South Lincolnshire Reservoir Strategic Resource Options - Environmental Assessment Report

July 2021

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Issue and Revision Record

Revision	Date	Originator	Checker	Approver	Description
A	21.04.21	H Dodd	J Fookes	P Harvey	For client comment
B	27.05.21	H Dodd	J Fookes	P Harvey	Amended with client comments
C	13.07.21	H Dodd	J Fookes	D Ocio	Amended with comments

Document reference: 100410795-002-04 |

Information class: Standard

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Contents

1 Introduction

1.1 Overview

The Environment Assessment Report (EAR) has been prepared to support the Gate 1 submission report to the Regulators' Alliance for Progressing Infrastructure Development (RAPID) for the South Lincolnshire Reservoir (SLR) Strategic Regional Option (SRO).

1.2 SLR Options

The three options described in this report have been selected for concept design, from a larger list of potential solutions in consultation with stakeholders. A fourth theoretical option has also been included to establish a cost and carbon baseline, which is referred to as CDO0 in Table 7.3 within this document. However, this option has not been developed into a concept design for the purposes of the environmental assessment and is therefore excluded from all other assessments.

Following discussion with Affinity Water and Anglian Water, three options within the Black Sluice catchment were selected for the Gate 1 submission. These options are shown in Table 1.1. Further details on the options are set out in Section 2: Scheme Description.

Table 1.1: SLR Options

Option Name	Description Overview
Concept Design Option 1 (CDO1)	This option consists of the construction of a multi-purpose reservoir. Extraction points are assumed to be located on the River Witham and South Forty Foot Drain with transfers to the reservoir via pipeline. A third indirect intake provides for transfers from the River Trent to River Witham.
Concept Design Option 2 (CDO2)	This option consists of a single purpose public water supply reservoir. The transfer of water to the reservoir is achieved through diversions from the River Witham to the South Forty Foot Drain via open water transfer with flows then transferred through the South Forty Foot Drain to the reservoir.
Concept Design Option 3 (CDO3)	This option consists of a single purpose public water supply reservoir. Extraction from the River Witham is achieved through open water transfer to the reservoir via the South Forty Foot Drain. The Trent to Witham Transfer is also included within this option.

1.3 Structure of the Report

This document presents:

- Section 2 Scheme Description: An overview of the SLR options;
- Section 3 Regulatory Assessment Report: Information on the regulatory assessments undertaken as part of the Gate 1 submission
- Section 4 Invasive Non-Native Species Risk: INNS risk assessment undertaken of the options;
- Section 5 Natural Capital and Biodiversity Net Gain: NC and BNG assessment undertaken on the options;
- Section 6 Wider Benefits: High level socio-economic assessment undertaken on the options;
- Section 7 Assessment of Opportunities for Net Zero Carbon Contributions: High level carbon assessment undertaken for the SLR Scheme; and
- Section 8 Summary conclusions

1.4 Methodology

While SLR is a Water Resources East (WRE) schemes, the environmental assessments were undertaken using the Water Resources South East (WRSE) methodology. Due to the Integrated Environmental Assessment scoping consultation only recently being completed, the WRE methodology was not ready to use in time for the preparation of the GATE 1 deliverables. Using the WRSE methodology is also justified on the basis that the receiving Water Resources Zone (WRZ) is within the WRSE region. As the WRSE and WRE methodologies are very similar, this is not considered to be a constraint to the environmental assessments for the SROs.

2 Scheme Description

2.1 Overview

As part of the Water Resource Management Plan 2019 (WRMP19), Anglian Water (AW) and Affinity Water (AFW) projected an increasing deficit between water supply and demand in several Water Resource Zones (WRZs) over the coming decades. The development of South Lincolnshire Reservoir (SLR), a winter storage reservoir in South Lincolnshire, was identified in AW WRMP19 as the preferred supply side option to meet their long-term demand for water.

A full scheme description can be found in the Concept Design Report which forms part of the Gate 1 submission, however a summary of the main aspects of the options is included below.

2.2 Options Descriptions

For Gate 1, three options have been considered for the SLR as described in Table 2.1. Figures of the options are provided in Figure 2.1, Figure 2.2 and Figure 2.3 accordingly.

Table 2.1: SLR Gate 1 Options

Option Name	Option Description
Concept Design Option 1 (CDO1)	This option consists of the construction of a multi-purpose reservoir. Extraction points are assumed to be located on the River Witham and South Forty Foot Drain with transfers to the reservoir via pipeline. A third indirect intake provides for transfers from the River Trent to River Witham. A third pipeline then transfers flow from the SLR and is sized to allow for the treatment and transfer of 150Ml/d Deployable Output (DO). Benefits: Water resource (232Ml/d), flood risk mitigation in the in the lower part of the South Forty Foot Drain and Irrigation supply of 2,500Ml/year. Interdependencies: Anglian Water to Affinity Water Transfer Scheme.
Concept Design Option 2 (CDO2)	This option consists of a single purpose public water supply reservoir. The transfer of water to the reservoir is achieved through diversions from the River Witham to the South Forty Foot Drain via open water transfer with flows then transferred through the South Forty Foot Drain to the reservoir. The Trent to Witham Transfer is also included within this option. Finall, a second pipeline then transfers flow from the SLR and is sized to allow for the treatment and transfer of 150Ml/d Deployable Output (DO). Benefits: Water resource (189Ml/d), Flood risk mitigation in the South Forty Foot Drain and in the high-level carriers, particularly in Swaton and Billingborough, Increased summer flows in the South Forty Flood Drain and improved water quality in the Black Sluice catchment. Interdependencies: Anglian Water to Affinity Water Transfer Scheme.
Concept Design Option 3 (CDO3)	This option consists of a single purpose public water supply reservoir. Extraction from the River Witham is achieved through open water transfer to the reservoir via the South Forty Foot Drain. The Trent to Witham Transfer is also included within this option. A second pipeline then transfers flow from the SLR and is sized to allow for the treatment and transfer of 150Ml/d Deployable Output (DO). Benefits: Water resource (189Ml/d), flood risk mitigation in the River Glen downstream of Surfleet reservoir, irrigation supply of 2,500Ml/year, increased summer flows in the South Forty Flood Drain, and improved water quality in the Black Sluice catchment. Interdependencies: Anglian Water to Affinity Water Transfer Scheme.

Figure 2.1: SLR Concept Design 1

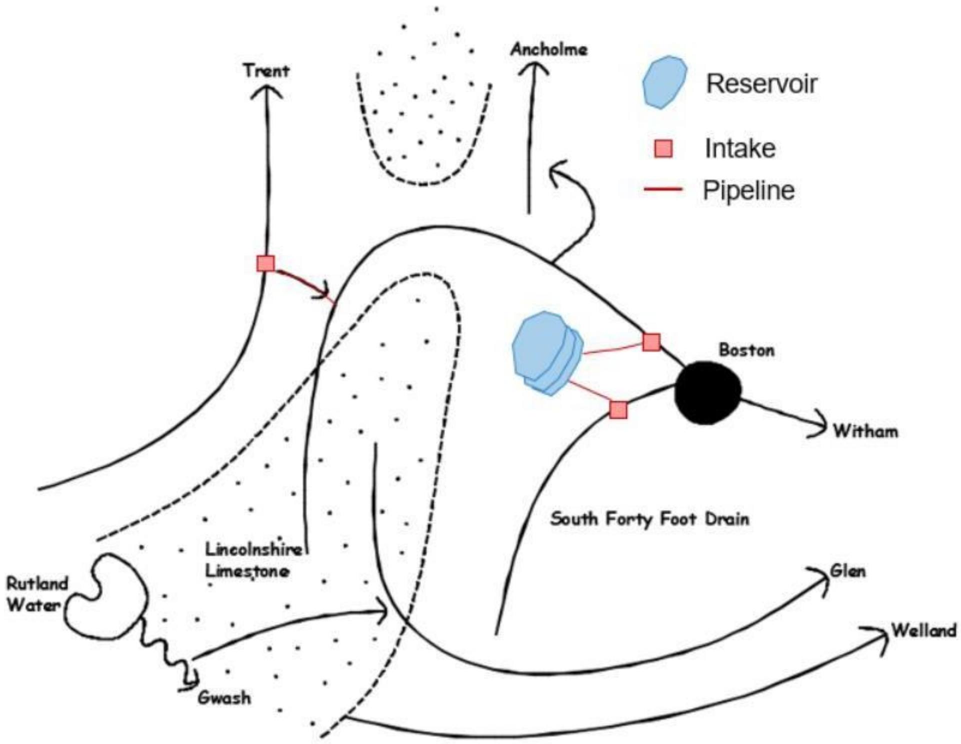


Figure 2.2: SLR Concept Design 2

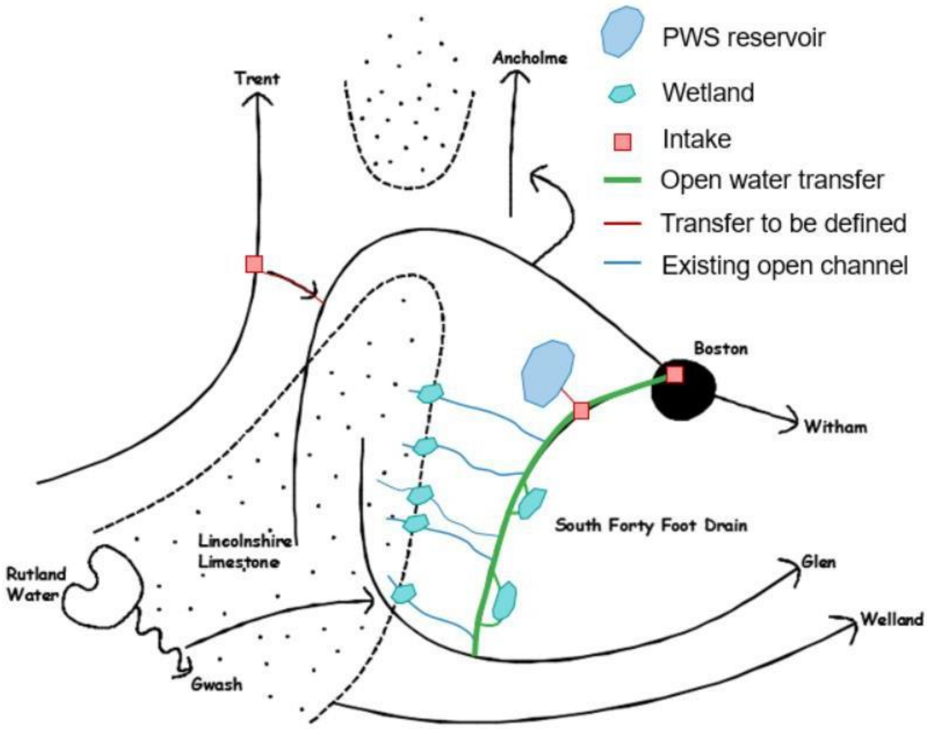
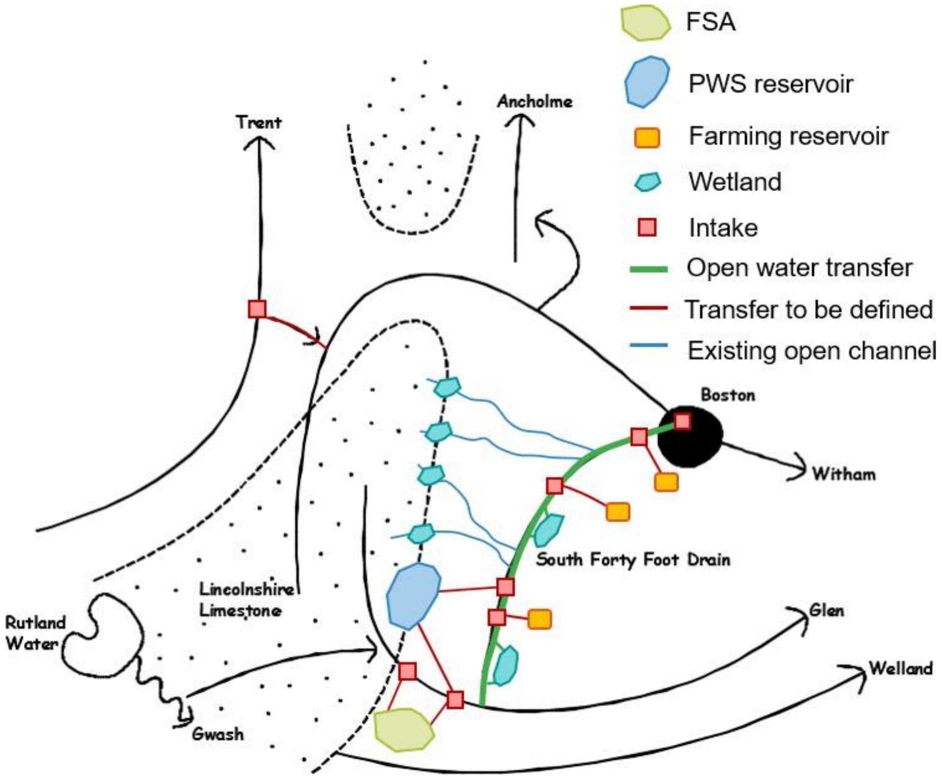


Figure 2.3: SLR Concept Design 3



3 Regulatory Assessment Reports

Three regulatory assessments have been undertaken to support the Gate 1 submissions and are presented as standalone reports and are summarised below.

3.1 Habitats Regulations Assessment

A HRA was undertaken for the three SLR options and provides information on the Habitats Regulations Assessment (HRA) screening (HRA Stage 1). All three options identified one pathway during operation due to water abstraction and reduction in flows which has the potential to affect the following designated sites:

- The Wash SPA;
- The Wash Ramsar;
- The Wash and North Norfolk Coast SAC;
- Humber Estuary SAC;
- Baston fen SAC
- Humber Estuary SPA; and
- Humber Estuary Ramsar.

We note that an HRA Stage 2 Appropriate Assessment (AA) has not been undertaken at this stage, as it requires hydraulic modelling information that is yet to be produced. This will need consideration at the next stage of the process once the relevant information has been produced. Undertaking the Stage 2 HRA without understanding the extent of the potential effects would result in inconclusive results given to the existing level of uncertainty in relation with changes in flows downstream of the proposed intakes.

3.2 Water Framework Directive Assessment

A WFD assessment was undertaken for the SLR options. It provides information on the WFD screening (Level 1 – basic screening) applied to all SLR options and on the further assessment (Level 2 – detailed impact screening) undertaken for the SLR options that were screened in at Level 1.

All three options ‘screened in’ impacts and a further assessment was undertaken. Level 2 WFD assessments were completed for seven waterbodies in total which were:

- GB205030051515: Black Sluice IDB draining to the South Forty Foot Drain;
- GB104028053110: Trent from Soar to The Beck;
- GB105030056780: Witham - conf Cringle Bk to conf Brant;
- GB205030062426: Lower Witham;
- GB105031050595: Brook Drain (including Marholm Brook);
- GB105030056520: South Beck;
- GB105030056515: Swaton Drains; and
- GB105031050720: Glen.

For all three options the assessment identified possible deterioration risks to fish, invertebrates, hydrological regime, dissolved oxygen and phosphate. This reflects a potential risk of reduced flow due to increased abstraction, and the additional intake structure required. It also identified potential impediments to meeting Good Ecological Status, if the hydrological regime of the waterbody was affected to the extent that Physico-chemical concentrations could increase, particularly those elements which are currently below good or if water body objectives could be compromised (by changes to the hydrological regime or due to physical modification).

Based on this areas for future focus include:

- Consultation with the Environment Agency to present and discuss key WFD risks and proposed approach to improving certainty of assessments;
- Collation and review of Heavily Modified Waterbody (HMWB) measures information from the Environment Agency for inclusion into the assessment of potential impediment to obtaining Good Ecological Potential (GEP);
- Collation and review of detailed baseline data concerning WFD biological, physicochemical and hydromorphological elements identified as being at yellow, amber, or red risk in the Level 2 assessments. This may include existing Environment Agency and as well as Thames Water, Affinity and Anglian Water long term WFD and water quality monitoring data within the relevant waterbodies, and targeted baseline surveys being undertaken specifically for the SRO assessments;
- Development of a conceptual model linking together how potential hydrological changes could influence water quality and the sensitivity of aquatic communities to those changes;
- Further information on the design and operation of the options;
- Under Concept Design Options 2 and 3, there is potential to incorporate ecological/hydromorphological mitigation/enhancements through creation of more ‘natural’ and channel cross-sectional profiles1 as part of the open water transfer scheme. This should be explored at Gate 2 and beyond;
- Assessment of the combined potential WFD effects/risks of inter-reliant multiple options (where SLR is reliant on other SROs being delivered);
- Update to Level 2 WFD assessments to incorporate additional information; and
- Outlining further work or modelling required to demonstrate compliance into Gate 3.

The output of the Level 2 findings found, that subject to their progression through the approvals process, further WFD assessment would be required for all options, to improve the certainty of the levels of WFD risk outlined in the Gate 1 WFD Level 2 assessments

3.3 Strategic Environmental Assessment

The SEA report presents the findings of a SEA applied to the three SLR options.

Based on the SEA outputs for residual effects (post mitigation), the three options are predicted to result in similar effects across all the SEA objectives.

A summary table is provided below:

Table 3.1: Summary of the Potential Benefits and Adverse Effects of the Scheme

Topic	Benefits	Adverse effects
Biodiversity, flora and fauna	The reservoir does have the potential to create new habitat, with floating wetlands/ islands and planting considered within the wider benefits of the study and all options have an opportunity to protect and enhance biodiversity during operation. Negative residual effects identified due to a number of internationally protected sites having pathways to the reservoir.	All options are located within 200m of designated sites. There are a number of N2K and internationally protected sites that have potential pathways to the reservoir that could result in negative impacts. These are The Wash and North Norfolk Coast SAC, The Wash Ramsar, The Wash SPA, Humber Estuary SAC ,The Humber Estuary SAC and the Humber Estuary Ramsar. There is BAP and priority habitat within the footprint of the reservoir which will be permanently lost.

