Thames to Affinity Transfer

Technical Supporting Document B1b

Environmental Appraisal Report

Beckton Reuse Indirect Option

Notice

Position Statement

- This document has been produced as the part of the process set out by RAPID for the development of the Strategic Resource Options (SROs). This is a regulatory gated process allowing there to be control and appropriate scrutiny on the activities that are undertaken by the water companies to investigate and develop efficient solutions on behalf of customers to meet future drought resilience challenges.
- This report forms part of a suite of documents that make up the 'Gate 2 submission.' That submission details all the work undertaken by Thames Water and Affinity Water in the ongoing development of the proposed SROs. The intention of this stage is to provide RAPID with an update on the concept design, feasibility, cost estimates and programme for the schemes, allowing decisions to be made on their progress and future funding requirements.
- Should a scheme be selected and confirmed in the companies' final Water Resources Management Plan, in most cases it would need to enter a separate process to gain permission to build and run the final solution. That could be through either the Town and Country Planning Act 1990 or the Planning Act 2008 development consent order process. Both options require the designs to be fully appraised and in most cases an environmental statement to be produced. Where required that statement sets out the likely environmental impacts and what mitigation is required.
- Community and stakeholder engagement is crucial to the development of the SROs. Some high level activity has been undertaken to date. Much more detailed community engagement and formal consultation is required on all the schemes at the appropriate point. Before applying for permission Thames Water and Affinity Water will need to demonstrate that they have presented information about the proposals to the community, gathered feedback and considered the views of stakeholders. We will have regard to that feedback and, where possible, make changes to the designs as a result.
- The SROs are at a very early stage of development, despite some options having been considered for several years. The details set out in the Gate 2 documents are still at a formative stage and consideration should be given to that when reviewing the proposals. They are for the purposes of allocating further funding not seeking permission.

Disclaimer

This document had been written in line with the requirements of the RAPID Gate 2 Guidance and to comply with the regulatory process pursuant to Thames Water's and Affinity Water's statutory duties. The information presented relates to material or data which is still in the course of completion. Should the solution presented in this document be taken forward, Thames Water and Affinity Water will be subject to the statutory duties pursuant to the necessary consenting process, including environmental assessment and consultation as required. This document should be read with those duties in mind.

Contents

Tables

Glossary

Term	Definition
Agricultural Land Classification (ALC)	ALC provides a framework for classifying land according to the extent to which its physical or chemical characteristics impose long-term limitations on agricultural use. It classifies agricultural land in five categories according to versatility and suitability for growing crops: • Grade 1 – excellent quality agricultural land • Grade 2 – very good quality agricultural land • Grade 3 – split into Subgrade 3a of good quality agricultural land, and Subgrade 3b of moderate quality agricultural land • Grade 4 – poor quality agricultural land • Grade 5 – very poor quality agricultural land Grades 1, 2 and 3a are classed as best and most versatile (BMV) and greater consideration of these soil resources are made during planning applications.
Ancient and veteran trees	An ancient tree is one that has passed beyond maturity and is old, or aged, in comparison with other trees of the same species. Veteran is a term describing a tree with habitat features such as wounds or decay. All ancient trees are veteran, but not all veterans are old enough to be ancient. An ancient tree is exceptionally valuable. Attributes include its: 1) great age; 2) size; 3) condition; 4) biodiversity value as a result of significant wood decay and the habitat created from the ageing process; 5) cultural and heritage value. (Sources: https://www.gov.uk/guidance/ancient-woodland-ancient-trees-and-veteran-trees-advice-for-making-planning-decisions and https://www.woodlandtrust.org.uk/media/1836/what-are-ancient-trees.pdf)
Ancient Tree Inventory	An inventory database of ancient, veteran, and notable trees identified across the UK.
Ancient Woodland	Any area that's been wooded continuously since at least 1600 AD, or a date otherwise specified by the Overseeing Organisation including: 1) ancient semi-natural woodland mainly made up of trees and shrubs native to the site, usually arising from natural regeneration plantations on ancient woodland sites; 2) replanted with conifer or broad-leaved trees that retain ancient woodland features, such as undisturbed soil, ground flora and fungi; 3) wood pastures identified as ancient;

Term	Definition
	4) historic parkland, which is protected as a heritage asset in the relevant planning policy. (Source: https://www.gov.uk/guidance/ancient-woodland-ancient-trees-and-veteran-trees-advice-for-making-planning-decisions)
Area of Outstanding Natural Beauty (AONB)	Land protected by the Countryside and Rights of Way Act 2000 on account of factors such as landscape or scenic quality, relative wildness or tranquillity, and / or natural or cultural heritage features. It protects the land to conserve and enhance its natural beauty. (Source: Natural England)
Background noise level	Prevailing noise level in a specified environment measured in the absence of the noise being studied
Baseline data	Data used to describe the current conditions of the environment, against which future predictions can be made.
Benefits	Positive impacts on wellbeing.
Best and Most Versatile (BMV)	Defined as Grades 1, 2 and 3a by policy guidance. This is the land which is most flexible, productive and efficient in response to inputs and which can best deliver future crops.
Biodiversity Net Gain (BNG)	Biodiversity Net Gain is an approach to development that leaves biodiversity in a measurably better state than before.
Carbon Sequestration	The uptake and storage of carbon, for instance by absorption of carbon dioxide by trees and plants which then release the oxygen.
Conceptual Model (CM)	A written or pictorial representation of sources, pathways, and receptors at potentially contaminated sites, in line with LCRM guidance.
Conservation Area	Defined by the Planning (Listed Buildings and Conservation Areas) Act 1990 as an area 'of special architectural or historic interest, the character of which it is desirable to preserve or enhance'.
Construction	Any activity involved with the provision of a new structure (or structures), its modification or refurbishment. A structure will include a residential dwelling, office building, retail outlet, road, etc.
Construction Environmental Management Plan (CEMP)	A document which sets out site-specific procedures and mitigation measures to monitor and control environmental impacts throughout the construction phase of the project.

Term	Definition
Contaminated land	Defined in Part 2A of the Environmental Protection Act 1990 as land where significant harm is being caused or there is a significant possibility of such harm being caused; or significant pollution of controlled waters is being or is likely to be caused.
Disbenefits	Negative impacts on wellbeing.
Discounting	A method for translating future costs or benefits into present values using a discount rate.
Dust	Solid particles that are suspended in air or have settled out onto a surface after having been suspended in air. The terms dust and particulate matter (PM) are often used interchangeably, although in some contexts one term tends to be used in preference to the other. In this assessment the term 'dust' has been used to include the particles that give rise to soiling, and to human health (i.e. PM_{10} or $PM_{2.5}$) and ecological effects. Note: this is different from the definition given in BS 6069-2:1994, where dust refers to particles up to 75µm in diameter.
Earthworks	Covers the processes of soil-stripping, ground-levelling, excavation and landscaping.
Ecosystem	A dynamic complex of living things (animals, plants and micro-organisms) and their physical environment interacting as a functional unit.
Ecosystem Services	Functions of the natural environment, that directly or indirectly provide benefits for people.
Environmental Impact Assessment (EIA)	Statutory process under e.g. Town and Country Planning (EIA) Regulations 2017 (as amended), consisting of: 1. Preparation of an Environmental Statement 2. Consultation 3. Examination by the competent authority of the information contained within the Environmental Statement 4. The reasoned (justified or evidenced) conclusion by the competent authority on the significant effects of the project on the environment 5. The reasoned (justified or evidenced) decision by the competent authority to grant or refuse development consent.
Eutrophic	Rich in organic and mineral nutrients and supporting an abundant plant life, which in the process of decaying depletes the oxygen supply for animal life.
GDP (Gross Domestic Product)	The value of output or national income of a country over a 12 month period.
GDP Deflator	An index of the general price level in the economy, measured by the ratio of Gross Domestic Product (GDP) in nominal terms to GDP at constant prices.

Term	Definition
Habitat	A place where an organism or community of organisms normally live.
Heavy Duty Vehicle (HDV)	Goods vehicles and buses greater than 3.5 tonne (t) gross vehicle weight.
Historic Landscape Character	Historic Landscapes are defined by perceptions that emphasise the evidence of the past and its significance in shaping the present landscape. The definition encompasses all landscapes, including the countryside, townscapes and industrial landscapes as well as designed landscapes, such as gardens and parks.
Key characteristics (landscape)	The elements or combination of elements that are particularly important to the current distinctive character of the landscape and help to give an area its particularly distinctive sense of place. (Source: GLVIA3)
LAeq	A steady noise level (weighted) which over a period of time has the same sound energy as the time varying noise
Landscape Character	A distinct, recognisable and consistent pattern of elements in the landscape that makes one landscape different from another, rather than better or worse. (Source: GLVIA3)
Landscape Character Area (LCA)	A discrete geographical area of a particular landscape type. (Source: GLVIA3)
Landscape Character Assessment	Process of identifying and describing variation in character of the landscape - the unique combination of elements and features that make landscapes distinctive - to assist in managing change in the landscape. (Source: GLVIA3)
Landscape Value	Relative value or importance attached to different landscapes by society on account of their landscape qualities, including natural and cultural heritage, landscape condition, associations, distinctiveness, recreational value, perceptual value (scenic/wildness and tranquillity) and functionality. (Source: GLVIA3 and Landscape Institutes Technical Guidance Note; TGN 02/21 'Assessing landscape value outside national designations')
Light Duty Vehicle (LDV)	Cars and small vans less than 3.5t gross vehicle weight.
Listed building	A building or structure designated under section 69 of the Planning (Listed Building and Conservation Areas) Act 1990 as being of 'special architectural or historic interest'.

Term	Definition
Mineral Safeguarding Areas (MSA)	Areas of known mineral resources that are of sufficient economic or conservation value (such as building stones) to warrant protection for generations to come.
National Nature Reserve (NNR)	A statutory designation afforded to land declared under the National Parks and Access to the Countryside Act 1949 or Wildlife and Countryside Act (1981), as amended, and include some of the best examples of wildlife and geology.
National Planning Policy Framework (NPPF)	Sets out the Government's economic, environmental and social planning policies. A revised National Planning Policy Framework was published by the Ministry of Housing, Communities and Local Government in July 2021 which replaced the previous NPPF published in March 2012 and revised in February 2019.
Natural Capital	Stocks of the elements of nature that have value to society, such as forests, fisheries, rivers, biodiversity, land and minerals. Natural capital includes both the living and non-living aspects of ecosystems. Stocks of natural capital provide flows of environmental or 'ecosystem' services over time. These services, often in combination with other forms of capital (human, produced and social) produce a wide range of benefits
Particulate matter	Airborne particulate matter is made up of a collection of solid and/or liquid materials of various sizes that range from a few nanometres in diameter (about the size of a virus) to around 100 microns (about the thickness of a human hair).
Phase 1 habitat survey	The Phase 1 habitat classification and methodology is a widely used and industry accepted technique for habitat survey across the UK.
PM_{10}	Particulate matter with an aerodynamic diameter of 10 microns or less.
$PM_{2.5}$	Particulate matter with an aerodynamic diameter of 2.5 microns or less.
Present Value	The sum of a stream of future values discounted at an appropriate discount rate (such as the Green Book social discount rate) to bring them to today's value.
Public Right of Way (PRoW)	A public right of way is a right by which the public can pass along linear routes over land at all times. Although the land may be owned by a private individual, the public have a legal right across that land along a specific route. (Source: https://www.devon.gov.uk/prow/what-are-public-rights-of-way/_
Replacement Cost	The cost of providing a substitute good or engineering solution that performs a similar function to the environmental good. For example, wetlands that provide flood protection may be valued on the basis of the cost of building man-made defences of equal effectiveness. Since wetlands provide a range of

Term	Definition
	ecosystem services, this costing would be a minimum estimate of the value of a wetland.
Risk	The likelihood of an adverse event occurring.
Scheduled Monument	A monument which has been scheduled is protected against disturbance. The Secretary of State must be informed about any work which might affect a monument above or below ground, and English Heritage gives advice to the Government on each application. In assessing each application, the Secretary of State will try to ensure that damage done to protected sites is kept to a minimum.
Sensitivity	Term applied to specific receptors, combining judgements of the susceptibility of the receptor to specific type of change proposed and the value related to that receptor. (Source: GLIVA3)
Setting	Contribution of the surroundings to the appearance of an area or feature and the interrelationship of the area or feature to the wider context and sense of place. (Source: LA107)
Silencer	A device used for reducing noise within air and gas flow systems. Can be fitted to exhausts of construction plant
Site of Special Scientific Interest (SSSI)	Sites of Special Scientific Interest represent the best examples of habitats present within the UK, and the designation provides statutory protection and a duty for the landowner to maintain the habitats
Special Area of Conservation (SAC)	Special Areas of Conservation are strictly protected sites designated under the EC Habitats Directive.
Study area	Study areas are used to define the spatial extent of environmental assessments. Each environmental factor defines its own study area(s) individually, taking account of relevant guidance.
Susceptibility	Ability of a defined landscape or visual receptor to accommodate the specific proposed change without negative consequences. (Source: GLIVIA3)
Visual amenity	Overall enjoyment of a particular area, surroundings, or views in terms of people's activities - living, recreating, travelling through, visiting, or working. (Source: GLIVIA3)
Visual receptor	Individuals and/or defined groups of people who potentially could be affected by a project.

Term	Definition
	(Source: GLIVIA3)
World Heritage Site	A site which has been listed by the United Nations Educational, Scientific and Cultural Organization (UNESCO) due to its cultural or physical significance.
Zone of theoretical visibility (ZTV)	Map produced (usually digitally) to specific criteria to illustrate the area(s) from which a project can theoretically be visible. (Source: GLIVIA3)

Abbreviations

Abbreviation	Full term
AA	Appropriate Assessment
ACWG	All Companies Working Group
AEP	Annual Probability Event
ALC	Agricultural Land Classification
AOD	Above Ordnance Datum
AONB	Area of Outstanding Natural Beauty
APA	Archaeological Priority Area
AQMA	Air Quality Management Area
BAP	Biodiversity Action Plan
BEIS	Business, Energy and Industrial Strategy
BGS	British Geological Survey
BOA	Biodiversity Opportunity Areas
BMERC	Buckinghamshire and Milton Keynes Environmental Records Centre
BMV	Best and Most Versatile
BNG	Biodiversity Net Gain
BPM	Best Practicable Means
BRC	Biological Record Centres

Abbreviation	Full term
BS	British Standard
BU	Biodiversity Units
CAZ	Clean Air Zone
CCD	Check, clean, dry
CCRA	Climate Change Risk Assessment
CEH	Centre for Ecology and Hydrology
CEMP	Construction Environmental Management Plan
CIRIA	Construction Industry Research and Information Association
CM	Conceptual Site Model
CO_2	Carbon Dioxide
CRT	Canal and River Trust
cSAC	Candidate Special Area of Conservation
DBA	Desk-Based Assessment
Defra	Department for Environment, Food and Rural Affairs
DI	Ductile Iron
DRA	Direct River Abstraction
EAR	Environmental Appraisal Report
ECoW	Ecological Clerk of Works
EIA	Environmental Impact Assessment
ELMS	Environmental Land Management System
EMS	Environmental Management System
ENCA	Enabling a Natural Capital Approach guidance
EPA	Environmental Protection Act
EPUK	Environmental Protection UK
EU	European Union
GCN	Great Crested Newts
GDP	Gross Domestic Product
GiGL	Greenspace Information for Greater London

Abbreviation	Full term
GIS	Geographical Information System
GHG	Greenhouse Gas
GLHER	Greater London Historic Environment Record
GLVIA3	Guidelines for Landscape and Visual Impact Assessment Third Edition
GRP	Glass Fibre Reinforced Plastic
GVA	Gross Value Added
GWDTE	Groundwater Dependant Terrestrial Ecosystem
HDV	Heavy Duty Vehicle
HGV	Heavy Goods Vehicles
HER	Historic Environment Record
HERC	Hertfordshire Environmental Records Centre
HRA	Habitats Regulations Assessment
IAQM	Institute of Air Quality Management
IEMA	Institute of Environmental Management and Assessment
IMD	Index of Multiple Deprivation
INNS	Invasive Non-Native Species
JNCC	Joint Nature Conservation Committee
LAQM	Local Air Quality Management
LCRM	Land Contamination Risk Management
LCA	Landscape Character Area
LDV	Light Duty Vehicle
LFRMS	Local Flood Risk Management Strategy
LLFA	Lead Local Flood Authority
LNP	Local Nature Partnership
LNR	Local Nature Reserve
LOAEL	Lowest Observed Adverse Effect Level
LSOA	Lower Layer Super Output Areas
LWS	Local Wildlife Site

Abbreviation	Full term
NaFRA	National Flood Risk Assessment
NAP	National Adaption Programme
NAU	National Appraisal Unit
NBN	National Biodiversity Network
NC	Natural Capital
NCA	Natural Capital Assessment
NCN	National Cycle Network
NEP	Natural Environment Partnership
NERC	Natural Environment and Rural Communities
NEVO	Natural Environment Valuation Online tool
NFM	Natural Flood Management
NHLE	National Heritage List for England
NNR	National Nature Reserve
NOEL	No Observed Effect Level
NOx	Oxides of Nitrogen
NO_2	Nitrogen Dioxide
NPPF	National Planning Policy Framework
NPS	National Policy Statement
NPSE	National Policy Statement for England
NRMM	Non-Road Mobile Machinery
NRN	Nature Recovery Network
NWG	Northumbrian Water Group
ONS	Office for National Statistics
ORVal	Outdoor Recreational Valuation
OS	Ordnance Survey
PEA	Preliminary Ecological Appraisal
PPG	Pollution Prevention Guidance
PM	Particulate Matter

Abbreviation	Full term
PPE	Personal Protective Equipment
PROW	Public Right of Way
pSPA	Potential Special Protection Area
PTAL	Public Transport Accessibility Level
RAPID	Regulators' Alliance for Progressing Infrastructure Development
REGO	Renewable Energy Guarantees of Origin
RIGS	Regionally Important Geological Sites
RMNI	River Macrophyte Nutrient Index
RPA	Root Protection Area
RSBP	Royal Society for Protection of Birds
RWT	Raw Water Transfer
SAC	Special Area of Conservation
SAI-RAT	SRO Aquatic INNS Risk Assessment Tool
SEA	Strategic Environmental Assessment
SEPA	Scottish Environment Protection Agency
SESRO	South East Strategic Reservoir Option
SFRM	Strategic Flood Risk Management
SINC	Sites of Importance for Nature Conservation
SOAEL	Significant Observed Adverse Effect Level
SPA	Special Protection Area
SPZ	Source Protection Zone
SRN	Strategic Route Network
SRO	Strategic Resource Options
SSSI	Site of Special Scientific Interest
STT	Severn Thames Transfer
STW	Sewage Treatment Works
SuDs	Sustainable Drainage Systems
SWMP	Surface Water Management Plan

Abbreviation	Full term
T2AT	Thames to Affinity Transfer
TfL	Transport for London
TPO	Tree Preservation Orders
TVERC	Thames Valley Environmental Records Centre
UK	United Kingdom
UK Hab	UK Habitat Classification
UKTAG	UK Technical Advisory Group
WACA	Wildlife and Countryside Act 1981
WFD	Water Framework Directive
WRMP	Water Resources Management Plan
WRSE	Water Resources South East
WTW	Water Treatment Works
ZoI	Zone of Influence
ZTV	Zone of Theoretical Visibility

Executive summary

Introduction

The Environment Assessment Report (EAR) is a technical supporting document prepared to support the Gate 2 submission report to the Regulators' Alliance for Progressing Infrastructure Development (RAPID) for the Thames to Affinity Transfer (T2AT) Strategic Resource Option (SRO).

