraction, water pollution, management of aquatic and bank vegetation for drainage purposes, removal of sediments, canalisation, modification of hydrographic functioning, general, modifying structures of inland water courses, management of water levels, drying out / accumulation of organic material, eutrophication, acidification, invasion by a species, competition; introduction of disease. Main threats: bait digging, sand and gravel extraction, water pollution, management of aquatic and bank vegetation for drainage purposes, Removal of sediments, canalisation, modification of hydrographic functioning, general, modifying structures of inland water courses, management of water levels, drying out / accumulation of organic material, eutrophication, acidification, invasion by a species, competition and introduction of disease. **1099 River lamprey *Lampetra fluviatilis*: Favourable –** (range: favourable, population: favourable, habitat: unknown, future prospects: favourable). Main pressures: Agricultural activities generating point source pollution to surface or ground waters, Agricultural activities generating diffuse pollution to surface or ground waters, Hydropower (dams, weirs, run-off-the-river), including infrastructure, Discharge of urban waste water (excluding storm overflows and/or urban run-offs) generating pollution to surface or ground water, Mixed source pollution to surface and ground waters (limnic and terrestrial) , Drainage, Development and operation of dams, Modification of hydrological flow, Physical alteration of water bodies, and Change of habitat location, size, and / or quality due to climate change. Main threats: same as main pressures. **S1163 Bullhead *Cottus gobio*: Unknown –** (range: favourable, population: unknown, habitat: unknown, future prospects: unknown) - main pressures: Fish and Shellfish Aquaculture; Sand and gravel extraction; water pollution; management of aquatic and bank vegetation for drainage purposes; Canalisation; Modification of hydrographic functioning, general; modifying structures of inland water courses; management of water levels; Erosion; Silting up; predation; competition. Main threats: same as pressures. **1355 Otter *Lutra lutra*: Stable –** (range: favourable, population: favourable, habitat: favourable, future prospects: favourable). Main Pressures: modification of hydrological flow or physical alteration of water bodies for agriculture (excluding development and operation of dams), roads, paths, railroads and related infrastructure (e.g. bridges, viaducts, tunnels), illegal shooting/killing, bycatch and incidental killing (due to fishing and hunting activities), mixed source pollution to surface and ground waters (limnic and terrestrial), mixed source marine water pollution (marine and coastal). Main threats: use of plant protection chemicals in agriculture, modification of hydrological flow or physical alteration of water bodies for agriculture (excluding development and operation of dams), roads, paths, railroads and related infrastructure, illegal shooting/killing, bycatch and incidental killing (due to fishing and hunting activities), mixed source pollution to surface and ground waters (limnic and terrestrial), mixed source marine water pollution (marine and coastal), and abstraction from groundwater, surface water or mixed water.	
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.	

[40] 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:	**River Dee and Bala Lake (UK0030252)**	
SSSI Condition assessment:	River Dee (England) SSSI: 59.65% Favourable and 40.35% Unfavourable – no change.	
Site Improvement Plan:	Information not currently available	
Potential Effects		
Element:		Risk of Likely Significant Effects?
River Vyrnwy Mitigation - Vyrnwy release (100Mld) and Bypass (80Mld)	The River Dee and Bala Lake SAC boundary is located [redacted] north of the closest element; the proposed Bypass pipeline route. The proposed route is located outside of the River Dee catchment with no identified hydrological connectivity or potential impact pathways identified for construction of the bypass pipeline route or operation of the pipeline, reservoir release, or reduction in abstraction of the Shrewsbury intake on the River Severn. This is due to the distance between the designated site and element, which limits disturbance, water quality, habitat availability and quality, habitat connectivity, or air quality impacts on qualifying features of the SAC. Operation of this element is unlikely to affect the qualifying features of the SAC, due to absence of hydrological connectivity between the River Vyrnwy and River Severn and the River Dee SAC. Therefore, no LSE are anticipated.	**No**
River Vyrnwy Mitigation – Vyrnwy Bypass release (155Mld)	The River Dee and Bala Lake SAC boundary is located [redacted] north of the closest element the proposed Bypass pipeline route. The proposed route is located outside of the River Dee catchment, with no identified hydrological connectivity or potential impact pathways identified for construction of the bypass pipeline route or operation of the pipeline or reduction in abstraction of the Shrewsbury intake on the River Severn. This is due to the distance between the designated site and element, which limits disturbance, water quality, habitat availability and quality, habitat connectivity, or air quality impacts on qualifying features of the SAC. Operation of this option element is unlikely to affect the qualifying features of the SAC, due to absence of hydrological connectivity between the River Vyrnwy and River Severn and the River Dee SAC. Therefore, no LSE are anticipated.	**No**
River Vyrnwy Mitigation – Vyrnwy Bypass release (180Mld)	The River Dee and Bala Lake SAC boundary is located [redacted] north of the closest element the proposed Bypass pipeline route. The proposed route is located outside of the River Dee catchment, with no identified hydrological connectivity or potential impact pathways identified for construction of the bypass pipeline route or operation of the pipeline or reduction in abstraction of the Shrewsbury intake on the River Severn. This is due to the distance between the designated site and element, which limits disturbance, water quality, habitat availability and quality, habitat connectivity, or air quality impacts on qualifying features of the SAC. Operation of this option element is unlikely to affect the qualifying features of the SAC, due to absence of hydrological connectivity between the River Vyrnwy and River Severn and the River Dee SAC. Therefore, no LSE are anticipated.	**No**

Designated site name:	**River Usk (UK0013007)**	
Designation type: (SAC, SPA, Ramsar):	**SAC**	
Qualifying features:	3260 Water courses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation.1106 Atlantic salmon *Salmo salar* 1095 Sea lamprey *Petromyzon marinus* 1096 Brook lamprey *Lampetra planeri* 1099 River lamprey *Lampetra fluviatilis* 1103 Twaite shad *Alosa fallax* 1102 Allis shad *Alosa alosa* 1106 Atlantic salmon *Salmo salar* 1163 Bullhead *Cottus gobio* 1355 Otter *Lutra lutra*	**Water Dependency:** Habitats and species identified as water dependent[41]: • 3260 Water courses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation. • 1106 Atlantic salmon *Salmo salar.* • 1095 Sea lamprey *Petromyzon marinus.* • 1096 Brook lamprey *Lampetra planeri.* • 1099 River lamprey *Lampetra fluviatilis.* • 1163 Bullhead *Cottus gobio.* • 1355 Otter *Lutra lutra.* • 1103 Twaite shad *Alosa fallax* • 1102 Allis shad *Alosa alosa*
Current conservation status:	**3260 Water courses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation: Bad and deteriorating –** (range: favourable, area: inadequate, structure and function: bad and deteriorating, future prospects: bad and deteriorating). Main pressures: pollution, hydrological interventions, physical interventions and biological interventions. Main threats: pollution, hydrological interventions, physical interventions, biological interventions and climate change. **1106 Atlantic salmon *Salmo salar:* Unfavourable - inadequate (**Range: favourable, Population: unfavourable – inadequate, habitat for the species: favourable, Future prospects: unfavourable – inadequate). Main pressures: modification of hydrological flow or physical alteration of water bodies for agriculture (excluding development and operation of dams), roads, paths, railroads and related infrastructure (e.g. bridges, viaducts, tunnels), illegal shooting/killing, bycatch and incidental killing (due to fishing and hunting activities), mixed source pollution to surface and ground waters (limnic and terrestrial) and mixed source marine water pollution (marine and coastal). Main threats: use of plant protection chemicals in agriculture, modification of hydrological flow or physical alteration of water bodies for agriculture (excluding development and operation of dams), roads, paths, railroads and related infrastructure (e.g. bridges, viaducts, tunnels), illegal shooting/killing, bycatch and incidental killing (due to fishing and hunting activities), mixed source pollution to surface and ground waters (limnic and terrestrial), mixed source marine water pollution (marine and coastal), and abstraction from groundwater and surface water or mixed water. diffuse water pollution, air pollution, management of fishing stocks and game, invasive alien species, problematic native species (I04), mixed source water pollution, flow modification and natural succession. **1103 *Alosa fallax*; Twaite shad:** Unfavourable – inadequate (range: unfavourable - inadequate, population: unfavourable - inadequate, habitats for the species: unfavourable - inadequate, future prospects: unfavourable – inadequate). Main Pressures: mixed source pollution to surface and ground waters (limnic and terrestrial), modification of hydrological flow, physical alteration of water bodies. Threats: wind, wave and tidal power, including infrastructure, hydropower (dams, weirs, run-off-the-river), including infrastructure, mixed source pollution to surface and ground waters (limnic and terrestrial), modification of hydrological flow (K04), physical alteration of water bodies. **1103 *Alosa alosa*; Allis shad:** Unfavourable – inadequate (range: unfavourable - inadequate, population: unfavourable - inadequate, habitats for the species: unfavourable - inadequate, future prospects: unfavourable – inadequate). Main Pressures: mixed source pollution to surface and ground waters (limnic and terrestrial), modification of hydrological flow, physical alteration of water bodies. Threats: wind, wave and tidal power, including infrastructure, hydropower (dams, weirs, run-off-the-river), including infrastructure, mixed source pollution to surface and ground waters (limnic and terrestrial), modification of hydrological flow (K04), physical alteration of water bodies. **1095 Sea lamprey *Petromyzon marinus*: Unknown** (Range: unknown, Population: unknown, habitat for the species: unknown, Future prospects: unknown). Main pressures: agricultural activities generating point source pollution to surface or ground waters, agricultural activities generating diffuse pollution to surface or ground waters, forestry activities generating pollution to surface or ground waters, hydropower (dams, weirs, run-off-the-river), including infrastructure and discharge of urban wastewater (excluding storm overflows and/or urban run-offs) generating pollution to surface or ground water. Main threats: same as main pressures. **S1096 Brook lamprey *Lampetra planeri*: Inadequate but improving –** (range: favourable, population: unknown, habitat: inadequate but improving, future prospects: favourable). Main pressures: bait digging, sand and gravel extraction, water pollution, management of aquatic and bank vegetation for drainage purposes, removal of sediments, canalisation, modification of hydrographic functioning, general, modifying structures of inland water courses, management of water levels, drying out / accumulation of organic material, eutrophication, acidification, invasion by a species, competition; introduction of disease. Main threats: bait digging, sand and gravel extraction, water pollution, management of aquatic and bank vegetation for drainage purposes, Removal of sediments, canalisation, modification of hydrographic functioning, general, modifying structures of inland water courses, management of water levels, drying out / accumulation of organic material, eutrophication, acidification, invasion by a species, competition and introduction of disease. **1099 River lamprey *Lampetra fluviatilis*: Favourable –** (range: favourable, population: favourable, habitat: unknown, future prospects: favourable). Main pressures: Agricultural activities generating point source pollution to surface or ground waters, Agricultural activities generating diffuse pollution to surface or ground waters, Hydropower (dams, weirs, run-off-the-river), including infrastructure, Discharge of urban waste water (excluding storm overflows and/or urban run-offs) generating pollution to surface or ground water, Mixed source pollution to surface and ground waters (limnic and terrestrial) , Drainage, Development and operation of dams, Modification of hydrological flow, Physical alteration of water bodies, and Change of habitat location, size, and / or quality due to climate change. Main threats: same as main pressures. **S1163 Bullhead *Cottus gobio*: Unknown –** (range: favourable, population: unknown, habitat: unknown, future prospects: unknown) - main pressures: Fish and Shellfish Aquaculture; Sand and gravel extraction; water pollution; management of aquatic and bank vegetation for drainage purposes; Canalisation; Modification of hydrographic functioning, general; modifying structures of inland water courses; management of water levels; Erosion; Silting up; predation; competition. Main threats: same as pressures. **1355 Otter *Lutra lutra*: Stable –** (range: favourable, population: favourable, habitat: favourable, future prospects: favourable). Main Pressures: modification of hydrological flow or physical alteration of water bodies for agriculture (excluding development and operation of dams), roads, paths, railroads and related infrastructure (e.g. bridges, viaducts, tunnels), illegal shooting/killing, bycatch and incidental killing (due to fishing and hunting activities), mixed source pollution to surface and ground waters (limnic and terrestrial), mixed source marine water pollution (marine and coastal). Main threats: use of plant protection chemicals in agriculture, modification of hydrological flow or physical alteration of water bodies for agriculture (excluding development and operation of dams), roads, paths, railroads and related infrastructure, illegal shooting/killing, bycatch and incidental killing (due to fishing and hunting activities), mixed source pollution to surface and ground waters (limnic and terrestrial), mixed source marine water pollution (marine and coastal), and abstraction from groundwater, surface water or mixed water.	
Conservation objectives:	Conservation Objective for the water course • The capacity of the habitats in the SAC to support each feature at near-natural population levels, as determined by predominantly unmodified ecological and hydromorphological processes and characteristics, should be maintained as far as possible, or restored where necessary.	

[41] 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:	**River Usk (UK0013007)**	
	• The ecological status of the water environment should be sufficient to maintain a stable or increasing population of each feature. This will include elements of water quantity and quality, physical habitat and community composition and structure. It is anticipated that these limits will concur with the relevant standards used by the Review of Consents process • Flow regime, water quality and physical habitat should be maintained in, or restored as far as possible to, a near-natural state, in order to support the coherence of ecosystem structure and function across the whole area of the SAC. • All known breeding, spawning and nursery sites of species features should be maintained as suitable habitat as far as possible, except where natural processes cause them to change. • Flows, water quality, substrate quality and quantity at fish spawning sites and nursery areas will not be depleted by abstraction, discharges, engineering or gravel extraction activities or other impacts to the extent that these sites are damaged or destroyed. • The river planform and profile should be predominantly unmodified. Physical modifications having an adverse effect on the integrity of the SAC, including, but not limited to, revetments on active alluvial river banks using stone, concrete or waste materials, unsustainable extraction of gravel, addition or release of excessive quantities of fine sediment, will be avoided. • River habitat SSSI features should be in favourable condition. In the case of the Usk Tributaries SSSI, the SAC habitat is not underpinned by a river habitat SSSI feature. In this case, the target is to maintain the characteristic physical features of the river channel, banks and riparian zone. • Artificial factors impacting on the capability of each species feature to occupy the full extent of its natural range should be modified where necessary to allow passage, eg. weirs, bridge sills, acoustic barriers. • Natural factors such as waterfalls, which may limit the natural range of a species feature or dispersal between naturally isolated populations, should not be modified • Flows during the normal migration periods of each migratory fish species feature will not be depleted by abstraction to the extent that passage upstream to spawning sites is hindered. • Flow objectives for assessment points in the Usk Catchment Abstraction Management Strategy will be agreed between EA and CCW as necessary. It is anticipated that these limits will concur with the standards used by the Review of Consents process given in Annex 1 of this document. • Levels of nutrients, in particular phosphate, will be agreed between EA and CCW for each Water Framework Directive water body in the Usk SAC, and measures taken to maintain nutrients below these levels. It is anticipated that these limits will concur with the standards used by the Review of Consents process. • Levels of water quality parameters that are known to affect the distribution and abundance of SAC features will be agreed between EA and CCW for each Water Framework Directive water body in the Usk SAC, and measures taken to maintain pollution below these levels. It is anticipated that these limits will concur with the For all other features the conservation objectives are: • The conservation objective for the water course as defined above must be met • The population of the feature in the SAC is stable or increasing over the long term. • The natural range of the feature in the SAC is neither being reduced nor is likely to be reduced for the foreseeable future. The natural range is taken to mean those reaches where predominantly suitable habitat for each life stage exists over the long term. Suitable habitat is defined in terms of near-natural hydrological and geomorphological processes and forms eg. Suitable flows to allow upstream migration, depth of water and substrate type at spawning sites, and ecosystem structure and functions eg. Food supply. Suitable habitat need not be present throughout the SAC but where present must be secured for the foreseeable future. Natural factors such as waterfalls may limit the natural range of individual species. Existing artificial influences on natural range that cause an adverse effect on site integrity, such as physical barriers to migration, will be assessed in view the population of the feature in the SAC is stable or increasing over the long term. There is, and will probably continue to be, a sufficiently large habitat to maintain the feature's population in the SAC on a long-term basis.	
SSSI Condition assessment:	Information not currently available	
Site Improvement Plan:	Information not currently available	
Potential Effects		
Element:		Risk of Likely Significant Effects?
Minworth WwTW discharge diversion (115 Ml/d)	The River Usk SAC rises in the Black Mountain range in the west of the Brecon Beacons National Park and flows east and then south, to enter the Severn Estuary at Newport. The River Usk will not be in hydrological connectivity with the STT as such that unsupported abstraction or support flows would impact on the watercourse. The operation of the Minworth WwTW discharge diversion will result in the transfer of water that is currently discharged into the River Tame to the River Avon. The Environment Agency and Natural England have identified that there is uncertainty regarding the potential impact on migratory cues (chemical) for migratory species that could result in LSE on the SAC.	**Yes**

Designated site name:	**River Wye (UK0012642)**	
Designation type: (SAC, SPA, Ramsar):	**SAC**	
Qualifying features:	1095 Sea lamprey *Petromyzon marinus* 1096 Brook lamprey *Lampetra planeri* 1099 River lamprey *Lampetra fluviatilis* 1103 Twaite shad *Alosa fallax* 1102 Allis shad *Alosa alosa* 1106 Atlantic salmon *Salmo salar* 1163 Bullhead *Cottus gobio* 1355 Otter *Lutra lutra* 1092 White-clawed (or Atlantic stream) crayfish *Austropotamobius pallipes*	**Water Dependency:** Habitats and species identified as water dependent[42]: • 1106 Atlantic salmon *Salmo salar.* • 1095 Sea lamprey *Petromyzon marinus.* • 1096 Brook lamprey *Lampetra planeri.* • 1099 River lamprey *Lampetra fluviatilis.* • 1163 Bullhead *Cottus gobio.* • 1355 Otter *Lutra lutra.* • 1103 Twaite shad *Alosa fallax* • 1102 Allis shad *Alosa alosa* • 1092 White-clawed (or Atlantic stream) crayfish Austropotamobius pallipes
Current conservation status:	**1106 Atlantic salmon *Salmo salar:* Unfavourable - inadequate (**Range: favourable, Population: unfavourable – inadequate, habitat for the species: favourable, Future prospects: unfavourable – inadequate). Main pressures: modification of hydrological flow or physical alteration of water bodies for agriculture (excluding development and operation of dams), roads, paths, railroads and related infrastructure (e.g. bridges, viaducts, tunnels), illegal shooting/killing, bycatch and incidental killing (due to fishing and hunting activities), mixed source pollution to surface and ground waters (limnic and terrestrial) and mixed source marine water pollution (marine and coastal). Main threats: use of plant protection chemicals in agriculture, modification of hydrological flow or physical alteration of water bodies for agriculture (excluding development and operation of dams), roads, paths, railroads and related infrastructure (e.g. bridges, viaducts, tunnels), illegal shooting/killing, bycatch and incidental killing (due to fishing and hunting activities), mixed source pollution to surface and ground waters (limnic and terrestrial), mixed source marine water pollution (marine and coastal), and abstraction from groundwater and surface water or mixed water. diffuse water pollution, air pollution, management of fishing stocks and game, invasive alien species, problematic native species (I04), mixed source water pollution, flow modification and natural succession. **1103 *Alosa fallax*; Twaite shad:** Unfavourable – inadequate (range: unfavourable - inadequate, population: unfavourable - inadequate, habitats for the species: unfavourable - inadequate, future prospects: unfavourable – inadequate). Main Pressures: mixed source pollution to surface and ground waters (limnic and terrestrial), modification of hydrological flow, physical alteration of water bodies. Threats: wind, wave and tidal power, including infrastructure, hydropower (dams, weirs, run-off-the-river), including infrastructure, mixed source pollution to surface and ground waters (limnic and terrestrial), modification of hydrological flow (K04), physical alteration of water bodies. **1103 *Alosa alosa*; Allis shad:** Unfavourable – inadequate (range: unfavourable - inadequate, population: unfavourable - inadequate, habitats for the species: unfavourable - inadequate, future prospects: unfavourable – inadequate). Main Pressures: mixed source pollution to surface and ground waters (limnic and terrestrial), modification of hydrological flow, physical alteration of water bodies. Threats: wind, wave and tidal power, including infrastructure, hydropower (dams, weirs, run-off-the-river), including infrastructure, mixed source pollution to surface and ground waters (limnic and terrestrial), modification of hydrological flow (K04), physical alteration of water bodies. **1095 Sea lamprey *Petromyzon marinus*: Unknown** (Range: unknown, Population: unknown, habitat for the species: unknown, Future prospects: unknown). Main pressures: agricultural activities generating point source pollution to surface or ground waters, agricultural activities generating diffuse pollution to surface or ground waters, forestry activities generating pollution to surface or ground waters, hydropower (dams, weirs, run-off-the-river), including infrastructure and discharge of urban waste water (excluding storm overflows and/or urban run-offs) generating pollution to surface or ground water. Main threats: same as main pressures. **S1096 Brook lamprey *Lampetra planeri*: Inadequate but improving –** (range: favourable, population: unknown, habitat: inadequate but improving, future prospects: favourable). Main pressures: bait digging, sand and gravel extraction, water pollution, management of aquatic and bank vegetation for drainage purposes, removal of sediments, canalisation, modification of hydrographic functioning, general, modifying structures of inland water courses, management of water levels, drying out / accumulation of organic material, eutrophication, acidification, invasion by a species, competition; introduction of disease. Main threats: bait digging, sand and gravel extraction, water pollution, management of aquatic and bank vegetation for drainage purposes, Removal of sediments, canalisation, modification of hydrographic functioning, general, modifying structures of inland water courses, management of water levels, drying out / accumulation of organic material, eutrophication, acidification, invasion by a species, competition and introduction of disease. **1099 River lamprey *Lampetra fluviatilis*: Favourable –** (range: favourable, population: favourable, habitat: unknown, future prospects: favourable). Main pressures: Agricultural activities generating point source pollution to surface or ground waters, Agricultural activities generating diffuse pollution to surface or ground waters, Hydropower (dams, weirs, run-off-the-river), including infrastructure, Discharge of urban waste water (excluding storm overflows and/or urban run-offs) generating pollution to surface or ground water, Mixed source pollution to surface and ground waters (limnic and terrestrial) , Drainage, Development and operation of dams, Modification of hydrological flow, Physical alteration of water bodies, and Change of habitat location, size, and / or quality due to climate change. Main threats: same as main pressures. **S1163 Bullhead *Cottus gobio*: Unknown –** (range: favourable, population: unknown, habitat: unknown, future prospects: unknown) - main pressures: Fish and Shellfish Aquaculture; Sand and gravel extraction; water pollution; management of aquatic and bank vegetation for drainage purposes; Canalisation; Modification of hydrographic functioning, general; modifying structures of inland water courses; management of water levels; Erosion; Silting up; predation; competition. Main threats: same as pressures. **1355 Otter *Lutra lutra*: Stable –** (range: favourable, population: favourable, habitat: favourable, future prospects: favourable). Main Pressures: modification of hydrological flow or physical alteration of water bodies for agriculture (excluding development and operation of dams), roads, paths, railroads and related infrastructure (e.g. bridges, viaducts, tunnels), illegal shooting/killing, bycatch and incidental killing (due to fishing and hunting activities), mixed source pollution to surface and ground waters (limnic and terrestrial), mixed source marine water pollution (marine and coastal). Main threats: use of plant protection chemicals in agriculture, modification of hydrological flow or physical alteration of water bodies for agriculture (excluding development and operation of dams), roads, paths, railroads and related infrastructure, illegal shooting/killing, bycatch and incidental killing (due to fishing and hunting activities), mixed source pollution to surface and ground waters (limnic and terrestrial), mixed source marine water pollution (marine and coastal), and abstraction from groundwater, surface water or mixed water. **1092 White-clawed (or Atlantic stream) crayfish *Austropotamobius pallipes*:** Deteriorating - Stable – (range: unfavourable - bad, population: unfavourable - bad, habitat: favourable, future prospects: unfavourable - bad). Main Pressures: Invasive alien species of Union concern, interspecific relations (competition, predation, parasitism, pathogens). Threats: Invasive alien species of Union concern, interspecific relations (competition, predation, parasitism, pathogens).	
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	

[42] 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:	**River Wye (UK0012642)**	
	• The supporting processes on which qualifying natural habitats and habitats of qualifying species rely • The populations of qualifying species, and, • The distribution of qualifying species within the site	
SSSI Condition assessment:	River Wye SSSI: 12.69% Favourable and 87.31% Unfavourable – declining.	
Site Improvement Plan:	Information not currently available	
Potential Effects		
Element:		Risk of Likely Significant Effects?
Minworth WwTW discharge diversion (115 Ml/d)	The Wye, on the border of England and Wales, is a large river with a geologically mixed catchment, including shales and sandstones. There is a clear transition between the upland reaches, with characteristic bryophyte-dominated vegetation, and the lower reaches, with extensive water crow-foot *Ranunculus* beds. The River Wye will not be in hydrological connectivity with the STT as such that unsupported abstraction or support flows would impact on the watercourse. The operation of the Minworth WwTW discharge diversion will result in the transfer of water, that is currently discharged into the River Tame, to the River Avon. The Environment Agency and Natural England have identified that there is uncertainty regarding the potential impact on migratory cues (chemical) for migratory species that could result in LSE on the SAC.	**Yes**

Designated site name:	**Rodborough Common (UK0012826)**	
Designation type: (SAC, SPA, Ramsar):	**SAC**	
Qualifying features:	6210 Semi-natural dry grasslands and scrubland facies on calcareous substrates (*Festuco-Brometalia*) (*important orchid sites).	**Water Dependency** Habitat not identified as water dependent but it will be important to protect the rooting structure of the qualifying features[43].
Current conservation status:	**6210 Semi-natural dry grasslands and scrubland facies on calcareous substrates (*Festuco-Brometalia*): Favourable.** (range: favourable area: inadequate but improving, structure and function: bad but improving, future prospects: favourable).	
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:	Rodborough Common SSSI: 99.77% Favourable and 0.23% Unfavourable – declining.	
Site Improvement Plan:	1. Undergrazing – Pressure/Threat - 6210 Semi-natural dry grasslands and scrubland facies on calcareous substrates - Increase grazing pressure in key areas. 2. Public Access/Disturbance – Pressure/Threat - 6210 Semi-natural dry grasslands and scrubland facies on calcareous substrates - Reduce impact of recreational use. 3. Air Pollution: risk of atmospheric nitrogen deposition – Threat - 6210 Semi-natural dry grasslands and scrubland facies on calcareous substrates - Further investigate potential atmospheric nitrogen impacts.	
Potential Effects		
Element:		Risk of Likely Significant Effects?
Canal conveyance, including piping to Culham (300 Ml/d)	This element is [redacted] (closest proposed pipeline) north-east of Rodborough Common SAC and it will not require any land take from within the boundaries of the SAC. The SIP threat of potential relevance is (3) air pollution, which could occur during construction. Atmospheric nitrogen deposition is approximately 18 kg N/ha/yr at the site which is not above the maximum critical load for semi-natural dry grasslands of 25 kg N/ha/yr[44]. No significant air quality impacts are anticipated as the number of vehicle movements will come under the commonly applied threshold for potential air quality impacts of 1000 AADT or 200 HGV movements per day (within 200m of a designated site) during construction works. In addition, based on the assumption that a 20 m working area will be required during the pipeline installation, all of the proposed works will be restricted by linear features already present between Rodborough Common and the proposed pipeline, which include: Rodborough Lane, Butterow Hill and the railway line from Stroud. The operation of this element will not significantly impact on the qualifying features of the SAC as it is not hydrologically connected downstream of the intake and outfall sites and the qualifying habitat feature has not been identified as water dependent. Therefore, no LSE are anticipated.	**No**

[43] 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.
[44] Air Pollution Information System (2017). Rodborough Common SAC. Accessed from: http://www.apis.ac.uk/srcl/select-a-feature?site=UK0016372&SiteType=SAC&submit=Next

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[43]: • 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*):** **1110 Sandbanks which are slightly covered by sea water all the time: 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: Unknown** (range: favourable, population: unknown, habitats for the species: unknown, future prospects: unknown). **1099 *Lampetra fluviatilis;* River lamprey: Favourable** (range: favourable, population: favourable, habitats for the species: unknown, future prospects: favourable). **1103 *Alosa fallax*; Twaite shad: Unfavourable – inadequate** (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		
Element:		Risk of Likely Significant Effects?
Vyrnwy Reservoir regulation release (75 Ml/d)	The element is located approximately [redacted] north-west of the Severn Estuary SAC and [redacted] north-west via hydrological connectivity. The SIP threats and pressures of potential relevance to this proposed element are (2) physical modification, (6) changes in species distribution, (7) water pollution and (12) invasive species. No construction works are required.	**Yes**

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	River lamprey, sea lamprey and twaite shad There are potential impact pathways of this element on functional spawning and nursery habitats, not within the boundary of the SAC during operation. Elevated volumes of water transported down the River Vyrnwy and subsequent rise in water flow could cause an increase in suspended sediment, disturbance/ displacement of river and sea lamprey ammocoetes present in silt beds (nursery habitat) upstream and increased velocities over nursery habitats. The water velocity of mid-stream sites occupied by river lamprey ammocoetes has previously ranged from 1 – 50 cm s^{-1} and 0.03 – 0.8 m s^{-1} for sea lamprey[45]. Adult river lamprey migrate upstream from October – December and spawn from March - April. The operation of this element may overlap with river lamprey migration. Monitoring undertaken during trial releases in support of the investigations of physical losses from a Vyrnwy reservoir support release concluded that a 75Ml/d release (in addition to the 45Ml/d) will not result in increased velocities and depth that would result in impacts on the fish community of the reaches of the River Vyrnwy from downstream of the reservoir to the confluence with the River Banwy. Further monitoring is required to support the conclusions. It is noted that the Vyrnwy Reservoir forms part of the River Severn Regulation operation and a review of the past 10 years of data suggests that releases in support of a STT could often occur when regulation releases are being made. At times of both regulation and support release, flows would exceed the recommended 75Ml/d releases). The elevated volumes of water and subsequent rise in water flow could increase energy expenditure required to successfully migrate to spawning sites upstream. Adult sea lamprey migrate upstream from April – May and spawn from late May – June. Therefore, both species could similarly be affected by the proposed element (depending on additional regulation releases). This could have long term implications on the size of the river lamprey and sea lamprey populations, if fewer individuals were successfully able to spawn or where nursery habitats are damaged. Therefore, LSE on river lamprey and sea lamprey cannot be discounted at this stage. This is in consideration of both the 75Ml/d Vyrnwy reservoir support release and regulation releases for regulation of the River Severn occurs at the same time. Adult twaite shad migrate upstream to spawn from mid May – mid July45. 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, therefore, considered unlikely that increased releases in the River Vyrnwy will result in impacts on spawning of twaite shad. However, NRW and the EA have identified that Unlocking the Severn scheme may potentially result in an increase in the extent of spawning habitat of twaite shad and increased flows in the reaches of the River Severn as a result of support releases from the Vyrnwy Reservoir could impact on twait shad in the future. Therefore, LSE on twaite shad cannot be discounted at this stage. Further assessment will consider the following conservation objectives - **River lamprey, sea lamprey and twaite shad**: the migratory passage of both adult and juvenile river lamprey, sea lamprey and twaite shad through the Severn Estuary between the Bristol Channel and any of their spawning rivers is not obstructed or impeded by physical barriers, changes in flows, or poor water quality; and the size of the river lamprey, sea lamprey and twaite shad populations in the Severn Estuary and the rivers which drain into it, is at least maintained and is at a level that is sustainable in the long term[46].	
	Estuaries, mudflats and sandflats, Atlantic salt meadows, sandbanks and reefs The spread of invasive species from the Lake Vyrnwy Reservoir to the Severn Estuary SAC has been identified as a potential impact pathway effecting qualifying habitat features during operation. Notable invasive species present in the River Vyrnwy during kick sampling and eDNA in spring and summer 2020 included quagga mussel (*Dreissena bugensis*), zebra mussel (*Dreissena polymorpha*) and Asian clam (*Corbicula fluminea*). Due to the low salinity tolerance of quagga mussel (5 ptt), the spread of this species is limited to freshwater habitats; the species was also absent in eDNA samples collected at Netheridge discharge point. Both zebra mussel and the Asian clam were recorded during eDNA sampling at Netheridge discharge point, therefore no further spread is anticipated from this element (as already present downstream). No impact pathways for the maximum regulation release of this element have been identified for qualifying features of the SAC. This is because the proposed flow rate of regulation releases from Lake Vyrnwy Reservoir is low in comparison to the natural fluctuations of the Severn Estuary, considering its large tidal range. In addition, due to abstraction points downstream of the regulation release, elevated flows will be reduced and flows into the Severn Estuary will be protected by the relevant hands-off flow conditions put in place. Therefore, no LSE are anticipated for this element.	**No**
River Vyrnwy Mitigation - Vyrnwy release (100Mld) and Bypass (80Mld)	The element is located approximately [redacted] (at closest point) north-west of the Severn Estuary SAC and is approximately [redacted] north-west via hydrological connectivity. The SIP threats and pressures of potential relevance to this element are (2) physical modification, (6) changes in species distribution, (7) water pollution and (12) invasive species. **River lamprey, sea lamprey and twaite shad** There are potential impact pathways of this element on functional spawning and nursery habitats, not within the boundary of the SAC during operation. Monitoring undertaken during trial releases in support of the investigations of physical losses from a Vyrnwy reservoir support release concluded that a 75Ml/d release (in addition to the 45Ml/d) will not result in increased velocities and depth that would result in impacts on the fish community of the reaches of the River Vyrnwy from downstream of the reservoir to the confluence with the River Banwy. Further monitoring is required to support the conclusions. However, this element includes 75 Ml/d regulation release from Lake Vyrnwy Reservoir, 80 Ml/d from the Vyrnwy Aqueduct to the River Vyrnwy via a bypass and a contribution of 25 Ml/d from the abstraction reduction at Shrewsbury. There are potentially times when the element will be operational when regulation releases are also being made from the Vyrnwy Reservoir for the River Severn regulation. The elevated volumes of water transported down the River Vyrnwy and subsequent rise in water flow could cause an increase in suspended sediment, disturbance/ displacement of river and sea lamprey ammocoetes present in silt beds (nursery habitat) upstream and increased velocities over nursery habitats. The water velocity of mid-stream sites occupied by river lamprey ammocoetes has previously ranged from 1 – 50 cm s^{-1} and 0.03 – 0.8 m s^{-1} for sea lamprey[45]. Adult river lamprey migrate upstream from October – December and spawn from March - April. During drought/severe drought conditions the proposed element may overlap with river lamprey migration. The elevated volumes of water and subsequent rise in water flow could increase energy expenditure required to successfully migrate to spawning sites upstream. Adult sea lamprey migrate upstream from April – May and spawn from late May – June. The elevated volumes of water and subsequent rise in water flow could increase energy expenditure required to successfully migrate to spawning sites upstream. Adult sea lamprey migrate upstream from April – May and spawn from late May – June. Therefore, both species could similarly be affected by the proposed element. This could have long term implications on the size of the river lamprey and sea lamprey populations, if fewer individuals were successfully able to spawn or where nursery habitats are damaged. Therefore, LSE on river lamprey and sea lamprey cannot be discounted at this stage.	**Yes**

[45] Maitland P.S (2003). *Ecology of the River, Brook and Sea Lamprey*. Conserving Natura 2000 Rivers Ecology Series No. 5. 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

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	Adult twaite shad migrate upstream to spawn from mid May – mid July45. 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, therefore, considered unlikely that increased releases in the River Vyrnwy will result in impacts on spawning of twaite shad. However, NRW and the EA have identified that Unlocking the Severn scheme may potentially result in an increase in the extent of spawning habitat of twaite shad and increased flows in the reaches of the River Severn as a result of support releases from the Vyrnwy Reservoir could impact on twait shad in the future. Therefore, LSE on twaite shad cannot be discounted at this stage. Further assessment will consider the following conservation objectives - **River lamprey, sea lamprey and twaite shad**: the migratory passage of both adult and juvenile river lamprey, sea lamprey and twaite shad through the Severn Estuary between the Bristol Channel and any of their spawning rivers is not obstructed or impeded by physical barriers, changes in flows, or poor water quality; and the size of the river lamprey, sea lamprey and twaite shad populations in the Severn Estuary and the rivers which drain into it, is at least maintained and is at a level that is sustainable in the long term .	
	<u>Estuaries, mudflats and sandflats, Atlantic salt meadows, sandbanks and reefs</u> The spread of invasive species from the Lake Vyrnwy Reservoir and Vyrnwy Aqueduct to the Severn Estuary SAC has been identified as a potential impact pathway effecting qualifying habitat features during operation. Notable invasive species present in the River Vyrnwy during kick sampling and eDNA in spring and summer 2020 included quagga mussel (*Dreissena bugensis*), zebra mussel (*Dreissena polymorpha*) and Asian clam (*Corbicula fluminea*). Due to the low salinity tolerance of quagga mussel (5 ptt), the spread of this species is limited to freshwater habitats; the species was also absent in eDNA samples collected at Netheridge discharge point. Both zebra mussel and the Asian clam were recorded during eDNA sampling at Netheridge discharge point, therefore no further spread is anticipated from this element (as already present downstream). Potential impact pathways on qualifying habitat features of the SAC also include changes in hydrological regime and periods of inundation; the latter is relevant to mudflats and sandflats not covered by seawater at low tide and Atlantic salt meadows. However, considering the large tidal range of the Severn Estuary and natural fluctuations that qualifying habitat features are exposed to, the impact of 180 Ml/d elevated flows during operation of this element are considered negligible. In addition, due to abstraction points downstream of the regulation release, elevated flows will be reduced and flows into the Severn Estuary will be protected by the relevant hands-off flow conditions put in place. Therefore, no LSE are anticipated for this element.	**No**
River Vyrnwy Mitigation – Vyrnwy Bypass release (155Mld)	This element includes the regulation release of 155 Ml/d from the Vyrnwy Aqueduct, (which feeds Oswestry WTW) to the River Vyrnwy and a contribution of 25 Ml/d from the abstraction reduction at Shrewsbury. The element is located approximately [redacted] (at closest point) north-west of the Severn Estuary SAC and is approximately [redacted] north-west via hydrological connectivity. The SIP threats and pressures of potential relevance to this proposed element are (2) physical modification, (6) changes in species distribution, (7) water pollution and (12) invasive species. No impact pathways are anticipated during construction. **<u>River lamprey, sea lamprey and twaite shad</u>** There are potential impact pathways of this element on functional spawning and nursery habitats, not within the boundary of the SAC during operation. Monitoring undertaken during trial releases in support of the investigations of physical losses from a Vyrnwy reservoir support release concluded that a 75Ml/d release (in addition to the 45Ml/d) will not result in increased velocities and depth that would result in impacts on the fish community of the reaches of the River Vyrnwy from downstream of the reservoir to the confluence with the River Banwy. Further monitoring is required to support the conclusions. However, this element includes 75 Ml/d regulation release from Lake Vyrnwy Reservoir, 80 Ml/d from the Vyrnwy Aqueduct to the River Vyrnwy via a bypass and a contribution of 25 Ml/d from the abstraction reduction at Shrewsbury. There are potentially times when the element will be operational when regulation releases are also being made from the Vyrnwy Reservoir for the River Severn regulation. The elevated volumes of water transported down the River Vyrnwy and subsequent rise in water flow could cause an increase in suspended sediment, disturbance/ displacement of river and sea lamprey ammocoetes present in silt beds (nursery habitat) upstream and increased velocities over nursery habitats. The water velocity of mid-stream sites occupied by river lamprey ammocoetes has previously ranged from 1 – 50 cm s^{-1} and 0.03 – 0.8 m s^{-1} for sea lamprey[45]. Adult river lamprey migrate upstream from October – December and spawn from March - April. During drought/severe drought conditions the proposed element may overlap with river lamprey migration. The elevated volumes of water and subsequent rise in water flow could increase energy expenditure required to successfully migrate to spawning sites upstream. Adult sea lamprey migrate upstream from April – May and spawn from late May – June. The elevated volumes of water and subsequent rise in water flow could increase energy expenditure required to successfully migrate to spawning sites upstream. Adult sea lamprey migrate upstream from April – May and spawn from late May – June. Therefore, both species could similarly be affected by the proposed element. This could have long term implications on the size of the river lamprey and sea lamprey populations, if fewer individuals were successfully able to spawn or where nursery habitats are damaged. Therefore, LSE on river lamprey and sea lamprey cannot be discounted at this stage. Adult twaite shad migrate upstream to spawn from mid May – mid July45. 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, therefore, considered unlikely that increased releases in the River Vyrnwy will result in impacts on spawning of twaite shad. However, NRW and the EA have identified that Unlocking the Severn scheme may potentially result in an increase in the extent of spawning habitat of twaite shad and increased flows in the reaches of the River Severn as a result of support releases from the Vyrnwy Reservoir could impact on twait shad in the future. Further assessment will consider the following conservation objectives. Therefore, LSE on twaite shad cannot be discounted at this stage. **River lamprey, sea lamprey and twaite shad**: the migratory passage of both adult and juvenile river lamprey, sea lamprey and twaite shad through the Severn Estuary between the Bristol Channel and any of their spawning rivers is not obstructed or impeded by physical barriers, changes in flows, or poor water quality; and the size of the river lamprey, sea lamprey and twaite shad populations in the Severn Estuary and the rivers which drain into it, is at least maintained and is at a level that is sustainable in the long term .	**Yes**
	<u>Estuaries, mudflats and sandflats, Atlantic salt meadows, sandbanks and reefs</u> The spread of invasive species from the Vyrnwy Aqueduct to the Severn Estuary SAC has been identified as a potential impact pathway effecting qualifying habitat features during operation. Notable invasive species present in the River Vyrnwy during kick sampling and eDNA in spring and summer 2020 included quagga mussel (*Dreissena bugensis*), zebra mussel (*Dreissena polymorpha*) and Asian clam (*Corbicula fluminea*). Due to the low salinity tolerance of quagga mussel (5 ptt), the spread of this species is limited to freshwater habitats; the species was also absent in eDNA samples collected at Netheridge discharge point. Both zebra mussel and the Asian clam were recorded during eDNA sampling at Netheridge discharge point, therefore no further spread is anticipated from this element (as already present downstream).	**No**

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	Potential impact pathways on qualifying habitat features of the SAC also include changes in hydrological regime and periods of inundation; the latter is relevant to mudflats and sandflats not covered by seawater at low tide and Atlantic salt meadows. However, considering the large tidal range of the Severn Estuary and natural fluctuations that qualifying habitat features are exposed to, the impact of 180 Ml/d elevated flows during operation of this element (combined contribution of Vyrnwy Aqueduct and Shrewsbury abstraction reduction) are considered negligible. In addition, due to abstraction points downstream of the regulation release, elevated flows will be reduced and flows into the Severn Estuary will be protected by the relevant hands-off flow conditions put in place. Therefore, no LSE are anticipated for this element.	
River Vyrnwy Mitigation – Vyrnwy Bypass release (180Mld)	The element is located approximately [redacted] (at closest point) north-west of the Severn Estuary SAC and is approximately [redacted] north-west via hydrological connectivity. The SIP threats and pressures of potential relevance to this element are (2) physical modification, (6) changes in species distribution, (7) water pollution and (12) invasive species. No impact pathways are anticipated during construction. **<u>River lamprey, sea lamprey and twaite shad</u>** This element comprises a raw water pipeline which will transport 180 Ml/d from the Vyrnwy Aqueduct, (which feeds Oswestry WTW) to the River Severn. Potential impact pathways include increased suspended sediment at the outfall location and fluctuations in pH, water temperature, dissolved oxygen and nutrient concentrations, depending on the water quality of the raw water discharge. On the basis that discharged water must be compliant with Water Framework Directive water quality standards and the discharge rate will be controlled, no likely significant effects are anticipated on localised abiotic parameters. In addition, elevating the flow rate in the Upper River Severn could impact on the successful upstream migration of river lamprey, sea lamprey and twaite shad to suitable spawning habitats. From the Vyrnwy confluence to downstream of Shrewsbury, hydrological modelling has confirmed that on 58% of the supporting flow dates, the same flow band would be retained. For the remaining 42% of the supporting flow dates, the flow bands would increase from 1 to >2; with the largest changes all occurring from exceptionally low to normal flow[47]. This elevation of water flow during low flow periods may benefit anadromous species that rely on sufficient water flow to migrate upstream to spawn, particularly sea lamprey that migrate upstream from April – May and spawn from late May – June and twaite shad, that migrate upstream to spawn from mid May – mid July. Downstream of Shrewsbury to the Avon confluence the impacts of discharging 180 Ml/d from the proposed bypass (option 7) on flow reduce, with retention of the flow band for 70% of the supporting flow dates. Considering the sporadic nature that this element will be operational and the negligible changes in flow (maximum change to normal flow conditions), no risk of likely significant effects on river lamprey, sea lamprey and twaite shad are anticipated.	**No**
	<u>Estuaries, mudflats and sandflats, Atlantic salt meadows, sandbanks and reefs</u> The spread of invasive species from Vyrnwy Aqueduct to the Severn Estuary SAC has been identified as a potential impact pathway effecting qualifying habitat features during operation. Notable invasive species present in the River Vyrnwy during kick sampling and eDNA in spring and summer 2020 included quagga mussel (*Dreissena bugensis*), zebra mussel (*Dreissena polymorpha*) and Asian clam (*Corbicula fluminea*). Due to the low salinity tolerance of quagga mussel (5 ptt), the spread of this species is limited to freshwater habitats; the species was also absent in eDNA samples collected at Netheridge discharge point. Both zebra mussel and the Asian clam were recorded during eDNA sampling at Netheridge discharge point, therefore no further spread is anticipated from this element (as already present downstream). Potential impact pathways on qualifying habitat features of the SAC also include changes in hydrological regime and periods of inundation; the latter is relevant to mudflats and sandflats not covered by seawater at low tide and Atlantic salt meadows. However, considering the large tidal range of the Severn Estuary and natural fluctuations that qualifying habitat features are exposed to, the impact of 180 Ml/d elevated flows during operation of this element are considered negligible. In addition, due to abstraction points downstream of the regulation release, elevated flows will be reduced and flows into the Severn Estuary will be protected by the relevant hands-off flow conditions put in place. Therefore, no LSE are anticipated for this element.	**No**
Vyrnwy Mitigation – Shrewsbury redeployment (25 Ml/d)	The element is located approximately [redacted] north-west of the Severn Estuary SAC and is approximately [redacted] north-west via hydrological connectivity. The SIP threats and pressures of potential relevance to this element are (2) physical modification threat, (6) changes in species distribution and (7) water pollution. The proposed scheme will not require land take from within the designated site however, the element is hydrologically linked to the designated site. No construction works are required and due to the distance from the designated site and small abstraction reduction proposed, no LSE are anticipated on any of the designated sites.	**No**
Pipeline conveyance, Deerhurst to Culham (300, 400 and 500 Ml/d)	This element is located approximately [redacted] north of the Severn Estuary SAC and approximately [redacted] north via hydrological connectivity. The SIP threats and pressures of potential relevance to this element are (2) physical modification threat, (3) impacts of development, (6) changes in species distribution (7) water pollution, (8) air pollution and (12) invasive species. Given the significant distance of the element to the European Marine Site, air quality impacts can be excluded at this stage. Physical modification, impacts of development, water pollution and the spread of invasive species are considered more feasible, particularly within any potential off-site functional habitat. The proposed scheme will not require land take from within the designated site and construction activities are at a sufficient distance that no significant impacts on the qualifying habitat features are anticipated because of construction. **<u>River lamprey, sea lamprey and twaite shad</u>** Off-site functional habitat could potentially be affected along the Severn between the river intake at Deerhurst and the designated site during construction, due to localised increases in suspended sediment (siltation and deposition), potential invasive species spread, noise and vibration disturbance, entrapment and impingement and potential water pollution incidents. Reduced water flow surrounding the abstraction point may also cause localised changes in nutrient loading, turbidity, salinity regime, reduced dissolved oxygen and changes in dilution of pollutants. In the absence of mitigation, LSE cannot be discounted for designated fish species. The Environment Agency has advised a STT abstraction licence would be limited to not reduce flow at Deerhurst flow gauging station below 2,568 Ml/d, a hands-off flow (HoF) condition. At flows greater than this HoF, up to 172 Ml/d is available for abstraction without support, and at flows greater than 3,333 Ml/d an additional 355 Ml/d is available for abstraction without support. As such, the impact on downstream river levels is not expected to be of a magnitude that would impede upstream passage of qualifying fish or impact on the supporting processes within the estuary. The hands-off flow conditions are already in place to limit abstraction to moderately low flows and prohibit any abstraction at low flows. Further assessment will consider the following conservation objectives - **River lamprey, sea lamprey and twaite shad**: the migratory passage of both adult and juvenile river lamprey, sea lamprey and twaite shad through the Severn Estuary between the Bristol Channel and any of their spawning rivers is not obstructed or impeded by physical barriers, changes in flows, or poor	**Yes**

[47] Ricardo (2021). *Seven to Thames Transfer SRO. Evidence Report: River Severn – Vyrnwy Confluence to Downstream of Shrewsbury*. Report for United Utilities.