Topic	Benefits	Adverse effects
Soil	No benefits identified.	All options intersect Grade 1 – 3 land. SLR 3 will result in the permanent loss of agricultural land. Land could be reinstated where pipelines are buried. All options would be located within 500m of historic landfills.
Water	All options deliver reliable and resilient water supplies.	The majority of the routes for all options is located within Flood Zone 2 and 3. The abstraction and release has the potential to have an effect on water levels, flows and quality during the operational phase.
Air	No benefits identified.	All options are likely to generate short-term vehicle emissions and dust from construction activities.
Climatic factors	All options reduce vulnerability to climate change risks and hazards. All options have the opportunity to utilise greener and/or renewable energy.	All options will have negative carbon impacts due to construction and operation of the reservoir.
Landscape	Positive effects have been identified given the new reservoir providing a new valued landscape that is used by people. Measures such as planting on embankments, floating wetlands/ islands, embankment structuring/ landscape contouring and building a visitor centre, public art space and creation of footpaths, cycle routes, nature trails and bridleways have all been considered within the wider benefits piece.	All options fall within national landscape character areas and there will be minor negative effects during the construction phase on these areas.
Historic environment	No benefits identified.	There are several listed buildings and several scheduled monuments within the area. There is potential for the setting of these historic assets to be affected during the construction phase. There is a potential for unknown archaeology to be discovered during excavation of the reservoir.
Population and human health	No benefits identified.	All options intersect a number of community facilities and are located within 500m of other community facilities.
Material assets	No benefits identified.	All options intersect minor roads.

4 Invasive Non-Native Species Risk Assessment

4.1 Introduction

Mott MacDonald Ltd (MM) were commissioned by Anglian Water Services Ltd (AWS) and Affinity Water (AFW) to undertake an invasive non-native species (INNS) risk assessment in support of the proposed South Lincolnshire Reservoir (SLR). For the purpose of this risk assessment, Several potential sources were considered including the Rivers Nene, Welland, Witham, Trent, and the South Forty Foot Drain (the SFFD). This Chapter provides a summary of this assessment, the full assessment is provided in Appendix A of this report.

4.2 Results and Mitigations

A desk study highlighted the presence of 26 INNS within the WFD Operational catchments of potential SLR sources, including three flowering plants, six fish, as well as 17 distinct invertebrate taxa. This was supplemented with field surveys, which found 16 INNS including 10 invertebrate taxa and five plant species, as well as crayfish plague, *Aphanomyces astaci.* The potentially high impact species quagga mussel *Dreissena bugensis*, signal crayfish *Pacifastacus leniusculus*, and Chinese mitten crab *Eriocheir sinensis*, were targeted by environmental DNA sampling but not detected in any waterbody.

Screening against Environment Agency (EA) guidance (Managing risk of spread of Invasive Non Natives Species through water transfers, 2017 and Invasive Non-Native Species Isolated Catchment Mapping, 2018) highlighted that all waterbodies are connected to Canal and River Trust (CRT) navigable canals. This necessitates a risk assessment, which the EA will use to decide whether subsequent mitigation is required.

All potential SLR sources contain species listed under key legislation aiming to reduce the spread of INNS. No risk of re-classification of High Status Water Framework Directive (WFD) waterbodies was highlighted.

All potential SLR sources were assessed to have a moderate ‘Freshwater Invasion Risk’ based on cross-referencing with heatmaps which predict the invasion of Ponto-Caspian species.

The River Nene and River Welland estuaries were assessed to have a moderate ‘Marine Invasion Risk’, based on previous work assessing marine pathway intensity. The River Witham and SFFD were precautionarily judged to have a high Marine Invasion Risk due to the connection via the Fossdyke Canal to the tidal reaches of the River Trent and Humber estuary.

Fourteen SLR abstraction scenarios were risk assessed using a tool produced by Northumbrian Water Group to appraise raw water transfers. These scenarios included abstraction from the Rivers Nene, Welland, SFFD, and Witham, as well as additional water transfer from the River Trent. Transfer from the River Trent was assessed using either the current Trent-to-Witham Abstraction Scheme (TWAS), a new open channel, or a new underground pipeline. Each abstraction option was assessed under scenarios involving transfer to the SLR by either a new open water transfer, or new underground pipeline.

The risk assessment tool ranked these scenarios from lowest to highest risk. Source waterbodies were in the following order: SFFD, River Witham, River Welland, River Nene, and River Trent. Transfer of water from the Trent was therefore highlighted as a priority for mitigation.

The risk assessment tool was also used to provisionally explore which mitigation measures might be most effective. This exercise indicated that individual measures would be limited in their capacity to reduce risk, as they would not be effective for all INNS life stages. If full water treatment is not feasible then combinations of measures may be required to adequately reduce INNS risk.

4.3 Conclusions and Recommendations

Key design and operational risks highlighted included the nature of the transfer to the SLR (e.g. open channel or pipeline), and recreation along the transfer or in the reservoir. In the case of an open channel, or recreational use within the transfer or reservoir, effective mitigation would need to be applied to reduce the risk of INNS spread.

On 15 December 2020 an INNS workshop was held, including attendees from AECOM (in relation to the potential to draw water from the River Trent), Affinity Water, Anglian Water, the Environment Agency, the Lincolnshire Wildlife Trust, Natural England, and Mott MacDonald.

Key outputs included an aspiration for national alignment of SRO INNS risk assessment methodologies, an emphasis on developing the pathway-propagule risk assessment model, and that INNS do not represent a 'showstopper' at Gate 1 of the RAPID process.

It is therefore recommended that a single tool for assessing SRO INNS risk is developed nationally. This tool should then be used for Gate 2 assessment of the SLR. It is also advised that assessment of INNS risk is actively undertaken alongside development of the concept design. This should utilise GIS to ensure all relevant information and possible interactions are captured and assessed. Continued work with stakeholder and regulators will be key to achieving appropriate mitigation.

5 Natural Capital and Biodiversity Net Gain

5.1 Introduction

As part of Gate 1 environmental assessment each SRO is expected to undertake an initial assessment of any potential impacts on Natural Capital (NC) and Biodiversity resulting from the scheme. The group of water companies involved in developing SROs have been working together to increase consistency in approaches for SRO development across the country. The NC and Biodiversity Net Gain (BNG) assessment was carried out following the latest guidance from the Environment Agency, Natural England and the ACWG. Section 5.3 provides information on the datasets reviewed, Section 5.2 provides information on the assessment methodology and Section 5.3 and 5.4 respectively provide the NC and BNG assessment findings and conclusions.

5.2 Methodology

The assessment of impacts on NC and BNG has been carried out following the draft guidance from the Environment Agency: Water resources planning guideline supplementary guidance – Environment and society in decision-making (2020). This guidance has defined the minimum expectations for the assessment as part of the Gate 1 process. In addition, methodologies and best practice have been taken from:

- All Companies Working Group (ACWG) WRMP environmental assessment guidance and applicability with SROs (Mott MacDonald, 2020)
- Department for Environment, Food and Rural Affairs (DEFRA) (2020) Enabling a Natural Capital Approach;
- HM Treasury and government finance, (2018) The Green Book: appraisal and evaluation in central government;
- Natural England, (2019) The Biodiversity Metric 2.0 auditing and accounting for biodiversity; and
- Natural England, (2020), Natural Capital Indicators: for defining and measuring change in NC.

In addition, the assessment was undertaken following the following WRSE guidance documents:

- WRSE Natural Capital & Biodiversity Net Gain Method Statement (Mott MacDonald, 2020); and
- WRSE Regional Plan Environmental Assessment Methodology Guidance (Mott MacDonald, 2020).

Following this guidance, the NC stocks and BNG units within the direct footprint of the options were assessed. The potential impact of each option on each the five NC metrics as defined within the supplementary guidance (biodiversity and habitat, climate regulation, natural hazard regulation, water purification, water regulation) was reported. In addition, in line with the WRSE regional assessment three other NC metrics were considered, these were food production, air pollutant removal and recreation and amenity value.

The assessment considered the potential impact of construction and operation of each option. The NC metrics were then quantified as ecosystem services in order to provide monetised values for NC benefit of loss. The assessments were undertaken to a level considered suitable for the available information. No onsite data collection took place to inform the NC and BNG outputs.

5.2.1 Assessment Assumptions and limitations

The assessments were undertaken to the required level of detail as stated in the Environment Agency and Natural England Gate 1 Assessment Expectations and utilised the best available information.

For NC:

- The cost of the options was not considered within the assessments as it is captured elsewhere within the multi criteria assessment
- The provision of public water supply has been excluded from all assessments to avoid potential double accounting of benefits within the multi-criteria optimisation
- Natural capital stocks presumed temporarily lost are expected to be reinstated/compensated
- Mitigation of natural capital stocks has only been considered when outlined in the options description, or where standard mitigation must be applied

For BNG:

- No enhancement of biodiversity post construction was considered. BNG units were assigned to the pre-construction land use according to the habitats presented in the project boundary. The post construction land use, including agreed mitigation, was used to calculate the post construction biodiversity score
- At this stage of design development and for RAPID Gate 1, it is assumed that options will require further assessment as the design evolves. For RAPID Gate 2, this will include surveys to ground truth the BNG assessment in the form of Phase 1 habitat surveys. It is likely that these could result in a net increase/decrease in the BNG outputs. At this point, the BNG assessment can be revisited and mitigation or enhancement opportunities developed further to provide a clearer commitment to BNG.
- As this assessment was carried out using only open source data, a precautionary approach was applied, presuming that where not specifically known, habitats were assigned the maximum habitat score. This is recommended as a suitable methodology for the scale of the regional plan and will allow for the individual companies to utilise this work within their own WRMPs and supplement the open source habitat data with local datasets or Phase 1 site data to increase the accuracy of calculations for each option.

Further information can be found in the methodologies referenced in Section 5.2.

5.3 WRSE Natural Capital and Biodiversity Net Gain Findings

The findings of the NC and BNG assessment, per option, are presented below. The assessment considered the temporary land taken associated with the new pipelines and permanent land for the reservoir and associated infrastructure.

5.3.1 Summary of the Natural Capital assessment

Table 5.1 presents a summary of the area of NC stock that would likely change as a result of the construction of the options.

Table 5.1: Summary of the NC assessment: Change in area (ha) of the stock post construction

Option Name	Coastal and Floodplain Grazing Marsh	Arable	Other Semi-Natural Grassland	Broadleaved, Mixed and Yew Woodland	Modified Waters (Reservoirs)	Ponds & linear features	Reedbeds
Option 1							
Baseline	38.24	693.88	0	0	0	13.76	0
Post - construction	110.00	5.70	68.18	30.00	532.00	0	0
Change	71.76	-688.18	68.18	30.00	532.00	-13.76	0
Option 2							
Baseline	0.19	976.77	0	9.15	0.00	9.74	0
Post - construction	105.20	4.94	40.00	15.00	806.83	0	20.00
Change	105.01	-971.83	40.00	5.85	806.83	-9.74	20.00
Option 3							
Baseline	1.38	895.32	0	0.96	0	13.99	0
Post - construction	40.20	12.42	15.00	10.00	818.00	0	5.05
Change	38.82	-882.90	15.00	9.04	818.00	-13.99	5.05

5.3.2 BNG findings

Table 5.2: Summary of the outputs of the BNG metric calculations

Option Name	On-Site Baseline (habitat units)	On-Site Post Intervention (habitat units)	Total Net Unit Change (habitat units)	Total Percentage Change (%)
Option 1	2212.94	3059.81	846.87	38.27
Option 2	2400.75	4446.23	2045.48	85.20
Option 3	2185.26	4226.57	2041.31	93.41

5.3.3 Ecosystem services findings

Table 5.3: Outputs of the ecosystem services screening

Option Name	Ecosystem Service (change in value £/year)					Estimated total change in value (£ per year)
	Carbon Storage[1]	Natural Hazard Management[2]	Air Pollutant Removal[3]	Recreation and Amenity Value[4]	Food Production[5]	
Option 1	£12,082.89	Scoped Out	Scoped Out	£133,995.00	-£321,800.00	-£175,722.11
Option 2	£5,158.02	Scoped Out	Scoped Out	£140,609.00	-£414,100.00	-£268,332.98
Option 3	-£2,865.54	Scoped Out	Scoped Out	£107,298.00	£-274,100.00	-£169,667.54

Notes: 1. Baseline value provided by each stock calculated using the high short-term traded sector carbon value for policy appraisal for 2020, provided by the standard methods and the Department for Business, Energy and Industrial Strategy (BEIS) Interim Non-Traded Carbon Values which can be found in the WRSE Natural Capital & Biodiversity Net Gain Method Statement (Mott MacDonald, 2020). 2. Scoped out when the option does not cause the loss of associated stocks. 3. Scoped out when the option does not cause the loss of stocks within an AQMA. 4. Scoped out when Addthe option does not permanently impact recreational and amenity sites. 5. Scoped out when the option does not cause permanent loss of associated stock.

5.4 Conclusions

5.4.1 Natural Capital

The outputs of the methodology show that all of the all options are likely to generate a permanent change in NC stocks - broadleaved mixed woodland, arable land, and ponds are predicted to be lost. All options are however anticipated likely to generate a gain in high value NC stocks post construction. The creation of new areas of surface water, grassland and floodplain grazing marsh associated with the scheme should lead to a gain in high value natural capital.

5.4.2 Biodiversity Net Gain

Applying the BNG assessment methodology, of all options are likely to result in a gain in BNG habitat units due to the creation of habitats during construction and arable land being predominately replaced. The construction of the pipelines is expected to result in a loss of BNG units due to habitat clearance.

5.4.3 Ecosystem Services

The options predicted are likely to generate the gain of NC stocks associated with the provision of several ecosystem services. Major construction impacts include the release of CO2, loss of food production, and water purification due to habitat clearance. However, the post construction landscape design and wetland creation are likely to generate a gain in ecosystem service provision. This includes carbon sequestration as well as recreational and amenity value. The likely gain in carbon sequestration post-construction will likely act to offset part of the overall project's gross emissions, but do not contribute to the delivery of Net Zero.

All the options present potential opportunities to improve the existing habitats along the pipeline route through post construction remediation and replacement of low value habitats with those with greater value. As such the options present opportunities to provide offsetting planting of trees which will likely be permanently lost as a result of these options. Potential opportunities provided have not been factored into the NCA, BNG or ecosystem services assessment.

5.5 Comparison

When reviewing the assessments outputs of the pipelines and the proposed options, the best option for the provision of Biodiversity units and ecosystem services would be Option 3 while Option 2 rank worse for Ecosystem Services impacts and Options 1 rank the worse for Biodiversity Net Gain.

While the NC and BNG assessments undertaken provide an indication of the impact of the options, it is important to note the following limitations:

- The calculations do not consider the implementation of mitigation measures; and

As such, we recommend that further investigation into the potential BNG and NC effects should be undertaken at Gate 2 in order to assess the latest routes and that proposed mitigations and opportunities are further defined to allow consideration in the assessments.

6 Wider Benefits

6.1 Introduction

The purpose of this section is to outline the potential social benefits of the SLR scheme. This section:

- summarises the potential benefits of water resource planning;
- considers the potential benefits of the SLR reservoir for the Region;
- sets out potential mitigation measures to address areas of potential adverse impacts and enhance areas of potential positive impact; and
- considers the potential social benefits that could be delivered in local communities.

6.2 Benefits of Water Resource Planning for Customers and Communities

Water resource planning is undertaken at a regional level to manage water resources over an extended period of time(e.g. toward 2100) and to coordinate approaches between water companies. Many of the considerations that inform this process relate to delivering social benefits:

The consideration of a new reservoir has the potential to deliver a number of social benefits:

- **Supply growth**: to serve a growing population, additional properties and to meet per capita consumption (PCC) rates.
- **Supply management:** to manage seasonal fluctuations in order to provide water to homes, industry and farming as winter storage for irrigation.
- **Recreation:** water stored in a reservoir can facilitate water-oriented activities (i.e. boating and fishing), while the wider reservoir site, largely due to its proximity to water, can provide an attractive place to undertake recreational activities such as walking and cycling.
- **Environment:** meeting the objectives of the national environmental improvement programme (WINEP), which will also deliver landscape, habitat and recreational benefits for people to enjoy.
- **Resilience:** identifying drought scenarios and the required resilience to withstand future drought conditions, to enable provision of a secure water supply to people's homes.

A WRSE research project on 'Customer Preferences to Inform Long-term Water Resource Planning'[1] identifies customer preferences and priorities to support water resource and resilience planning. The research involved nearly 100 customers from different water company areas in the south east. Findings from this study include:

- Customers want companies to develop resilient plans for future water supplies and these should avoid damage to the environment and the need for severe water use restrictions.
- There is a high level of support for a collaborative approach to long-term planning for water resources and resilience to drought and unexpected events. Customers have a good and increasing awareness of climate and population pressures and are reassured that companies are planning for future risks.
- Customers have little patience for companies competing with each other for water resources that are felt to belong to everyone. It is important to customers that their voices are heard on

[1] Water Resources South East (2021) Customer Preferences to Inform Long-term Water Resource Planning. Part B Deliberative Research'. [Only published in draft as at Feb 21 – reference to be updated when final version published]

water resource and resilience issues that are fundamental to the long-term security of their water supply.

- Customer also support the sharing of resources, but more detail needs to be provided on the strategic context (availability of water by location) as well as local level impacts to help customers decide whether specific strategic resource options are the right choice for them.

6.3 Benefits of SLR for the Region

Winter storage reservoirs, such as SLR, are designed to balance the supply and demand of water over large areas. The ability of a reservoir to store water means that seasonal fluctuations can be managed to ensure a reliable supply of water in months when resources are more limited. This ensures a more constant and reliable supply to meet the region's growing demand.

Anglian Water covers the largest geographic area for a water company in England and Wales, serving over 6 million customers in the east of England and Hartlepool, which is projected to grow. The provision of a secure water supply to this region will assist in the delivery of other developments, required to realise these growth aspirations, such as the provision of affordable housing and other key infrastructure. The security of water supply is also likely to have a positive impact on local business water users; reducing the risk that poor water availability poses to business growth and agricultural production.