This EAR presents the environmental appraisal work for the Beckton Reuse Indirect Option and has been informed by desk based assessments using publicly available information in line with the requirements of the Gate 2 submission. The work is at a preliminary stage and establishes an initial appraisal that can be built on during subsequent project stages. In future, this will also be informed by the undertaking of site surveys and collection of additional information and data that will inform an Environmental Impact Assessment (EIA) likely to be required as part of any future consenting process.

This EAR does not definitively scope potential environmental effects in or out at this stage and the recommendations for further technical work outlined within this EAR are subject to change as further information becomes available at subsequent project stages. Future work will be carried out in conjunction with relevant stakeholders to inform the approach to the EIA.

The details set out in this EAR are still at a formative stage and consideration should be given to that when reviewing the proposals. They are for the purposes of making decisions on progress and further funding not seeking permission.

Overview of the Beckton Reuse Indirect Option

The Beckton Reuse Indirect Option involves the abstraction of raw water from the River Lee flood relief channel and transfer to a new WTW, followed by conveyance of the drinking water produced to an existing service reservoir in the vicinity of Brookmans Park and directly into the existing drinking water transfer network. A proportion of the water would then be able to flow under gravity to the existing booster pumping station in the vicinity of North Mymms. Whilst a proportion of the raw water may arise naturally in the River Lee catchment, in terms of water resources the scheme would depend on the indirect transfer

of recycled water from the Beckton Water Recycling option of the London Effluent Reuse SRO. The proposed abstraction point would be located on the River Lee flood relief channel, downstream of the outfall from the Beckton Water Recycling option of the London Effluent Reuse SRO.

The key components of the Beckton Reuse Indirect Option are summarised below.

- An intake and raw water pumping station (within this report referred to as 'River Lee Intake' and 'Raw Water Pumping Station'). The indicative location identified for the River Lee Intake is referred to as 'Indicative Intake Location' and the indicative site identified for the Raw Water Pumping Station is referred to as the 'Indicative Raw Water Pumping Station Site.'
- A raw water transfer pipeline to a new WTW (within this report referred to as the 'Raw Water Transfer Main'). The indicative route corridor identified for the Raw Water Transfer Main is referred to as the 'Raw Water Transfer Main Route Corridor'.
- A new WTW (within this report referred to as the 'new WTW') to the north of the River Lee Intake (within this report referred to as the 'Indicative WTW Site').
- A drinking water transfer pipeline from the new WTW to an existing service reservoir in the vicinity of Brookmans Park (within this report referred to as the 'Drinking Water Transfer Main'). The indicative route corridor identified for the Drinking Water Transfer Main is referred to as the 'Drinking Water Transfer Main Route Corridor'.
- A connection to a service reservoir in the vicinity of Brookmans Park (within this report referred to as the 'Brookmans Park Service Reservoir Connection').
- A drinking water transfer pipeline from the Brookmans Park Service Reservoir to a booster pumping station in the vicinity of North Mymms (within this report referred to as the 'Drinking Water Transfer Main to North Mymms'). The indicative route corridor identified for the Drinking Water Transfer Main to North Mymms is referred to as the 'Drinking Water Transfer Main to North Mymms Route Corridor'.
- A connection to an existing booster pumping station in the vicinity of North Mymms (within this report referred to as the 'North Mymms Booster Station Connection').

A more detailed scheme description is provided in Technical Supporting Document A1b, Concept Design Report.

Informal regulatory assessments

Three informal regulatory assessments have been completed for the Beckton Reuse Indirect Option. The informal Habitats Regulations Assessment (HRA) and Water Framework Directive (WFD) compliance assessment are summarised in this report and presented as separate Technical Supporting Documents (B2 and B3 respectively). The Strategic Environmental Assessment (SEA) prepared for the Water Resources South East (WRSE) Regional Plan has also been reviewed in light of the design development at Gate 2, and desk based assessment work undertaken across the topics, with updates to the assessment presented in Technical Supporting Document B4, Strategic Environmental Assessment Review.

Habitats Regulations Assessment

The HRA Stage 1 Screening Assessment identified the potential for Likely Significant Effects on the Lee Valley Special Protection Area (SPA), Lee Valley Ramsar site and Wormley Hoddesdonpark Woods SAC due to potential hydrological connection and risk of pollution events during construction. The HRA Stage 2 Appropriate Assessment (AA) for these sites concluded that with the use of best practice control measures there would be no adverse effects on the integrity of these sites.

As no residual effects are expected from the implementation of this option, an in-combination assessment is not required for the Beckton Reuse Indirect Option. As the option progresses, this should be reviewed and if residual effects are identified, the option should go through an in-combination effects assessment as part of a formal HRA will be completed pursuant to the consenting stage.

Water Framework Directive Compliance Assessment

As a result of the WFD Level 1 – basic screening assessment, one surface water body was carried through to the Level 2 – detailed impact assessment: Lea Navigation Enfield Lock to Tottenham Locks. The Level 2 assessment determined that impacts associated with the new or increased surface water abstraction do not have the potential to deteriorate the WFD elements of the Lea Navigation Enfield Lock to Tottenham Locks water body or prevent it from attaining Good status in the future. All other waterbodies were determined to have an impact score of less than 1 and were scoped out of further assessment at the Level 1 stage. Therefore, at this stage, the Beckton Reuse Indirect Option is considered to be compliant with the WFD.

Strategic Environmental Assessment Review

Technical Supporting Document B4, Strategic Environmental Assessment Review, presents an update to the SEA level option assessment prepared by WRSE, in-line with the methodology in the WRSE Regional Plan Environmental Assessment Methodology Guidance[1]. This involved the identification of potential effects for each SEA objective at both the construction and operational phases, pre and post mitigation, with each SEA objective scored against an eight-point scale.

Major positive effects were identified for the SEA objective on delivering reliable and resilient water supplies given the Beckton Reuse Indirect Option improves the transfer of water across regions.

Major negative effects (pre-mitigation) and moderate negative effects (post-mitigation) were identified for biodiversity, flora and fauna for the construction of the Beckton Reuse Indirect Option as the Indicative Intake Location is located within the Chingford Reservoir SSSI.

Carbon would be generated as a result of construction as well as during operation. The SEA identified minor negative effects associated with carbon emissions during the construction phase and moderate negative effects during the operational phase.

Moderate negative effects (pre-mitigation) and minor negative effects (post-mitigation) were also identified for the construction phase for the SEA objective on soil given the potential for disturbance and permanent loss of agricultural land (Grade 3) and there is potential for disturbance of contaminants given the Beckton Reuse Indirect Option intersects or is within close proximity to historic and authorised landfill sites. The construction phase also has the potential to cause disruption to material assets therefore moderate negative effects (pre-mitigation) and minor negative effects (post-mitigation) identified.

The Beckton Reuse Indirect Option passes through Air Quality Management Areas (AQMAs) with moderate negative effects (pre-mitigation) and minor negative effects (post-mitigation) identified for the SEA objective on air quality at the construction phase. Given the Beckton Reuse Indirect Option passes through community or recreational facilities, moderate negative effects (pre-mitigation) and minor negative effects (post-mitigation) were identified for both objectives related to population and human health at the construction phase.

[1] Mott MacDonald (2020). Water Resources South East (WRSE) Regional Plan Environmental Assessment Methodology Guidance. https://www.wrse.org.uk/media/lb0g0tsr/wrse_file_1347_wrse-regional-plan-environmental-assessment-methodology-guidance.pdf [Accessed April 2022]

For the SEA objective on flood risk, the Beckton Reuse Indirect Option is identified to have moderate negative effects (pre-mitigation) and minor negative effects (post-mitigation) for both the construction and operational phases given the locations of elements of the option within Flood Zone 2 and 3.

Minor negative or neutral effects were identified for the remaining SEA objectives.

Mitigation measures to prevent, reduce or off-set adverse environmental effects have been identified as part of the SEA. These measures do not always completely eliminate effects or result in the downgrading of effects, from moderate to minor for example, however, if implemented, they would contribute to reducing the effects identified for the SEA objective.

It is recommended that the environmental assessment information from the SEA is fed into the WRSE Regional Plan and the Thames Water and Affinity Water WRMP24s (Water Resource Management Plan 24) so that the Beckton Reuse Indirect Option is more appropriately assessed for SEA purposes as part of the SEA for the WRMP24s and WRSE Regional Plan.

Environmental appraisal outcomes by topic

Biodiversity, flora and fauna

Terrestrial ecology

The Beckton Reuse Indirect Option has the potential to directly impact Chingford Reservoir Site of Special Scientific Interest (SSSI) and the Lea Valley Important Bird Area and indirectly affect Northaw Great Woods SSSI and Northaw Great Wood Country Park Local Nature Reserve (LNR) during construction. A Construction Environmental Management Plan (CEMP) would be in place and it is anticipated that with mitigation measures in place during construction, there would be no adverse effects on the integrity of these sites.

A number of non-statutory designated nature conservation sites could be negatively impacted during construction including the Lea Valley Site of Importance for Nature Conservation (SINC) of Metropolitan Importance and Woodlands Farm Meadows, Wood, South of Barn Hill Wood and Barn Hill Wood Local Wildlife Sites (LWSs), could be negatively impacted due to disturbance during construction of the Raw Water Transfer Main, and Thompsons Wood LWS, which could be which could be negatively impacted due to disturbance during construction of the Indicative WTW Site.

The Gunpowder Park LWS, Lea Valley SINC of Metropolitan Importance, New River SINC of Metropolitan Importance, Tolmers Park LWS Wood N. of Postern Gate LWS, Woodland Strip N. of School Camp LWS, Hell Wood LWS and Coldharbour Plantation & Broombarns Wood LWS would potentially be directly impacted due to open cut excavation for the Drinking Water Transfer Main, and the Legg North LWS, Peplin's Wood LWS, Meadow N. of Peplins Wood LWS, Potterells Wood LWS, Grassland N. of Potterells Wood LWS and Brick Kiln Wood (nr Brookmans Park) LWS could be directly impacted during construction of the Drinking Water Transfer Main to North Mymms.

No other statutory or non-statutory sites are likely to be negatively impacted due to the distance from the pipeline route and the lack of an impact pathway.

There are potential impacts on areas of ancient woodland adjacent to the Drinking Water Transfer Main to North Mymms Route Corridor (including Brick Kiln Wood and Peplin's Wood).

Coastal and floodplain grazing marsh priority habitat present would be negatively impacted by vegetation removal during construction work for the River Lee Intake and the Raw Water Pumping Station. Where open cut excavation is proposed for the transfer mains, several Priority habitats could be bisected including good quality semi-improved grassland and deciduous woodland, which all have the potential to be directly impacted by construction works.

The Beckton Reuse Indirect Option has the potential to impact protected and priority species, including where the transfer mains cross watercourses, including the River Lee, Turkey Brook, New River Canal and Ray Brook. Notable species with the potential to be present include (but are not limited to) badgers, bats, hazel dormice, reptiles, Great Crested Newts (GCN), and breeding birds. If present, these species may be adversely affected by construction works through disruption to commuting opportunities and routes. There could also be indirect effects due to disturbance from construction plant and machinery, the presence of people, lighting, creation of dust etc.

Other protected species with the potential to be present include otter and water vole. These species have the potential to be present at the river crossing locations. Trenchless techniques are proposed to cross the watercourses, which is likely to reduce impacts during construction. However, works are likely be required to facilitate this, and as such, potential negative impacts via disturbance and local habitat loss may occur if these species are present.

Planned maintenance or replacement of pipeline sections during operation have the potential to impact habitats and protected species, however impacts are likely to be highly localised and likely to be sufficiently mitigated by Ecological Method Statements and ecological supervision.

During operation, the new WTW could cause disturbance to protected and priority species through increasing lighting to the surrounding habitats, which could affect bats and barn owls, and potential increases in noise and disturbance to the surrounding habitats.

In order to mitigate potential issues arising from construction of the Beckton Reuse Indirect Option on biodiversity, the transfer mains should be routed to avoid ancient woodland, non-statutory designated nature conservation sites, priority habitats and those habitats that provide higher/better potential for protected and priority species. If this cannot be accommodated, trenchless techniques should be considered to allow the pipeline to cross under these areas. Where this is not possible, compensatory habitat would be required.

It should be noted that the protected and priority species suggested as being present are likely to be amended following completion of surveys and should not be considered final. Surveys are recommended at a subsequent project stage both to refine habitat mapping and identify the presence of protected species. Surveys should be phased in nature and proportionate to the level of design.

A Preliminary Ecological Appraisal is recommended to assess the likelihood of protected and priority species and habitats being present. As part of this, protected species data should be obtained from biological records centres and site visits undertaken to ground truth the findings of the desk based habitat mapping before a survey programme for protected species and habitats is established. The timing of surveys would vary depending on the protected species in question, as optimum windows for differing species vary.

Aquatic ecology

For the aquatic environment, the assessment of effects associated with recycled water being fed into the river, and the associated abstraction, will be assessed as part of the London Effluent Reuse SRO assessments. As such, only the construction related activities have been assessed. The only designated nature conservation site which includes aquatic communities as the qualifying/notifiable features is the Cornmill Stream and Old River Lea SSSI. The site is located upstream of the proposed transfer corridor and would not be affected by the construction activities.

During construction, there is a risk of construction related impacts on the aquatic communities. The construction related impacts include localised impacts on water quality due to increased sediment loads and/or pollution incidents and temporary disturbance of

fish communities. Overall, the aquatic communities associated with the construction activities are considered to be tolerant and impacts are considered temporary and reversible. Any impacts on the aquatic communities are therefore expected to be short term with, no or negligible change in aquatic ecological community receptors.

Soils

Soil resources

The Beckton Reuse Indirect Option is within developed and undeveloped land. The Indicative Intake Location, Indicative Raw Water Pumping Station Site and Raw Water Transfer Main Route Corridor are within undeveloped land and agricultural fields. The Indicative WTW Site is predominantly located within a developed area with commercial premises but also covers undeveloped land and agricultural fields. The Drinking Water Transfer Main Route Corridor and the Drinking Water Transfer Main to North Mymms Route Corridor predominantly pass through undeveloped land and agricultural fields.

Soil along the eastern end and western two-thirds of the transfer corridor is anticipated to predominantly be comprised of a slowly permeable seasonally waterlogged fine loamy over clayey soil. Soil associated with flatland adjacent to the River Lee is anticipated to comprise a stoneless clayey soil which is seasonally waterlogged by fluctuating groundwater. West of the River Lee, soil is anticipated to be a deep permeable mainly fine loamy soil becoming a deep stoneless well drained silty soil as the alignment progresses westwards, with these soils are free draining permeable soils in unconsolidated loams or clays.

Ground disturbance in the form of topsoil/subsoil stripping may adversely affect soil quality during the construction process through inappropriate handling during stripping, stockpiling and reinstatement. This can impact soil function which could ultimately affect crop/vegetation growth.

For temporary works, it is anticipated that the majority of stripped topsoil/subsoil resource would be reinstated. A volume of subsoil may be permanently loss from the volume of strip that is associated with space occupied by underground pipelines. These soils should be appropriately stockpiled and managed prior to reinstatement upon the completion of pipe installation for a particular section.

For permanent land-take, topsoil/subsoil strip is anticipated to precede construction works and would present a permanent loss of topsoil/subsoil resource (where present) from the stripped area.

Soil resource from areas where reinstatement is not possible should firstly be considered for reuse within the scheme. If this is not viable and/or there are excess soil quantities, topsoil/subsoil may be sold for use in other construction projects or industries. It should be stated that landfilling of soil resource should be the last resort, as this would represent a permanent loss of stripped topsoil/subsoil resource from the scheme.

Based on the provisional Agricultural Land Classification (ALC) data, the Beckton Reuse Indirect Option components are situated in Grade 3 land, non-agricultural land or urban land. Note that the provisional ALC data does not subdivide Grade 3 into 3a (representing best and most versatile land) and 3b (not presenting best and most versatile land).

Where detailed ALC survey is available, some areas of the Drinking Water Transfer Main Route Corridor have been classified as Grade 3b (in the northern section of the route corridor between Goffs Oak and Brookmans Park Service Reservoir.

It is recommended that a detailed soil survey (soil resource survey and/or ALC survey) is undertaken at a subsequent project stage to confirm soil resources present. The findings should inform a soil management plan which would provide guidance for stripping, stockpiling, maintenance, reinstatement and after care of soil resources. During construction activities, it is recommended that a qualified soil scientist undertake on-site monitoring visits to ensure the best practice and guidance as stated in the soil management plan is followed.

Land quality

Based on the identified historical and current land uses within the components of the Beckton Reuse Indirect Option and within the surrounding areas, there is the potential for contamination to be present within the ground and groundwater underlying the sites as well as potential ground gas, particularly within the western extent of the Drinking Water Transfer Main Route Corridor where the route passes through an historical landfill site and close to surrounding historical landfill sites.

Consultation would be required with the landowner, local authorities and the Environment Agency, at a subsequent project stage, with regard to potential routing through landfill and associated risks. Design details of the historical landfill should be requested from the Local Authority (if these exist) to enable further assessments to be carried out to ensure that risks from the pipeline acting as an additional pathway to human health and controlled waters are mitigated. In addition, early consultation should be initiated to determine options for discharge/ treatment of potentially contaminated groundwater.

Where the Drinking Water Transfer Main Route Corridor passes through a landfill site, the feasibility of undertaking ground investigation should be considered. Additional health and safety/ chemical and geotechnical testing and aquifer protection measures will be required along with other requirements for drilling and/ or construction on a site where landfilling is present.

Once further assessments have been carried out at a subsequent project stage, detailed geotechnical and geo-environmental Preliminary Risk Assessments should be completed, and the envisaged land quality mitigation measures reviewed to understand whether these are sufficient to mitigate the potential impacts to acceptable levels and therefore confirm the feasibility or not of the preferred route. As part of the Preliminary Risk Assessments, ground investigation aims would be determined.

A site-specific geotechnical and geo-environmental ground investigation would be the key mitigation in reducing the uncertainty associated with the majority of the identified risks for the preferred route. It is envisaged that a preliminary phase of ground investigation works would provide initial information to assist in the development and delivery of the next project stage which includes finalised feasibility, pre-planning investigations and planning applications. A detailed phase of ground investigation would be required at a later stage in the project delivery.