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	water quality; and the size of the river lamprey, sea lamprey and twaite shad populations in the Severn Estuary and the rivers which drain into it, is at least maintained and is at a level that is sustainable in the long term[48].	
	Estuaries, mudflats and sandflats, Atlantic salt meadows, sandbanks and reefs Due do the distance of the proposed abstraction/element from reef features and subtidal sandbanks, no impact pathways are anticipated. During construction potential impact pathways on the estuary include siltation and deposition, impedance of movement, entrapment and impingement, noise and vibration disturbance, salinity regime changes and temperature changes. During operation, abstraction from the River Severn will reduce the volume of water transported downstream to the Severn Estuary, in addition to reduced dissolved oxygen and change in dilution of pollutants. The reduced flow could also expose a greater area of peripheral habitats in the Severn Estuary including mudflats and sandflats and Atlantic salt meadows during times of operation (summer). However, due to the large tidal range, high flow rates within the estuary and distance of this element from the designated site, no LSE are anticipated.	**No**
Netheridge WwTW discharge diversion, Deerhurst pipeline (35 Ml/d)	This element is located approximately [redacted] north-east of the Severn Estuary SAC and is approximately [redacted] north-east via hydrological connectivity. The most relevant SIP threats and pressures of this element 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 element during operation is (2) physical modification. **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. Due to the distance between the proposed works and the designated site via hydrological connectivity, temporary nature of constructing the outfall and relatively small footprint of the outfall on the river bank (250 m²), no LSE are anticipated on qualifying species of the SAC during construction. Potential impact pathways of this element 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 discharge from Netheridge WwTW. Due to the large tidal range of the Severn Estuary and small volume 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 water quality and migratory fish species are anticipated.	**No**
	Estuaries, mudflats and sandflats, Atlantic salt meadows, sandbanks and reefs The footprint of this element is outside of the boundary of the SAC. During proposed construction works for this element 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 SAC 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. Due to the large tidal range of the Severn Estuary and small volume 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**
Netheridge WwTW discharge diversion, Cotswold Canals (35 Ml/d)	This element is located approximately [redacted] north-east of the Severn Estuary SAC and is approximately [redacted] north-east via hydrological connectivity. The most relevant SIP threats and pressures of this element 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 element during operation is (2) physical modification. **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. Due to the distance between the proposed works and the designated site via hydrological connectivity, temporary nature of constructing the outfall and relatively small footprint of the outfall on the river bank (250 m²), no LSE are anticipated on qualifying fish features of the SAC during construction. Potential impact pathways of this element 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 water released from Netheridge WwTW. Due to the large tidal range of the Severn Estuary and small volume 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 water quality and migratory fish species are anticipated.	**No**
	Estuaries, mudflats and sandflats, Atlantic salt meadows, sandbanks and reefs The footprint of this element is outside of the boundary of the SAC. During proposed construction works for this element 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 SAC 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. Due to the large tidal range of the Severn Estuary and small volume 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**
Canal conveyance, including piping to Culham (300 Ml/d)	This element is located approximately [redacted] north-east of the Severn Estuary SAC at its closest point and is approximately [redacted] north-east via hydrological connectivity. The SIP threats and pressures of potential relevance to this element are (2) physical modification threat, (3) impacts of development, (7) water pollution, (8) air pollution and (12) invasive species. The proposed scheme will not require land take from within the designated site. **River lamprey, sea lamprey, twaite shad, allis shad, Atlantic salmon, sea trout and European eel** Off-site functional habitat could potentially be affected along the Severn between the river intake at Gloucester and the designated site, due to localised increases in suspended sediment, the potential spread of invasive species and potential water pollution incidents during construction. Reduced water flow surrounding the abstraction point may also cause localised changes in nutrient loading, turbidity, salinity and oxygenation. In the absence of mitigation, there is a risk of likely significant effects for designated fish species. However, the impact on downstream river levels is not expected to be enough to impede upstream passage of qualifying fish species to a significant extent. The Environment Agency has advised a STT abstraction licence would be limited to not	**Yes**

[48] 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.

Designated site name:	Severn Estuary SAC (UK0013030)	
	reduce flow at Deerhurst flow gauging station below 2,568 Ml/d, a hands-off flow (HoF) condition. At flows greater than this HoF, up to 172Ml/d is available for abstraction without support, and at flows greater than 3,333Ml/d an additional 355Ml/d is available for abstraction without support. As such, the impact on downstream river levels is not expected to be of a magnitude that would impede upstream passage of qualifying fish or impact on the supporting processes within the estuary. Further assessment will consider the following conservation objectives - **River lamprey, sea lamprey and twaite shad**: the migratory passage of both adult and juvenile river lamprey, sea lamprey and twaite shad through the Severn Estuary between the Bristol Channel and any of their spawning rivers is not obstructed or impeded by physical barriers, changes in flows, or poor water quality; and the size of the river lamprey, sea lamprey and twaite shad populations in the Severn Estuary and the rivers which drain into it, is at least maintained and is at a level that is sustainable in the long term..	
	Estuaries, mudflats and sandflats, Atlantic salt meadows, sandbanks and reefs No significant air quality impacts are anticipated during construction, due to the distance between the proposed construction works and these qualifying habitat features. Due do the distance of the proposed abstraction/element from reef features and subtidal sandbanks, no impact pathways are anticipated. During operation, abstraction from the River Severn will reduce the volume of water transported downstream to the Severn Estuary. This could expose a greater area of peripheral habitats in the Severn Estuary including mudflats and sandflats and Atlantic salt meadows during times of operation (summer). However, due to the large tidal range, high flow rates within the estuary and distance of this element from the designated site, no LSE are anticipated.	**No**
Mythe abstraction reduction (15 Ml/d)	The element is located approximately [redacted] north-east of the Severn Estuary SAC and is approximately [redacted] north-east via hydrological connectivity. The SIP threats and pressures of potential relevance to this element is (2) physical modification threat and (7) water pollution. The proposed scheme will not require land take from within the designated site however, the element is hydrologically linked to the designated site. No construction works are required and due to the distance from the designated site and small abstraction reduction proposed, no LSE are anticipated on any of the designated sites.	**No**
Minworth WwTW discharge diversion (115 Ml/d)	The element is located [redacted] north-east of the Severn Estuary SAC and is approximately 1[redacted]km north-east via hydrological connectivity. The SIP threats of potential relevance to this element are (2) physical modification, (3) impacts of development, (6) changes in species distribution, (7) water pollution, (8) air pollution and (12) invasive species. The proposed scheme will not require land take from within the designated site however, the element is hydrologically linked to the designated site. **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. Due to the distance between the proposed works and the designated site via hydrological connectivity, temporary nature of constructing the outfall and relatively small footprint of the outfall on the river bank (500 m²), no LSE are anticipated on qualifying species of the SAC during construction. Off-site functional habitat along the River Avon and River Severn between the proposed outfall location in Warwick and the designated site during operation could also be affected. This is due to localised increases in suspended sediment and the potential introduction/ spread of invasive and non-native species. The effluent will be treated before discharge and on the assumption that it will meet Water Framework Directive standards, no LSE from the introduction/ spread of invasive and non-native species are anticipated. As the element will also only be operational during low flows and the flow rate of discharge will be controlled as appropriate, no LSE from localised increases in suspended sediment are expected. Increased water flow created by the diverted WwTW discharge could also increase the energetic cost of migrating upstream, resulting in reduced spawning success (although noted that no records have been identified for river lamprey, sea lamprey, twaite shad, allis shad and Atlantic salmon in the River Avon; only European eel identified during eDNA sampling). Based on hydrological assessments between Warwick and the Severn confluence on 279 of the supporting flow dates (50%) the same flow band would be retained, 214 dates (38%) would result in change by one flow band, 61 dates (11%) would result in change by two flow bands, and 9 (2%) would change by three flow bands - all from exceptionally low to normal. Therefore, during low flow periods the operation of this element could potentially have positive benefits on migration of qualifying species of the SAC as flow in the River Avon will increase to normal flow bands. Despite the tertiary treatment to mitigate any water quality impacts, the Environment Agency and Natural England has raised concerns with regards to the chemical cues (olfaction) to migration as a result of the diversion of WwTW discharge from the Tame. There is also the potential that the transfer of WwTW discharge into the River Avon and, subsequently the Severn Estuary could result in ongoing and potentially increasing bioaccumulation of olfactory inhibitors. Therefore, LSE are anticipated from this element.	**Yes**
	Estuaries, mudflats and sandflats, Atlantic salt meadows, sandbanks and reefs The footprint of this element is outside of the boundary of the SAC. Due to the distance between this element and qualifying habitats of the SAC, no LSE are anticipated during construction works. Invasive species spread has also been identified as a potential impact pathway during operation. Invasive species present in the River Avon at the discharge location include *Physella acuta,* Jenkins' Spire snail *(Potamopyrgus antipodarum),* demon shrimp *(Dikerogammarus haemobaphes),* Nuttall's waterweed *(Elodea nuttallii)* and *Hypania invalida. Physella acuta, Hypania invalida,* Jenkin's Spire snail and demon shrimp were present during sampling at Netheridge discharge point and therefore, already present in the River Severn. Nuttall's waterweed has similarly been recorded in Gloucester and it is not anticipated that the discharge diversion in Minworth will cause any further spread into the designated site. Based on hydrological assessments between Warwick and the Severn confluence on 279 of the supporting flow dates (50%) the same flow band would be retained, 214 dates (38%) would result in change by one flow band, 61 dates (11%) would result in change by two flow bands, and 9 (2%) would change by three flow bands - all from exceptionally low to normal. Therefore, during low flow periods the operation of this element could potentially have positive benefits on wetted habitats of the Ramsar site, as flow in the River Avon will increase to normal flow bands. Therefore, no LSE are anticipated for this element.	**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[49]. • 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.	

[49]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)**	
Potential Effects		
Element:		Risk of Likely Significant Effects?
Vyrnwy Reservoir release (75 Ml/d)	The element is located approximately [redacted] north-west of the Severn Estuary SPA and is approximately [redacted] north-west via hydrological connectivity. The SIP threats and pressures of potential relevance to this proposed element are (5) changes in species distribution and (6) water pollution. No construction works are required and no direct impacts during operation have been identified for this element on bird assemblages associated with the SPA. This is due to the timing of the proposed operational works (outside of overwintering season) and negligible impacts of regulation releases from the Lake Vrynwy Reservoir on water flow within the Severn Estuary. Therefore, no LSE from this element are anticipated.	**No**
River Vyrnwy Mitigation - Vyrnwy release (100Mld) and Bypass (80Mld)	The element is located approximately [redacted] (at closest point) north-west of the Severn Estuary SPA and is approximately [redacted] north-west via hydrological connectivity. The SIP threats and pressures of potential relevance to this proposed element are (5) changes in species distribution and (6) water pollution. No direct impacts during construction or operation have been identified for this element on bird assemblages associated with the SPA. This is due to the timing of the proposed operational works (outside of overwintering season) and distance from the designated site. Therefore, no LSE from this element are anticipated.	**No**
River Vyrnwy Mitigation – Vyrnwy Bypass release (155Mld)	The element is located approximately [redacted] (at closest point) north-west of the Severn Estuary SPA and is approximately [redacted] north-west via hydrological connectivity. The SIP threats and pressures of potential relevance to this proposed element are (5) changes in species distribution and (6) water pollution. No direct impacts during construction or operation have been identified for this element on bird assemblages associated with the SPA. This is due to the timing of the proposed operational works (outside of overwintering season) and distance from the designated site. Therefore, no LSE from this element are anticipated.	**No**
River Vyrnwy Mitigation – Vyrnwy Bypass release (180Mld)	The element is located approximately [redacted] (at closest point) north-west of the Severn Estuary SPA and is approximately [redacted] north-west via hydrological connectivity. The SIP threats and pressures of potential relevance to this proposed element are (5) changes in species distribution and (6) water pollution. No direct impacts during construction or operation have been identified for this element on bird assemblages associated with the SPA. This is due to the timing of the proposed operational works (outside of overwintering season) and distance from the designated site. Therefore, no LSE from this element are anticipated.	**No**
Vyrnwy Mitigation – Shrewsbury redeployment (25 Ml/d)	The element is located approximately [redacted] (at closest point) north-west of the Severn Estuary SPA and is approximately [redacted] north-west via hydrological connectivity. The SIP threats and pressures of potential relevance to this element are (5) changes in species distribution and (6) water pollution. The proposed scheme will not require land take from within the designated site however, the element is hydrologically linked to the designated site. No construction works are required and no LSE on the SPA have been identified during operation due to the timing (outside of overwintering season) and distance from the designated site.	**No**
Pipeline conveyance, Deerhurst to Culham (300, 400 and 500 Ml/d)	This element is located approximately 2[redacted] north of the Severn Estuary SPA and approximately [redacted] north via hydrological connectivity. The SIP threats and pressures of potential relevant to this element are (2) impacts of development, (5) changes in species distributions, (6) water pollution and (7) air pollution. Given the significant distance of the construction works to the Severn Estuary SPA and the relatively specialist habitat requirements of the qualifying bird species, no noise and vibration disturbance impacts are anticipated either within the site or whilst utilising off-site functional habitat. No direct impact pathways have been identified for this element during operational works due to the proposed timing of abstraction (outside of overwintering season) and distance from the designated site. Significant air quality impacts during construction are not anticipated for this element due to the distance between the qualifying species and the proposed construction works. Therefore, no LSE are anticipated.	**No**
Netheridge WwTW discharge diversion, Deerhurst pipeline (35 Ml/d)	This element is located approximately [redacted] north-east of the Severn Estuary SPA and is approximately [redacted] north-east via hydrological connectivity. The SIP threats and pressures of potential relevance to this element during construction are (2) impacts of development, (5) changes in species distributions, (6) water pollution and (7) air pollution. The footprint of this element 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 most relevant SIP threat and pressure to this element 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 element during operational works, due to the proposed timing of the WwTW discharge (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 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 supporting habitat of the SPA are anticipated.	**No**
Netheridge WwTW discharge diversion, Cotswold canals (35 Ml/d)	This element is located approximately [redacted] north-east of the Severn Estuary SPA and is approximately [redacted] north-east via hydrological connectivity. The SIP threats and pressures of potential relevance to this element during construction are (2) impacts of development, (5) changes in species distributions, (6) water pollution and (7) air pollution. The footprint of this element 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 most relevant SIP threat and pressure to this element 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 element during operational works, due to the proposed timing of the WwTW discharge (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 proposed for diversion and discharge by Gloucester Docks, negligible amendments to water flow within the river reach during operation are anticipated. Therefore, no LSE on supporting habitat of the SPA are anticipated.	**No**
Canal conveyance, including piping to Culham (300 Ml/d)	This element is located approximately [redacted] north-east of the Severn Estuary SPA at its closest point and is approximately [redacted] north-east via hydrological connectivity. The SIP threats and pressures of potential relevance to this element are (2) impacts of development, (3) coastal squeeze, (5) changes in species distributions, (6) water pollution, (7) air pollution, (10) marine litter and (11) marine pollution incidents. The proposed scheme will not require land take from within the designated site.	**No**

Designated site name:	**Severn Estuary SPA (UK9015022)**	
	Significant air quality impacts during construction are not anticipated for this element due to the distance between the proposed construction works and the qualifying species. If construction works to rehabilitate the canals pounds and locks took place during the overwintering season there is a potential noise disturbance impact on bird assemblages, particularly while utilising off-site functional habitat although this is considered a short term impact not resulting in a risk of a likely significant effect. No direct impact pathways have been identified for this element during operational works due to the proposed timing of abstraction (outside of overwintering season) and distance from the designated site via hydrological connectivity. Therefore, no LSE are anticipated.	
Mythe abstraction reduction (15 Ml/d)	The element is located approximately [redacted] north-east of the Severn Estuary SPA and is approximately [redacted] north-east via hydrological connectivity. The SIP threats and pressures of potential relevance to this element 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 element is hydrologically linked to the designated site. No construction works are required and no risk of likely significant effects on the SPA have been identified during operation due to the timing (outside of overwintering season) and distance from the designated site via hydrological connectivity. Therefore, no LSE are anticipated.	**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		
Element:		Risk of Likely Significant Effects?
Vyrnwy Reservoir release (75 Ml/d)	The element is located approximately [redacted] north-west of the Severn Estuary Ramsar site and is approximately [redacted] north-west via hydrological connectivity. No impact pathways are anticipated during construction. **Ramsar Criterion 4 and 8** No impacts on European eel are anticipated as they spawn in offshore marine environments and the species has been excluded from any further consideration. There are potential impact pathways of this element on functionally linked/ supporting spawning and nursery habitats not within the boundary of the Ramsar site during operation. In particular Atlantic salmon, sea trout, sea lamprey, river lamprey, allis shad, twaite shad. Monitoring undertaken during trial releases in support of the investigations of physical losses from a Vyrnwy reservoir support release concluded that a 75Ml/d release (in addition to the 45Ml/d) will not result in increased velocities and depth that would result in impacts on the fish community of the reaches of the River Vyrnwy from downstream of the reservoir to the confluence with the River Banwy. Further monitoring is required to support the conclusions. It is noted that the Vyrnwy Reservoir forms part of the River Severn Regulation operation and a review of the past 10 years of data suggests that releases in support of a STT could often occur when regulation releases are being made. At times of both regulation and support release, flows would exceed the recommended 75Ml/d releases). The elevated volumes of water transported down the River Vyrnwy and subsequent rise in water flow could cause an increase in suspended sediment and disturbance/ displacement of juvenile fish species present in nursery habitats upstream. Therefore, LSE on qualifying species associated with Ramsar Criterion 4 and 8 cannot be discounted at this stage. This is in consideration of the support releases coinciding with regulation releases	**Yes**
	Ramsar Criterion 1 and 3 The spread of invasive species from the Lake Vyrnwy Reservoir to the Severn Estuary Ramsar site has been identified as a potential impact pathway effecting qualifying habitat features during operation. Notable invasive species present in the River Vyrnwy during kick sampling and eDNA in spring and summer 2020 included quagga mussel (*Dreissena bugensis*), zebra mussel (*Dreissena polymorpha*) and Asian clam (*Corbicula fluminea*). Due to the low salinity tolerance of quagga mussel (5 ptt), the spread of this species is limited to freshwater habitats; the species	**No**

Designated site name:	Severn Estuary Ramsar (UK11081)	
	was also absent in eDNA samples collected at Netheridge discharge point. Both zebra mussel and the Asian clam were recorded during eDNA sampling at Netheridge discharge point, therefore no further spread is anticipated from this element (as already present downstream). No impact pathways for the maximum regulation release of this element have been identified for qualifying features of the Ramsar site. This is because the proposed flow rate of regulation releases from Lake Vyrnwy Reservoir is low in comparison to the natural fluctuations of the Severn Estuary, considering its large tidal range. In addition, due to abstraction points downstream of the regulation release, elevated flows will be reduced and flows into the Severn Estuary will be protected by the relevant hands-off flow conditions put in place. Therefore, no LSE are anticipated for this element.	
	Ramsar Criterion 5 and 6 No construction works are required and no direct impacts during operation of this element have been identified on qualifying species/ populations of waterbird associated with the Ramsar site. This is due to the timing of the proposed operational works (outside of overwintering season) and negligible impacts of regulation releases from the Lake Vyrnwy Reservoir on water flow within the Severn Estuary. Therefore, no LSE from this element are anticipated on qualifying species/ populations of waterbird associated with the Ramsar site.	**No**
River Vyrnwy Mitigation - Vyrnwy release (100Mld) and Bypass (80Mld)	This element includes 75 Ml/d regulation release from Lake Vyrnwy Reservoir, 80 Ml/d from the Vyrnwy Aqueduct to the River Vyrnwy via a bypass (option 5) and a contribution of 25 Ml/d from the abstraction reduction at Shrewsbury. The element is located approximately [redacted] (at closest point) north-west of the Severn Estuary Ramsar site and is approximately [redacted] north-west via hydrological connectivity. **Ramsar Criterion 4 and 8** No impacts on European eel are anticipated as they spawn in offshore marine environments and the species has been excluded from any further consideration. There are potential impact pathways of this element on functionally linked/ supporting spawning and nursery habitats not within the boundary of the Ramsar site during operation. In particular Atlantic salmon, sea trout, sea lamprey, river lamprey, allis shad, twaite shad. Monitoring undertaken during trial releases in support of the investigations of physical losses from a Vyrnwy reservoir support release concluded that a 75Ml/d release (in addition to the 45Ml/d) will not result in increased velocities and depth that would result in impacts on the fish community of the reaches of the River Vyrnwy from downstream of the reservoir to the confluence with the River Banwy. Further monitoring is required to support the conclusions. It is noted that the Vyrnwy Reservoir forms part of the River Severn Regulation operation and a review of the past 10 years of data suggests that releases in support of a STT could often occur when regulation releases are being made. At times of both regulation and support release, flows would exceed the recommended 75Ml/d releases). The elevated volumes of water transported down the River Vyrnwy and subsequent rise in water flow could cause an increase in suspended sediment and disturbance/ displacement of juvenile fish species present in nursery habitats upstream. Therefore, LSE on qualifying species associated with Ramsar Criterion 4 and 8 cannot be discounted at this stage.	**Yes**
	Ramsar Criterion 1 and 3 The spread of invasive species from the Lake Vyrnwy Reservoir and Vyrnwy Aqueduct to the Severn Estuary Ramsar site has been identified as a potential impact pathway effecting qualifying habitat features during operation. Notable invasive species present in the River Vyrnwy during kick sampling and eDNA in spring and summer 2020 included quagga mussel (*Dreissena bugensis*), zebra mussel (*Dreissena polymorpha*) and Asian clam (*Corbicula fluminea*). Due to the low salinity tolerance of quagga mussel (5 ptt), the spread of this species is limited to freshwater habitats; the species was also absent in eDNA samples collected at Netheridge discharge point. Both zebra mussel and the Asian clam were recorded during eDNA sampling at Netheridge discharge point, therefore no further spread is anticipated from this element (as already present downstream). Potential impact pathways on qualifying habitat features of the Ramsar site also include changes in hydrological regime and extended periods of inundation. However, considering the large tidal range of the Severn Estuary and natural fluctuations that qualifying habitat features are exposed to, the impact of 180 Ml/d elevated flows during operation of this element are considered negligible. In addition, due to abstraction points downstream of the regulation release, elevated flows will be reduced and flows into the Severn Estuary will be protected by the relevant hands-off flow conditions put in place. Therefore, no LSE are anticipated for this element.	**No**
	Ramsar Criterion 5 and 6 No direct impacts during construction and operation of this element have been identified on qualifying species/ populations of waterbird associated with the Ramsar site. This is due to the distance between construction works and the Ramsar site, timing of the proposed operational works (outside of overwintering season) and negligible impacts of regulation releases from the Lake Vyrnwy Reservoir on water flow within the Severn Estuary. Therefore, no LSE from this element are anticipated on qualifying species/ populations of waterbird associated with the Ramsar site.	**No**
River Vyrnwy Mitigation – Vyrnwy Bypass release (155Mld)	This element includes the regulation release of 155 Ml/d from the Vyrnwy Aqueduct, (which feeds Oswestry WTW) to the River Vyrnwy and a contribution of 25 Ml/d from the abstraction reduction at Shrewsbury. The element is located approximately [redacted] (at closest point) north-west of the Severn Estuary Ramsar site and is approximately [redacted] north-west via hydrological connectivity. **Ramsar Criterion 4 and 8** No impacts on European eel are anticipated as they spawn in offshore marine environments and the species has been excluded from any further consideration. There are potential impact pathways of this element on functionally linked/ supporting spawning and nursery habitats not within the boundary of the Ramsar site during operation. The elevated volumes of water transported down the River Vyrnwy and subsequent rise in water flow could cause an increase in suspended sediment and disturbance/ displacement of juvenile fish species present in nursery habitats upstream. Long term impacts of this element may include alteration of the structure and function of suitable spawning and nursery habitat. In addition, the elevated volumes of water and subsequent rise in water flow could increase energy expenditure required for species to successfully migrate to spawning sites upstream. For example, adult sea lamprey migrate upstream from April – May and spawn from late May – June and adult twaite shad migrate upstream to spawn from mid May – mid July**Error! Bookmark not defined.** which could both overlap with the o perational timing of this element and have long term implications on population abundance. Therefore, LSE on qualifying species associated with Ramsar Criterion 4 and 8 cannot be discounted at this stage.	**Yes**

Designated site name:	**Severn Estuary Ramsar (UK11081)**	
	Ramsar Criterion 1 and 3 The spread of invasive species from the Lake Vyrnwy Reservoir and Vyrnwy Aqueduct to the Severn Estuary Ramsar site has been identified as a potential impact pathway effecting qualifying habitat features during operation. Notable invasive species present in the River Vyrnwy during kick sampling and eDNA in spring and summer 2020 included quagga mussel (*Dreissena bugensis*), zebra mussel (*Dreissena polymorpha*) and Asian clam (*Corbicula fluminea*). Due to the low salinity tolerance of quagga mussel (5 ptt), the spread of this species is limited to freshwater habitats; the species was also absent in eDNA samples collected at Netheridge discharge point. Both zebra mussel and the Asian clam were recorded during eDNA sampling at Netheridge discharge point, therefore no further spread is anticipated from this element (as already present downstream). Potential impact pathways on qualifying habitat features of the Ramsar site also include changes in hydrological regime and extended periods of inundation. However, considering the large tidal range of the Severn Estuary and natural fluctuations that qualifying habitat features are exposed to, the impact of 180 Ml/d elevated flows during operation of this element are considered negligible. In addition, due to abstraction points downstream of the regulation release, elevated flows will be reduced and flows into the Severn Estuary will be protected by the relevant hands-off flow conditions put in place. Therefore, no LSE are anticipated for this element.	**No**
	Ramsar Criterion 5 and 6 No direct impacts during construction and operation of this element have been identified on qualifying species/ populations of waterbird associated with the Ramsar site. This is due to the distance between construction works and the Ramsar site, timing of the proposed operational works (outside of overwintering season) and negligible impacts of regulation releases from the Lake Vyrnwy Reservoir on water flow within the Severn Estuary. Therefore, no LSE from this element are anticipated on qualifying species/ populations of waterbird associated with the Ramsar site.	**No**
River Vyrnwy Mitigation – Vyrnwy Bypass release (180Mld)	The element is located approximately [redacted] (at closest point) north-west of the Severn Estuary Ramsar site and is approximately [redacted] north-west via hydrological connectivity. No impact pathways are anticipated during construction. **Ramsar Criterion 4 and 8** This element comprises a raw water pipeline which will transport 180 Ml/d from the Vyrnwy Aqueduct, (which feeds Oswestry WTW) to the River Severn. Potential impact pathways include increased suspended sediment at the outfall location and fluctuations in pH, water temperature, dissolved oxygen and nutrient concentrations, depending on the water quality of the raw water discharge. On the basis that discharged water must be compliant with Water Framework Directive water quality standards and the discharge rate will be controlled, no likely significant effects are anticipated on localised abiotic parameters. In addition, elevating the flow rate in the Upper River Severn could impact on the successful upstream migration of river lamprey, sea lamprey and twaite shad to suitable spawning habitats. From the Vyrnwy confluence to downstream of Shrewsbury, hydrological modelling has confirmed that on 58% of the supporting flow dates, the same flow band would be retained. For the remaining 42% of the supporting flow dates, the flow bands would increase from 1 to >2; with the largest changes all occurring from exceptionally low to normal flow[50]. This elevation of water flow during low flow periods may benefit anadromous species that rely on sufficient water flow to migrate upstream to spawn, particularly sea lamprey that migrate upstream from April – May and spawn from late May – June and twaite shad, that migrate upstream to spawn from mid May – mid July. Downstream of Shrewsbury to the Avon confluence the impacts of discharging 180 Ml/d from the proposed bypass (option 7) on flow reduce, with retention of the flow band for 70% of the supporting flow dates. Considering the sporadic nature that this element will be operational and the negligible changes in flow (maximum change to normal flow conditions), no risk of likely significant effects on river lamprey, sea lamprey and twaite shad are anticipated.	**No**
	Ramsar Criterion 1 and 3 The spread of invasive species from the Vyrnwy Aqueduct to the Severn Estuary Ramsar site has been identified as a potential impact pathway effecting qualifying habitat features during operation. Notable invasive species present in the River Vyrnwy during kick sampling and eDNA in spring and summer 2020 included quagga mussel (*Dreissena bugensis*), zebra mussel (*Dreissena polymorpha*) and Asian clam (*Corbicula fluminea*). Due to the low salinity tolerance of quagga mussel (5 ptt), the spread of this species is limited to freshwater habitats; the species was also absent in eDNA samples collected at Netheridge discharge point. Both zebra mussel and the Asian clam were recorded during eDNA sampling at Netheridge discharge point, therefore no further spread is anticipated from this element (as already present downstream). Potential impact pathways on qualifying habitat features of the Ramsar site also include changes in hydrological regime and extended periods of inundation. However, considering the large tidal range of the Severn Estuary and natural fluctuations that qualifying habitat features are exposed to, the impact of 180 Ml/d elevated flows during operation of this element are considered negligible. In addition, due to abstraction points downstream of the regulation release, elevated flows will be reduced and flows into the Severn Estuary will be protected by the relevant hands-off flow conditions put in place. Therefore, no LSE are anticipated for this element.	**No**
	Ramsar Criterion 5 and 6 No direct impacts during construction and operation of this element have been identified on qualifying species/ populations of waterbird associated with the Ramsar site. This is due to the distance between construction works and the Ramsar site, timing of the proposed operational works (outside of overwintering season) and negligible impacts of regulation releases from the Lake Vyrnwy Reservoir on water flow within the Severn Estuary. Therefore, no LSE from this element are anticipated on qualifying species/ populations of waterbird associated with the Ramsar site.	**No**
Vyrnwy Mitigation – Shrewsbury	The element is located approximately [redacted] (at closest point) north-west of the Severn Estuary Ramsar site and is approximately [redacted] north-west via hydrological connectivity. The proposed scheme will not require land take from within the designated site however, the element is hydrologically linked to the designated site. No construction works are required and due to the distance from the designated site and small abstraction reduction proposed, no LSE are anticipated on any of the designated sites.	**No**

[50] Ricardo (2021). *Seven to Thames Transfer SRO. Evidence Report: River Severn – Vyrnwy Confluence to Downstream of Shrewsbury*. Report for United Utilities.

Designated site name:	Severn Estuary Ramsar (UK11081)	
abstraction reduction (25 Ml/d)		
Pipeline conveyance, Deerhurst to Culham (300, 400 and 500 Ml/d)	This element is located approximately [redacted] north of the Severn Estuary Ramsar site and approximately [redacted] north via hydrological connectivity. The proposed scheme will not require land take from within the designated site and construction activities are at a sufficient distance that no significant impacts on the qualifying habitat features are anticipated as a result of construction. **Ramsar Criterion 4 and 8** Off-site functional habitat could potentially be affected along the Severn between the river intake at Deerhurst and the designated site during construction, due to localised increases in suspended sediment (siltation and deposition), potential invasive species spread, noise and vibration disturbance, entrapment and impingement and potential water pollution incidents. Reduced water flow surrounding the abstraction point may also cause localised changes in nutrient loading, turbidity, salinity regime, reduced dissolved oxygen and changes in dilution of pollutants. In the absence of mitigation, there is a risk of likely significant effects for designated fish species. The Environment Agency has advised a STT abstraction licence would be limited to not reduce flow at Deerhurst flow gauging station below 2,568 Ml/d, a hands-off flow (HoF) condition. At flows greater than this HoF, up to 172Ml/d is available for abstraction without support, and at flows greater than 3,333Ml/d an additional 355Ml/d is available for abstraction without support. As such, the impact on downstream river levels is not expected to be of a magnitude that would impede upstream passage of qualifying fish or impact on the supporting processes within the estuary. Further assessment will also consider Criterion 4 of the Ramsar site designation: qualifies as it is important for the run of migratory fish between sea and river via estuary as well as 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[51].	**Yes**
	Ramsar Criterion 1 and 3 Due do the distance of the proposed abstraction/element from reef features and subtidal sandbanks, no impact pathways are anticipated. During construction potential impact pathways on the estuary include siltation and deposition, impedance of movement, entrapment and impingement, noise and vibration disturbance, salinity regime changes and temperature changes. During operation, abstraction from the River Severn will reduce the volume of water transported downstream to the Severn Estuary and the same impact pathways apply, in addition to reduced dissolved oxygen and change in dilution of pollutants. The reduced flow could also expose a greater area of peripheral habitats in the Severn Estuary including mudflats and sandflats and Atlantic salt meadows during times of operation (summer). However, due to the large tidal range, high flow rates within the estuary and distance of this element from the designated site, no LSE are anticipated.	**No**
	Ramsar Criterion 5 and 6 Significant air quality impacts during construction are not anticipated due to the distance between the proposed construction works and qualifying feature. Given the significant distance of the construction works to the Severn Estuary Ramsar site and the relatively specialist habitat requirements of the qualifying bird species, no noise and vibration disturbance impacts are anticipated either within the site or whilst utilising off-site functional habitat. No direct impact pathways have been identified for this element during operational works due to the proposed timing of abstraction (outside of overwintering season) and distance from the designated site therefore, no LSE are anticipated.	**No**
Netheridge WwTW discharge diversion, Deerhurst pipeline (35 Ml/d)	This element is located approximately 1[redacted] north-east of the Severn Estuary Ramsar site and is approximately 4[redacted] 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. Due to the distance between the proposed works and the designated site via hydrological connectivity, temporary nature of constructing the outfall and relatively small footprint of the outfall on the river bank (250 m²), no LSE are anticipated on qualifying species of the Ramsar site during construction. Potential impact pathways of this element 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 discharge from Netheridge WwTW. Due to the large tidal range of the Severn Estuary and small volume 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 Criterion 4 and 8 of the Ramsar site are anticipated.	**No**
	Ramsar Criterion 5 and 6 The footprint of this element 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 element 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 element during operational works, due to the proposed timing of the WwTW discharge (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 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 supporting habitat of the Ramsar site are anticipated.	**No**
	Ramsar Criterion 1 and 3 The footprint of this element is outside of the boundary of the Ramsar site. During proposed construction works for this element 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	**No**

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

Designated site name:	Severn Estuary Ramsar (UK11081)	
	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. Due to the large tidal range of the Severn Estuary and small volume proposed for diversion and discharge in the freshwater River Severn, negligible amendments to water flow within the river reach during operation are expected. Therefore, no LSE anticipated on qualifying habitats of the Ramsar site.	
Netheridge WwTW discharge diversion, Cotswold Canal (35 Ml/d)	This element is located approximately [redacted] north-east of the Severn Estuary Ramsar site and is approximately [redacted] 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. Due to the distance between the proposed works and the designated site via hydrological connectivity, temporary nature of constructing the outfall and relatively small footprint of the outfall on the river bank (250 m²), no LSE are anticipated on qualifying species of the Ramsar site during construction. Potential impact pathways of this element 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 water released from Netheridge WwTW. Due to the large tidal range of the Severn Estuary and small volume proposed for diversion and discharge close to Gloucester Docks, negligible amendments to water flow within the river reach during operation are anticipated. Therefore, no LSE on Criterion 4 and 8 of the Ramsar site are anticipated.	**No**
	Ramsar Criterion 5 and 6 The footprint of this element 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 element 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 element during operational works, due to the proposed timing of the WwTW discharge (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 proposed for diversion and discharge close to Gloucester Docks, negligible amendments to water flow within the river reach during operation are anticipated. Therefore, no LSE on supporting habitat of the Ramsar site are anticipated.	**No**
	Ramsar Criterion 1 and 3 The footprint of this element is outside of the boundary of the Ramsar site. During proposed construction works for this element 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. Due to the large tidal range of the Severn Estuary and small volume proposed for diversion and discharge close to Gloucester Docks, negligible amendments to water flow within the river reach during operation are expected. Therefore, no LSE anticipated on qualifying habitats of the Ramsar site.	**No**
Canal conveyance, including piping to Culham (300 Ml/d)	This element is located approximately [redacted] north-east of the Severn Estuary Ramsar site at its closest point and is approximately [redacted] north-east via hydrological connectivity. The proposed scheme will not require land take from within the designated site. **Ramsar Criterion 4 and 8** Off-site functional habitat could potentially be affected along the Severn between the river intake at Deerhurst and the designated site during construction, due to localised increases in suspended sediment (siltation and deposition), potential invasive species spread, noise and vibration disturbance, entrapment and impingement and potential water pollution incidents. Reduced water flow surrounding the abstraction point may also cause localised changes in nutrient loading, turbidity, salinity regime, reduced dissolved oxygen and changes in dilution of pollutants. In the absence of mitigation, there is a risk of likely significant effects for designated fish species. The Environment Agency has advised a STT abstraction licence would be limited to not reduce flow at Deerhurst flow gauging station below 2,568 Ml/d, a hands-off flow (HoF) condition. At flows greater than this HoF, up to 172 Ml/d is available for abstraction without support, and at flows greater than 3,333 Ml/d an additional 355 Ml/d is available for abstraction without support. As such, the impact on downstream river levels is not expected to be of a magnitude that would impede upstream passage of qualifying fish or impact on the supporting processes within the estuary. Further assessment will also consider Criterion 4 of the Ramsar site designation: qualifies as it is important for the run of migratory fish between sea and river via estuary as well as 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[52].	**Yes**
	Ramsar Criterion 1 and 3 Construction works including the rehabilitation of the canal pounds and locks are within [redacted] of qualifying habitat features. No significant air quality impacts are anticipated during construction due to the distance between the proposed works and the qualifying features. Due do the distance of the proposed abstraction/element from reef features and subtidal sandbanks, no impact pathways are anticipated. During operation, abstraction from the River Severn will reduce the volume of water transported downstream to the Severn Estuary. This could expose a greater area of peripheral habitats in the Severn Estuary including mudflats and sandflats and Atlantic salt meadows during times of operation (summer). However, due to the large tidal range, high flow rates within the estuary and distance of this element from the designated site, no LSE are anticipated.	**No**

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

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	Ramsar Criterion 5 and 6 Significant air quality impacts during construction are not anticipated for this element due to the distance between the proposed works and the qualifying features. If construction works to rehabilitate the canals pounds and locks took place during the overwintering season there is a potential noise disturbance impact on bird assemblages particularly while utilising off-site functional habitat. No direct impact pathways have been identified for this element during operational works due to the proposed timing of abstraction (outside of overwintering season) and distance from the designated site and therefore, no LSE are anticipated.	**No**
Mythe abstraction reduction (15 Ml/d)	The element is located approximately [redacted] north-east of the Severn Estuary Ramsar site and is approximately [redacted] north-east via hydrological connectivity. The proposed scheme will not require land take from within the designated site however, the element is hydrologically linked to the designated site. No construction works are required and due to the distance from the designated site and small abstraction reduction proposed, no LSE are anticipated on any of the designated sites.	**No**
Minworth WwTW discharge diversion (115 Ml/d)	The element is located [redacted] north-east of the Severn Estuary Ramsar site and is approximately [redacted] north-east via hydrological connectivity. The proposed scheme will not require land take from within the designated site however, the element is hydrologically linked to the designated site. **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. Due to the distance between the proposed works and the designated site via hydrological connectivity, temporary nature of constructing the outfall and relatively small footprint of the outfall on the river bank (500 m²), no LSE are anticipated on qualifying species of the Ramsar site during construction. Off-site functional habitat along the River Avon and River Severn between the proposed outfall location in Warwick and the designated site during operation could also be affected. This is due to localised increases in suspended sediment and the potential introduction/ spread of invasive and non-native species. The water will be treated before discharge and on the assumption that it will meet Water Framework Directive standards, no LSE from the introduction/ spread of invasive and non-native species are anticipated. As the element will also only be operational during low flows and the flow rate of discharge will be controlled as appropriate, no LSE from localised increases in suspended sediment are expected. Increased water flow created by the diverted dischargecould also increase the energetic cost of migrating upstream, resulting in reduced spawning success (although noted that no records have been identified for river lamprey, sea lamprey, twaite shad, allis shad and Atlantic salmon in the River Avon; only European eel identified during eDNA sampling). Based on hydrological assessments between Warwick and the Severn confluence on 279 of the supporting flow dates (50%) the same flow band would be retained, 214 dates (38%) would result in change by one flow band, 61 dates (11%) would result in change by two flow bands, and 9 (2%) would change by three flow bands - all from exceptionally low to normal. Therefore, during low flow periods the operation of this element could potentially have positive benefits on migration of qualifying species of the Ramsar site as flow in the River Avon will increase to normal flow bands. Therefore, no LSE are anticipated from this element.	**Yes**
	Ramsar Criterion 1 and 3 Due to the distance between this element and qualifying habitats of the Ramsar site, no LSE are anticipated during construction works. Invasive species spread has also been identified as a potential impact pathway during operation. Invasive species present in the River Avon at the discharge location include *Physella acuta,* Jenkins' Spire snail *(Potamopyrgus antipodarum),* demon shrimp *(Dikerogammarus haemobaphes),* Nuttall's waterweed *(Elodea nuttallii)* and *Hypania invalida. Physella acuta, Hypania invalida,* Jenkin's Spire snail and demon shrimp were present during sampling at Netheridge discharge point and therefore, already present in the River Severn. Nuttall's waterweed has similarly been recorded in Gloucester and it is not anticipated that the discharge diversion in Minworth will cause any further spread into the designated site. Based on hydrological assessments between Warwick and the Severn confluence on 279 of the supporting flow dates (50%) the same flow band would be retained, 214 dates (38%) would result in change by one flow band, 61 dates (11%) would result in change by two flow bands, and 9 (2%) would change by three flow bands - all from exceptionally low to normal. Therefore, during low flow periods the operation of this element could potentially have positive benefits on wetted habitats of the Ramsar site, as flow in the River Avon will increase to normal flow bands. Therefore, no LSE are anticipated for this element.	**No**
	Ramsar Criterion 5 and 6 No noise disturbance impacts from the construction of the pipeline are anticipated due to the distance between the element and the designated site. No impacts from the operation of this element have also been identified. Therefore, no LSE are anticipated for this element.	**No**

Designated site name:	**Tanat and Vyrnwy Bat sites (UK0014783)**	
Designation type: (SAC, SPA, Ramsar):	**SAC**	
Qualifying features:	1303 *Rhinolophus hipposideros;* Lesser horseshoe bat	**Water Dependency:** Species not identified as water dependent[53] however, lesser horseshoe bats utilise riparian habitats.
Current conservation status:	**1303 Lesser horseshoe bat *Rhinolophus hipposideros:* Improving** (range: favourable, population: favourable, habitat for the species: favourable, future prospects: favourable). Main pressures: removal of small landscape features for agricultural land consolidation, abandonment of grassland management, livestock farming (without grazing), conversion to other types of forests including monocultures, logging without replanting or natural regrowth, extraction of minerals, roads, paths, railroads and related infrastructure, construction or modification in existing urban or recreational areas, sports, tourism and leisure activities. Main threats: as identified above for main pressures in addition to other natural catastrophes.	
Conservation objectives:	The conservation objective is for the feature be in a favourable conservation status, where all of Performance Indicator conditions are satisfied, and all factors affecting the achievement of these conditions are under control. Performance indicators include performance indicators for feature condition: • Pre-parturition population(s) in maternity roosts • Population(s) in hibernation roosts. Performance indicators for factors affecting the feature: Site Security, Roost entrance(s), external disturbance, stability of roost, external condition of building, internal condition of the roost area, and the quality and quantity of woodland/scrub/hedgerow	
SSSI Condition assessment:	Hendre, Llangedwyn SSSI: 100% Favourable Allt-y-Main Main SSSI: 100% Favourable	
Site Improvement Plan:	Information not currently available	
Potential Effects		
Element:		Risk of Likely Significant Effects?
River Vyrnwy Mitigation - Vyrnwy release (100Mld) and Bypass (80Mld)	Management Unit 7 and 8 which form the Hendre Llangedwyn SSSI are located [redacted] west of Bypass pipeline route to the Lower Vyrnwy. Management Unit 7 is designated for a maternity roost of lesser horseshoe bats with Unit 8 designated for the presence of hedgerows that provide the only connectivity to adjacent woodland habitats that are used for foraging. There is no hydrological connectivity between the proposed bypass option and the Tanat and Vyrnwy Bat sites SAC Units 7 and 8. Preferred foraging habitats include broadleaved woodland well connected by commuting routes such as hedges, woodland edge and riparian trees (Bontadina *et al.*, 2002; Schofield *et al.*, 2002). Core Sustenance Zones (CSZs) are the area surrounding a communal bat roost within which habitat availability and quality will have a significant influence on the resilience and conservation status of the colony using the roost. The CSZ for lesser horseshoe bats is identified as 2km by Collins, 2016[54]. Therefore, the temporary habitat loss required during construction of the Vyrnwy bypass pipeline route is unlikely to significantly adversely affect the lesser horseshoe roost at Hendre Llangedwyn. The Vyrnwy release and alteration of the abstraction at Shrewsbury will occur over 10km from the SAC boundary and do not require construction. Therefore, there will be no potential for construction related impacts from these elements. Construction of the pipeline could result in temporary disturbance and fragmentation of foraging habitats however, as the proposed route is predominantly over [redacted] from the Hendre roost site and are outside of the CSZ for lesser horseshoe bats ([redacted] from roost), no significant effects are anticipated during construction of this element. The reach of the River Vyrnwy that will receive the reservoir release is located [redacted] south of Units 7 and 8 at Hendre and [redacted] south of Unit 9 Allt-y-main, which is a disused mine that supports hibernating lesser horseshoe bats. The reach of the River Vyrnwy is over 10km upstream of the bypass pipeline discharge to the River Vyrnwy and Shrewsbury intake on the River Severn downstream of the Vyrnwy confluence. Although lesser horseshoe bats utilise riparian habitats for foraging and commuting, they are not considered to be a water dependent species and are not considered to be sensitive to changes in flow velocity or water level in foraging habitats. Therefore, no LSE are anticipated during operation of the reservoir release, bypass pipeline or Shrewsbury intake.	**No**
River Vyrnwy Mitigation – Vyrnwy Bypass release (155Mld)	Management Unit 7 and 8 which form the Hendre Llangedwyn SSSi are located [redacted] west of Bypass pipeline route to the Lower Vyrnwy. Management Unit 7 is designated for a maternity roost of lesser horseshoe bats with Unit 8 designated for the presence of hedgerows that provide the only connectivity to adjacent woodland habitats that are used for foraging. There is no hydrological connectivity between the proposed bypass option and the Tanat and Vyrnwy Bat sites SAC Units 7 and 8. Preferred foraging habitats include broadleaved woodland well connected by commuting routes such as hedges, woodland edge and riparian trees (Bontadina *et al.*, 2002; Schofield *et al.*, 2002). CSZs are the area surrounding a communal bat roost within which habitat availability and quality will have a significant influence on the resilience and conservation status of the colony using the roost. The CSZ for lesser horseshoe bats is identified as 2 km by Collins, 2016[54]. Therefore, the temporary habitat loss required during construction of the Vyrnwy bypass pipeline route is unlikely to significantly adversely affect the lesser horseshoe roost at Hendre Llangedwyn. The Vyrnwy release and alteration of the abstraction at Shrewsbury will occur over [redacted] from the SAC boundary and do not require construction. Therefore, there will be no potential for construction related impacts from these elements. Construction of the pipeline could result in temporary disturbance and fragmentation of foraging habitats however as the proposed route is predominantly over 10km from the Hendre roost site and are outside of the CSZ for lesser horseshoe bats (2 km from roost) no significant effects are anticipated during construction element. The SAC is over 10km upstream of the bypass pipeline discharge to the River Vyrnwy and Shrewsbury intake on the River Severn downstream of the Vyrnwy confluence. Although lesser horseshoe bats utilise riparian habitats for foraging and commuting, they are not considered to be a water dependent species and are not considered to be sensitive to changes in flow velocity or water level in foraging habitats. This in addition to the large distance from the hydrologically affected reaches mean no LSE are anticipated during operation of the bypass pipeline or Shrewsbury intake.	**No**

[53] 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.
[54] Collins, J. (ed.) (2016) Bat Surveys for Professional Ecologists: Good Practice Guidelines (3rd edn). The Bat Conservation Trust, London. ISBN-13 978-1-872745-96-1.