Avoiding placing additional pressure on local water sources will also benefit the region. The east of England relies on both groundwater and river sources for its water. Increasing pressure on these sources can lead to environmental damage. As well as affecting natural ecosystems, this can also impact the livelihoods of those who depend on these natural resources being available and the recreation and amenity benefits by the local community.

6.4 Mitigating adverse impacts and enhancing positive social impacts of SLR

The design of the SLR water storage reservoir site options have been developed with the aim of avoiding impacts on people. Considerations include:

- avoiding sites through existing residential developments;
- avoiding community facilities where possible; and
- not prejudicing plans for future residential and commercial development.

The Strategic Environmental Assessment (SEA) includes consideration of social effects, principally through the following SEA objectives:

- Maintain and enhance the health and wellbeing of the local community, including economic and social wellbeing; and
- Maintain and enhance tourism and recreation.

The SEA objectives are applied to the SLR water storage reservoir site options. The impacts during construction and operation, following mitigation, for each site options are outlined below.

6.4.1 Maintain and enhance the health and wellbeing of the local community, including economic and social wellbeing

6.4.1.1 Construction

Across all three site options a minor and temporary positive effect on the health of local communities through employment opportunities for people in the local area during construction. The surface water and bathing water quality will also be maintained within statutory limits bringing minor and temporary positive effect across all three site options.

SLR Option 1 is within 500m of play spaces, registered common land, religious buildings and religious grounds but does not directly impact any of these. SLR Option 1 is likely to have a minor and temporary negative effect on human health from changes to environmental conditions such as noise and air quality. There may need to be compensatory measures and/or realignment of the reservoir boundary where commercial and other properties are affected but potential for minor negative effects to remain.

SLR Option 2 is within 500m of several play spaces, an allotment, registered common land, schools, religious buildings and religious grounds but does not directly impact any of these. SLR Option 3 is within 500m of golf courses, greenspace, registered common land and religious buildings but does not directly impact any of these.

6.4.1.2 Operation

As reported in the SEA, all three options lead to major positive effects on the health of local communities and will ensure that surface water and bathing water quality is maintained within statutory limits. All three option enhance existing, recreational facilities, publicly accessible greenspace which will provide beneficial health and wellbeing outcomes for local communities.

6.4.2 Maintain and enhance tourism and recreation

6.4.2.1 Construction

As stated in the SEA, SLR Option 1 and Option 2 would result in the severance to a primary road and there may be disruption to recreation as a result of a reduction in access. SLR Option 3 is adjacent to an A Road and there are major roads within the pipeline boundaries which are directly affected. Therefore, there may also be disruption to recreation near to SLR Option 3.

Across all three sites best practice mitigation measures will be implemented to minimise effects during construction, however some disruption likely to remain during the construction phase. All options have minor and temporary negative effects and reduce the availability and quality of existing recreational facilities and/or tourism during the construction period.

6.4.2.2 Operation

For all three site options, several opportunities are presented in the Landscape Concept Design Report. These common aspirations and opportunities that are applicable to all sites are:

- **Wetland creation** – this could be an important and complementary asset to the reservoir development, promoting ecological benefits and restoring wetland landscape.
- **Floating islands ecosystems** – this could provide a measurable increase towards Biodiversity Net Gain and improved nesting opportunities for birds. The Biodiversity Net Gain components are covered further in Chapter 5 of this report.
- **Enhanced access and connectivity** – the provision of footpaths, cycle paths and nature trails to both wetlands and the wider reservoir development could provide positive opportunities for the local community and other visitors. Where possible footpaths, cycle paths and nature trails could connect to and extend the existing Public Right of Way (PRoW) network.
- **Species rich meadow creation and woodland enhancement** – on the banks of the open reservoir a variety of wildflower meadows could be introduced as well as woodland enhancement through the introduction of native shrubs. This could help link existing woodland links and enhance natural wildlife corridors of the landscape.
- **Visitor Centre/Outdoor Recreation Hub** – a multi-use venue could both serve on-site recreational activities, school visits, corporate workshops and serve as a community hub.

These proposals could help provide a new revenue stream to the local economy and opportunities for the Lincolnshire region as a whole.

As a result of these enhancements, during operation there are anticipated major beneficial impacts for local communities (as reported within the SEA).

The potential recreational benefit has been further assessed utilising the Outdoor recreational Valuation (ORVal) User Guide[2] to ascertain the likely number of visits per year. These are provided below:

- Option 1 – 29,079
- Option 2 – 26,079
- Option 3 – 30,081

For each of the options, the method of transport to each of the options has also been assessed using ORVal. The majority of trips to all three of the sites will be by car. It is predicted that travellers will travel more not by car to Option 2 and Option 3, compared to Option 1, due to connectivity to existing walking and cycling routes.

It is recommended that the recreational benefits are further assessed at the next stage of the assessment to understand in greater detail how the local population may benefit from the proposed enhancements.

6.5 Benefits of SLR for Local Communities

Anglian Water emphasises the need to provide greater public value in its activities and were the first water company to embed public interest and social value in its company constitution. The company's 'Articles of Association' set out the 'Purpose' as delivering long-term value for the regions and communities it serves and seeking positive outcomes for society and the environment.

Affinity Water have also set out new principles and goals in the last five years, reorientating the company towards more social and community responsibility outcomes. The company has also set out their goal to become the 'leading community focused water company' in England.[3]

These are aligned to prevailing trends in the wider water industry, where it is recognised that publicly-stated commitments to contribute positively to society and the environment, can enable companies to increase customer trust and improve reputations for responsible and socially aware business. A trusted relationship between water companies and the communities they serve is required to ensure that the companies properly take responsibility for the wider impact their operations have on the environment, their employees, and society as a whole, and consequently the extent to which those operations deliver public value.

As part of these goals, Anglian Water has also developed an explicit commitment to a 'two-way social contract' with their customers to protect the environment and deliver social prosperity to the region. As shown in Figure 6.1 below, the contract is framed around ten customer outcomes, split into three overarching themes covering business, communities and the environment.

[2] Land, Environment, Economics and Policy (LEEP) Institute (2018) 'Outdoor Recreation Valuation (ORVal) User Guide' Available at - Outdoor Recreation Valuation (ORVal) User Guide (exeter.ac.uk)

[3] Affinity Water (2021), 'Corporate Responsibility'. Available at: https://www.affinitywater.co.uk/corporate/about/responsibility#:~:text=Our%20Corporate%20Social%20Responsibility%20('CSR,STEM')%20education%20and%20future%20skills

Figure 6.1: Anglian Water's 10 customer outcomes

Source: Anglian Water, 2021

Affinity Water aim to achieve their social responsibility goals through their Corporate Social Responsibility Programme. The Programme has three main strands- protecting local rivers and habitats; developing community partnerships; and investing in STEM education.[4]

Potential programmes and initiatives that could be implemented as part of the SLR scheme to deliver public value. For example:

- Anglian Water and Affinity Water both encourage employees to undertake volunteering in local communities, such as through Anglians initiative 'RiverCare and BeachCare'; and Affinity Waters 'Affinity Days'.
- Anglian Water has a community education team who provide free lessons for students either digitally or via school visits. They also have a purpose-built education centre at Chelmsford water recycling site.
- Affinity Water monitors the health of local rivers through their National Environmental Programme; and has implemented a customer focused water saving programme[5]

More widely, socio-economic benefits could accrue through:

- Job and training opportunities, particularly in the construction sector. This will occur primarily during the construction period through supply chain benefits generated by the SLR scheme, together with the spend by construction workers and contractors in local communities.
- Cascading benefits through procurement, by requiring companies in the supply chain to demonstrate how they will provide social value to local communities in executing construction works or operation and maintenance contracts.

[4] Affinity Water (2021), 'Corporate Responsibility'. Available at: https://www.affinitywater.co.uk/corporate/about/responsibility#:~:text=Our%20Corporate%20Social%20Responsibility%20('CSR,STEM')%20education%20and%20future%20skills

[5] Affinity Water (2021), 'Corporate Responsibility'. Available at: https://www.affinitywater.co.uk/corporate/about/responsibility#:~:text=Our%20Corporate%20Social%20Responsibility%20('CSR,STEM')%20education%20and%20future%20skills

7 Assessment of Opportunities for Net-Zero Carbon Contributions

7.1 Introduction

This Section reviews and summarises options for integrating the SLR scheme with Anglian Water's and Affinity Water's net zero carbon ambition.

In 2020 Water UK released its net zero routemap, which laid out a range of decarbonisation options and pathways the sector could look to adopt to move towards net zero emissions. English water companies have made several Public Interest Commitments[6] (PICs) to demonstrate the broad value they deliver to society. One of these PICs included a commitment to be a net zero operational carbon sector by 2030. Individual companies are preparing their own net zero plans to be ready by July 2021[7].

The sector Net Zero commitment does not include capital carbon or user carbon emissions and a such capital carbon will be addressed separately by the companies and Water UK. The scope boundary of the net zero sector level PIC, and that covered in the net zero routemap, is the same as the mandatory scope used in the UKWIR Carbon Accounting Workbook (CAW), which covers:

- Scope 1: Emissions from burning of fossil fuels, process and fugitive emissions (e.g. Nitrous oxide and methane from wastewater/sludge treatment and emissions from owned or leased vehicles)
- Scope 2: Purchased electricity
- Some scope 3 emissions, e.g. business travel, outsourced activities and T&D losses
- Net emissions taking into account export of surplus renewable generation and purchase of REGO backed green tariff electricity

The scope above covers the minimum scope of the PIC and individual companies have the discretion to broaden their boundary to include further scopes of emissions.

The SLR has not set its own Net Zero target at this stage, as such no definitive Net Zero boundary for individual schemes is set. Our assessment for gate 1 has, however, sought to consider both operational and capital carbon emissions, as appropriate to the stage of design, and we will continue to develop our approach in line with relevant guidance, sector, AWS and Affinity Net Zero approaches in the Gate 2 assessment. .

7.1.1 Net Zero ambition – what does it mean and how efficiently can it be achieved?

Net Zero reflects an ambition for an operating environment where the water sector will have no overall impact on the atmosphere from its carbon emissions within the sector's Net Zero boundary by 2030. This means that emissions will be reduced as far as possible and any residual emissions will be counterbalanced by an equivalent sequestration of carbon from the atmosphere.

The water sector has not yet clearly defined how the sector's net zero ambition will apply equally at programme, project, or company level. Whilst delivering net zero is an important

[6] Public Interest Commitment | Water UK

[7] Link to Net Zero 2030 - Strategies for Success (britishwater.co.uk)

commitment made by the sector, there is also the ongoing duty to deliver this transition cost-effectively to maintain efficient and affordable services for customers.

Companies may choose to set net zero targets across their overall operations, their investment plans or individual schemes. The net zero target is currently at sector-level and once the water company net zero plans are finalised, the sector will have a better understanding on whether individual projects, programmes of work or entire company operations are the right level to set a net zero target. The main consideration for net zero is for the sector to take a view on what is the most cost-effective way to reach net zero. For example, it may not be most economical for an individual project to have a net zero target if there are other assets in a company's region that present greater opportunities to be net zero or carbon negative (e.g. a wastewater asset managing bioresources differently could contribute to a company's net zero target more efficiently than purchasing market offsets for a project whose own carbon reductions can only reach 80%). Cost-effectiveness is an important factor for a water company and the water sector to consider when developing their net zero plans.

It is important to note that capital carbon is not currently in the sector's net zero boundary and that individual companies may set a separate capital carbon reduction target or include it in their own net zero company boundary.

7.1.2 What is a net zero scheme?

If a net zero target is applied at project/scheme level, then a net zero scheme can be defined as a scheme where all greenhouse gas (GHG) emissions emitted during its construction and operation are balanced by an equivalent level of emissions being offset or removed from the atmosphere.

Therefore, it is possible for schemes to achieve net zero without focussing on reducing emissions from their activities and purely focussing on offsets instead. However, the water sector net zero target follows a decarbonisation hierarchy that is based on good international practice – emissions must be reduced as much as possible first before any sequestration options are considered. The water sector routemap provides further details on the decarbonisation hierarchy (this is also presented in Figure 7.1). An important point to note for sequestration options is that companies will have to assess what opportunities for natural sequestration exist in their own landholdings before considering purchasing offsets in the international carbon markets.

All schemes will need to reduce their carbon emissions as much as possible to minimise the required level of offsets. This is because there are not enough offsets available to cover the current level of global emissions and so it is expected that there will be significant competition for available offsets going forward and likely significant costs. Therefore, reducing emissions on the scheme will also reduce residual emissions offsetting costs if market-based options are considered.

7.1.3 Delivering net zero efficiently at scheme level

Companies will need to consider the overall impact of new strategic schemes, such as the SLR, and incorporate this into the broader company plans to deliver net zero. This will help companies, and the sector, make the best strategic decisions in relation to infrastructure requirements and identify the most efficient way to deliver net zero as a company/sector.

Section 7.3 sets out some of the options for consideration during development of the SLR scheme to decarbonise and drive towards net zero.

7.2 Methodology

The decarbonisation options take into account the minimum scope of the net zero PIC but also align to the carbon consideration requirements under EA Water Resource Planning guidelines, as of February 2021. The latest guidance[8] states the WRMPs:

- should assess the carbon cost of both the construction and operation of your options, along with the impact of land use change on carbon sequestration
- take into account any mitigation. For example using renewable energy or carbon off-setting. Carbon off-setting can contribute to wider environmental benefits such as tree planting or upland and peatland restoration, if there is no alternative to reducing emissions.
- use the carbon costs as per government guidance and present these costs together with your options cost. You should also present the tonnes of carbon you will emit from the construction and operation of your preferred options.

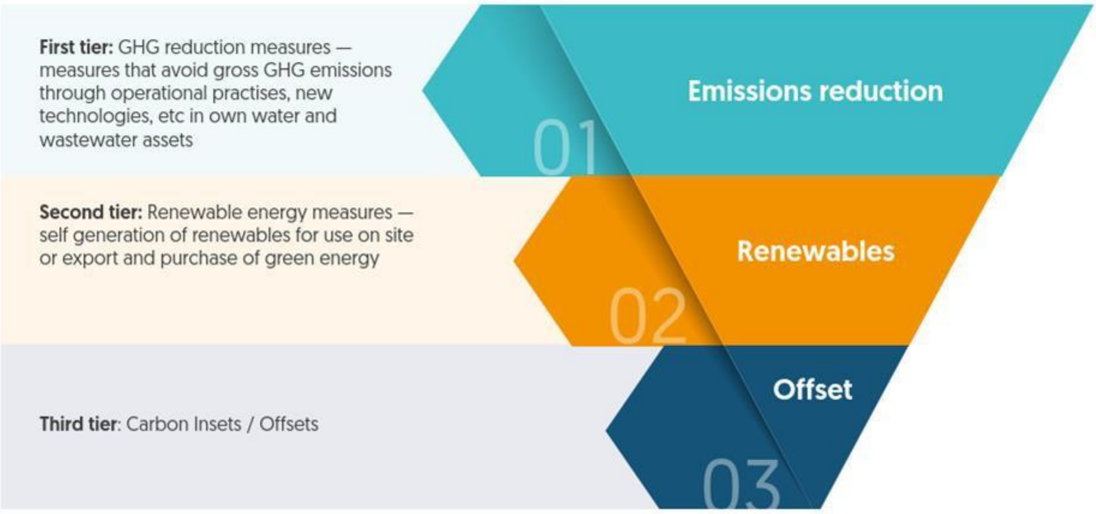
User carbon emissions (i.e. the emissions associated with the heating of water in the home) are not considered in this assessment.

7.2.1 Net zero considerations

The considerations made take on the principles of the emissions reduction hierarchy (Figure 7.1), whereby efforts to reasonably reduce emissions are prioritised, followed by looking at opportunities for renewable generation, and finally considering opportunities to offset residual emissions.

Considerations for reducing embedded carbon in the SLR options are included, however it will be down to the water company to decide whether capital carbon emissions will be part of the company's or the scheme's net zero consideration.

Figure 7.1: Emissions reduction hierarchy

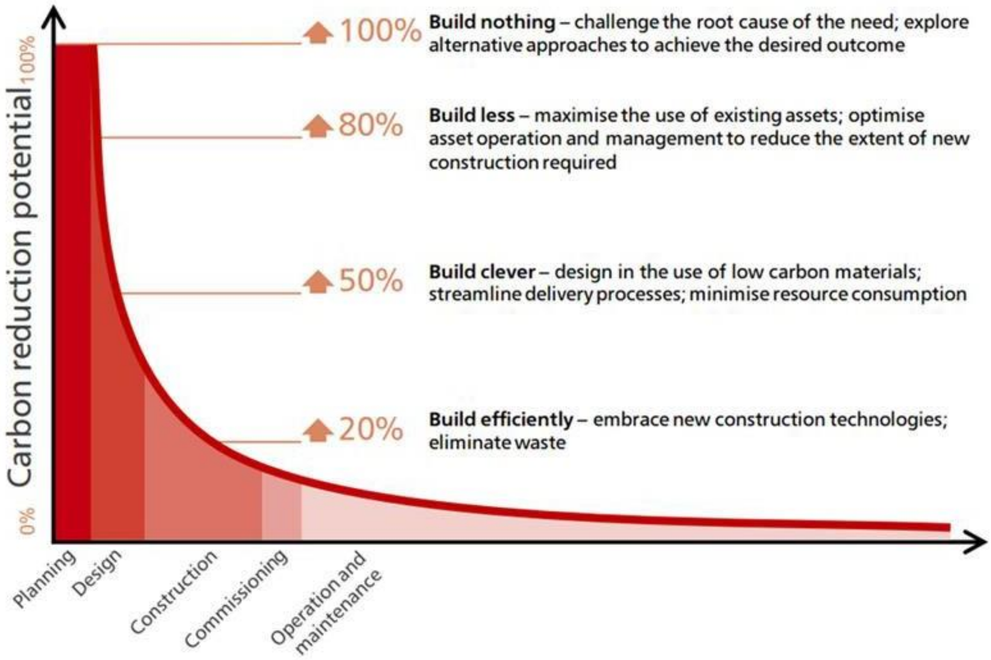


Source: Water UK Net zero 2030 routemap (Figure 4.1).