Water

Aquatic environment appraisal

For the aquatic environment, the assessment of effects associated with recycled water being fed into the river, and the associated abstraction, will be assessed as part of the London Effluent Reuse SRO assessments. As such, only the construction related activities have been assessed. Construction activity risks such as disturbance resulting from general construction activity of the transfer corridor and crossing of watercourses are anticipated to be managed through mitigation measures.

Groundwater

The Indicative Intake Location and Indicative Raw Water Pumping Station Site, Drinking Water Transfer Main Route Corridor, Drinking Water Transfer Main to North Mymms Route Corridor and North Mymms Booster Station Connection are located within areas defined as Source Protection Zone (SPZ) 1 and SPZ2. The Raw Water Transfer Main Route Corridor is within SPZ2 The Indicative WTW Site and Brookmans Park Service Reservoir Connection are

not located within SPZs. Construction within SPZs requires additional assessment and potentially mitigation to ensure no adverse impacts on public water supplies. Prior to construction a hydrogeological risk assessment would be required for works within SPZ1 or 2.

Neither of the groundwater bodies considered in the Level 1 – basic screening assessment were carried through to the Level 2 – detailed screening assessment. This has resulted in no further requirements for assessment of groundwater flow under the WFD at this stage. If any of the design assumptions or mitigation measures change, this will be reconsidered at subsequent project stages.

Flood risk

Examination of fluvial flood risk from the Environment Agency's Flood Zone maps and modelled river levels indicates that the Indicative Intake Location is within Flood Zones 2 and 3 and part of the Indicative Raw Water Pumping Station Site is within Flood Zone 2, and therefore are at risk of fluvial flooding. The Indicative Intake Location is at low risk of surface water flooding. However, the Indicative Raw Water Pumping Station Site is within a medium surface water flood risk area.

Examination of fluvial flood risk from the Environment Agency's Flood Zone maps and modelled river levels indicates that the Raw Water Transfer Main Route Corridor is not within Flood Zones 2 and 3 and surface water flooding. The Raw Water Transfer Main Route Corridor is considered to be at low risk of groundwater flooding and is not at risk of flooding from reservoir, canal and or other sources of artificial flooding.

Examination of fluvial flood risk from the Environment Agency's Flood Zone maps and modelled river levels indicates that the Indicative WTW Site is at low risk of fluvial flooding. A small part of the Indicative WTW Site is considered to be at high risk of surface water flooding. A sustainable drainage system would therefore be required for the Indicative WTW Site and the Raw Water Pumping Station, and it is recommended that a closed loop system be put into place for the new WTW to capture any potential contaminants from the treatment process.

The Indicative WTW Site is considered to be at low risk of surface water flooding. Care should be taken with the storage of equipment and materials to ensure stockpiled materials and other items are not washed into local drains to prevent blockages which could lead to localised flooding.

The Indicative WTW Site is considered to be at low risk of groundwater flooding and is not at risk of flooding from reservoir, canal and or other sources of artificial flooding.

The Drinking Water Transfer Main Route Corridor is at risk of fluvial flooding from the River Lee and Colne and associated tributaries where the pipeline crosses the watercourses. It is assumed that predominantly no-dig methods would be utilised for major river crossings and that there would be no displacement of fluvial flooding as the pipeline would be underground. There is still a risk of flooding during the construction phase near any watercourse and it is recommended that works within the river during forecasts of wet weather or issued flood warnings should be avoided. Therefore, construction timings should be considered during the design development stage. Pipeline maintenance access points should be located in areas where there is low risk of flooding to ensure that they are accessible at all times and ensure pipe design and cover is enough to withstand seepage from flooding into the pipes.

In the vicinity of Brookmans Park, the Drinking Water Transfer Main Route Corridor bedrock geology is chalk. It is recommended that a groundwater model is requested at a subsequent project stage to assess the risk of groundwater flooding on the development of the Drinking Water Transfer Main Route Corridor within chalk bedrock areas. It is also recommended that groundwater risk is taken into consideration during design of the Drinking Water Transfer Main, and groundwater designs are implemented to assist with protection the asset.

The Indicative Intake Location, Indicative Raw Water Pumping Station Site and part of the Drinking Water Transfer Main Route Corridor through Waltham Cross and Waltham Abbey are shown to be at risk from reservoir, canal and or other sources of artificial flooding. The consequences of flooding from reservoirs are very high, however the inspection and maintenance regime under the Reservoirs Act (1975) means that the probability of occurrence of flooding from these sources is considered low.

The Brookmans Park Service Reservoir Connection is considered to be at low risk of fluvial and surface water flooding, is considered to be at low risk of groundwater flooding and is not considered to be at risk of flooding from reservoir, canal and or other sources of artificial flooding.

The North Mymms Booster Station Connection is partly within Flood Zones 2 and 3, and therefore considered to be at risk of fluvial flooding. The North Mymms Booster Station Connection would be to an existing pumping station and minimal works are anticipated to facilitate this. Therefore, the North Mymms Booster Station Connection is unlikely to have consequential effects on the displacement of fluvial flooding.

Air quality

All of the Beckton Reuse Indirect Option components except the Drinking Water Transfer Main Route Corridor are located outside an Air Quality Management Area (AQMA). There are no Clean Air Zones in their vicinity. However, it should be noted that there are proposals for the Ultra Low Emission Zone in London to cover the whole of Greater London from August 2023, which includes the London Borough of Enfield.

The assessment indicates that the nitrogen dioxide (NO_2) and particulate matter (PM_{10} and $PM_{2.5}$) objectives may be exceeded in regions of the Drinking Water Transfer Main Route Corridor that are located close to the roadside within Enfield AQMA, which was declared for exceedances of the annual mean NO_2 and 24-hour mean PM_{10} objectives. Exceedances of the objectives are unlikely to occur in suburban and urban background locations, where the Indicative Intake Location, Indicative Raw Water Pumping Station Site, Indicative WTW Site, Raw Water Transfer Main Route Corridor, Drinking Water Transfer Main to North Mymms Route Corridor and majority of the Drinking Water Transfer Main Route Corridor are located. There are sensitive human and ecological receptors within 350m of the Beckton Reuse Indirect Option which could be impacted as a result of construction activities. Therefore, a number of construction dust mitigation measures have been recommended in accordance with the Institute of Air Quality Management (IAQM) guidance. A dust risk assessment should be undertaken at a later stage once more information is available to determine the construction dust risk at these sensitive receptors and whether additional construction dust mitigation is required.

The air quality impacts associated with vehicle traffic during the construction phase and the impacts from the standby generators should also be assessed once further details of these activities are available. If significant effects are predicted as result of these activities, additional mitigation may be required.

The impacts on air quality associated with vehicles during operation are not anticipated to be significant as, based on current information, the Beckton Reuse Indirect Option would generate an additional annual average flow of one to three Heavy Duty Vehicles (HDVs) per day throughout its operation, which is well below the Environmental Protection UK /IAQM screening threshold of 25 HDVs per day on average each year.

The impacts associated with standby generators during operation have not been assessed, in part because it has been assumed that the impact on air quality would be mitigated within their design. Specifically, it is assumed that the generators would be designed to optimise dispersion of pollutants. For example, the generators should be designed with a

sufficient stack height and should not have rain caps or cowls attached, which could impede the exhaust flow.

Climatic factors

Climate change risk assessment

The main climatic risks are:

- Flood risk being exacerbated by climate change and negatively impacting the pipeline.
- Higher temperatures and drought, leading to desiccation of soil, loss of strength, ground movement and damage to the new WTW and Raw Water Pumping Station foundations and pipeline bedding.
- Pumping station capacity not coping with increased future demand due to increases in temperature.
- New WTW and Raw Water Pumping Station operational temperature limits being exceeded leading to shut downs.

It is recommended that these measures are mitigated by considering the changes in climate in the designs of the pipeline and assets. This includes planning for a higher range of thermal variation, increased flood risk and ground movement.

Carbon footprinting assessment

The Beckton Reuse Indirect Option would have both capital and operational carbon emissions. The majority of the capital carbon sits within the construction associated with the transfer pipelines and WTW. The capital carbon emissions associated with pipeline construction result predominantly from the embodied carbon of the pipe material itself, with backfill/reinstatement and excavation also contributing to emissions. The capital carbon emissions for the WTW were driven by aspects of the treatment process that comprise of predominantly civil components such as potable water storage, clarifiers and filtration. Power consumption for pumping is the significant contributor to operational emissions.

Capital carbon mitigation opportunities include material selection, optimising the design of the WTW to reduce use of high carbon materials, reducing pipe size diameter, consideration given to not installing dual tunnels at every trenchless crossing, reviewing backfill and reinstatement to reduce the amount of imported material required, consideration given to single rather than dual supply for pumping stations and waste minimisation, e.g. through use of modular or off-site manufacture options.

Operational carbon mitigation opportunities include reducing operational carbon at carbon hotspot areas such as optimising energy efficiency and maintenance activities to prolong asset life/ performance, low carbon power generation and decarbonised electricity procurement choices and renewable energy generation.

Landscape

Construction of the River Lee Intake would require the temporary closure of a public right of way (PRoW) and, together with construction of the Raw Water Pumping Station, has the potential to change the setting of the area of Special Landscape Character (London Borough of Enfield) and reduce tranquillity within the green belt and river corridors due to the presence of construction activity. Removal of trees and woodland within the floodplain would open views from the river corridor to the light industrial buildings, road infrastructure and business units on the A112 Sewardstone Road.

Construction of the Raw Water Transfer Main, Drinking Water Transfer Main and Drinking Water Transfer Main to North Mymms has the potential to result in a temporary change to the land use and to the varied landforms of the recreational landscape of the River Lee valley and Hertfordshire Plateau, due to large scale excavation and stockpiling of materials within the working corridor, all of which lies within the London Green Belt. The temporary diversion or closure of footpaths and cycleways, including the London Loop, National Cycle Network (NCN) route 1, Hertfordshire Chain Walk, Hertfordshire Way and NCN route 12, would temporarily reduce recreational connectivity.

Construction of the Raw Water Transfer Main, Drinking Water Transfer Main and Drinking Water Transfer Main to North Mymms has the potential to result in the loss of vegetation both in the working corridor and where temporary construction compounds are located. This is of particular concern along watercourses, field boundaries and where vegetation has a screening effect, for example in screening existing roads (such as the M25 and A1000) and rail infrastructure. There is potential for loss of vegetation and disturbance to the setting of ancient woodlands at Whitewebbs Wood, Cattlegate Wood, Hook Wood, Great/Broombarns Woods, Peplin's Wood and Brick Kiln Wood. Perceptual and experiential value may be adversely affected in the vicinity of PRoWs and residential properties as a result of the presence of construction activity which may result in a reduction in tranquillity of the landscape.

There is potential for permanent loss of areas of ancient woodland at Peplin's Wood, Brick Kiln Wood and Northaw Wood and riparian vegetation along the River Lee, Black Ditch,

River Lee Navigation, Small River Lee, Turkey Brook, Cuffley Brook, Northaw Brook and Ray Brook and the introduction of man-made culverts at the intersection of the pipeline with these watercourses, which unless designed sympathetically, would locally detract from the character of the river corridors. Removal of roadside vegetation, most notably along the M25 corridor and A1000 Great North Road, has the potential to open up views of detracting elements for residential and recreational receptors. Removal of roadside vegetation and trees within residential areas, including A112 Sewardstone Road, A1055 Mollison Avenue, A1010 Hertford Road, Turkey Street, Hook Lane, Coopers Lane, Bell Lane and Bulls Lane would result in an adverse effect on the townscape character in the area.

Although the pipeline would be buried below the surface of the ground, the pipeline corridor may be evident where vegetation is lost during construction along watercourses and PRoWs, in particular where vegetation, such as trees and woodland, cannot be replaced because it falls within the pipeline easement. This may result in a permanent change to the character along stretches of watercourses and PRoWs, which may in turn affect their perceptual and experiential value for users of the ProWs and waterside footpaths.

Construction of the new WTW would involve the removal of areas of existing vegetation and, as a result, there would be localised, adverse landscape effects. The Indicative WTW Site is proposed on a site existing of predominantly of existing industrial/commercial use and the introduction of a new WTW on this site would not be considered a notable change in land use within the landscape context.

The study area is divided into two distinct areas: the southern section lies within the urban area of greater London, and the northern section lies beyond the M25 corridor and has a more rural character. As such, visual receptors are typical of the urban and urban/rural interface and include (but are not limited to) residential receptors; recreational receptors, including users of public rights of way, cyclists, visitors to country parks, recreational users of the waterways and people engaging in outdoor recreation at formal sports facilities; transport receptors, including users of the road and rail networks; and employment and education receptors. These types of visual receptors would be considered and potentially taken through to assessment at a subsequent project stages, once more detailed design information is available.

Construction of the Raw Water Transfer Main, Drinking Water Transfer Main and Drinking Water Transfer Main to North Mymms has the potential to impact protected trees including those within the Turkey Street and Forty Hill Conservation Areas, and with Tree Preservation Orders (TPOs).

There are wider opportunities within the Beckton Reuse Indirect Option to enhance landcover value and strengthen the blue-green network, for example through use of re-

wilding techniques in the restoration of temporary compound areas and use of mitigation planting to link existing green infrastructure elements across the wider landscape.

Recommended future technical work to be undertaken at a subsequent project stage includes the following:

- Refining the pipeline construction corridor and location of above ground structures to reduce the likely loss of vegetation and impact to sensitive landscape features.
- Once the location of above ground structures has been refined, a Zone of Theoretical Visibility (ZTV) should be produced to aid identification of possible visual receptors.
- Site visits should be to be carried out along the refined pipeline route corridor to confirm the findings of this desk-based assessment (DBA) and the ZTV.
- Design landscape mitigation to integrate the above ground structures into the landscape and replace any vegetation removed during construction within the working corridor.
- To support to the detailed design phase of the Beckton Reuse Indirect Option, it is recommended that a full BS5837:2012 survey is conducted, and an arboricultural impact assessment and tree protection plan produced. Where sensitive sites cannot be avoided, extra mitigation is likely to be required to minimise impacts during the construction phase.

Historic environment

There are 60 Listed Buildings, three Scheduled Monuments, two conservation areas and two Registered Parks and Gardens within 500m of the Beckton Reuse Indirect Option. There are no World Heritage Sites or conservation areas within this area. No direct effects on the designated heritage assets in the study area are anticipated. There is potential for above ground structures associated with the River Lee Intake and the Raw Water Pumping Station to permanently and adversely alter the setting of Luthers Grade II* Listed Building, through visual intrusion. Mitigation would be required to reduce impacts.

The presence of the new WTW site would result in minimal changes to the setting of the Grade II listed Netherhouse Farmhouse whilst in operation, assuming that the new WTW infrastructure does not exceed the height of the buildings that currently separate the Indicative WTW Site and the listed building.

There are 138 non-designated heritage assets within 500m of the Beckton Reuse Indirect Option, as mapped by the GLHER, Essex Historic Environment Record (HER) and Hertfordshire HER. Data within these HERs, along with archaeological excavation reports, has identified a generally high potential for archaeological remains of all periods, with the exception of early medieval. Archaeological potential is less understood along the northern

extent of the transfer route corridors, in light of the paucity of archaeological investigation in this area.

The excavation required for the Raw Water Transfer Main, Drinking Water Transfer Main and Drinking Water Transfer Main to North Mymms and above ground infrastructure, including the Raw Water Pumping Station and new WTW would severely truncate, or remove entirely, potential archaeological remains.

Further assessment at a subsequent project stage would refine the need for archaeological investigation and in consultation with local archaeological advisors. A programme of geophysical survey in undeveloped areas and test pitting in developed areas would help identify the presence of archaeological remains. Should remains of potential high significance be identified, a diversion of the pipeline route should be considered, to facilitate preservation in situ. The results of the survey or test pitting would enable a programme of targeted archaeological investigation to be developed at a subsequent project stage, such as targeted trial trench evaluation, to ensure no significant archaeological remains are removed without adequate record.

Noise

By careful design, noise impacts from constructing the Beckton Reuse Indirect Option could be minimised. The alignment of the Raw Water Transfer Main, Drinking Water Transfer Main and Drinking Water Transfer Main to North Mymms should be chosen to be at least 85m from noise sensitive receptors (130m where trenchless techniques occur) in order to minimise significant adverse noise impacts. It is considered that this can be achieved along the vast majority of these corridors although there are some areas within Enfield where this would not be possible and temporary noise effects may occur.

There are noise sensitive receptors within close proximity to the Indicative Raw Water Pumping Station Site and the Indicative WTW Site. It is likely therefore that there would be temporary construction noise impacts.

Once the final alignments of the transfer mains have been agreed, the areas where residual construction noise impacts may occur should be identified and the noise mitigation options to be included in a Construction Noise Management Plan considered.

At this stage, it is considered likely that baseline noise surveys and construction noise assessments would be required at a subsequent project stage since the potential for construction noise impacts has been identified.

All operational noise impacts for above ground infrastructure should be designed out through a number of methods including acoustic enclosure of plant, acoustic louvres, ducts silencers and plena for ventilation paths to enclosures and buildings, vibration isolation of plant and acoustic barriers, where required. All of these means of noise mitigation have been used extensively and are well understood and therefore any potential adverse noise impacts can be designed out.

At this stage, it is considered likely that baseline noise surveys and operational noise assessments would be required at a subsequent project stage since the potential for noise impacts has been identified. This would determine the background noise levels and inform detailed design. If required, baseline noise monitoring should be undertaken in order to set noise limits in accordance with BS4142: 2014 for operational noise in the area of all of the above ground facilities. Once the noise baseline has been established use the derived criteria as design constraints for these facilities.

Population and human health

The Beckton Reuse Indirect Option is located within 500m of housing and private property, businesses, community facilities and areas of open space and recreation. The Indicative Raw Water Pumping Station Site and Indicative WTW Site are within areas of private property which are also businesses. The Raw Water Transfer Main Route Corridor, Drinking Water Transfer Main Route Corridor and Drinking Water Transfer Main to North Mymms Route Corridor cross agricultural land and bisect areas of open space and recreation, including a country park and several ProWs.

Health indicators for the population within the three local authority areas in which the Beckton Reuse Indirect Option is located were also analysed. Life expectancy (for both genders) is slightly higher across all areas compared to the England average. The under-75 mortality rates (from all causes and cancer) are less than the national rates for all local authorities. With the exception of Enfield, a large proportion of residents living within 500 m of the Beckton Reuse Indirect Option live in the fifth least to least deprived deciles in the country.

There are anticipated to be a range of community and human health impacts affecting housing and private property, businesses and open space and recreation as a result of the Beckton Reuse Indirect Option during both construction and operation. These impacts include permanent land requirements affecting existing businesses, and temporary land requirements affecting a country park, PRoW closure and travel disruption. Depending on

the construction methodologies, there may also be a change in environmental conditions as a result of a combination of noise, air quality, visual impacts or presence of HGV vehicles.

To avoid or mitigate potential disruption and disturbance to communities during construction and operation of the Beckton Reuse Indirect Option, best practice mitigation should be implemented during construction.