Designated site name:	**Tanat and Vyrnwy Bat sites (UK0014783)**	
River Vyrnwy Mitigation – Vyrnwy Bypass release (180Mld)	Management Unit 7 and 8 which form the Hendre Llangedwyn SSSI are located [redacted] west of Bypass pipeline route to the Lower Vyrnwy. Management Unit 7 is designated for a maternity roost of lesser horseshoe bats with Unit 8 designated for the presence of hedgerows that provide the only connectivity to adjacent woodland habitats that are used for foraging. There is no hydrological connectivity between the proposed bypass option and the Tanat and Vyrnwy Bat sites SAC Units 7 and 8. Preferred foraging habitats include broadleaved woodland well connected by commuting routes such as hedges, woodland edge and riparian trees (Bontadina *et al.*, 2002; Schofield *et al.*, 2002). CSZs are the area surrounding a communal bat roost within which habitat availability and quality will have a significant influence on the resilience and conservation status of the colony using the roost. The CSZ for lesser horseshoe bats is identified as 2 km by Collins, 2016[54]. Therefore, the temporary habitat loss required during construction of the Vyrnwy bypass pipeline route is unlikely to significantly affect the lesser horseshoe roost at Hendre Llangedwyn. The Vyrnwy release and alteration of the abstraction at Shrewsbury will occur over [redacted] from the SAC boundary and do not require construction. Therefore, there will be no potential for construction related impacts from these elements. Construction of the pipeline could result in temporary disturbance and fragmentation of foraging habitats however as the proposed route is predominantly over [redacted] from the Hendre roost site and are outside of the core sustenance zone for lesser horseshoe bats (2 km from roost) no significant effects are anticipated during construction element. The reach of the River Vyrnwy that will receive the reservoir release is located [redacted] south of Units 7 and 8 at Hendre and [redacted] south of Unit 9 Allt-y-main, which is a disused mine that supports hibernating lesser horseshoe bats. The reach of the River Vyrnwy is over 10km upstream of the bypass pipeline discharge to the River Severn or Shrewsbury intake on the River Severn downstream of the Vyrnwy confluence. Although lesser horseshoe bats utilise riparian habitats for foraging and commuting, they are not considered to be a water dependent species and are not considered to be sensitive to changes in flow velocity or water level in foraging habitats. Therefore, no LSE are anticipated during operation of the reservoir release, bypass pipeline or Shrewsbury intake.	**No**
Vyrnwy Mitigation – Shrewsbury redeployment (25 Ml/d)	This element comprises of multiple elements with the pumping station for Pant DSR located [redacted] east of the Tanat and Vyrnwy Bat sites SAC. Potential impact pathways during construction of the pumping station include temporary noise, light and vibration disturbance, fragmentation of foraging habitat, air pollution and pollution incidents from construction vehicles. Due to the location of the pumping station close to the A483 and lack of linear vegetation, no significant impacts on foraging habitat are anticipated. In addition, due to the distance between the proposed pumping station and the SAC, noise, light and vibration disturbance and pollution incidents from construction works are considered unlikely to impact on qualifying species of the SAC. No significant air quality impacts are anticipated as the option element is sufficiently distant from the designated sites. Hydrological changes during operation of this element must also be considered. Lesser horseshoe bats are not considered to be a water dependent species and are not considered to be sensitive to changes in flow velocity or water level in foraging habitats. Therefore, no LSE are anticipated during operation of Shrewsbury redeployment	**No**

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[55]: • *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		
Element:		Risk of Likely Significant Effects?
Netheridge WwTW discharge diversion, Deerhurst pipeline (35 Ml/d)	This element is located [redacted] south-east of Walmore Common SPA. The SIP threats and pressures of potential relevance to this element 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 specie distribution. As Bewick's swans overwinter at Walmore Common from October – March, hydrological changes in the Severn Estuary during operation of the element will not directly impact on the population. Negligible impacts on hydrological regime are anticipated within the Severn Estuary and therefore, no impacts on supporting saltmarsh habitat are expected. In conclusion, no LSE are anticipated.	**No**
Netheridge WwTW discharge diversion, Cotswold Canal (35 Ml/d)	This element is located [redacted] south-east of Walmore Common SPA. The SIP threats and pressures of potential relevance to this element 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 specie distribution. As Bewick's swans overwinter at Walmore Common from October – March, hydrological changes in the Severn Estuary during operation of the element will not directly impact on the population. Negligible impacts on hydrological regime are anticipated within the Severn Estuary and therefore, no impacts on supporting saltmarsh habitat are expected. In conclusion, no LSE are anticipated.	**No**
Canal conveyance, including piping to Culham (300 Ml/d)	This element is located [redacted] south-east of Walmore Common SPA. The SIP threats and pressures of relevant to this element are (1) hydrological changes, (2) changes in species distribution and (4) offsite habitat availability/management. The impact of noise/ vibration/ light disturbance on species distribution during construction works to rehabilitate the canal pounds and locks is anticipated to be minimal, due to the distance between Gloucester and sharpness canal and Walmore Common SPA and likely sporadic nature of the works. As Bewick's swans overwinter at Walmore Common (October – March), hydrological changes in the Severn Estuary during operation at low flows (spring – summer) will not impact on this population. No offsite grazing areas have also been identified in proximity of the proposed intake site and water quality deterioration during low flow conditions downstream of the intake site are expected to remain localised. Therefore, no LSE are anticipated.	**No**

[55] 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[56]: • *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		
Element:		Risk of Likely Significant Effects?
Netheridge WwTW discharge diversion, Deerhurst pipeline (35 Ml/d)	This element is located [redacted] 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. As Bewick's swans overwinter at Walmore Common from October – March, hydrological changes in the Severn Estuary during operation of the element will not directly impact on the population. Negligible impacts on hydrological regime are anticipated within the Severn Estuary and therefore, no impacts on supporting saltmarsh habitat are expected. In conclusion, no LSE are anticipated.	**No**
Netheridge WwTW discharge diversion, Cotswold canal (35 Ml/d)	This element is located [redacted] 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. As Bewick's swans overwinter at Walmore Common from October – March, hydrological changes in the Severn Estuary during operation of the element will not directly impact on the population. Negligible impacts on hydrological regime are anticipated within the Severn Estuary and therefore, no impacts on supporting saltmarsh habitat are expected. In conclusion, no LSE are anticipated.	**No**
Canal conveyance, including piping to Culham (300 Ml/d)	This element is located [redacted] south-east of Walmore Common Ramsar site. The impact of noise/ vibration/ light disturbance on species distribution during construction works to rehabilitate the canal pounds and locks is anticipated to be minimal, due to the distance between Gloucester and sharpness canal and Walmore Common Ramsar site and likely sporadic nature of the works. As Bewick's swans overwinter at Walmore Common (October – March), hydrological changes in the Severn Estuary during operation at low flows (spring – summer) will not impact on this population. No offsite grazing areas have also been identified in proximity of the proposed intake site and water quality deterioration during low flow conditions downstream of the intake site are expected to remain localised. Therefore, no LSE are anticipated.	**No**

[56] 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.

4.2 HRA Screening conclusions

A summary of the outcomes of the HRA screening process for elements is presented in **Table 4.3.**

Table 4.3: Summary of the outcomes of HRA Screening Assessment of the Elements for Severn to Thames Transfer, indicating which require Stage 2 Appropriate Assessment due to a risk of likely significant effects on European designated sites.

European designated site	Elements	Risk of Likely significant effect?
Berwyn and South Clywd Mountains SAC	Vyrnwy Reservoir release (75 Ml/d) River Vyrnwy Mitigation – Vyrnwy release (100 Ml/d) and Bypass (80 Ml/d)	No
Berwyn SPA	Vyrnwy Reservoir release (75 Ml/d) River Vyrnwy Mitigation – Vyrnwy release (100 Ml/d) and Bypass (80 Ml/d)	No
Bredon Hill SAC	Pipeline conveyance, Deerhurst to Culham (300, 400 and 500 Ml/d) Mythe abstraction reduction (15 Ml/d)	No
Chilterns Beechwoods SAC	Pipeline conveyance, Deerhurst to Culham (300, 400 and 500 Ml/d) Canal conveyance, including piping to Culham (300 Ml/d)	No
Cothill Fen SAC	Pipeline conveyance, Deerhurst to Culham (300, 400 and 500 Ml/d) Canal conveyance, including piping to Culham (300 Ml/d)	No
Cotswold Beechwoods SAC	Netheridge WwTW discharge diversion, Deerhurst pipeline (35 Ml/d) Netheridge WwTW discharge diversion, Cotswold canal (35 Ml/d) Canal conveyance, including piping to Culham (300 Ml/d) Pipeline conveyance, Deerhurst to Culham (300, 400 and 500 Ml/d)	No
Dixton Wood SAC	Netheridge WwTW discharge diversion, Deerhurst pipeline (35 Ml/d) Netheridge WwTW discharge diversion, Cotswold canal (35 Ml/d) Pipeline conveyance, Deerhurst to Culham (300, 400 and 500 Ml/d) Mythe abstraction reduction (15 Ml/d)	No
Hartslock Wood SAC	Pipeline conveyance, Deerhurst to Culham (300, 400 and 500 Ml/d) Canal conveyance, including piping to Culham (300 Ml/d)	No
Little Wittenham SAC	Pipeline conveyance, Deerhurst to Culham (300, 400 and 500 Ml/d) Canal conveyance, including piping to Culham (300 Ml/d)	No
Montgomery Canal SAC	River Vyrnwy Mitigation – Vyrnwy release (100 Ml/d) and Bypass (80 Ml/d) River Vyrnwy Mitigation – Vyrnwy Bypass release (155Mld) River Vyrnwy Mitigation – Vyrnwy Bypass release (180Mld)	No
Midland Meres and Mosses Phase 1 Ramsar	River Vyrnwy Mitigation – Vyrnwy release (100 Ml/d) and Bypass (80 Ml/d) River Vyrnwy Mitigation – Vyrnwy Bypass release (155Mld) River Vyrnwy Mitigation – Vyrnwy Bypass release (180Mld) River Vyrnwy Mitigation – Shrewsbury Redeployment (25Mld)	No
Midland Meres and Mosses Phase 2 Ramsar	River Vyrnwy Mitigation – Vyrnwy release (100 Ml/d) and Bypass (80 Ml/d) River Vyrnwy Mitigation – Vyrnwy Bypass release (155Mld) River Vyrnwy Mitigation – Vyrnwy Bypass release (180Mld) River Vyrnwy Mitigation – Shrewsbury Redeployment (25Mld)	No
North Meadow and Clattinger Farm SAC	Canal conveyance, including piping to Culham (300 Ml/d)	No
River Dee and Bala Lake SAC	River Vyrnwy Mitigation – Vyrnwy release (100 Ml/d) and Bypass (80 Ml/d) River Vyrnwy Mitigation – Vyrnwy Bypass release (155Mld) River Vyrnwy Mitigation – Vyrnwy Bypass release (180Mld)	No
River Clun SAC	Minworth WwTW discharge diversion – 115 Ml/d	Yes
River Usk SAC	Minworth WwTW discharge diversion – 115 Ml/d	Yes
River Wye SAC	Minworth WwTW discharge diversion – 115 Ml/d	Yes
Rodborough Common SAC	Canal conveyance, including piping to Culham (300 Ml/d)	No
Severn Estuary SAC	Netheridge WwTW discharge diversion, Deerhurst pipeline (35 Ml/d)	No
	Netheridge WwTW discharge diversion, Cotswold canal (35 Ml/d)	No
	Pipeline conveyance, Deerhurst to Culham (300, 400 and 500 Ml/d)	Yes

European designated site	Elements	Risk of Likely significant effect?
	Vyrnwy Reservoir release (75 Ml/d)	Yes
	River Vyrnwy Mitigation – Vyrnwy release (100 Ml/d) and Bypass (80 Ml/d)	Yes
	River Vyrnwy Mitigation – Vyrnwy Bypass release (155Mld)	Yes
	River Vyrnwy Mitigation – Vyrnwy Bypass release (180Mld)	No
	River Vyrnwy Mitigation – Shrewsbury Redeployment (25Mld)	No
	Canal conveyance, including piping to Culham (300 Ml/d)	Yes
	Mythe abstraction reduction (15 Ml/d)	No
	Minworth WwTW discharge diversion – 115 Ml/d	Yes
Severn Estuary SPA	Netheridge WwTW discharge diversion, Deerhurst pipeline (35 Ml/d)	No
	Netheridge WwTW discharge diversion, Cotswold canal (35 Ml/d)	No
	Pipeline conveyance, Deerhurst to Culham (300, 400 and 500 Ml/d)	No
	Vyrnwy Reservoir release (75 Ml/d)	No
	River Vyrnwy Mitigation – Vyrnwy release (100 Ml/d) and Bypass (80 Ml/d)	No
	River Vyrnwy Mitigation – Vyrnwy Bypass release (155Mld)	No
	River Vyrnwy Mitigation – Vyrnwy Bypass release (180Mld)	No
	River Vyrnwy Mitigation – Shrewsbury Redeployment (25Mld)	No
	Canal conveyance, including piping to Culham (300 Ml/d)	No
	Mythe abstraction reduction (15 Ml/d)	No
	Minworth WwTW discharge diversion (115 Ml/d)	No
Severn Estuary Ramsar	Netheridge WwTW discharge diversion, Deerhurst pipeline (35 Ml/d)	No
	Netheridge WwTW discharge diversion, Cotswold canal (35 Ml/d)	No
	Pipeline conveyance, Deerhurst to Culham (300, 400 and 500 Ml/d)	Yes
	Vyrnwy Reservoir release (75 Ml/d)	Yes
	River Vyrnwy Mitigation – Vyrnwy release (100 Ml/d) and Bypass (80 Ml/d)	Yes
	River Vyrnwy Mitigation – Vyrnwy Bypass release (155Mld)	Yes
	River Vyrnwy Mitigation – Vyrnwy Bypass release (180Mld)	No
	River Vyrnwy Mitigation – Shrewsbury Redeployment (25Mld)	No
	Canal conveyance, including piping to Culham (300 Ml/d)	Yes
	Mythe abstraction reduction (15 Ml/d)	No
	Minworth WwTW discharge diversion (115 Ml/d)	Yes
Tanat and Vyrnwy Bat sites SAC	River Vyrnwy Mitigation – Vyrnwy release (100 Ml/d) and Bypass (80 Ml/d) River Vyrnwy Mitigation – Vyrnwy Bypass release (155Mld) River Vyrnwy Mitigation – Vyrnwy Bypass release (180Mld) River Vyrnwy Mitigation – Shrewsbury Redeployment (25Mld)	No
Walmore Common SPA	Netheridge WwTW discharge diversion, Deerhurst pipeline (35 Ml/d) Netheridge WwTW discharge diversion, Cotswold canal (35 Ml/d) Canal conveyance, including piping to Culham (300 Ml/d)	No
Walmore Common Ramsar	Netheridge WwTW discharge diversion, Deerhurst pipeline (35 Ml/d) Netheridge WwTW discharge diversion, Cotswold canal (35 Ml/d) Canal conveyance, including piping to Culham (300 Ml/d)	No

The HRA screening has indicated that there are several elements that require further assessment and will be subject to the principles of the Stage 2 Appropriate Assessment to identify if they can meet the requirements of the integrity test and if further survey, assessment and mitigation development is required to provide greater certainty to any conclusions. A summary of the qualifying features and associated elements being screened in for Stage 2 Appropriate Assessment is presented in **Table 4.4.**

Table 4.4: Summary of the outcome of the HRA Screening Assessment of the Elements for Severn to Thames Transfer, indicating individual qualifying features which require Stage 2 Appropriate Assessment due to potential likely significant effects on European designated sites.

Element	Qualifying features	Likely significant effect?
Severn Estuary SAC and Ramsar		
Vyrnwy Reservoir release (75 Ml/d)	Estuaries	No
	Mudflats and sandflats not covered by seawater at low tide	No
	Atlantic salt meadows	No
	Sandbanks which are slightly covered by sea water all the time	No
	Reefs	No
	Sea lamprey	Yes – uncertain
	River lamprey	Yes – uncertain
	Twaite shad	Yes – uncertain
	Ramsar criterion 1 and 3	No
	Ramsar criterion 5 and 6	No
	Ramsar criterion 4 and 8	Yes – uncertain
River Vyrnwy Mitigation – Vyrnwy release (100 Ml/d) and Bypass (80 Ml/d)	Estuaries	No
	Mudflats and sandflats not covered by seawater at low tide	No
	Atlantic salt meadows	No
	Sandbanks which are slightly covered by sea water all the time	No
	Reefs	No
	Sea lamprey	Yes – uncertain
	River lamprey	Yes – uncertain
	Twaite shad	Yes – uncertain
	Ramsar criterion 1 and 3	No
	Ramsar criterion 5 and 6	No
	Ramsar criterion 4 and 8	Yes – uncertain
River Vyrnwy Mitigation – Vyrnwy Bypass release (155 Ml/d)	Estuaries	No
	Mudflats and sandflats not covered by seawater at low tide	No
	Atlantic salt meadows	No
	Sandbanks which are slightly covered by sea water all the time	No
	Reefs	No
	Sea lamprey	Yes – uncertain
	River lamprey	Yes – uncertain
	Twaite shad	Yes – uncertain
	Ramsar criterion 1 and 3	No
	Ramsar criterion 5 and 6	No
	Ramsar criterion 4 and 8	Yes – uncertain
Minworth WwTW discharge reuse	Estuaries	No
	Mudflats and sandflats not covered by seawater at low tide	No

Element	Qualifying features	Likely significant effect?
	Atlantic salt meadows	No
	Sandbanks which are slightly covered by sea water all the time	No
	Reefs	No
	Sea lamprey	Yes – uncertain
	River lamprey	Yes – uncertain
	Twaite shad	Yes – uncertain
	Ramsar criterion 1 and 3	No
	Ramsar criterion 5 and 6	No
	Ramsar criterion 4 and 8	Yes – uncertain
Pipeline conveyance, Deerhurst to Culham (300, 400 and 500 Ml/d)	Estuaries	No
	Mudflats and sandflats not covered by seawater at low tide	No
	Atlantic salt meadows	No
	Sandbanks which are slightly covered by sea water all the time	No
	Reefs	No
	Sea lamprey	Yes – uncertain
	River lamprey	Yes – uncertain
	Twaite shad	Yes – uncertain
	Ramsar criterion 1 and 3	No
	Ramsar criterion 5 and 6	No
	Ramsar criterion 4 and 8	Yes – uncertain
Canal conveyance, including piping to Culham (300 Ml/d)	Estuaries	No
	Mudflats and sandflats not covered by seawater at low tide	No
	Atlantic salt meadows	No
	Sandbanks which are slightly covered by sea water all the time	No
	Reefs	No
	Sea lamprey	Yes – uncertain
	River lamprey	Yes – uncertain
	Twaite shad	Yes – uncertain
	Ramsar criterion 1 and 3	No
	Ramsar criterion 5 and 6	No
	Ramsar criterion 4 and 8	Yes – uncertain
River Clun SAC		
Minworth WwTW discharge diversion (115Ml/d)	Freshwater pearl mussel	Yes – uncertain
River Usk SAC		
Minworth WwTW discharge diversion (115Ml/d)	Water courses of plain to montane levels with the Ranunculion fluitantis and Callitricho-Batrachion vegetation.	No
	Atlantic salmon	Yes – uncertain
	Sea lamprey	Yes – uncertain
	Brook lamprey	No

Element	Qualifying features	Likely significant effect?
	River lamprey	Yes – uncertain
	Twaite shad	Yes – uncertain
	Allis shad	Yes – uncertain
	Bullhead	No
	Otter	No
River Wye SAC		
Minworth WwTW discharge diversion (115Ml/d)	Water courses of plain to montane levels with the Ranunculion fluitantis and Callitricho-Batrachion vegetation.	No
	Transition mires and quaking bogs	No
	White-clawed (or Atlantic stream) crayfish	No
	Atlantic salmon	Yes – uncertain
	Sea lamprey	Yes – uncertain
	Brook lamprey	No
	River lamprey	Yes – uncertain
	Twaite shad	Yes – uncertain
	Bullhead	No
	Otter	No

5 Information to Inform Stage 2 Appropriate Assessment

5.1 Baseline

5.1.1 Severn Estuary SAC

The boundary of the Severn Estuary SAC (central location: Latitude 51.468611, Longitude -2.978055)[57] covers 737.14km² of the Severn Estuary; the largest coastal plain estuary in the UK[58] which supports a diversity of subtidal and intertidal habitats (approximately 2/3 subtidal and 1/3 intertidal)[59]. 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[58]. 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)[60]. Additional baseline information provided in the River Avon confluence to tidal limit Environmental Assessment Report[61]

River lamprey

River lamprey occupy a large region from southern Norway to the western Mediterranean in coastal, transitional and freshwater waterbodies[62]. 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[62]. 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[62]. Access to these functional habitats is vital for the species to complete its lifecycle[59]. Relevant marine data for this feature has not been collected[58] and records within the Severn Estuary itself are lacking, with the most recent observation logged in 1939[63]. Supporting datasets from inflowing rivers have recorded river lamprey in the River Severn (close to Gloucester) in 2014[64]. 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[67]. 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[67].

Sea lamprey

Sea lamprey is the largest species 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[65]. However, unlike river lamprey, it is absent from many northern and southern rivers in the UK due to pollution

[57] JNCC (2016). *Natura 2000 – Standard Data Form*. Natura 2000 Database, European Environment Agency.
[58] NRW (2018). *Severn Estuary / Môr Hafren Special Area of Conservation, Indicative site level feature condition assessments 2018*. NRW Evidence Report No: 235.
[59] 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.
[60] 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.
[61] United Utilities (2021). Severn to Thames Transfer SRO downstream River Avon confluence to the tidal limit. Report by Ricardo Energy and Environment.
[62] 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.
[63] NBN (2019) *Human observation of Lampetra fluviatilis (Linnaeus, 1758), River Lamprey recorded on 1939-12-31*. Bristol Regional Environmental Records Centre.
[64] NBN (2017) *Human observation of Lampetra fluviatilis (Linnaeus, 1758), River Lamprey recorded on 2014-10-20.* Environment Agency.
[65] 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.

incidents and the construction of migratory barriers[65]. 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[65]. Access to these functional habitats is vital for the species to complete its lifecycle[69]. 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[66]. NRW Monitoring programmes in the River Usk and Wye have previously assessed ammocoete densities as failing from 2007 - 2012[67]. 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[67].

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[68]. Populations in the Severn Estuary utilise the River Seven, Usk and Wye as spawning grounds (freshwater phase around 3 months[67]) and the estuary itself as nursery habitat where juvenile shad feed on plankton[69]. Adult twaite shad migrate upstream to spawn from mid May – mid July[68]. 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[70]. 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[67]. Water quality deterioration has also been highlighted as a factor directly impacting on the condition of this feature in the Severn Estuary SAC[67].

5.1.2 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[71]. 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*)[71]. 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 [72].

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[73]. 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.

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[66] NBN (2019). *Human observation of Petromyzon marinus (Linnaeus, 1758), Sea Lamprey recorded 1933-12-31*. Bristol Regional Environmental Records Centre.
[67] NRW (2018). *Severn Estuary / Môr Hafren Special Area of Conservation, Indicative site level feature condition assessments 2018*. NRW Evidence Report No: 235.
[68] 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.
[69] 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.
[70] NBN (2020). Occurrence records. Weblink: here. Date accessed: 08/12/2020.
[71] JNCC (2008). *Information Sheet on Ramsar Wetlands (RIS), Severn Estuary*. JNCC, Version 3, 1 – 13.
[72] United Utilities (2021). Severn to Thames Transfer SRO downstream River Avon confluence to the tidal limit. Report by Ricardo Energy and Environment.
[73] 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.

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[74]. 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[76].

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[75]. 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[76].

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[75]. The Severn Estuary supports an important eel and elver fishery and has the largest eel run in Britain[76].

5.1.3 River Clun SAC

The boundary of the River Clun SAC (central location: Latitude 52.37277778, Longitude - 2.891666667) covers 14.64ha. The River Clun is a tributary of the River Teme, which is the second largest tributary of the River Severn, draining a hilly, predominantly rural catchment of Silurian and Devonian rocks. The site includes only the lower reaches of the river and extends upstream from the confluence with the Teme to Broadward Bridge near Marlow. This section of the river holds a population of the freshwater pearl mussel one of the few lowland populations left in the UK. The freshwater pearl mussel larvae attach to the gills of salmon and trout before eventually detaching and settling in the riverbed gravels where they grow to adulthood.

Freshwater Pearl Mussel

The species is widely distributed in Europe, Fennoscandia and north-eastern North America, but has suffered serious decline and is threatened with extinction or is highly vulnerable in every part of its former range. It is listed as ‘vulnerable’ by IUCN, but is believed to be even more threatened. Outside Britain and Ireland, recruiting populations of international importance survive in probably fewer than 50 rivers world-wide. However, England and Wales are each now believed to support only a single recruiting population. In Northern Ireland, the species formerly occurred widely in several catchments, but is now restricted to a few sites. Many UK rivers now contain only scattered individuals, with no juvenile mussels recorded; such populations may become extinct due to lack of recruitment.

5.1.4 River Usk SAC

The boundary of the River Usk SAC (central location: Latitude 51.79583333, Longitude -3.013888889)[77] covers 967.97 km². The River Usk SAC rises in the Black Mountain range in the west of the Brecon Beacons National Park and flows east and then south, to enter the Severn Estuary at Newport. The run-off characteristics and nutrient status are significantly modified by land use in the catchment, which is predominantly pastoral with some woodland and commercial forestry in the headwaters and arable in the lower catchment. The Usk catchment is entirely within Wales. The

[74] Hendry, K. & Cragg-Hine, D (2003). *Ecology of Atlantic Salmon*. Conserving Natura 2000 Rivers Ecology Series No. 7. English Nature, Peterborough.
[75] Miller, P. J and Loates, M. J (1997) Fish of Britain and Europe. *Harper Collins Publishers*, 1 – 288.
[76] 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.
[77] JNCC (2016). *Natura 2000 – Standard Data Form*. Natura 2000 Database, European Environment Agency.

ecological structure and functions of the site are dependent on hydrological and geomorphological processes (often referred to as hydromorphological processes), as well as the quality of riparian habitats and connectivity of habitats. Animals that move around and sometimes leave the site, such as migratory fish and otters, may also be affected by factors operating outside the site.

5.1.5 River Wye SAC

The Wye, on the border of England and Wales, is a large river with a geologically mixed catchment, including shales and sandstones. There is a clear transition between the upland reaches, with characteristic bryophyte-dominated vegetation, and the lower reaches, with extensive water crow-foot *Ranunculus* beds. It represents most of the habitat conditions in which bullhead occurs in Britain. The site provides exceptionally good quality habitat for lampreys and supports healthy populations. The sea lamprey population is found in the main stem below Llyswen, whilst river and brook lampreys are widely distributed in the catchment. The Wye also contains high quality spawning grounds and juvenile habitat for Atlantic salmon. Twaite shad *Alosa fallax* have long been abundant in the Wye. The river also supports allis shad *A. alosa.*

5.2 Vyrnwy Reservoir release (75 Ml/d)

Vyrnwy reservoir regulation release involves the release of water from Lake Vyrnwy Reservoir into the River Vyrnwy for regulation of flow in the River Severn and downstream re-abstraction from the River Severn at Deerhurst. The water will subsequently be transferred into the River Thames to supply TW. The reservoir is owned and operated by WwTW but predominately supplies water to UU who hold the abstraction rights for the reservoir and who have offered the water to TW when required.

5.2.1 Potentially Affected European Sites

The HRA Screening concluded that implementation of Vyrnwy Reservoir regulation releases has the potential to result in likely significant effects on the **Severn Estuary SAC and Ramsar Site**.

Monitoring undertaken during trial releases in support of the investigations of physical losses from a Vyrnwy reservoir support release concluded that a 75Ml/d release (in addition to the 45Ml/d) will not result in increased velocities and depth that would result in impacts on the fish community of the reaches of the River Vyrnwy from downstream of the reservoir to the confluence with the River Banwy[78]. Further monitoring is required to support the conclusions. It is noted that the Vyrnwy Reservoir forms part of the River Severn Regulation operation and a review of the past 10 years of data suggests that releases in support of a STT could often occur when regulation releases are being made. At times of both regulation and support release, flows would exceed the recommended 75Ml/d releases).

The following qualifying features of the Severn Estuary SAC and Ramsar Site were screened in for further assessment through Appropriate Assessment:

- **Sea lamprey:** increase in water flow could cause disturbance and/or displacement of ammocoetes present in nursery habitats in the River Vyrnwy, increase energy expenditure required to successfully migrate to spawn upstream during severe drought conditions and alter the structure and function of suitable spawning habitats.
- **River lamprey:** increase in water flow could cause disturbance and/or displacement of ammocoetes present in nursery habitats in the River Vyrnwy, increase energy expenditure required to successfully migrate to spawn upstream during very dry weather, drought conditions and severe drought conditions, and alter the structure and function of suitable spawning habitats.
- **Twaite shad:** increase in water flow could increase energy expenditure required to successfully migrate to spawn upstream during very dry weather, drought conditions and severe drought conditions, and alter the structure and function of suitable spawning habitats.

[78] Ricardo Energy & Environment. Severn to Thames Transfer SRO. River Vyrnwy Test Releases. Initial Ecological Findings. Report for Thames Water. 1 February 2021

- **Allis shad:** increase in water flow could increase energy expenditure required to successfully migrate to spawn upstream during severe drought conditions and alter the structure and function of suitable spawning habitats. Migration upstream occurs from April – June typically[79].
- **Atlantic salmon:** increase in water flow could alter the structure and function of suitable spawning habitats. Migration upstream occurs from November – December typically[80].
- **Sea trout:** increase in water flow could increase energy expenditure required to successfully migrate to spawn upstream during dry weather periods, drought conditions and severe drought conditions, and alter the structure and function of suitable spawning habitats. Migration upstream occurs from September – December typically[80].

Conservation Objectives and Favourable Condition Targets

Specific attributes and targets associated with the conservation objectives for each qualifying feature of the SAC are provided in **Table 5.1** and current conservation status, SSSI condition assessment and site improvement plan are provided in **Table 4.2**.

[79] Maitland, P. S and Hatton-Ellis, T. S (2003). *Ecology of the Allis and Twaite Shad*. Conserving Natura 2000 Rivers Ecology Series No. 3. English Nature, Peterborough.
[80] Miller, P. J and Loates, M. J (1997) Fish of Britain and Europe. *Harper Collins Publishers*, 1 – 288.

Table 5.1: Assessment of adverse effects of the Vyrnwy Reservoir release (75 Ml/d) on the Severn Estuary SAC and Ramsar site

Qualifying Feature	Attribute	Target	Potential Effects	Mitigation & Monitoring	Adverse Effects Predicted
River lamprey Sea lamprey	Migratory access (barriers to migration).	– **Water quality** is sufficient to support migratory passage. Levels (for temperature, salinity, turbidity, pH, and dissolved oxygen) should comply with targets established under the EA Review of Consents and the Water Framework Directive. – **Water flows**: Flows from the rivers Wye, Usk and Severn into the estuary must be sufficient to allow migration. – **Physical barriers:** No artificial barriers significantly impairing adults from reaching existing and historical spawning grounds or juveniles from moving downstream.	**Construction** No construction of additional infrastructure is required for the Vyrnwy release option element **Operation** The results of an ongoing water quality monitoring programme indicated limited changes in water quality and that any changes are generally limited to the ~3km reach of the River Vyrnwy immediately downstream of the reservoir[81]. As such, water quality impacts on migration are considered negligible. Operationally there would be additional releases of 75Ml/d from Vyrnwy Reservoir for intermittent periods of typically 30 days, up to ~100 days, notably in June to November, particularly in the July, August & September period. Overall operation would be in the order of ~15% of dates at times of low flows in the lower River Severn. These flow changes would continue along the River Severn to the re-abstraction location with no overall change in flows to the Severn Estuary. 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 siltbeds), 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 10–11°C[82]. 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 support releases from the reservoir will typically occur outside of the river and sea lamprey upstream migration period except in the case of severe drought where releases could occur in October during the river lamprey upstream migration period. Post metamorphic individuals usually migrate downstream in late spring and early summer. Although this will coincide with potential support periods, the additional flows may provide a minor benefit to downstream migrating species. Any impacts on migration as a result of the support releases form the Vyrnwy Reservoir will, therefore, only coincide with river lamprey migration in the River Vyrnwy in late autumn. It is unlikely that river lamprey would have migrated to the upper reaches of the catchment so early in the migration period. Regardless, the monitoring completed during the trial releases to inform physical losses identified that a support release of 75Ml/d will not have a negative impact on velocity and depths and is unlikely to impact on river lamprey migration. There also remains some uncertainty with regards to the extent of spawning habitat for lamprey species in the River Vyrnwy and the subsequent extent to which the lamprey populations in the River Vyrnwy contribute to the lamprey community of the Severn SAC. Available data suggests that the lamprey population in the River Vyrnwy are very limited when compared to the other supporting watercourses (e.g. River Wye and River Usk). The release from Vyrnwy Reservoir will be 75 Ml/d is only a small percentage of the natural flow variation in the River Severn. In the summer, flows can exceed 8000Ml/d (e.g. in 2011), so the addition of 75Ml/d during lower flows (when the abstraction is likely to be required) is so small a change within the context of the natural flow variation of the River Severn as to be insignificant in relation to availability of conditions suitable for lamprey migration. Should support releases coincide with other regulation releases from Vyrnwy Reservoir these would cause major negative flow effects in the 24km reach of the River Vyrnwy to the River Banwy confluence, moderate negative effects further downstream in the River Vyrnwy and effects reducing to negligible in the River Severn. At times when the support releases from the Vyrnwy reservoir coincide with regulation releases for extended periods, the risk to migration will be higher, however it is noted that upstream migration of both river and lamprey	The operational rules of the Severn Regulation require a review and update to ensure support flows and regulation releases do not coincide. This could include, for example, the temporary use of alternative sources for regulation during times of support releases form the Vyrnwy Reservoir. The Maintained Flow and HoF needs to be reviewed to determine to what extent the compensation flow from the Vyrnwy reservoir is considered "abstractable" to further reduce the volume of releases from the Vyrnwy Reservoir.	No adverse effects predicted (there is a risk of adverse effects should support releases coincide with extended periods of regulation releases) **<u>Further monitoring assessment required:</u>** Targeted lamprey surveys to understand the distribution of lamprey species in the River Vyrnwy and an assessment of the potential contribution to the Severn Estuary populations. Mapping of optimal and sub-optimal lamprey ammocoete habitat is required. Mapping of the extent and location of lamprey spawning habitat is required. Review of potential barriers and possibility during higher flows. Further review of the contribution of the River Vyrnwy community to the Severn Estuary community based on updated data.

[81] Ricardo Energy & Environment (2019). Vyrnwy water quality monitoring study Interim Report – September 2019. Report on behalf of Thames Water. 26 September 2019.
[82] Hardisty MW & Potter IC (eds) (1971). *The biology of lampreys*. Academic Press, London.

Qualifying Feature	Attribute	Target	Potential Effects	Mitigation & Monitoring	Adverse Effects Predicted
			species generally occur at much higher flows than the compensation flows of the River Vyrnwy. Adverse affect on site integrity associated with Vyrnwy Reservoir 75Ml/d release are not predicted. Where regulation and support releases coincide for a short period/infrequently, adverse effects on site integrity are not predicted. This is in consideration of a precautionary approach and assumes that the River Vyrnwy provides significant spawning habitat resulting in the lamprey communities of the River Vyrnwy significantly contributing to the lamprey community of the Severn SAC. There remains some uncertainty with regards to the risk associated with the support releases that coincide with regulation releases for extent periods and the potential impact on migration. As such, it is concluded that adverse effects on site integrity are predicted when support and regulation releases coincide. In particular, when support releases and regulation releases exceed 175Ml/d for continuous periods. This is in consideration of a precautionary approach and assumes that the River Vyrnwy provides significant spawning habitat resulting in the lamprey communities of the River Vyrnwy significantly contributing to the lamprey community of the Severn SAC.		
	Population size (returning adults)	No decline in number of returning adults from established baseline.	**Construction** No construction of additional infrastructure is required for the Vyrnwy release option element **Operation** The river and sea lamprey population size in the Severn Estuary SAC is dependent on several factors including breeding success, which is reliant on the availability of functional spawning and nursery habitats in the River Usk SAC, River Wye SAC and River Severn. In addition, natural fluctuations in food and host availability will also impact on population size[83]. The number of returning adults to the estuary is dependent on a range of biotic and abiotic parameters relevant to marine and estuarine systems including predation pressures and environmental conditions. There is no potential for a reduction in water quality, flow, or water level within the estuarine habitats that support adult sea and river lamprey. The number of returning adults could, however, be impacted where there are impacts on spawning and nursery habitats as this could reduce the number of post-metamorphic individuals that migrate downstream which, in turn, would reduce the number of adults that would return in future. It is noted that no targeted lamprey surveys have been completed in the reaches of the River Vyrnwy from the Vyrnwy Reservoir to the confluence with the River Banwy. This information is important to understand the extent to which the reach contributes to the designated populations of the Severn Estuary. Information on the distribution of sub-optimal and optimal lamprey also remains uncertain. The assessment and conclusion are, therefore, based on the precautionary principal and assumes that the River Vyrnwy will provide a significant contribution to the overall population of the SAC Operationally there would be additional releases of 75Ml/d from Vyrnwy Reservoir for intermittent periods of typically 30 days, up to ~100 days, notably in June to November, particularly in the July, August & September period. Overall operation would be in the order of ~15% of dates at times of low flows in the lower River Severn. These flow changes would continue along the River Severn to the re-abstraction location with no overall change in flows to the Severn Estuary. As noted above, monitoring undertaken during trial releases in support of the investigations of physical losses from a Vyrnwy reservoir support release concluded that a 75Ml/d release (in addition to the 45Ml/d) will not result in increased velocities and depth that would result in impacts on the fish community of the reaches of the River Vyrnwy from downstream of the reservoir to the confluence with the River Banwy.	The operational rules of the Severn Regulation require a review and update to ensure support flows and regulation releases do not coincide. This could include, for example, the temporary use of alternative sources for regulation during times of support releases form the Vyrnwy Reservoir. The Maintained Flow and HoF needs to be reviewed to determine to what extent the compensation flow from the Vyrnwy reservoir is considered "abstractable" to further reduce the volume of releases from the Vyrnwy Reservoir. .	No adverse effects predicted (there is a risk of adverse effects should support releases coincide with extended periods of regulation releases) **<u>Further monitoring assessment required:</u>** Targeted lamprey surveys to understand the distribution of lamprey species in the River Vyrnwy and an assessment of the potential contribution to the Severn Estuary populations. Mapping of optimal and sub-optimal lamprey ammocoete habitat is required. Mapping of the extent and location of lamprey spawning habitat is required. Review of potential barriers and possibility during higher flows. Further review of the contribution of the River Vyrnwy community to the Severn Estuary community

[83] 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.

Qualifying Feature	Attribute	Target	Potential Effects	Mitigation & Monitoring	Adverse Effects Predicted
			Impacts on spawning and nursery habitat are, therefore, considered unlikely with adverse effects on site integrity not predicted, regardless of the extent to which the River Vyrnwy supports the lamprey populations of the Severn SAC. Further monitoring at during representative flow conditions are required to confirm the conclusions. At times when the support releases from the Vyrnwy reservoir coincide with regulation releases, adverse affect on site integrity are predicted. In particular, when support releases and regulation releases exceed 175Ml/d for continuous periods. This is in consideration of the precautionary principal and assumes that the River Vyrnwy significantly contributes to the lamprey population of the SAC.		based on updated data
	Prey species	No significant reduction in abundance of key prey species against an established baseline	**Construction** No construction of additional infrastructure is required for the Vyrnwy release option element **Operation** Lamprey ammocoetes are filter feeders which do not prey on fish or macroinvertebrates. Adult river lamprey feed on a range of estuarine species including herring (*Clupea harengus*), sprat (*Sprattus sprattus*) and flounder (*Platichthys flesus*)[84], adult river lamprey do not typically feed in freshwater so are dependent on estuarine prey species. Adult sea lamprey feed on a wide variety of marine and anadromous fishes, including sturgeon (*Acipenser sturio*), herring (*Clupea harengus*), salmon (*Salmo salar*), cod (*Gadus morhua*) and haddock (*Melanogrammus aeglefinus*). Salmon and sea trout (*Salmo trutta*) entering rivers are also exploited by sea lamprey[85]. Due to the absence of prey species in freshwater habitats and limited hydrological impacts downstream of the river Vyrnwy there is considered to be no potential for changes in the abundance of prey species for sea or river lamprey. Monitoring undertaken during trial releases in support of the investigations of physical losses from a Vyrnwy reservoir support release concluded that a 75Ml/d release (in addition to the 45Ml/d) will not result in increased velocities and depth that would result in impacts on the fish community of the reaches of the River Vyrnwy from downstream of the reservoir to the confluence with the River Banwy. Impacts on feeding as a result of a 75Ml/d release alone is unlikely to result in adverse effects on site integrity. Where regulation and support releases coincide for a short period/infrequently, adverse effect on site integrity are not predicted. At times when the support releases from the Vyrnwy reservoir coincide with regulation releases for extended periods, adverse effects on site integrity are predicted. In particular, when support releases and regulation releases exceed 175Ml/d for continuous periods. This is related to the potential risk of increased velocities over sub-optimal and optimal lamprey habitat and a reduction in the availability of food or impacts on feeding success of ammocoetes. This is in consideration of the precautionary principal and assumes that the River Vyrnwy significantly contributes to the lamprey population of the SAC.	The operational rules of the Severn Regulation require a review and update to ensure support flows and regulation releases do not coincide. This could include, for example, the temporary use of alternative sources for regulation during times of support releases form the Vyrnwy Reservoir. The Maintained Flow and HoF needs to be reviewed to determine to what extent the compensation flow from the Vyrnwy reservoir is considered “abstractable” to further reduce the volume of releases from the Vyrnwy Reservoir.	No adverse effects predicted (there is a risk of adverse effects should support releases coincide with extended periods of regulation releases) **<u>Further monitoring assessment required:</u>** Targeted lamprey surveys to understand the distribution of lamprey species in the River Vyrnwy and an assessment of the potential contribution to the Severn Estuary populations. Mapping of optimal and sub-optimal lamprey ammocoete habitat is required. Mapping of the extent and location of lamprey spawning habitat is required. Review of potential barriers and possibility during higher flows. Further review of the contribution of the River Vyrnwy community to the Severn Estuary community based on updated data
Twaite shad	Migratory access (barriers to migration).	– **Water quality** is sufficient to support migratory passage. Levels (for temperature, salinity, turbidity, pH, and dissolved oxygen) should comply with	**Operation** Depending on the operational pattern, the operation of the STT could result in the following: • Increased velocity and depths at spawning sites; • Direct washout/loss of incubating eggs and damage to spawning habitats;	The operational rules of the Severn Regulation require a review and update to ensure support flows and regulation releases do not coincide. This	No adverse effects predicted (there is a risk of adverse effects should support releases coincide with extended periods of regulation releases)

[84] Maitland PS (2003). *Ecology of the River, Brook and Sea Lamprey*. Conserving Natura 2000 Rivers Ecology Series No. 5. English Nature, Peterborough.
[85] Maitland PS (2003). *Ecology of the River, Brook and Sea Lamprey*. Conserving Natura 2000 Rivers Ecology Series No. 5. English Nature, Peterborough.

Qualifying Feature	Attribute	Target	Potential Effects	Mitigation & Monitoring	Adverse Effects Predicted
		targets established under the EA Review of Consents and the Water Framework Directive. – **Water flows**: Flows from the rivers Wye, Usk and Severn into the estuary must be sufficient to allow migration. – **Physical barriers:** No artificial barriers significantly impairing adults from reaching existing and historical spawning grounds or juveniles from moving downstream. –	• Increased erosion and siltation in some areas or the loss of spawning habitat; • Changes in water quality (in particular temperature and dissolved oxygen) as a result of support flows. The literature review completed by APEM[86] 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. It is, however, noted that the Unlocking the Severn scheme could result in an increase in the distribution for twait shad. Mature adults enter the estuaries of many European rivers from April onwards and migrate some distance upstream, though the exact distance is variable. In the River Wye, some fish travel over 190 km to reach their spawning grounds at Builth Wells. Unlike salmonids, however, shads do not enter narrow streams even when these are accessible. It is, therefore, likely that twait shad could in the future reach the River Vyrnwy. Assuming that spawning habitat is available, twait shad could also potentially spawn in the River Vyrnwy. The operation of the STT could coincide with migration periods (within the current and future migration limits). The spawning habitat of twaite shad in the rivers Wye, Usk,Tywi and Teme comprises a fast-flowing, shallow area of unconsolidated gravel/pebble and/or cobble substrate. Most of the substrates at the twaite shad spawning sites identified in rivers in England and Wales are described as 'gravel'. In France, twaite shad have been recorded as spawning in relatively slow-flowing deep water, and in the River Severn some may spawn at depths of up to 3 m. The fact that egg density was found to decline with depth suggests that, in these particular rivers, twaite shad prefer to deposit their eggs in shallow areas where the water depth is around 45 cm. Although spawning sites are not necessarily very deep, they are always in places where the river is still tens of metres wide. In Britain, the narrowest site in which spawning has been recorded (on the River Teme) is around 20 m wide The River Vyrnwy is expected to provide limited spawning habitat, especially in the lower reaches. Regardless, the velocity and depths changes are expected to remain within the required spawning conditions for twaite shad. It is concluded that there will be no risk to the twaite shad population as a result of the operation of the Vyrnwy bypass. Further monitoring is required to understand the suitability of spawning habitat in the reaches of the River Vyrnwy and the River Severn downstream of the confluence with the River Severn. However, impacts on feeding as a result of a 75Ml/d release alone is unlikely to result in adverse effects on site integrity. Where regulation and support releases coincide for a short period/infrequently, adverse effects on site integrity are not predicted. Operationally there would be additional releases of 75Ml/d from Vyrnwy Reservoir for intermittent periods of typically 30 days, up to ~100 days, notably in June to November, particularly in the July, August & September period. Overall operation would be in the order of ~15% of dates at times of low flows in the lower River Severn. These flow changes would continue along the River Severn to the re-abstraction location with no overall change in flows to the Severn Estuary. The release from Lake Vyrnwy will be 75 Ml/d is only a small percentage of the natural flow variation in the River Severn. In the summer, flows can exceed 8000Mld-1 (e.g. in 2011), so the addition of 75Ml/d during lower flows (when the abstraction	could include, for example, the temporary use of alternative sources for regulation during times of support releases form the Vyrnwy Reservoir. The Maintained Flow and HoF needs to be reviewed to determine to what extent the compensation flow from the Vyrnwy reservoir is considered "abstractable" to further reduce the volume of releases from the Vyrnwy Reservoir.	) **<u>Further monitoring assessment required:</u>** There is some uncertainty regarding the suitability of habitat in the upper Severn catchment for shad (allis shad twaite shad) spawning and therefore the extent to which these areas may be colonised by shad in future following improvements in connectivity under the 'Unlocking the Severn' project. Walkover/habitat surveys to consider the potential/suitability of habitat in the Upper River Severn and River Vyrnwy is required
	Population size (returning adults)	No decline in number of returning adults from established baseline.			
	River population	River population targets for the Usk and Wye must be met Baseline yet to be established. Noble et al. (2007) provides some information on juvenile densities[87].			
	Prey species	No significant reduction in abundance of key prey species against an established baseline Baseline is yet to be established through fish surveys in estuary and river			

[86] APEM (2020). STT Ecological Literature Review. APEM Scientific Report P00004288. Severn Thames Transfer Partnership, September 2020, v2.0 Final, 480 pp
[87] https://naturalresources.wales/media/673887/severn-estuary-sac-spa-and-ramsar-reg-33-advice-from-ne-and-ccw-june-09.pdf

Qualifying Feature	Attribute	Target	Potential Effects	Mitigation & Monitoring	Adverse Effects Predicted
			is likely to be required) is so small a change within the context of the natural flow variation as to be insignificant. Even at times when the support releases coincide with regulation releases, the impacts on spawning and migration of twaite shad within the *existing* migration limits are considered negligible with adverse effects on site integrity not predicted. At times when the support releases from the Vyrnwy reservoir coincide with regulation releases, adverse effects on site integrity are predicted. In particular, when support releases and regulation releases exceed 175Ml/d for continuous periods. This is in consideration of the precautionary principal and assumes that the River Vyrnwy significantly contributes to the shad population of the SAC.		
Ramsar criterion 4: Run of migratory fish species Sea Lamprey *Petromyzon marinus* River lamprey *Lampetra fluviatilis* Twaite shad *Alosa. fallax* Allis shad *Alosa alosa* Atlantic salmon *Salmo salar* Sea trout *S. trutta* European eel *Anguilla anguilla*. **Ramsar criterion 8: fish of the whole estuarine and river system** 110 species recorded	The feature will be considered to be in favourable condition when, subject to natural processes, each of the following conditions are met:	– . the migratory passage of both adults and juveniles of the assemblage of migratory fish species through the Severn Estuary between the Bristol Channel and any of their spawning rivers is not obstructed or impeded by physical barriers, changes in flows, or poor water quality; – ii the size of the populations of the assemblage species in the Severn Estuary and the rivers which drain into it, is at least maintained and is at a level that is sustainable in the long term; – – iii. the abundance of prey species3 forming the principal food resources for the assemblage species within the estuary, is maintained. – iv. Toxic contaminants in the water column4 and sediment are below levels which would pose a risk to the ecological objectives described above	**Construction** No construction of additional infrastructure is required for the Vyrnwy release option element. No additional physical barriers will be created to facilitate the operation of the reservoir release option element. **Operation** The populations of three of the assemblage species (river lamprey, sea lamprey and twaite shad) are designated as features of the SAC for which separate specific objectives have been written. The populations of these species depend on habitat in the adjacent River Usk SAC, River Wye SAC and River Severn. The habitats in these rivers, including spawning and nursery areas, are essential for the fulfilment of the species' lifecycle and therefore these features can only be in favourable condition if the conservation objectives pertaining to the River Usk SAC and River Wye SAC are also met in full and there is a continued recorded presence of these species in the River Severn. The adverse effects of the Vyrnwy reservoir release on river lamprey, sea lamprey and twaite shad have been considered as qualifying features of the Severn Estuary SAC. Therefore, these three species have been excluded from further assessment of the Ramsar fish assemblage (refer to above sections for river lamprey, sea lamprey and twaite shad). Available baseline data indicate that within the River Vyrnwy the fish community also include Atlantic salmon and potentially sea trout. Atlantic salmon migrate upstream to spawn from November – December. Operationally there would be additional releases of 75Ml/d from Vyrnwy Reservoir for intermittent periods of typically 30 days, up to ~100 days, notably in June to November, particularly in the July, August & September period. Overall operation would be in the order of ~15% of dates at times of low flows in the lower River Severn. These flow changes would continue along the River Severn to the re-abstraction location with no overall change in flows to the Severn Estuary. The increased flows are, therefore, unlikely to occur during migration and spawning periods. The increased flows downstream of the discharge during operation are not anticipated to result in adverse changes to water quality that could alter Atlantic salmon migration[88]. The results of an ongoing water quality monitoring programme indicated limited changes in water quality and that any changes are generally limited to the ~3km reach of the River Vyrnwy immediately downstream of the reservoir[89]. As such, water quality impacts on migration are considered negligible. There appears to be limited information regarding the distribution of suitable spawning and juvenile salmonid habitat within the River Vyrnwy. Spawning habitat is known to be present upstream of the Banwy confluence and the low numbers of 0+ individual observed in the River Vyrnwy downstream of the confluence with the River Banwy possibly suggests that the habitats provide more of a nursery function. It is noted that this is based on very limited data (spatially and temporally). Data available for the tributaries in the reach of the River Vyrnwy from the confluence with the River Banwy to the confluence with the River Severn suggest that the River Vyrnwy provides a migratory route for some species. Historical data (pre 2005)	The operational rules of the Severn Regulation require a review and update to ensure support flows and regulation releases do not coincide. This could include, for example, the temporary use of alternative sources for regulation during times of support releases form the Vyrnwy Reservoir. The Maintained Flow and HoF needs to be reviewed to determine to what extent the compensation flow from the Vyrnwy reservoir is considered "abstractable" to further reduce the volume of releases from the Vyrnwy Reservoir.	No adverse effects predicted (there is a risk of adverse effects should support releases coincide with extended periods of regulation releases) **<u>Further monitoring assessment required:</u>** There is some uncertainty regarding the suitability of habitat in the upper Severn catchment for shad (allis shad twaite shad) spawning and therefore the extent to which these areas may be colonised by shad in future following improvements in connectivity under the 'Unlocking the Severn' project. Walkover/habitat surveys to consider the potential/suitability of habitat in the Upper River Severn and River Vyrnwy is required Targeted lamprey surveys to understand the distribution of lamprey species in the River Vyrnwy and an assessment of the potential contribution to the Severn Estuary populations. Mapping of optimal and sub-optimal lamprey ammocoete habitat is required. Mapping of the extent and location of lamprey spawning habitat is required. Mapping of spawning and juvenile salmonid habitat in

[88] Thames Water (2016), Severn Thames Transfer: Water Quality and Ecology Assessment - Phase 2: Main Project Report (issued October 2016). Report by Cascade Consulting and HR Wallingford on behalf of Thames Water.
[89] Ricardo Energy & Environment (2019). Vyrnwy water quality monitoring study Interim Report – September 2019. Report on behalf of Thames Water. 26 September 2019.