The carbon reduction hierarchy sets out emissions reduction opportunities during a project lifecycle into four categories, summarised in Figure 7.2.

[8] Water resources planning guideline - GOV.UK (www.gov.uk)

Figure 7.2: Carbon reduction hierarchy



Source: Infrastructure Carbon Review, 2013

The build nothing option is not considered as the options appraisal approach for the individual company WRMPs and the WRE regional plan will determine the most balanced plan and which combination of supply and demand side schemes to implement.

The remaining considerations thus focus on the build clever and build efficiently options for the SLR options.

7.3 Baseline carbon emissions hotspots and mitigation opportunities

A key part of delivering an efficient net zero strategy is to focus efforts on where the largest and most efficient reductions can be made. As a starting point it would be important to develop an understanding of the major carbon contributors from a capital and operational perspective for the scheme to help focus efforts on areas with the greatest reduction potential.

It is recommended that as the design progresses a more granular baseline is analysed to provide a more detailed understanding of specific carbon emission sources for the scheme. Plans are already in place through the WRE regional plan to develop a consistent carbon assessment approach. This regional plan level carbon assessment alongside individual company WRMP24 option carbon assessments will help inform future more detailed carbon assessments for the RAPID gate process. The assessment of capital carbon by scheme element has been reviewed in the following sections and used to highlight likely carbon hotspots associated with these and the opportunities to mitigate them.

7.3.1 Capital carbon (see Figure 7.3)

Figure 7.3: Capital costs breakdown by scheme element

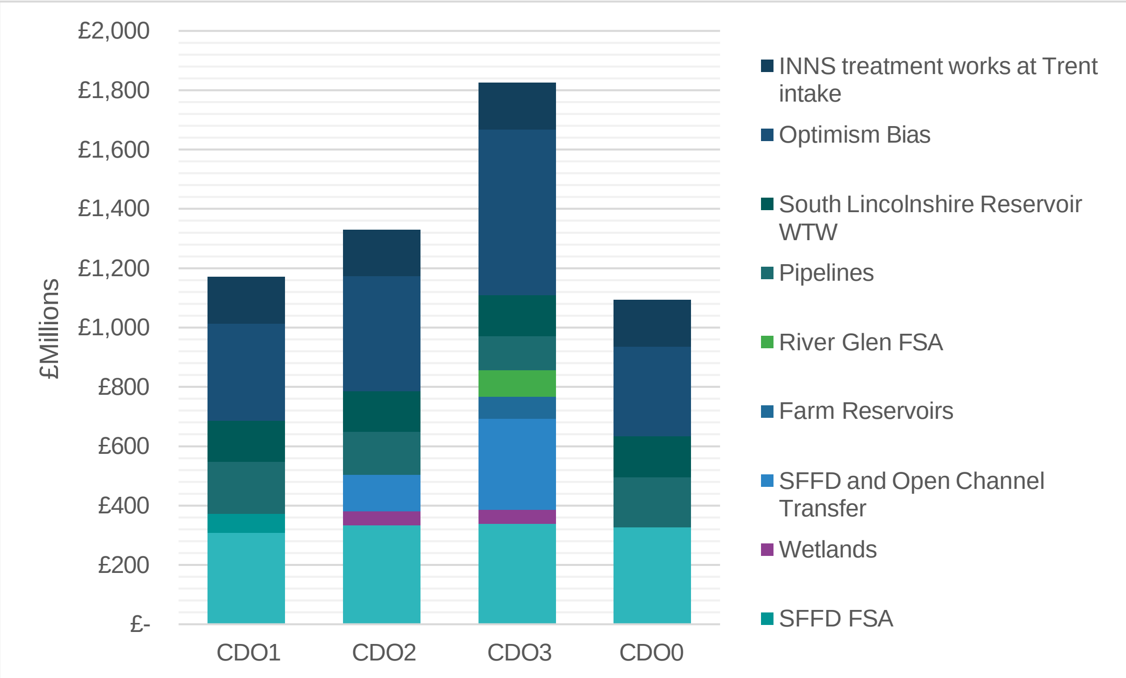


Figure 7.3 highlights the major areas of hotspots within the SLR concept designs. All four concept designs how the PWS reservoirs, pipelines and Flood Storage Areas (FSA) as key capital carbon hotspots areas. The construction of these is dominated by earthworks activities and associated fuel consumption. An overview of opportunities to mitigate these capital carbon hotspot areas is outlined below.

Efficient construction approaches and waste minimisation

Significant emissions and costs on construction projects can result from the importation of additional engineering fill; the transport and double handling of excavated or imported engineering materials; and the generation of waste and the requirement to dispose of it. This is particularly relevant to the SLR, where a large quantity of earthworks is required to construct the reservoir embankments and the open water channels, as well as other associated infrastructure. Minimising the quantity of imported engineering fill for such earthworks by maximising the use of on-site or excavated material can help to reduce carbon emissions associated with disposal and transport. Where importation is necessary, minimising transportation distances can also help to reduce the associated carbon emissions.

Specifying construction techniques, such as modular and off-site manufacture can help reduce the amount of waste associated with construction projects and hence reduce carbon emissions, whilst at the same time improving health and safety and overall operational performance of assets.

Understanding the type, quantity and quality of waste likely to be produced can help identify opportunities to re-use waste either within the project site boundary or locally rather than requiring it to be transported larger distances. Having a robust waste management plan and engaging other potential users of surplus excavations can help reduce emissions associated with waste disposal.

Low carbon construction plant

The SLR scheme will require significant construction plant effort associated with excavation, reinstatement, and disposal of surplus material. These are typically diesel powered and therefore can generate significant carbon emissions. The scheme could consider alternative low or zero carbon construction plant relying on alternatives to diesel fuel, this could include plant powered by:

- Biomethane;
- Hydrogen; or
- Electric.

There are likely to be significant barriers to adopting these technologies immediately due to their relative low penetration into Heavy Goods Vehicle (HGV) fleets. However, as other sectors decarbonise to help support national decarbonisation activities, more opportunities to adopt these lower carbon vehicles as part of projects will develop over time. The project team should look to identify what options there are for low carbon vehicles for spoil removal activities and engage appropriate suppliers who may be able to supply these services to better understand how feasible this would be.

Materials (reinforced concrete, pipelines):

Additional to the earthworks there is still significant amount of embodied carbon in the reinforced concrete for different elements of the scheme and also the material for the pipelines for the transfer. Overall, specifying the lowest carbon materials and working with the supply chain to reduce the embodied carbon of the materials they supply will be significant opportunities to reduce the carbon impact of each of the concept designs.

7.3.2 Operational carbon (see Table 7.1)

Table 7.1: Overall estimate of average annual operational carbon for each concept design

Concept Design	Breakdown	Operational Costs for 1 Year (k£/year Assuming running at full capacity)	Comments
CDO1	Reservoir Pumping Stations	£44,165	Power consumption only
	SFFD to SLR 1	£530,343	Power consumption only
	River Witham to SLR 1	£2,121,372	Power consumption only
	SLR1 to AWSR	£2,121,372	Power consumption only
	River Trent to River Witham	£1,697,098	Power consumption only
	SLR WTW	£2,454,021	Chemicals + power consumption
	INNS WTW	£2,435,587	Chemicals + power consumption
	Total	**£11,403,958**	
CDO2	Reservoir Pumping Stations	£688,974	Power consumption only
	SFFD to SLR 2	£1,697,098	Power consumption only
	SLR 2 to AWSR	£1,697,098	Power consumption only

	River Trent to River Witham	£1,697,098	Power consumption only
	SLR WTW	£2,454,021	Chemicals + power consumption
	INNS WTW	£2,435,587	Chemicals + power consumption
	Total	£10,669,875	
CDO3	Reservoir Pumping Stations	£1,793,099	Power consumption only
	SFFD to SLR 3	£1,272,823	Power consumption only
	Bourne Eau	£848,549	Power consumption only
	SLR 3 to AWSR	£1,697,098	Power consumption only
	River Trent to River Witham	£1,697,098	Power consumption only
	SLR WTW	£2,454,021	Chemicals + power consumption
	INNS WTW	£2,435,587	Chemicals + power consumption
	Total	£12,198,275	
CDO0	Reservoir Pumping Stations	£842,079	Power consumption only
	SLR to AWSR	£2,121,372	Power consumption only
	River Witham to SLR	£2,121,372	Power consumption only
	River Trent to River Witham	£1,697,098	Power consumption only
	SLR WTW	£2,454,021	Chemicals + power consumption
	INNS WTW	£2,435,587	Chemicals + power consumption
	Total	£11,671,529.57	

Table 7.1 highlights that power consumption is the major operational carbon source for the SLR, driven by the requirement to pump water into the reservoir and to other scheme elements. Opportunities to mitigate the carbon intensity of this hotspot are summarised below:

Power consumption: The major carbon impact on the operational carbon is from power consumption. In particular, the power intensity of the pumping requirements and the treatment processes is a significant source of carbon emissions. There are several factors to consider when considering the carbon impact of power and how to mitigate these emissions, these include:

- **Opportunities for renewable generation:** To mitigate the impact of the significant power consumption, the scheme could look to generate all or a proportion of the power demand through renewables onsite. Alternatively, the scheme could look for commercial arrangements to procure green power through a direct wire Power Purchase Agreement.

This would reduce the carbon impact of the associated power consumption with the site from the grid average value to zero.

The three concept design options for SLR provide limited opportunities for energy recovery on a scale which compares to their overall power requirements. However, the initial WTW and pumping station sites are in rural and open areas and therefore could provide scope for wind generation.

There is also an opportunity to install solar panels floating on the water surface of the PWS reservoir or on land around the reservoir. In case of CD01, since it includes the construction of a second reservoir for flood storage connected by a pipeline to the PWS reservoir, there is also the opportunity to install a pumped-storage hydroelectric system to allow for energy storage of the excess electricity from the solar arrays when the FSA is not providing a flood protection function.

These opportunities have not been costed or had their benefit assessed at Gate 1 but could be considered and developed at later project stages.

- **Procurement of green tariff electricity:** A more immediate decision could be made to procure all power associated with the site through Renewable Energy Guarantees of Origin (REGO) backed green energy tariffs. This would reduce the generation impact of grid power from the grid average to zero but would still incur the associated transmission and distribution losses associated with grid supply. There are currently plenty of green tariffs available on the market and the price premium for these is currently relatively small, however, this may change over time as the competition for REGO backed green electricity increases.

Additionally, consideration of grid carbon intensity at the point the scheme is due to come on-line should also be considered. The recent trend of UK grid carbon intensity shows significant reduction in the carbon intensity of power generation. The Business, Energy and Industrial Strategy (BEIS) grid carbon intensity forecasts[9] show an expectation for the UK grid to continue to significantly decarbonise over the coming years (up to 70% by 2030). This will reduce the carbon impact of the power demand associated with the treatment plant and also potential carbon/cost benefit assessments associated with renewable generation schemes. However, self-generation schemes can support this national decarbonisation and also potentially boost the resilience of schemes.

7.4 Residual emissions

Most infrastructure construction projects will not be able to reduce emissions to absolute zero through decarbonisation activities alone, particularly when considering capital carbon and other indirect emissions produced along the delivering company's value chain, which rely on other sectors to decarbonise. Therefore, it is likely that even after reducing emissions as much as possible within the scheme there will be residual emissions that could be offset. Possibilities to offset emissions could come from:

Natural sequestration improvements

The scheme could look to offset emissions as part of an individual scheme through investments in improving natural sequestration around the scheme. This could include tree planting or promoting alternative land use around the reservoir sites and pipeline routes. Consideration would need to be given to land availability around the selected reservoir sites, treatment sites, and the pipeline route, including and potential requirements for providing ongoing access for maintenance. It is also important to consider the significant non-carbon associated benefits

[9] Table 1 (https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/793632/data-tables-1-19.xlsx)

associated with nature-based options, such as BNG and plan land-use around the scheme to maximise overall benefits rather than just focus on carbon benefits.

The greatest benefits from natural sequestration schemes are likely to come from large regional or national improvement schemes that have been planned and developed to maximise co-benefits and are at a sufficient scale to sequester significant emissions. Therefore, it is recommended if the scheme were considering natural sequestration improvements these are planned through a multi-stakeholder approach at a regional level. To this end WRE is developing a Systematic Conservation Planning approach as part of their natural capital plan in order to consider the possibilities for carbon sequestration.

Export of renewable energy

The other opportunity to offset emissions from the scheme is to export excess renewable energy to other end-users. This requires surplus energy to be generated by the scheme and given the relatively high-power demand of the transfer options this is unlikely to be possible for the SLR options. Opportunities to generate renewable power in and around the scheme are to be explored further as the design develops.

7.5 Recommendations and Next Steps

An important part of turning some of the above considerations into deliverable opportunities is to have a robust carbon management process embedded into the scheme development. This includes understanding scheme carbon emissions sources, challenging these through value engineering sessions and engaging into the broader supply chain to identify and implement lower carbon opportunities/technologies.

The key recommendations for next steps are:

1. The capital and whole life carbon baseline should be interrogated for asset and material level hotspots for the scheme to inform focus areas for decarbonisation activities.
2. A low carbon workshop be held to review the hotspots and prioritise the low carbon opportunities that need to be investigated further. This should include specific actions on who will be responsible for driving these emissions reductions activities and when they need to be undertaken in the design process.
3. Design principles be developed incorporating some key activities and requirements to help decarbonise the scheme, this should include requirements to engage the broader supply chain and incorporate carbon into procurement and material specification criteria.
4. A clear carbon management process be embedded into the option development process to identify low carbon opportunities and track them through to implementation.

8 Summary Conclusions

The assessments undertaken and described above have identified a number of opportunities that could be realised through the scheme, with particular items including:

- Opportunities for compensatory habitat creation or habitat reinstatement which should be explored, as well as opportunities to improve the existing habitats and plant additional trees; and
- Opportunities for reinstating land to achieve potential positive community effects which should also be explored for example by improving access to recreational and open space and improving access to community resources.

The assessments have also identified several next steps that should be undertaken:

- HRA Stage 2 Appropriate assessments required for all options;
- Updates to the Level 2 WFD assessments to incorporate additional information, as well as further work and modelling to be developed in consultation with the Environment Agency;
- To align with the process with the SEA Objectives within WRE's Integrated Environmental Assessment as well as any new information gathered at Gate 2;
- The INNS risk associated with SLR transfers should be reviewed when further design information is available. Surveys should be undertaken and analysed in summer 2022;
- Further investigation into the potential BNG and NC effects in order to assess the developed options so that proposed mitigation and opportunities are further defined to allow consideration in the assessments;
- Interrogation of the capital and whole life carbon baseline with design principles developed to help decarbonise the scheme, with a clear carbon management process set up; and
- Identification of any opportunities for social benefits for all options with investigations undertaken during subsequent project stages.

A. Invasive Non-Native Species Risk Assessment

South Lincolnshire Reservoir

Invasive Non-Native Species Risk Assessment

May 2021

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Invasive Non-Native Species Risk Assessment

May 2021

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Issue and Revision Record

Revision	Date	Originator	Checker	Approver	Description
1	26/02/2021	A. Anderson N. Hall	C. Figueira	D. Ocio	Draft first issue
2	17/05/2021	A. Anderson N. Hall	C. Figueira	D. Ocio	Second issue addressing EA comments

Document reference: 100410795VA04 | 01 | B

Information class: Standard

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Introduction

Mott MacDonald Ltd (MM) was commissioned by Anglian Water Services Ltd (AWS) and Affinity Water (AFW) to undertake an invasive non-native species (INNS) risk assessment in support of the proposed South Lincolnshire Reservoir (SLR). Several sources of water are being considered to supply the SLR, including the Rivers Nene, Welland, Witham, Trent, and the South Forty Foot Drain (the SFFD). This report details the risk assessment undertaken.

Results and mitigations

A desk study highlighted the presence of 26 INNS within the WFD Operational catchments of potential SLR sources, including three flowering plants, six fish, as well as 17 distinct invertebrate taxa. This was supplemented with field surveys, which found 16 INNS including 10 invertebrate taxa and five plant species, as well as crayfish plague *Aphanomyces astaci*. Quagga mussel *Dreissena bugensis*, signal crayfish, and Chinese mitten crab were not detected.

Screening against Environment Agency (EA) guidance highlighted that all waterbodies are connected either directly or indirectly to Canal and River Trust (CRT) navigable canals. This necessitates a risk assessment, which the EA will use to decide whether subsequent mitigation is required.

All potential SLR sources contain species listed under key legislation aiming to reduce the spread of INNS. No risk of re-classification of High Status Water Framework Directive (WFD) waterbodies was highlighted.

All potential SLR sources were assessed to have a moderate ‘Freshwater Invasion Risk’ based on cross-referencing with heatmaps which predicted the invasion of Ponto-Caspian species. The River Nene, River Welland estuaries were assessed to have a moderate ‘Marine Invasion Risk’, based on previous work assessing marine pathway intensity. The River Witham and SFFD were precautionarily judged to have a high Marine Invasion Risk due to the connection via the Fossdyke Canal to the tidal reaches of the River Trent and Humber estuary.

Fourteen SLR abstraction scenarios were risk assessed using a tool produced by Northumbrian Water Group to appraise raw water transfers. These scenarios included abstraction from the Rivers Nene, Welland, SFFD, and Witham, as well as additional water transfer from the River Trent. Transfer from the River Trent was assessed using either the current Trent-to-Witham Abstraction Scheme (TWAS), a new open channel, or a new underground pipeline. Each abstraction option was assessed under scenarios involving transfer to the SLR by either a new open water transfer, or new underground pipeline.

The risk assessment tool ranked these scenarios from lowest to highest risk. Source waterbodies were in the following order: SFFD, River Witham, River Welland, River Nene, and River Trent. Transfer of water from the Trent was therefore highlighted as a priority for mitigation.

The risk assessment tool was also used to provisionally explore which mitigation measures might be most effective. This exercise indicated that individual measures would be limited in their capacity to reduce risk, as they would not be effective for all INNS life stages. If full water treatment is not feasible, combinations of measures may be required to adequately reduce INNS risk.