Further assessment is recommended at a subsequent project stage to understand the timing and extent of the population and human health impacts and whether the impacts are temporary or permanent.

Material assets

The Beckton Reuse Indirect Option has the potential to affect other material assets during construction and operation including transport, energy, water and wastewater, waste and minerals infrastructure.

Based upon high level estimates of HGVs and staff vehicles that may be required during the construction and operational phases of the Beckton Reuse Indirect Option, at this stage, it is not considered that the vehicles volumes generated would present additional constraints to the road network, and the majority of roads are anticipated to provide practical options such as the A10 (three lanes in both directions), dual carriageway of Lieutenant Ellis Way and single carriageways of Dowding Way (A121), Sewardstone Road (A112) and Mollison Avenue. Potential issues have been identified in some areas, for example, a private access road, for which access would need to be attained prior to the commencement construction works. These access issues would need to be investigated at subsequent project stages.

The Raw Water Transfer Main Route Corridor, Drinking Water Transfer Main Route Corridor and Drinking Water Transfer Main to North Mymms Route Corridor intersect with ProWs and there are ProWs in proximity to the indicative locations for temporary construction compounds, the Indicative Intake Location, Indicative Raw Water Pumping Site and the Indicative WTW Site. Although this provides a potential opportunity in terms of adequate public accessibility to these sites, it also provides a constraint when undergoing development works where construction areas may impact on nearby ProWs. It is recommended that consideration is given to maintaining walking routes around temporary construction compounds and ensuring they are accessible and safe to use.

The Drinking Water Transfer Main Route Corridor intersects with National Cycle Network (NCN) route 1. Consequently, appropriate mitigation is likely to be required, potentially including a temporary diversion.

The Drinking Water Transfer Main Route Corridor crosses the West Anglia Main Line, Lea Valley Line, East Coast Main Line, River Lee Navigation and highways and local roads, as well as NCN route 1. Engagement would be required with the relevant stakeholders including National Highways, Network Rail and Canal and River Trust at a subsequent project stage.

The Beckton Reuse Indirect Option has the potential to affect other material assets during construction including potential safety hazards from overhead powerlines, and strategic areas of minerals. During operation, there is potential for temporary disruption during maintenance work.

Recommended areas for future technical work at a subsequent project stage are summarised below:

- Review any changes to the conceptual design following Gate 2 in terms of access routes to the indicative locations for temporary construction compounds, pipeline crossings and HGV/workforce access for the new WTW.
- Review construction HGV and workforce numbers and programme once known to determine construction flows to assess future potential impact on roads.
- Review construction vehicle types once known to enable access roads and site access point suitability to be assessed.
- Collect baseline traffic data, depending on the expected volume of vehicles and the programme. Traffic surveys are only likely to be required at specific junctions. The scope of traffic surveys and need for modelling would be subject to engagement with the highway authorities.
- Update review of local authority local plans / transport schemes to understand potential cumulative effects from other projects to determine the modelling extents and junction analysis required.
- Pursuant to the consenting process, a Transport Assessment would be undertaken and supporting documents such as a Construction Traffic Management Plan, Travel Plan and Servicing and Delivery Plan would be produced detailing how transport impacts are mitigated and managed.

Potential cumulative effects

An initial cumulative effects assessment has been undertaken. It is understood that if the Beckton Reuse Indirect Option is selected as an option in the WRSE Regional Plan, as well as Thames Water WRMP24 and Affinity Water WRMP24, it will be subject to an in-combination effects assessment with the other selected options, neighbouring water companies plans and neighbouring regional plans. Until the WRSE Best Value Regional Plan has been developed and agreed, it is not known when the Beckton Reuse Indirect Option would be implemented, and therefore, which other developments could act in-combination with it.

The source of water for the Beckton Reuse Indirect Option is the River Lee. However, the natural flow in the river is insufficient and so operation of the scheme will be dependent on recycled water being fed into the river from the London Effluent Reuse SRO. The operation of the Beckton Reuse Indirect Option, therefore, assumes that sufficient water will be available for the abstraction and that impacts on the aquatic communities are considered negligible. Cumulative effects with the London Effluent Reuse SRO are unlikely during construction or operation since impacts on the aquatic communities for the Beckton Reuse Indirect Option are considered negligible.

There are no other SROs geographically near to the Beckton Reuse Indirect Option and therefore effects during construction are unlikely to occur. Cumulative operational effects with other SROs are unlikely.

From the review of the plans, programmes and projects, seven developments were identified that have the potential for cumulative effects. The construction programmes for these developments and the Beckton Reuse Indirect Option potentially overlap and for all but one of the developments, there is potential for cumulative construction effects arising from visual intrusion, traffic disruption, noise, vibration and air quality on receptors. No cumulative impacts resulting from operation are anticipated.

Eleven further sites were identified within 3km of the Lee Valley Ramsar/SPA. The HRA Stage 2 AA conducted for Beckton Reuse Indirect Option identified no adverse effects on the integrity of the Lee Valley SPA and Lee Valley Ramsar if appropriate mitigation is implemented. Therefore, no adverse effects on the integrity of the European Sites are considered likely either alone or in-combination. The distance between the developments and the Beckton Reuse Indirect Option are also significant enough that no other common receptors were identified with potential for cumulative effects.

Invasive non-native species risk assessment

The invasive non-native species (INNS) risk assessment identified that the Beckton Reuse Indirect Option would not introduce a new hydrological connection between previously isolated catchments. Although a large range of aquatic and riparian INNS have been identified within the study area, including within the River Lee and reservoirs in the vicinity, suggesting a high level of connectivity and risk of future invasion and transmission of INNS, there is a very low risk that the Beckton Reuse Indirect Option would facilitate their spread as water transfer is through a closed system, therefore eliminating the risk of further INNS translocation.

The main risk associated with the water transfer component of the Beckton Reuse Indirect Option was identified as raw water movement between the source at the River Lee and the new WTW. Although biosecurity measures have been identified, there would be minimal benefit from their implementation in reducing the risk relating to the rare event of water leakage and implementation of these measures may be considered disproportionate in relation to the risk. There would be negligible risk of INNS transfer for the Drinking Water Transfer Main and further biosecurity/mitigation measures would have no tangible benefit.

The INNS risk associated with the proposed new assets (River Lee Intake, Raw Water Pumping Station and the new WTW) was assessed as being Low. The assets are designed to move water within a sealed system, therefore it is considered unlikely that additional biosecurity measures would reduce the risk further.

Natural capital and biodiversity net gain

Natural Capital Assessment (NCA) and Biodiversity Net Gain (BNG) calculations were undertaken for the Beckton Reuse Indirect Option.

Natural capital refers to the elements of the natural world that provide benefits to society and includes aspects such as woodland, grassland, freshwater, marine, urban greenspace and wetland habitats. The benefits that are provided to humans by the natural environment vary from regulating services such as natural flood management to cultural services such as recreational value.

BNG refers specifically to the combination of habitats present within a site and their ability to support biodiversity. Each habitat is given a distinct score that relates to its area, condition, distinctiveness and connectivity. The change in habitat due to the construction

and operation of the regional plan options informs the overall BNG score and whether they are likely to contribute to a net gain in biodiversity.

The T2AT SRO is committed to achieving a minimum 10% BNG, which would be reviewed when the precise regulatory and legislative requirements are known (e.g. under the Environment Act 2021[2]. Opportunities were identified to achieve this for the Beckton Reuse Indirect Option, however specific habitat mitigation and enhancement proposals would be set out at a subsequent project stage.

The NCA identified that the Beckton Reuse Indirect Option would likely cause the temporary and permanent loss of natural capital stocks during construction. Stocks that are likely to be permanently lost include coastal and floodplain grazing marsh, arable land, pasture, active floodplain, and broadleaved, mixed and yew woodland. However, best practice mitigation (such as the use of trenchless techniques) and reinstatement/compensation of habitat means that some natural capital stocks post construction would have no to little change and would likely have no permanent impact on the provision of ecosystem services.

The NCA identified that the transfer routes could be optimised within the current transfer route corridors to reduce the loss of natural capital stocks. An optimised route could result in the quantity of river length temporarily impacted and the quantity of broadleaved, mixed and yew woodland that would be permanently lost as a result of the scheme, while increasing the quantity of pasture and active floodplain lost as a result of the scheme, and in greater value retained for ecosystem services. The feasibility of an optimised route should be further investigated at a subsequent project stage against engineering, environmental, social, and planning constraints, as well as against potential opportunity areas and proposals for environmental net gain.

The assessment of BNG calculates that approximately 129 BNG habitat units could be lost due to the temporary removal of habitats during construction. This could be reduced to 113 BNG habitat units through optimisation of the transfer routes.

Opportunities identified in the NCA and BNG assessments have the potential to contribute to government ambitions for environmental net gain. This could take the form of habitat compensation, creation and/or species relocation schemes. Any schemes would need to be taken forward based on a comprehensive understanding of the interaction between natural systems and between natural systems and social uses of land.

[2] Environment Act 2021, c.30. Available at: https://www.legislation.gov.uk/ukpga/2021/30/contents/enacted [Accessed: April 2022]

At a subsequent project stage, it is recommended that the underlying data sources are confirmed and refined with on-site surveys to provide a more-detailed understanding of habitat condition. Opportunities should also be considered to create and improve habitat on-site and off-site through local schemes, Nature Recovery Networks and wildlife corridors in order to achieve a minimum 10% net gain in BNG units and increase the provision of ecosystem services, therefore aiding in developing more resilient options for the future provision of water for T2AT SRO.

Wider benefits

Wider benefits are those areas of environmental and social value that are associated with constructing and operating the scheme. Areas of disbenefit are also considered.

The consideration of wider benefits draws on the findings of other assessment work to inform the Gate 2 submission, as well as introducing additional information where material in the context of the Beckton Reuse Indirect Option.

The main findings from a review of the wider benefits associated with the Beckton Reuse Indirect Option are as follows.

Beneficial economic impacts associated with new operational phase jobs are anticipated to generate approximately £13 million (over a 30 year appraisal period).

Proposals to enhance green infrastructure links and local footpaths could lead to health and well-being benefits. Further work to develop these opportunities and incorporate into the scheme design could be undertaken at a subsequent project stage.

A draft partnership strategy has been developed as a basis for future engagement with stakeholders in order to help deliver some of the benefits and enhancements from changes to land use and provision of BNG.

Summary of main findings

A number of constraints and issues for further investigation have been identified however, the preliminary desk-based environmental appraisal undertaken at this stage, based upon the conceptual design, did not identify any environmental risks which could affect the viability of the Beckton Reuse Indirect Option. As stated above, the recommendations

outlined in this environmental appraisal do not definitively scope potential environmental effects in or out at this stage; this would be done as part of an EIA scoping process to be undertaken at the appropriate time and based on up to date information at that time.

The table below presents a summary of the environmental appraisal for the Beckton Reuse Indirect Option.

Assessment / topic	Environmental appraisal summary
Informal Habitats Regulations Assessment	Stage 1 Screening: Potential for Likely Significant Effects on Lea Valley SPA/Ramsar and Wormley Hoddesdonpark Woods SAC. Stage 2 AA: No adverse effects on the integrity of Lea Valley SPA/Ramsar or Wormley Hoddesdonpark Woods SAC are expected. In-combination effects assessment not required as no residual effects are expected.
Water Framework Directive Compliance Assessment	Level 1 Screening: One surface water river (Lea Navigation Enfield Lock to Tottenham Locks) had an impact score greater than 1 due to new or increased abstraction. No groundwater bodies were carried through to the Level 2 – detailed screening assessment. Level 2 Screening: Determined that new or increased surface water abstraction activity does not have the potential to deteriorate the WFD elements of the Lea Navigation Enfield Lock to Tottenham Locks water body or prevent it from attaining Good status in the future. The Beckton Reuse Indirect Option is therefore considered to be compliant with the WFD.
Strategic Environmental Assessment Review	Major positive effects identified on delivering reliable and resilient water supplies. Major negative effects (pre-mitigation) and moderate negative effects (post-mitigation) were identified for biodiversity, flora and fauna for the construction of the Beckton Reuse Indirect Option. Moderate negative effects on carbon emissions during the operational phase. Moderate negative effects (pre-mitigation) and minor negative effects (post-mitigation) were identified for soil, flood risk, air quality, and population and human health for the construction of the Beckton Reuse Indirect Option. Minor negative or neutral effects were identified for the remaining SEA objectives.

Assessment / topic	Environmental appraisal summary
Biodiversity, flora and fauna	Potential for direct impacts on Chingford Reservoir SSSI and Lea Valley IBA as a result of construction of the River Lee Intake. Potential for indirect effects on other statutory designated sites including Northaw Great Woods SSSI and Northaw Great Wood Country Park LNR, although neither of these are Groundwater Dependent Terrestrial Ecosystems. Direct and indirect negative effects on non-statutory designated sites, including Gunpowder Park LWS, Lea Valley SINC of Metropolitan Importance, New River SINC of Metropolitan Importance, Tolmers Park LWS Wood N. of Postern Gate LWS, Woodland Strip N. of School Camp LWS, Hell Wood LWS and Coldharbour Plantation & Broombarns Wood, and Legg North LWS, Peplin's Wood, Meadow N. of Peplins Wood, Potterells Wood, Grassland N. of Potterells Wood and Brick Kiln Wood (nr Brookmans Park). Potential for impacts on ancient woodland although temporary construction compounds could be sited and the pipeline aligned to avoid these areas. Potential loss of coastal and floodplain grazing marsh and deciduous woodland priority habitat and potential impacts on protected species. For the aquatic environment, the only designated site which includes aquatic communities as the qualifying/notifiable features is the Cornmill Stream and Old River Lea SSSI. The site is located upstream of the proposed transfer corridor and would not be affected by the construction activities. Impacts on the aquatic communities are expected to be short term and reversible. As such, no or negligible change in aquatic ecological community receptors are expected.
Soils	No direct or indirect impacts on designated geological sites. Potential for permanent loss of Grade 3 agricultural land at the Indicative Intake Location, Indicative Raw Water Pumping Station Site and Indicative WTW Site as above ground infrastructure. Potential for temporary loss of Grade 3 (including 3b) agricultural land due to pipeline construction within the Drinking Water Transfer Main Route Corridor. Potential for contamination due to construction works within historic landfills and other contaminated land.

Assessment / topic	Environmental appraisal summary
Water	Construction activity risks such as disturbance resulting from general construction activity of the transfer corridor and crossing of watercourses are anticipated to be managed through mitigation measures. The assessment of effects associated with recycled water being fed into the river, and the associated abstraction, will be assessed as part of the London Effluent Reuse SRO assessments. The Indicative Intake Location and Indicative Raw Water Pumping Station Site, Drinking Water Transfer Main Route Corridor, Drinking Water Transfer Main to North Mymms Route Corridor and North Mymms Booster Station Connection are located within areas defined as SPZ1 and SPZ2, with potential risk of pollution during construction. No further requirements for assessment of groundwater flow under the WFD at this stage as neither of the groundwater bodies considered in the Level 1 – basic screening assessment were carried through to the Level 2 – detailed screening assessment. The Indicative Intake Location is within Flood Zones 2 and 3 and part of the Indicative Raw Water Pumping Station Site is within Flood Zone 2, and therefore considered to be at risk of fluvial flooding. The Indicative WTW is in flood zone 1. The Indicative Intake Location and Indicative WTW Site are considered to be at low risk of surface water flooding. However, the Indicative Raw Water Pumping Station Site is within a medium surface water flood risk area. A closed loop sustainable drainage system would be required for the Raw Water Pumping Station and new WTW to capture potential contaminants from the treatment process. Fluvial flood risk along the Drinking Water Transfer Main Route Corridor and Drinking Water Transfer Main to North Mymms Route Corridor near watercourse crossings would need to be managed during construction.
Air	Majority of Beckton Reuse Indirect Option is not within AQMAs. Annual mean NO_2, PM_{10} and $PM_{2.5}$ objectives may be exceeded during construction in areas that are located close to the roadside within Enfield AQMA. Operational effects associated with traffic and standby generators for the new WTW are unlikely to exceed air quality objectives.

Assessment / topic	Environmental appraisal summary
Climatic factors	Climatic risks include exacerbation of flood risk, higher temperatures and drought leading to change in ground conditions, and exceedance of operational temperature limits leading to shutdowns. Construction carbon emissions associated with the transfer pipelines and WTW. Operational carbon emissions primarily associated with power consumption for pumping.
Landscape	Potential for permanent change in landscape character along the pipeline route where vegetation, such as trees and woodland, is lost during construction and cannot be replaced because it falls within the pipeline easement. Construction of the new WTW site would involve the removal of areas of existing vegetation and as a result there would be localised, adverse landscape effects. Indicative WTW Site is proposed on a site predominantly of existing industrial/commercial use and the introduction of a new WTW would not be considered a notable change in land use within the landscape context. Potential visual receptors identified include residential, recreational (including users of PRoW and cyclists), users of transport networks and employment and education receptors. Potential impacts on protected trees within proximity to the Drinking Water Transfer Main Route Corridor including within the Turkey Street and Forty Hill Conservation Areas and TPOs. Opportunities to enhance landcover value and strengthen the blue-green network, for example through use of re-wilding techniques in the restoration of temporary compound areas and use of mitigation planting to link existing green infrastructure elements across the wider Lea Valley landscape.
Historic environment	No direct impacts on designated heritage assets. Potential for above ground structures associated with the River Lee Intake and the Raw Water Pumping Station to permanently and adversely alter the setting of Luthers Grade II* Listed Building, through visual intrusion. Mitigation would be required to reduce impacts. Minimal changes to the setting of Netherhouse Farmhouse Grade II Listed Building whilst in operation, assuming that the new WTW infrastructure does not exceed the height of the buildings that currently separate the Indicative WTW Site and the listed building. High potential for archaeological remains, particularly dating to the prehistoric period. Excavation during construction would severely truncate, or remove entirely, potential archaeological remains.

Assessment / topic	Environmental appraisal summary
Noise	Pipeline alignment should be chosen to be at least 85m from noise sensitive receptors (130m where trenchless techniques occur) in order to minimise significant adverse noise impacts. This could be achieved along the vast majority of the Raw Water Transfer Main Route Corridor, Drinking Water Transfer Main Route Corridor and Drinking Water Transfer Main to North Mymms Route Corridor and should be factored into refinement of the pipeline route alignment. There are some areas within Enfield where this would not be possible and temporary noise effects may occur. Construction and operational noise impacts from the River Lee Intake, Raw Water Pumping Station and Indicative WTW are possible due the proximity of noise sensitive receptors and would require mitigation.
Population and human health	Community and human health impacts affecting housing and private property, businesses and open space and recreation during both construction and operation, including land requirements for the Indicative WTW Site affecting existing businesses and temporary land requirements affecting a country park, PRoW closure, travel disruption and a change in environmental conditions as a result of a combination of noise, air quality, visual impacts or presence of HGV vehicles. No permanent loss of housing and private property, community facilities or recreational assets.
Material assets	It is not considered that the vehicles volumes generated during construction and operation would present additional constraints to the road network. The majority of roads are anticipated to provide practical options for construction access. There are some localised construction access issues to be investigated in further detail at a subsequent project stage. Major infrastructure crossings including M25, West Anglia Main Line, Lea Valley Line, East Coast Main Line and River Lee Navigation would require further investigation and agreement with stakeholders at a subsequent project stage. Potential impacts on existing utilities and strategic mineral resources.