Qualifying Feature	Attribute	Target	Potential Effects	Mitigation & Monitoring	Adverse Effects Predicted
			suggest high abundances of Atlantic salmon in the lower reaches of the River Banwy. Similarly, high abundances of Atlantic salmon have also been recorded on the River Cain. Monitoring undertaken during trial releases in support of the investigations of physical losses from a Vyrnwy reservoir support release concluded that a 75Ml/d release (in addition to the 45Ml/d) will not result in increased velocities and depth that would result in impacts on the fish community of the reaches of the River Vyrnwy from downstream of the reservoir to the confluence with the River Banwy. The review completed by APEM[90] suggest that eel populations are well documented and widespread throughout the River Severn catchment, despite the presence of partial barriers to migration. Elvers returning to mature within UK rivers between the months of February and May annually. The baseline data shows that European eel are widespread within the catchment including the main stem River Severn and tributaries. Elver migration is not directly linked to increased flow as for salmonids, however, directional cues are still taken from flow. Similar to salmonid smolt, silver eel migration is linked to periods of increased flow within the migration window. European eel are a robust species able to deal with a wide range of water temperatures and water quality. Elver are relatively weak swimming and increased velocities in the River Vyrnwy associated with the reservoir releases may affect upstream migration within the River Vyrnwy. Monitoring undertaken during trial releases in support of the investigations of physical losses from a Vyrnwy reservoir support release concluded that a 75Ml/d release (in addition to the 45Ml/d) will not result in increased velocities and depth that would result in impacts on the fish community of the reaches of the River Vyrnwy from downstream of the reservoir to the confluence with the River Banwy. Flows changes as a result of the 75Ml/d release is considered negligible in the River Severn and flows are not expected to impact on the migration of silver eel. Releases from the Vyrnwy Reservoir could result in a change in the suitable habitat (velocity, depth and substrate) for flow sensitive macroinvertebrate taxa in the River Vyrnwy above the confluence with the River Severn which could result in changes in the community structure. Baseline data suggest a macroinvertebrate community with a preference for fast flowing water and high sensitivity to reductions in flows. The magnitude of changes in the River Severn are expected to be within the current envelope of change and flow changes are not expected to result in changes in structure of the macroinvertebrate community. The macroinvertebrate communities present in the River Vyrnwy are associated with high flow velocities and are likely to be relatively tolerant of increases in flow velocity associated with operation of the option element. However due to the likely timing of the increased flows in summer (June – September) there is potential for reduced recruitment for river fly species due to washing out of eggs or more juvenile lifestages which are more sensitive to increases in flow velocity. The increase in flows may also alter distribution of minor fish species such as minnow, juvenile salmonids which would be predated by migratory species such as eel or salmonids. Although it is unlikely to be significant change in the abundance or distribution of prey species which support the freshwater life stages of the anadromous fish species. Based on the available data, adverse effects on site integrity associated with Vyrnwy Reservoir 75Ml/d release are not predicted. Where regulation and support releases coincide for a short period/infrequently, adverse effects on site integrity is not predicted. At times when the support releases from the Vyrnwy reservoir coincide with regulation releases, adverse effects on site integrity are predicted. In particular, when support releases and regulation releases exceed 175Ml/d for continuous periods. This is in consideration of the precautionary principal and assumes that the River Vyrnwy significantly contributes to the Atlantic salmon population of the SAC.		the lower reaches of the River Vyrnwy Review of potential barriers and possibility during higher flows. Further review of the contribution of the River Vyrnwy Atlantic salmon and lamprey populations to the Severn Estuary populations based on updated data

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

5.3 River Vyrnwy Mitigation – Vyrnwy release (100 Ml/d) and Bypass (80 Ml/d)

5.3.1 Potentially Affected European Sites

The HRA Screening concluded that implementation of River Vyrnwy Mitigation – Vyrnwy release (100 Ml/d) and Bypass (80 Ml/d) has the potential to result in likely significant effects on the **Severn Estuary SAC and Ramsar Site**. The following qualifying features of the Severn Estuary SAC and Ramsar Site were screened in for further assessment through Appropriate Assessment:

- **Sea lamprey:** increase in water flow could cause disturbance and/or displacement of ammocoetes present in nursery habitats in the River Vyrnwy, increase energy expenditure required to successfully migrate to spawn upstream during severe drought conditions and alter the structure and function of suitable spawning habitats.
- **River lamprey:** increase in water flow could cause disturbance and/or displacement of ammocoetes present in nursery habitats in the River Vyrnwy, increase energy expenditure required to successfully migrate to spawn upstream during very dry weather, drought conditions and severe drought conditions, and alter the structure and function of suitable spawning habitats.
- **Twaite shad:** increase in water flow could increase energy expenditure required to successfully migrate to spawn upstream during very dry weather, drought conditions and severe drought conditions, and alter the structure and function of suitable spawning habitats.
- **Allis shad:** increase in water flow could increase energy expenditure required to successfully migrate to spawn upstream during severe drought conditions and alter the structure and function of suitable spawning habitats. Migration upstream occurs from April – June typically[91].
- **Atlantic salmon:** increase in water flow could alter the structure and function of suitable spawning habitats. Migration upstream occurs from November – December typically[92].
- **Sea trout:** increase in water flow could increase energy expenditure required to successfully migrate to spawn upstream during dry weather periods, drought conditions and severe drought conditions, and alter the structure and function of suitable spawning habitats. Migration upstream occurs from September – December typically.

Conservation Objectives and Favourable Condition Targets

Specific attributes and targets associated with the conservation objectives for each qualifying feature of the SAC are provided in **Table 5.2** and current conservation status, SSSI condition assessment and site improvement plan are provided in **Table 4.2.**

[91] Maitland, P. S and Hatton-Ellis, T. S (2003). *Ecology of the Allis and Twaite Shad*. Conserving Natura 2000 Rivers Ecology Series No. 3. English Nature, Peterborough.
[92] Miller, P. J and Loates, M. J (1997) Fish of Britain and Europe. *Harper Collins Publishers*, 1 – 288.

Table 5.2: Assessment of adverse effects of the Vyrnwy mitigation, Lower Vyrnwy regulation release options on the Severn Estuary SAC and Ramsar Site.

Qualifying Feature	Attribute	Target	Potential Effects	Mitigation	Adverse Effect Predicted?
1099 River lamprey (SAC interest feature 5) 1095 Sea lamprey (SAC interest feature 6)	Migratory access (barriers to migration).	– **Water quality** is sufficient to support migratory passage. Levels (for temperature, salinity, turbidity, pH, and dissolved oxygen) should comply with targets established under the EA Review of Consents and the Water Framework Directive. – **Water flows**: Flows from the rivers Wye, Usk and Severn into the estuary must be sufficient to allow migration. – **Physical barriers:** No artificial barriers significantly impairing adults from reaching existing and historical spawning grounds or juveniles from moving downstream.	**Construction** The construction of the mitigation bypass (Option 2a) will be located approximately [redacted] (at closest point) north-west of the Severn Estuary SAC and is approximately [redacted] north-west via hydrological connectivity. Construction work associated with pipeline that could have an impact on river and sea lamprey spawning habitats, ammocoete habitats, and migration routes. The River Vyrnwy could potentially be considered a supporting habitat for the SAC. No additional barriers to migration would be created through construction of the pipeline. Potential impact pathways on migration during in-river works include water pollution incidents, spread and introduction of invasive non-native species (INNS), noise/ vibration/ light disturbance, localised increases in suspended sediment, entrapment and impingement and fluctuations in dissolved oxygen. Proposed mitigation measures to reduce noise/ vibration/ light disturbance include no night-time in river working during the migration season; this has not been included in the CDR. As in river construction works will be localised and short term, no adverse effects are anticipated from increases in suspended sediment, entrapment and dissolved oxygen fluctuations. There will be marginal habitat loss associated with the installation of the outfall however due to the identified mitigation, small size and low likelihood of lamprey being present this is unlikely to be significant. Potential impact pathways from topsoil stripping, excavations and movement of construction vehicles include the introduction and spread of INNS, exposure to pollution from accidental oil spills and run-off, localised increases in suspended sediment and noise/ vibration/ light disturbance. As construction works on the riverbank will be localised and short term, no adverse effects are anticipated from increased suspended sediment, noise and vibration disturbance and run-off. Proposed mitigation measures to use directional/ baffled lighting during works on the riverbank will minimise light disturbance on the River Severn; this has not been included in the CDR. Following best practice guidelines to minimise the possible introduction and spread of INNS and pollution incidents are viewed as sufficient to ensure no adverse effects on qualifying features of the Severn Estuary SAC. Exposure of topsoil, movement of construction vehicles throughout the River Vyrnwy catchment, and in river works to install the outfall could result in the introduction or spread of invasive non-native species. Best practice construction and biosecurity measures to guard against the introduction or spread of invasive non-native species would need to be employed as standard. No additional barriers to migration would be created through construction of the pipeline from Oswestry to the discharge point on the lower River Vyrnwy. Topsoil stripping, excavations, and in river works have potential for indirect adverse effects on lamprey through from pollution or increased sedimentation of spawning and migratory habitats from site run-off and accidental pollution, such as oil/fuel spills. Pollution from construction could result in degradation of functionally linked spawning and ammocoete habitats downstream of the works. Due to the distance from the Option to the designated site ([redacted] (at closest point) north-west of the Severn Estuary SAC and is approximately [redacted]), there are highly unlikely to be significant adverse effects to water quality in the Severn Estuary SAC boundary as a result of construction of the bypass pipeline. **Operation** In operation there would be additional releases of 75Ml/d from Vyrnwy Reservoir together with 80Ml/d support releases to the lower Afon Vyrnwy and a 25Ml/d reduction in abstraction from the River Severn at Shrewsbury for intermittent periods of typically 30 days, up to ~100 days, notably in June to November, particularly in the July, August & September period. Overall operation would be in the order of ~15% of dates at times of low flows in the lower River Severn. At times of compensation releases from Vyrnwy Reservoir these support releases for this element would cause minor negative flow effects in the River Vyrnwy reducing to neutral effects in the River Severn. Should STT support releases coincide with other regulation releases from Vyrnwy Reservoir these would cause up to major negative flow effects.	**Construction** Best practice biosecurity measures, as recommended by the GB Non-Native Species Secretariat (http://www.nonnativespecies.org/index.cfm?sectionid=58) would guard against any potential for spreading invasive species as a result of construction. Adherence to EA Pollution Prevention Guidelines (now formally withdrawn but still relevant and useful) Best practice construction methods. ECoW to identify potential ammocoete habitats in footprint of outfall works and undertake translocation/removal prior to works to reduce mortality. No night-time in river working to avoid disturbance of migration/spawning during April - May **Operation** The operational rules of the Severn Regulation require a review and update to ensure support flows and regulation releases do not coincide. This could include, for example, the temporary use of alternative sources for regulation during times of support releases form the Vyrnwy Reservoir. The Maintained Flow and HoF needs to be reviewed to determine to what extent the compensation flow from the Vyrnwy reservoir is considered “abstractable” to further reduce the volume of releases from the Vyrnwy Reservoir.	No adverse effects predicted (there is a risk of adverse effects should support releases coincide with extended periods of regulation releases) **<u>Further monitoring assessment required:</u>** Targeted lamprey surveys to understand the distribution of lamprey species in the River Vyrnwy and an assessment of the potential contribution to the Severn Estuary populations. Mapping of optimal and sub-optimal lamprey ammocoete habitat is required. Mapping of the extent and location of lamprey spawning habitat is required. Mapping of spawning and juvenile salmonid habitat in the lower reaches of the River Vyrnwy Review of potential barriers and possibility during higher flows. Further monitoring of the potential changes in velocity and depth changes in the lower River Vyrnwy Further review of the contribution of the River Vyrnwy Atlantic lamprey populations to the Severn Estuary populations based on updated data

Qualifying Feature	Attribute	Target	Potential Effects	Mitigation	Adverse Effect Predicted?
			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 siltbeds), 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 10–11°C[93]. 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 support releases from the reservoir will typically occur outside of the river and sea lamprey upstream migration period except in the case of severe drought where releases could occur in October during the river lamprey upstream migration period. Post metamorphic individuals usually migrate downstream in late spring and early summer. Although this will coincide with potential support periods, the additional flows may provide a minor benefit to downstream migrating species. Any impacts on migration as a result of the support releases form the Vyrnwy Reservoir will, therefore, only coincide with river lamprey migration in the River Vyrnwy in late autumn. It is unlikely that river lamprey would have migrated to the upper reaches of the catchment so early in the migration period. There also remains some uncertainty with regards to the extent of spawning habitat for lamprey species in the River Vyrnwy and the subsequent extent to which the lamprey populations in the River Vyrnwy contribute to the lamprey community of the Severn SAC. The available baseline data suggests that the River Vyrnwy from the Vyrnwy Reservoir to the confluence with the River Banwy supports low abundances of lamprey species. No lamprey species were sampled during the surveys completed by Atkins in 2020. Targeted lamprey surveys undertaken in 2014 and 2015 by UU, indicated very low numbers throughout the River Vyrnwy with no lamprey species observed above Dolanog Falls during these surveys, reflecting the natural migratory barrier that these waterfalls present to lamprey species. Data available from NRW suggests limited abundances of lamprey species. This information is important to understand the extent to which the reach contributes to the designated populations of the Severn Estuary. Information on the distribution of sub-optimal and optimal lamprey habitat remains uncertain. However, consideration should be made for the future enhancement of suitable habitats which may become accessible with the addition of fish passes or removal of weirs at obstacles which pose a current migratory barrier for the species above. The increase in flows could affect the ability of lamprey to pass over barriers to migration through increased flow velocity over obstacles and increase energy expenditure for adults during the upstream migration. However due to the location of the discharge and natural variability of the flows within the watercourses the increased flows are unlikely to have a significant adverse effect on lamprey migration. The operation of the release and discharge are unlikely to alter the ability of lamprey to undertake downstream migration to the estuary. Based on the available data, adverse effects on site integrity are not predicted. Where regulation and support releases coincide for a short period/infrequently, adverse effects on site integrity are not predicted. However, further monitoring is required to understand the velocity depth changes as a result of operation of the elements combined. At times when the support releases coincide with regulation releases for extended periods, adverse effects on site integrity are precited. This is in consideration of a precautionary approach and assumes that the River Vyrnwy provides significant spawning habitat resulting in the lamprey communities of the River Vyrnwy significantly contributing to the lamprey community of the Severn SAC.		
	Population size (returning adults)	No decline in number of returning adults from established baseline.	**Construction** As identified above construction of the pipeline without suitable mitigation has the potential to adversely affect lamprey spawning and nursery habitats associated with the River Severn and River Vyrnwy (although limited information is known about the location and extent of spawning sites in the River Vyrnwy). Which may negatively impact on the number of returning adult river and sea lamprey to the Severn Estuary SAC. This is due to potential impact pathways during in-river	**Construction** Best practice biosecurity measures, as recommended by the GB Non-Native Species Secretariat (http://www.nonnativespecies.	No adverse effects predicted (there is a risk of adverse effects should support releases coincide with extended periods of regulation releases)

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

Qualifying Feature	Attribute	Target	Potential Effects	Mitigation	Adverse Effect Predicted?
			works, which include: water pollution incidents, spread and introduction INNS, noise/ vibration/ light disturbance, localised increases in suspended sediment, entrapment and impingement and fluctuations in dissolved oxygen. Proposed mitigation measures to reduce noise/ vibration/ light disturbance include no night-time in river working during the migration season; this has not been included in the CDR. As construction works will be localised and short term, no adverse effects are anticipated from increases in suspended sediment, entrapment, and dissolved oxygen fluctuations on population size of river and sea lamprey. Impact pathways from topsoil stripping, excavations, and movement of construction vehicles along the riverbank include the introduction and spread of INNS, exposure to pollution from accidental oil spills and run-off, localised increases in suspended sediment and noise/ vibration/ light disturbance. As construction works on the riverbank for pipeline construction and outfall installation will be localised and short term, no significant adverse effects are anticipated from increased suspended sediment, noise and vibration disturbance and run-off. Proposed mitigation measures to use directional/ baffled lighting during works on the riverbank will minimise light disturbance on the River Severn; this has not been included in the CDR. Following best practice guidelines to minimise the possible introduction and spread of INNS and pollution incidents are viewed as sufficient to ensure no adverse effects on qualifying features of the Severn Estuary SAC. Therefore, due to the identified mitigation and low contribution to the population from the river Vyrnwy and River Severn this unlikely to result in adverse effects on site integrity. **Operation** River and sea lamprey population size in the Severn Estuary SAC is dependent on several factors including breeding success, which is reliant on the availability of functional spawning and nursery habitats in the River Usk SAC, River Wye SAC and River Severn. In addition, natural fluctuations in food and host availability will also impact on population size[94]. The number of returning adults to the estuary is dependent on a range of biotic and abiotic parameters relevant to marine and estuarine systems including predation pressures and environmental conditions. The impacts on migration of the lamprey species has been discussed in more detail in the section above. Based on the available data, adverse effects on site integrity are not predicted. At times when the support releases coincide with regulation releases for extended periods, adverse effects on site integrity are predicted. This is in consideration of a precautionary approach and assumes that the River Vyrnwy provides significant spawning habitat resulting in the lamprey communities of the River Vyrnwy significantly contributing to the lamprey community of the Severn SAC. Impacts on ammocoete habitat and the potential long-term impacts on returning adults are discussed in more detail below.	org/index.cfm?sectionid=58) would guard against any potential for spreading invasive species as a result of construction. Adherence to EA Pollution Prevention Guidelines (now formally withdrawn but still relevant and useful) Best practice construction methods. ECoW to identify potential ammocoete habitats in footprint of outfall works and undertake translocation/removal prior to works to reduce mortality. No night-time in river working to avoid disturbance of migration/spawning during April - May **Operation** The operational rules of the Severn Regulation require a review and update to ensure support flows and regulation releases do not coincide. This could include, for example, the temporary use of alternative sources for regulation during times of support releases form the Vyrnwy Reservoir. The Maintained Flow and HoF needs to be reviewed to determine to what extent the compensation flow from the Vyrnwy reservoir is considered “abstractable” to further reduce the volume of releases from the Vyrnwy Reservoir.	**<u>Further monitoring assessment required:</u>** Targeted lamprey surveys to understand the distribution of lamprey species in the River Vyrnwy and an assessment of the potential contribution to the Severn Estuary populations. Mapping of optimal and sub-optimal lamprey ammocoete habitat is required. Mapping of the extent and location of lamprey spawning habitat is required. Review of potential barriers and possibility during higher flows. Further monitoring of the potential changes in velocity and depth Further review of the contribution of the River Vyrnwy community to the Severn Estuary community based on updated data
	Ammocoete population in tributary rivers	River population targets for the Usk and Wye must be met Baseline is the survey of ammocoete abundance and distribution in the Rivers Usk and Wye commissioned by CCW in 2005 (Harvey et al. 2007).	**Construction** The construction of the new outfall will require in river working in the margin of the River Vyrnwy and may result in a small scale loss of functionally linked habitat which supports lamprey ammocoetes. However due to the scale of habitat loss and disturbance this is highly unlikely to adversely affect site integrity and taking into account the proposed mitigation it is unlikely to affect the ability of the site to meet the targets for lamprey adult and ammocoete population. As described above for water quality there is potential for pollution and sediment run off during construction of the bypass pipeline. However, taking into account the mitigation identified for pollution control, in river works, and biosecurity this is unlikely to adversely affect site integrity. **Operation**	**Construction** Best practice biosecurity measures, as recommended by the GB Non-Native Species Secretariat (http://www.nonnativespecies.org/index.cfm?sectionid=58) would guard against any potential for spreading invasive species as a result of construction.	No adverse effects predicted (there is a risk of adverse effects should support releases coincide with extended periods of regulation releases) **<u>Further monitoring assessment required:</u>** Targeted lamprey surveys to understand the distribution of

[94] 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.

Qualifying Feature	Attribute	Target	Potential Effects	Mitigation	Adverse Effect Predicted?
			Lamprey ammocoetes live in burrows in fine sediment and can tolerate periodic low oxygen levels[95]. Localised impacts of changes in water temperature due to the discharge could adversely affect embryo development in lamprey eggs for functionally linked spawning habitats. Laboratory studies on the effect of temperature on the development of embryos have shown that successful hatching of free-swimming ammocoetes is only possible within a relatively restricted range of water temperatures (Damas 1950, Maitland 2003)[96]. Water quality impacts as a result of the discharge will be localised and are not expected to result in a significant impact downstream of the bypass outfall. However, further monitoring will be required to understand the potential impact. There will be no potential for reduction in water quality to adversely affect the adult habitats in the River Severn Estuary within the SAC or the breeding populations within the rivers Wye and Usk. The use of the Vyrnwy bypass reduces the potential for adverse effects on lamprey spawning and nursery habitats by bypassing the habitats within the upper River Vyrnwy and avoiding the higher proportional of flow increase through discharge at a downstream location where the baseline river flow is greater allowing for greater buffering of flow change, temperature and water quality. In operation there would be additional releases of 75Ml/d from Vyrnwy Reservoir together with 80Ml/d support releases to the lower Afon Vyrnwy and a 25Ml/d reduction in abstraction from the River Severn at Shrewsbury for intermittent periods of typically 30 days, up to ~100 days, notably in June to November, particularly in the July, August & September period. Overall operation would be in the order of ~15% of dates at times of low flows in the lower River Severn. At times of compensation releases from Vyrnwy Reservoir these STT support releases (from the Vyrnwy Reservoir and the Bypass) would cause minor negative flow effects in the River Vyrnwy reducing to neutral effects in the River Severn. The increase in flows could affect ammocoete habitat by removing fine sediment and detritus. Any impacts are expected to be local as the overall hydrological effects are assessed as minor. As note din the section above, there remains some uncertainty with regards to the extent of spawning habitat for lamprey species in the River Vyrnwy and the subsequent extent to which the lamprey populations in the River Vyrnwy contribute to the lamprey community of the Severn SAC. Available data does not show an extensive lamprey population and minor impacts on the lamprey community is not expected to result in significant impacts on the populations in the estuary (given the importance of other rivers such as the River Wye and River Usk) Based on the available data, adverse effects on site integrity associated are not predicted. Where regulation and support releases coincide for a short period/infrequently, adverse effects on site integrity are not predicted. However, further monitoring is required to understand the velocity depth changes as a result of operation of the elements combined. At times when the support releases coincide with regulation releases for extended periods adverse effects on site integrity are predicted. This is in consideration of a precautionary approach and assumes that the River Vyrnwy provides significant spawning habitat resulting in the lamprey communities of the River Vyrnwy significantly contributing to the lamprey community of the Severn SAC.	Adherence to EA Pollution Prevention Guidelines (now formally withdrawn but still relevant and useful) Best practice construction methods. ECoW to identify potential ammocoete habitats in footprint of outfall works and undertake translocation/removal prior to works to reduce mortality. No night time in river working to avoid disturbance of migration/spawning during April - May **Operation** The operational rules of the Severn Regulation require a review and update to ensure support flows and regulation releases do not coincide. This could include, for example, the temporary use of alternative sources for regulation during times of support releases form the Vyrnwy Reservoir. The Maintained Flow and HoF needs to be reviewed to determine to what extent the compensation flow from the Vyrnwy reservoir is considered “abstractable” to further reduce the volume of releases from the Vyrnwy Reservoir.	lamprey species in the River Vyrnwy and an assessment of the potential contribution to the Severn Estuary populations. Mapping of optimal and sub-optimal lamprey ammocoete habitat is required. Mapping of the extent and location of lamprey spawning habitat is required. Review of potential barriers and possibility during higher flows. Further monitoring of the potential changes in velocity and depth Further review of the contribution of the River Vyrnwy community to the Severn Estuary community based on updated data
	Prey species	– No significant reduction in abundance of key prey species against an established baseline	Lamprey ammocoetes are filter feeders which do not prey on fish or macroinvertebrates. Adult river lamprey feed on a range of estuarine species including herring (*Clupea harengus*), sprat (*Sprattus sprattus*) and flounder (*Platichthys flesus*)[97], adult river lamprey do not typically feed in freshwater so are dependent on estuarine prey species. Adult sea lamprey feed on a wide variety of marine and anadromous fishes, including sturgeon (*Acipenser sturio*), herring (*Clupea harengus*), salmon (*Salmo salar*), cod (*Gadus morhua*) and haddock (*Melanogrammus aeglefinus*). Salmon and sea trout (*Salmo trutta*) entering rivers are also exploited by sea lamprey[98].	The operational rules of the Severn Regulation require a review and update to ensure support flows and regulation releases do not coincide. This could include, for example, the temporary use of alternative sources for regulation during times of support releases form the Vyrnwy Reservoir.	No adverse effects predicted (there is a risk of adverse effects should support releases coincide with extended periods of regulation releases) **<u>Further monitoring assessment required:</u>** Targeted lamprey surveys to understand the distribution of

[95] Maitland PS (2003). *Ecology of the River, Brook and Sea Lamprey*. Conserving Natura 2000 Rivers Ecology Series No. 5. English Nature, Peterborough
[96] Damas H (1950). La ponte en aquarium des lamproies fluviatiles et de planer. Ann. Soc. R. Zool. Belg. 81, 151–162.
[97] Maitland PS (2003). *Ecology of the River, Brook and Sea Lamprey*. Conserving Natura 2000 Rivers Ecology Series No. 5. English Nature, Peterborough.
[98] Maitland PS (2003). *Ecology of the River, Brook and Sea Lamprey*. Conserving Natura 2000 Rivers Ecology Series No. 5. English Nature, Peterborough.

Qualifying Feature	Attribute	Target	Potential Effects	Mitigation	Adverse Effect Predicted?
			Due to the absence of prey species in freshwater habitats and limited hydrological impacts downstream of the river Vyrnwy there is considered to be no potential for changes in the abundance of prey species for sea or river lamprey. Increased flows could impact on the ammocoete nursery habitats and food sources, especially where increased flows removed detritus and fie particulate matter from nursery beds. In operation there would be additional releases of 75Ml/d from Vyrnwy Reservoir together with 80Ml/d support releases to the lower Afon Vyrnwy and a 25Ml/d reduction in abstraction from the River Severn at Shrewsbury for intermittent periods of typically 30 days, up to ~100 days, notably in June to November, particularly in the July, August & September period. Overall operation would be in the order of ~15% of dates at times of low flows in the lower River Severn. At times of compensation releases from Vyrnwy Reservoir these STT support releases (from the Vyrnwy Reservoir and the Bypass) would cause minor negative flow effects in the River Vyrnwy reducing to neutral effects in the River Severn. The increased flows are not expected to result in a significant impact on food sources for lamprey species, and, based on the available data, adverse effects on site integrity are not predicted. Where regulation and support releases coincide for a short period/infrequently, adverse effects on site integrity are not predicted. However, further monitoring is required to understand the velocity depth changes as a result of operation of the elements combined. At times when the support releases from the Vyrnwy reservoir coincide with regulation releases for extended periods, adverse effects on site integrity are predicted. This is related to the potential risk of increased velocities over sub-optimal and optimal lamprey habitat and a reduction in the availability of food or impacts on feeding success of ammocoetes. This is in consideration of the precautionary principal and assumes that the River Vyrnwy significantly contributes to the lamprey population of the SAC.	The Maintained Flow and HoF needs to be reviewed to determine to what extent the compensation flow from the Vyrnwy reservoir is considered “abstractable” to further reduce the volume of releases from the Vyrnwy Reservoir.	lamprey species in the River Vyrnwy and an assessment of the potential contribution to the Severn Estuary populations. Mapping of optimal and sub-optimal lamprey ammocoete habitat is required. Mapping of the extent and location of lamprey spawning habitat is required. Review of potential barriers and possibility during higher flows. Further review of the contribution of the River Vyrnwy community to the Severn Estuary community based on updated data
1103 Twaite shad	Migratory access (barriers to migration).	– **Water quality** is sufficient to support migratory passage. Levels (for temperature, salinity, turbidity, pH, and dissolved oxygen) should comply with targets established under the EA Review of Consents and the Water Framework Directive. – **Water flows**: Flows from the rivers Wye, Usk and Severn into the estuary must be sufficient to allow migration. – **Physical barriers:** No artificial barriers significantly impairing adults from reaching existing and historical spawning grounds or juveniles from moving downstream. –	Twaite shad are restricted in upstream migration on the River Severn by the presence of a weir at Worcester which restricts its current spawning range to the lower 23 km of the River Severn[99]. **Construction** The construction of the Proposed Vyrnwy bypass release pipeline will occur approximately [redacted] from eth Severn Estuary and [redacted] via hydrological connectivity. No additional barriers to migration would be created through construction of the pipeline. Due to the restricted range within the River Severn and the mitigation proposed for construction activities it is highly unlikely that adverse effects on twaite shad migration from flow, water quality or physical barriers would occur as a result of construction of the pipeline. **Operation** Depending on the operational pattern, the operation of the STT could result in the following: • Increased velocity and depths at spawning sites; • Direct washout/loss of incubating eggs and damage to spawning habitats; • Increased erosion and siltation in some areas or the loss of spawning habitat; • Changes in water quality (in particular temperature and dissolved oxygen) as a result of support flows. The literature review completed by APEM[100] 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,	The operational rules of the Severn Regulation require a review and update to ensure support flows and regulation releases do not coincide. This could include, for example, the temporary use of alternative sources for regulation during times of support releases form the Vyrnwy Reservoir. The Maintained Flow and HoF needs to be reviewed to determine to what extent the compensation flow from the Vyrnwy reservoir is considered “abstractable” to further reduce the volume of releases from the Vyrnwy Reservoir.	No adverse effects predicted (there is a risk of adverse effects should support releases coincide with extended periods of regulation releases) **<u>Further monitoring assessment required:</u>** There is some uncertainty regarding the suitability of habitat in the upper Severn catchment for shad (allis shad twaite shad) spawning and therefore the extent to which these areas may be colonised by shad in future following improvements in connectivity under the ‘Unlocking the Severn’ project. Walkover/habitat surveys to consider the potential/suitability of habitat in the Upper River Severn and River Vyrnwy is required

[99] Unlocking the Severn for LIFE – LIFE – Shad Severn: Conservation and restoration of twaite shad in the Severn Estuary Special Area of Conservation project description. LIFE15 NAT/UK/00021. Accessed on 11/12/2020. Available at: https://ec.europa.eu/environment/life/project/Projects/index.cfm?fuseaction=search.dspPage&n_proj_id=5866&docType=pdf

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

Qualifying Feature	Attribute	Target	Potential Effects	Mitigation	Adverse Effect Predicted?
	Population size (returning adults)	No decline in number of returning adults from established baseline.	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. It is, however, noted that the Unlocking the Severn scheme could result in an increase in the distribution for twait shad. Mature adults enter the estuaries of many European rivers from April onwards and migrate some distance upstream, though the exact distance is variable. In the River Wye, some fish travel over 190 km to reach their spawning grounds at Builth Wells. Unlike salmonids, however, shads do not enter narrow streams even when these are accessible. It is, therefore, likely that twait shad could in the future reach the River Vyrnwy. Assuming that spawning habitat is available, twait shad could also potentially spawn in the River Vyrnwy. The operation of the STT could coincide with migration periods (within the current and future migration limits). Further monitoring is required to understand the suitability of spawning habitat in the reaches of the River Vyrnwy and the River Severn downstream of the confluence with the River Severn. In operation there would be additional releases of 75Ml/d from Vyrnwy Reservoir together with 80Ml/d support releases to the lower Afon Vyrnwy and a 25Ml/d reduction in abstraction from the River Severn at Shrewsbury for intermittent periods of typically 30 days, up to ~100 days, notably in June to November, particularly in the July, August & September period. Overall operation would be in the order of ~15% of dates at times of low flows in the lower River Severn. At times of compensation releases from Vyrnwy Reservoir these STT support releases (from the Vyrnwy Reservoir and the Bypass) would cause minor negative flow effects in the River Vyrnwy reducing to neutral effects in the River Severn. The spawning habitat of twaite shad in the rivers Wye, Usk,Tywi and Teme comprises a fast-flowing, shallow area of unconsolidated gravel/pebble and/or cobble substrate. Most of the substrates at the twaite shad spawning sites identified in rivers in England and Wales are described as 'gravel'. In France, twaite shad have been recorded as spawning in relatively slow-flowing deep water, and in the River Severn some may spawn at depths of up to 3 m. The fact that egg density was found to decline with depth suggests that, in these particular rivers, twaite shad prefer to deposit their eggs in shallow areas where the water depth is around 45 cm. Although spawning sites are not necessarily very deep, they are always in places where the river is still tens of metres wide. In Britain, the narrowest site in which spawning has been recorded (on the River Teme) is around 20 m wide The River Vyrnwy is expected to provide limited spawning habitat, especially in the lower reaches. Regardless, the velocity and depths changes are expected to remain within the required spawning conditions for twaite shad. It is concluded that there will be no risk to the twaite shad population as a result of the operation of the Vyrnwy bypass. However, further monitoring is required to understand (1) the distribution of potential spawning habitat within the River Vyrnwy and (2) the potential velocity depth changes associated with the operation of the bypass. At times when the support releases from the Vyrnwy reservoir coincide with regulation releases adverse effects on site integrity are predicted. This is in consideration of the precautionary principal and assumes that the River Vyrnwy *could* significantly contributes to the twait shad population of the SAC. As the proposed Vyrnwy Bypass release discharge would occur in the upper River Severn approximately [redacted] upstream of the Severn Estuary SAC any changes in water quality are highly unlikely to affect twaite shad spawning or migration in the lower reaches due to dilution from flow accretion prior to reaching reaches of the River Severn accessible to shad.		Targeted lamprey surveys to understand the distribution of lamprey species in the River Vyrnwy and an assessment of the potential contribution to the Severn Estuary populations. Mapping of optimal and sub-optimal lamprey ammocoete habitat is required. Mapping of the extent and location of lamprey spawning habitat is required. Mapping of spawning and juvenile salmonid habitat in the lower reaches of the River Vyrnwy Review of potential barriers and possibility during higher flows. Further review of the contribution of the River Vyrnwy lamprey populations to the Severn Estuary populations based on updated data
	River population	River population targets for the Usk and Wye must be met Baseline yet to be established. Noble et al. (2007) provides some information on juvenile densities[101].			

[101] https://naturalresources.wales/media/673887/severn-estuary-sac-spa-and-ramsar-reg-33-advice-from-ne-and-ccw-june-09.pdf

Qualifying Feature	Attribute	Target	Potential Effects	Mitigation	Adverse Effect Predicted?
	Prey species	No significant reduction in abundance of key prey species against an established baseline Baseline is yet to be established through fish surveys in estuary and river	The proposed bypass pipeline and outfall to discharge to the River Severn are located over [redacted] direct distance and [redacted] via hydrological connectivity from the Severn Estuary consequently no water quality or flow impacts are anticipated in the estuary as a result of construction of the Vyrnwy mitigation Bypass pipeline element. Whilst the marine stage of the shad's life cycle is not well understood, literature suggests a suitable estuarine habitat is likely to be very important for adults and juveniles[102]. Based on commercial bycatch data, adult allis shad occur near estuaries or coastal areas (depths 10- 150m) with juveniles present in estuaries occupying areas with low flow shoaling close to the surface[103]. Juvenile shad are generalist feeders, using a wide range of trophic resources available in the continental and estuarine environments, including aquatic insect larvae, molluscs and zooplankton. In the Severn estuary, the diet of juvenile shad is reported to be dominated by Crustacea including copepods, Mysidacea, Gammaridae, and Calanoidea in addition to fish as the juvenile shad get larger (Aprahamian 1989)[104] [105],. Adult twaite shad in estuaries and coastal waters feed on zooplankton and other fish, especially the juveniles of other shoaling pelagic members of Clupeidae, such as sprat *Sprattus sprattus* and herring *Clupea harengus* (Maitland & Lyle 1995)[106]. No water quality, flow, or level impacts are anticipated with the estuary (below the tidal limit) as a result of operation of the Vyrnwy mitigation bypass option. As adult and juvenile twaite shad are dependent on estuarine and marine prey species in the Severn estuary SAC and surrounding coastal habitats no changes to prey availability are anticipated so adverse effects site integrity are not predicted		
Ramsar criterion 4: Run of migratory fish species Sea Lamprey *Petromyzon marinus* River lamprey *Lampetra fluviatilis* Twaite shad *Alosa. fallax* Allis shad *Alosa alosa* Atlantic salmon *Salmo salar* Sea trout *S. trutta* European eel *Anguilla anguilla*. **Ramsar criterion 8: fish of the whole estuarine and river system** 110 species	- The feature will be considered to be in favourable condition when, subject to natural processes, each of the following conditions are met:	– . the migratory passage of both adults and juveniles of the assemblage of migratory fish species through the Severn Estuary between the Bristol Channel and any of their spawning rivers is not obstructed or impeded by physical barriers, changes in flows, or poor water quality; – ii the size of the populations of the assemblage species in the Severn Estuary and the rivers which drain into it, is at least maintained and is at a level that is sustainable in the long term; – – iii. the abundance of prey species3 forming the principal food resources for the assemblage species within the estuary, is maintained. – - iv. Toxic contaminants in the water column4 and	The populations of three of the assemblage species (river lamprey, sea lamprey and twaite shad) are designated as features of the SAC for which separate specific objectives have been written. The populations of these species depend on habitat in the adjacent River Usk SAC, River Wye SAC and River Severn. The habitats in these rivers, including spawning and nursery areas, are essential for the fulfilment of the species' lifecycle and therefore these features can only be in favourable condition if the conservation objectives pertaining to the River Usk SAC and River Wye SAC are also met in full and there is a continued recorded presence of these species in the River Severn. The adverse effects of the Vyrnwy Bypass on river lamprey, sea lamprey and twaite shad have been considered as qualifying features of the Severn Estuary SAC. Therefore, these three species have been excluded from further assessment of the Ramsar fish assemblage (refer to above sections for river lamprey, sea lamprey and twaite shad). Available baseline data indicate that within the River Vyrnwy the fish community also include Atlantic salmon and potentially sea trout. Based on the available information, it is assumed that the Atlantic salmon population of the River Vyrnwy significantly contributes to the fish assemblage of the Ramsar site **Construction** The construction of the Vyrnwy pipeline will occur approximately 115km north of the Severn Estuary Ramsar site. Construction work associated with the Vyrnwy mitigation pipeline that could adversely affect the migratory fish species of the Seven estuary Ramsar include, stripping and opencut installation in the pipeline corridor, works adjacent to watercourse within the River Vyrnwy catchment, and installation of the outfall at the discharge point. Allis shad are limited in upstream migration by the presence of weirs in the lower River Severn, as a identified above for twaite shad, therefore due to the distance to the proposed pipeline route and discharge point they are high unlikely to be adversely affected by construction impacts. Atlantic salmon and sea trout are known to migrate to the River Vyrnwy and other tributaries of the River Severn upstream of the proposed discharge point. Potential impacts during in-river construction on migratory access to upstream spawning sites in the River Severn and River	The operational rules of the Severn Regulation require a review and update to ensure support flows and regulation releases do not coincide. This could include, for example, the temporary use of alternative sources for regulation during times of support releases form the Vyrnwy Reservoir. The Maintained Flow and HoF needs to be reviewed to determine to what extent the compensation flow from the Vyrnwy reservoir is considered "abstractable" to further reduce the volume of releases from the Vyrnwy Reservoir.	No adverse effects predicted (there is a risk of adverse effects should support releases coincide with extended periods of regulation releases) **<u>Further monitoring assessment required:</u>** There is some uncertainty regarding the suitability of habitat in the upper Severn catchment for shad (allis shad twaite shad) spawning and therefore the extent to which these areas may be colonised by shad in future following improvements in connectivity under the 'Unlocking the Severn' project. Walkover/habitat surveys to consider the potential/suitability of habitat in the Upper River Severn and River Vyrnwy is required Targeted lamprey surveys to understand the distribution of lamprey species in the River Vyrnwy and an assessment of the potential contribution to the Severn Estuary populations.

[102] Joint Nature Conservation Committee. 2007. Second Report by the UK under Article 17 on the implementation of the Habitats Directive from January 2001 to December 2006. Peterborough: JNCC. Available from: www.jncc.gov.uk/article17
[103] ICES. 2015. Report of the Workshop on Lampreys and Shads (WKLS), 27–29 November 2014, Lisbon, Portugal. ICES CM 2014/SSGEF:13. 206 pp
[104] Aprahamian, M.W. 1989. The diet of juvenile and adult twaite shad Alosa *fallax fallax* (Lacépède) from the rivers Severn and Wye (Britain). Hydrobiologia, 179: 173-182.
[105] ICES. 2015. Report of the Workshop on Lampreys and Shads (WKLS), 27–29 November 2014, Lisbon, Portugal. ICES CM 2014/SSGEF:13. 206 pp
[106] Maitland PS and Lyle AA (1995). *Shad and smelt in the Cree Estuary, SW Scotland.* Report to Scottish Natural Heritage, Edinburgh.

Qualifying Feature	Attribute	Target	Potential Effects	Mitigation	Adverse Effect Predicted?
recorded		sediment are below levels which would pose a risk to the ecological objectives described above	Vyrnwy for Atlantic salmon and sea trout include the following: water pollution incidents, spread and introduction of invasive non-native species (INNS), noise/ vibration/ light disturbance, localised increases in suspended sediment, entrapment and impingement and fluctuations in dissolved oxygen. With proposed mitigation measures to minimise night-time, in-river disturbance during migration (not included in CDR) and following best practice guidelines no adverse effects as a result of disturbance are anticipated. Construction works will be localised and short term, therefore no adverse effects on migratory access from fluctuating abiotic factors and entrapment are anticipated. Impact pathways from topsoil stripping, excavations, and movement of construction vehicles along the riverbank include the introduction and spread of INNS, exposure to pollution from accidental oil spills and run-off, localised increases in suspended sediment and noise/ vibration/ light disturbance. As construction works on the riverbank for pipeline and in river workings for the outfall installation will be localised and short term, no adverse effects are anticipated from increased suspended sediment, noise/ vibration disturbance and run-off. Where possible, additional mitigation has been proposed to use directional/ baffled lighting on the riverbank to minimise light disturbance in the River Severn (not included in CDR). Following best practice mitigation measures to minimise the possible introduction and spread of INNS and pollution incidents are viewed as sufficient to ensure no adverse effects on qualifying features of the Severn Estuary Ramsar site. **Operation** Atlantic salmon migrate upstream to spawn from November – December. In operation there would be additional releases of 75Ml/d from Vyrnwy Reservoir together with 80Ml/d support releases to the lower Afon Vyrnwy and a 25Ml/d reduction in abstraction from the River Severn at Shrewsbury for intermittent periods of typically 30 days, up to ~100 days, notably in June to November, particularly in the July, August & September period. Overall operation would be in the order of ~15% of dates at times of low flows in the lower River Severn. At times of compensation releases from Vyrnwy Reservoir these STT support releases would cause minor negative flow effects in the River Vyrnwy. The increased flows are, therefore, unlikely to occur during migration and spawning periods. The increased flows downstream of the discharge during operation are not anticipated to result in adverse changes to water quality that could alter Atlantic salmon migration[107]. Data available for the tributaries in the reach of the River Vyrnwy from the confluence with the River Banwy to the confluence with the River Severn suggest that the River Vyrnwy provides a migratory route for some species. Historical data (pre 2005) suggest high abundances of Atlantic salmon in the lower reaches of the River Banwy. Similarly, high abundances of Atlantic salmon have also been recorded on the River Cain. Upstream migration of salmon primarily occurs at higher river flows, and is typically triggered by increases in flow. Increased flows in October and November are, therefore, not expected to prevent migration in the River Vyrnwy There appears to be limited information regarding the distribution of suitable spawning and juvenile salmonid habitat within the River Vyrnwy. Spawning habitat is known to be present upstream of the Banwy confluence and the low numbers of 0+ individual observed in the River Vyrnwy downstream of the confluence with the River Banwy possibly suggests that the habitats provide more of a nursery function. It is noted that this is based on very limited data (spatially and temporally). Monitoring undertaken during trial releases in support of the investigations of physical losses from a Vyrnwy reservoir support release concluded that a 75Ml/d release (in addition to the 45Ml/d) will not result in increased velocities and depth that would result in impacts on the fish community of the reaches of the River Vyrnwy from downstream of the reservoir to the confluence with the River Banwy. The hydrological changes downstream of the bypass outfall is also not expected to result in changes that will impact on the population to such an extent that the number of return adults will decrease. Further monitoring of the potential velocity and depth changes are, however, required to confirm this assumption.		Mapping of optimal and sub-optimal lamprey ammocoete habitat is required. Mapping of the extent and location of lamprey spawning habitat is required. Mapping of spawning and juvenile salmonid habitat in the lower reaches of the River Vyrnwy Review of potential barriers and possibility during higher flows. Further review of the contribution of the River Vyrnwy Atlantic salmon and lamprey populations to the Severn Estuary populations based on updated data

[107] Thames Water (2016), Severn Thames Transfer: Water Quality and Ecology Assessment - Phase 2: Main Project Report (issued October 2016). Report by Cascade Consulting and HR Wallingford on behalf of Thames Water.