Conclusions and recommendations

Key design and operational risks highlighted included the nature of the transfer to the SLR (e.g. open channel or pipeline), and recreation along the transfer or in the reservoir. In the case of an open channel, or recreational use within the transfer or reservoir, effective mitigation would need to be applied to reduce the risk of INNS spread.

On 15 December 2020 an INNS workshop was held, including attendees from AECOM (in relation to the potential to draw water from the River Trent), Affinity Water, Anglian Water, the Environment Agency, the Lincolnshire Wildlife Trust, Natural England, and Mott MacDonald. Key outputs included an aspiration for national alignment of SRO INNS risk assessment methodologies, an emphasis on developing the pathway-propagule risk assessment model, and that INNS do not represent a 'showstopper' at Gate 1 of the RAPID process.

It is therefore recommended that a single tool for assessing SRO INNS risk is developed nationally. This tool should then be used for Gate 2 assessment of the SLR. It is also advised that assessment of INNS risk is actively undertaken alongside development of the concept design. This should utilise GIS to ensure all relevant information and possible interactions are captured and assessed. Continued work with stakeholder and regulators will be key to achieving appropriate mitigation.

1 Introduction

1.1 Background

Mott MacDonald Ltd (MM) is supporting Anglian Water Services (AWS) and Affinity Water (AFW) in undertaking baseline studies to inform the location and design of a new winter storage reservoir in Lincolnshire, referred to as the South Lincolnshire Reservoir (SLR). The proposed scheme is one of a number of Strategic Resource Options (SROs) being considered to improve the resilience of water supplies across southern and central England by the Regulators' Alliance for Progressing Infrastructure Development (RAPID). Several sources of water are being considered to supply the SLR, including the Rivers Nene, Welland, Witham, Trent, and the South Forty Foot Drain (hereafter referred to as the SFFD).

The transfer of raw water to the new reservoir creates a risk of spreading invasive non-native species (INNS) via the transfer itself or new the reservoir, which could have significant ecological and operational impacts. Understanding the INNS risk associated with each of the proposed SLR transfer options is essential to inform the options appraisal process and the development of appropriate mitigation measures.

The RAPID schedule requires that options being considered undergo a high-level screening for INNS risk, ideally supported by a provisional assessment of INNS risk, and consideration of possible mitigation measures, by July 2021. Mott MacDonald has been commissioned by AWS to undertake this assessment. This report details the assessment and supporting work which has been undertaken.

1.2 Scope of Report

1.2.1 Aims and Objectives

The overall aims of this study were to undertake a high-level screening and initial assessment of INNS risk for the SLR raw water transfer options being considered, and to develop a provisional understanding of potential mitigation measures. These aims were underpinned by the following objectives:

1. To review potential SLR options against relevant Environment Agency (EA) guidance.
2. To determine whether potential SLR options are located within areas of high risk of INNS invasion.
3. To identify INNS within an appropriate study area to understand current INNS distribution.
4. To undertake a high-level screening of potential SLR options against key legislation.
5. To use an INNS risk assessment tool to assess risk for potential SLR options based on the concept design information currently available.
6. To develop a provisional understanding of potential mitigation measures.

1.2.2 Study Area

Recent baseline hydrological studies have highlighted catchments where water may be available for abstraction to supply the SLR, as well as potential abstraction points within those catchments. The watercourses being considered for abstraction are the Rivers Nene, Welland, Witham, Trent, and SFFD.

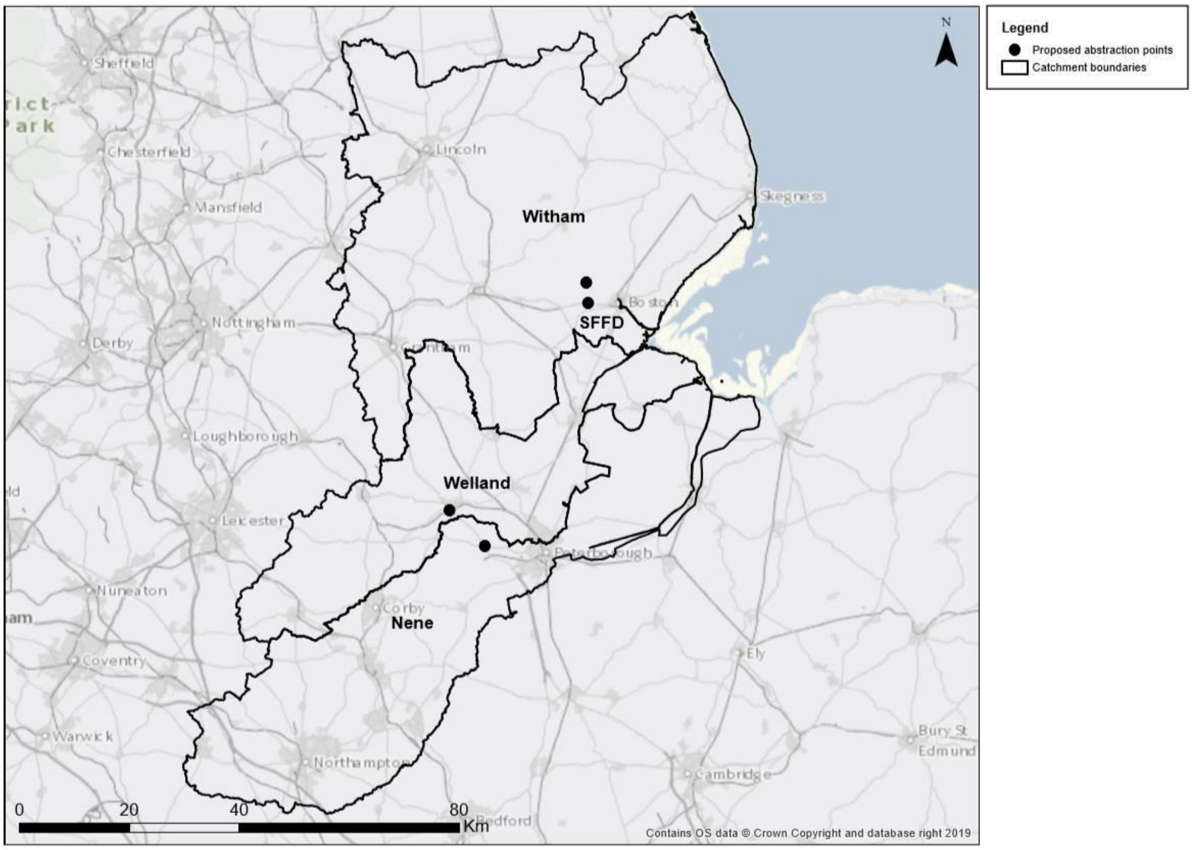
Water drawn from the River Trent would be first moved to the River Witham before transfer to the SLR. Potential abstraction point locations are detailed in Table 1.1. The river catchment study area, including potential abstraction points, is shown in Figure **1.1**.

Table 1.1: Potential abstraction points

River	Location	NGR	WFD Management Catchment	WFD Operational Catchment
River Nene	Wansford	TL0816799575	Nene	Nene Middle
River Welland	Tinwell	TF0173306051	Welland	Welland Upper
River Witham	Langrick Bridge	TF2658647549	Witham	Witham Lower
SFFD	Hubberts Bridge	TF2694543652	Witham	South Forty Foot Drain
River Trent	Torksey Lock	SK8339978125	Trent Lower and Erewash	Trent and Trib

Several locations have been identified for the siting of theb SLR. For the purposes of this assessment, one of the shortlisted locations was selected (SLR_47; TF 19679 27588). It was advised that could be a suitable exemplar option at the time of this assessment. It is located near the town of Pinchbeck, Lincolnshire, within the Witham Management Catchment / South Forty Foot Drain Operational Catchment.

Figure 1.1 **Study area and potential raw water intakes on the Rivers Nene, Welland, Witham and SFFD**



2 Legislation and Policy

2.1 Key Legislation

The following national legislation is relevant to the INNS risk associated with the proposed SLR scheme:

- Under the Wildlife and Countryside Act 1981 (as amended), it may be an offence to release or allow to escape into the wild any animal which 'is of a kind which is not ordinarily resident in and is not a regular visitor to Great Britain in a wild state'; or is included in Part I of Schedule 9.
- Under the Wildlife and Countryside Act 1981 (as amended), it may be an offence to plant or otherwise cause 'to grow in the wild any plant which is included in Part II of Schedule 9'.
- The Invasive Non-native Species (Amendment etc.) (EU Exit) Regulations 2019 ensures the continued operability of EU legislation which provides for a set of measures to combat the spread of INNS on the list of EU concern, through prevention, early detection and eradication, and management.
- Under the Invasive Alien Species (Enforcement & Permitting) Order 2019, it may be an offence to release, cause to escape, plant, or grow species of animal or plant 'not ordinarily resident in' and 'not a regular visitor to Great Britain in a wild state', or otherwise listed in Schedule 2.
- Waterbodies initially classified as 'High Status' (representing near-natural conditions) under the Water Environment (Water Framework Directive) (England and Wales) Directive 2017, will be reclassified to the lesser 'Good Status' if populations of 'High Impact' INNS are introduced. 'High Impact' INNS are identified on the current aquatic alien species list produced by the Water Framework Directive UK Technical Advisory Group (WFD UKTAG).

3 Methodology

3.1 Screening Against Environment Agency Guidance

The EA position statement *Managing the Risk of Spread of Invasive Non-Native Species Through Raw Water Transfers* (EA, 2017) outlines the organisation's position on how it will manage INNS risks associated with raw water transfers. The following key points from this document have specific relevance to the SLR:

- The focus of the EA's approach is on the pathways that the transfers create, not on current INNS distribution.
- New schemes that create a hydrological connection between isolated catchments must have mitigation measures in place to ensure INNS cannot be spread by the new transfer.
- Where water transfer into another watercourse remains the preferred solution, mitigation will need to be fail safe, resilient, and completely effective for all life stages and forms (e.g. plant propagules, animals, microscopic organisms and larval stages).
- Where catchments are already connected, a risk assessment will be required, which the EA will use to decide whether subsequent mitigation is required, to ensure the risk of INNS transfer is not significantly increased.

All potential SLR options were therefore screened to determine whether they created a link to isolated catchments, as mapped in the EA document *Invasive Non-Native Species Isolated Catchment Mapping* (EA, 2018).

3.2 Screening Against Heatmaps

To determine whether potential source, transfer or reservoir sites are located within areas that are at high risk of future INNS invasion, these locations were cross-referenced using heatmaps from the following two sources:

- *Mapping Ponto Caspian Invaders in Great Britain* (Gallardo and Aldridge, 2012); and,
- *Introduction of Marine Non-Indigenous Species into Great Britain and Ireland: Hotspots of Introduction and the Merit of Risk Based Monitoring* (Cefas, 2014).

'Freshwater Invasion Risk' was assessed using the heatmaps produced by Gallardo and Aldridge (2012). This study used species distribution models based on climatic factors, water chemistry and altitude to map probability of presence of 16 Ponto-Caspian species based on the match between the environmental conditions in Great Britain and those of the European range of the species. For the purpose of this risk assessment, the predicted number of species present was taken as a proxy for future invasion risk, and translated to low/moderate/high Freshwater Invasion Risk categories as shown in Table 3.1.

For each SLR option, a single Freshwater Invasion Risk category was assigned, based upon the risk category of the source and transfer locations. Where these sites traversed multiple categories, the highest risk category was assigned.

Table 3.1: Freshwater Invasion Risk categories

Predicted number of species	Freshwater Invasion Risk
0-1	Low
2-3	
4-5	Moderate

6-7	
8-9	
10-11	High
12-13	
14-15	

'Marine Invasion Risk' was assessed using a heatmap of marine non-native species pathway intensity produced by Cefas (2014). This heatmap was created by combining heatmaps of individual marine INNS pathway intensity including commercial shipping, recreational boating, aquaculture stock imports, natural dispersal by ocean current, likelihood of offshore structure facilitating introduction. All heatmaps produced in this study were in the form of 50 x 50km coastal grids of pathway intensity.

The resulting marine pathway intensity categories were translated to low/moderate/high Marine Invasion Risk categories as shown in Table 3.2. Each SLR option was assigned a Marine Invasion Risk category based upon the invasion risk of the source estuary. Where an estuary encompassed multiple risk categories, the highest was assigned.

Table 3.2: Marine Invasion Risk categories

Marine pathway intensity	Marine Invasion Risk
>0 – 1.99	Low
2 – 9.99	
10 – 24.99	Moderate
25 – 49.99	
50 – 74.99	High
75 – 100	

3.3 Desk Study

Open source macroinvertebrate, macrophyte, and fish data for the period 1965 to 2020 were obtained for the study area (see Section 1.2.2) from the EA Ecology and Fish Data Explorer app[1]. These datasets allow non-native species to be filtered, which enabled INNS records in the study area to be isolated. INNS records were collated at WFD Management Catchment level for each of the proposed transfer options (for details see Section 1.2.2). The SFFD option was the only exception as the proposed abstraction point from SFFD is located within the Witham WFD Management Catchment. Therefore, INNS records were instead identified to WFD Operational Catchment level to distinguish the SFFD study area from the Witham study area.

Additional records of the treatment of floating pennywort *Hydrocotyle ranunculoides* along and within the vicinity of the Fossdyke Canal and River Witham were also provided by the EA.

INNS records for the River Trent obtained from the EA Ecology and Fish Data Explorer app were cross-checked against INNS records provided by AECOM, these having been gathered for a baseline ecology and gap analysis study of the Tame, Trent, and Humber being undertaken in support of two SROs, including the SLR.

[1] Available at https://environment.data.gov.uk/ecology-fish/

3.4 Field Study

3.4.1 Survey Methodology

Surveys were undertaken within each of the waterbodies proposed to supply the SLR to capture recent invasions or previously undetected aquatic INNS within the study area. Eight survey sites were visited, details of which are presented in Table 3.3.

Table 3.3: INNS field survey sites

Site No.	Waterbody	Location	NGR	Survey Date
1	River Nene	Wansford	TL 07502 99107	02/10/2020
2	River Nene	Near tidal limit and North Side	TL 27105 99294	02/10/2020
3	River Welland	Near Tinwell	TF 00857 06198	02/10/2020
4	River Welland	Near tidal limit, Spalding	TF 26010 24027	02/10/2020
5	SFFD	Swineshead Bridge	TF 21785 42860	01/10/2020
6	SFFD	Near tidal limit, Boston	TF 32483 42917	01/10/2020
7	Brayford Pool	Lincoln, at Fossdyke-Witham confluence	SK 97285 71053	01/10/2020
8	River Witham	Towards tidal limit, Antons Gowt	TF 29974 47435	01/10/2020

At each site, the survey comprised the following elements:

- Collection of a single environmental DNA (eDNA) sample;
- Visual search for non-native plants, aided by use of a grapnel to retrieve specimens for identification; and
- Manual search for non-native aquatic invertebrates using a pond net.

eDNA sampling kits were provided by NatureMetrics and the samples were collected in accordance with the instructions provided. In summary, up to 1,000mL of sampled water was filtered through an encapsulated disk filter immediately upon collection. A preservative solution was then added to the filter units and they were promptly sent to NatureMetrics for analysis.

3.4.2 Biosecurity Considerations

Biosecurity measures were implemented to prevent the spread of diseases and INNS between survey sites. Sites were surveyed in an upstream-to-downstream direction. Different sampling equipment was used in each waterbody. Substrate (for example silt or sand) and plant fragments were removed from survey equipment and personal protective equipment (including waders) between visits to different survey locations. Additionally, all equipment was washed using Virkon® Aquatic disinfectant between surveys, in accordance with the manufacturer's instructions.

3.4.3 Laboratory Processing

eDNA was extracted from the disk filters using commercially available DNA extraction kits, and further purified to remove inhibitors. Quantitative polymerase chain reaction (qPCR) amplification was then conducted in 12 replicates per sample per target, using target-specific assays, in the presence of both positive controls and negative controls. The target taxa were:

- White-clawed crayfish *Austropotamobius pallipes*
- Signal crayfish *Pacifastacus leniusculus*
- Crayfish plague *Aphanomyces astaci*
- Chinese mitten crab *Eriocheir sinensis*
- Zebra mussel *Dreissena polymorpha*
- Dressenidae (a family of aquatic bivalve mussels)

Purified DNAs were also metabarcoded for a ~100 bp region of the 16S rRNA gene to target mussels and clams belonging to the Venerida order (but also inclusive of some bivalve species outside of this order, e.g. Dreissenidae species). PCR replicates were prepared into sequencing libraries and sequenced using an Illumina MiSeq V3 kit at 12 pM with a 10% PhiX spike in.

3.5 Screening Against INNS Legislation

Field and desk study INNS data were screened against the Wildlife and Countryside Act (as amended) 1981 Schedule 9, the EU Invasive Alien Species of Union concern[2], and the UKTAG list of aquatic alien species (WFD-UKTAG, 2015) to provide an indication of legal risk. For the purpose of this assessment, it was assumed that the potential transfer of a species either specifically named, or implied by description in the legislation, to another waterbody, would constitute a legal risk. However, this was a precautionary decision, and it should not be interpreted that an offence would definitely occur. Furthermore, it does not take account the impact of potential mitigation measures on either the transfer or reservoir to reduce this risk.

The high/moderate/low risk categories relating to the WFD are based solely on the reclassification of High-Status waterbodies in the presence of High Impact INNS, and not on the risk of deterioration which may result from ecological interactions such as predation and competition. Risk categories were assigned as shown in Table 3.4.