Assessment / topic	Environmental appraisal summary
INNS Risk Assessment	Beckton Reuse Indirect Option would not introduce a new hydrological connection between previously isolated catchments. Very low risk that the Beckton Reuse Indirect Option would facilitate spread of INNS as water transfer is through a closed system. Main risk identified is raw water movement between the source / intake and the new WTW. Minimal benefit from implementation of biosecurity measures and implementation of these measures may be considered disproportionate in relation to the risk. Negligible risk of INNS transfer of drinking water and further biosecurity/mitigation measures would have no tangible benefit. Low risk associated with the new assets as they are designed to move water within a sealed system; unlikely that additional biosecurity measures would reduce risk further.
Natural Capital Assessment and Biodiversity Net Gain	Potential for temporary loss of natural capital and ecosystem services as a result of the pipeline and permanent loss as a result of above ground components. Transfer routes could be optimised within the current transfer route corridors to reduce the loss of natural capital stocks. Approximately 129 BNG habitat units could be lost due to the temporary removal of habitats during construction. This could be reduced to 113 BNG habitat units through optimisation of the transfer routes.

Taking into account the key legislation and national planning policy outlined in this EAR, and with the information available at this stage, it is not considered that there any insurmountable environmental issues that should prevent the Beckton Reuse Indirect Option from progressing. A summary of key risks is outlined below.

- Potential indirect effects on statutory designated sites and direct and indirect effects on non-statutory designated sites, priority habitat and protected species would require further consideration in terms of draft National Policy Statement[3] (NPS) and National Planning Policy Framework[4] (NPPF) Section 15 (paragraph 180) , which states that *'as a general principle, and subject to the specific policies below, development should avoid*

[3] Department for Environment, Food & Rural Affairs (2018) Draft National Policy Statement for Water Resources Infrastructure. Available at: https://consult.defra.gov.uk/water/draft-national-policy-statement/supporting_documents/draftnpswaterresourcesinfrastructure.pdf [Accessed April 2022]
[4] Ministry of Housing, Communities & Local Government (2021) National Planning Policy Framework. Available at: https://www.gov.uk/government/publications/national-planning-policy-framework--2 [Accessed April 2022]

significant harm to biodiversity and geological conservation interests and contribute overall to net biodiversity gain. Where significant harm cannot be avoided or mitigated, as a last resort, appropriate compensation measures should be sought to provide net gains for biodiversity.' Further technical work, including surveys, is recommended at a subsequent project stage to investigate potential impacts, proposed mitigation and proposals for biodiversity net gain.

Recommendations for future technical work

Recommendations for future technical work at a subsequent project stage are presented in this section. It is recommended that the following activities are prioritised ahead of commencing formal environmental assessment process pursuant to the consenting process.

- Stakeholder engagement on the transfer routes and sites, including with statutory environmental stakeholders (Natural England, Environment Agency and Historic England), Local Planning Authorities, including County Archaeologists, and non-statutory environmental stakeholders including Wildlife Trusts.
- Further work on pipeline routing and siting of above ground infrastructure to avoid constraints such as non-statutory designated sites and priority habitats; this includes investigating the engineering feasibility of the NC Optimised Route and determining future environmental baseline.
- Informing the design to review biosecurity measures and improve resilience to physical climate change risks.
- Further work to understand contamination risks including a geotechnical and geo-environmental ground investigation and a hydrogeological risk assessment to identify risks to SPZs and likely mitigation.
- Scope and undertake surveys and investigations in order to inform design development and EIA scoping, including:
  - Preliminary Ecological Appraisal to identify the targeted ecology surveys required.
  - Continued aquatic ecology and water quality monitoring.
  - Targeted aquatic ecology surveys of the minor water bodies associated with the Drinking Water Main Route Corridors and the new WTW.
  - Preparation of a ZTV to identify visual receptors followed by site visits to confirm the ZTV and identify viewpoints and locations for visually verified views.
  - Initial arboricultural survey to inform ahead of a full BS5837:2012 survey.
  - Historic environment walkovers and engagement with local archaeological advisors to determine the programme of geophysical and intrusive survey required.
  - Transport Assessment Scoping to identify the traffic surveys and assessment required.
- Undertake optioneering on delivering BNG, including identifying specific locations for opportunities and investigating the merits of the timing of interventions, and developing

partnerships to help deliver some of the benefits and enhancements from changes to land use and provision of BNG.

1 Introduction

1.1 Purpose of this report

1.1. The Environment Assessment Report (EAR) is a technical supporting document prepared to support the Gate 2 Submission to the Regulators' Alliance for Progressing Infrastructure Development (RAPID) for the Thames to Affinity Transfer (T2AT) Strategic Resource Option (SRO).

1.2. This EAR presents the environmental appraisal work for the Beckton Reuse Indirect Option. This option would enable the transfer of water from the River Lee in the Thames Region to Brookmans Park and North Mymms, in the Affinity Region.

1.3. The purpose of this EAR is to meet the requirements of the RAPID Gate 2 guidance[5] and to draw together the conclusions of all the Gate 2 environmental appraisal work into a single document.

1.4. This EAR has been informed by desk based assessments using publicly available information in line with the requirements of the Gate 2 submission. The work is at a preliminary stage and establishes an initial appraisal that can be built on during subsequent project stages. In future, this will also be informed by the undertaking of site surveys and collection of additional information and data that will inform an Environmental Impact Assessment (EIA) likely to be required as part of any future consenting process.

1.5. This EAR does not definitively scope potential environmental effects in or out at this stage and the recommendations for further technical work outlined within this EAR are subject to change as further information becomes available at subsequent project stages. Future work will be carried out in conjunction with relevant stakeholders to inform the approach to the EIA.

1.6. The details set out in this EAR are still at a formative stage and consideration should be given to that when reviewing the proposals. They are for the purposes of making decisions on progress and further funding not seeking permission.

[5] Regulators' Alliance for Progressing Infrastructure Development (RAPID) Strategic Regional Water Resource Solutions Guidance for Gate Two. Available at: https://www.ofwat.gov.uk/wp-content/uploads/2022/02/Strategic-regional-water-resource-solutions-guidance-for-gate-two_Feb_2022.pdf [Accessed April 2022]

1.2 Scope of environmental appraisal

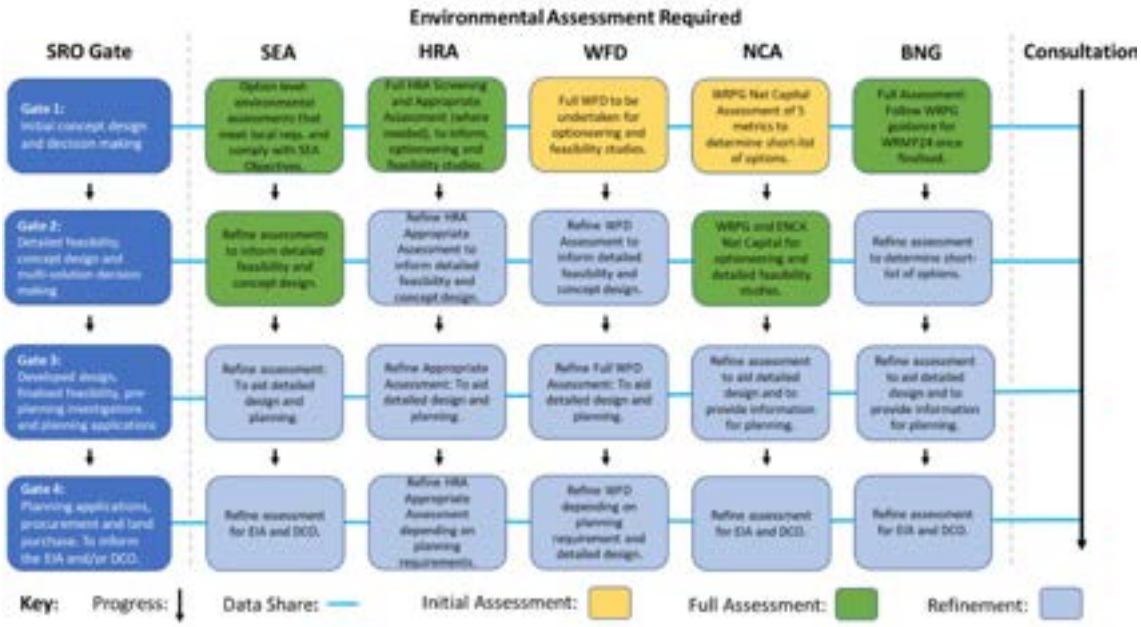
1.7. For the purpose of the Gate 2 Submission, the Beckton Reuse Indirect Option has been subject to a desk-based environmental appraisal, building on the work undertaken at Gate 1, to identify potential environmental and social impacts, potential mitigation measures and enhancement opportunities. The following have been undertaken.

- Informal Habitats Regulations Assessment (HRA), updating the Gate 1 HRA.
- Informal Water Framework Directive Assessment (WFD), updating the Gate 1 WFD assessment.
- Review and update of the Strategic Environmental Assessment (SEA) undertaken for the purpose of aligning with the Water Resources South East (WRSE) Regional Plan and reported at Gate 1.
- Topic-based desk-based assessments, updating Gate 1 work on baseline and assessment of effects.
- Invasive and non-native species (INNS) risk assessment, updating the Gate 1 risk assessment.
- Natural capital assessment (NCA), updating the Gate 1 assessment.
- Biodiversity net gain (BNG) calculations, undertaken using Biodiversity Metric 3.0.
- Wider benefits assessment.

1.8. Figure 1.1 below shows the integration of the environmental assessments (i.e. SEA, HRA, WFD, NCA/BNG) within the RAPID gated process. This schematic is taken from the All Companies Working Group (ACWG) guidance that was released in Gate 1[6]. While this is still largely relevant and followed, it has been somewhat superseded by the RAPID Gate 2 guidance[5], which the Gate 2 assessments have followed.

[6] All Companies Working Group, WRMP environmental assessment guidance and applicability with SROs, Mott MacDonald, October 2020.

Figure 1.1: Environmental assessment integration with SRO gates



1.9. The environmental appraisal is based upon currently available desk-based information and considered to be an appropriate approach for Gate 2 (which, as shown in Figure 1.1: Environmental assessment integration with SRO Gates, is a detailed feasibility and conceptual design stage). Information provided by third parties, including publicly available information and databases, is considered correct at the time of assessment (April/May 2022).

1.10. The following Technical Supporting Documents have informed the EAR and are referred to within this report:

- A1b, Concept Design Report (Beckton Reuse Indirect Option)
- A3b, Carbon Report (Beckton Reuse Indirect Option)
- A4, Options Appraisal Methodology Report
- A5, Options Refinement Report
- B2, Habitats Regulations Assessment
- B3, Water Framework Directive Assessment Compliance Assessment
- B4, Strategic Environmental Assessment Review

1.3 Stakeholder engagement

1.11. The principles for our approach to environmental engagement are as follows:

- To build on the engagement undertaken to date, taking account of any issues and concerns raised by local communities or stakeholders, ensuring discussions are timely.
- To fit within the regulatory process established under the guidance to understand and agree expectations.
- To be integrated with regional/company water resource planning.

1.12. Engagement during Gate 2 has focused on development of the pipeline route corridor and location of above ground infrastructure.

1.13. Regular engagement has been undertaken with the National Appraisal Unit (NAU) (comprising Environment Agency and Natural England) through a series of Technical Liaison Forums during Gate 2. The NAU has had opportunity to comment on development of the design and the outcomes of the environmental appraisal.

1.14. Initial engagement has also been undertaken with Local Planning Authorities, as set out in Technical Supporting Document A4, Options Appraisal Methodology Report, with a focus on introducing the options appraisal process and providing an overview of the Beckton Reuse Indirect Option.

1.4 Structure of the report

1.15. This EAR presents:

- Chapter 2 (Summary scheme description) presents an overview of the Beckton Reuse Indirect Option and signposts to other Technical Supporting Documents where further information can be found.
- Chapter 3 (Informal regulatory assessments) presents information on the regulatory assessments (informal HRA, WFD assessment and updates to the WRSE SEA as part of the Gate 2 submission).
- Chapters 4-13 present the topic-based desk-based assessment undertaken to inform the Gate 2 submission.
- Chapter 14 (Potential cumulative effects) presents an initial local, SRO-specific cumulative effects assessment undertaken to inform the Gate 2 submission.
- Chapter 14 (Invasive non-native species risk assessment) presents the INNS risk assessment undertaken to inform the Gate 2 submission.

- Chapter 16 (Natural capital and biodiversity net gain) presents the NCA and BNG assessments undertaken to inform the Gate 2 submission.
- Chapter 17 (Wider benefits) presents a summary of the potential wider benefits associated with the Beckton Reuse Indirect Option.
- Chapter 18 presents a summary of the main findings and recommendations for future technical work to be undertaken at a subsequent project stage.

2 Summary scheme description

2.1 Scheme overview

2.1. Raw water for the Beckton Reuse Indirect Option would be abstracted from the River Lee flood relief channel. As the natural flow in the river is insufficient, the operation of the scheme would be dependent on recycled water being fed into the river from the Beckton Water Recycling option of the London Effluent Reuse SRO. Implementation of this option is therefore a pre-requisite for the Beckton Reuse Indirect Option, hence the name of this T2AT option.

2.2. The Beckton Water Recycling option of the London Effluent Reuse SRO entails the construction of an advanced water recycling plant at Thames Water's Beckton Sewage Treatment Plant. The recycled water would be conveyed to the existing Lockwood Shaft which currently receives flow from the Thames Lee tunnel. Water from the Lockwood shaft would be pumped into the River Lee upstream of the abstraction point for the Beckton Reuse Indirect Option.

2.3. At the River Lee flood relief channel intake, the concept design proposes a passive wedge wire screen located in the riverbed. The necessary equipment for backflushing or 'airburst' would be housed away from the riverbank to ensure that there is a minimum of visible intrusion at the intake site. However, it is anticipated that at the minimum an access track and kiosk would be required on the riverbank. The passive screens and connecting pipework would be configured such that half of the screens can be taken out of service for maintenance when required.

2.4. Water would flow by gravity within buried pipes to a new raw water pumping station set back from the riverbank.

2.5. The raw water would then be conveyed in a new buried transfer main to a new water treatment works (WTW). Drinking water produced by the WTW would pass through a storage tank before entering a high-lift pumping station from where it would be conveyed via a buried drinking water transfer main to an existing service reservoir in the vicinity of Brookmans Park.

2.6. A proportion of the water would then be able to flow under gravity to the existing booster pumping station in the vicinity of North Mymms.

2.7. There are several major crossings along the route of the drinking water pipelines including the M25 motorway, four railway lines and three major watercourses within the Lee Valley.

2.8. The main delivery point for the Beckton Reuse Indirect Option is an existing service reservoir in the vicinity of Brookmans Park, which is a distribution hub within the Affinity Water network. Modifications to the network downstream from the reservoir, which would be required to distribute the additional water to customers, are currently being determined by Affinity Water and form part of their wider water resources planning and investment programme.

2.9. The key components of the Beckton Reuse Indirect Option are summarised below.

- An intake and raw water pumping station (within this report referred to as 'River Lee Intake' and 'Raw Water Pumping Station'). The indicative location identified for the River Lee Intake is referred to as 'Indicative Intake Location' and the indicative site identified for the Raw Water Pumping Station is referred to as the 'Indicative Raw Water Pumping Station Site.'
- A raw water transfer pipeline to a new WTW (within this report referred to as the 'Raw Water Transfer Main'). The indicative route corridor identified for the Raw Water Transfer Main is referred to as the 'Raw Water Transfer Main Route Corridor'.
- A new WTW (within this report referred to as the 'new WTW') to the north of the River Lee Intake (within this report referred to as the 'Indicative WTW Site').
- A drinking water transfer pipeline from the new WTW to an existing service reservoir in the vicinity of Brookmans Park (within this report referred to as the 'Drinking Water Transfer Main'). The indicative route corridor identified for the Drinking Water Transfer Main is referred to as the 'Drinking Water Transfer Main Route Corridor'.
- A connection to an existing reservoir in the vicinity of Brookmans Park (within this report referred to as the 'Brookmans Park Service Reservoir Connection').
- A drinking water transfer pipeline from the Brookmans Park Service Reservoir Connection to a booster pumping station in the vicinity of North Mymms (within this report referred to as the 'Drinking Water Transfer Main to North Mymms'). The indicative route corridor identified for the Drinking Water Transfer Main to North Mymms is referred to as the 'Drinking Water Transfer Main to North Mymms Route Corridor'.
- A connection to an existing booster pumping station in the vicinity of North Mymms (within this report referred to as the 'North Mymms Booster Station Connection').

2.10. Two alternative capacities have been considered for the Beckton Reuse Indirect Option which are sized to provide an increase of 50Ml/d and 100Ml/d of average deployable output to Affinity Water respectively.

2.11. A more detailed scheme description is provided in Technical Supporting Document A1b, Concept Design Report (Beckton Reuse Indirect Option).

2.2 Alternatives considered

2.12. Technical Supporting Document A4, Options Appraisal Methodology Report provides a description of the options identification, appraisal and screening process that has been undertaken to identify the constrained and currently preferred options for the T2AT SRO. The Beckton Reuse Indirect Option is one of the two preferred options.

2.13. An unconstrainted list of 33 options was compiled in consultation with Affinity Water and Thames Water and screened against a set of initial screening criteria, which included consideration of impacts on statutory designated sites. Options which passed the initial screening stage were then screened against secondary screening criteria, which included consideration of environmental designations and features, impact on natural capital stocks, impact on Water Framework Directive no-deterioration objectives and impact on European Sites[7]. Consideration was also given to whether the option offered opportunities for biodiversity improvement and/or chalk stream enhancement, and whether any of the potential environmental impacts identified could be mitigated, and the level of mitigation that would be required.

2.14. Eight options remaining after screening:

- Maidenhead: abstraction of raw water at a new Maidenhead intake, conveyance to a new WTW at an existing service reservoir in the vicinity of Harefield, and utilisation of available storage capacity at the existing Harefield service reservoir.
- Sunnymeads 1: abstraction of raw water at the existing Affinity Water Sunnymeads intake, conveyance to a new WTW at an existing service reservoir in the vicinity of Harefield, and utilisation of the available storage capacity at the existing service reservoir.
- Teddington Direct River Abstraction (DRA): Abstraction of raw water at a new intake at Teddington, upstream of Teddington weir and upstream of the proposed London Effluent Reuse SRO Teddington DRA option outfall (treated effluent from Mogden STW); conveyance to a new WTW in the vicinity of Harefield; and utilisation of the available storage capacity at the existing service reservoir in the vicinity of Harefield.
- Sunnymeads 2a: abstraction of raw water at the existing Affinity Water Sunnymeads intake and conveyance to a new WTW at Iver (Iver 2), near to the existing Iver WTW. The drinking water is then conveyed to Harefield to utilise the available storage capacity at an existing service reservoir in the vicinity of Harefield.