Qualifying Feature	Attribute	Target	Potential Effects	Mitigation	Adverse Effect Predicted?
			The review completed by APEM[108] suggest that eel populations are well documented and widespread throughout the River Severn catchment, despite the presence of partial barriers to migration. Elvers returning to mature within UK rivers between the months of February and May annually. The baseline data shows that European eel are widespread within the catchment including the main stem River Severn and tributaries. Elver migration is not directly linked to increased flow as for salmonids, however, directional cues are still taken from flow. Similar to salmonid smolt, silver eel migration is linked to periods of increased flow within the migration window. European eel are a robust species able to deal with a wide range of water temperatures and water quality. Elver are relatively weak swimming and increased velocities in the River Vyrnwy may affect upstream migration within the River Vyrnwy. However, velocities are not expected to increase to such an extent that this will result in a barrier to migration. Further monitoring is required to understand the changes in velocity and depth as a result of the operation of the element Support releases from the Vyrnwy Reservoir could result in a change in the suitable habitat (velocity, depth and substrate) for flow sensitive macroinvertebrate taxa in the River Vyrnwy above the confluence with the River Severn which could result in changes in the community structure. Baseline data suggest a macroinvertebrate community with a preference for fast flowing water and high sensitivity to reductions in flows. The magnitude of changes in the River Severn are expected to be within the current envelope of change and flow changes are not expected to result in changes in structure of the macroinvertebrate community. The macroinvertebrate communities present in the River Vyrnwy are associated with high flow velocities and are likely to be relatively tolerant of increases in flow velocity associated with operation of the option element. However due to the likely timing of the increased flows in summer (June – September) there is potential for reduced recruitment for river fly species due to washing out of eggs or more juvenile life stages which are more sensitive to increases in flow velocity. The increase in flows may also alter distribution of minor fish species such as minnow, juvenile salmonids which would be predated by migratory species such as eel or salmonids. Although it is unlikely to be significant change in the abundance or distribution of prey species which support the freshwater life stages of the anadromous fish species. Based on the available data, adverse effects on site integrity are not predicted. Where regulation and support releases coincide for a short period/infrequently, adverse effects on site integrity are not predicted. At times when the support releases coincide with regulation releases for extended periods, adverse effects on site integrity are predicted. This is in consideration of a precautionary approach and assumes that the River Vyrnwy Atlantic salmon population contributes significantly to the Atlantic salmon population of the Severn Estuary.		

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

5.4 River Vyrnwy Mitigation, Vyrnwy Bypass release (155 Ml/d)

This element comprises a raw water pipeline which will transport 155 Ml/d from the Vyrnwy Aqueduct, (which feeds Oswestry WTW) to the River Vyrnwy. The pipeline will be sized for 180 Ml/d and is a mitigation measure for the impact of a release from the Lake Vyrnwy source support element on the River Vyrnwy.

This element will also include a contribution of 25 Ml/d from the abstraction reduction at Shrewsbury, to contribute a total of 180 Ml/d to the STT scheme.

The construction impacts associated with this element will be similar to those assessed for the River Vyrnwy Mitigation, Vyrnwy Release (100Mld) and Bypass (80Ml/d) (see **Table 5.2**).

Operationally, the impacts on the physical environment will be comparable to those of the Vyrnwy Mitigation, Vyrnwy Release (100Mld) and Bypass (80Ml/d) (see **Table 5.2**). The exception will be the zone of influence which will be limited to the reaches of the River Vyrnwy downstream of the bypass outfall to the River Severn.

As such, the conclusions in **Table 5.2** are also applicable to this element.

5.5 Minworth WwTW discharge diversion (115Ml/d)

Currently water from STW's Minworth WwTW is discharged into the River Tame, a tributary of the River Trent. It is proposed to divert a 115 Ml/d portion to a new outfall on the River Avon and hence into the River Severn catchment to support STT abstraction from the River Severn at Deerhurst. WwTW discharge transfer for STT support would not be continuous – only discharging to the River Avon according to an operating regime when support is required to enable abstraction from the River Severn. The discharge would be a regulating release augmenting flows in the downstream Rivers Avon and Severn to the STT abstraction location at Deerhurst.

The element will have result in a transfer of up to 115 Ml/d into the River Avon and is also subject of a separate assessment under the STW Minworth SRO.

The HRA Screening concluded that implementation of Minworth WwTW discharge diversion (115Ml/d) potential to result in likely significant effects on the **River Clun SAC**, **River Usk SAC**, **River Wye SAC** and the **Severn Estuary SAC and Ramsar Site**.

The following qualifying features were screened in for further assessment through Appropriate Assessment:

- **Freshwater Pearl Mussel:** The freshwater pearl mussel larvae attach to the gills of salmon and trout before eventually detaching and settling in the riverbed gravels where they grow to adulthood. The Environment Agency and Natural England has raised concerns with regards to the chemical cues to migration as a result of the diversion of WwTW discharge from the Tame;
- **Sea lamprey:** The Environment Agency and Natural England has raised concerns with regards to the chemical cues to migration as a result of the diversion of WwTW discharge from the Tame;
- **River lamprey:** The Environment Agency and Natural England has raised concerns with regards to the chemical cues to migration as a result of the diversion of WwTW discharge from the Tame;
- **Twaite shad:** The Environment Agency and Natural England has raised concerns with regards to the chemical cues to migration as a result of the diversion of WwTW discharge from the Tame;
- **Allis shad:** The Environment Agency and Natural England has raised concerns with regards to the chemical cues to migration as a result of the diversion of WwTW discharge from the Tame; and
- **Sea trout:** The Environment Agency and Natural England has raised concerns with regards to the chemical cues to migration as a result of the diversion of WwTW discharge from the Tame.

Conservation Objectives and Favourable Condition Targets

Specific attributes and targets associated with the conservation objectives for each qualifying feature of the SAC are provided in **Table 5.3** to **Table 5.7** and current conservation status, SSSI condition assessment and site improvement plan are provided in **Table 4.2**.

Table 5.3: Assessment of adverse effects of the Minworth WwTW discharge diversion element on the River Clun SAC.

Qualifying Feature	Attribute	Target	Potential Effects	Mitigation	Adverse Effect Predcited?
Freshwater Pearl Mussel	Passage of host fish	Maintain the free movement of host fish populations into and through the SAC	**Construction** The construction activities of this element are not in hydrological connectivity with the site **Operation**: Freedom of movement throughout the river system is critical to all life stages of fish host populations. Barriers to adult fish migration can limit the ability of individuals to successfully each their spawning grounds. Because of their critical relationship, barriers to host fish movement may indirectly have adverse effects on freshwater pearl mussel populations. Currently water from STW's Minworth WwTW is discharged into the River Tame, a tributary of the River Trent. It is proposed to divert a 115 Ml/d portion to a new outfall on the River Avon and hence into the River Severn catchment to support STT abstraction from the River Severn at Deerhurst. In operation there would be relocation of 115Ml/d from Minworth WwTW to the middle River Avon for intermittent periods of typically 30 days, up to ~100 days, notably in June to November, particularly in the July, August & September period. Overall operation would be in the order of ~15% of dates at times of low flows in the lower River Severn. Screening has identified a risk associated with the Minworth discharge diversion due to the potential impact on chemical cues for migration which could result in a reduced number of adults returning to spawning grounds in the catchment and potentially a reduction in juvenile salmonids that are an important host in the lifecycle of this feature. The impact on migration as a result of other water quality and hydrological changes is considered negligible. The abstraction for the transfer at Deerhurst during operation could cause a reduction in the dilution of effluents, create salinity barriers, changes to nutrient loading, turbidity and reduced dissolved oxygen. However, hydrological modelling of the lower River Severn[109] identified no discernible changes in river flow due to abstraction associated with the Deerhurst to Culham pipeline. Even the maximum abstraction of 500 Ml/d flow reduction would cause a very limited change to the flow pattern of the River Severn from the Avon confluence to the tidal limit. During 86% of the strategic scheme flow dates the same flow band would be retained, while 14% would result in change by one flow band[110]. Therefore, no adverse effects are anticipated as a result of changes in flow on migratory access. Water quality assessments confirmed that further study of water quality data, measured at NRW water quality monitoring sites is required, in order to fully determine the water quality and chemistry representation of the River Severn downstream of the Avon confluence. To obtain a discharge permit, tertiary treatment of the effluent will be required for the general water chemistry, sanitary, nutrient, and some hazardous substances (nickel and mercury) determinands in the Minworth WwTW final effluent. More advanced treatment would be needed to address a number of hazardous substances including benzo(a)pyrene, bioavailable zinc, bioavailable nickel and bioavailable manganese. Therefore, no adverse effects are anticipated as a result of changes in water quality on migratory access. Despite the tertiary treatment, the Environment Agency and Natural England has raised concerns with regards to the chemical cues (olfaction) to migration as a result of the diversion of WwTW discharge from the Tame. The up–river spawning migrations of salmonids, generally comprise a number of phases, including an initial rapid movement into fresh water, a quiescent phase made up of long periods of holding interspersed with discontinuous movement, and a final spawning run (Milner, 1990[111]). The final phase of the upstream migration determines the annual distribution of spawning in the river and may thus have a significant effect on recruitment of the next year class. It is widely accepted that fine-scale home stream identification during spawning migrations in anadromous salmonids is guided by olfaction, a hypothesis described by Hasler & Scholz (1983)[112]. Olfaction is a chemoreception that forms the sense of smell in fishes and occurs when odorants bind to specific sites on	Tertiary treatment of effluent prior to release in the River Avon	No adverse effects predicted **<u>Further monitoring assessment required:</u>** Further research is required to understand the potential parameters that should be considered in an impact assessment on olfactory cues and the possible extent of dilution of the diverted WwTW discharge in the Severn Estuary.
	Fisheries host population	Restore the abundance of juvenile salmonids to the following levels expected for the river type under conditions of high physical and chemical quality; • an abundance of > 0.1 native juvenile host salmonids per m2. • the regular presence of fish infected with glochidia between September and May			
	Supporting offsite riverine habitat	Maintain the extent and quality of any riverine habitats present beyond the SAC boundary upon which freshwater pearl mussel population of the SAC depend			

[109] Thames Water (2016), Severn Thames Transfer: Water Quality and Ecology Assessment - Phase 2: Main Project Report (issued October 2016). Report by Cascade Consulting and HR Wallingford on behalf of Thames Water.
[110] United Utilities (2021). Severn to Thames Transfer SRO downstream River Avon confluence to the tidal limit. Report by Ricardo Energy and Environment.
[111] Milner, N.J. (Ed.) (1990) *Fish movement in relation to freshwater flow and quality*. AST Blue Book Series, Atlantic Salmon Trust, Pitlochry. 54pp.
[112] Hasler, A.D. & Scholz, A. T. (1983). Olfactory imprinting and homing in salmon. Investigations in the mechanism of the imprinting process.

Qualifying Feature	Attribute	Target	Potential Effects	Mitigation	Adverse Effect Predcited?
			olfactory receptors located in the nasal cavity. Juvenile migratory salmonids are thought to imprint upon the site-specific odour signature of their natal stream and, when they return to freshwater as spawning adults, they are able to discriminate that imprinted odour signature to identify, and navigate to, their natal river or tributary. The mechanism by which the chemical make-up of home stream water is imprinted, and the array of key odorants utilised during imprinting are both still poorly understood[113, 114]. Though the exact chemical nature of the odorant profile used by salmonids to discern their natal stream is not known (and may well be population and/or site-specific), it is hypothesised that these odours are a complex, catchment-specific mixture of inorganic and organic chemicals from soil, plants and aquatic organisms[112]. Recent research suggests that the chemical array during imprinting is likely to consist of a combination of amino acids, some steroids, bile acids and slats, prostaglandins and cations such as calcium and magnesium[115]. Recently, amino acids have been identified as a primary candidate for olfactory cues in salmonids and studies have demonstrated that different combinations of amino acids present in natural stream waters act as chemo-attractants for homing salmon (although this research is not specific to Atlantis salmon or sea trout), and these compounds may represent an important part of the chemical signature used to discriminate their home stream[116, 117]. In terms of bioaccumulation of olfactory inhibitors, studies have shown that exposure to a range of substances including metals, pesticides and surfactants can inhibit olfaction in fish (e.g. Tierney *et al*., 2007[118]). However, olfactory toxicity occurs via multiple, complex pathways and the degree of toxicity of a given substance is often a factor of concentration, exposure time, fish lifestage and a number of environmental variables including pH, alkalinity, and temperature. Thus, predicting the impact of a toxic substance at a given concentration is complex. There is potential that the transfer of WwTW discharge into the River Avon and, subsequently the Severn Estuary could result in ongoing and potentially increasing bioaccumulation of olfactory inhibitors. The increased ratio of WwTW discharge to river water could also result in masking of essential olfactory cues for returning adults in the lower River Severn with associated delays. It is, therefore, possible that the transfer of WwTW discharge, which is usually discharged into the River Tame, into the River Avon could impact on the olfactory cues downstream of the confluence with the River Severn. While there may be times when there are smaller upriver runs of Atlantic salmon, the main runs in the Severn occurs from October. Based on the representative operational pattern , the Minworth option will only operate intermittently during the main migration period for Atlantic salmon. Operational rules should also potentially consider the potential risk to chemical cues for migration and operation should be limited/avoided from the month of October to March. Furthermore, there is no known threshold in terms of dilution rate of natal water salmonid navigation ceases although Sutterlin & Gray (1973)[119] reported that Atlantic salmon were attracted to natal water that had been diluted to 0.1% and other fish species are known to discern and react to chemical cues at concentrations as low as parts per trillion (ppt)[120], corresponding to concentrations of natural odorants such as amino acids[116] and bile acids[121] in surface waters. Adverse effects on site are not predicted. Further research is required to understand the potential parameters that should be considered in an impact assessment on olfactory cues and the possible extent of dilution of the diverted WwTW discharge in the Severn Estuary.		

[113] McCormick, S. D., Hansen, L. P., Quinn, T. P., & Saunders, R. L. (1998). Movement, migration, and smolting of Atlantic salmon (Salmo salar). Canadian Journal of Fisheries and Aquatic Sciences, 55(S1), 77-92.
[114] Ueda, H. (2012). Physiological mechanisms of imprinting and homing migration in Pacific salmon Oncorhynchus spp. Journal of Fish Biology, 81(2), 543-558.
[115] Bett, N. N., & Hinch, S. G. (2016). Olfactory navigation during spawning migrations: a review and introduction of the Hierarchical Navigation Hypothesis. Biological Reviews, 91(3), 728-759.
[116] 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(1-4), 249-251.
[117] Yamamoto, Y., Hino, H., & Ueda, H. (2010). Olfactory imprinting of amino acids in lacustrine sockeye salmon. PLoS One, 5(1), e8633.
[118] Tierney, K. B., Singh, C. R., Ross, P. S., & Kennedy, C. J. (2007). Relating olfactory neurotoxicity to altered olfactory-mediated behaviors in rainbow trout exposed to three currently-used pesticides. Aquatic Toxicology, 81(1), 55-64.
[119] Sutterlin, A. M., & Gray, R. (1973). Chemical basis for homing of Atlantic salmon (Salmo salar) to a hatchery. Journal of the Fisheries Board of Canada, 30(7), 985-989.
[120] 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(2), 196-202.
[121] 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(2), 161-171.

Table 5.4: Assessment of adverse effects of the Minworth WwTW discharge diversion element on the River Usk SAC.

Qualifying Feature	Attribute	Target	Potential Effects	Mitigation	Adverse Effect Predicted? (
Sea lamprey	Distribution within catchment	Suitable habitat adjacent to or downstream of known spawning sites should contain Petromyzon ammocoetes	**Construction** The construction activities of this element are not in hydrological connectivity with the site **Operation**: Impacts on the migration of Annex II species to spawning grounds could directly impact on the abundances of juveniles and in directly through a reduce number of individuals that would potentially return to spawning grounds as adults. The latter would result in impacts that may not be immediately observed and is considered a long-term impact. Currently water from STW's Minworth WwTW is discharged into the River Tame, a tributary of the River Trent. It is proposed to divert a 115 Ml/d portion to a new outfall on the River Avon and hence into the River Severn catchment to support STT abstraction from the River Severn at Deerhurst. In operation there would be relocation of 115Ml/d from Minworth WwTW to the middle River Avon for intermittent periods of typically 30 days, up to ~100 days, notably in June to November, particularly in the July, August & September period. Overall operation would be in the order of ~15% of dates at times of low flows in the lower River Severn. Screening has identified a risk associated with the Minworth discharge diversion due to the potential impact on chemical cues for migration which could result in a reduced number of adults fish returning to spawning grounds in the catchment and potentially a reduction in juvenile salmonids that are an important host in the lifecycle of this feature. The impact on migration as a result of other water quality and hydrological changes is considered negligible. The abstraction for the transfer at Deerhurst during operation could cause a reduction in the dilution of effluents, create salinity barriers, changes to nutrient loading, turbidity and reduced dissolved oxygen. However, hydrological modelling of the lower River Severn[122] identified no discernible changes in river flow due to abstraction associated with the Deerhurst to Culham pipeline. Even the maximum abstraction of 500 Ml/d flow reduction would cause a very limited change to the flow pattern of the River Severn from the Avon confluence to the tidal limit. During 86% of the strategic scheme flow dates the same flow band would be retained, while 14% would result in change by one flow band[123]. Therefore, no adverse effects are anticipated as a result of changes in flow on migratory access. Water quality assessments confirmed that further study of water quality data, measured at NRW water quality monitoring sites is required, in order to fully determine the water quality and chemistry representation of the River Severn downstream of the Avon confluence. To obtain a discharge permit, tertiary treatment of the effluent will be required for the general water chemistry, sanitary, nutrient, and some hazardous substances (nickel and mercury) determinands in the Minworth WwTW final effluent. More advanced treatment would be needed to address a number of hazardous substances including benzo(a)pyrene, bioavailable zinc, bioavailable nickel and bioavailable manganese. Therefore, no adverse effects are anticipated as a result of changes in water quality on migratory access. Despite the tertiary treatment, the Environment Agency and Natural England has raised concerns with regards to the chemical cues (olfaction) to migration as a result of the diversion of WwTW discharge from the Tame. The up–river spawning migrations of salmonids, generally comprise a number of phases, including an initial rapid movement into fresh water, a quiescent phase made up of long periods of holding interspersed with discontinuous movement, and a final spawning run (Milner, 1990[124]). The final phase of the upstream migration determines the annual distribution of spawning in the river and may thus have a significant effect on recruitment of the next year class.	Tertiary treatment of effluent prior to release in the River Avon	No adverse effects predicted **<u>Further monitoring assessment required:</u>** Further research is required to understand the potential parameters that should be considered in an impact assessment on olfactory cues and the possible extent of dilution of the diverted WwTW discharge in the Severn Estuary.
	Ammocoete density	Ammocoetes should be present in at least four sampling sites each not less than 5km apart			
		Overall catchment mean >0.1m-2			
River lamprey	Age/size structure of ammocoete population	Samples < 50 ammocoetes ~ 2 size classes Samples > 50 ammocoetes ~ at least 3 size classes			
	Distribution of ammocoetes within catchment	Present at not less that 2/3 of sites surveyed within natural range			
		No reduction in distribution of ammocoetes			
	Ammocoete density	Optimal habitat: >10m-2 Overall, catchment mean: >5m-2			
Atlantic salmon	Adult run size	Conservation Limit (CL) complied with at least four years in five			
	Juvenile densities	Expected densities for each sample site using HABSCORE			
	Biological quality	Biological GQA class A			
Twaite shad and Allis shad	Spawning distribution	No decline in spawning distribution			

[122] Thames Water (2016), Severn Thames Transfer: Water Quality and Ecology Assessment - Phase 2: Main Project Report (issued October 2016). Report by Cascade Consulting and HR Wallingford on behalf of Thames Water.
[123] United Utilities (2021). Severn to Thames Transfer SRO downstream River Avon confluence to the tidal limit. Report by Ricardo Energy and Environment.
[124] Milner, N.J. (Ed.) (1990) *Fish movement in relation to freshwater flow and quality*. AST Blue Book Series, Atlantic Salmon Trust, Pitlochry. 54pp.

Qualifying Feature	Attribute	Target	Potential Effects	Mitigation	Adverse Effect Predicted? (
			While there may be times when there are smaller upriver runs of Atlantic salmon, the main runs in the Severn occurs from October. Based on the representative operational pattern, the Minworth option will only operate intermittently during the main migration period for Atlantic salmon. Operational rules should also potentially consider the potential risk to chemical cues for migration and operation should be limited/avoided from the month of October to March. Smolt mostly migrate downstream in April and May Although this will coincide with potential support periods, the additional flows may provide a minor benefit to downstream migrating species. 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 10–11°C[125]. 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 support releases from the reservoir will typically occur outside of the river and sea lamprey upstream migration period except in the case of severe drought where releases could occur in October during the river lamprey upstream migration period. Post metamorphic individuals usually migrate downstream in late spring and early summer. Although this will coincide with potential support periods, the additional flows may provide a minor benefit to downstream migrating species. Mature adults enter the estuaries of many European rivers from April onwards and migrate some distance upstream, though the exact distance is variable. As such, the spawning migration could coincide with the operation of the Minworth discharge diversion. It is widely accepted that fine-scale home stream identification during spawning migrations in anadromous salmonids is guided by olfaction, a hypothesis described by Hasler & Scholz (1983)[126]. Olfaction is a chemoreception that forms the sense of smell in fishes and occurs when odorants bind to specific sites on olfactory receptors located in the nasal cavity. Juvenile migratory salmonids are thought to imprint upon the site-specific odour signature of their natal stream and, when they return to freshwater as spawning adults, they are able to discriminate that imprinted odour signature to identify, and navigate to, their natal river or tributary. The mechanism by which the chemical make-up of home stream water is imprinted, and the array of key odorants utilised during imprinting are both still poorly understood[127, 128]. Though the exact chemical nature of the odorant profile used by salmonids to discern their natal stream is not known (and may well be population and/or site-specific), it is hypothesised that these odours are a complex, catchment-specific mixture of inorganic and organic chemicals from soil, plants and aquatic organisms[112]. Recent research suggests that the chemical array during imprinting is likely to consist of a combination of amino acids, some steroids, bile acids and slats, prostaglandins and cations such as calcium and magnesium[129]. Recently, amino acids have been identified as a primary candidate for olfactory cues in salmonids and studies have demonstrated that different combinations of amino acids present in natural stream waters act as chemo-attractants for homing salmon (although this research is not specific to Atlantis salmon or sea trout), and these compounds may represent an important part of the chemical signature used to discriminate their home stream[130, 131]. In terms of bioaccumulation of olfactory inhibitors, studies have shown that exposure to a range of substances including metals, pesticides and surfactants can inhibit olfaction in fish (e.g. Tierney *et al*., 2007[132]). However, olfactory toxicity occurs via multiple, complex pathways and the degree of toxicity of a given substance is often a factor of concentration, exposure time, fish life stage and a number of environmental variables including pH, alkalinity, and temperature. Thus, predicting the impact of a toxic substance at a given concentration is complex.		

[125] Hardisty MW & Potter IC (eds) (1971). *The biology of lampreys*. Academic Press, London.
[126] Hasler, A.D. & Scholz, A. T. (1983). Olfactory imprinting and homing in salmon. Investigations in the mechanism of the imprinting process.
[127] McCormick, S. D., Hansen, L. P., Quinn, T. P., & Saunders, R. L. (1998). Movement, migration, and smolting of Atlantic salmon (Salmo salar). Canadian Journal of Fisheries and Aquatic Sciences, 55(S1), 77-92.
[128] Ueda, H. (2012). Physiological mechanisms of imprinting and homing migration in Pacific salmon Oncorhynchus spp. Journal of Fish Biology, 81(2), 543-558.
[129] Bett, N. N., & Hinch, S. G. (2016). Olfactory navigation during spawning migrations: a review and introduction of the Hierarchical Navigation Hypothesis. Biological Reviews, 91(3), 728-759.
[130] 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(1-4), 249-251.
[131] Yamamoto, Y., Hino, H., & Ueda, H. (2010). Olfactory imprinting of amino acids in lacustrine sockeye salmon. PLoS One, 5(1), e8633.
[132] Tierney, K. B., Singh, C. R., Ross, P. S., & Kennedy, C. J. (2007). Relating olfactory neurotoxicity to altered olfactory-mediated behaviors in rainbow trout exposed to three currently-used pesticides. Aquatic Toxicology, 81(1), 55-64.

Qualifying Feature	Attribute	Target	Potential Effects	Mitigation	Adverse Effect Predicted? (
			There is potential that the transfer of WwTW discharge into the River Avon and, subsequently the Severn Estuary could result in ongoing and potentially increasing bioaccumulation of olfactory inhibitors. The increased ratio of WwTW discharge to river water could also result in masking of essential olfactory cues for returning adults in the lower River Severn with associated delays. It is, therefore, possible that the transfer of WwTW discharge usually discharged into the River Tame into the River Avon could impact on the olfactory cues downstream of the confluence with the River Severn. It is well known that olfaction plays a role in the migration and spawning activities of salmonids. However, many other species are also depended on olfaction as part of the species life history. Twaite shad is reported as being sensitive to pollution, but few data appear to be available. Bird (2002)[133] reviewed the likely impacts of pollutants in the Severn Estuary and noted that (i) pollutants increase in bioavailability with decreasing conductivity and (ii) as well as causing mortality, metals may affect migration behaviour by sublethal effects on locomotion and olfaction. Previous observations suggested that lamprey utilize the odour of conspecific larvae to select streams for spawning. With regards to sea lamprey, normally males appear on the nesting sites first and are apparently highly attractive to females, possibly by the secretion of an olfactory sex attractant While there may be times when there are smaller upriver runs of Atlantic salmon, the main runs in the Severn occurs from October. Based on the representative operational pattern, the Minworth option will only operate intermittently during the main migration period for Atlantic salmon. Operational rules should also potentially consider the potential risk to chemical cues for migration and operation should be limited/avoided from the month of October to March. Similar, operational rules could also avoid the impacts on migration of lamprey. There is no known threshold in terms of dilution rate of natal water salmonid navigation ceases although Sutterlin & Gray (1973)[134] reported that Atlantic salmon were attracted to natal water that had been diluted to 0.1% and other fish species are known to discern and react to chemical cues at concentrations as low as parts per trillion (ppt)[135], corresponding to concentrations of natural odorants such as amino acids[116] and bile acids[136] in surface waters. Adverse effects on site integrity are not predicted. Further research is required to understand the potential parameters that should be considered in an impact assessment on olfactory cues and the possible extent of dilution of the diverted WwTW discharge in the Severn Estuary.		

Table 5.5: Assessment of adverse effects of the Minworth WwTW discharge diversion element on the River Wye SAC

Qualifying Feature	Attribute	Target	Potential Effects	Mitigation	Adverse Effect Predicted?
Sea lamprey and River lamprey	Juvenile densities	Restore juvenile densities at those expected under unimpacted conditions throughout the site, taking into account natural habitat conditions and allowing for natural fluctuations	**Construction** The construction activities of this element are not in hydrological connectivity with the site **Operation**: Impacts on the migration of Annex II species to spawning grounds could directly impact on the abundances of juveniles and in directly through a reduce number of individuals that would potentially return to spawning grounds as adults. The latter would result in impacts that may not be immediately observed and is considered a long-term impact. Currently water from STW's Minworth WwTW is discharged into the River Tame, a tributary of the River Trent. It is proposed to divert a 115 Ml/d portion to a new outfall on the River Avon and hence into the River Severn catchment to support STT abstraction from the River Severn at Deerhurst. In operation there would be the relocation of 115 Ml/d from Minworth WwTW to the middle River Avon for intermittent periods of typically 30 days, up to ~100 days, notably in June to November, particularly in the July, August &	Tertiary treatment of effluent prior to release in the River Avon	No adverse effects predicted (there is a risk of adverse effects should support releases coincide with extended periods of regulation releases) **<u>Further monitoring assessment required:</u>** Further research is required to understand
	Population abundance	Restore the abundance of the population to a level which is close to that expected under unimpacted conditions throughout the site (subject to natural habitat conditions and			

[133] Bird DJ (2002) *Environmental Factors Affecting Migratory Fish in the Severn Estuary with Particular Reference to Species of Shad and Lamprey*. Environment Agency Wales, Cardiff.
[134] Sutterlin, A. M., & Gray, R. (1973). Chemical basis for homing of Atlantic salmon (Salmo salar) to a hatchery. Journal of the Fisheries Board of Canada, 30(7), 985-989.
[135] 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(2), 196-202.
[136] 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(2), 161-171.

Qualifying Feature	Attribute	Target	Potential Effects	Mitigation	Adverse Effect Predicted?
		allowing for natural fluctuations), whilst avoiding deterioration from its current level as indicated by the latest mean peak count or equivalent.	September period. Overall operation would be in the order of ~15% of dates at times of low flows in the lower River Severn. Screening has identified a risk associated with the Minworth discharge diversion due to the potential impact on chemical cues for migration which could result in a reduced number of adults fish returning to spawning grounds in the catchment and potentially a reduction in juvenile salmonids that are an important host in the lifecycle of this feature. The impact on migration as a result of other water quality and hydrological changes is considered negligible. The abstraction for the transfer at Deerhurst during operation could cause a reduction in the dilution of effluents, create salinity barriers, changes to nutrient loading, turbidity and reduced dissolved oxygen. However, hydrological modelling of the lower River Severn[137] identified no discernible changes in river flow due to abstraction associated with the Deerhurst to Culham pipeline. Even the maximum abstraction of 500 Ml/d flow reduction would cause a very limited change to the flow pattern of the River Severn from the Avon confluence to the tidal limit. During 86% of the strategic scheme flow dates the same flow band would be retained, while 14% would result in change by one flow band[138]. Therefore, no adverse effects are anticipated as a result of changes in flow on migratory access. Water quality assessments confirmed that further study of water quality data, measured at NRW water quality monitoring sites is required, in order to fully determine the water quality and chemistry representation of the River Severn downstream of the Avon confluence. To obtain a discharge permit, tertiary treatment of the effluent will be required for the general water chemistry, sanitary, nutrient, and some hazardous substances (nickel and mercury) determinands in the Minworth WwTW final effluent. More advanced treatment would be needed to address a number of hazardous substances including benzo(a)pyrene, bioavailable zinc, bioavailable nickel and bioavailable manganese. Therefore, no adverse effects are anticipated as a result of changes in water quality on migratory access. Despite the tertiary treatment, the Environment Agency and Natural England has raised concerns with regards to the chemical cues (olfaction) to migration as a result of the diversion of WwTW discharge from the Tame. The up–river spawning migrations of salmonids, generally comprise a number of phases, including an initial rapid movement into fresh water, a quiescent phase made up of long periods of holding interspersed with discontinuous movement, and a final spawning run (Milner, 1990[139]). The final phase of the upstream migration determines the annual distribution of spawning in the river and may thus have a significant effect on recruitment of the next year class. While there may be times when there are smaller upriver runs of Atlantic salmon, the main runs in the Severn occurs from October. Based on the representative operational pattern, the Minworth option will only operate intermittently during the main migration period for Atlantic salmon. Operational rules should also potentially consider the potential risk to chemical cues for migration and operation should be limited/avoided from the month of October to March. Smolt mostly migrate downstream in April and May Although this will coincide with potential support periods, the additional flows may provide a minor benefit to downstream migrating species. 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 10–11°C[140]. 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 support releases from the reservoir will typically occur outside of the river and sea lamprey upstream migration period except in the case of severe drought where releases could occur		the potential parameters that should be considered in an impact assessment on olfactory cues and the possible extent of dilution of the diverted WwTW discharge in the Severn Estuary.
	Biological connectivity	The movement of characteristic biota should not be artificially constrained			
Atlantic salmon	Adult run size	Restore the population to that expected under un-impacted conditions, allowing for natural fluctuations. This should include a seasonal pattern of migration characteristic of the river and maintenance of the multi-seawinter component. As a minimum, the Conservation Limit for the river system should be complied with.			
	Juvenile densities	Restore juvenile densities at those expected under unimpacted conditions throughout the site, taking into account natural habitat conditions and allowing for natural fluctuations			
	Spawning distribution	Restore the distribution of spawning to reflect unimpacted conditions through the site, and avoid reductions in existing levels.			
	Biological connectivity	The movement of characteristic biota should not be artificially constrained			
Twaite shad and Allis shad	Adult run size	Restore the population to that expected under un-impacted conditions, allowing for natural fluctuations. This should include a seasonal pattern of migration characteristic of the river and a natural age structure.			
	Juvenile densities	Restore juvenile densities at those expected under unimpacted conditions throughout the site, taking into account natural habitat conditions and allowing for natural fluctuations			

[137] Thames Water (2016), Severn Thames Transfer: Water Quality and Ecology Assessment - Phase 2: Main Project Report (issued October 2016). Report by Cascade Consulting and HR Wallingford on behalf of Thames Water.
[138] United Utilities (2021). Severn to Thames Transfer SRO downstream River Avon confluence to the tidal limit. Report by Ricardo Energy and Environment.
[139] Milner, N.J. (Ed.) (1990) *Fish movement in relation to freshwater flow and quality*. AST Blue Book Series, Atlantic Salmon Trust, Pitlochry. 54pp.
[140] Hardisty MW & Potter IC (eds) (1971). *The biology of lampreys*. Academic Press, London.

Qualifying Feature	Attribute	Target	Potential Effects	Mitigation	Adverse Effect Predicted?
	Spawning distribution	Restore the distribution of spawning to reflect unimpacted conditions through the site, and avoid reductions in existing levels.	in October during the river lamprey upstream migration period. Post metamorphic individuals usually migrate downstream in late spring and early summer. Although this will coincide with potential support periods, the additional flows may provide a minor benefit to downstream migrating species. Mature adults enter the estuaries of many European rivers from April onwards and migrate some distance upstream, though the exact distance is variable. As such, the spawning migration could coincide with the operation of the Minworth discharge diversion. It is widely accepted that fine-scale home stream identification during spawning migrations in anadromous salmonids is guided by olfaction, a hypothesis described by Hasler & Scholz (1983)[141]. Olfaction is a chemoreception that forms the sense of smell in fishes and occurs when odorants bind to specific sites on olfactory receptors located in the nasal cavity. Juvenile migratory salmonids are thought to imprint upon the site-specific odour signature of their natal stream and, when they return to freshwater as spawning adults, they are able to discriminate that imprinted odour signature to identify, and navigate to, their natal river or tributary. The mechanism by which the chemical make-up of home stream water is imprinted, and the array of key odorants utilised during imprinting are both still poorly understood[142, 143]. Though the exact chemical nature of the odorant profile used by salmonids to discern their natal stream is not known (and may well be population and/or site-specific), it is hypothesised that these odours are a complex, catchment-specific mixture of inorganic and organic chemicals from soil, plants and aquatic organisms[112]. Recent research suggests that the chemical array during imprinting is likely to consist of a combination of amino acids, some steroids, bile acids and slats, prostaglandins and cations such as calcium and magnesium[144]. Recently, amino acids have been identified as a primary candidate for olfactory cues in salmonids and studies have demonstrated that different combinations of amino acids present in natural stream waters act as chemo-attractants for homing salmon (although this research is not specific to Atlantis salmon or sea trout), and these compounds may represent an important part of the chemical signature used to discriminate their home stream[145, 146]. In terms of bioaccumulation of olfactory inhibitors, studies have shown that exposure to a range of substances including metals, pesticides and surfactants can inhibit olfaction in fish (e.g. Tierney *et al.*, 2007[147]). However, olfactory toxicity occurs via multiple, complex pathways and the degree of toxicity of a given substance is often a factor of concentration, exposure time, fish life stage and a number of environmental variables including pH, alkalinity, and temperature. Thus, predicting the impact of a toxic substance at a given concentration is complex. There is potential that the transfer of WwTW discharge into the River Avon and, subsequently the Severn Estuary could result in ongoing and potentially increasing bioaccumulation of olfactory inhibitors. The increased ratio of WwTW discharge to river water could also result in masking of essential olfactory cues for returning adults in the lower River Severn with associated delays. It is, therefore, possible that the transfer of WwTW discharge usually discharged into the River Tame into the River Avon could impact on the olfactory cues downstream of the confluence with the River Severn. It is well known that olfaction plays a role in the migration and spawning activities of salmonids. However, many other species are also depended on olfaction as part of the species life history. Twaite shad is reported as being sensitive to pollution, but few data appear to be available. Bird (2002)[148] reviewed the likely impacts of pollutants in the Severn Estuary and noted that (i) pollutants increase in		
	Biological connectivity	The movement of characteristic biota should not be artificially constrained			

[141] Hasler, A.D. & Scholz, A. T. (1983). Olfactory imprinting and homing in salmon. Investigations in the mechanism of the imprinting process.
[142] McCormick, S. D., Hansen, L. P., Quinn, T. P., & Saunders, R. L. (1998). Movement, migration, and smolting of Atlantic salmon (Salmo salar). Canadian Journal of Fisheries and Aquatic Sciences, 55(S1), 77-92.
[143] Ueda, H. (2012). Physiological mechanisms of imprinting and homing migration in Pacific salmon Oncorhynchus spp. Journal of Fish Biology, 81(2), 543-558.
[144] Bett, N. N., & Hinch, S. G. (2016). Olfactory navigation during spawning migrations: a review and introduction of the Hierarchical Navigation Hypothesis. Biological Reviews, 91(3), 728-759.
[145] 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(1-4), 249-251.
[146] Yamamoto, Y., Hino, H., & Ueda, H. (2010). Olfactory imprinting of amino acids in lacustrine sockeye salmon. PLoS One, 5(1), e8633.
[147] Tierney, K. B., Singh, C. R., Ross, P. S., & Kennedy, C. J. (2007). Relating olfactory neurotoxicity to altered olfactory-mediated behaviors in rainbow trout exposed to three currently-used pesticides. Aquatic Toxicology, 81(1), 55-64.
[148] Bird DJ (2002) *Environmental Factors Affecting Migratory Fish in the Severn Estuary with Particular Reference to Species of Shad and Lamprey*. Environment Agency Wales, Cardiff.

Qualifying Feature	Attribute	Target	Potential Effects	Mitigation	Adverse Effect Predicted?
			bioavailability with decreasing conductivity and (ii) as well as causing mortality, metals may affect migration behaviour by sublethal effects on locomotion and olfaction. Previous observations suggested that lamprey utilize the odour of conspecific larvae to select streams for spawning. With regards to sea lamprey, normally males appear on the nesting sites first and are apparently highly attractive to females, possibly by the secretion of an olfactory sex attractant While there may be times when there are smaller upriver runs of Atlantic salmon, the main runs in the Severn occurs from October. Based on the representative operational pattern, the Minworth option will only operate intermittently during the main migration period for Atlantic salmon. Operational rules should also potentially consider the potential risk to chemical cues for migration and operation should be limited/avoided from the month of October to March. Similar, operational rules could also avoid the impacts on migration of lamprey. There is no known threshold in terms of dilution rate of natal water salmonid navigation ceases although Sutterlin & Gray (1973)[149] reported that Atlantic salmon were attracted to natal water that had been diluted to 0.1% and other fish species are known to discern and react to chemical cues at concentrations as low as parts per trillion (ppt)[150], corresponding to concentrations of natural odorants such as amino acids[116] and bile acids[151] in surface waters. Adverse effects on site are not predicted. Further research is required to understand the potential parameters that should be considered in an impact assessment on olfactory cues and the possible extent of dilution of the diverted WwTW discharge in the Severn Estuary		

Table 5.6: Assessment of adverse effects of the Minworth WwTW discharge diversion element on the Severn Estuary SAC and Ramsar site

Qualifying Feature	Attribute	Target	Potential Effects	Mitigation & Monitoring	Adverse Effect Predicted? (
River lamprey Sea lamprey	Migratory access (barriers to migration).	– **Water quality** is sufficient to support migratory passage. Levels (for temperature, salinity, turbidity, pH, and dissolved oxygen) should comply with targets established under the EA Review of Consents and the Water Framework Directive. – **Water flows**: Flows from the rivers Wye, Usk and Severn into the estuary must be sufficient to allow migration. – **Physical barriers:** No artificial barriers significantly impairing adults from reaching existing and historical spawning grounds or juveniles from moving downstream.	**Construction** The construction activities of this element are not in hydrological connectivity with the site **Operation**: Impacts on the migration of Annex II species to spawning grounds could directly impact on the abundances of juveniles and in directly through a reduce number of individuals that would potentially return to spawning grounds as adults. The latter would result in impacts that may not be immediately observed and is considered a long-term impact. Currently water from STW's Minworth WwTW is discharged into the River Tame, a tributary of the River Trent. It is proposed to divert a 115 Ml/d portion to a new outfall on the River Avon and hence into the River Severn catchment to support STT abstraction from the River Severn at Deerhurst. In operation there would be relocation of 115Ml/d from Minworth WwTW to the middle River Avon for intermittent periods of typically 30 days, up to ~100 days, notably in June to November, particularly in the July, August & September period. Overall operation would be in the order of ~15% of dates at times of low flows in the lower River Severn. Screening has identified a risk associated with the Minworth discharge diversion due to the potential impact on chemical cues for migration which could result in a reduced number of adults fish returning to spawning grounds in the catchment and potentially a reduction in juvenile salmonids that are an important host in the lifecycle of this feature.	Tertiary treatment of effluent prior to release in the River Avon	No adverse effects predicted (there is a risk of adverse effects should support releases coincide with extended periods of regulation releases) **<u>Further monitoring assessment required:</u>** Further research is required to understand the potential parameters that should be considered in an impact assessment on olfactory cues and the possible extent of dilution of the diverted WwTW discharge in the Severn Estuary. Assessment of the distribution of physical
	Population size (returning adults)	No decline in number of returning adults from established baseline.			

[149] Sutterlin, A. M., & Gray, R. (1973). Chemical basis for homing of Atlantic salmon (Salmo salar) to a hatchery. Journal of the Fisheries Board of Canada, 30(7), 985-989.
[150] 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(2), 196-202.
[151] 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(2), 161-171.

Qualifying Feature	Attribute	Target	Potential Effects	Mitigation & Monitoring	Adverse Effect Predicted? (
Twaite shad	Migratory access (barriers to migration).	– **Water quality** is sufficient to support migratory passage. Levels (for temperature, salinity, turbidity, pH, and dissolved oxygen) should comply with targets established under the EA Review of Consents and the Water Framework Directive. – **Water flows**: Flows from the rivers Wye, Usk and Severn into the estuary must be sufficient to allow migration. – **Physical barriers:** No artificial barriers significantly impairing adults from reaching existing and historical spawning grounds or juveniles from moving downstream. –	The impact on migration as a result of other water quality and hydrological changes is considered negligible. The abstraction for the transfer at Deerhurst during operation could cause a reduction in the dilution of effluents, create salinity barriers, changes to nutrient loading, turbidity and reduced dissolved oxygen. However, hydrological modelling of the lower River Severn[152] identified no discernible changes in river flow due to abstraction associated with the Deerhurst to Culham pipeline. Even the maximum abstraction of 500 Ml/d flow reduction would cause a very limited change to the flow pattern of the River Severn from the Avon confluence to the tidal limit. During 86% of the strategic scheme flow dates the same flow band would be retained, while 14% would result in change by one flow band[153]. Therefore, no adverse effects are anticipated as a result of changes in flow on migratory access. Water quality assessments confirmed that further study of water quality data, measured at NRW water quality monitoring sites is required, in order to fully determine the water quality and chemistry representation of the River Severn downstream of the Avon confluence. To obtain a discharge permit, tertiary treatment of the effluent will be required for the general water chemistry, sanitary, nutrient, and some hazardous substances (nickel and mercury) determinands in the Minworth WwTW final effluent. More advanced treatment would be needed to address a number of hazardous substances including benzo(a)pyrene, bioavailable zinc, bioavailable nickel and bioavailable manganese. Therefore, no adverse effects are anticipated as a result of changes in water quality on migratory access. Despite the tertiary treatment, the Environment Agency and Natural England has raised concerns with regards to the chemical cues (olfaction) to migration as a result of the diversion of WwTW discharge from the Tame. The up–river spawning migrations of salmonids, generally comprise a number of phases, including an initial rapid movement into fresh water, a quiescent phase made up of long periods of holding interspersed with discontinuous movement, and a final spawning run (Milner, 1990[154]). The final phase of the upstream migration determines the annual distribution of spawning in the river and may thus have a significant effect on recruitment of the next year class. While there may be times when there are smaller upriver runs of Atlantic salmon, the main runs in the Severn occurs from October. Based on the representative operational pattern, the Minworth option will only operate intermittently during the main migration period for Atlantic salmon. Operational rules should also potentially consider the potential risk to chemical cues for migration and operation should be limited/avoided from the month of October to March. Smolt mostly migrate downstream in April and May Although this will coincide with potential support periods, the additional flows may provide a minor benefit to downstream migrating species. 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[155]. 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 support releases from the reservoir will typically occur outside of the river and sea lamprey upstream migration period except in the case of severe drought where releases could occur in October during the river lamprey upstream migration period. Post metamorphic individuals usually migrate downstream in late spring and early summer. Although this will coincide with potential support periods, the additional flows may provide a minor benefit to downstream migrating species. Mature adults enter the estuaries of many European rivers from April onwards and migrate some distance upstream, though the exact distance is variable. As such, the spawning migration could coincide with the operation of the Minworth discharge diversion. The review completed by APEM[156] suggest that eel populations are well documented and widespread throughout the River Severn catchment, despite the presence of partial barriers to migration. Elvers returning to mature within UK rivers between the months of February and May annually. The baseline data		barriers that may impact on eel migration (upstream) and the consequent changes in passability as a result of increased flows
	Population size (returning adults)	No decline in number of returning adults from established baseline.			
	River population	River population targets for the Usk and Wye must be met Baseline yet to be established. Noble et al. (2007) provides some information on juvenile densities[168].			
Ramsar criterion 4: Run of migratory fish species Sea Lamprey *Petromyzon marinus* River lamprey *Lampetra fluviatilis* Twaite shad *Alosa. fallax* Allis shad *Alosa alosa* Atlantic salmon *Salmo salar* Sea trout *S. trutta* European eel *Anguilla anguilla*.	The feature will be considered to be in favourable condition when, subject to natural processes, each of the following conditions are met:	– . the migratory passage of both adults and juveniles of the assemblage of migratory fish species through the Severn Estuary between the Bristol Channel and any of their spawning rivers is not obstructed or impeded by physical barriers, changes in flows, or poor water quality; – ii the size of the populations of the assemblage species in the Severn Estuary and the rivers which drain into it, is at least maintained and is at a level that is sustainable in the long term; – – iii. the abundance of prey species3 forming the principal food resources for the assemblage species within the			

[152] Thames Water (2016), Severn Thames Transfer: Water Quality and Ecology Assessment - Phase 2: Main Project Report (issued October 2016). Report by Cascade Consulting and HR Wallingford on behalf of Thames Water.
[153] United Utilities (2021). Severn to Thames Transfer SRO downstream River Avon confluence to the tidal limit. Report by Ricardo Energy and Environment.
[154] Milner, N.J. (Ed.) (1990) *Fish movement in relation to freshwater flow and quality*. AST Blue Book Series, Atlantic Salmon Trust, Pitlochry. 54pp.
[155] Hardisty MW & Potter IC (eds) (1971). *The biology of lampreys*. Academic Press, London.
[156] APEM (2020). STT Ecological Literature Review. APEM Scientific Report P00004288. Severn Thames Transfer Partnership, September 2020, v2.0 Final, 480 pp
[168] https://naturalresources.wales/media/673887/severn-estuary-sac-spa-and-ramsar-reg-33-advice-from-ne-and-ccw-june-09.pdf

Qualifying Feature	Attribute	Target	Potential Effects	Mitigation & Monitoring	Adverse Effect Predicted? (
Ramsar criterion 8: fish of the whole estuarine and river system 110 species recorded		estuary, is maintained. – iv. Toxic contaminants in the water column4 and sediment are below levels which would pose a risk to the ecological objectives described above	shows that European eel are widespread within the catchment including the main stem River Severn and tributaries. Elver migration is not directly linked to increased flow as for salmonids, however, directional cues are still taken from flow. Similar to salmonid smolt, silver eel migration is linked to periods of increased flow within the migration window. European eel are a robust species able to deal with a wide range of water temperatures and water quality. Surveys have found juveniles European eel between Tewkesbury and Strensham on the River Avon, indicating the presence of suitable habitat upstream of the confluence with the River Severn. Historical studies have also recorded juveniles as far upstream as Chadbury on the River Avon (approximately 37 km from the confluence with the River Severn), and elvers as far as Nafford (approximately 15 km from the confluence). Given the localised nature of the anticipated changes in flow, coupled with the distance upstream from the confluence between the River Avon and the River Severn, it is highly unlikely that the migratory behaviour and ability of eels will be impacted. There is some uncertainty with regards to the potential barriers in the River Avon and the subsequent impact of the increased through changes in hydraulic conditions (changes in velocity, water depth or head drop across a structure) and the consequences for upstream migration. It is widely accepted that fine-scale home stream identification during spawning migrations in anadromous salmonids is guided by olfaction, a hypothesis described by Hasler & Scholz (1983)[157]. Olfaction is a chemoreception that forms the sense of smell in fishes and occurs when odorants bind to specific sites on olfactory receptors located in the nasal cavity. Juvenile migratory salmonids are thought to imprint upon the site-specific odour signature of their natal stream and, when they return to freshwater as spawning adults, they are able to discriminate that imprinted odour signature to identify, and navigate to, their natal river or tributary. The mechanism by which the chemical make-up of home stream water is imprinted, and the array of key odorants utilised during imprinting are both still poorly understood[158, 159]. Though the exact chemical nature of the odorant profile used by salmonids to discern their natal stream is not known (and may well be population and/or site-specific), it is hypothesised that these odours are a complex, catchment-specific mixture of inorganic and organic chemicals from soil, plants and aquatic organisms[112]. Recent research suggests that the chemical array during imprinting is likely to consist of a combination of amino acids, some steroids, bile acids and slats, prostaglandins and cations such as calcium and magnesium[160]. Recently, amino acids have been identified as a primary candidate for olfactory cues in salmonids and studies have demonstrated that different combinations of amino acids present in natural stream waters act as chemo-attractants for homing salmon (although this research is not specific to Atlantis salmon or sea trout), and these compounds may represent an important part of the chemical signature used to discriminate their home stream[161, 162]. In terms of bioaccumulation of olfactory inhibitors, studies have shown that exposure to a range of substances including metals, pesticides and surfactants can inhibit olfaction in fish (e.g. Tierney *et al.*, 2007[163]). However, olfactory toxicity occurs via multiple, complex pathways and the degree of toxicity of a given substance is often a factor of concentration, exposure time, fish life stage and a number of environmental variables including pH, alkalinity, and temperature. Thus, predicting the impact of a toxic substance at a given concentration is complex. There is potential that the transfer of treated WwTW discharge into the River Avon and, subsequently the Severn Estuary could result in ongoing and potentially increasing bioaccumulation of olfactory inhibitors. The increased ratio of WwTW discharge to river water could also result in masking of essential olfactory cues for returning adults in the lower River Severn with associated delays. It is, therefore, possible that the transfer of WwTW discharge usually discharged into the River Tame into the River Avon could impact on the olfactory cues downstream of the confluence with the River Severn.		