Table 3.4: Assignment of legislative risk categories

Legislation	Risk Category	Justification
Wildlife and Countryside Act (as amended) 1981 Schedule 9	Low	• As a result of the transfer option, no identified risk of spread to a new waterbody of either a Schedule 9 species, or any species 'of a kind which is not ordinarily resident in' and 'not a regular visitor to Great Britain in a wild state.'
	Moderate	• As a result of the transfer option, unclear* risk of any species listed in Schedule 9 being spread new a waterbody; or, • As a result of the transfer option, unclear* risk any species 'of a kind which is not ordinarily resident in' and 'not a regular visitor to Great Britain in a wild state' being spread to a new waterbody. * May be 'unclear' if such species are present in source waterbody, but pathway risk is uncertain; or if there is doubt concerning the definition of species as described.
	High	• As a result of the transfer option, clear risk of spread of any species listed in Schedule 9 being spread to new a waterbody; or, • As a result of the transfer option, clear risk of spread of any species 'of a kind which is not ordinarily resident in' and 'not a regular visitor to Great Britain in a wild state' being spread to a new waterbody.
Invasive Non-native Species (Amendment etc.) (EU Exit) Regulations 2019	Low	• As a result of the transfer option, no identified risk of spread of INNS of EU concern to a new waterbody.
	Moderate	• As a result of the transfer option, unclear whether a pathway will be created which would allow the spread of INNS of EU concern to a new waterbody.
	High	• As a result of the transfer option, clear risk of INNS of EU concern being spread to a new waterbody.
Invasive Alien Species (Enforcement & Permitting) Order 2019	Low	• As a result of the transfer option, no identified risk of either a Schedule 2 species, or any species 'of a kind which is not ordinarily resident in' and 'not a regular visitor to Great Britain in a wild state' being released into, caused to escape into, or to grow in the wild.
	Moderate	• As a result of the transfer option, unclear* risk of a species listed in Schedule 2 being released into, caused to escape into, or to grow in the wild; or,

[2] Available from https://www.wfduk.org/sites/default/files/Media/Assessing%20the%20status%20of%20the%20water%20environment/UKTAG%20classification%20of%20alien%20species%20working%20paper%20v7.6.pdf (accessed 19/02/2021)

Legislation	Risk Category	Justification
		• As a result of the transfer option, unclear* risk any species 'of a kind which is not ordinarily resident in' and 'not a regular visitor to Great Britain in a wild state' being released into, caused to escape into, or to grow in the wild. * May be 'unclear' if such species are present in source waterbody, but pathway risk is uncertain; or if there is doubt concerning the definition of species as described.
	High	• As a result of the transfer option, clear risk of a species listed in Schedule 2 being released into, caused to escape into, or to grow in the wild; or, • As a result of the transfer option, a clear risk of any species 'of a kind which is not ordinarily resident in' and 'not a regular visitor to Great Britain in a wild state' being released into, caused to escape into, or to grow in the wild.
Water Environment (Water Framework Directive) (England and Wales) Directive 2017	Low	• As a result of the transfer option, no identified risk of 'high impact' INNS being introduced to a High Status WFD waterbody.
	Moderate	• As a result of the transfer option, it is unclear whether a pathway will be created which would allow the transfer of 'high-impact' INNS in the study area to a High Status WFD waterbody.
	High	• As a result of the transfer option, clear risk of 'high impact' INNS being introduced to a High Status WFD waterbody.
Overall	**Low**	• All legislative risks categorised as Low.
	Moderate	• One or two legislative risks categorised as Moderate, and no legislative risks classed as High.
	High	• Three or more legislative risks classed as Moderate; or any legislative risks categorised as High.

3.6 Risk Assessment

3.6.1 Tool Overview

The risk assessment tool used here was developed by Northumbrian Water Group (NWG) to meet the requirements of the EA's Price Review 2019 (PR19) guidance on the assessment of raw water transfers, and is hereafter referred to as 'the tool.' There have been many revisions of the tool due to its continual development, and for the purpose of this assessment Version 8a was used. It takes a pathway-based approach and is centred around a list of functional groups of INNS encompassing different life stages.

The functional group approach accounts for all potential INNS at risk of spread, rather than just focusing on the species that are currently present within the source waterbody. The functional groups used in the tool are shown in Table 3.5.

Table 3.5: INNS functional groups

Functional group	Description
1	Aquatic plant spread by fragments
2	Riparian plant spread by seed or fragment
3	Attached invertebrate/fish egg
4	Free swimming fish
5	Freely mobile invertebrates
6	Pathogen

The risk assessment matrix takes the form of a Microsoft Excel spreadsheet, into which data and information about the different SLR raw water transfer options were entered and used to generate a risk score for each. In common with many health and safety risk assessments, INNS risk scores are a product of probability scores (herein referred to as 'Pathway Occurrence Scores') and 'Severity Scores'.

Pathway Occurrence Scores reflect the probability of INNS transfer by a particular transfer pathway, taking into account:

- 'Pathway Volume Score' – based on the volume of water transferred, in Megalitres/day (Ml/d);
- 'Pathway Frequency Score' – based on the frequency with which water is transferred, from infrequent to continuous; and,
- 'Pathway Distance Score' – based on whether water is to be transferred within the same WFD waterbody, or between different WFD waterbodies, WFD Operational Catchments or WFD Management Catchments.

Severity Scores reflect the potential impact of INNS transfer by a particular transfer pathway. Therefore, different Severity Scores are assigned to every combination of transfer pathway and INNS functional group. For example, if a freely mobile aquatic invertebrate were spread in silt to land, it would be unlikely to survive and impact the environment, and this combination would be assigned a low score. Conversely, if an aquatic plant propagule was transferred via a raw water connection, it would be free to invade the receptor waterbody, and this combination would be assigned a high Severity Score.

The tool calculates three type of INNS risk score:

- **Inherent Risk Score**, designed to reflect the inherent risk associated with a raw water transfer option, irrespective of 'Exacerbating Factors', 'Mitigation Options', or the presence of INNS, protected species or protected habitats.
- **Adjusted Risk Score**, whereby the **Inherent Risk Score** is adjusted according to factors that may reduce or increase the impact of INNS functional groups being transferred by a given transfer pathway. It is calculated by applying multiplier scores according to the relevant Exacerbating Factors or Mitigation Options.
  - Exacerbating Factors are those which may increase risk, for example, whether a pathway is open or closed, navigation within the pathway route, use of the pathway and/or receptor waterbody for recreational activities and the nature of water storage at the receptor site.
  - Mitigation Options may reduce risk, for example, physical screening at source, water transfer direct to a WTW, chemical treatment at source or within the pathway, and specific biosecurity measures.
- **Weighted Risk Score,** whereby **Adjusted Risk Scores** are weighted to account for known INNS in source waters. A multiplier score is allocated to each INNS functional group based on their WFD UKTAG impact category (UKTAG, 2015). Protected sites and species of conservation importance near the receptor site are also accounted for at this stage.

Inherent, Adjusted, and Weighted Risk Scores generated for each SLR option were categorised into low/moderate/high ranking on a percentile basis, whereby scores at or below the 33rd percentile were classed as low, scores from the 33rd to 66th percentile were classed as moderate, and scores above the 66th percentile were classed as high. This was undertaken purely to highlight relative difference between SLR options, and not to indicate overall risk compared to the current baseline, or to other SRO options.

3.6.2 Test Scenarios

Test scenarios were developed for the Nene, Welland, Witham and SFFD to SLR raw water transfer options based on the current conceptual design being developed by MM. For each of the options, one test scenario was devised for raw water transfer via an open channel, and another scenario was devised for raw water transfer via an underground pipeline. Of the pathway types included in the tool, open channel and underground pipeline represent the highest and lowest scoring options, respectively. Therefore, developing scenarios to test both pathway types provided a potential minimum and maximum INNS risk score for each transfer option. Details of the test scenarios are shown in Table 3.6.

As development of the concept design is ongoing, some of the information required to run the INNS risk assessment tool was not available for this assessment. In particular, measures to mitigate INNS risk have not yet been considered, for example the screening and/or chlorination of raw water at source and/or prior to discharge at the receptor waterbody. While it is likely that mitigation measures will be included in the transfer design, for the purposes of this risk assessment it was generally assumed that no mitigation measures will be applied, thereby presenting a 'worst-case' scenario. It was determined that this would not significantly affect the comparison of source and transfer options given that mitigation measures could be applied to any.

Table 3.6: INNS risk assessment test scenarios for raw water transfers to the SLR

Risk type	Input variable	Nene - Open	Nene - Pipeline	Welland - Open	Welland - Pipeline	SFFD - Open	SFFD - Pipeline	Witham - Open	Witham - Pipeline
Inherent	Transfer pathway	New raw water transfer		New raw water transfer		New raw water transfer		New raw water transfer	
	Transfer frequency	Seasonal - continuous		Seasonal - continuous		Seasonal - continuous		Seasonal - continuous	
	Transfer volume	>100 Ml/d		50-100 Ml/d		>100 Ml/d		>100 Ml/d	
	Transfer distance	Between Management Catchments		Between Management Catchments		Between waterbodies		Between Operational Catchments	
Adjusted	Risk of arrival of new INNS at source	High for functional groups already at source Low for functional groups not currently at source		High for functional groups already at source Low for functional groups not currently at source		High for functional groups already at source Low for functional groups not currently at source		High for functional groups already at source Low for functional groups not currently at source	
	How raw water is conveyed	Open channel	Pipeline	Open channel	Pipeline	Open channel	Pipeline	Open channel	Pipeline
	Facilitation works	Not applicable to open transfer	Lay new under-ground pipeline	Not applicable to open transfer	Lay new under-ground pipeline	Not applicable to open transfer	Lay new under-ground pipeline	Not applicable to open transfer	Lay new under-ground pipeline
	Storage at receptor	Long-term storage in large reservoir		Long-term storage in large reservoir		Long-term storage in large reservoir		Long-term storage in large reservoir	
	Navigation along transfer	Whole route navigable	Not applicable to pipeline	Whole route navigable	Not applicable to pipeline	Whole route navigable	Not applicable to pipeline	Whole route navigable	Not applicable to pipeline
	Recreation at receptor	Only boats and equipment hired on site used		Only boats and equipment hired on site used		Only boats and equipment hired on site used		Only boats and equipment hired on site used	
	Riparian recreation at receptor	Only equipment hired on site used		Only equipment hired on site used		Only equipment hired on site used		Only equipment hired on site used	

Risk type	Input variable	Nene - Open	Nene - Pipeline	Welland - Open	Welland - Pipeline	SFFD - Open	SFFD - Pipeline	Witham - Open	Witham - Pipeline
	Screening at source	No		No		No		No	
	Chlorination at source	No		No		No		No	
	Transfer direct to WTW	No		No		No		No	
	Screening prior to discharge	No		No		No		No	
	Operational protocol to mitigate risk	No		No		No		No	
	Salt water barrier	No		No		No		No	
Weighted	Weighting of known INNS at source	Score assigned to reflect the species with the highest impact level in each of the functional groups present		Score assigned to reflect the species with the highest impact level in each of the functional groups present		Score assigned to reflect the species with the highest impact level in each of the functional groups present		Score assigned to reflect the species with the highest impact level in each of the functional groups present	
	Protected species in or near receptor	No		No		No		No	
	Protected sites in or near receptor	No		No		No		No	
	Existing connections between source and receptor	No		No		No		No	

Abstraction of water from the Witham to supply the SLR would likely be complemented by a raw water transfer from the Trent to the Witham. It is possible that the existing Trent-Witham-Ancholme Scheme (TWAS) would be utilised for this purpose. The TWAS pumps water from the Trent near Torksey Lock along Fossdyke Navigation to Brayford Pool, where the channel converges with the Witham at Lincoln. Alternatively, a new transfer pathway may be constructed to link the two rivers. For the purposes of this assessment, it was assumed that the new transfer would follow a similar route to Fossdyke Navigation, with water abstracted from the Trent near Torksey Lock and discharged to the Witham near Lincoln. The TWAS operates year-round, however it was assumed that a new transfer would only be operational on a seasonal basis to coincide with raw water between the Witham and SLR.

Test scenarios were devised for the TWAS and for the potential new transfer. As for the other transfer options, both open channel and underground pipeline pathway types were tested for the potential new Trent to Witham transfer. Details of the Trent to Witham test scenarios are shown in Table 3.7.

Table 3.7: INNS risk assessment test scenarios for raw water transfers from Trent to Witham

Risk type	Input variable	Trent to Witham via TWAS	Trent to Witham via new open channel	Trent to Witham via new underground pipeline
Inherent	Transfer pathway	Permanent existing raw water transfer	New or temp raw water transfer	New or temp raw water transfer
	Transfer frequency	Year round - continuous	Seasonal - continuous	Seasonal – continuous
	Transfer volume	100 Ml/d	100 Ml/d	100 Ml/d
	Transfer distance	Between Management Catchments	Between Management Catchments	Between Management Catchments
Adjusted	Risk of arrival of new INNS at source	High for functional groups already at source Low for functional groups not currently at source	High for functional groups already at source Low for functional groups not currently at source	High for functional groups already at source Low for functional groups not currently at source
	How raw water is conveyed	Open channel	Open channel	Underground pipeline
	Facilitation works	Not applicable to open transfer	Not applicable to open transfer	Lay new underground pipeline
	Storage at receptor	Discharge to flowing water course	Discharge to flowing water course	Discharge to flowing water course
	Navigation along transfer	Whole route navigable	Whole route navigable	Not applicable to pipeline
	Recreation at receptor	Only boats and equipment hired on site used	Only boats and equipment hired on site used	Only boats and equipment hired on site used
	Riparian recreation at receptor	Only equipment hired on site used	Only equipment hired on site used	Only equipment hired on site used
	Screening at source	No	No	No
	Chlorination at source	No	No	No
	Transfer direct to WTW	No	No	No
	Screening prior to discharge	No	No	No
	Operational protocol to mitigate risk	No	No	No
	Salt water barrier	No	No	No
Weighted	Weighting of known INNS at source	Score assigned to reflect the species with the highest impact level in each of the functional groups present	Score assigned to reflect the species with the highest impact level in each of the functional groups present	Score assigned to reflect the species with the highest impact level in each of the functional groups present
	Protected species in or near receptor	No	No	No
	Protected sites in or near receptor	No	No	No
	Existing connections between source and receptor	No	Yes (TWAS plus Torksey Lock)	Yes (TWAS plus Torksey Lock)

3.7 Mitigation Measures

Using the Mitigation Option and Exacerbating Factor multipliers from the risk assessment tool, the relative benefit of different mitigation measures was estimated and categorised into a five-point scale to provide an indication of the which measures would have the most INNS risk reduction benefit.

Exacerbating Factors

The following Exacerbating Factors were included:

- Nature of raw water conveyance e.g. open channel, overground or underground tunnel;
- New transfer construction;
- Nature of storage at transfer destination;
- Navigation along transfer;
- In-water recreational access / navigation at transfer destination;
- Riparian / land-based recreational at transfer destination; and
- Risk of arrival of new INNS at source.

In the tool, Exacerbating Factors are incorporated as multiplier scores which are applied to each functional group depending on how it is judged that they would respond to the factor. These scores range from 1 to 3, where a multiplier score of 1 will have no impact on risk scores, and a score of 3 will have the greatest impact. An example is shown in Table 3.8 below, which shows four possible options for riparian / land-based recreation access at the transfer destination. As shown, the tool aims to represent the impacts of different options on the risk associated with each organism functional group.

Table 3.8: Example of Exacerbating Factor multiplier scores used in the tool

Riparian / land-based recreational access at transfer destination	Group 1 - Aquatic plant spread by fragments	Group 2 - Riparian plant spread by seed or fragment	Group 3 - Attached invertebrate / fish egg	Group 4 - Free swimming fish	Group 5 - Free swimming invert or mollusc	Group 6 - Pathogen
Equipment being brought to and leaving site regularly	1.25	1.5	1.5	1	1	1
Equipment being brought to and leaving site occasionally	1.1	1.25	1.25	1	1	1
Only equipment hired on site used	1	1	1	1	1	1
Not applicable to pathway	1	1	1	1	1	1

Most Exacerbating Factors in the tool are based on the scheme design options and therefore the benefits should be considered alongside other mitigation measures. For these Exacerbating Factors, the following steps were followed to generate a benefit category:

1. For each relevant option, the mean multiplier score across all six functional groups was calculated.
2. This was converted to a percentage increase e.g. a multiplier score of 3 is equivalent to a 200% increase from a baseline of 1.
3. The percentage increase was assigned a benefit category on the basis shown in Table 3.9.

Table 3.9: Exacerbating Factor benefits categorisation

Percentage increase in mean risk score	Benefit category
>150%	0 - None
>100 – 150%	1 - Low
>50 – 100%	2 - Moderate
>0-50%	3 - High
0%	4 - Very High

Mitigation Options

The following Mitigation Options were included:

- Screens before transfer (mesh of 2mm, 3-10mm, 11-25mm, >25mm)
- Screens before discharge to receptor (mesh of 2mm, 3-10mm, 11-25mm, >25mm)
- Continuous chlorination of water at source
- Intermittent chlorination of water at source
- Transfer of water direct to water treatment works (WTW)
- Two-stage treatment (coagulation and filtration)
- Saltwater barrier e.g. discharges to estuary or tidal river
- Operational instruction written to mitigate risk in place and followed, either with or without audits to demonstrate to adherence.

Similarly to Exacerbating Factors, Mitigation Options are represented in the tool by multiplier scores ranging from 0 to 1, again applied to each organism functional group for each option. A multiplier score of 0 has the effect of completely nullifying the risk score for that functional group, whilst a score of 1 has no impact. An example of Mitigation Option multiplier scores is given in Table 3.10.

Table 3.10: Example of Mitigation Option multiplier scores used in the tool

Screening at source (before transfer)	Group 1 - Aquatic plant spread by fragments	Group 2 - Riparian plant spread by seed or fragment	Group 3 - Attached invertebrate / fish egg	Group 4 - Free swimming fish	Group 5 - Free swimming invert or mollusc	Group 6 - Pathogen
Screens 2mm mesh	0.5	0.8	1	0.65	0.5	0.8
Screens 3-10mm mesh	0.8	0.9	1	0.9	0.8	0.9
Screens 11-25mm mesh	0.95	1	1	0.975	0.95	1
Screens >25mm mesh	1	1	1	1	1	1

For Mitigation Options, the following steps were followed to generate a benefit category:

1. For each relevant option, the mean multiplier score across all six functional groups was calculated.
2. This was converted to a percentage reduction.
3. The percentage reduction was converted to a benefit category on the basis shown in Table 3.11. This categorisation was devised to place more emphasis on the options which may offer complete or very high risk reduction and is thus categories are not evenly distributed.