[7] This includes Special Protection Areas (SPAs) and Special Areas of Conservation (SACs), proposed and candidate SPAs and SACs (pSPAs and cSACs). The network also extends to wetland sites of international importance (Ramsar sites)

- Walton 2b: abstraction of raw water via an extension to the existing Affinity Water Walton intake and conveyance to the proposed Iver 2 WTW. The drinking water is then conveyed to an existing service reservoir in the vicinity of Harefield to utilise the available storage capacity at the existing service reservoir.
- Mogden Reuse Indirect 3: this option comprises the same infrastructure as Walton 2b but utilises water from the proposed London Effluent Reuse SRO Mogden effluent reuse option. For the Mogden Reuse Indirect 3 option in T2AT, an extension of the London Effluent Reuse SRO Mogden effluent reuse option outfall pipeline is required from the reach containing the Thames Water Walton intake, to the reach containing the Affinity Water Walton intake i.e. to a point upstream of Sunbury weirs.
- Lower Thames Reservoir 2a: Water from Thames Water's Wraysbury and Queen Mother reservoirs is abstracted via a proposed connection into Affinity Water's existing Wraysbury (100" inch) tunnel at the existing Iver WTW site. This raw water is then diverted to the proposed Iver 2 WTW. The drinking water is subsequently conveyed to an existing service reservoir in the vicinity of Harefield to utilise the available storage capacity at the existing service reservoir.
- Beckton Reuse Indirect: Indirect transfer of recycled water from Beckton STW to a new WTW and new service reservoir near North Mymms. The proposed abstraction point would be located on the River Lee, downstream of the outfall from the proposed Beckton effluent reuse option (including extension from Lockwood shaft), within the London Effluent Reuse SRO. Another potential source for this option is water abstracted as part of the London Effluent Reuse SRO Teddington DRA option, which abstracts river water upstream of the recycled water discharge from Mogden STW and utilises the existing Thames-Lee Tunnel (with an extension), which would discharge in a similar location to the proposed Beckton Water Recycling option (London Effluent Reuse SRO). N.B. In the period since option selection, modelling by both WRSE and Affinity Water has identified a constraint in the distribution network between the proposed import point at North Mymms and a service reservoir in the vicinity of Brookmans Park in WRZ3. This option has therefore been extended to include a drinking water conveyance component from North Mymms to Brookmans Park. Furthermore, since Gate 1, the Beckton Reuse Indirect Option has been extended to feed an existing service reservoir in the vicinity of Brookmans Park due to the limited existing transfer capacity from North Mymms to Brookmans Park.

2.15. The eight options were assessed by WRSE in January 2021, in-line with the methodology in the WRSE guidance[8]:

- Habitats Regulations Assessment (HRA) Stage 1: Test of Likely Significance (Screening Assessment)

[8] Mott MacDonald (2020). Water Resources South East (WRSE) Regional Plan Environmental Assessment Methodology Guidance. Available at: https://www.wrse.org.uk/media/lb0g0tsr/wrse_file_1347_wrse-regional-plan-environmental-assessment-methodology-guidance.pdf [Accessed April 2022]

- WFD Assessment Level 1: Basic Screening
- SEA
- Natural Capital Assessment and Biodiversity Net Gain

2.16. Environmental assessments carried out prior to the Gate 1 submission, which followed further refinement of infrastructure siting and pipeline route optimisation included:

- Updated Stage 1 HRA and Stage 2 Appropriate Assessment, if required, in accordance with the WRSE guidance.
- Updated Level 1 WFD Basic Screening and Level 2 Detailed Impact Screening, if required, in accordance with the WRSE guidance.
- Consideration of local level data (Local Wildlife Sites (LWS) and Tree Preservation Orders (TPO)) in-line with the methodology in the ACWG guidance9.
- Review of SEA against refined options to confirm any changes to the WRSE metrics.
- INNS risk assessment.
- Assessment of opportunities for net zero carbon contributions.
- Consideration of wider benefits including societal benefits and environmental net gain.

2.17. Technical Supporting Document A4, Options Appraisal Methodology Report provides a comparison of the eight options taken forward against the following themes: technical challenge, carbon footprint, environment and community, and planning complexity.

2.18. Maidenhead, Teddington DRA and Walton 2b / Mogden Reuse Indirect 3 did not perform as well under the environment and community theme due to WFD risks and in the case of Teddington DRA and Walton 2b / Mogden Reuse Indirect 3, higher loss of ecosystem services and biodiversity than other options, potentially due to the length of pipeline, which was longer than other options, also resulting in higher carbon emissions. Maidenhead also performed poorly due to proximity of the Chilterns Area of Outstanding Natural Beauty (AONB) to construction work and the pipeline intersecting with two historic parks and gardens.

2.19. The Lower Thames Reservoir Option compared well under all the themes considered within the options appraisal, including environment and community, and hence would be a favourable option for development to Gate 2. The Beckton Reuse Indirect Option also compared well to the other transfer options, and in particular the other two options which rely on reuse water. This is the most favourable reuse option for development to Gate 2 and is the only T2AT option which feeds directly into the

[9] WRMP Environmental Assessment Guidance and Applicability with SROs – ACWG - October 2020.

eastern side of Affinity Water's Supply area.

2.20. Which, if any, of the T2AT options are carried past Gate 2 will be determined by the further outputs of the WRSE regional modelling, the best value plan which it informs, and the outcomes of the resultant public consultation processes on the emerging and draft plans. The process will consider and compare the merits of whole solutions, of which the transfer scheme would be just one component in a system which ensures continuity of supply to customers. Of particular relevance is the choice of option (or other SRO) to provide the source of new raw water for the T2AT scheme, whether linked to additional effluent reuse, new raw water storage or an inter-regional transfer. The optimisation of the whole system relies on the WRSE best value planning and modelling process, but the choice will also be informed by the relative merits of the different options. The model also considers consequential benefits such as reductions in groundwater abstraction and additional water discharges into the environment. The assessments of the T2AT options are therefore to be considered within the larger context of the overall solutions which constitute the best value plan.

2.21. The preferred options for the T2AT SRO are the Lower Thames Reservoir Option and the Beckton Reuse Indirect Option.

2.22. Technical Supporting Document A5, Options Refinement Report provides a description of how the preferred options for the T2AT SRO have been developed since Gate 1, including the options appraisal process that has been undertaken to select indicative route corridors for the Raw Water Transfer Main, Drinking Water Transfer Main and Drinking Water Transfer Main to North Mymms, and an Indicative Intake Location, Indicative Raw Water Pumping Station Site and Indicative WTW Site.

2.23. The routes and sites were developed based on series of criteria that consider engineering, environmental, social, and planning constraints. The route for each option has been identified within a wider corridor that meets a majority of the criteria and therefore avoids a large number of environmental designations and communities. This report presents the assessment of the indicative route corridors and indicative sites for above ground infrastructure for the purpose of the Gate 2 submission.

2.24. This EAR presents the assessment of the indicative route corridors for the Raw Water Transfer Main, Drinking Water Transfer Main and Drinking Water Transfer Main to North Mymms, and the Indicative Intake Location, Indicative Raw Water Pumping Station Site and Indicative WTW Site for the purpose of the Gate 2 submission. Those alternatives discounted through the options appraisal process are not considered within this EAR; Technical Supporting Document A5, Options Refinement Report should be referred to for further information on these alternatives and the reasons for discounting them at this stage. It should be noted that the indicative route corridors and sites, along with the alternatives considered, would be subject to stakeholder engagement and a public consultation exercise.

2.3 Key assumptions

2.25. The following key assumptions have been used within the assessments.

2.26. Abstraction from the River Lee would be in line with licence agreements from the Environment Agency, which are dependent on the additional volumes being provided by the London Effluent Reuse SRO.

2.27. As stated in Paragraph 2.24, the EAR is based upon the route corridors for the Raw Water Transfer Main, the Drinking Water Transfer Main and the Drinking Water Transfer Main to North Mymms, as shown in Figure 2.1: Beckton Reuse Indirect Option key components. These corridors are up to 500m wide in unconstrained locations and it has been assumed for the purpose of the desk based assessments that pipeline construction works could be undertaken anywhere within the route corridors.

2.28. At this stage, it is assumed that construction would require a maximum 50m working width in unconstrainted locations along the Raw Water Transfer Main, Drinking Water Transfer Main and Drinking Water Transfer Main to North Mymms pipeline routes, and topsoil would be stripped to accommodate excavations, site haul roads and other construction features. An indicative route has been identified within the route corridors based upon engineering, environmental and planning considerations and forms the basis of calculations for agricultural landtake, indicative estimates of HGVs and staff vehicles, NCA and BNG, to enable a realistic scenario to be assessed.

2.29. It is assumed that temporary construction compounds would be required and indicative locations for these have been identified approximately every 2km within the route corridors.

2.30. As stated in Paragraph 2.22, an Indicative Intake Location, Indicative Raw Water Pumping Station Site and Indicative WTW Site have been identified following an options appraisal process. The EAR is based upon these indicative locations.

2.31. A construction period of 2030 – 2034 has been assumed based the WRSE emerging draft plan that was issued for consultation in January 2022[10]. The Beckton Reuse Indirect Option is anticipated to be operational from 2034.

2.32. The following assumptions have been made in relation to construction methodology:

- Below ground structures would be constructed such that they would not form a preferential pathway for pollution to groundwater or cause alterations in groundwater flow or levels.

[10] Water Resources South East (2022) Our Regional Plan. Available at: https://wrse.uk.engagementhq.com/our-regional-plan [Accessed April 2022]

- Risk assessments would be undertaken for excavation works and dewatering to ensure no adverse impact on watercourses, wetland habitats or abstractions. Dewatering discharge would be treated before discharge.
- The pipe network would not be buried any deeper than 8m below existing ground level. The exceptions to this are transitions into micro-tunnelled crossings, the gravity pipe from the River Lee Intake to the Raw Water Pumping Station and the Raw Water Pumping Station, which is expected to be approximately 10 m below existing ground level.
- Water extracted from the ground during construction would be treated to a standard agreed with the regulatory authority before discharging at less than the agreed maximum rate to the water environment.
- Any discharge from the new WTW would be to the WFD waterbody which the new WTW is situated in and would be treated to a standard agreed with the regulatory authority at less than the agreed maximum rate, so as to not cause any potential impacts to water quality of the receiving water body.
- Any discharge from commissioning lagoons would be treated to a standard agreed with the regulatory authority at less than the agreed maximum rate so as to not cause any potential impacts to water quality of the receiving water body.
- The majority of crossings including main rivers, railways and the M25 would be via micro-tunnel. All other roads would be crossed using an open cut method across the road with traffic management in place. Where watercourses would not be micro-tunnelled, it is assumed they would be flumed during construction. This would be a short term construction activity (i.e. less than seven days), which would ensure the watercourse is returned to its natural function following installation of the pile section.

2.33. It is assumed that a Construction Environmental Management Plan (CEMP) would be developed at an appropriate stage to ensure that environmental risks such as uncontrolled discharges from construction are minimised and that Emergency Response Plans are in place in the event of an incident. Best practice pollution prevention would be followed for all construction works with reference to:

- CIRIA C741 Environmental Good Practice on Site Guide (Charles and Edwards, 2015)[11].
- CIRIA C532 Control of water pollution from construction sites (Masters-Williams *et al.* 2001)[12].
- Environment Agency's Pollution Prevention Guidance Notes[13] including PPG1: General Guide to Prevention of Pollution (July 2013); PPG5: Works and

[11] Charles P. and Edwards P (2015) *Environmental good practice on site guide.* CIRIA C741, 260p.
[12] Masters-Williams H., Heap A., Kitts H. *et al.* (2001) *Control of water pollution from construction sites.* CIRIA C532, 27p.
[13] Note, the Environment Agency Pollution Prevention Guidance Notes have been withdrawn by the Government, although the principles within them are robust and still form a reasonable basis for pollution prevention measures.

maintenance in or near water (October 2007), PPG6: Pollution prevention guidance for working at construction and demolition sites (April 2010); PPG21: Pollution incident response planning (March 2009); PPG22: Dealing with spillages on highways (April 2011).

2.34. Thames Water and Affinity Water have Environmental Management Systems (EMS) in place for their assets. The EMS aims to identify and implement the necessary actions to avoid adverse effects to the environment during the operational phase. For example, the EMS would include standard measures relating to pollution control and control of disturbance from light or noise. As such, it is expected that these would be updated to incorporate the requirements of new assets commissioned as part of the Beckton Reuse Indirect Option, and it is assumed that the appropriate EMS would be followed in order to avoid adverse effects to the environment.

3 Informal regulatory assessments

3.1. Three informal regulatory assessments have been undertaken to support the Gate 2 submission and are presented as standalone Technical Supporting Documents. This section of the EAR presents a summary of these assessments.

3.1 Habitats Regulations Assessment

3.2. Technical Supporting Document B2, Habitats Regulations Assessment contains the results of the informal HRA undertaken for the Beckton Reuse Indirect Option. It provides information on the HRA screening (HRA Stage 1) and the further Appropriate Assessment (AA) (HRA Stage 2) undertaken to assess the potential effects of the option on European Sites[14].

3.3. The HRA Stage 1 Screening Assessment identified the potential for Likely Significant Effects on the Lee Valley Special Protection Area (SPA), Lee Valley Ramsar site and Wormley Hoddesdonpark Woods SAC due to potential hydrological connection and risk of pollutions events during construction.

3.4. The HRA Stage 2 AA for these sites concluded that with the use of best practice control measures there would be no adverse effects on the integrity of these sites.

3.5. This assessment must be revised if further design iterations result in changes to potential impact pathways and potential effects upon European Sites as part of a formal HRA completed pursuant to the consenting stage.

3.6. As no residual effects are expected from the implementation of this option, an in-combination assessment is not required for the Beckton Reuse Indirect Option. As the option progresses, this should be reviewed and if residual effects are identified, the option should go through an in-combination effects assessment as part of a formal HRA will be completed pursuant to the consenting stage.

3.7. It should be noted that Technical Supporting Document B2, Habitats Regulations Assessment, presents the results of an informal HRA assessment based upon a conceptual design. The conclusions should therefore be considered preliminary. The HRA should be reviewed as the design is developed and a full assessment carried out at a subsequent project stage, pursuant to the consenting process.

[14] This includes Special Protection Areas (SPAs) and Special Areas of Conservation (SACs), proposed and candidate SPAs and SACs (pSPAs and cSACs). The network also extends to wetland sites of international importance (Ramsar sites).

3.2 Water Framework Directive assessment

3.8. Technical Supporting Document B3, Water Framework Directive Compliance Assessment, contains the results of the informal WFD assessment undertaken for the Beckton Reuse Indirect Option. The WFD Assessment follows the ACWG methodology[15], which comprises a Level 1 basic screening stage and a Level 2 detailed impact assessment.

3.9. The Level 1 – basic screening assessment was completed to determine which activities have the potential to impact the surface water bodies. The Level 1 basic screening identified nine water bodies in relation to the Beckton Reuse Indirect Option: six surface water rivers, one surface water transfer and two groundwater bodies.

3.10. Only one surface water body: Lea Navigation Enfield Lock to Tottenham Locks, received an impact score greater than 1 and was carried through to the Level 2 – detailed impact assessment. No groundwater bodies were determined to have an impact score greater than 1. Hence, no groundwater bodies were carried through to the Level 2 – detailed assessment.

3.11. The Level 2 detailed assessment determined that impacts associated with the new or increased surface water abstraction do not have the potential to deteriorate the WFD elements of the Lea Navigation Enfield Lock to Tottenham Locks WFD water body or prevent them from the attainment of Good status in the future.

3.12. The Beckton Reuse Indirect Option is therefore considered to be compliant with the WFD at this stage.

3.13. It should be noted that Technical Supporting Document B3, Water Framework Directive Compliance Assessment, presents the results of an informal WFD assessment based upon a conceptual design. The conclusions should therefore be considered preliminary. The WFD assessment should be reviewed as the design is developed and a full assessment carried out at a subsequent project stage, pursuant to the consenting process.

[15] WRSE (2020) All Company Working Group Water Framework Directive: Consistent framework for undertaking no deterioration assessments

3.3 Strategic Environmental Assessment

3.14. Technical Supporting Document B4, Strategic Environmental Assessment Review, presents an update to the SEA level option assessment prepared by WRSE, in-line with the methodology in the WRSE Regional Plan Environmental Assessment Methodology Guidance[16]. This involved the identification of potential effects for each SEA objective at both the construction and operational phases, pre and post mitigation, with each SEA objective scored against an eight-point scale. The SEA objectives are presented in the table below.

Table 3.1: SEA objectives

SEA topic	SEA objective
Biodiversity, flora and fauna	Protect and enhance biodiversity, priority species, vulnerable habitats and habitat connectivity (no loss and improve connectivity where possible)
Soil	Protect and enhance the functionality, quantity and quality of soils
Water	Increase resilience and reduce flood risk
	Protect and enhance the quality of the water environment and water resources
	Deliver reliable and resilient water supplies
Air	Reduce and minimise air emissions
Climatic factors	Reduce embodied and operational carbon emissions
	Reduce vulnerability to climate change risks and hazards
Landscape	Conserve, protect and enhance landscape, townscape and seascape character and visual amenity
Historic environment	Conserve, protect and enhance the historic environment, including archaeology
Population and human health	Maintain and enhance the health and wellbeing of the local community, including economic and social wellbeing
	Maintain and enhance tourism and recreation
Material assets	Minimise resource use and waste production
	Avoid negative effects on built assets and infrastructure

[16] Mott MacDonald (2020). Water Resources South East (WRSE) Regional Plan Environmental Assessment Methodology Guidance. https://www.wrse.org.uk/media/lb0g0tsr/wrse_file_1347_wrse-regional-plan-environmental-assessment-methodology-guidance.pdf [Accessed April 2022]

3.15. It should be noted that the SEA update presented in Technical Supporting Document B4, Strategic Environmental Assessment Review, is not a formal SEA under The Environmental Assessment of Plans and Programmes Regulations 2004 as it is a project not a plan/programme and is therefore, outside the scope of the SEA Regulations[17]. The SEA has been carried out as best practice and to help inform the regional planning and Water Resource Management Plan 2024 (WRMP24) SEAs. Technical Supporting Document B4, Strategic Environmental Assessment Review does not constitute an Environmental Report under the Regulations and therefore, does not contain all of the information as set out in Schedule 2. A compliant Environmental Report will be produced for the WRMP24.

3.16. Major positive effects have been identified for the SEA objective on delivering reliable and resilient water supplies given the Beckton Reuse Indirect Option improves the transfer of water across regions.