[157] Hasler, A.D. & Scholz, A. T. (1983). Olfactory imprinting and homing in salmon. Investigations in the mechanism of the imprinting process.
[158] McCormick, S. D., Hansen, L. P., Quinn, T. P., & Saunders, R. L. (1998). Movement, migration, and smolting of Atlantic salmon (Salmo salar). Canadian Journal of Fisheries and Aquatic Sciences, 55(S1), 77-92.
[159] Ueda, H. (2012). Physiological mechanisms of imprinting and homing migration in Pacific salmon Oncorhynchus spp. Journal of Fish Biology, 81(2), 543-558.
[160] Bett, N. N., & Hinch, S. G. (2016). Olfactory navigation during spawning migrations: a review and introduction of the Hierarchical Navigation Hypothesis. Biological Reviews, 91(3), 728-759.
[161] 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(1-4), 249-251.
[162] Yamamoto, Y., Hino, H., & Ueda, H. (2010). Olfactory imprinting of amino acids in lacustrine sockeye salmon. PLoS One, 5(1), e8633.
[163] Tierney, K. B., Singh, C. R., Ross, P. S., & Kennedy, C. J. (2007). Relating olfactory neurotoxicity to altered olfactory-mediated behaviors in rainbow trout exposed to three currently-used pesticides. Aquatic Toxicology, 81(1), 55-64.

Qualifying Feature	Attribute	Target	Potential Effects	Mitigation & Monitoring	Adverse Effect Predicted? (
			It is well known that olfaction plays a role in the migration and spawning activities of salmonids. However, many other species are also depended on olfaction as part of the species life history. Twaite shad is reported as being sensitive to pollution, but few data appear to be available. Bird (2002)[164] reviewed the likely impacts of pollutants in the Severn Estuary and noted that (i) pollutants increase in bioavailability with decreasing conductivity and (ii) as well as causing mortality, metals may affect migration behaviour by sublethal effects on locomotion and olfaction. Previous observations suggested that lamprey utilize the odor of conspecific larvae to select streams for spawning. With regards to sea lamprey, normally males appear on the nesting sites first and are apparently highly attractive to females, possibly by the secretion of an olfactory sex attractant. Olfaction may also play a key role in elver migration orientating themselves towards freshwater inputs. Previous research has shown that elver prefer natural inland surface water over odourless water with the same physical properties (Creutzberg, 1961[1]). Attractive substances include, but are not limited to, earthy and green odours (Sola & Tongiorgi, 1996[1]), amino acids (Sola *et al.*, 1993[1]) and bile salts or taurine which are readily released from other eels (Sola and Tosi, 1993[1]). While there may be times when there are smaller upriver runs of Atlantic salmon, the main runs in the Severn occurs from October. Based on the representative operational pattern, the Minworth option will only operate intermittently during the main migration period for Atlantic salmon. Operational rules should also potentially consider the potential risk to chemical cues for migration and operation should be limited/avoided from the month of October to March. Similar, operational rules could also avoid the impacts on migration of lamprey. There is no known threshold in terms of dilution rate of natal water salmonid navigation ceases although Sutterlin & Gray (1973)[165] reported that Atlantic salmon were attracted to natal water that had been diluted to 0.1% and other fish species are known to discern and react to chemical cues at concentrations as low as parts per trillion (ppt)[166], corresponding to concentrations of natural odorants such as amino acids[116] and bile acids[167] in surface waters. Adverse effects on site integrity are not predicted. Further research is required to understand the potential parameters that should be considered in an impact assessment on olfactory cues and the possible extent of dilution of the diverted WwTW discharge in the Severn Estuary		

[164] Bird DJ (2002) *Environmental Factors Affecting Migratory Fish in the Severn Estuary with Particular Reference to Species of Shad and Lamprey*. Environment Agency Wales, Cardiff.
[165] Sutterlin, A. M., & Gray, R. (1973). Chemical basis for homing of Atlantic salmon (Salmo salar) to a hatchery. Journal of the Fisheries Board of Canada, 30(7), 985-989.
[166] 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(2), 196-202.
[167] 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(2), 161-171.

5.6 Pipeline conveyance, Deerhurst to Culham (300, 400 and 500 Ml/d)

A supported conveyance pipeline option transporting raw water from Deerhurst on the River Severn to Culham on the River Thames with a 300, 400 or 500Ml/d capacity Ml/d capacity and a total length of 88 km. The element includes all engineering works required to transfer the flow to the River Thames. This includes the following: a river intake structure at Deerhurst including inlet screens and a twin pipeline to a low lift pump station, a raw water low lift pump station and a twin pipeline to the water treatment works, treatment works, a treated water high lift pump station, a rising main, a break pressure tank at the high point, a gravity main to discharge, an outfall at Culham with an actuated valve and an aeration cascade, washouts along the route provided with permanent discharge pipework to adjacent watercourses and a tee off the main pipeline for SWOX supply.

The Environment Agency has advised a STT abstraction licence would be limited to not reduce flow at Deerhurst flow gauging station below 2,568 Ml/d, a hands-off flow (HoF) condition. At flows greater than this HoF, up to 172Ml/d is available for abstraction without support, and at flows greater than 3,333Ml/d an additional 355Ml/d is available for abstraction without support. As such, the impact on downstream river levels is not expected to be of a magnitude that would impede upstream passage of qualifying fish or impact on the supporting processes within the estuary.

As such, the assessment has considered the construction activities associated with the intake and pipeline and operational impacts are limited to entrainment only.

5.6.1 Potentially Affected European Sites

The HRA Screening concluded that implementation of the pipeline conveyance from Deerhurst - Culham has the potential to result in likely significant effects on the **Severn Estuary SAC and Ramsar Site**. The following qualifying features of the Severn Estuary SAC and Ramsar Site were screened in for further assessment through Appropriate Assessment:

- **Sea lamprey:** localised increases in suspended sediment (siltation and deposition), potential invasive species spread, noise and vibration disturbance, entrapment and impingement and potential water pollution incidents during construction. During operation reduced water flow downstream of the intake may also cause localised changes in nutrient loading, turbidity, salinity regime, reduced dissolved oxygen and changes in dilution of pollutants, potentially impacting individuals locally present and during migration upstream (April – May) to functional spawning habitats.
- **River lamprey:** localised increases in suspended sediment (siltation and deposition), potential invasive species spread, noise and vibration disturbance, entrapment and impingement and potential water pollution incidents during construction. During operation reduced water flow downstream of the intake may also cause localised changes in nutrient loading, turbidity, salinity regime, reduced dissolved oxygen and changes in dilution of pollutants, potentially impacting individuals locally present and during migration upstream (October - December) to functional spawning habitats.
- **Twaite shad:** localised increases in suspended sediment (siltation and deposition), potential invasive species spread, noise and vibration disturbance, entrapment and impingement and potential water pollution incidents during construction. During operation reduced water flow downstream of the intake may also cause localised changes in nutrient loading, turbidity, salinity regime, reduced dissolved oxygen and changes in dilution of pollutants, potentially impacting individuals locally present and during migration upstream (mid May – mid July) to functional spawning habitats.
- **Allis shad:** localised increases in suspended sediment (siltation and deposition), potential invasive species spread, noise and vibration disturbance, entrapment and impingement and potential water pollution incidents during construction. During operation reduced water flow downstream of the intake may also cause localised changes in nutrient loading, turbidity, salinity regime, reduced dissolved oxygen and changes in dilution of pollutants, potentially

impacting individuals locally present and during migration upstream (April - June[169]) to functional spawning habitats.

- **Atlantic salmon:** localised increases in suspended sediment (siltation and deposition), potential invasive species spread, noise and vibration disturbance, entrapment and impingement and potential water pollution incidents during construction. During operation reduced water flow downstream of the intake may also cause localised changes in nutrient loading, turbidity, salinity regime, reduced dissolved oxygen and changes in dilution of pollutants, potentially impacting individuals locally present and during migration upstream (November - December[170]) to functional spawning habitats.
- **Sea trout:** localised increases in suspended sediment (siltation and deposition), potential invasive species spread, noise and vibration disturbance, entrapment and impingement and potential water pollution incidents during construction. During operation reduced water flow downstream of the intake may also cause localised changes in nutrient loading, turbidity, salinity regime, reduced dissolved oxygen and changes in dilution of pollutants, potentially impacting individuals locally present and during migration upstream (September - December[170]) to functional spawning habitats.

Conservation Objectives and Favourable Condition Targets

Specific attributes and targets associated with the conservation objectives for each qualifying feature of the SAC are provided in **Table 5.7** and current conservation status, SSSI condition assessment and site improvement plan are provided in **Table 4.2**.

[169] Maitland, P. S and Hatton-Ellis, T. S (2003). *Ecology of the Allis and Twaite Shad*. Conserving Natura 2000 Rivers Ecology Series No. 3. English Nature, Peterborough.
[170] Miller, P. J and Loates, M. J (1997) Fish of Britain and Europe. *Harper Collins Publishers*, 1 – 288.

Table 5.7: Assessment of adverse effects of the pipeline conveyance, Deerhurst to Culham (300, 400 and 500 Ml/d) on the Severn Estuary SAC and Ramsar Site

Qualifying Feature	Attribute	Target	Potential Effects	Mitigation	Adverse Effect Predicted?)
1099 River lamprey (SAC interest feature 5) 1095 Sea lamprey (SAC interest feature 6)	Migratory access (barriers to migration).	– **Water quality** is sufficient to support migratory passage. Levels (for temperature, salinity, turbidity, pH, and dissolved oxygen) should comply with targets established under the EA Review of Consents and the Water Framework Directive. – **Water flows**: Flows from the rivers Wye, Usk and Severn into the estuary must be sufficient to allow migration. – **Physical barriers:** No artificial barriers significantly impairing adults from reaching existing and historical spawning grounds or juveniles from moving downstream.	River lamprey migrate upstream from October to December, with spawning occurring in British rivers typically from March – April[171]. once water temperatures reach 10 – 11 ºC[172]. Sea lamprey present in European waterbodies migrate upstream from April - May and spawn typically from late May – June[171]. 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 siltbeds), and provides adequate flows for migratory passage. It is important that this element does not adversely impact on upstream migration to functionally linked spawning habitats. As noted in the sections above. The Environment Agency has advised a STT abstraction licence would be limited by a HoF to protect flows into the estuary. **Construction** The construction of the Deerhurst to Culham pipeline will occur approximately 24.1km north of the Severn Estuary SAC and 45.91km north via hydrological connectivity. Construction work associated with the Deerhurst to Culham pipeline that could impact river and sea lamprey during upstream migration in the River Severn includes the following: two sets of two stage screening (bar and bandscreens) which will be positioned in front of the dual pipe culverts, penstock valve chambers on each main and construction of vehicle access required for maintenance of the screens and penstocks. The footprint of the works will be reduced using band screens and the penstock valve chamber will be around 10m x 5.5m x 5m. No additional barriers to migration would be created through construction of the pipeline. Potential impact pathways on migration during in-river works include water pollution incidents, spread and introduction of invasive non-native species (INNS), noise/ vibration/ light disturbance, localised increases in suspended sediment, entrapment and impingement and fluctuations in dissolved oxygen. Proposed mitigation measures to reduce noise/ vibration/ light disturbance include no night-time in river working during the migration season; this has not been included in the CDR. As construction works will be localised and short term, no adverse effects are anticipated from increases in suspended sediment, entrapment and dissolved oxygen fluctuations. Impact pathways from topsoil stripping, excavations and movement of construction vehicles along the riverbank include the introduction and spread of INNS, exposure to pollution from accidental oil spills and run-off, localised increases in suspended sediment and noise/ vibration/ light disturbance. As construction works on the riverbank will be localised and short term, no adverse effects are anticipated from increased suspended sediment, noise and vibration disturbance and run-off. Proposed mitigation measures to use directional/ baffled lighting during works on the riverbank will minimise light disturbance on the River Severn; this has not been included in the CDR. Following best practice guidelines to minimise the possible introduction and spread of INNS and pollution incidents are viewed as sufficient to ensure no adverse effects on qualifying features of the Severn Estuary SAC. **Operation** This element will transport unsupported flow from the River Severn to the River Thames both when required and when flows are above the hands-off flow (infrastructure already present). If below the hands-off flow, then a 'put and take' arrangement will operate using raw water from other appropriate option elements. During times of operation, depleted flows downstream of the intake could act as a barrier to migration upstream and corresponding spawning habitats. Based on species specific timings for upstream migration, sea lamprey is particularly vulnerable as they migrate upstream during low flow conditions (April – May). Depleted flows downstream could reduce successful migration to upstream spawning habitats; although noted this will be in operation for short time periods. However, with the hands-off flow system installed and conditions provided by the Environment Agency, no adverse effects on river and sea lamprey are anticipated as flows will be maintained at a favourable rate for migration. The decreased flows downstream of the intake during operation could also cause a reduction in the dilution of effluents, create salinity barriers, changes to nutrient loading, turbidity and reduced	**Construction** - Best practice biosecurity measures will be followed, as recommended by the GB Non-Native Species Secretariat[175] to guard against any potential for spreading invasive and non-native species during construction (not included in CDR; although noted that invasive species on site to be identified and removed in advance of construction). - Works will be conducted in adherence to EA Pollution Prevention Guidelines; now archived (not included in CDR, but the following is stated: all vehicles and any chemical/ oil storage will be fully bunded to prevent any accidental pollution of groundwater or watercourses). - Construction Environmental Management Plan with risk assessment for pollution incidents and introduction/ spread of INNS and a response plan if either occurred (not included CDR). - No night-time in river working to avoid noise/ vibration/ light disturbance during upstream migration from October – December for river lamprey and April – May for sea lamprey is proposed (not included in CDR). - Where possible, it is proposed that lighting will be directional/ baffled for works on the riverbank to minimise light disturbance in the River Severn (not included in CDR). - Spoil from pipeline construction will be distributed across the construction easement before topsoil replacement. - Earthworks drainage will 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. **Operation** - Two sets of two stage screening will be installed to exclude fish during times of operation. This includes large bar screens and band screens fitted with fish return channels to isolate fish and return individuals directly back to the watercourse. - Any maintenance works required during operation will follow best practice biosecurity measures and EA Pollution Prevention Guidelines as listed above. - Inlet screens and rapid gravity filtration (removes 99 % of 5 µm sized particles) with bypass safeguards will be used to remove larvae of invasive species before transfer of raw water from Deerhurst to Culham.	No adverse effects predicted

[171] Maitland PS (2003). *Ecology of the River, Brook and Sea Lamprey*. Conserving Natura 2000 Rivers Ecology Series No. 5. English Nature, Peterborough.
[172] Hardisty MW & Potter IC (eds) (1971). *The biology of lampreys*. Academic Press, London.
[175] Non-native species secretariat (2021). *Biosecurity and Prevention*. Accessed from: http://www.nonnativespecies.org/index.cfm?sectionid=58

Qualifying Feature	Attribute	Target	Potential Effects	Mitigation	Adverse Effect Predicted?)
			dissolved oxygen, negatively impacting on migration upstream. However, hydrological modelling of the lower River Severn[173] identified no discernible changes in river flow due to abstraction associated with the Deerhurst to Culham pipeline. At the maximum abstraction rate proposed, the 500 Ml/d flow reduction would cause a very limited change to the flow pattern of the River Severn from the Avon confluence to the tidal limit. During 86% of the strategic scheme flow dates the same flow band would be retained, while 14% would result in change by one flow band[174]. Therefore, no adverse effects are anticipated as a result of changes in flow on migratory access. Water quality assessments confirmed that further study of water quality data, measured at NRW water quality monitoring sites is required, in order to fully determine the water quality and chemistry representation of the River Severn downstream of the Avon confluence prior to a detail assessment of impacts to water quality from STT options and schemes[174]. River and sea lamprey may also become entrapped causing injury and/or enter the treatment works resulting in mortality during operation at the intake site. Considering the mitigation measures (two stage screening) and the relatively short duration that the intake will operate, adverse effects are not predicted.	- The Environment Agency has advised a STT abstraction licence would be limited to not reduce flow at Deerhurst flow gauging station below 2,568 Ml/d, a hands-off flow (HoF) condition. At flows greater than this HoF, up to 172Ml/d is available for abstraction without support, and at flows greater than 3,333Ml/d an additional 355Ml/d is available for abstraction without support.	
	Population size (returning adults)	No decline in number of returning adults from established baseline.	River and sea lamprey population size in the Severn Estuary SAC is dependent on several factors including breeding success, which is reliant on the availability of functional spawning and nursery habitats in the River Usk SAC, River Wye SAC and River Severn. In addition, natural fluctuations in food and host availability will also impact on population size[176]. The number of returning adults to the estuary is dependent on a range of biotic and abiotic parameters relevant to marine and estuarine systems including predation pressures and environmental conditions. **Construction** The construction of the Deerhurst to Culham pipeline may negatively impact on the number of returning adult river and sea lamprey to spawning habitats associated with the River Severn and River Vyrnwy (although limited information is known about the location and extent of spawning sites in the River Vyrnwy). This is due to potential impact pathways during in-river works, which include: water pollution incidents, spread and introduction INNS, noise/ vibration/ light disturbance, localised increases in suspended sediment, entrapment and impingement and fluctuations in dissolved oxygen. Proposed mitigation measures to reduce noise/ vibration/ light disturbance include no night-time in river working during the migration season; this has not been included in the CDR. As construction works will be localised and short term, no adverse effects are anticipated from increases in suspended sediment, entrapment and dissolved oxygen fluctuations on population size of river and sea lamprey. Impact pathways from topsoil stripping, excavations and movement of construction vehicles along the riverbank include the introduction and spread of INNS, exposure to pollution from accidental oil spills and run-off, localised increases in suspended sediment and noise/ vibration/ light disturbance. As construction works on the riverbank will be localised and short term, no adverse effects are anticipated from increased suspended sediment, noise and vibration disturbance and run-off. Proposed mitigation measures to use directional/ baffled lighting during works on the riverbank will minimise light disturbance on the River Severn; this has not been included in the CDR. Following best practice guidelines to minimise the possible introduction and spread of INNS and pollution incidents are viewed as sufficient to ensure no adverse effects on qualifying features of the Severn Estuary SAC. **Operation** During times of operation, depleted flows downstream of the intake could act as a barrier to migration upstream and corresponding spawning habitats, which could impact on long term population trends. Based on species specific timings for upstream migration sea lamprey is particularly vulnerable as they migrate upstream during low flow conditions (April – May). Depleted flows downstream could reduce successful migration to upstream spawning habitats; although noted this will be in operation for short time periods. However, with the hands-off flow system installed and conditions provided by the Environment Agency, no adverse effects on river and sea lamprey are anticipated as flows will be maintained at a favourable rate for migration. The decreased flows downstream of the intake during operation could also cause a reduction in the dilution of effluents, create salinity barriers, changes to nutrient loading, turbidity and reduced dissolved oxygen, negatively impacting on migration upstream. However, hydrological modelling	**Construction** - Best practice biosecurity measures will be followed, as recommended by the GB Non-Native Species Secretariat[179] to guard against any potential for spreading invasive and non-native species during construction (not included in CDR; although noted that invasive species on site to be identified and removed in advance of construction). - Works will be conducted in adherence to EA Pollution Prevention Guidelines; now archived (not included in CDR, but the following is stated: all vehicles and any chemical/ oil storage will be fully bunded to prevent any accidental pollution of groundwater or watercourses). - Construction Environmental Management Plan with risk assessment for pollution incidents and introduction/ spread of INNS and a response plan if either occurred (not included CDR). - No night-time in river working to avoid noise/ vibration/ light disturbance during upstream migration from October – December for river lamprey and April – May for sea lamprey is proposed (not included in CDR). - Where possible, it is proposed that lighting will be directional/ baffled for works on the riverbank to minimise light disturbance in the River Severn (not included in CDR). - Spoil from pipeline construction will be distributed across the construction easement before topsoil replacement. - Earthworks drainage will 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.	No adverse effects predicted

[173] Thames Water (2016), Severn Thames Transfer: Water Quality and Ecology Assessment - Phase 2: Main Project Report (issued October 2016). Report by Cascade Consulting and HR Wallingford on behalf of Thames Water.
[174] United Utilities (2021). Severn to Thames Transfer SRO downstream River Avon confluence to the tidal limit. Report by Ricardo Energy and Environment.
[176] 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.
[179] Non-native species secretariat (2021). *Biosecurity and Prevention*. Accessed from: http://www.nonnativespecies.org/index.cfm?sectionid=58

Qualifying Feature	Attribute	Target	Potential Effects	Mitigation	Adverse Effect Predicted?)
			of the lower River Severn[177] identified no discernible changes in river flow due to abstraction associated with the Deerhurst to Culham pipeline. At the maximum abstraction rate proposed, the 500 Ml/d flow reduction would cause a very limited change to the flow pattern of the River Severn from the Avon confluence to the tidal limit. During 86% of the strategic scheme flow dates the same flow band would be retained, while 14% would result in change by one flow band[178]. Therefore, no adverse effects on population size are anticipated as a result of changes in water flow. Water quality assessments confirmed that further study of water quality data, measured at NRW water quality monitoring sites is required, in order to fully determine the water quality and chemistry representation of the River Severn downstream of the Avon confluence prior to a detail assessment of impacts to water quality from STT options and schemes[178]. River and sea lamprey may also become entrapped causing injury and/ or enter the treatment works resulting in mortality during operation at the intake site. Considering the mitigation measures (two stage screening) and the relatively short duration that the intake will operate, no adverse effects are predicted.	- **Operation** - Two sets of two stage screening will be installed to exclude fish during times of operation. This includes large bar screens and band screens fitted with fish return channels to isolate fish and return individuals directly back to the watercourse. - Any maintenance works required during operation will follow best practice biosecurity measures and EA Pollution Prevention Guidelines as listed above. - Inlet screens and rapid gravity filtration (removes 99 % of 5 µm sized particles) with bypass safeguards will be used to remove larvae of invasive species before transfer of raw water from Deerhurst to Culham. - The Environment Agency has advised a STT abstraction licence would be limited to not reduce flow at Deerhurst flow gauging station below 2,568 Ml/d, a hands-off flow (HoF) condition. At flows greater than this HoF, up to 172Ml/d is available for abstraction without support, and at flows greater than 3,333Ml/d an additional 355Ml/d is available for abstraction without support. -	
	Ammocoete population in tributary rivers	River population targets for the Usk and Wye must be met Baseline is the survey of ammocoete abundance and distribution in the Rivers Usk and Wye commissioned by CCW in 2005 (Harvey et al. 2007).	River and sea lamprey ammocoetes live in burrows created in silt beds (nursery habitat) upstream, where they remain for a several years undergoing larval development. Once metamorphosis takes place (morphological changes from larva to adult), lamprey migrate downstream[182]. **Construction** Due to the location of the proposed Deerhurst to Culham pipeline and associated intake site, no direct impacts from construction of the pipeline downstream have been identified on ammocoete populations present in tributaries upstream. However, adopting the precautionary principle, it cannot be assumed at this stage that suitable habitat and therefore, ammocoetes are not present in the lower reaches of the River Severn. If present during in-river works, the following impact pathways have been identified: water pollution incidents, spread and introduction INNS, noise/ vibration/ light disturbance, localised increases in suspended sediment/ siltation, entrapment and impingement and fluctuations in dissolved oxygen. Mitigation measures have been proposed to identify if suitable habitat is present within proximity of the construction site (with 100m buffer). Electrofishing surveys in 1m² quadrats would also provide information on the current ammocoete populations present at the site. However, due to the scale and temporary nature of the construction works, no adverse effects on ammocoete populations are anticipated. **Operation** Due to the location of the proposed Deerhurst – Culham pipeline and associated intake site, no direct impacts from the operation of the pipeline have been identified on ammocoete populations in tributaries upstream. However, adopting the precautionary principle it cannot be assumed at this stage that suitable habitat and therefore, ammocoetes are not present. If present, they will be exposed to reduced water flows during 14% of the proposed flow dates, at the maximum abstraction rate (500 Ml/d). During 86% of the strategic scheme flow dates the same flow band would be retained[180]. Therefore, no adverse effects on ammocoete populations are anticipated as a result of changes in water flow. Water quality assessments confirmed that further study of water quality data, measured at NRW water quality monitoring sites is required, in order to fully	- Best practice biosecurity measures will be followed, as recommended by the GB Non-Native Species Secretariat[181] to guard against any potential for spreading invasive and non-native species during construction (not included in CDR; although noted that invasive species on site to be identified and removed in advance of construction). - Works will be conducted in adherence to EA Pollution Prevention Guidelines; now archived (not included in CDR, but the following is stated: all vehicles and any chemical/ oil storage will be fully bunded to prevent any accidental pollution of groundwater or watercourses). - Construction Environmental Management Plan with risk assessment for pollution incidents and introduction/ spread of INNS and a response plan if either occurred (not included CDR). - No night-time in river working to avoid noise/ vibration/ light disturbance during upstream migration from October – December for river lamprey and April – May for sea lamprey is proposed (not included in CDR). - Where possible, it is proposed that lighting will be directional/ baffled for works on the riverbank to minimise light disturbance in the	No adverse effects predicted (

[177] Thames Water (2016), Severn Thames Transfer: Water Quality and Ecology Assessment - Phase 2: Main Project Report (issued October 2016). Report by Cascade Consulting and HR Wallingford on behalf of Thames Water.
[178] United Utilities (2021). Severn to Thames Transfer SRO downstream River Avon confluence to the tidal limit. Report by Ricardo Energy and Environment.
[180] United Utilities (2021). Severn to Thames Transfer SRO downstream River Avon confluence to the tidal limit. Report by Ricardo Energy and Environment.
[181] Non-native species secretariat (2021). *Biosecurity and Prevention*. Accessed from: http://www.nonnativespecies.org/index.cfm?sectionid=58

Qualifying Feature	Attribute	Target	Potential Effects	Mitigation	Adverse Effect Predicted?)
			determine the water quality and chemistry representation of the River Severn downstream of the Avon confluence prior to a detail assessment of impacts to water quality from STT options and schemes[180]. In addition, the baseline for the site is based on ammocoete abundances within the River Wye and River Usk. As there is no potential for adverse effects within these watercourses from either the construction or operation of the proposed pipeline, no adverse effects on ammocoete populations associated with the Severn Estuary SAC are predicted.	River Severn (not included in CDR). - Habitat suitability monitoring is required at the construction site, including a 100m buffer do identify if suitable silt beds are present for ammocoetes. Electrofishing surveys in 1m² quadrats would also provide information on the current ammocoete populations present at the site (not included in CDR). **Operation** - Two sets of two stage screening will be installed to exclude fish during times of operation. This includes large bar screens and band screens fitted with fish return channels to isolate fish and return individuals directly back to the watercourse. - Any maintenance works required during operation will follow best practice biosecurity measures and EA Pollution Prevention Guidelines as listed above. - Inlet screens and rapid gravity filtration (removes 99 % of 5 µm sized particles) with bypass safeguards will be used to remove larvae of invasive species before transfer of raw water from Deerhurst to Culham. - The Environment Agency has advised a STT abstraction licence would be limited to not reduce flow at Deerhurst flow gauging station below 2,568 Ml/d, a hands-off flow (HoF) condition. At flows greater than this HoF, up to 172Ml/d is available for abstraction without support, and at flows greater than 3,333Ml/d an additional 355Ml/d is available for abstraction without support.	
	Prey species	– No significant reduction in abundance of key prey species against an established baseline	Adult river lamprey feed on a range of estuarine prey species including herring (*Clupea harengus*), sprat (*Sprattus sprattus*) and flounder (*Platichthys flesus*)[182], and typically do not feed in freshwater habitats. Adult sea lamprey feed on a wide variety of marine and anadromous prey species, including Atlantic sturgeon (*Acipenser sturio*), herring (*Clupea harengus*), Atlantic salmon (*Salmo salar*), cod (*Gadus morhua*) and haddock (*Melanogrammus aeglefinus*)[182]. **Construction** Most of the prey species listed above breed and spawn offshore and therefore, are unlikely to be affected by the proposed construction works in the River Severn. For species such as Atlantic sturgeon that migrate upstream to spawn from spring – early summer[183] and Atlantic salmon from November – December[184], the following impact pathways have been identified: water pollution incidents, spread and introduction of INNS, noise/ vibration/ light disturbance, localised increases in suspended sediment, entrapment and impingement and fluctuations in dissolved oxygen. Proposed mitigation measures to reduce noise/ vibration/ light disturbance include no night-time in river working during the migration season; this has not been included in the CDR. As construction works will be localised and short term, no adverse effects are anticipated from increases in suspended sediment, entrapment and dissolved oxygen fluctuations on prey species. Impact pathways from topsoil stripping, excavations and movement of construction vehicles along the riverbank include the introduction and spread of INNS, exposure to pollution from accidental oil spills and run-off, localised increases in suspended sediment and noise/vibration disturbance. As construction works on the riverbank will be localised and short term, no adverse effects are anticipated from increased suspended sediment, noise and vibration disturbance and run-off. Proposed mitigation measures to use directional/ baffled lighting during works on the	**Construction** - Best practice biosecurity measures will be followed, as recommended by the GB Non-Native Species Secretariat[187] to guard against any potential for spreading invasive and non-native species during construction (not included in CDR; although noted that invasive species on site to be identified and removed in advance of construction). - Works will be conducted in adherence to EA Pollution Prevention Guidelines; now archived (not included in CDR, but the following is stated: all vehicles and any chemical/ oil storage will be fully bunded to prevent any accidental pollution of groundwater or watercourses). - Construction Environmental Management Plan with risk assessment for pollution incidents and introduction/ spread of INNS and a response plan if either occurred (not included CDR). - No night-time in river working to avoid noise/ vibration/ light disturbance during upstream	No adverse effects predicted

[182] Maitland PS (2003). *Ecology of the River, Brook and Sea Lamprey*. Conserving Natura 2000 Rivers Ecology Series No. 5. English Nature, Peterborough.
[183] Miller, P. J and Loates, M. J (1997) Fish of Britain and Europe. *Harper Collins Publishers*, 1 – 288.
[184] Miller, P. J and Loates, M. J (1997) Fish of Britain and Europe. *Harper Collins Publishers*, 1 – 288.
[187] Non-native species secretariat (2021). *Biosecurity and Prevention*. Accessed from: http://www.nonnativespecies.org/index.cfm?sectionid=58

Qualifying Feature	Attribute	Target	Potential Effects	Mitigation	Adverse Effect Predicted?)
			riverbank will minimise light disturbance on the River Severn; this has not been included in the CDR. Following best practice guidelines to minimise the possible introduction and spread of INNS and pollution incidents are viewed as sufficient to ensure no adverse effects prey species. **Operation** No impact pathways have been identified for the majority of river and sea lamprey prey species as they occupy estuarine and/ or marine habitats and spawn offshore. As operation of this element will be during low flow periods (spring and summer), Atlantic salmon is also unlikely to be affected, as the species migrates upstream to spawn from November – December. As Atlantic sturgeon migrate upstream in spring – early summer, depleted flows downstream of the intake could act as a barrier to migration and corresponding spawning habitats. This could negatively impact on long term population trends and prey availability for lamprey species, however, due to the lack of identified spawning sites and records of Atlantic sturgeon in the River Vyrnwy, negligible effects are anticipated from this element. The decreased flows downstream of the intake during operation could also cause a reduction in the dilution of effluents, create salinity barriers, changes to nutrient loading, turbidity and reduced dissolved oxygen, negatively impacting on migration upstream. However, hydrological modelling of the lower River Severn[185] identified no discernible changes in river flow due to abstraction associated with the Deerhurst to Culham pipeline. At the maximum abstraction rate proposed, the 500 Ml/d flow reduction would cause a very limited change to the flow pattern of the River Severn from the Avon confluence to the tidal limit. During 86% of the strategic scheme flow dates the same flow band would be retained, while 14% would result in change by one flow band[186]. Therefore, no adverse effects o prey species are anticipated as a result of changes in water flow. Water quality assessments confirmed that further study of water quality data, measured at NRW water quality monitoring sites is required, in order to fully determine the water quality and chemistry representation of the River Severn downstream of the Avon confluence prior to a detail assessment of impacts to water quality from STT options and schemes[186]. Prey species may also become entrapped causing injury and/or enter the treatment works resulting in mortality during operation at the intake site. Considering the mitigation measures (two stage screening) and the relatively short duration that the intake will operate, no adverse effects are predicted.	migration from October – December for river lamprey and April – May for sea lamprey is proposed (not included in CDR). - Where possible, it is proposed that lighting will be directional/ baffled for works on the riverbank to minimise light disturbance in the River Severn (not included in CDR). - Spoil from pipeline construction will be distributed across the construction easement before topsoil replacement. - Earthworks drainage will 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. **Operation** - Two sets of two stage screening will be installed to exclude fish during times of operation. This includes large bar screens and band screens fitted with fish return channels to isolate fish and return individuals directly back to the watercourse. - Any maintenance works required during operation will follow best practice biosecurity measures and EA Pollution Prevention Guidelines as listed above. - Inlet screens and rapid gravity filtration (removes 99 % of 5 µm sized particles) with bypass safeguards will be used to remove larvae of invasive species before transfer of raw water from Deerhurst to Culham. - The Environment Agency has advised a STT abstraction licence would be limited to not reduce flow at Deerhurst flow gauging station below 2,568 Ml/d, a hands-off flow (HoF) condition. At flows greater than this HoF, up to 172Ml/d is available for abstraction without support, and at flows greater than 3,333Ml/d an additional 355Ml/d is available for abstraction without support. -	
1103 Twaite shad	Migratory access (barriers to migration).	– **Water quality** is sufficient to support migratory passage. Levels (for temperature, salinity, turbidity, pH, and dissolved oxygen) should comply with targets established under the EA Review of Consents and the Water Framework Directive. – **Water flows**: Flows from the rivers Wye, Usk and Severn into the estuary must be sufficient to allow migration.	Twaite shad migrate upstream to spawn in British rivers from mid May – mid July; notably twaite shad will spawn close to the tidal limit and further upstream[188]. In the River Severn, the upstream migration of Twaite shad is restricted by the presence of a weir at Worcester. Therefore, their current spawning range is limited to the lower 23 km of the River Severn[189]. Although it is noted that the unlocking the Severn programme may remove in-river barriers in the River Severn prior to future implementation of this element. **Construction** The construction of the Deerhurst to Culham pipeline will occur approximately 24.1km north of the Severn Estuary SAC and 45.91km north via hydrological connectivity. Construction work associated with the Deerhurst to Culham pipeline that could impact on twaite shad during	**Construction** - Best practice biosecurity measures will be followed, as recommended by the GB Non-Native Species Secretariat[191] to guard against any potential for spreading invasive and non-native species during construction (not included in CDR; although noted that invasive species on site to be identified and removed in advance of construction). - Works will be conducted in adherence to EA	No adverse effects predicted

[185] Thames Water (2016), Severn Thames Transfer: Water Quality and Ecology Assessment - Phase 2: Main Project Report (issued October 2016). Report by Cascade Consulting and HR Wallingford on behalf of Thames Water.
[186] United Utilities (2021). Severn to Thames Transfer SRO downstream River Avon confluence to the tidal limit. Report by Ricardo Energy and Environment.
[188] Lythgoe, G and Lythgoe J. (1971). Fishes of the sea, the coastal waters of the British Isles, Northern Europe and the Mediterranean. Blandford Press Ltd, 6 – 312.
[189] Unlocking the Severn for LIFE – LIFE – Shad Severn: Conservation and restoration of twaite shad in the Severn Estuary Special Area of Conservation project description. LIFE15 NAT/UK/00021. Accessed on 11/12/2020. Available at: https://ec.europa.eu/environment/life/project/Projects/index.cfm?fuseaction=search.dspPage&n_proj_id=5866&docType=pdf

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

Qualifying Feature	Attribute	Target	Potential Effects	Mitigation	Adverse Effect Predicted?)
		– **Physical barriers:** No artificial barriers significantly impairing adults from reaching existing and historical spawning grounds or juveniles from moving downstream. –	upstream migration in the River Severn includes the following installations: two sets of two stage screening (bar and bandscreens) which will be positioned in front of the dual pipe culverts, penstock valve chambers on each main and construction of vehicle access required for maintenance of the screens and penstocks. The footprint of the works will be reduced using band screens and the penstock valve chamber will be around 10m x 5.5m x 5m. No additional barriers to migration would be created through construction of the pipeline. Potential impact pathways on migration during in-river works include water pollution incidents, spread and introduction of INNS, noise/ vibration/ light disturbance, localised increases in suspended sediment, entrapment and impingement and fluctuations in dissolved oxygen. Although construction works will be localised and short term, it is noted that juveniles are likely to congregate in the upper Severn estuary and if suitable spawning sites are present (clean gravels), may spawn close to the tidal limit which is where the proposed intake site is located. Proposed mitigation measures to reduce noise/ vibration/ light disturbance include no night-time in river working during the migration season; this has not been included in the CDR. As construction works will be localised and short term, no adverse effects are anticipated from increases in suspended sediment, entrapment and dissolved oxygen fluctuations on twaite shad. Impact pathways from topsoil stripping, excavations and movement of construction vehicles along the riverbank include the introduction and spread of INNS, exposure to pollution from accidental oil spills and run-off, localised increases in suspended sediment and noise/ vibration/ light disturbance. As construction works on the riverbank will be localised and short term, no adverse effects are anticipated from increased suspended sediment, noise and vibration disturbance and run-off. Where possible, additional mitigation has been proposed to use directional/ baffled lighting on the riverbank to minimise light disturbance in the River Severn (not included in CDR). Following best practice mitigation measures to minimise the possible introduction and spread of INNS and pollution incidents are viewed as sufficient to ensure no adverse effects on qualifying features of the Severn Estuary SAC. **Operation** This element will transport unsupported flow from the River Severn to the River Thames both when required and when flows are above the hands-off flow (infrastructure already present). If below the hands-off flow, then a 'put and take' arrangement will operate using raw water from other appropriate elements. During times of operation, depleted flows downstream of the intake could act as a barrier to migration upstream and corresponding spawning habitats. Twaite shad will be vulnerable to changes in flow during operation, as they migrate upstream to spawn from mid May – mid July. In addition, the effects of flow depletion due to increased abstraction may reduce (or improve) the suitability of habitat in the lower River Severn as a spawning and nursery area for twaite shad. However, with the hands-off flow system installed and conditions provided by the Environment Agency, no adverse effects on twaite shad are anticipated as flows will be maintained at a favourable rate for migration. The decreased flows downstream of the intake during operation could also cause a reduction in the dilution of effluents, create salinity barriers, changes to nutrient loading, turbidity and reduced dissolved oxygen, negatively impacting on migration upstream. At the maximum abstraction rate proposed, the 500 Ml/d flow reduction would cause a very limited change to the flow pattern of the River Severn from the Avon confluence to the tidal limit. During 86% of the strategic scheme flow dates the same flow band would be retained, while 14% would result in change by one flow band[190]. Therefore, no adverse effects are anticipated as a result of changes in flow on migratory access. Water quality assessments confirmed that further study of water quality data, measured at NRW water quality monitoring sites is required, in order to fully determine the water quality and chemistry representation of the River Severn downstream of the Avon confluence prior to a detail assessment of impacts to water quality from STT options and schemes[190]. Twaite shad may also become entrapped causing injury and/or enter the treatment works resulting in mortality during operation at the intake site. Considering the mitigation measures (two stage screening) and the relatively short duration that the intake will operate, no adverse effects are predicted.	Pollution Prevention Guidelines; now archived (not included in CDR, but the following is stated: all vehicles and any chemical/ oil storage will be fully bunded to prevent any accidental pollution of groundwater or watercourses). - Construction Environmental Management Plan with risk assessment for pollution incidents and introduction/ spread of INNS and a response plan if either occurred (not included CDR). - No night-time in river working to avoid noise/ vibration/ light disturbance during upstream migration from mid May – mid July is proposed (not included in CDR). - Where possible, it is proposed that lighting will be directional/ baffled for works on the riverbank to minimise light disturbance in the River Severn (not included in CDR). - Spoil from pipeline construction will be distributed across the construction easement before topsoil replacement. - Earthworks drainage will 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. - Habitat suitability monitoring is proposed within proximity of the intake site to determine if spawning habitat for twaite shad is present (not included in CDR). **Operation** - Two sets of two stage screening will be installed to exclude fish during times of operation. This includes large bar screens and band screens fitted with fish return channels to isolate fish and return individuals directly back to the watercourse. - Any maintenance works required during operation will follow best practice biosecurity measures and EA Pollution Prevention Guidelines as listed above. - Inlet screens and rapid gravity filtration (removes 99 % of 5 µm sized particles) with bypass safeguards will be used to remove larvae of invasive species before transfer of raw water from Deerhurst to Culham. The Environment Agency has advised a STT abstraction licence would be limited to not reduce flow at Deerhurst flow gauging station below 2,568 Ml/d, a hands-off flow (HoF) condition. At flows greater than this HoF, up to 172Ml/d is available for abstraction without support, and at flows greater than 3,333Ml/d an additional 355Ml/d is available for abstraction without support.	