Table 3.11: Mitigation Option benefits categorisation

Percentage increase in mean risk score	Benefit category
0%	0 - None
>0% - <50%	1 - Low
50 - <95%	2 - Moderate
95 - <100%	3 - High
100%	4 - Very High

3.8 Workshop

On 15 December 2020, an online INNS workshop was held to present and discuss the risk assessment tool, the provisional results generated, potential mitigation measures, and other aspects of INNS risk assessment. Representatives of the following organisations were in attendance:

- AECOM (in relation to the potential to draw water from the River Trent)
- Affinity Water (AFW)
- Anglian Water (AWS)
- Environment Agency (EA)
- Mott MacDonald (MM)

Representatives from Natural England (NE) and Lincolnshire Wildlife Trust (LWT) were also invited, but were unable to attend the workshop.

3.9 Constraints, Limitations and Assumptions

3.9.1 Constraints

With respect to eDNA sampling, it is generally recommended that samples are collected on at least two occasions to increase the probability of detecting species and to provide additional validation of results. Only an autumn sample was possible given the timeframe of this project. However, eDNA sampling in one season was still considered a useful method to apply given its potential to detect species that may be difficult to observe by other means.

Macrophytes are typically surveyed in the peak growing season of June to September inclusive. Technically, the field surveys were undertaken outside of this window, on the first two days of October. However, macrophyte growth was observed to be abundant and seasonality was therefore not considered to significantly affect the results.

3.9.2 Limitations

The tool used in this assessment primarily quantifies the risk associated with the operational phase of a raw water transfer, rather than the construction phase. For any one of the test scenarios, the construction phase would likely involve either the laying of new underground pipework or excavation of an open channel between the source waterbody and receptor, as well as the construction of other infrastructure, such as pumping stations. This work poses the risk of INNS being spread through the movement of personnel, vehicles and equipment to and from construction sites.

The test scenarios outlined in Section 3.6.2 were based on the latest available concept design. As the concept design is still in development, these details may be subject to change. The INNS risk assessment should be revised during the design process to capture the effect of changes on the INNS risk scores. A detailed exploration of potential mitigation measures was not possible at this early stage in the design process, though should be an integral part of this process going forward.

It is recognised that the categorisation of scores generated by the risk assessment tool into low, moderate, and high may not be reflective of the risk relative to the current baseline risk or other SLR options. This approach may be used to rank SRO options nationally only if scores have been generated in a consistent manner using the same tool.

The potential legal risks of INNS transfer are poorly understood. It must be emphasised that risk categories assigned in this assessment are purely indicative and should not be used to interpret the probability of an offence being caused.

3.9.3 Assumptions

For the purpose of this assessment it was assumed that the SLR would be located at a location near Pinchbeck, Lincolnshire (TF 19679 27588). This location is uncertain and may be subject to change; however, this was considered an acceptable uncertainty for the purpose of this provisional assessment. Significant changes to the conclusions of this report would only be likely in the event that the preferred location is moved to a different WFD Management Catchment.

With the tool, all open channel transfer scenarios were assumed to be navigable throughout the whole transfer route, which could introduce INNS through the release of contaminated ballast water and hull fouling.

AWS typically prevents the use of personal recreation equipment at their reservoir sites, with only boats and equipment hired on site allowed to be used. It was assumed that the SLR will be subject to the same rule, and this was reflected in the calculation of Adjusted Risk Score.

4 Results and Discussion

4.1 Screening Against Environment Agency Guidance

All catchments being considered for abstraction fall within areas 92 or 93 of the EA *Invasive Non-Native Species Isolated Catchment Mapping* v3 (EA, 2018). These areas are classified as 'Canal – CRT', meaning that they are connected to Canal and River Trust (CRT) navigable canals. Connecting watercourses listed include the Grand Union Canal, Grantham Canal, Fossdyke Canal, and the River Witham itself.

The man-made connectivity of potential source waterbodies necessitates a risk assessment, which the EA will use to decide whether subsequent mitigation is required, to ensure the risk of INNS transfer is not significantly increased.

4.2 Screening Against Heatmaps

4.2.1.1 Freshwater Invasion Risk

Using the heatmaps produced by Gallardo and Aldridge (2012) which predict Ponto-Caspian INNS distribution, all potential SLR sources fall within a moderate Freshwater Invasion Risk area, in which between six and nine of the 16 modelled Ponto-Caspian invasives are predicted. This is supported by the INNS records gathered, which revealed the presence of Ponto-Caspian invasives in all potential source waterbodies.

That this analysis should not differentiate between SLR options is unsurprising given the similarity in climate, altitude, and water chemistry across all potential source waters. However, this methodology may differentiate between the Freshwater Invasion Risk of different SRO options nationally.

4.2.1.2 Marine Invasion Risk

Using the heatmap of marine non-native species pathway intensity produced by Cefas (2014), the marine invasion risk was determined to be moderate for the River Nene and River Welland abstraction options, and high for abstraction from the Rivers Trent, Witham, and SFFD.

The River Nene, River Welland, and Haven estuaries all drain into the Wash embayment, which in this context all fall within the same 50 x 50 km grid located around the west Wash. This grid has been assigned a moderate ranking due to its overall pathway activity intensity falling within the 10-24.99 band. As shown in Table 4.1, potential offshore structures present the greatest threat of introduction of marine INNS in the west Wash, and therefore to these estuaries. The risk of arrival of marine INNS via recreational boating is assessed to be low, though it is noted that this activity may facilitate the movement of INNS within the lower Nene.

The Humber estuary is at elevated risk from potential offshore structures, however, is also at significant risk from current commercial shipping. The mouth of the Humber estuary is interpreted to have a high Marine Invasion Risk, due to the maximum overall pathway activity intensity falling within the 50-74.99 banding. The risk of arrival of marine INNS via recreational boating is assessed to be low, though it is noted that this activity may facilitate the movement of INNS between the lower Trent and the Fossdyke Canal. This presents a potential risk to the Witham if species with wide salinity tolerances are able to disperse through the Fossdyke Canal. If such species are subsequently able to disperse through the lower Witham, they may also be able to colonise the SFFD via the confluence in Boston. For the purpose of the risk assessment, it was therefore decided to adopt a precautionary approach and categorise the Marine Invasion Risk for the River Witham, SFFD, and River Trent abstraction options as high, though recognising that further investigation may reveal the actual risk to be lower. This highlights the need to understand potential changes in salinity which may be caused by the SLR, and the potential impacts on INNS distribution and dispersal.

Table 4.1: Components of Marine Invasion Risk

Pathway	The west Wash	Humber estuary
Commercial shipping pathway intensity	<1.99 (low)	75-100 (high)
Recreational boating pathway intensity	None (low)	None (low)
Aquaculture pathway intensity	<1.99 (low)	<1.99 (low)
Ocean current dispersal pathway intensity	Impact unlikely (low)	Impact unlikely (low)
Offshore structure pathway intensity	10-24.99 (moderate)	75-100 (high)
Overall	**10-24.99 (moderate)**	**50-74.99 (high)**

4.3 Desk Study

Environment Agency INNS records for the study area are summarised in Table 4.2. Species found during this search included 13 flowering plants, six fish, as well as 17 distinct invertebrate taxa.

In addition, the high-impact Ponto-Caspian invasive killer shrimp *Dikerogammarus villosus* is present in Pitsford Reservoir, which is located in the River Nene catchment, and flows into the River Nene via Faxton Brook. The potential future spread of the species should be taken into account.

Similarly, the high-impact invasive mollusc the Quagga mussel *Dreissena bugensis*, which can have significant operational impacts on water infrastructure, has been found in Hall Reservoir, which is fed by the River Trent, as well as Rutland Water. Again, these locations fall outside the study area as defined in this assessment, however the future spread of the species should be considered.

Table 4.2: EA records of INNS in the study area

Species / taxon	Group	Non-native status[3]	Nene	Welland	Witham	SFFD	Trent
Canadian waterweed *Elodea canadensis*	Flowering plant	WACA Sch. 9, UKTAG High	✓	✓	✓	✓	✓
Curly water thyme *Lagarosiphon major*	Flowering plant	WACA Sch. 9, IAS Sch. 2, UKTAG High		✓			
Floating pennywort *Hydrocotyle ranunculoides*	Flowering plant	WACA Sch. 9, IAS Sch. 2, UKTAG High	✓				✓
New Zealand pigmyweed *Crassula helmsii*	Flowering plant	WACA Sch. 9, UKTAG High			✓		
Nuttall's pondweed *Elodea nuttallii*	Flowering plant	IAS Sch. 2, UKTAG High	✓	✓	✓	✓	

[3] Includes listings under the Wildlife and Countryside Act 1981 (as amended) Schedule 9, the Invasive Non-native Species (Amendment etc.) (EU Exit) Regulations 2019, and the WFD-UKTAG aquatic alien species list (WFD-UKTAG, 2015).

Species / taxon	Group	Non-native status[3]	Nene	Welland	Witham	SFFD	Trent
Parrot's feather *Myriophyllum aquaticum*	Flowering plant	WACA Sch. 9, IAS Sch. 2, UKTAG High	✓	✓		✓	
Water fern *Azolla filiculoides*	Flowering plant	WACA Sch. 9, UKTAG High	✓	✓	✓	✓	✓
Brazilian waterweed *Egeria densa*	Flowering plant	UKTAG Moderate					✓
Least duckweed *Lemna minuta*	Flowering plant	UKTAG Unknown	✓	✓	✓		✓
Indian balsam *Impatiens glandulifera*	Flowering plant	WACA Sch. 9, IAS Sch. 2, UKTAG High	✓	✓	✓	✓	✓
Japanese knotweed *Reynoutria japonica*	Flowering plant	WACA Sch. 9, UKTAG High		✓			✓
Sweet flag *Acorus calamus*	Flowering plant	UKTAG Low	✓				✓
Orange balsam *Impatiens capensis*	Flowering plant	UKTAG Low	✓	✓			
Common carp *Cyprinus carpio*	Fish	UKTAG High	✓	✓	✓		✓
Goldfish *Carassius auratus*	Fish	UKTAG High	✓	✓	✓		
Golden orfe *Leuciscus idus*	Fish	UKTAG Low	✓				
Grass carp *Ctenopharyngodon idella*	Fish	UKTAG Low					
Rainbow trout *Oncorhynchus mykiss*	Fish	UKTAG Low	✓	✓	✓		✓
Zander *Sander lucioperca*	Fish	WACA Sch. 9, UKTAG Moderate	✓	✓			✓
Asiatic clam *Corbicula fluminea*	Invertebrate	UKTAG High	✓		✓		✓
Bloody red mysid *Hemimysis anomala*	Invertebrate	UKTAG High	✓		✓		✓
Conrad's false mussel *Mytilopsis leucophaeata*	Invertebrate	UKTAG Unknown				✓	
Chinese mitten crab *Eriocheir sinensis*	Invertebrate	WACA Sch. 9, IAS Sch. 2, UKTAG High					✓
Demon shrimp *Dikerogammarus haemobaphes*	Invertebrate	UKTAG High	✓	✓	✓		✓
North American signal crayfish *Pacifastacus leniusculus*	Invertebrate	WACA Sch. 9, IAS Sch. 2, UKTAG High	✓	✓	✓		✓

Species / taxon	Group	Non-native status[3]	Nene	Welland	Witham	SFFD	Trent
Quagga mussel *Dreissena bugensis*	Invertebrate	UKTAG High					
Zebra mussel *Dreissena polymorpha*	Invertebrate	UKTAG High	✓		✓	✓	✓
Northern river crangonyctid *Crangonyx pseudogracilis*	Invertebrate	UKTAG Low	✓		✓	✓	✓
Northern river / Florida crangonyctid *Crangonyx pseudogracilis / floridanus*	Invertebrate	UKTAG Low	✓	✓	✓	✓	✓
Jenkins' spire snail *Potamopyrgus antipodarum*	Invertebrate	UKTAG Moderate		✓	✓	✓	✓
Caspian mud shrimp *Chelicorophium curvispinum*	Invertebrate	UKTAG Unknown	✓	✓	✓	✓	✓
Bladder snail *Physa acuta*	Invertebrate	UKTAG Unknown	✓	✓	✓	✓	✓
Oblong orb mussel *Musculium transversum*	Invertebrate	UKTAG Unknown	✓				
Gulf Wedge clam *Rangia cuneata*	Invertebrate	Non-native				✓	
Polychaete worm *Hypania invalida*	Invertebrate	UKTAG Unknown	✓				✓
Sideswimmer *Gammarus tigrinus*	Invertebrate	Non-native	✓	✓	✓	✓	✓
Wautier's limpet *Ferrissia wautieri*	Invertebrate	UKTAG Unknown	✓	✓	✓		✓

4.4 Field Survey

Field survey results are shown in Table 4.3. Fifteen non-native taxa were found during the surveys, including ten invertebrate taxa and five plant species. Seven of the invertebrate taxa, and all five plants were detected by physical observation. Four species of bivalve molluscs were detected using eDNA, three of which were not found by physical sampling, which highlights the advantage of combining approaches to detect the broadest range of species. In addition, the DNA of crayfish plague *Aphanomyces astaci* was detected, indicating the presence of a host species, most likely signal crayfish *Pacifastacus leniusculus*, given their presence within wider catchments.

Quagga mussel *Dreissena bugensis*, signal crayfish, white-clawed crayfish and Chinese mitten crab were not detected at any site by either physical survey or eDNA sampling.

Results of the field survey suggest that the SFFD hosts the greatest variety of INNS, with 10 species identified across the two survey sites. In all catchments except the Welland, a greater number of INNS was found towards the tidal limits, highlighting the invasion risk of lower river reaches.

Table 4.3: Positive INNS field survey results

Species	Group	Non-native status	Method	Nene		Welland		SFFD		Witham	
				1	2	3	4	5	6	7	8
Demon shrimp *Dikerogammarus haemobaphes*	Invertebrate	UKTAG High	Physical		✓					✓	✓
Indian balsam *Impatiens glandulifera*	Flowering plant	UKTAG High	Physical	✓		✓					
Nuttall's waterweed *Elodea nuttallii*	Flowering plant	IAS Sch. 2, UKTAG High	Physical		✓			✓			✓
Water fern *Azolla filiculoides*	Flowering plant	WACA Sch. 9, UKTAG High	Physical							✓	✓
Least duckweed *Lemna minuta*	Flowering plant	UK TAG Unknown	Physical		✓			✓	✓	✓	✓
Red duckweed *Lemna turionifera*	Flowering plant	Non-native	Physical					✓	✓		
Zebra mussel *Dreissena polymorpha*	Invertebrate	UKTAG High	Physical					✓	✓		✓
			eDNA	✓	✓	✓	✓				✓
Bloody red mysid *Hemimysis anomola*	Invertebrate	UKTAG High	Physical						✓		
Asiatic clam *Corbicula fluminea*	Invertebrate	UKTAG High	eDNA							✓	
Caspian mud shrimp *Chelicorophium curvispinum*	Invertebrate	UKTAG Unknown	Physical						✓		✓
Conrad's false mussel *Mytilopsis leucophaeata*	Invertebrate	UK TAG Unknown	eDNA					✓	✓	✓	✓
Sideswimmer *Gammarus tigrinus*	Invertebrate	Non-native	Physical					✓	✓		
Gulf wedge clam *Rangia cuneata*	Invertebrate	Non-native	eDNA						✓		✓
Jenkin's spire shell *Potamopyrgus antipodarum*	Invertebrate	UKTAG Moderate	Physical	✓	✓	✓			✓		
Northern river / Florida crangonyctid *Crangonyx pseudogracilis / floridanus*	Invertebrate	Non-native	Physical	✓	✓		✓				
Crayfish plague *Aphanomyces astaci*	Water mould	UKTAG High	eDNA	✓		✓					

4.5 Screening Against Relevant Legislation

As shown in Table 4.2 and Table 4.3, species listed in the Wildlife and Countryside Act (as amended) 1981 Schedule 9, the EU Invasive Alien Species of Union concern, and the UKTAG list of aquatic alien species are present in all waters being considered for abstraction. This is reflected in the categorisation of all SLR options as presented a high legal risk as defined in this assessment (see Table 4.4). This suggests that any legal risk associated with spreading INNS as currently distributed is similar across all SLR options. This assessment highlights the need for mitigation measures to reduce the risk of spreading these species, and to work closely with regulators to achieve this.

None of the waterbodies likely to be impacted by the SLR are classified as High Status under the WFD. As such, no risk of re-classification due to the presence of UKTAG High Impact INNS was identified. It should be emphasised however that there may still be a risk of deterioration due to other impacts from INNS such as predation and competition, which would require further assessment.

Table 4.4: Risk of contravention of legislation

Legislation	Nene, via pipe to SLR	Nene, via open transfer to SLR	Welland, via pipe to SLR	Welland, via open transfer to SLR	Witham, via pipe to SLR	Witham, via open transfer to SLR	SFFD, via pipe to SLR	SFFD, via open transfer to SLR	Trent via TWAS, then pipe to SLR	Trent via TWAS, then open transfer to SLR	Trent via new pipe, then pipe to SLR	Trent via new pipe, via open transfer to SLR	Trent via new open transfer, then pipe to SLR	Trent via new open transfer, then open transfer to SLR
Wildlife and Countryside Act (as amended) 1981 Schedule 9	High	High	High	High	High	High	High	High	High	High	High	High	High	High
Invasive Non-native Species (Amendment etc.) (EU Exit) Regulations 2019	High	High	High	High	High	High	High	High	High	High	High	High	High	High
Invasive Alien Species (Enforcement & Permitting) Order 2019	High	High	High	High	High	High	High	High	High	High	High	High	High	High
Water Environment (Water Framework Directive) (England and Wales) Directive 2017 – threat to High Status waterbodies only	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
Overall	High	High	High	High	High	High	High	High	High	High	High	High	High	High

4.6 Risk Assessment

The INNS risk scores generated by the tool for each of the SLR options are presented in Table 4.5 below. As determined by the methodology described in Section 3.6.1, cells are coloured according to their percentile within the range of scores (green = ≤33%ile, yellow = 33 - ≤66%ile, red = >66%ile).