3.17. Carbon would be generated as a result of construction as well as during operation. The SEA identified minor negative effects associated with carbon emissions during the construction phase and moderate negative effects during the operational phase.

3.18. Major negative effects (pre-mitigation) and moderate negative effects (post-mitigation) were identified for biodiversity, flora and fauna for the construction of the Beckton Reuse Indirect Option given the Indicative Intake Location is located within the Chingford Reservoir SSSI. There is potential for effects on international and nationally designated sites, and potential impacts on priority habitat, protected species and woodland during the construction phase. The HRA Stage 1 Screening Assessment identified the potential for likely significant effects on the Lee Valley SPA and Ramsar site as a result of the construction phase and HRA Stage 2 AA was therefore undertaken (see Technical Supporting Document B2, Habitats Regulations Assessment). The HRA Stage 2 Appropriate Assessment identified no adverse effects on the integrity of the sites where appropriate mitigation is implemented.

3.19. Moderate negative effects (pre-mitigation) and minor negative effects (post-mitigation) were also identified for the construction phase for the SEA objective on soil given the potential for disturbance and permanent loss of agricultural land (Grade 3) and there is potential for disturbance of contaminants given the Beckton Reuse Indirect Option intersects or is within close proximity to historic and authorised landfill sites. The construction phase also has the potential to cause disruption to material assets therefore moderate negative effects (pre-mitigation) and minor negative effects (post-mitigation) identified.

3.20. The Beckton Reuse Indirect Option passes through Air Quality Management Areas (AQMAs) with moderate negative effects (pre-mitigation) and minor negative effects (post-mitigation) identified for the SEA objective on air quality at the construction phase for. Given the Beckton Reuse Indirect Option passes through community or recreational facilities, moderate negative effects (pre-mitigation) and minor negative

[17] UK Government (2004). The Environmental Assessment of Plans and Programmes Regulations 2004. Available at: https://www.legislation.gov.uk/uksi/2004/1633/contents/made [Accessed April 2022]

effects (post-mitigation) were identified for both objectives related to population and human health at the construction phase.

3.21. For the SEA objective on flood risk, the Beckton Reuse Indirect Option is identified to have moderate negative effects (pre-mitigation) and minor negative effects (post-mitigation) for both the construction and operational phases given the locations of elements of the option within Flood Zone 2 and 3.

3.22. Minor negative or neutral effects were identified for the remaining SEA objectives.

3.23. Mitigation measures to prevent, reduce or off-set adverse environmental effects have been identified as part of the SEA. These measures do not always completely eliminate effects or result in the downgrading of effects, from moderate to minor for example, however they do contribute to reducing the effects identified for the SEA objective.

3.24. It is recommended that the environmental assessment information from the SEA is fed into the WRSE Regional Plan and the Thames Water and Affinity Water WRMP24s so that the Beckton Reuse Indirect Option is more appropriately assessed for SEA purposes as part of SEA for the WRMP24s and WRSE Regional Plan.

4 Biodiversity, flora and fauna

4.1 Introduction

4.1. This chapter presents a desk-based assessment undertaken to identify the potential impacts on ecological features from the transfer corridors and above ground infrastructure including the intake and WTW. The objectives of the desk-based assessment were to identify the key ecological features, constraints and opportunities and the issues and features that may require further investigation at a subsequent project stage.

4.2. The need to consider biodiversity, flora and fauna is driven by legislation (including the Conservation of Habitats and Species Regulations 2017 (as amended), Wildlife and Countryside Act 1981 (as amended) and Natural Environment and Rural Communities Act 2006) and national planning policy (draft National Policy Statement (NPS) for Water Resource Infrastructure[18], Sections 3.3 (Habitats Regulations Assessment) and 4.3 (biodiversity and nature conservation), and National Planning Policy Framework (NPPF)[19] (Section 15 (conserving and enhancing the natural environment), paragraphs 174-175, 179-182).

4.2 Terrestrial ecology

4.2.1 Methodology

4.2.1.1 Study area and sources of information

4.3. The desk-based assessment focused on the transfer route corridors, location of associated infrastructure and the surrounding area within a 2km study area for statutory designated nature conservation sites and a 1km study area for non-statutory designated nature conservation sites and habitats. Where it was recognised that impacts could extend beyond the proposed study areas due to potential indirect impacts, the assessment boundaries were extended accordingly to

[18] Department for Environment, Food & Rural Affairs (2018) Draft National Policy Statement for Water Resources Infrastructure. https://consult.defra.gov.uk/water/draft-national-policy-statement/supporting_documents/draftnpswaterresourcesinfrastructure.pdf [Accessed April 2022]

[19] Ministry of Housing, Communities & Local Government (2021) National Planning Policy Framework. Available at: https://www.gov.uk/government/publications/national-planning-policy-framework--2 [Accessed April 2022]

address the geographic extent of the potential impacts.

4.4. Table 4.1 outlines the baseline data sources which were collated and considered in the desk-based assessment.

Table 4.1: Sources of information (biodiversity, flora and fauna)

Data collected	Source
Greenspace sites; open map local roads; surface water; woodland	Ordnance Survey (OS) Open Data
Land cover data including statutory designated sites, ancient woodland and priority habitat inventory	Multi-Agency Geographic Information for the Countryside (www.magic.gov.uk)[20]
Descriptions / designations of statutory designated nature conservation sites (and candidate designated sites)	Natural England/Joint Nature Conservation Committee (JNCC)
Important Bird Areas	Royal Society for Protection of Birds (RSPB)
Habitats	Derived from OS MasterMap
Biodiversity Action Plan (BAP) priority habitats and species	UK Government – MAGIC Maps Website[20] / the National Biodiversity Network (NBN) Atlas[21] / local authority information on BAP priority habitats and species
Non-statutory designated nature conservation site data	Local Biological Record Centres (BRCs) – Greenspace Information for Greater London (GiGL) and Hertfordshire Environmental Records Centre (HERC), and Epping Forest District Council

4.2.1.2 Approach to impact appraisal

4.5. A qualitative approach was undertaken to evaluate the biodiversity of the study area and assess where there was potential for the Beckton Reuse Indirect Option to result in impacts on key ecological features. Where there was potential for impact to protected and priority habitats and species, recommendations have been made for further surveys that may need to be undertaken at a subsequent project stage, as

[20] Defra, Multi-Agency Geographic Information for the Countryside. Available at: https://magic.defra.gov.uk/ [Accessed April 2022]
[21] National Biodiversity Network (NBN) Atlas. Available at: https://nbnatlas.org/ [Accessed April 2022]

appropriate.

4.6. An initial desk-based habitat mapping exercise was undertaken using key desktop sources of information including GIS mapping systems, OS mapping and available land cover datasets. Available data was used to produce GIS maps using the ESRI ArcGIS system that broadly correspond to JNCC Phase 1 habitats and descriptions within the Handbook for Phase 1 habitat survey (JNCC, 2010[22]), the standardised system for classifying and mapping wildlife habitats in all parts of Great Britain, including urban areas. (Note that it is recommended that this is converted to UKHabs classification system at a subsequent project stage).

4.7. The habitat maps were used to determine the potential for key ecological features present in the study area. The potential for protected and/or priority species to be present was evaluated using experience and professional judgement, based on the habitats present and using open web-based sources such as the UK government's MAGIC website[20], the National Biodiversity Network (NBN) Atlas[21] and local authority information on UK BAP priority habitats and species, where available.

4.8. Online sources of aerial photography, where the quality/resolution was of sufficiently high quality, were also used where appropriate. Sources included, but were not limited to, Google and Bing aerial photography, Google Streetview, and the various aerial photography suites in Esri ArcPro (which itself sources from Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community).

4.9. Once the key ecological features were defined, an assessment as to the potential for these features to be affected by the Beckton Reuse Indirect Option during construction and operation was undertaken. Positive impacts were identified as well as negative ones. Ecological constraints and opportunities associated with the Beckton Reuse Indirect Option were identified, and any recommendations for further survey or investigation, to be undertaken at a subsequent project stage, highlighted.

4.2.1.3 Assumptions and limitations

4.10. This chapter presents a purely desk-based assessment, and as such, site visits have not been undertaken at this stage to map and classify habitats present, or identify potential evidence of protected or priority species. Protected or priority species records were not collected and instead, the potential for protected species to be present was determined through a review of habitat types.

4.11. Chapter 15 presents the INNS Risk Assessment in relation to potential spread of INNS

[22] Joint Nature Conservation Committee (2010) Handbook for Phase 1 habitat survey: A technique for environmental audit. Available at: https://data.jncc.gov.uk/data/9578d07b-e018-4c66-9c1b-47110f14df2a/Handbook-Phase1-HabitatSurvey-Revised-2016.pdf [Accessed April 2022]

as a result of the abstraction and transfer of raw water. It has not been possible to assess the scope for INNS from construction-related activities, as data from online and desk-based sources is generally very limited. It is recommended that a construction phase INNS assessment is undertaken once specific habitat mapping and INNS surveys have been undertaken at a subsequent project stage. Where INNS are identified, best practice procedures within CIRIA Manual C679 'Invasive species management for infrastructure managers and the construction industry'[23] and 'The Knotweed Code of Practice – managing Japanese Knotweed on development sites'[24] should be followed to reduce the spread of INNS for all construction works, as a minimum standard.

4.2.2 Understanding of the baseline

4.2.2.1 Statutory designated nature conservation sites

4.12. There is one SPA within the study area, as presented in Table 4.2 below and shown on Figure 4.1: Statutory designated nature conservation sites.

Table 4.2: Special Protection Area

SPA Name	Closest distance to Beckton Reuse Indirect Option components	Summary description
Lee Valley	1.1km (Drinking Water Transfer Main Route Corridor)	The Lee Valley SPA comprises a series of embanked water supply reservoirs, sewage treatment lagoons and former gravel pits that display a range of man-made and semi-natural wetland and valley bottom habitats. Classified under Article 4.1 of EC Directive 79/409 on the Conservation of Wild Birds (the Birds Directive) as it is used regularly by 1% or more of the Great Britain populations of the species, in any season; bittern (*Botaurus stellari*). And it is used regularly by 1% or more of the biogeographical populations of the following regularly occurring migratory species, in any season; shoveler (*Anas clypeata*) and gadwall (*Anas strepera*).

[23] CIRIA (2008), Invasive species management for infrastructure managers and the construction industry (C679). Authors Wade, M, Booy, O, and White, V.
[24] Environment Agency (2013), Managing Japanese knotweed on development sites (version 3) – The Knotweed Code of Practice. Withdrawn in 2016, but still outlines best practice.

4.13. There are two SACs within the study area as presented in Table 4.3 below and shown on Figure 4.1: Statutory designated nature conservation sites.

Table 4.3: Special Areas of Conservation

SAC name	Closest distance to Beckton Reuse Indirect Option components	Summary description
Wormley-Hoddesdonpark Woods	0.05km (Drinking Water Transfer Main Route Corridor)	Contains heath, dry grassland, deciduous woodland, coniferous woodland and mixed woodland. Primary reason for the selection of this site is the presence of the Annex I habitat of oak-hornbeam forests of the *Carpinion betuli.*
Epping Forest	1.2km (Indicative River Lee Intake Location) 1.1km (Indicative Raw Water Pumping Station Site)	Contains water bodies, fens, heath, dry grassland and deciduous woodland. Primary reason for the selection of this site is the presence of the Annex I habitat Atlantic acidophilous beech forest and the Annex II species stag beetle (*Lucanus cervus*). It is important for a range of rare species, including the moss, *Zygodon forsteri.*

4.14. There is one Ramsar site within the study area as presented in Table 4.4 below and shown on Figure 4.1: Statutory designated nature conservation sites.

Table 4.4: Ramsar site

Ramsar	Closest distance to Beckton Reuse Indirect components	Summary description
Lee Valley	1.1km (Drinking Water Transfer Main Route Corridor)	Comprises a series of embanked water supply reservoirs, sewage treatment lagoons, and former gravel pits. These waterbodies support internationally important numbers of wintering gadwell and shoveler and nationally important numbers of several other bird species.

4.15. There are nine biological Sites of Special Scientific Interest (SSSIs) within the study area as presented in Table 4.5 below and shown on Figure 4-1: Statutory designated nature conservation sites.

Table 4.5: Sites of Special Scientific Interest

SSSI name	Closest distance to Beckton Reuse Indirect Option components	Summary description
Chingford Reservoirs	0km (Indicative Intake Location)	Chingford Reservoirs are one of the major wintering grounds for wildfowl and wetland birds in the London area and hold nationally important numbers of some species. The reservoirs also form a moult refuge for large populations of wildfowl during the late summer months.
Water End Swallow Holes	0.12km (Drinking Water Transfer Main to North Mymms Route Corridor)	Water End Swallow Holes are the only major sinkholes in chalk which are a permanent feature of the landscape, and they constitute the drainage outlet for the largest enclosed karstic basin in England. The willow carr/swamp community adjacent to the sinkholes is of biological importance.
Redwell Wood	1.66km (Drinking Water Transfer Main to North Mymms Route Corridor)	Contains ancient woodland of the pedunculate oak/hornbeam type and heathland, together with well-developed scrub and secondary woodland.
Northaw Great Wood	0.08km (Drinking Water Transfer Main Route Corridor)	Comprises one of the country's most extensive areas of ancient hornbeam dominated woodland. The diverse breeding bird community also includes tree pipit (*Anthus trivialis*), nuthatch (*Sitta europaea*) and great spotted woodpecker (*Dendrocopos major*).
Wormley-Hoddesdonpark Wood South	0.29km (Drinking Water Transfer Main Route Corridor)	A series of woods containing a mosaic of vegetation. Most of this large woodland block is ancient with associated areas of secondary woodland which have developed by natural succession on old fields or woodland glades. Nationally the woods are regarded as the best remaining example of the south eastern sessile oak-hornbeam woods with associated flora and fauna.

SSSI name	Closest distance to Beckton Reuse Indirect Option components	Summary description
Turnford & Cheshunt Pits	1.29km (Drinking Water Transfer Main Route Corridor)	Forms part of the internationally important Lee Valley complex. Includes ten former gravel pits, several of which have extensive shorelines. The pits are of national importance for wintering gadwall; (regularly supporting some 2.9% of the UK population) and for wintering shoveler (about 1.3% of the UK population). The site is of regional importance for wintering coot (*Fulica atra*) and is locally important for wintering snipe (*Gallinago gallinago*) and bittern.
Waltham Abbey	1.6km (Drinking Water Transfer Main Route Corridor)	Area of alder woodland on damp alluvial soils overlying fluvio-glacial gravel in the valley of the River Lee. The woodland supports the largest heronry in Essex.
Cornmill Stream and Old River Lea	1.4km (Drinking Water Transfer Main Route Corridor)	A freshwater habitat with one of the most diverse invertebrate faunas in Essex. The site supports an outstanding assemblage of dragonflies and damselflies (Odonata); eighteen species have been recorded, including two notable scarce species. The slow-moving streams support a rich and varied aquatic and marginal flora. Associated with this habitat is one of the richest gastropod molluscan faunas in the county including two vulnerable species of freshwater snail and other invertebrates including a rare sawfly and a rare soldier fly
Epping Forest	1.2km (Indicative River Lee Intake Location) 1.1km (Indicative Raw Water Pumping Station Site)	One of only a few remaining large-scale examples of ancient wood-pasture in lowland Britain and has retained habitats of high nature conservation value including ancient semi-natural woodland, old grassland plains and scattered wetland. Also supports a nationally outstanding assemblage of invertebrates, a major amphibian interest and an exceptional breeding bird community.

4.16. The SSSI Impact Risk Zone of one SSSI that is not within the study area, and therefore not mentioned in Table 4.5, intersects with the study area. This is listed below in Table 4.6.

Table 4.6: SSSI Impact Risk Zone

SSSI	Summary description	Relevant criteria
Wormley-Hoddesdonpark Woods North	A series of woodland blocks that have developed from ancient wood-pasture and heath. Nationally important as an example of lowland south-eastern sessile oak/hornbeam type with the pedunculate oak/hornbeam variant also present.	Discharge – Any discharge of water or liquid waste of more than 20m³/day to ground (i.e. to seep away) or to surface water, such as a beck or stream. Infrastructure – Pipelines, pylons and overhead cables.

4.17. There is one National Nature Reserve (NNR) within the study area (Broxbourne Woods), 0.42km from the Drinking Water Transfer Main Route Corridor. Broxbourne Woods NNR is Hertfordshire's only NNR and is encompassed by Wormley Hoddesdonpark Woods SAC.

4.18. There is one Local Nature Reserve (LNR) within the study area (Northaw Great Wood Country Park), 0.16km from the Drinking Water Transfer Main Route Corridor. Northaw Great Wood LNR is a remnant of the extensive forest that covered much of the area before the Norman conquest and contains ancient woodland. Habitat incudes mainly oak, birch, hornbeam woodland, that supports woodland habitat birds, such as nightingale, tree pipit, wood warbler and redstart.

4.2.2.2 Non-statutory designated nature conservation sites

4.19. There are 53 non-statutory nature conservation sites within the study area comprising four Sites of Importance for Nature Conservation (SINCs) and 49 Local Wildlife Sites (LWSs). The sites located within or immediately adjacent to the route corridors are listed below in Table 4.7. All sites within the search area are included in Appendix B and shown on Figure 4.2: Non-statutory designated nature conservation sites.

Table 4.7: Non-statutory designated nature conservation sites

Site	Designation	Closest distance to Beckton Reuse Indirect Option components	Summary description
Woodlands Farm Meadow	LWS	0km (Raw Water Transfer Main Route Corridor)	This site comprises old hillslope grassland. It does not appear to be intensively managed, although some horse-grazing is evident in the narrow southern strip. In the past, cowslip (*Primula veris*) and pepper-saxifrage (*Silaum silaus*) have both been recorded from here. These are both plants indicative of old, relatively unimproved grassland sites.
Gunpowder Park	LWS	0km (Drinking Water Transfer Main Route Corridor)	Extensive area of rough grassland and scattered scrub. Some brownfield invertebrate habitat is present and the invertebrate faunas is now being re-established. Also supports a locally important population of breeding skylark and supports reed and sedge warblers.
Cattlins Wood	LWS	0km (Drinking Water Transfer Main Route Corridor)	Old semi-natural broadleaved woodland comprising mainly pedunculate oak (*Quercus robur*) standards with hornbeam (*Carpinus betulus*) and hazel (*Corylus avellana*) coppice.
Lea Valley	SINC of Metropolitan Importance	0km (Indicative Intake Location, Indicative Raw Water Pumping Site, Raw Water Transfer Main Route Corridor and Drinking Water Transfer Main Route Corridor)	This sprawling series of open spaces, in the valley of the River Lee, includes lakes, reservoirs, marshes and wet grassland. The wonderfully diverse range of wetland habitats has made this area a haven for many rare plants and a tremendous range of birds. The site is also very important for water vole, which is locally abundant, and great crested newt. The reed beds and other riparian habitats support a nationally important assemblage of invertebrates.