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

Qualifying Feature	Attribute	Target	Potential Effects	Mitigation	Adverse Effect Predicted?)
	Population size (returning adults)	No decline in number of returning adults from established baseline.	Twaite shad population size in the Severn Estuary SAC is dependent on several factors including breeding success, which is reliant on the availability of functional spawning and nursery habitats in the River Usk SAC, River Wye SAC and River Severn. In addition, natural fluctuations in food availability will also impact on population size[192]. **Construction** The construction of the Deerhurst to Culham pipeline may negatively impact on the number of returning Twaite shad to spawning habitats associated with the River Severn. This is due to potential impact pathways during in-river works, which include: water pollution incidents, spread and introduction INNS, noise/ vibration/ light disturbance, localised increases in suspended sediment, entrapment and impingement and fluctuations in dissolved oxygen. Although construction works will be localised and short term, it is noted that juveniles are likely to congregate in the upper Severn estuary and if suitable spawning sites are present (clean gravels), may spawn close to the tidal limit which is where the proposed intake site is located. Proposed mitigation measures to reduce noise/ vibration/ light disturbance include no night-time in river working during the migration season; this has not been included in the CDR. As construction works will be localised and short term, no adverse effects are anticipated from increases in suspended sediment, entrapment and dissolved oxygen fluctuations on population size. Impact pathways from topsoil stripping, excavations and movement of construction vehicles along the riverbank include the introduction and spread of INNS, exposure to pollution from accidental oil spills and run-off, localised increases in suspended sediment and noise/ vibration/ light disturbance. As construction works on the riverbank will be localised and short term, no adverse effects are anticipated from increased suspended sediment, noise and vibration disturbance and run-off. Where possible, additional mitigation has been proposed to use directional/ baffled lighting on the riverbank to minimise light disturbance on the River Severn (not included in CDR). Following best practice mitigation measures to minimise the possible introduction and spread of INNS and pollution incidents are viewed as sufficient to ensure no adverse effects on qualifying features of the Severn Estuary SAC. **Operation** During times of operation, depleted flows downstream of the intake could act as a barrier to migration upstream and corresponding spawning habitats, which could impact on long term population trends. Based on species specific timings for upstream migration twaite shad are vulnerable as they migrate upstream during low flow conditions (mid May – mid July). However, with the hands-off flow system installed and conditions provided by the Environment Agency, no adverse effects on twaite shad are anticipated as flows will be maintained at a favourable rate for migration. The decreased flows downstream of the intake during operation could also cause a reduction in the dilution of effluents, create salinity barriers, changes to nutrient loading, turbidity and reduced dissolved oxygen, negatively impacting on migration upstream. However, hydrological modelling of the lower River Severn[193] identified no discernible changes in river flow due to abstraction associated with the Deerhurst to Culham pipeline. At the maximum abstraction rate proposed, the 500 Ml/d flow reduction would cause a very limited change to the flow pattern of the River Severn from the Avon confluence to the tidal limit. During 86% of the strategic scheme flow dates the same flow band would be retained, while 14% would result in change by one flow band[194]. Therefore, no adverse effects on population size of returning adults are anticipated as a result of changes in water flow. Water quality assessments confirmed that further study of water quality data, measured at NRW water quality monitoring sites is required, in order to fully determine the water quality and chemistry representation of the River Severn downstream of the Avon confluence prior to a detail assessment of impacts to water quality from STT options and schemes[194]. Twaite shad may also become entrapped causing injury and/ or enter the treatment works resulting in mortality during operation at the intake site. Considering the mitigation measures (two stage screening) and the relatively short duration that the intake will operate, no adverse effects are predicted.	**Construction** - Best practice biosecurity measures will be followed, as recommended by the GB Non-Native Species Secretariat[195] to guard against any potential for spreading invasive and non-native species during construction (not included in CDR; although noted that invasive species on site to be identified and removed in advance of construction). - Works will be conducted in adherence to EA Pollution Prevention Guidelines; now archived (not included in CDR, but the following is stated: all vehicles and any chemical/ oil storage will be fully bunded to prevent any accidental pollution of groundwater or watercourses). - Construction Environmental Management Plan with risk assessment for pollution incidents and introduction/ spread of INNS and a response plan if either occurred (not included CDR). - No night-time in river working to avoid noise/ vibration/ light disturbance during upstream migration from mid May – mid July is proposed (not included in CDR). - Where possible, it is proposed that lighting will be directional/ baffled for works on the riverbank to minimise light disturbance in the River Severn (not included in CDR). - Spoil from pipeline construction will be distributed across the construction easement before topsoil replacement. - Earthworks drainage will 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. **Operation** - Two sets of two stage screening will be installed to exclude fish during times of operation. This includes large bar screens and band screens fitted with fish return channels to isolate fish and return individuals directly back to the watercourse. - Any maintenance works required during operation will follow best practice biosecurity measures and EA Pollution Prevention Guidelines as listed above. - Inlet screens and rapid gravity filtration (removes 99 % of 5 µm sized particles) with bypass safeguards will be used to remove larvae of invasive species before transfer of raw water from Deerhurst to Culham. The Environment Agency has advised a STT	No adverse effects predicted

[192] 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.
[193] Thames Water (2016), Severn Thames Transfer: Water Quality and Ecology Assessment - Phase 2: Main Project Report (issued October 2016). Report by Cascade Consulting and HR Wallingford on behalf of Thames Water.
[194] United Utilities (2021). Severn to Thames Transfer SRO downstream River Avon confluence to the tidal limit. Report by Ricardo Energy and Environment.
[195] Non-native species secretariat (2021). *Biosecurity and Prevention*. Accessed from: http://www.nonnativespecies.org/index.cfm?sectionid=58

Qualifying Feature	Attribute	Target	Potential Effects	Mitigation	Adverse Effect Predicted?)
				abstraction licence would be limited to not reduce flow at Deerhurst flow gauging station below 2,568 Ml/d, a hands-off flow (HoF) condition. At flows greater than this HoF, up to 172Ml/d is available for abstraction without support, and at flows greater than 3,333Ml/d an additional 355Ml/d is available for abstraction without support.	
	River population	River population targets for the Usk and Wye must be met Baseline yet to be established. Noble et al. (2007) provides some information on juvenile densities[196].	Twaite shad river populations associated with the Severn Estuary SAC are dependent on adjacent rivers including the River Usk and Wye and the availability of suitable spawning and nursery sites to fulfil their lifecycle[196]. **Construction** Due to the location of the proposed Deerhurst to Culham pipeline and associated intake site on the River Severn, no direct impacts from construction of the pipeline have been identified on river populations and targets for the River Usk and Wye. **Operation** Due to the location of the proposed Deerhurst to Culham pipeline and associated intake site on the River Severn, no direct impacts from operation of the pipeline have been identified on river populations and targets for the River Usk and Wye. As there is no potential for adverse effects on the River Usk and Wye from either the construction or operation of the proposed pipeline, no adverse effects on river populations associated with the Severn Estuary SAC are predicted.	No mitigation measures required.	No adverse effects predicted
	Prey species	No significant reduction in abundance of key prey species against an established baseline Baseline is yet to be established through fish surveys in estuary and river	Twaite shad largely feed on estuarine and marine prey including crustaceans (mysids and copepods), fish (sprats and anchovies) and fish eggs[197]. **Construction** As twaite shad prey species largely occupy estuarine and marine habitats and spawn offshore, the likely presence of prey species during construction is considered low. If prey species are present in the lower River Severn during construction, the following impact pathways have been identified: water pollution incidents, spread and introduction of INNS, noise/ vibration/ light disturbance, localised increases in suspended sediment, entrapment and impingement and fluctuations in dissolved oxygen. Proposed mitigation measures to reduce noise/ vibration/ light disturbance include no night-time in river working during the migration season; this has not been included in the CDR. As construction works will be localised and short term, no adverse effects are anticipated from increases in suspended sediment, entrapment and dissolved oxygen fluctuations on prey species. Impact pathways from topsoil stripping, excavations and movement of construction vehicles along the riverbank include the introduction and spread of INNS, exposure to pollution from accidental oil spills and run-off, localised increases in suspended sediment and noise/ vibration/ light disturbance. As construction works on the riverbank will be localised and short term, no adverse effects are anticipated from increased suspended sediment, noise and vibration disturbance and run-off. Where possible, additional mitigation has been proposed to use directional/ baffled lighting on the riverbank to minimise light disturbance on the River Severn (not included in CDR). Following best practice mitigation measures to minimise the possible introduction and spread of INNS and pollution incidents are viewed as sufficient to ensure no adverse effects on prey species. **Operation** Although sprat (*Clupea sprattus*) tolerate low salinities (4 – 36 ppt) the species spawn offshore and therefore, are unlikely to be adversely affected by localised, reduced flows in the lower River Severn. Similarly, anchovies (*Engraulis encrasicholus*) spawn offshore. Therefore, no adverse effects on prey availability for twaite shad are anticipated. The decreased flows downstream of the intake during operation could cause a reduction in the dilution of effluents, create salinity barriers, changes to nutrient loading, turbidity and reduced dissolved oxygen, negatively impacting on migration upstream. This could impact on invertebrate populations and associated prey species of twaite shad. At the maximum abstraction rate proposed, the 500 Ml/d flow reduction would cause a very limited change to the flow pattern of the River Severn from the Avon confluence to the tidal limit. During 86% of the strategic scheme flow dates the same flow band would be retained, while 14% would result in change by one flow	**Construction** - Best practice biosecurity measures will be followed, as recommended by the GB Non-Native Species Secretariat[199] to guard against any potential for spreading invasive and non-native species during construction (not included in CDR; although noted that invasive species on site to be identified and removed in advance of construction). - Works will be conducted in adherence to EA Pollution Prevention Guidelines; now archived (not included in CDR, but the following is stated: all vehicles and any chemical/ oil storage will be fully bunded to prevent any accidental pollution of groundwater or watercourses). - Construction Environmental Management Plan with risk assessment for pollution incidents and introduction/ spread of INNS and a response plan if either occurred (not included CDR). - No night-time in river working to avoid noise/ vibration/ light disturbance during upstream migration of associated prey species (not included in CDR). - Where possible, it is proposed that lighting will be directional/ baffled for works on the riverbank to minimise light disturbance in the River Severn (not included in CDR). - Spoil from pipeline construction will be distributed across the construction easement before topsoil replacement. - Earthworks drainage will be controlled including use of temporary settlement ponds and measures will be taken to protect any	No adverse effects predicted

[196] 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.
[197] Maitland, P. S. and Hatton-Ellis, T. W. (2003). Ecology of the Allis and Twaite shad. Conserving Natura 2000 Rivers Ecology Series No. 3. Natural England, Peterborough.
[199] Non-native species secretariat (2021). *Biosecurity and Prevention*. Accessed from: http://www.nonnativespecies.org/index.cfm?sectionid=58

Qualifying Feature	Attribute	Target	Potential Effects	Mitigation	Adverse Effect Predicted?)
			band[198]. Therefore, no adverse effects are anticipated as a result of changes in flow on prey species. Water quality assessments confirmed that further study of water quality data, measured at NRW water quality monitoring sites is required, in order to fully determine the water quality and chemistry representation of the River Severn downstream of the Avon confluence prior to a detail assessment of impacts to water quality from STT options and schemes[198]. Prey species may also become entrapped causing injury and/or enter the treatment works resulting in mortality during operation at the intake site. Considering the mitigation measures (two stage screening) and the relatively short duration that the intake will operate, no adverse effects are predicted.	temporarily exposed bare soil from runoff during heavy rainfall events. **Operation** - Two sets of two stage screening will be installed to exclude fish during times of operation. This includes large bar screens and band screens fitted with fish return channels to isolate fish and return individuals directly back to the watercourse. - Any maintenance works required during operation will follow best practice biosecurity measures and EA Pollution Prevention Guidelines as listed above. - Inlet screens and rapid gravity filtration (removes 99 % of 5 µm sized particles) with bypass safeguards will be used to remove larvae of invasive species before transfer of raw water from Deerhurst to Culham. - The Environment Agency has advised a STT abstraction licence would be limited to not reduce flow at Deerhurst flow gauging station below 2,568 Ml/d, a hands-off flow (HoF) condition. At flows greater than this HoF, up to 172Ml/d is available for abstraction without support, and at flows greater than 3,333Ml/d an additional 355Ml/d is available for abstraction without support.	
Ramsar criterion 4: Run of migratory fish species Sea Lamprey *Petromyzon marinus* River lamprey *Lampetra fluviatilis* Twaite shad *Alosa. fallax* Allis shad *Alosa alosa* Atlantic salmon *Salmo salar* Sea trout *S. trutta* European eel *Anguilla anguilla*. **Ramsar criterion 8: fish of the whole estuarine and river system** 110 species recorded	- Migratory access (barriers to migration).	– **Water quality** is sufficient to support migratory passage. Levels (for temperature, salinity, turbidity, pH, and dissolved oxygen) should comply with targets established under the EA Review of Consents and the Water Framework Directive. – **Water flows**: Flows from the rivers into the estuary must be sufficient to allow migration. – **Physical barriers:** No artificial barriers significantly impairing adults from reaching existing and historical spawning grounds or juveniles from moving downstream.	The adverse effects of the Deerhurst to Culham pipeline on river lamprey, sea lamprey and twaite shad have been considered as designated features of the SAC. Therefore, these three species have been excluded from further assessment (refer to above sections for river lamprey, sea lamprey and twaite shad). As European eel migrate to offshore breeding sites to spawn, they have been excluded from any further consideration regarding migratory access. **Construction** The construction of the Deerhurst to Culham pipeline will occur approximately 24.1km north of the Severn Estuary Ramsar site and 45.91km north via hydrological connectivity. Construction work associated with the Deerhurst to Culham pipeline that could impact fish assemblages during upstream migration in the River Severn includes the following: installation of two sets of two stage screening (bar and bandscreens) which will be positioned in front of the dual pipe culverts, penstock valve chambers on each main and construction of vehicle access required for maintenance of the screens and penstocks. The footprint of the works will be reduced using band screens and the penstock valve chamber will be around 10m x 5.5m x 5m. No additional barriers to migration would be created through construction of the pipeline. Potential impacts during in-river construction on migratory access to upstream spawning sites in the River Severn and River Vyrnwy for Allis shad, Atlantic salmon and sea trout include the following: water pollution incidents, spread and introduction of invasive non-native species (INNS), noise/ vibration/ light disturbance, localised increases in suspended sediment, entrapment and impingement and fluctuations in dissolved oxygen. With proposed mitigation measures to minimise night-time, in-river disturbance during migration (not included in CDR) and following best practice guidelines no adverse effects as a result of disturbance are anticipated. Construction works will be localised and short term, therefore no adverse effects on migratory access from fluctuating abiotic factors and entrapment are anticipated. Impact pathways from topsoil stripping, excavations and movement of construction vehicles along the riverbank include the introduction and spread of INNS, exposure to pollution from accidental oil spills and run-off, localised increases in suspended sediment and noise/ vibration/ light disturbance. As construction works on the riverbank will be localised and short term, no adverse effects are anticipated from increased suspended sediment, noise/ vibration disturbance and run-off. Where possible, additional mitigation has been proposed to use directional/ baffled	**Construction** - Best practice biosecurity measures will be followed, as recommended by the GB Non-Native Species Secretariat[202] to guard against any potential for spreading invasive and non-native species during construction (not included in CDR; although noted that invasive species on site to be identified and removed in advance of construction). - Works will be conducted in adherence to EA Pollution Prevention Guidelines; now archived (not included in CDR, but the following is stated: all vehicles and any chemical/ oil storage will be fully bunded to prevent any accidental pollution of groundwater or watercourses). - Construction Environmental Management Plan with risk assessment for pollution incidents and introduction/ spread of INNS and a response plan if either occurred (not included CDR). - No night-time in river working to avoid noise/ vibration/ light disturbance during upstream migration of associated fish assemblages (not included in CDR). - Where possible, it is proposed that lighting will be directional/ baffled for works on the riverbank to minimise light disturbance in the River Severn (not included in CDR).	No adverse effects predicted (there is a risk of adverse effects should support releases coincide with extended periods of regulation releases).

[198] United Utilities (2021). Severn to Thames Transfer SRO downstream River Avon confluence to the tidal limit. Report by Ricardo Energy and Environment.
[202] Non-native species secretariat (2021). *Biosecurity and Prevention*. Accessed from: http://www.nonnativespecies.org/index.cfm?sectionid=58

Qualifying Feature	Attribute	Target	Potential Effects	Mitigation	Adverse Effect Predicted?)
			lighting on the riverbank to minimise light disturbance in the River Severn (not included in CDR). Following best practice mitigation measures to minimise the possible introduction and spread of INNS and pollution incidents are viewed as sufficient to ensure no adverse effects on qualifying features of the Severn Estuary Ramsar site. **Operation** This element will transport unsupported flow from the River Severn to the River Thames both when required and when flows are above the hands-off flow (infrastructure already present). If below the hands-off flow, then a 'put and take' arrangement will operate using raw water from other appropriate elements. Atlantic salmon migrate upstream to spawn from November – December. As the abstraction point will only be operational during low flow periods associated with spring and summer, no adverse effects on the migration of Atlantic salmon upstream are anticipated. Allis shad migrates upstream to spawn from April – June and sea trout from September – December. Therefore, both species overlap with potential timeframes of operation during low flow periods in spring and summer. However, with the hands-off flow system installed and conditions provided by the Environment Agency, no adverse effects on twaite shad are anticipated as flows will be maintained at a favourable rate for migration. The decreased flows downstream of the intake during operation could also cause a reduction in the dilution of effluents, create salinity barriers, changes to nutrient loading, turbidity and reduced dissolved oxygen, negatively impacting on migration upstream. However, hydrological modelling of the lower River Severn[200] identified no discernible changes in river flow due to abstraction associated with the Deerhurst to Culham pipeline. At the maximum abstraction rate proposed, the 500 Ml/d flow reduction would cause a very limited change to the flow pattern of the River Severn from the Avon confluence to the tidal limit. During 86% of the strategic scheme flow dates the same flow band would be retained, while 14% would result in change by one flow band[201]. Therefore, no adverse effects are anticipated as a result of changes in water flow on migratory access. Water quality assessments confirmed that further study of water quality data, measured at NRW water quality monitoring sites is required, in order to fully determine the water quality and chemistry representation of the River Severn downstream of the Avon confluence prior to a detail assessment of impacts to water quality from STT options and schemes[201]. Allis shad and sea trout may also become entrapped causing injury and/or enter the treatment works resulting in mortality during operation at the intake site. Considering the mitigation measures (two stage screening) and the relatively short duration that the intake will operate, no adverse effects are predicted on the migration capacity of allis shad and sea trout.	- Spoil from pipeline construction will be distributed across the construction easement before topsoil replacement. - Earthworks drainage will 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. **Operation** - Two sets of two stage screening will be installed to exclude fish during times of operation. This includes large bar screens and band screens fitted with fish return channels to isolate fish and return individuals directly back to the watercourse. These are compliant with current eel regulations[203]. - Any maintenance works required during operation will follow best practice biosecurity measures and EA Pollution Prevention Guidelines as listed above. - Inlet screens and rapid gravity filtration (removes 99 % of 5 µm sized particles) with bypass safeguards will be used to remove larvae of invasive species before transfer of raw water from Deerhurst to Culham. The Environment Agency has advised a STT abstraction licence would be limited to not reduce flow at Deerhurst flow gauging station below 2,568 Ml/d, a hands-off flow (HoF) condition. At flows greater than this HoF, up to 172Ml/d is available for abstraction without support, and at flows greater than 3,333Ml/d an additional 355Ml/d is available for abstraction without support.	
	- Population size (returning adults).	- No decline in number of returning adults from established baseline.	Allis shad, Atlantic salmon, sea trout and European eel population size in the Severn Estuary Ramsar site is dependent on several factors including breeding success, which is reliant on the availability of functional spawning and nursery habitats in the River Usk SAC, River Wye SAC and River Severn. In addition, natural fluctuations in food availability will also impact on population size[204]. Most the fish species that form the fish assemblages in the Severn Estuary Ramsar site are anadromous and so are dependent on marine and estuarine habitats (rather than freshwater) to support adult populations and the number of returning adults. **Construction** The construction of the Deerhurst to Culham pipeline may negatively impact on the number of returning adults to spawning habitats associated with the River Severn. This is due to potential impact pathways during in-river works, which include: water pollution incidents, spread and introduction INNS, noise/ vibration/ light disturbance, localised increases in suspended sediment, entrapment and impingement and fluctuations in dissolved oxygen. With proposed mitigation measures to minimise night-time, in-river disturbance during migration (not included in CDR) and following best practice guidelines no adverse effects on population size from in-river construction are anticipated. Impact pathways from topsoil stripping, excavations and movement of construction vehicles along the riverbank include the introduction and spread of INNS, exposure to pollution from accidental oil spills and run-off, localised increases in suspended sediment and noise/ vibration/ light disturbance. As construction works on the riverbank will be localised and short term, no	**Construction** - Best practice biosecurity measures will be followed, as recommended by the GB Non-Native Species Secretariat[207] to guard against any potential for spreading invasive and non-native species during construction (not included in CDR; although noted that invasive species on site to be identified and removed in advance of construction). - Works will be conducted in adherence to EA Pollution Prevention Guidelines; now archived (not included in CDR, but the following is stated: all vehicles and any chemical/ oil storage will be fully bunded to prevent any accidental pollution of groundwater or watercourses). - Construction Environmental Management Plan with risk assessment for pollution incidents and introduction/ spread of INNS and a response plan if either occurred (not	No adverse effects predicted

[200] Thames Water (2016), Severn Thames Transfer: Water Quality and Ecology Assessment - Phase 2: Main Project Report (issued October 2016). Report by Cascade Consulting and HR Wallingford on behalf of Thames Water.
[201] United Utilities (2021). Severn to Thames Transfer SRO downstream River Avon confluence to the tidal limit. Report by Ricardo Energy and Environment.
[203] UK Legislation (2009). The Eels (England and Wales) Regulations 2009. No. 3344, UK Statutory Instruments. Accessed from: https://www.legislation.gov.uk/uksi/2009/3344/made
[204] 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.
[207] Non-native species secretariat (2021). *Biosecurity and Prevention*. Accessed from: http://www.nonnativespecies.org/index.cfm?sectionid=58

Qualifying Feature	Attribute	Target	Potential Effects	Mitigation	Adverse Effect Predicted?)
			adverse effects are anticipated from increased suspended sediment, noise and vibration disturbance and run-off. Where possible, additional mitigation has been proposed to use directional/ baffled lighting on the riverbank to minimise light disturbance on the River Severn (not included in CDR). Following best practice mitigation measures to minimise the possible introduction and spread of INNS and pollution incidents are viewed as sufficient to ensure no adverse effects on qualifying features of the Severn Estuary Ramsar site. **Operation** During times of operation, depleted flows downstream of the intake could act as a barrier to migration upstream and corresponding spawning habitats, which could impact on long term population trends. However, with the hands-off flow system installed and conditions provided by the Environment Agency, no adverse effects on twaite shad are anticipated as flows will be maintained at a favourable rate for migration. The decreased flows downstream of the intake during operation could also cause a reduction in the dilution of effluents, create salinity barriers, changes to nutrient loading, turbidity and reduced dissolved oxygen, negatively impacting on migration upstream. However, hydrological modelling of the lower River Severn[205] identified no discernible changes in river flow due to abstraction associated with the Deerhurst to Culham pipeline. At the maximum abstraction rate proposed, the 500 Ml/d flow reduction would cause a very limited change to the flow pattern of the River Severn from the Avon confluence to the tidal limit. During 86% of the strategic scheme flow dates the same flow band would be retained, while 14% would result in change by one flow band[206]. Therefore, no adverse effects are anticipated as a result of changes in water flow on population size. Water quality assessments confirmed that further study of water quality data, measured at NRW water quality monitoring sites is required, in order to fully determine the water quality and chemistry representation of the River Severn downstream of the Avon confluence prior to a detail assessment of impacts to water quality from STT options and schemes[206]. Allis shad, Atlantic salmon, sea trout and European eels may also become entrapped causing injury and/ or enter the treatment works resulting in mortality during operation at the intake site. Considering the mitigation measures (two stage screening) and the relatively short duration that the intake will operate, no adverse effects are predicted.	included CDR). - No night-time in river working to avoid noise/ vibration/ light disturbance during upstream migration of associated fish assemblages is proposed (not included in CDR). - Where possible, it is proposed that lighting will be directional/ baffled for works on the riverbank to minimise light disturbance in the River Severn (not included in CDR). - Spoil from pipeline construction will be distributed across the construction easement before topsoil replacement. - Earthworks drainage will 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. - Habitat suitability monitoring is proposed within proximity of the intake site to determine if spawning habitat is present (not included in CDR). **Operation** - Two sets of two stage screening will be installed to exclude fish during times of operation. This includes large bar screens and band screens fitted with fish return channels to isolate fish and return individuals directly back to the watercourse. These are compliant with current eel regulations[208]. - Any maintenance works required during operation will follow best practice biosecurity measures and EA Pollution Prevention Guidelines as listed above. - Inlet screens and rapid gravity filtration (removes 99 % of 5 µm sized particles) with bypass safeguards will be used to remove larvae of invasive species before transfer of raw water from Deerhurst to Culham. The Environment Agency has advised a STT abstraction licence would be limited to not reduce flow at Deerhurst flow gauging station below 2,568 Ml/d, a hands-off flow (HoF) condition. At flows greater than this HoF, up to 172Ml/d is available for abstraction without support, and at flows greater than 3,333Ml/d an additional 355Ml/d is available for abstraction without support.	
	- River population	No decline in the populations of the Wye and Usk - Baseline is yet to be established through fish surveys in estuary and river	Fish populations associated with the Severn Estuary Ramsar site are dependent on adjacent rivers including the River Usk and Wye and the availability of suitable spawning and nursery sites to fulfil their lifecycle[209]. **Construction** Due to the location of the proposed Deerhurst to Culham pipeline and associated intake site on the River Severn, no direct impacts from construction of the pipeline have been identified on river populations and targets for the River Usk and Wye.	No mitigation measures required.	No adverse effects predicted .

[205] Thames Water (2016), Severn Thames Transfer: Water Quality and Ecology Assessment - Phase 2: Main Project Report (issued October 2016). Report by Cascade Consulting and HR Wallingford on behalf of Thames Water.
[206] United Utilities (2021). Severn to Thames Transfer SRO downstream River Avon confluence to the tidal limit. Report by Ricardo Energy and Environment.
[208] UK Legislation (2009). The Eels (England and Wales) Regulations 2009. No. 3344, UK Statutory Instruments. Accessed from: https://www.legislation.gov.uk/uksi/2009/3344/made
[209] 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.

Qualifying Feature	Attribute	Target	Potential Effects	Mitigation	Adverse Effect Predicted?)
			Operation Due to the location of the proposed Deerhurst to Culham pipeline and associated intake site on the River Severn, no direct impacts from operation of the pipeline have been identified on river populations and targets for the River Usk and Wye. As no adverse effects on the River Usk and Wye have been identified from either the construction or operation of the proposed pipeline, no adverse effects on river populations associated with the Severn Estuary Ramsar site are predicted.		
	- Prey species	No significant reduction in abundance of key prey species against an established baseline - Baseline is yet to be established through fish surveys in estuary and river	Like twaite shad, allis shad largely feed on estuarine and marine prey including crustaceans (mysids and copepods), fish (sprats and anchovies) and fish eggs[210]. European eel feed on benthic invertebrates including crustaceans and small fish species. Both Atlantic salmon and sea trout (diet understudied) feed on fish including herring, sprat and sand eel and a range of crustaceans[211]. **Construction** As the prey species of allis shad, Atlantic salmon, sea trout and European eel largely occupy estuarine and marine habitats and the fish species spawn offshore, the likely presence of prey species during construction is considered low. If prey species are present in the lower River Severn during construction, the following impact pathways have been identified: water pollution incidents, spread and introduction of INNS, noise/ vibration/ light disturbance, localised increases in suspended sediment, entrapment and impingement and fluctuations in dissolved oxygen. Proposed mitigation measures to reduce noise/ vibration/ light disturbance include no night-time in river working during the migration season; this has not been included in the CDR. As construction works will be localised and short term, no adverse effects are anticipated from increases in suspended sediment, entrapment and dissolved oxygen fluctuations on prey species. Impact pathways from topsoil stripping, excavations and movement of construction vehicles along the riverbank include the introduction and spread of INNS, exposure to pollution from accidental oil spills and run-off, localised increases in suspended sediment and noise/ vibration/ light disturbance. As construction works on the riverbank will be localised and short term, no adverse effects are anticipated from increased suspended sediment, noise and vibration disturbance and run-off. Where possible, additional mitigation has been proposed to use directional/ baffled lighting on the riverbank to minimise light disturbance on the River Severn (not included in CDR). Following best practice mitigation measures to minimise the possible introduction and spread of INNS and pollution incidents are viewed as sufficient to ensure no adverse effects on prey species. **Operation** Although sprat tolerate low salinities (4 – 36 ppt) the species spawn offshore and therefore, are unlikely to be adversely affected by localised, reduced flows in the lower River Severn. Similarly, anchovies, herring and sand eels spawn offshore. Therefore, no adverse effects on prey availability for twaite shad are anticipated. The decreased flows downstream of the intake during operation could cause a reduction in the dilution of effluents, create salinity barriers, changes to nutrient loading, turbidity and reduced dissolved oxygen, negatively impacting on migration upstream. This could impact on invertebrate populations and associated prey species of allis shad, Atlantic salmon, sea trout and European eel. However, hydrological modelling of the lower River Severn[212] identified no discernible changes in river flow due to abstraction associated with the Deerhurst to Culham pipeline. At the maximum abstraction rate proposed, the 500 Ml/d flow reduction would cause a very limited change to the flow pattern of the River Severn from the Avon confluence to the tidal limit. During 86% of the strategic scheme flow dates the same flow band would be retained, while 14% would result in change by one flow band[213]. Therefore, no adverse effects are anticipated as a result of changes in water flow on prey species. Water quality assessments confirmed that further study of water quality data, measured at NRW water quality monitoring sites is required, in order to fully determine the water quality and chemistry representation of the River Severn downstream of the Avon confluence prior to a detail assessment of impacts to water quality from STT options and schemes[213]. Prey species may also become entrapped causing injury and/or enter the treatment works	**Construction** - Best practice biosecurity measures will be followed, as recommended by the GB Non-Native Species Secretariat[214] to guard against any potential for spreading invasive and non-native species during construction (not included in CDR; although noted that invasive species on site to be identified and removed in advance of construction). - Works will be conducted in adherence to EA Pollution Prevention Guidelines; now archived (not included in CDR, but the following is stated: all vehicles and any chemical/ oil storage will be fully bunded to prevent any accidental pollution of groundwater or watercourses). - Construction Environmental Management Plan with risk assessment for pollution incidents and introduction/ spread of INNS and a response plan if either occurred (not included CDR). - No night-time in river working to avoid noise/ vibration/ light disturbance during upstream migration of associated prey species is proposed (not included in CDR). - Where possible, it is proposed that lighting will be directional/ baffled for works on the riverbank to minimise light disturbance in the River Severn (not included in CDR). - Spoil from pipeline construction will be distributed across the construction easement before topsoil replacement. - Earthworks drainage will 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. **Operation** - Two sets of two stage screening will be installed to exclude fish during times of operation. This includes large bar screens and band screens fitted with fish return channels to isolate fish and return individuals directly back to the watercourse. These are compliant with current eel regulations[215]. - Any maintenance works required during	No adverse effects predicted

[210] Maitland, P. S. and Hatton-Ellis, T. W. (2003). Ecology of the Allis and Twaite shad. Conserving Natura 2000 Rivers Ecology Series No. 3. Natural England, Peterborough.
[211] Bird, D. J. (2008). The Biology and Conservation of the Fish Assemblage of the Severn Estuary. CCW Report CCW/SER/08/01.
[212] Thames Water (2016), Severn Thames Transfer: Water Quality and Ecology Assessment - Phase 2: Main Project Report (issued October 2016). Report by Cascade Consulting and HR Wallingford on behalf of Thames Water.
[213] United Utilities (2021). Severn to Thames Transfer SRO downstream River Avon confluence to the tidal limit. Report by Ricardo Energy and Environment.
[214] Non-native species secretariat (2021). *Biosecurity and Prevention*. Accessed from: http://www.nonnativespecies.org/index.cfm?sectionid=58
[215] UK Legislation (2009). The Eels (England and Wales) Regulations 2009. No. 3344, UK Statutory Instruments. Accessed from: https://www.legislation.gov.uk/uksi/2009/3344/made

Qualifying Feature	Attribute	Target	Potential Effects	Mitigation	Adverse Effect Predicted?)
			resulting in mortality during operation at the intake site. Considering the mitigation measures (two stage screening) and the relatively short duration that the intake will operate, no adverse effects are predicted.	operation will follow best practice biosecurity measures and EA Pollution Prevention Guidelines as listed above. - Inlet screens and rapid gravity filtration (removes 99 % of 5 µm sized particles) with bypass safeguards will be used to remove larvae of invasive species before transfer of raw water from Deerhurst to Culham. The Environment Agency has advised a STT abstraction licence would be limited to not reduce flow at Deerhurst flow gauging station below 2,568 Ml/d, a hands-off flow (HoF) condition. At flows greater than this HoF, up to 172Ml/d is available for abstraction without support, and at flows greater than 3,333Ml/d an additional 355Ml/d is available for abstraction without support.	

5.7 Canal conveyance, including piping to Culham (300 Ml/d)

The concept of canal conveyance is to utilise the historic infrastructure of the Cotswold Canals (Stroudwater Navigation and Thames and Severn Canals), in conjunction with the Gloucester and Sharpness Ship Canal, to transfer water from the River Severn to the River Thames. The engineering concept can be split into four broad segments: River Severn (at Gloucester) to Summit Pound; Summit Pound; Summit Pound to Lechlade; and Lechlade to Culham/ River Thames.

5.7.1 Potentially Affected European Sites

The HRA Screening concluded that implementation of the canal conveyance, including piping to Culahm has the potential to result in likely significant effects on the **Severn Estuary SAC and Ramsar Site**. The following qualifying features of the Severn Estuary SAC and Ramsar Site were screened in for further assessment through Appropriate Assessment:

- **Sea lamprey:** localised increases in suspended sediment (siltation and deposition), potential invasive species spread, noise and vibration disturbance, entrapment and impingement and potential water pollution incidents during construction. During operation reduced water flow downstream of the intake may also cause localised changes in nutrient loading, turbidity, salinity regime, reduced dissolved oxygen and changes in dilution of pollutants, potentially impacting individuals locally present and during migration upstream (April – May) to functional spawning habitats.
- **River lamprey:** localised increases in suspended sediment (siltation and deposition), potential invasive species spread, noise and vibration disturbance, entrapment and impingement and potential water pollution incidents during construction. During operation reduced water flow downstream of the intake may also cause localised changes in nutrient loading, turbidity, salinity regime, reduced dissolved oxygen and changes in dilution of pollutants, potentially impacting individuals locally present and during migration upstream (October - December) to functional spawning habitats.
- **Twaite shad:** localised increases in suspended sediment (siltation and deposition), potential invasive species spread, noise and vibration disturbance, entrapment and impingement and potential water pollution incidents during construction. During operation reduced water flow downstream of the intake may also cause localised changes in nutrient loading, turbidity, salinity regime, reduced dissolved oxygen and changes in dilution of pollutants, potentially impacting individuals locally present and during migration upstream (mid May – mid July) to functional spawning habitats.
- **Allis shad:** localised increases in suspended sediment (siltation and deposition), potential invasive species spread, noise and vibration disturbance, entrapment and impingement and potential water pollution incidents during construction. During operation reduced water flow downstream of the intake may also cause localised changes in nutrient loading, turbidity, salinity regime, reduced dissolved oxygen and changes in dilution of pollutants, potentially impacting individuals locally present and during migration upstream (April - June[216]) to functional spawning habitats.
- **Atlantic salmon:** localised increases in suspended sediment (siltation and deposition), potential invasive species spread, noise and vibration disturbance, entrapment and impingement and potential water pollution incidents during construction. During operation reduced water flow downstream of the intake may also cause localised changes in nutrient loading, turbidity, salinity regime, reduced dissolved oxygen and changes in dilution of pollutants, potentially impacting individuals locally present and during migration upstream (November - December[217]) to functional spawning habitats.
- **Sea trout:** localised increases in suspended sediment (siltation and deposition), potential invasive species spread, noise and vibration disturbance, entrapment and impingement and potential water pollution incidents during construction. During operation reduced water flow

[216] Maitland, P. S and Hatton-Ellis, T. S (2003). *Ecology of the Allis and Twaite Shad*. Conserving Natura 2000 Rivers Ecology Series No. 3. English Nature, Peterborough.
[217] Miller, P. J and Loates, M. J (1997) Fish of Britain and Europe. *Harper Collins Publishers*, 1 – 288.

downstream of the intake may also cause localised changes in nutrient loading, turbidity, salinity regime, reduced dissolved oxygen and changes in dilution of pollutants, potentially impacting individuals locally present and during migration upstream (September - December[170]) to functional spawning habitats.

Conservation Objectives and Favourable Condition Targets

Specific attributes and targets associated with the conservation objectives for each qualifying feature of the SAC are provided in **Table 5.8** and current conservation status, SSSI condition assessment and site improvement plan are provided in **Table 4.2**.

Table 5.8: Assessment of adverse effects of the Canal conveyance, including piping to Culham (300 Ml/d) on the Severn Estuary SAC and Ramsar Site

Qualifying Feature	Attribute	Target	Potential Effects	Mitigation	Adverse Effect Predicted?
1099 River lamprey (SAC interest feature 5) 1095 Sea lamprey (SAC interest feature 6)	Migratory access (barriers to migration).	– **Water quality** is sufficient to support migratory passage. Levels (for temperature, salinity, turbidity, pH, and dissolved oxygen) should comply with targets established under the EA Review of Consents and the Water Framework Directive. – **Water flows**: Flows from the rivers Wye, Usk and Severn into the estuary must be sufficient to allow migration. – **Physical barriers:** No artificial barriers significantly impairing adults from reaching existing and historical spawning grounds or juveniles from moving downstream.	River lamprey migrate upstream from October to December, with spawning occurring in British rivers typically from March – April[218]. once water temperatures reach 10 – 11 ºC[219]. Sea lamprey present in European waterbodies migrate upstream from April - May and spawn typically from late May – June[218]. 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 siltbeds), and provides adequate flows for migratory passage. It is important that this element does not adversely impact on upstream migration to functionally linked spawning habitats. **Construction** The construction of the canal conveyance will occur approximately 2.1km north-east of the Severn Estuary SAC and 32.7km north-east via hydrological connectivity. Construction work associated with the canal conveyance that could impact river and sea lamprey during upstream migration in the River Severn includes the following: construction of at least two portals/ inlets into the riverside retaining wall, two stage screening including coarse bar screens and rotating band screens, small control kiosks, penstock, penstock actuators and a box culvert. Potential impact pathways on migration during in-river works include water pollution incidents, spread and introduction of invasive non-native species (INNS), noise/ vibration/ light disturbance, localised increases in suspended sediment, entrapment and impingement and fluctuations in dissolved oxygen. Proposed mitigation measures to reduce noise/ vibration/ light disturbance include no night-time in river working during the migration season; this has been agreed with the client. As construction works will be localised and short term, no adverse effects are anticipated from increases in suspended sediment, entrapment and dissolved oxygen fluctuations. Impact pathways from topsoil stripping, excavations and movement of construction vehicles along the riverbank include the introduction and spread of INNS, exposure to pollution from accidental oil spills and run-off, localised increases in suspended sediment and noise/ vibration/ light disturbance. Proposed mitigation measures to reduce light disturbance during works on the riverbank include the use of directional/ baffled lighting to minimise light disturbance on the River Severn; this has been agreed with the client. As construction works on the riverbank will be localised and short term, no adverse effects are anticipated from increased suspended sediment, noise and vibration disturbance and run-off. Following best practice guidelines to minimise the possible introduction and spread of INNS and pollution incidents are viewed as sufficient to ensure no adverse effects on qualifying features of the Severn Estuary SAC. **Operation** This element will transfer unsupported flow from the River Severn via a combination of existing and refurbished canal sections, over the Cotswold hills and discharged via a new pipeline to the River Thames near Culham. The abstracted water will be transferred both when required and when flows are above the hands-off flow (infrastructure already present). If below the hands-off flow, then a	**Construction** - Best practice biosecurity measures will be followed, as recommended by the GB Non-Native Species Secretariat[221] to guard against any potential for spreading invasive and non-native species during construction (not included in CDR). - Works will 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 either occurred. - No night-time in river working to avoid noise/ vibration/ light disturbance during upstream migration from October – December for river lamprey and April – May for sea lamprey is proposed (not included in CDR, although agreed by client). - Where possible, it is proposed that lighting will be directional/ baffled for works on the riverbank to minimise light disturbance in the River Severn (not included in CDR, although agreed by the client). **Operation** - Two sets of two stage screening will be installed to exclude fish during times of operation. This includes band screens fitted with fish return channels to isolate fish and return individuals directly back to the watercourse. - Any maintenance works required during operation will follow best practice biosecurity measures and EA Pollution Prevention Guidelines as listed above. - Inlet screens and rapid gravity filtration (removes 99 % of 5 µm sized particles) with bypass safeguards will be used to remove larvae of invasive species before transfer of raw water from the River Sever intake, along the canal to the Culham outfall. - Hands-off flow requirements to be confirmed with Environment Agency, to mitigate environmental impacts.	No adverse effects predicted

[218] Maitland PS (2003). *Ecology of the River, Brook and Sea Lamprey*. Conserving Natura 2000 Rivers Ecology Series No. 5. English Nature, Peterborough.
[219] Hardisty MW & Potter IC (eds) (1971). *The biology of lampreys*. Academic Press, London.
[221] Non-native species secretariat (2021). *Biosecurity and Prevention*. Accessed from: http://www.nonnativespecies.org/index.cfm?sectionid=58

Qualifying Feature	Attribute	Target	Potential Effects	Mitigation	Adverse Effect Predicted?
			'put and take' arrangement will operate using raw water from other appropriate elements. During times of operation, depleted flows downstream of the intake could act as a barrier to migration upstream and corresponding spawning habitats. Based on species specific timings for upstream migration, sea lamprey is particularly vulnerable as they migrate upstream during low flow conditions (April – May). The depleted flows downstream could reduce successful migration to upstream spawning habitats; although noted this will be in operation for short time periods. However, with the hands-off flow system installed and conditions provided by the Environment Agency, no adverse effects on river and sea lamprey are anticipated as flows will be maintained at a favourable rate for migration. The decreased flows downstream of the intake during operation could also cause a reduction in the dilution of effluents, create salinity barriers, changes to nutrient loading, turbidity and reduced dissolved oxygen, negatively impacting on migration upstream. Hydrological impact assessments have confirmed that the 300Ml/d flow reduction would result in a negligible change to the flow pattern of the River Severn up to the tidal limit. On 642 of the strategic scheme flow dates (92%) the same flow band would be retained, while 57 dates (8%) would result in change by one flow band. Therefore, no adverse effects anticipated as a result of water flow changes on migratory access[220]. Water quality assessments confirmed that further study of water quality data, measured at NRW water quality monitoring sites is required, in order to fully determine the water quality and chemistry representation of the River Severn downstream of the Avon confluence prior to a detail assessment of impacts to water quality from STT options and schemes[220]. River and sea lamprey may also become entrapped causing injury and/or enter the treatment works resulting in mortality during operation at the intake site. Considering the mitigation measures (two stage screening) and the relatively short duration that the intake will operate, no adverse effects are predicted.		
	Population size (returning adults)	No decline in number of returning adults from established baseline.	River and sea lamprey population size in the Severn Estuary SAC is dependent on several factors including breeding success, which is reliant on the availability of functional spawning and nursery habitats in the River Usk SAC, River Wye SAC and River Severn. In addition, natural fluctuations in food and host availability will also impact on population size[222]. As anadromous species, the number of returning adults to the estuary is dependent on a range of biotic and abiotic parameters relevant to marine and estuarine systems including predation pressures and environmental conditions. **Construction** Construction work associated with the Canal conveyance that could impact river and sea lamprey during upstream migration in the River Severn includes the following: construction of at least two portals/ inlets into the riverside retaining wall, two stage screening including coarse bar screens and rotating band screens, small control kiosks, penstock, penstock actuators and a box culvert. Potential impact pathways on migration during in-river works include water pollution incidents, spread and introduction of invasive non-native species (INNS), noise/ vibration/ light disturbance, localised increases in suspended sediment, entrapment and impingement and fluctuations in dissolved oxygen. Proposed mitigation measures to reduce noise/ vibration/ light disturbance include no night-time in	**Construction** - Best practice biosecurity measures will be followed, as recommended by the GB Non-Native Species Secretariat[224] to guard against any potential for spreading invasive and non-native species during construction (not included in CDR). - Works will 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 either occurred. - No night-time in river working to avoid noise/ vibration/ light disturbance during upstream migration from October – December for river lamprey and April – May for sea lamprey is proposed (not included in CDR, although agreed by client). - Where possible, it is proposed that lighting will be directional/ baffled for works on the riverbank to minimise light disturbance in the River Severn (not included in CDR, although agreed by the client).	No adverse effects predicted

[220] United Utilities (2021). Severn to Thames Transfer SRO downstream River Avon confluence to the tidal limit. Report by Ricardo Energy and Environment.
[222] 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.
[224] Non-native species secretariat (2021). *Biosecurity and Prevention*. Accessed from: http://www.nonnativespecies.org/index.cfm?sectionid=58

Qualifying Feature	Attribute	Target	Potential Effects	Mitigation	Adverse Effect Predicted?
			river working during the migration season; this has been agreed with the client. As construction works will be localised and short term, no adverse effects are anticipated from increases in suspended sediment, entrapment and dissolved oxygen fluctuations on population size. Impact pathways from topsoil stripping, excavations and movement of construction vehicles along the riverbank include the introduction and spread of INNS, exposure to pollution from accidental oil spills and run-off, localised increases in suspended sediment and noise/ vibration/ light disturbance. Proposed mitigation measures to reduce light disturbance during works on the riverbank include the use of directional/ baffled lighting to minimise light disturbance on the River Severn; this has been agreed with the client. As construction works on the riverbank will be localised and short term, no adverse effects are anticipated from increased suspended sediment, noise and vibration disturbance and run-off. Following best practice guidelines to minimise the possible introduction and spread of INNS and pollution incidents are viewed as sufficient to ensure no adverse effects on qualifying features of the Severn Estuary SAC. **Operation** During times of operation, depleted flows downstream of the intake could act as a barrier to migration upstream and corresponding spawning habitats. Based on species specific timings for upstream migration, sea lamprey is particularly vulnerable as they migrate upstream during low flow conditions (April – May). The depleted flows downstream could reduce successful migration to upstream spawning habitats; although noted this will be in operation for short time periods. However, with the hands-off flow system installed and conditions provided by the Environment Agency, no adverse effects on river and sea lamprey population size are anticipated as flows will be maintained at a favourable rate for migration. Hydrological impact assessments have confirmed that the 300Ml/d flow reduction would result in a negligible change to the flow pattern of the River Severn up to the tidal limit. On 642 of the strategic scheme flow dates (92%) the same flow band would be retained, while 57 dates (8%) would result in change by one flow band. Therefore, no adverse effects anticipated as a result of water flow changes on population size[223]. The decreased flows downstream of the intake during operation could also cause a reduction in the dilution of effluents, create salinity barriers, changes to nutrient loading, turbidity and reduced dissolved oxygen. Water quality assessments confirmed that further study of water quality data, measured at NRW water quality monitoring sites is required, in order to fully determine the water quality and chemistry representation of the River Severn downstream of the Avon confluence prior to a detail assessment of impacts to water quality from STT options and schemes[223]. River and sea lamprey may also become entrapped causing injury and/or enter the treatment works resulting in mortality during operation at the intake site. Considering the mitigation measures (two stage screening) and the relatively short duration that the intake will operate, no adverse effects are predicted on population size.	**Operation** - Two sets of two stage screening will be installed to exclude fish during times of operation. This includes band screens fitted with fish return channels to isolate fish and return individuals directly back to the watercourse. - Any maintenance works required during operation will follow best practice biosecurity measures and EA Pollution Prevention Guidelines as listed above. - Inlet screens and rapid gravity filtration (removes 99 % of 5 µm sized particles) with bypass safeguards will be used to remove larvae of invasive species before transfer of raw water from the River Sever intake, along the canal to the Culham outfall. - Hands-off flow requirements to be confirmed with Environment Agency, to mitigate environmental impacts.	
	Ammocoete population in tributary rivers	River population targets for the Usk and Wye must be met Baseline is the survey of ammocoete abundance and distribution in the Rivers	River and sea lamprey ammocoetes live in burrows created in silt beds (nursery habitat) upstream, where they remain for a several years undergoing larval development. Once metamorphosis takes place (morphological changes from larva to adult), lamprey migrate	No mitigation measures required. Unlikely	No adverse effects predicted

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

Qualifying Feature	Attribute	Target	Potential Effects	Mitigation	Adverse Effect Predicted?
		Usk and Wye commissioned by CCW in 2005 (Harvey et al. 2007).	downstream[182]. **Construction** Due to the location of the proposed canal conveyance and associated intake site, no direct impacts from construction of the intake, refurbishment of the canal and construction of the pipeline downstream have been identified on ammocoete populations present in tributaries upstream. **Operation** Due to the location of the proposed canal conveyance and associated intake site, no direct impacts from the operation of water transfer have been identified on ammocoete populations in tributaries upstream. In addition, the baseline for the site is based on ammocoete abundances within the River Wye and River Usk. As there is no potential for adverse effects within these watercourses from either the construction or operation of the proposed canal conveyance, no adverse effects on ammocoete populations associated with the Severn Estuary SAC are predicted.		
	Prey species	– No significant reduction in abundance of key prey species against an established baseline	Adult river lamprey feed on a range of estuarine prey species including herring (*Clupea harengus*), sprat (*Sprattus sprattus*) and flounder (*Platichthys flesus*)[225], and typically do not feed in freshwater habitats. Adult sea lamprey feed on a wide variety of marine and anadromous prey species, including Atlantic sturgeon (*Acipenser sturio*), herring (*Clupea harengus*), Atlantic salmon (*Salmo salar*), cod (*Gadus morhua*) and haddock (*Melanogrammus aeglefinus*)[182]. **Construction** Most of the prey species listed above breed and spawn offshore and therefore, are unlikely to be affected by the proposed construction works in the River Severn. For species such as Atlantic sturgeon that migrate upstream to spawn from spring – early summer[226] and Atlantic salmon from November – December[227], the following impact pathways have been identified: water pollution incidents, spread and introduction of INNS, noise/ vibration/ light disturbance, localised increases in suspended sediment, entrapment and impingement and fluctuations in dissolved oxygen. Proposed mitigation measures to reduce noise/ vibration/ light disturbance include no night-time in river working during the migration season; agreed with client. As construction works will be localised and short term, no adverse effects are anticipated from increases in suspended sediment, entrapment and dissolved oxygen fluctuations on prey species. Impact pathways from topsoil stripping, excavations and movement of construction vehicles along the riverbank include the introduction and spread of INNS, exposure to pollution from accidental oil spills and run-off, localised increases in suspended sediment and noise/vibration disturbance. As construction works on the riverbank will be localised and short term, no adverse effects are anticipated from increased suspended sediment, noise and vibration disturbance and run-off. Proposed mitigation measures to use directional/ baffled lighting during works on the riverbank will minimise light disturbance on the River Severn; agreed with client. Following best practice guidelines to minimise the possible introduction and spread of INNS and pollution incidents are viewed as sufficient to ensure no adverse effects prey species.	**Construction** - Best practice biosecurity measures will be followed, as recommended by the GB Non-Native Species Secretariat[229] to guard against any potential for spreading invasive and non-native species during construction (not included in CDR). - Works will 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 either occurred. - No night-time in river working to avoid noise/ vibration/ light disturbance during upstream migration from of associated prey species (not included in CDR, although agreed by client). - Where possible, it is proposed that lighting will be directional/ baffled for works on the riverbank to minimise light disturbance in the River Severn (not included in CDR, although agreed by the client). **Operation** - Two sets of two stage screening will be installed to exclude fish during times of operation. This includes band screens fitted with fish return channels to isolate fish and return individuals directly back to the watercourse. - Any maintenance works required during operation will follow best practice biosecurity measures and EA Pollution Prevention Guidelines as listed above. - Inlet screens and rapid gravity filtration (removes 99 % of 5 µm sized particles) with bypass safeguards will be used to remove larvae of invasive species before transfer of raw water from the River Sever intake, along the canal to the Culham outfall. - Hands-off flow requirements to be confirmed with Environment Agency, to mitigate environmental impacts.	No adverse effects predicted

[225] Maitland PS (2003). *Ecology of the River, Brook and Sea Lamprey*. Conserving Natura 2000 Rivers Ecology Series No. 5. English Nature, Peterborough.
[226] Miller, P. J and Loates, M. J (1997) Fish of Britain and Europe. *Harper Collins Publishers*, 1 – 288.
[227] Miller, P. J and Loates, M. J (1997) Fish of Britain and Europe. *Harper Collins Publishers*, 1 – 288.
[229] Non-native species secretariat (2021). *Biosecurity and Prevention*. Accessed from: http://www.nonnativespecies.org/index.cfm?sectionid=58

Qualifying Feature	Attribute	Target	Potential Effects	Mitigation	Adverse Effect Predicted?
			Operation No impact pathways have been identified for the majority of river and sea lamprey prey species as they occupy estuarine and/ or marine habitats and spawn offshore. As operation of this element will be during low flow periods (spring and summer), Atlantic salmon is also unlikely to be affected, as the species migrates upstream to spawn from November – December. As Atlantic sturgeon migrate upstream in spring – early summer, depleted flows downstream of the intake could act as a barrier to migration and corresponding spawning habitats. This could negatively impact on long term population trends and prey availability for lamprey species, however, due to the lack of identified spawning sites and records of Atlantic sturgeon in the River Vyrnwy, negligible effects are anticipated from this element. The decreased flows downstream of the intake during operation could also cause a reduction in the dilution of effluents, create salinity barriers, changes to nutrient loading, turbidity and reduced dissolved oxygen. Hydrological impact assessments have confirmed that the 300Ml/d flow reduction would result in a negligible change to the flow pattern of the River Severn up to the tidal limit. On 642 of the strategic scheme flow dates (92%) the same flow band would be retained, while 57 dates (8%) would result in change by one flow band. Therefore, no adverse effects anticipated as a result of water flow changes on prey species[228]. Water quality assessments confirmed that further study of water quality data, measured at NRW water quality monitoring sites is required, in order to fully determine the water quality and chemistry representation of the River Severn downstream of the Avon confluence prior to a detail assessment of impacts to water quality from STT options and schemes[228]. Prey species may also become entrapped causing injury and/or enter the treatment works resulting in mortality during operation at the intake site. Considering the mitigation measures (two stage screening) and the relatively short duration that the intake will operate, no adverse effects are predicted.		
1103 Twaite shad	Migratory access (barriers to migration).	– **Water quality** is sufficient to support migratory passage. Levels (for temperature, salinity, turbidity, pH, and dissolved oxygen) should comply with targets established under the EA Review of Consents and the Water Framework Directive. – **Water flows**: Flows from the rivers Wye, Usk and Severn into the estuary must be sufficient to allow migration. – **Physical barriers:** No artificial barriers significantly impairing adults from reaching existing and historical spawning grounds or juveniles from moving downstream. –	Twaite shad migrate upstream to spawn in British rivers from mid May – mid July; notably twaite shad will spawn close to the tidal limit and further upstream[230]. In the River Severn, the upstream migration of Twaite shad is restricted by the presence of a weir at Worcester. Therefore, their current spawning range is limited to the lower 23 km of the River Severn[231]. **Construction** The construction of the canal conveyance will occur approximately 2.1km north-east of the Severn Estuary SAC and 32.7km north-east via hydrological connectivity. Construction work associated with the canal conveyance that could impact on twaite shad during upstream migration in the River Severn includes the following: construction of at least two portals/ inlets into the riverside retaining wall, two stage screening including coarse bar screens and rotating band screens, small control kiosks, penstock, penstock actuators and a box culvert. No additional barriers to migration would be created through construction of the pipeline. Potential impact pathways on migration during in-river works	**Construction** - Best practice biosecurity measures will be followed, as recommended by the GB Non-Native Species Secretariat[233] to guard against any potential for spreading invasive and non-native species during construction (not included in CDR). - Works will 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 either occurred. - No night-time in river working to avoid noise/ vibration/ light disturbance during upstream migration from mid May – mid July is proposed (not included in CDR). - Where possible, it is proposed that lighting will be directional/ baffled for works on the riverbank to minimise light disturbance in the River Severn (not included in CDR).	No adverse effects predicted

[228] United Utilities (2021). Severn to Thames Transfer SRO downstream River Avon confluence to the tidal limit. Report by Ricardo Energy and Environment.
[230] Lythgoe, G and Lythgoe J. (1971). Fishes of the sea, the coastal waters of the British Isles, Northern Europe and the Mediterranean. Blandford Press Ltd, 6 – 312.
[231] Unlocking the Severn for LIFE – LIFE – Shad Severn: Conservation and restoration of twaite shad in the Severn Estuary Special Area of Conservation project description. LIFE15 NAT/UK/00021. Accessed on 11/12/2020. Available at: https://ec.europa.eu/environment/life/project/Projects/index.cfm?fuseaction=search.dspPage&n_proj_id=5866&docType=pdf

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

Qualifying Feature	Attribute	Target	Potential Effects	Mitigation	Adverse Effect Predicted?
			include water pollution incidents, spread and introduction of INNS, noise/ vibration/ light disturbance, localised increases in suspended sediment, entrapment and impingement and fluctuations in dissolved oxygen. Although construction works will be localised and short term, it is noted that juveniles are likely to congregate in the upper Severn estuary. Proposed mitigation measures to reduce noise/ vibration/ light disturbance include no night-time in river working during the migration season; this has been agreed with the client. As construction works will be localised and short term, no adverse effects are anticipated from increases in suspended sediment, entrapment and dissolved oxygen fluctuations on twaite shad. Impact pathways from topsoil stripping, excavations and movement of construction vehicles along the riverbank include the introduction and spread of INNS, exposure to pollution from accidental oil spills and run-off, localised increases in suspended sediment and noise/ vibration/ light disturbance. As construction works on the riverbank will be localised and short term, no adverse effects are anticipated from increased suspended sediment, noise and vibration disturbance and run-off. Where possible, additional mitigation has been proposed to use directional/ baffled lighting on the riverbank to minimise light disturbance in the River Severn (this has been agreed with the client). Following best practice mitigation measures to minimise the possible introduction and spread of INNS and pollution incidents are viewed as sufficient to ensure no adverse effects on qualifying features of the Severn Estuary SAC. **Operation** This element will transfer unsupported flow from the River Severn via a combination of existing and refurbished canal sections, over the Cotswold hills and discharged via a new pipeline to the River Thames near Culham. The abstracted water will be transferred both when required and when flows are above the hands-off flow (infrastructure already present). If below the hands-off flow, then a 'put and take' arrangement will operate using raw water from other appropriate elements. During times of operation, depleted flows downstream of the intake could act as a barrier to migration upstream and corresponding spawning habitats. Twaite shad will be vulnerable to changes in flow during operation, as they migrate upstream to spawn from mid May – mid July. In addition, the effects of flow depletion due to increased abstraction may reduce (or improve) the suitability of habitat in the lower River Severn as a spawning and nursery area for twaite shad. However, with the hands-off flow system installed and conditions provided by the Environment Agency, no adverse effects on twaite shad are anticipated as flows will be maintained at a favourable rate for migration. The decreased flows downstream of the intake during operation could also cause a reduction in the dilution of effluents, create salinity barriers, changes to nutrient loading, turbidity and reduced dissolved oxygen, negatively impacting on migration upstream. Hydrological impact assessments have confirmed that the 300Ml/d flow reduction would result in a negligible change to the flow pattern of the River Severn up to the tidal limit. On 642 of the strategic scheme flow dates (92%) the same flow band would be retained, while 57 dates (8%) would result in change by one flow band. Therefore, no adverse effects anticipated as a result of water flow changes on migratory access[232]. Water quality assessments confirmed that further study of water quality data, measured at NRW water quality monitoring sites is required, in order to fully determine the water quality and chemistry representation of the River Severn	**Operation** - Two sets of two stage screening will be installed to exclude fish during times of operation. This include band screens fitted with fish return channels to isolate fish and return individuals directly back to the watercourse. - Any maintenance works required during operation will follow best practice biosecurity measures and EA Pollution Prevention Guidelines as listed above. - Inlet screens and rapid gravity filtration (removes 99 % of 5 µm sized particles) with bypass safeguards will be used to remove larvae of invasive species before transfer of raw water from the River Sever intake, along the canal to the Culham outfall. - Hands-off flow requirements to be confirmed with Environment Agency, to mitigate environmental impacts.	