Table 4.5: INNS risk scores, ordered from lowest to highest Weighted Risk Score

Source waterbody	Transfer to SLR	Inherent Risk Score	Adjusted Risk Score	Weighted Risk Score
SFFD	Underground pipeline	432	2,808	5,616
River Witham	Underground pipeline	648	4,212	8,424
River Welland	Underground pipeline	648	5,076	10,584
SFFD	Open channel	432	6,188	12,377
River Nene	Underground pipeline	864	6,768	14,112
River Witham	Open channel	648	8,829	18,306
River Welland	Open channel	648	11,421	23,814
River Nene	Open channel	864	15,228	31,752
River Trent via new underground pipeline	Underground pipeline	2,088	58,740	120,168
River Trent via new underground pipeline	Open channel	2,088	63,357	130,050
River Trent via TWAS	Underground pipeline	1,800	74,772	153,288
River Trent via new open channel	Underground pipeline	2,088	79,295	163,244
River Trent via TWAS	Open channel	1,800	79,389	163,170
River Trent via new open channel	Open channel	2,088	83,912	173,126

Inherent Risk Scores, which are based purely on aspects of Pathway Distance, Frequency and Volume, ranged widely from 432 for abstraction from the SFFD, to 2,088 for abstraction via newly created channels from the River Trent. This reflects that the lowest risk is associated with a transfer from within the bounds of a WFD Management Catchment, whilst the highest risk is associated with creating a new transfer from the River Trent to the River Witham.

Adjusted Risk Scores take account of Exacerbating Factors and Mitigation Options, and within the tool generated a slightly different ranking to the Inherent Risk Scores. The scores ranged from a low of 2,808 for abstraction from the SFFD by an underground pipeline, to a high of 83,912 for abstraction from the Trent-to-Witham, and Witham-to-SLR by new open channels. The conveyance of raw water by either an open channel or underground pipeline had a significant impact on the results, as indicated by the lowest three scores being based upon an underground pipeline transfer.

In calculating the Adjusted Risk Scores it was assumed that only boats and equipment hired on site would be permitted. However, recreational users may use boats and other equipment on the River Witham that have been used elsewhere. This was accounted for when assessing the risk presented by recreational activities by applying a high multiplier score to the Trent-to-Witham transfer options, which influenced the relatively high scores for Trent-to-Witham transfer.

The Weighted Risk Score is largely determined by the WFD UKTAG impact level of species present in source waters. Species from the same four functional groups were identified in the field and desk study data for the Nene, Welland, Witham and Trent Lower and Erewash WFD Management Catchments: (1) aquatic plant spread by fragments; (2) riparian plant spread by seed or fragments; (4) free swimming fish; and (5) freely mobile invertebrate.

Crayfish plague (functional group 6; high impact) was also found in the Nene and Welland Management Catchments through eDNA analysis of raw water samples.

Only three functional groups were identified in records for the SFFD WFD Operational Catchment: (1) aquatic plant spread by fragments; (2) riparian plant spread by seed or fragments; and (5) freely mobile invertebrate. In all catchments, high impact INNS were identified for each of the functional groups present. Given the similarity of input data to the Weighted Risk Score calculation between transfer options, the ranking of scores was the same as for Adjusted Risk Score. The SFFD underground pipeline scenario had the lowest Weighted Risk Score at 5,616, whilst transfer from the Trent-to-Witham and Witham-to-SLR via new open channels generated the highest score of 173,126.

As aforementioned, abstraction from the Witham to supply the SLR would likely necessitate a raw water transfer from the Trent to the Witham. The results indicate that the least risk would be associated with creating a new underground Trent-to-Witham pipeline to deliver additional water. However, use of the existing TWAS generated similar risk scores, and with appropriate mitigation this may be a viable alternative. As also shown by the Adjusted Risk Score, a new open transfer from the River Trent to the River Witham would carry the greatest risk and need for mitigation. Though pathways exist between the two rivers, it is difficult to quantify the actual risk created by a new channel.

Overall, the results suggest that the most influential factors on risk scores are transfer distance, transfer frequency, how raw water will be conveyed (i.e. open channel or underground pipeline) and recreational activities in the receptor waterbody.

4.7 Mitigation Options

Following the methodology described in Section 3.7, potential mitigation measures as used in the tool are shown in Table 4.6.

Table 4.6: Impact on INNS risk scores due to mitigation measures

Factor	How is raw water conveyed	Mean multiplier	Mean impact %	Benefit
	Exacerbating Factors			
Raw water conveyance	Part length - open channel / river / aqueduct	2.5	+150	1 – Low
	If no open section - tunnel all or part	2	+100	2 – Mod
	If no open or tunnel - overground pipeline all or part	1.5	+50	3 – High
	If no open or tunnel - underground pipeline all or part	1	0	4 – V high
New transfer construction	Lay new overground pipeline	3	+200	0 – None
	Lay new underground pipeline	2	+100	2 – Mod
	Re-valve existing pipework	1.25	+25	3 – High
Storage at transfer destination	Discharge to natural / open / flowing watercourse	2	+100	2 – Mod
	Long term storage in large reservoir	1.5	+50	3 – High
	Short-term storage in bankside storage tank	1.25	+25	3 – High
Navigation	Canal link along all or part of transfer	3	+200	0 – None
	Navigation / boating access along all of transfer route	1.45	+45	3 – High
	Navigation / boating access along part of transfer route	1.22	+22.5	3 – High
	No navigation	1	0	4 – V high
In-water recreational access / navigation at transfer destination	Boats / equip. being brought to & leaving site regularly	1.58	+58.33	2 – Mod
	Boats / equip. being brought to & leaving site occasionally	1.29	+29.17	3 – High
	Only boats / equipment hired on site used	1	0	4 – V high
	No recreational access at transfer destination	1	0	4 – V high
	Equipment being brought to and leaving site regularly	1.21	+20.83	3 – High

Riparian / land-based recreational access at transfer destination	Equipment being brought to and leaving site occasionally	1.1	10	3 – High
	Only equipment hired on site used	1	0	4 – V high
Risk of arrival of 'new' INNS in source	High	2.5	+150	1 – Low
	Medium	1.75	+75	2 – Mod
	Low	1	0	4 – V high
Mitigation Options				
Screening at source (before transfer)	Screens 2mm mesh	0.65	-35	1 – Low
	Screens 3-10mm mesh	0.9	-10	1 – Low
	Screens 11-25mm mesh	0.975	-2.5	1 – Low
	Screens >25mm mesh / bar spacing, no screens or unknown	1	0	0 – None
Screening before discharge to receptor	Screens 2mm mesh	0.65	-35	1 – Low
	Screens 3-10mm mesh	0.9	-10	1 – Low
	Screens 11-25mm mesh	0.97	-2.5	1 – Low
	Screens >25mm mesh / bar spacing, no screens or unknown	1	0	0 – None
Chlorination at source / along transfer route	Continuous chlorination of water at source	0.78	-21.67	1 – Low
	Intermittent chlorination of water at source	0.93	-6.67	1 – Low
Transfer of water direct to WTW process	Transfer of water direct to WTW process (not bankside res)	0	-100	4 – V high
Treatment before discharge to receptor	Two stage treatment (assuming coagulation and filtration)	0	-100	4 – V high
Saltwater barrier	Saltwater barrier, e.g. discharges to estuary or tidal river	0.43	-56.67	2 – Mod
Mitigation operational instruction (OI)	OI written into relevant asset SOP & audits demonstrate adherence	0.5	-50	2 – Mod
	OI written into relevant asset SOP	0.8	-20	1 – Low

The following key points can be drawn from this analysis:

- This methodology indicates that the nature of the transfer has a significant impact on INNS risk. The greatest risk is presented by transfer being designed as a fully open channel, whilst the greatest risk limitation would be achieved with an underground pipeline.
- During the construction phase, the greatest risk reduction would be achieved by re-valving existing pipework, whilst a new overground pipe would present a greater risk than a new underground pipe.
- Transfer of water to a storage reservoir is significantly beneficial in comparison to transfer of raw water to another open watercourse, such as the Trent-to-Witham.
- Navigation access along a transfer has significant risk, which would be exacerbated with the addition of a canal link. Navigation access and other waterbody connections should be carefully considered.
- Boats being moved to and from the transfer destination has a significant impact on risk, and only allowing on-site equipment to be used represents a practical mitigation option which offers a significant risk reduction benefit.
- Controlling riparian recreation may also offer a risk reduction benefit, though this is less pronounced than in-water measures as this measure would apply largely to riparian species.
- The risk of arrival of new INNS species has a significant impact on the risk scores. It is unclear how this could be mitigated, though this highlights the benefits of a holistic approach to INNS risk management across the wider environment.

- Mesh size has an important impact on the effectiveness of screens, with a mesh size of >25mm offering little or no benefit. As they do not work for all life stages, screens alone do not offer a significant benefit, and so should be considered alongside other mitigation measures. A greater benefit may be achieved by using multiple screens in combination, for example at the source before transfer and at the receptor.
- Chlorination alone offers a relatively low benefit in terms of risk reduction due to its limited impact across all functional groups.
- Transfer of water directly to a WTW, or two-stage treatment would be highly effective risk reduction measures, though likely to be highly energy-intensive and costly.
- A saltwater barrier can offer a significant benefit where overflow water can be discharged to saline waters, as most freshwater propagules would not survive. This may be relevant in the context of the SLR due to the proximity of potential locations to saline waters.
- The mitigation measure ‘mitigation operational instruction’ is a generic measure category to capture specific site-specific operational practices in the tool, and may apply to one or multiple functional groups. Its inclusion in the tool alludes to the potential for additional management protocols to be deployed to manage INNS risk, which should be considered through the concept design process.

4.8 Workshop

The key points and actions arising from the INNS workshop held on 15 December 2020 were as follows:

- Early stakeholder and regulator engagement were welcomed at this stage in the RAPID process.
- Transparency of how the multiplier scores which underpin the tool would be welcomed.
- It would be desirable to align INNS risk assessment methodologies being used to assess SROs nationally.
- The benefits of future-proofing the tool and assessment process my focusing on propagule pathways was emphasised. This is accounted for in the tool by the focus on organism functional groups, however the current categorisation would benefit from further development.
- Simplification of the tool outputs, such as a red/amber/green (RAG) system, would make them more easily understood.
- There is extensive connectivity between waterbodies across the region. This may be further complicated by the proposed Boston to Peterborough Wetland Corridor, which would connect the SFFD, River Welland, and River Nene.
- In the case of an open transfer, a more heterogeneous, less heavily engineered channel may be less convenient for amenity value, but more resilient to INNS, and less likely to generate propagules. This mitigation option is not accounted for in the tool used.
- Holistic views of INNS risk management were encouraged, including more focus on monitoring and nutrient management, though it was acknowledged that any rising benefits would be challenging to quantify or build into a risk assessment tool.
- Full water treatment is the benchmark for mitigation to remove all life stages, although prohibitively costly and energy-intensive.
- Quagga mussel and killer shrimp are the two species of greatest concern. Quagga mussel would have the greater operational impact whilst killer shrimp present more of an ecological risk.
- Transfer of a Wildlife and Countryside Act (WACA) Schedule 9 species may present a legal risk. Quagga mussel are not named in WACA Schedule 9, though they would likely

constitute a species 'not ordinarily resident in' and 'not a regular visitor to Great Britain in a wild state.'

- It may be unhelpful to consider INNS as a 'showstopper' for any option prior to Gate 1 of the RAPID process (July 2021), as further investigation may reveal that the risk can be sufficiently mitigated.
- When potential assessing impacts on designated sites, threats to interest features should be the foremost consideration.

5 Conclusions and Recommendations

5.1 Conclusions

5.1.1 High-level screening

Risk assessment results are summarised in Table 5.1 below. The following conclusions are drawn from this assessment:

- All SLR options assessed have existing man-made connections to other catchments via Canal and River Trust canals. This necessitates an INNS risk assessment, which the EA will use to decide whether subsequent mitigation is required, to ensure the risk of INNS transfer is not significantly increased.
- All potential source waters contain either named or implied by description in key legislation designed to reduce the spread of INNS. All options being assessed therefore present a legal risk with regards to their transfer to other waterbodies, which will need to be addressed through mitigation measures.
- No threat of re-classification of High Status WFD waterbodies due to the spread of UKTAG High Impact species was identified, though deterioration of elements could be caused by the spread of INNS.
- Using a previous heatmap study (Gallardo and Aldridge, 2012) based on climate, water chemistry, and altitude as a proxy for future invasion, all potential source waterbodies were found to have a moderate risk of future invasion by Ponto-Caspian species.
- Using a previous heatmap study (Cefas, 2014) which mapped potential marine INNS pathway intensity, the Rivers Nene and Welland were found to have a moderate Marine Invasion Risk. This was lower than for the River Witham, SFFD and Trent options, for which the Marine Invasion Risk was assessed as High. This, however, was a precautionary assessment based on the risk associated with the Humber estuary, and its connection to the SFFD and River Witham via the lower Trent and Fossdyke Canal.

Table 5.1: INNS assessment results summary

	SLR Option													
INNS risk element	Nene, via pipe to SLR	Nene, via open transfer to SLR	Welland, via pipe to SLR	Welland, via open transfer to SLR	Witham, via pipe to SLR	Witham, via open transfer to SLR	SFFD, via pipe to SLR	SFFD, via open transfer to SLR	Trent via TWAS, then pipe to SLR	Trent via TWAS, then open transfer to SLR	Trent via new pipe, then pipe to SLR	Trent via new pipe, via open transfer to SLR	Trent via new open transfer, then pipe to SLR	Trent via new open transfer, then open transfer to SLR
Isolated Catchment	No	No	No	No	No	No	No	No	No	No	No	No	No	No
Legislation	High	High	High	High	High	High	High	High	High	High	High	High	High	High
Freshwater Invasion Risk	Mod	Mod	Mod	Mod	Mod	Mod	Mod	Mod	Mod	Mod	Mod	Mod	Mod	Mod
Marine Invasion Risk	Mod	Mod	Mod	Mod	High	High	High	High	High	High	High	High	High	High
Inherent Risk %ile	Mod	Mod	Low	Low	Low	Low	Low	Low	Mod	Mod	High	High	High	High
Adjusted Risk %ile	Mod	Mod	Low	Mod	Low	Mod	Low	Low	High	High	Mod	High	High	High
Weighted Risk %ile	Mod	Mod	Low	Mod	Low	Mod	Low	Low	High	High	Mod	High	High	High

5.1.2 Comparison of SLR options

- Inherent Risk Scores indicate that the lowest risks are associated with using the SFFD as a source, followed by the Rivers Witham, Welland and Nene, based primarily on the likely distance to the reservoir. This assessment indicates that abstraction from the Trent presents the greatest risk, due to the transfer of water between river catchments.
- Adjusted Risk Scores reflect that a greater risk is associated with an open transfer between the source waterbody and reservoir, as opposed to an underground pipeline. Options ranked by this score place SLR options from the lowest risk associated with filling the SLR from the SFFD via an underground pipeline, through to the highest risk being associated with filling the reservoir from the Trent via new open transfers.
- Weighted Risk Scores, pulling in additional information on species and habitat distribution, results in an identical risk ranking. This suggests that the distribution of INNS, protected species and sites do not have a significant bearing on the differentiation of SLR options.

5.1.3 Mitigation

- The mitigation analysis indicated that scheme design will have a significant impact on overall risk, particularly in terms of open-ness of the transfer and recreational use. However, it also showed that there is significant potential to mitigate this risk through measures such as control of equipment movement between the transfer, reservoir, and wider environment.
- This analysis indicated that individual measures to reduce INNS risk may not have significant effects as they would be limited in their impacts on the full range of life stages and functional groups. Reductions in risk scores of >50% are only likely using combinations of mitigation measures.
- Only relatively fine screens of ≤2mm mesh are likely to have a significant impact on INNS risk, and would ideally be placed at the connections between the source and transfer, and transfer and reservoir.
- Consideration of appropriate mitigation should ideally be a continual process which evolves alongside concept design.

5.2 Recommendations

5.2.1 Future tool development

- Following consultation with the EA, it is recommended that a single tool be used for assessing SRO INNS risk. Such a tool would need to be developed collaboratively between the EA and water industry.
- An expanded and preferably standardised selection of mitigation measures should be incorporated into the tool.
- It would be beneficial if a revised tool was able to account for any benefits of open transfers being more heterogeneous, less heavily engineered channel may be less convenient for amenity value, but more resilient to INNS, and therefore less likely to generate INNS propagules.
- An improved understanding of the cost-benefit of mitigation options will be needed, preferably facilitated by development of a cost-benefit model. This may draw upon the benefit categorisation methodology used in this assessment.
- Any tool which is devised for assessing all SROs should be accompanied with guidance to ensure its consistent and transparent use.
- Any tool or assessment technique must adequately account for construction phase as well as operational phase risks.

5.2.2 Future assessment work

- The INNS risk assessment should be updated for remaining SLR options, as refined through the RAPID process, between Gate 1 and 2 (July 2021 to July 2022).
- The updated risk assessment should be informed by a refreshed INNS data search, due to the ability of some species to rapidly disperse and colonise new habitats.
- Future impact assessments should be informed by up-to-date baseline fish, macroinvertebrate, macrophyte surveys across a network of sites covering all potentially impacted waterbodies. Any required surveys should be undertaken to inform RAPID Gate 2 submission, with data collected and analysed by July 2022.
- It is recommended that ecological surveys are supplemented with further targeted eDNA sampling focusing on high-impact INNS, prior to Gate 2 submission.
- Future impact assessments should be undertaken using GIS to spatially represent all relevant information in order to fully understand potential interactions between abstraction and INNS. For example, this should include information such as INNS records, monitoring sites, structures, predicted changes in salinity or nutrient concentration, habitat connectivity, protected species records, and protected sites. This approach should enable relationships between INNS and other impacts to be understood and assessed.
- An improved understanding of the legal risks, and an assessment technique which could be consistently applied across all SRO INNS risk assessments would be beneficial. This should be agreed with the regulators.

6 References

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