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

Qualifying Feature	Attribute	Target	Potential Effects	Mitigation	Adverse Effect Predicted?
			downstream of the Avon confluence prior to a detail assessment of impacts to water quality from STT options and schemes[232]. Twaite shad may also become entrapped causing injury and/or enter the treatment works resulting in mortality during operation at the intake site. Considering the mitigation measures (two stage screening) and the relatively short duration that the intake will operate, no adverse effects are predicted.		
	Population size (returning adults)	No decline in number of returning adults from established baseline.	Twaite shad population size in the Severn Estuary SAC is dependent on several factors including breeding success, which is reliant on the availability of functional spawning and nursery habitats in the River Usk SAC, River Wye SAC and River Severn. In addition, natural fluctuations in food availability will also impact on population size[234]. As anadromous species, the number of returning adults to the estuary is dependent on a range of biotic and abiotic parameters relevant to marine and estuarine systems including predation pressures and environmental conditions. **Construction** The construction of the canal conveyance may negatively impact on the number of returning twaite shad to spawning habitats associated with the River Severn. This is due to potential impact pathways during in-river works, which include: water pollution incidents, spread and introduction INNS, noise/ vibration/ light disturbance, localised increases in suspended sediment, entrapment and impingement and fluctuations in dissolved oxygen. Although construction works will be localised and short term, it is noted that juveniles are likely to congregate in the upper Severn estuary. Proposed mitigation measures to reduce noise/ vibration/ light disturbance include no night-time in river working during the migration season; agreed with client. As construction works will be localised and short term, no adverse effects are anticipated from increases in suspended sediment, entrapment and dissolved oxygen fluctuations on population size. Impact pathways from topsoil stripping, excavations and movement of construction vehicles along the riverbank include the introduction and spread of INNS, exposure to pollution from accidental oil spills and run-off, localised increases in suspended sediment and noise/ vibration/ light disturbance. As construction works on the riverbank will be localised and short term, no adverse effects are anticipated from increased suspended sediment, noise and vibration disturbance and run-off. Where possible, additional mitigation has been proposed to use directional/ baffled lighting on the riverbank to minimise light disturbance on the River Severn (agreed with client). Following best practice mitigation measures to minimise the possible introduction and spread of INNS and pollution incidents are viewed as sufficient to ensure no adverse effects on qualifying features of the Severn Estuary SAC. **Operation** During times of operation, depleted flows downstream of the intake could act as a barrier to migration upstream and corresponding spawning habitats, which could impact on long term population trends. Based on species specific timings for upstream migration twaite shad are vulnerable as they migrate upstream during low flow conditions (mid May – mid July). However, with the hands-off flow system installed and conditions provided by the Environment Agency, no adverse effects on twaite shad are anticipated as flows will be maintained at a favourable rate for migration.	**Construction** - Best practice biosecurity measures will be followed, as recommended by the GB Non-Native Species Secretariat[237] to guard against any potential for spreading invasive and non-native species during construction (not included in CDR). - Works will 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 either occurred. - No night-time in river working to avoid noise/ vibration/ light disturbance during upstream migration from mid May – mid July is proposed (not included in CDR). - Where possible, it is proposed that lighting will be directional/ baffled for works on the riverbank to minimise light disturbance in the River Severn (not included in CDR). **Operation** - Two sets of two stage screening will be installed to exclude fish during times of operation. This include band screens fitted with fish return channels to isolate fish and return individuals directly back to the watercourse. - Any maintenance works required during operation will follow best practice biosecurity measures and EA Pollution Prevention Guidelines as listed above. - Inlet screens and rapid gravity filtration (removes 99 % of 5 µm sized particles) with bypass safeguards will be used to remove larvae of invasive species before transfer of raw water from the River Sever intake, along the canal to the Culham outfall. - Hands-off flow requirements to be confirmed with Environment Agency, to mitigate environmental impacts.	No adverse effects predicted

[234] 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.
[237] Non-native species secretariat (2021). *Biosecurity and Prevention*. Accessed from: http://www.nonnativespecies.org/index.cfm?sectionid=58

Qualifying Feature	Attribute	Target	Potential Effects	Mitigation	Adverse Effect Predicted?
			The decreased flows downstream of the intake during operation could also cause a reduction in the dilution of effluents, create salinity barriers, changes to nutrient loading, turbidity and reduced dissolved oxygen. Hydrological impact assessments have confirmed that the 300Ml/d flow reduction would result in a negligible change to the flow pattern of the River Severn up to the tidal limit. On 642 of the strategic scheme flow dates (92%) the same flow band would be retained, while 57 dates (8%) would result in change by one flow band. Therefore, no adverse effects anticipated as a result of water flow changes on population size[235]. Water quality assessments confirmed that further study of water quality data, measured at NRW water quality monitoring sites is required, in order to fully determine the water quality and chemistry representation of the River Severn downstream of the Avon confluence prior to a detail assessment of impacts to water quality from STT options and schemes[236]. Twaite shad may also become entrapped causing injury and/ or enter the treatment works resulting in mortality during operation at the intake site. Considering the mitigation measures (two stage screening) and the relatively short duration that the intake will operate, no adverse effects are predicted.		
	River population	River population targets for the Usk and Wye must be met Baseline yet to be established. Noble et al. (2007) provides some information on juvenile densities[238].	Twaite shad river populations associated with the Severn Estuary SAC are dependent on adjacent rivers including the River Usk and Wye and the availability of suitable spawning and nursery sites to fulfil their lifecycle[238]. **Construction** Due to the location of the proposed canal conveyance and associated intake site on the River Severn, no direct impacts from construction of the intake, refurbishment of the canal and construction of the pipeline have been identified on river populations and targets for the River Usk and Wye. **Operation** Due to the location of the proposed canal conveyance and associated intake site on the River Severn, no direct impacts from operation of the water transfer have been identified on river populations and targets for the River Usk and Wye. As there is no potential for adverse effects on the River Usk and Wye from either the construction or operation of the proposed canal conveyance, no adverse effects on river populations associated with the Severn Estuary SAC are predicted.	No mitigation measures required.	No adverse effects predicted
	Prey species	No significant reduction in abundance of key prey species against an established baseline Baseline is yet to be established through fish surveys in estuary and river	Twaite shad largely feed on estuarine and marine prey including crustaceans (mysids and copepods), fish (sprats and anchovies) and fish eggs[239]. **Construction** As twaite shad prey species largely occupy estuarine and marine habitats and spawn offshore, the likely presence of prey species during construction is considered low. If prey species are present in the lower River Severn during construction, the following impact pathways have been identified: water pollution incidents, spread and introduction of INNS, noise/ vibration/ light disturbance, localised increases in suspended sediment, entrapment and impingement and fluctuations in dissolved oxygen. Proposed mitigation measures to reduce noise/ vibration/ light disturbance include no night-time in river working during the migration season; agreed with client. As construction works will be localised and short term, no adverse effects are anticipated from increases in	**Construction** - Best practice biosecurity measures will be followed, as recommended by the GB Non-Native Species Secretariat[241] to guard against any potential for spreading invasive and non-native species during construction (not included in CDR). - Works will 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 either occurred. - No night-time in river working to avoid noise/ vibration/ light disturbance during upstream migration for associated prey species is proposed (not included in CDR).	No adverse effects predicted

[235] United Utilities (2021). Severn to Thames Transfer SRO downstream River Avon confluence to the tidal limit. Report by Ricardo Energy and Environment.
[236] United Utilities (2021). Severn to Thames Transfer SRO downstream River Avon confluence to the tidal limit. Report by Ricardo Energy and Environment.
[238] 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.
[239] Maitland, P. S. and Hatton-Ellis, T. W. (2003). Ecology of the Allis and Twaite shad. Conserving Natura 2000 Rivers Ecology Series No. 3. Natural England, Peterborough.
[241] Non-native species secretariat (2021). *Biosecurity and Prevention*. Accessed from: http://www.nonnativespecies.org/index.cfm?sectionid=58

Qualifying Feature	Attribute	Target	Potential Effects	Mitigation	Adverse Effect Predicted?
			suspended sediment, entrapment and dissolved oxygen fluctuations on prey species. Impact pathways from topsoil stripping, excavations and movement of construction vehicles along the riverbank include the introduction and spread of INNS, exposure to pollution from accidental oil spills and run-off, localised increases in suspended sediment and noise/ vibration/ light disturbance. As construction works on the riverbank will be localised and short term, no adverse effects are anticipated from increased suspended sediment, noise and vibration disturbance and run-off. Where possible, additional mitigation has been proposed to use directional/ baffled lighting on the riverbank to minimise light disturbance on the River Severn (agreed with client). Following best practice mitigation measures to minimise the possible introduction and spread of INNS and pollution incidents are viewed as sufficient to ensure no adverse effects on prey species. **Operation** Although sprat (*Clupea sprattus*) tolerate low salinities (4 – 36 ppt) the species spawn offshore and therefore, are unlikely to be adversely affected by localised, reduced flows in the lower River Severn. Similarly, anchovies (*Engraulis encrasicholus*) spawn offshore. Therefore, no adverse effects on prey availability for twaite shad are anticipated. The decreased flows downstream of the intake during operation could cause a reduction in the dilution of effluents, create salinity barriers, changes to nutrient loading, turbidity and reduced dissolved oxygen, negatively impacting on migration upstream. This could impact on invertebrate populations and associated prey species of twaite shad. Hydrological impact assessments have confirmed that the 300Ml/d flow reduction would result in a negligible change to the flow pattern of the River Severn up to the tidal limit. On 642 of the strategic scheme flow dates (92%) the same flow band would be retained, while 57 dates (8%) would result in change by one flow band. Therefore, no adverse effects anticipated as a result of water flow changes on prey species[240]. Water quality assessments confirmed that further study of water quality data, measured at NRW water quality monitoring sites is required, in order to fully determine the water quality and chemistry representation of the River Severn downstream of the Avon confluence prior to a detail assessment of impacts to water quality from STT options and schemes[240]. Prey species may also become entrapped causing injury and/or enter the treatment works resulting in mortality during operation at the intake site. Considering the mitigation measures (two stage screening) and the relatively short duration that the intake will operate, no adverse effects are predicted.	- Where possible, it is proposed that lighting will be directional/ baffled for works on the riverbank to minimise light disturbance in the River Severn (not included in CDR). **Operation** - Two sets of two stage screening will be installed to exclude fish during times of operation. This include band screens fitted with fish return channels to isolate fish and return individuals directly back to the watercourse. - Any maintenance works required during operation will follow best practice biosecurity measures and EA Pollution Prevention Guidelines as listed above. - Inlet screens and rapid gravity filtration (removes 99 % of 5 µm sized particles) with bypass safeguards will be used to remove larvae of invasive species before transfer of raw water from the River Sever intake, along the canal to the Culham outfall. - Hands-off flow requirements to be confirmed with Environment Agency, to mitigate environmental impacts.	
Ramsar criterion 4: Run of migratory fish species Sea Lamprey *Petromyzon marinus* River lamprey *Lampetra fluviatilis* Twaite shad *Alosa. fallax*	- Migratory access (barriers to migration).	– **Water quality** is sufficient to support migratory passage. Levels (for temperature, salinity, turbidity, pH, and dissolved oxygen) should comply with targets established under the EA Review of Consents and the Water Framework Directive. – **Water flows**: Flows from the rivers into the estuary must be sufficient to allow migration. – **Physical barriers:** No artificial barriers significantly impairing adults from reaching existing and historical spawning	The adverse effects of the canal conveyance on river lamprey, sea lamprey and twaite shad have been considered as designated features of the SAC. Therefore, these three species have been excluded from further assessment (refer to above sections for river lamprey, sea lamprey and twaite shad). As European eel migrate to offshore breeding sites to spawn, they have been excluded from any further consideration regarding migratory access. **Construction** The construction of the canal conveyance will occur approximately 2.1km north-east of the Severn Estuary Ramsar and 32.7km north-east via hydrological connectivity. Construction work associated with the canal conveyance that could impact fish assemblages	**Construction** - Best practice biosecurity measures will be followed, as recommended by the GB Non-Native Species Secretariat[243] to guard against any potential for spreading invasive and non-native species during construction (not included in CDR). - Works will 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 either occurred.	No adverse effects predicted

[240] United Utilities (2021). Severn to Thames Transfer SRO downstream River Avon confluence to the tidal limit. Report by Ricardo Energy and Environment.
[243] Non-native species secretariat (2021). *Biosecurity and Prevention*. Accessed from: http://www.nonnativespecies.org/index.cfm?sectionid=58

Qualifying Feature	Attribute	Target	Potential Effects	Mitigation	Adverse Effect Predicted?
Allis shad *Alosa alosa* Atlantic salmon *Salmo salar* Sea trout *S. trutta* European eel *Anguilla anguilla*. **Ramsar criterion 8: fish of the whole estuarine and river system** 110 species recorded		grounds or juveniles from moving downstream. -	during upstream migration in the River Severn includes the following: construction of at least two portals/ inlets into the riverside retaining wall, two stage screening including coarse bar screens and rotating band screens, small control kiosks, penstock, penstock actuators and a box culvert. No additional barriers to migration would be created through construction of the pipeline. Potential impacts during in-river construction on migratory access to upstream spawning sites in the River Severn and River Vyrnwy for Allis shad, Atlantic salmon and sea trout include the following: water pollution incidents, spread and introduction of invasive non-native species (INNS), noise/ vibration/ light disturbance, localised increases in suspended sediment, entrapment and impingement and fluctuations in dissolved oxygen. With proposed mitigation measures to minimise night-time, in-river disturbance during migration (agreed with client) and following best practice guidelines no adverse effects as a result of disturbance are anticipated. Construction works will be localised and short term, therefore no adverse effects on migratory access from fluctuating abiotic factors and entrapment are anticipated. Impact pathways from topsoil stripping, excavations and movement of construction vehicles along the riverbank include the introduction and spread of INNS, exposure to pollution from accidental oil spills and run-off, localised increases in suspended sediment and noise/ vibration/ light disturbance. As construction works on the riverbank will be localised and short term, no adverse effects are anticipated from increased suspended sediment, noise/ vibration disturbance and run-off. Where possible, additional mitigation has been proposed to use directional/ baffled lighting on the riverbank to minimise light disturbance in the River Severn (agreed with client). Following best practice mitigation measures to minimise the possible introduction and spread of INNS and pollution incidents are viewed as sufficient to ensure no adverse effects on qualifying features of the Severn Estuary SAC. **Operation** This element will transfer unsupported flow from the River Severn via a combination of existing and refurbished canal sections, over the Cotswold hills and discharged via a new pipeline to the River Thames near Culham. The abstracted water will be transferred both when required and when flows are above the hands-off flow (infrastructure already present). If below the hands-off flow, then a 'put and take' arrangement will operate using raw water from other appropriate elements. Atlantic salmon migrate upstream to spawn from November – December. As the abstraction point will only be operational during low flow periods associated with spring and summer, no adverse effects on the migration of Atlantic salmon upstream are anticipated. Allis shad migrates upstream to spawn from April – June and sea trout from September – December. Therefore, both species overlap with potential timeframes of operation during low flow periods in spring and summer. However, with the hands-off flow system installed and conditions provided by the Environment Agency, no adverse effects on twaite shad are anticipated as flows will be maintained at a favourable rate for migration. The decreased flows downstream of the intake during operation could also cause a reduction in the dilution of effluents, create salinity barriers, changes to nutrient loading, turbidity and reduced dissolved oxygen, negatively impacting on migration upstream. Hydrological impact assessments have confirmed that the 300Ml/d flow reduction would result in a negligible change to the flow pattern	- No night-time in river working to avoid noise/ vibration/ light disturbance during upstream migration of associated fish assemblages is proposed (not included in CDR). - Where possible, it is proposed that lighting will be directional/ baffled for works on the riverbank to minimise light disturbance in the River Severn (not included in CDR). **Operation** - Two sets of two stage screening will be installed to exclude fish during times of operation. This include band screens fitted with fish return channels to isolate fish and return individuals directly back to the watercourse. - Mitigation measures for potential impacts on European eels will be considered in the detailed design stage and will be compliant with current eel regulations[244]. Currently inlet screens are proposed. - Any maintenance works required during operation will follow best practice biosecurity measures and EA Pollution Prevention Guidelines as listed above. - Inlet screens and rapid gravity filtration (removes 99 % of 5 µm sized particles) with bypass safeguards will be used to remove larvae of invasive species before transfer of raw water from the River Sever intake, along the canal to the Culham outfall. - Hands-off flow requirements to be confirmed with Environment Agency, to mitigate environmental impacts.	

[244] UK Legislation (2009). The Eels (England and Wales) Regulations 2009. No. 3344, UK Statutory Instruments. Accessed from: https://www.legislation.gov.uk/uksi/2009/3344/made

Qualifying Feature	Attribute	Target	Potential Effects	Mitigation	Adverse Effect Predicted?
			of the River Severn up to the tidal limit. On 642 of the strategic scheme flow dates (92%) the same flow band would be retained, while 57 dates (8%) would result in change by one flow band. Therefore, no adverse effects anticipated as a result of water flow changes on migratory access[242]. Water quality assessments confirmed that further study of water quality data, measured at NRW water quality monitoring sites is required, in order to fully determine the water quality and chemistry representation of the River Severn downstream of the Avon confluence prior to a detail assessment of impacts to water quality from STT options and schemes[242].Allis shad and sea trout may also become entrapped causing injury and/or enter the treatment works resulting in mortality during operation at the intake site. Considering the mitigation measures (two stage screening) and the relatively short duration that the intake will operate, no adverse effects are predicted on the migration capacity of allis shad and sea trout.		
	- Population size (returning adults)	- No decline in number of returning adults from established baseline.	Allis shad, Atlantic salmon, sea trout and European eel population size in the Severn Estuary Ramsar site is dependent on several factors including breeding success, which is reliant on the availability of functional spawning and nursery habitats in the River Usk SAC, River Wye SAC and River Severn. In addition, natural fluctuations in food availability will also impact on population size[245]. Most the fish species that form the fish assemblages in the Severn Estuary Ramsar site are anadromous and so are dependent on marine and estuarine habitats (rather than freshwater) to support adult populations and the number of returning adults. **Construction** The construction of the canal conveyance may negatively impact on the number of returning adults to spawning habitats associated with the River Severn. This is due to potential impact pathways during in-river works, which include: water pollution incidents, spread and introduction INNS, noise/ vibration/ light disturbance, localised increases in suspended sediment, entrapment and impingement and fluctuations in dissolved oxygen. With proposed mitigation measures to minimise night-time, in-river disturbance during migration (agreed with client) and following best practice guidelines no adverse effects on population size from in-river construction are anticipated. Impact pathways from topsoil stripping, excavations and movement of construction vehicles along the riverbank include the introduction and spread of INNS, exposure to pollution from accidental oil spills and run-off, localised increases in suspended sediment and noise/ vibration/ light disturbance. As construction works on the riverbank will be localised and short term, no adverse effects are anticipated from increased suspended sediment, noise and vibration disturbance and run-off. Where possible, additional mitigation has been proposed to use directional/ baffled lighting on the riverbank to minimise light disturbance on the River Severn (agreed with client). Following best practice mitigation measures to minimise the possible introduction and spread of INNS and pollution incidents are viewed as sufficient to ensure no adverse effects on qualifying features of the Severn Estuary Ramsar site. **Operation** During times of operation, depleted flows downstream of the intake could act as a barrier to migration upstream and corresponding spawning habitats, which could impact on long term population	**Construction** - Best practice biosecurity measures will be followed, as recommended by the GB Non-Native Species Secretariat[248] to guard against any potential for spreading invasive and non-native species during construction (not included in CDR). - Works will 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 either occurred. - No night-time in river working to avoid noise/ vibration/ light disturbance during upstream migration of associated fish assemblages is proposed (not included in CDR). - Where possible, it is proposed that lighting will be directional/ baffled for works on the riverbank to minimise light disturbance in the River Severn (not included in CDR). **Operation** - Two sets of two stage screening will be installed to exclude fish during times of operation. This include band screens fitted with fish return channels to isolate fish and return individuals directly back to the watercourse. - Mitigation measures for potential impacts on European eels will be considered in the detailed design stage and will be compliant with current eel regulations[249]. Currently inlet screens are proposed. - Any maintenance works required during operation will follow best practice biosecurity measures and EA Pollution Prevention Guidelines as listed above. - Inlet screens and rapid gravity filtration (removes 99 % of 5 µm sized particles) with bypass safeguards will be used to remove larvae of invasive species before transfer of raw water from the River Sever intake, along the canal to the Culham outfall. - Hands-off flow requirements to be confirmed with Environment Agency, to mitigate environmental impacts.	No adverse effects predicted

[242] United Utilities (2021). Severn to Thames Transfer SRO downstream River Avon confluence to the tidal limit. Report by Ricardo Energy and Environment.
[245] 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.
[248] Non-native species secretariat (2021). *Biosecurity and Prevention*. Accessed from: http://www.nonnativespecies.org/index.cfm?sectionid=58
[249] UK Legislation (2009). The Eels (England and Wales) Regulations 2009. No. 3344, UK Statutory Instruments. Accessed from: https://www.legislation.gov.uk/uksi/2009/3344/made

Qualifying Feature	Attribute	Target	Potential Effects	Mitigation	Adverse Effect Predicted?
			trends. However, with the hands-off flow system installed and conditions provided by the Environment Agency, no adverse effects on twaite shad are anticipated as flows will be maintained at a favourable rate for migration. The decreased flows downstream of the intake during operation could also cause a reduction in the dilution of effluents, create salinity barriers, changes to nutrient loading, turbidity and reduced dissolved oxygen, negatively impacting on migration upstream. Hydrological impact assessments have confirmed that the 300Ml/d flow reduction would result in a negligible change to the flow pattern of the River Severn up to the tidal limit. On 642 of the strategic scheme flow dates (92%) the same flow band would be retained, while 57 dates (8%) would result in change by one flow band. Therefore, no adverse effects anticipated as a result of water flow changes on population size[246]. Water quality assessments confirmed that further study of water quality data, measured at NRW water quality monitoring sites is required, in order to fully determine the water quality and chemistry representation of the River Severn downstream of the Avon confluence prior to a detail assessment of impacts to water quality from STT options and schemes[247]. Allis shad, Atlantic salmon, sea trout and European eels may also become entrapped causing injury and/ or enter the treatment works resulting in mortality during operation at the intake site. Considering the mitigation measures (two stage screening) and the relatively short duration that the intake will operate, no adverse effects are predicted.		
	- River population	No decline in the populations of the Wye and Usk - Baseline is yet to be established through fish surveys in estuary and river	Fish populations associated with the Severn Estuary Ramsar site are dependent on adjacent rivers including the River Usk and Wye and the availability of suitable spawning and nursery sites to fulfil their lifecycle[250]. **Construction** Due to the location of the proposed canal conveyance and associated intake site on the River Severn, no direct impacts from construction of the intake, refurbishment of the canal and construction of the pipeline have been identified on river populations and targets for the River Usk and Wye. **Operation** Due to the location of the proposed canal conveyance and associated intake site on the River Severn, no direct impacts from operation of the water transfer have been identified on river populations and targets for the River Usk and Wye. As no adverse effects on the River Usk and Wye have been identified from either the construction or operation of the proposed canal conveyance, no adverse effects on river populations associated with the Severn Estuary Ramsar site are predicted.	No mitigation measures required.	No adverse effects predicted
	- Prey species	No significant reduction in abundance of key prey species against an established baseline - Baseline is yet to be established through fish surveys in estuary and river	Like twaite shad, allis shad largely feed on estuarine and marine prey including crustaceans (mysids and copepods), fish (sprats and anchovies) and fish eggs[251]. European eel feed on benthic invertebrates including crustaceans and small fish species. Both Atlantic salmon and sea trout (diet understudied) feed on fish including Atlantic herring, sprat and sand eel species and a range of crustaceans[252]. **Construction** As the prey species of allis shad, Atlantic salmon, sea trout and European eel largely occupy estuarine and marine habitats and the	**Construction** - Best practice biosecurity measures will be followed, as recommended by the GB Non-Native Species Secretariat[254] to guard against any potential for spreading invasive and non-native species during construction (not included in CDR). - Works will be conducted in adherence to EA Pollution Prevention Guidelines; now archived. - Construction Environmental Management Plan with risk	No adverse effects predicted

[246] United Utilities (2021). Severn to Thames Transfer SRO downstream River Avon confluence to the tidal limit. Report by Ricardo Energy and Environment.
[247] United Utilities (2021). Severn to Thames Transfer SRO downstream River Avon confluence to the tidal limit. Report by Ricardo Energy and Environment.
[250] 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.
[251] Maitland, P. S. and Hatton-Ellis, T. W. (2003). Ecology of the Allis and Twaite shad. Conserving Natura 2000 Rivers Ecology Series No. 3. Natural England, Peterborough.
[252] Bird, D. J. (2008). The Biology and Conservation of the Fish Assemblage of the Severn Estuary. CCW Report CCW/SER/08/01.
[254] Non-native species secretariat (2021). *Biosecurity and Prevention*. Accessed from: http://www.nonnativespecies.org/index.cfm?sectionid=58

Qualifying Feature	Attribute	Target	Potential Effects	Mitigation	Adverse Effect Predicted?
			fish species spawn offshore, the likely presence of prey species during construction is considered low. If prey species are present in the lower River Severn during construction, the following impact pathways have been identified: water pollution incidents, spread and introduction of INNS, noise/ vibration/ light disturbance, localised increases in suspended sediment, entrapment and impingement and fluctuations in dissolved oxygen. Proposed mitigation measures to reduce noise/ vibration/ light disturbance include no night-time in river working during the migration season; agreed with client. As construction works will be localised and short term, no adverse effects are anticipated from increases in suspended sediment, entrapment and dissolved oxygen fluctuations on prey species. Impact pathways from topsoil stripping, excavations and movement of construction vehicles along the riverbank include the introduction and spread of INNS, exposure to pollution from accidental oil spills and run-off, localised increases in suspended sediment and noise/ vibration/ light disturbance. As construction works on the riverbank will be localised and short term, no adverse effects are anticipated from increased suspended sediment, noise and vibration disturbance and run-off. Where possible, additional mitigation has been proposed to use directional/ baffled lighting on the riverbank to minimise light disturbance on the River Severn (agreed with client). Following best practice mitigation measures to minimise the possible introduction and spread of INNS and pollution incidents are viewed as sufficient to ensure no adverse effects on prey species. **Operation** Although sprat tolerate low salinities (4 – 36 ppt) the species spawn offshore and therefore, are unlikely to be adversely affected by localised, reduced flows in the lower River Severn. Similarly, anchovies, herring and sand eel species spawn offshore. Therefore, no adverse effects on prey availability for twaite shad are anticipated. The decreased flows downstream of the intake during operation could cause a reduction in the dilution of effluents, create salinity barriers, changes to nutrient loading, turbidity and reduced dissolved oxygen, negatively impacting on migration upstream. This could impact on invertebrate populations and associated prey species of allis shad, Atlantic salmon, sea trout and European eel. Hydrological impact assessments have confirmed that the 300Ml/d flow reduction would result in a negligible change to the flow pattern of the River Severn up to the tidal limit. On 642 of the strategic scheme flow dates (92%) the same flow band would be retained, while 57 dates (8%) would result in change by one flow band. Therefore, no adverse effects anticipated as a result of water flow changes on prey species[253]. Water quality assessments confirmed that further study of water quality data, measured at NRW water quality monitoring sites is required, in order to fully determine the water quality and chemistry representation of the River Severn downstream of the Avon confluence prior to a detail assessment of impacts to water quality from STT options and schemes**Error! Bookmark not defined.**. Prey species may also become entrapped causing injury and/ or enter the treatment works resulting in mortality during operation at the intake site. Considering the mitigation measures (two stage screening) and the relatively short duration that the intake will operate, no adverse effects are predicted.	assessment for pollution incidents and introduction/ spread of INNS and a response plan if either occurred. - No night-time in river working to avoid noise/ vibration/ light disturbance during upstream migration of associated prey species is proposed (not included in CDR). - Where possible, it is proposed that lighting will be directional/ baffled for works on the riverbank to minimise light disturbance in the River Severn (not included in CDR). **Operation** - Two sets of two stage screening will be installed to exclude fish during times of operation. This include band screens fitted with fish return channels to isolate fish and return individuals directly back to the watercourse. - Mitigation measures for potential impacts on European eels will be considered in the detailed design stage and will be compliant with current eel regulations[255]. Currently inlet screens are proposed. - Any maintenance works required during operation will follow best practice biosecurity measures and EA Pollution Prevention Guidelines as listed above. - Inlet screens and rapid gravity filtration (removes 99 % of 5 µm sized particles) with bypass safeguards will be used to remove larvae of invasive species before transfer of raw water from the River Sever intake, along the canal to the Culham outfall. - Hands-off flow requirements to be confirmed with Environment Agency, to mitigate environmental impacts.	

[253] United Utilities (2021). Severn to Thames Transfer SRO downstream River Avon confluence to the tidal limit. Report by Ricardo Energy and Environment.
[255] UK Legislation (2009). The Eels (England and Wales) Regulations 2009. No. 3344, UK Statutory Instruments. Accessed from: https://www.legislation.gov.uk/uksi/2009/3344/made

6 In-combination assessment

6.1 Operation regime

Sections 4 and Sections 5 have mostly considered the elements that will form the STT SRO individually. It is noted that the operation of the STT will ultimately be depended on the level of support that is required. Modelling completed by Jacobs has identified preferred order of operation and the sequence in which elements will be implemented (**Table 6.1**)

Four potential "groupings" of individual elements have been identified to represent the operational regime of the STT SRO:

- **Group 1:** A pipeline conveyance, either unsupported or supported with all individual elements excluding the Minworth WwTW discharge diversion
- **Group 2**: A pipeline conveyance, either unsupported or supported with all individual elements including the Minworth WwTW discharge diversion
- **Group 3**: A canal conveyance, either unsupported or supported with all individual elements excluding the Minworth WwTW discharge diversion
- **Group 4**: A canal conveyance, either unsupported or supported with all individual elements including the Minworth WwTW discharge diversion

An in-combination assessment of these groupings has been completed in the sections below using the *principals* of HRA.

Table 6.1: Assessed groupings: components and order of preference for operation

Pipeline conveyance (full support)	Pipeline conveyance (without Minworth)	Canal conveyance (full support)	Canal conveyance (without Minworth)
Pipeline conveyance (full support)	Pipeline conveyance (without Minworth)	Canal conveyance (full support)	Canal conveyance (without Minworth)
Unsupported abstraction (to 300Ml/d)	Unsupported abstraction (to 300Ml/d)	Unsupported abstraction (to 300Ml/d)	Unsupported abstraction (to 300Ml/d)
Mythe abstraction reduction (15Mld)	Mythe abstraction reduction (15Mld)	Mythe abstraction reduction (15Mld)	Mythe abstraction reduction (15Mld)
Vyrnwy Reservoir release (50Mld)	Vyrnwy Reservoir release (50Mld)	Netheridge WwTW discharge diversion (35Mld)	Netheridge WwTW discharge diversion (35Mld)
Netheridge WwTW discharge diversion (35Mld)	Netheridge WwTW discharge diversion (35Mld)	Vyrnwy Reservoir release (50Mld)	Vyrnwy Reservoir release (50Mld)
Vyrnwy Reservoir release (25Mld)	Vyrnwy Reservoir release (25Mld)	Vyrnwy Reservoir release (25Mld)	Vyrnwy Reservoir release (25Mld)
River Vyrnwy Mitigation – Shrewsbury Redeployment (25Mld)	River Vyrnwy Mitigation – Shrewsbury Redeployment (25Mld)	River Vyrnwy Mitigation – Shrewsbury Redeployment (25Mld)	River Vyrnwy Mitigation – Shrewsbury Redeployment (25Mld)
River Vyrnwy Mitigation – Vyrnwy Bypass release (80Mld)	Minworth WwTW discharge diversion (115Mld)	River Vyrnwy Mitigation – Vyrnwy Bypass release (80Mld)	Minworth WwTW discharge diversion (115Mld)
-	River Vyrnwy Mitigation – Vyrnwy Bypass release (80Mld)	-	River Vyrnwy Mitigation – Vyrnwy Bypass release (80Mld)

6.2 Assessment of groupings

At times when the STT SRO will be operating without support, adverse effects site integrity are not predicted regardless off a canal or pipeline interconnector.

The decreased flows downstream of the canal/pipeline intake during operation could cause a reduction in the dilution of effluents, create salinity barriers, changes to nutrient loading, turbidity and reduced dissolved oxygen, negatively impacting on migration upstream. However, hydrological impact assessments have confirmed that the 300Ml/d flow reduction would result in a negligible change to the

flow pattern of the River Severn up to the tidal limit. On 642 of the strategic scheme flow dates (92%) the same flow band would be retained, while 57 dates (8%) would result in change by one flow band.

The scheme design will include two sets of two stage screening to exclude fish during times of operation. This includes large bar screens and band screens fitted with fish return channels to isolate fish and return individuals directly back to the watercourse. These are compliant with current eel regulations[256]. The Environment Agency has advised a STT abstraction licence would be limited to not reduce flow at Deerhurst flow gauging station below 2,568 Ml/d, a hands-off flow (HoF) condition. At flows greater than this HoF, up to 172Ml/d is available for abstraction without support, and at flows greater than 3,333Ml/d an additional 355Ml/d is available for abstraction without support. These HoFs will remain in place and will ensure protection of flows into the River Severn to aid in migration.

Subject to review it is understood that these HoFs relate to sustainable abstraction and neutral flow effects in the lower River Severn and Severn Estuary. At times of low flows locally abstraction would be lower, partially or wholly supported by STT support releases with no overall change in flows to the Severn Estuary.

At times when the STT SRO will be operating with support, water quality impacts are expected to be limited. The exception is the Minworth discharge diversion element which is discussed in more detail below. A long-term monitoring programme indicated limited changes in water quality and that any changes are generally limited to the ~3km reach of the River Vyrnwy immediately downstream of the reservoir. Monitoring during the test releases of 180Ml/d identified that impacts on water temperature can be exacerbated during periods of low flow and rapidly rising or falling air temperatures. The impact upon temperature during support releases is greatly reduced at 75Ml/d and can be further mitigated through operational rules. Further monitoring and assessment will be required to understand the potential risk of dissolved oxygen and temperature changes associated with a River Vyrnwy Mitigation (bypass pipeline release) and the local impacts on the lower reaches of the River Vyrnwy. Any impacts on the River Severn, downstream of the confluence with the River Vyrnwy is expected to be negligible. For the Mythe and Shrewsbury elements, there is no risk of water quality impacts during operation as these elements will see water usually abstracted, remain in the River Severn and at times of low flows, this could be considered a minor benefit.

There is some uncertainty regarding the water quality impacts associated with the Minworth discharge diversion element. To obtain a discharge permit, tertiary treatment of the effluent will be required for the general water chemistry, sanitary, nutrient, and some hazardous substances (nickel and mercury) determinands in the Minworth WwTW final effluent. More advanced treatment would be needed to address a number of hazardous substances including benzo(a)pyrene, bioavailable zinc, bioavailable nickel and bioavailable manganese. Therefore, no adverse effects are anticipated as a result of changes in water quality on migratory access.

The Environment Agency and Natural England has raised concerns with regards to the chemical cues (olfaction) to migration as a result of the diversion of WwTW discharge from the Tame. While there is no known threshold in terms of dilution rate of natal water for some of the Annex II species research has shown that that Atlantic salmon were attracted to natal water that had been diluted to 0.1% and other fish species are known to discern and react to chemical cues at concentrations as low as parts per trillion (ppt). Considering the dilution of the WwTW discharge within the River Avon, River Severn and Severn Estuary, adverse effects associated with this element are not predicted. Further research and assessment are required in Gate 2 to confirm this conclusion.

At times when the STT SRO will be operating with support, flow related impacts are also expected to be limited. Monitoring during trial releases for the Vyrnwy Reservoir option recommended that flows do not exceed 175Ml/d and recommended a Vyrnwy Reservoir support releases of 75Ml/d. Such a release will not result in increased velocities and depths that are outside the thresholds of the fish populations considered Annex II species of the Severn Estuary. While some localised impacts could be associated with the River Vyrnwy Mitigation (bypass pipeline release), the magnitude of the impact is not predicted

[256] UK Legislation (2009). The Eels (England and Wales) Regulations 2009. No. 3344, UK Statutory Instruments. Accessed from: https://www.legislation.gov.uk/uksi/2009/3344/made

to impact on the integrity of the Severn Estuary site. A more detailed hydrological assessment has indicated that flow impacts on the River Severn will be neutral.

There remains some uncertainty with regards to the Minworth discharge diversion element. The flow impact in the River Avon is considered major. While it should be considered that much of the River Avon is level controlled, there is some uncertainty with regards to the impact on the upstream migration of European eel and the subsequent long-term impacts on the population of the Severn Estuary.

The assessments assumed that the tributaries associated with the support option provides significant off-site functional habitat for the fish populations of the Severn Estuary protected site. This is through adoption of the precautionary approach and further research is required to understand the contribution of the fish populations to the SAC and Ramsar site (see section below).

6.3 Monitoring/assessment requirements to inform Gate 2

As noted in Section 3, the Gate 1 submission does not form a statutory plan or project. As such, the principles of the HRA process were applied to help identify risks to feasibility and deliverability of the elements. Several areas of uncertainty have been identified and further monitoring and assessment is required to inform the Gate 2 assessments. The requirements are summarised as follows:

- There is some uncertainty regarding the suitability of habitat in the upper Severn catchment for shad (allis shad twaite shad) spawning and therefore the extent to which these areas may be colonised by shad in future following improvements in connectivity under the 'Unlocking the Severn' project. Walkover/habitat surveys to consider the potential/suitability of habitat in the Upper River Severn and River Vyrnwy is required. This information will help inform the potential risk to the Annex II feature from increased flows in the River Vyrnwy.
- Targeted lamprey surveys are required to understand the distribution of lamprey species in the River Vyrnwy. This needs to inform an assessment of the potential contribution of the River Vyrnwy population to the Severn Estuary populations.
- Mapping of optimal and sub-optimal lamprey ammocoete habitat is required within the River Vyrnwy to understand the extent to which supporting habitat is provide within the watercourse.
- Mapping of the extent and location of lamprey spawning habitat is required within the River Vyrnwy to understand the extent to which supporting habitat is provide within the watercourse.
- Mapping of the extent and location of Atlantic almon spawning and juvenile habitat is required within the River Vyrnwy to understand the extent to which supporting habitat is provide within the watercourse.
- A review/assessment of the potential migration barriers in the River Avon is required. This should be supported by an assessment of the passability of the barriers in baseline/low flow conditions and the subsequent impact of the Minworth discharge diversion releases.
- A more detailed assessment of the proposed mitigation measures is required. This includes potential changes to the Severn Regulation operational regime to avoid support and regulation releases in the River Vyrnwy form coinciding.
- Assessment of the distribution of physical barriers in the River Avon that may impact on eel migration (upstream) and the consequent changes in passability as a result of increased flows
- The Gate 2 assessment needs to consider future demands, future climates, cumulative demands, other operating requirements, other operational controls
- The Gate 2 assessment needs to consider the impact on the River Vyrnwy as a result of the frequent release of supporting flows in addition to short-term regulation and flood drawdown releases. This is in the context of the River Vyrnwy potentially providing supporting habitats to the fish population of the Severn Estuary.

7 Conclusions and Recommendations

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.

As the Gate 1 submission does not form a statutory plan or project, UU has undertaken an assessment of the implications of the individual elements of the STT by adopting the *principles* of the HRA process to help identify risks to feasibility and deliverability of the elements as well as the additional monitoring and assessment work required to inform the formal HRA at Gate 2.

As such, the assessment has identified where there is a risk of LSE to occur as a result of each element and the STT SRO and, where a risk of LSE has been identified, where adverse effect on site integrity are predicted.

Screening concluded that the Vyrnwy Reservoir release (75 Ml/d), River Vyrnwy Mitigation release (100 Ml/d) and Bypass (80 Ml/d), River Vyrnwy Mitigation release (155 Ml/d), Minworth discharge diversion (115Ml/d), Deerhurst to Culham pipeline conveyance (300, 400 and 500 Ml/d) and Cotswold Canal conveyance including piping to Culham (300 Ml/d) had potential to cause LSE on European designated sites alone and they were taken through to Appropriate Assessment. This was due to a clear risk of LSE on qualifying habitats and species of the Severn Estuary SAC and Ramsar site or where mitigation measures would be required.

The Appropriate Assessment concluded that adverse effects on the site integrity of the Severn Estuary SAC and Ramsar site during construction and operation of the Deerhurst to Culham pipeline conveyance and Cotswold Canal conveyance are not predicted. This was due to consideration of the following embedded and additional mitigation measures: following best practice guidance for pollution prevention and biosecurity incidents, avoiding night-time works, using directional and/or baffled lighting when required, implementation of two stage screening and a hands-off flow (HoF) at the intake sites, to limit abstraction when flows at the gauging station are below 2,568 Ml/d. At flows greater than this HoF, up to 172 Ml/d is available for abstraction without support, and at flows greater than 3,333 Ml/d an additional 355 Ml/d is available for abstraction without support. These HoF limitations were also advised by the Environment Agency. Additional monitoring is required in order to determine whether suitable silt bed habitat for river lamprey and sea lamprey ammocoetes is present within close proximity of the intake sites for both elements. Water quality assessments confirmed that further study of water quality data, measured at NRW water quality monitoring sites is required, in order to fully determine the water quality and chemistry representation of the River Severn downstream of the Avon confluence prior to a detail assessment of impacts to water quality from STT options and schemes[257].

The Appropriate Assessment concluded that adverse effects on the site integrity of the Severn Estuary SAC and Ramsar site as a result of implementation of the Vyrnwy Reservoir release (75 Ml/d), River Vyrnwy Mitigation release (100 Ml/d) and Bypass (80 Ml/d), River Vyrnwy Mitigation release (155 Ml/d) are not predicted. This in in view of existing data on the velocity, depth and water quality impacts associated with these elements and consideration of operational measures to mitigate against any impacts. Further monitoring is required to understand the extent to which the River Vyrnwy provides supporting habitat to the fish populations of the Severn Estuary SAC and Ramsar site.

The Appropriate Assessment concluded that no adverse effects on site integrity of the Severn Estuary SAC and Ramsar, River Clun SAC, River Wye SAC and River Usk SAC is predicted as a result of the implementation of the Minworth discharge diversion (115Ml/d) This includes the implementation of tertiary treatment of WwTW discharge prior to release in the River Avon and operational rules to avoid

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

the upstream migration period of anadromous fish. There remains some uncertainty with regards to the potential impacts on migratory cues (chemical) and passability of barriers as a result of this element. The main concern relates to olfactory cues in species such as Atlantic salmon (*Salmo salar*), twait shad (*Alosa fallax*) sea lamprey (*Petromyzon marinus*), river lamprey (*Lampetra fluviatilis*) and European eel (*Anguilla anguilla*). European eel are also known to occur throughout the River Avon catchment and there is some uncertainty regarding the passability of barriers as a result of increased flow.

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 2 assessments. This includes consideration of any 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.

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