Site	Designation	Closest distance to Beckton Reuse Indirect Option components	Summary description
New River	SINC of Metropolitan Importance	0km (Drinking Water Transfer Main Route Corridor)	Probably London's cleanest river, this man-made waterway stretching from Hertfordshire to London now supports a range of aquatic plants, as well as fish, water birds and amphibians. Kingfishers are regularly seen and may breed. The aquatic invertebrate fauna is also likely to also be diverse, as indicated by the range of dragon/damselflies present, which include red-eyed damselfly, which is scarce in London, and very large populations of common blue damselfly. The river supports a good range of fish, including pike, perch, roach and carp, and may be of value for amphibians.
Kentish Lane Farm Wood (N.E. of Brookmans Park)	LWS	0km (Drinking Water Transfer Main Route Corridor)	Ancient semi-natural broadleaved woodland with coppice-with-standards pedunculate oak /hornbeam and silver birch *Betula pendula*/pedunculate oak with rowan (*Sorbus aucuparia*).
Coldharbour Plantation & Broombarns Wood	LWS	0km (Drinking Water Transfer Main Route Corridor)	This site has been left as a result of removing SSSIs from Wildlife Sites. This site buffers a SSSI.
Wood N. of Postern Gate	LWS	0km (Drinking Water Transfer Main Route)	Ancient semi-natural broadleaved coppice-with-standards woodland. Contains a small brook that flows southwards through the woodland within a narrow valley which is deeply incised in places. Old banks with remnant hedges and ditches are also present.
Woodland Strip N. of School Camp	LWS	0km (Drinking Water Transfer Main Route)	Ancient woodland with a semi-natural canopy and field evidence suggesting an ancient origin plus an old hedgerow.

Site	Designation	Closest distance to Beckton Reuse Indirect Option components	Summary description
Meadow N. of Peplins Wood	LWS	0km (Drinking Water Transfer Main to North Mymms Route Corridor)	Relatively unimproved grazing pasture supporting acid/neutral and part marshy grassland on wet flushes, with a small stream running through the middle of the site. There is a pond in the north-west corner with records for great crested newt (*Triturus cristatus*).
Peplin's Wood	LWS	0km (Drinking Water Transfer Main to North Mymms Route Corridor)	Ancient semi-natural acid woodland, with a good number of woodland indicators. Old boundary banks with hornbeam hedges are also present and several small ponds.
The Legg North	LWS	0km (Drinking Water Transfer Main to North Mymms Route Corridor)	Ancient woodland fragment with a semi-natural canopy, consisting of sycamore *Acer pseudoplatanus* with some pedunculate oak, ash (*Fraxinus excelsior*) and wild cherry (*Prunus avium*) plus poplar *Populus sp.* There is a pond on the edge of the wood and old hedge bank and ditch remnants.
Hell Wood	LWS	0km (Drinking Water Transfer Main Route Corridor)	Ancient semi-natural woodland largely replanted with Scots pine (*Pinus sylvestris*). There are old banks and small streams within the wood.
Tolmers Park	LWS	0km (Drinking Water Transfer Main Route)	Semi-natural woodland comprising several strips of woodland and a green lane to the east.
Brick Kiln Wood (nr Brookmans Park)	LWS	0km (Drinking Water Transfer Main to North Mymms Route Corridor)	Ancient woodland Inventory site. The woodland boundary supports remnant banks with old contorted hornbeam coppice stubs. Several ponds add to the habitat diversity of the wood.
Potterells Wood	LWS	0km (Drinking Water Transfer Main to North Mymms Route Corridor)	Ancient woodland with a semi-natural canopy and field evidence suggesting an ancient origin.

Site	Designation	Closest distance to Beckton Reuse Indirect Option components	Summary description
Grassland N. of Potterells Wood	LWS	0km (Drinking Water Transfer Main to North Mymms Route Corridor)	The site has the character of an overgrown Victorian/Edwardian garden. Neutral grassland indicators were recorded in the herb rich mown lawn areas around the buildings. Much of the lawn area north and west of the building is old wet grassland.

4.2.2.3 Important Bird Areas

4.20. There is Important Bird Area (IBA) within the study area, shown on Figure 4.2: Non-statutory designated nature conservation sites. The Indicative Intake Location and Raw Water Pumping Station are both within the IBA and it is also bisected by the Drinking Water Transfer Main Route Corridor. Lea Valley IBA comprises of a series of wetlands and reservoirs situated along the River Lee, to the north-east of London. A rich aquatic and marginal flora is present in the reservoirs and streams. The IBA is important for several breeding wetland bird species, including a large heronry, wintering wildfowl and late summer moults of *Aythya fuligula*.

4.2.2.4 Ancient woodland

4.21. There are a total of 21 ancient and ancient replanted woodland sites within the study area. Brick Kiln Wood and Peplin's Wood are immediately adjacent to the Drinking Water Transfer Main to North Mymms Route Corridor. Ancient woodland is shown on Figure 4.3: Ancient woodland and priority habitats.

4.2.2.5 Priority habitats

4.22. The following priority habitats are present within the study area: Deciduous woodland, good quality semi-improved grassland and coastal and floodplain grazing marsh.

4.23. There is coastal and floodplain grazing marsh priority habitat at the Indicative Intake Location and Indicative Raw Water Pumping Station Site, good quality semi-improved grassland priority habitat within the Drinking Water Transfer Main Route Corridor to the south of the M25 and deciduous woodland priority habitat within the

Raw and Drinking Water Transfer Main Route Corridors. Priority habitats are shown on Figure 4.3: Ancient woodland and priority habitats.

4.2.2.6 Nature Recovery Network

4.24. The corridor overlaps with Natural England's Nature Recovery Network (NRN), with two Natural England Network Enhancement Zones and one Network Expansion Zone. These do not carry any specific protection designations but do represent networks of habitats that can be complemented and contributed to, with any mitigation, compensation or enhancement proposals.

4.2.2.7 Desktop habitat mapping

4.25. Within the 1km study area, the Phase 1 habitats presented in Table 4.8 were deemed to be present based upon desktop habitat mapping, based on aerial imagery, as described in Section 4.2.1.1.

Table 4.8: Phase 1 habitat types identified from desktop mapping

Component	Phase 1 habitats identified
River Lee Intake and Raw Water Pumping Station	B6 – Poor Semi-improved grassland G2 – Running water J1.2 – Cultivated/disturbed land – amenity grassland J3.6 – Buildings J5 – Hardstanding
Raw Water Transfer Main Route Corridor	A2.1 Scrub – dense/continuous B6 – Poor Semi-improved grassland J1.2 – Cultivated/disturbed land – amenity grassland J5 – Hardstanding
Indicative WTW Site	A2.1 Scrub – dense/continuous J1.2 – Cultivated/disturbed land – amenity grassland J3.6 – Buildings J5 – Hardstanding

Component	Phase 1 habitats identified
Drinking Water Transfer Main Route Corridor	A1.1.1 – Broadleaved woodland – semi-natural A2.1 Scrub – dense/continuous B6 – Poor Semi-improved grassland G2 – Running water J1.2 – Cultivated/disturbed land – amenity grassland J3.6 – Buildings J5 – Hardstanding
Brookmans Park Service Reservoir Connection	G2 – Running water J1.2 – Cultivated/disturbed land – amenity grassland J5 – Hardstanding
Drinking Water Transfer Main to North Mymms	A1.1.1 – Broadleaved woodland – semi-natural G2 – Running water J1.2 – Cultivated/disturbed land – amenity grassland J5 – Hardstanding
North Mymms Booster Station Connection	J1.2 – Cultivated/disturbed land – amenity grassland J5 – Hardstanding

4.2.2.8 Protected and priority species potential

4.26. The components of the Beckton Reuse Indirect Option include a range of habitat types, with varying levels of suitability for protected and priority species. In the following sections the habitats with potential to support protected species are likely to be found in are described. Note that this is not a definitive list, and all areas should be assessed as appropriate as the scheme progresses.

Bat habitat assessment

4.27. Bats use a wide range of different habitats throughout the year as they feed, roost and commute through the landscape. They use foraging habitats to find food and commuting habitats (often linear features) to travel between roosts and foraging habitats. These habitats are vital for bats.

4.28. Bats commonly use a wide range of habitats for foraging throughout the landscape ranging from semi-natural to urban environments. Wooded areas are commonly used by foraging, roosting, hibernating, and breeding bats, especially areas that provide a mosaic of open and closed canopies. Grasslands provide important habitat

for foraging bats, especially those with reduced or no arable inputs, e.g. lowland calcareous grassland. Riparian areas are commonly used by bats for foraging and commuting with some species having a strong affinity for foraging above flowing and stagnant water bodies, e.g. Daubenton's bat (*Myotis 4-15 aubentoniid*). Common foraging habitats within arable landscapes include hedgerows, treelines, scattered dwellings and gardens, arable ponds, set aside margins and headlands.

4.29. Bats roost and breed in a wide range of features including features within trees such as woodpecker and rot holes, tear outs, crevices beneath loose bark, ivy cover and hazard beams. Trees can be used within a variety of habitats including woodlands, arable and urban environments. Features within buildings such as loft voids, crevices between roof tiles and batons and ill-fitting soffits, and in structures (bridges etc) such as cracks, expansion joints, voids etc, all have the potential to support roosting bats. Any feature that is likely to allow ingress by a particular species of bat into a crevice or void has the potential to support a roosting bat.

4.30. Bats are considered likely to be present across the Beckton Reuse Indirect Option with potential roosting, foraging, and commuting habitats present. These include, but are not limited to, habitats such as woodland, grassland, riparian, rivers, streams and arable field margins with associated ditches and hedgerows. For example, where the Drinking Water Transfer Main Route Corridor intersects two sections of the River Lee and the associated woodland and hedgerows, to the southwest of Waltham Abbey, bats are considered likely to be present as this area has a high number of linear features suitable for foraging and commuting.

Badger habitat assessment

4.31. Badgers (*Meles meles*) are found across the UK, with the highest numbers in southern England [25]. Ideal badger habitat is comprised of a mixture of woodland and open country. Each badger territory typically includes a main sett and several smaller setts of differing type and function. Badgers are opportunistic foragers that make use of a range of habitats, including for example woodlands, arable margins, grassland and terrestrial margins of riparian habitats. They forage over a large area and as a result need a relatively large area of habitat for their home range.

4.32. As badgers often use a mixture of woodland and grassland habitats they may reside anywhere where there is a woodland stand with some adjacent foraging habitat and therefore may occur across the Beckton Reuse Indirect Option. Furthermore, badgers can make their setts and home range on nearly entirely arable landscapes, therefore they have the potential to reside at any point within the route corridors.

[25] Mammal Society (2022) Species – Badger. Available at: https://www.mammal.org.uk/species-hub/full-species-hub/discover-mammals/species-badger/ [Accessed August 2022]

Great crested newt habitat assessment

4.33. Great crested newts (*Triturus cristatus*) (GCN) are found throughout the UK. GCN are primarily terrestrial but use ponds and other waterbodies such as ditches for breeding, foraging and shelter. Adult GCN generally hibernate on land (juveniles and sub-adults remain in ponds for up to five years), and therefore require hibernacula such as logs, log piles and rubble to hibernate in or under. GCN also use woodland, scrub, grassland and other habitat for dispersal and foraging. These habitats, along with a number of ponds and ditches, are present within the Raw Water Transfer Main Route Corridor, Drinking Water Transfer Main Route Corridor and Drinking Water Transfer Main to North Mymms Route Corridor, and well as the Indicative Intake Location, Indicative Site for the Raw Water Pumping Station and Indicative WTW Site. Where the above described habitats are present, there is the potential for GCN to be present.

Hazel dormouse habitat assessment

4.34. Hazel dormice (*Muscardinus avellanarius*) are found mainly in the southern counties of England[26] and are commonly associated with areas of deciduous woodland and overgrown hedgerows. Where large areas of woodland are present in the landscape, hazel dormice have also been found in other habitats such as reedbed. Hazel dormice often live at low population densities, amongst tree branches, rarely coming down to ground level.

4.35. Hazel dormice have the potential to be present where suitable habitats occur within the various components of the Beckton Reuse Indirect Option, especially in areas with high densities of deciduous woodland and where there are healthy networks of hedgerows.

Reptile habitat assessment

4.36. Widespread reptile species (grass snake (*Natrix natrix*), adder (*Vipera berus*), slow worm (*Anguis fragilis*) and common lizard (*Zootoca vivipara*)), are most widely distributed on large areas of habitat such as heathland, rough grassland, calcareous grassland and sand dunes. They are often present locally in a range of other land covers such as railways and disused railway lines, roadside embankments and verges, churchyards/ cemeteries, allotments, derelict/brownfield areas, neglected/ overgrown land, rough pasture, scrub, quarries and woodland glades. Localised features and the suitable vegetation cover/structure are important for reptile species to be present.

4.37. Sand lizard (*Lacerta agilis*) is far less common and widespread but is known to exist in localised areas in the midlands. It prefers heathland and dunes (the latter of which is not likely to be present in or around the study area).

[26] Mammal Society (2022) Species – Hazel Dormouse. Available at: https://www.mammal.org.uk/species-hub/full-species-hub/discover-mammals/species-hazel-dormouse/ [Accessed August 2022]

4.38. A number of habitats across the Beckton Reuse Indirect Option are suitable for reptile utilisation. For example, the Drinking Water Transfer Main Route Corridor follows roads in places and any excavation here could also affect the roadside embankments (if present), which could be potential land cover for widespread reptiles. Reptiles could also be present in the scrub habitat within the Raw Water Transfer Main Route Corridor.

Breeding bird habitat assessment

4.39. Breeding birds are found in nearly all UK habitats. Breeding birds in the UK are split into species assemblages. For example, farmland species assemblage, woodland species assemblage and wetland bird species.

4.40. Breeding birds, being found in nearly all UK habitats, are a potential constraint anywhere there is suitable nesting habitat such as hedgerows, trees, ditches, woodland, grassland and scrub, as well as structures, e.g. bridges, walls and buildings. Breeding birds are likely to be ubiquitous across the whole of the Beckton Reuse Indirect Option study area, including natural, semi-natural and built-up areas..

Other protected species

4.41. Otters (*Lutra lutra*) use a wide variety of watercourses and waterbodies including rivers, lakes, canals, and ditches. They have the potential to be present anywhere where there is suitable aquatic and terrestrial habitat. For example, the transfer route corridors cross the River Lee, Turkey Brook, New River Canal and Ray Brook, along with a multitude of minor watercourses and ditches connected to these. All of these have the potential to provide suitable habitat for otters.

4.42. Water vole (*Arvicola amphibius*) also use a variety of watercourses but generally prefer sites with earth banks for burrowing and with significant swathes of vegetation for foraging. They generally prefer slower flowing watercourses. Any habitat present within the route corridors that offers slower moving watercourses, appropriate gradient embankment, appropriate vegetative food sources and low levels of predation, have the potential to support water voles. Areas within the proposed corridors of the pipeline routes that may offer these habitats, and as a result have the for water vole to be present include (but are not limited to) the River Lee, Turkey Brook, New River Canal and Ray Brook, which the pipeline would cross, along with minor watercourses and ditches connected to these.

4.43. White-clawed crayfish (*Austropotamobius pallipes*) live in a diverse variety of clean aquatic habitats, but especially favour hard-water streams and rivers with large densities of refuge sites, available food sources and contact with other white-clawed crayfish populations, i.e. natural rivers not affected by dams and weirs. They also prefer high water quality with suitable levels of dissolved oxygen and calcium and absence of the non-native North American signal crayfish (*Pacifastacus leniusculus*)

and associated crayfish plague (*Aphanomyces astaci*). There appears to be suitable habitat present within the Beckton Reuse Indirect Option that has the potential to support this species, especially in more isolated streams. White-clawed crayfish populations are adversely affected by the presence of North American signal crayfish, and hence the associated crayfish plague, so this species also requires consideration. It is acknowledged, however, that white-clawed crayfish are unlikely to be present within the study area and therefore they are not considered further in this assessment.

4.2.3 Appraisal outcomes

4.2.3.1 Indicative Intake Location and Indicative Raw Water Pumping Station Site

Construction

4.44. Technical Supporting Document B2, Habitats Regulations Assessment, contains the results of the HRA undertaken for the Beckton Reuse Indirect Option. The Stage 1 Screening Assessment did not identify Likely Significant Effects for Epping Forest SAC and the Stage 2 HRA AA concluded no adverse effects on the integrity of the Lee Valley SPA and Ramsar site therefore these European Sites have not been considered further.

4.45. The Indicative Intake Location is within and directly adjacent to the Chingford Reservoir SSSI and the Lea Valley IBA. Any construction that occurs in these areas would have a potential negative impact on the SSSI and IBA through noise and lighting disturbance. The coastal and floodplain grazing marsh priority habitat present would also be negatively impacted by vegetation removal during construction work.

4.46. Construction works for the River Lee Intake and Raw Water Pumping Station have the potential to impact protected species, due to for example habitat loss and fragmentation, disturbance etc. The proposed locations for this are within amenity grassland, poor semi-improved grassland, hardstanding, running water and buildings. The Indicative Intake location is also in close proximity to the River Lee which has the potential for protected species to be present include but may not be limited to badgers, bats, reptiles, GCN and breeding birds. Otter and water vole may also be present in the River Lee and any associated ditches.

4.47. These species all have the potential to be present within the Indicative Intake Location and may all be adversely affected by construction works. The inevitable habitat loss would likely affect some or all of these species, with loss of shelter, foraging and commuting opportunities, severance of routes through the landscape, further fragmentation of habitat, etc. There are also likely to be indirect effects

associated with construction on protected species, due to disturbance from construction plant and machinery, the presence of people, lighting, creation of dust, etc.

Operation

4.48. During operation, the Raw Water Pumping Station would potentially increase lighting to the surrounding habitats, with exterior lights being installed. This could have adverse effects on crepuscular and nocturnal species, for example bats, barn owl, etc. There would also be a potential increase in noise and disturbance to the surrounding habitats.

4.2.3.2 Raw Water Transfer Main Route Corridor

Construction

4.49. No statutory designated sites or ancient woodland would be directly impacted by works to construct the Raw Water Transfer Main. The Lea Valley SINC of Metropolitan Importance is located to the immediate west of the Raw Water Transfer Main Route Corridor and could be negatively impacted due to disturbance. The Woodlands Farm Meadows (immediately adjacent), Wood, South of Barn Hill Wood (0.05km from the scheme) and Barn Hill Wood LWSs (0.01km from the scheme), located to the east of the Raw Water Transfer Main Route Corridor, could be negatively impacted due to disturbance.

4.50. Works to construct the Raw Water Transfer Main have the potential to impact deciduous woodland priority habitat and protected and priority species. Protected species with the potential to be present include (but are not limited to) badgers, bats, hazel dormice, widespread reptiles, GCN, breeding birds, water voles and otters. Habitat loss, habitat severance and fragmentation, and disturbance, could affect these protected species, if present.

Operation

4.51. During operation, impacts upon habitats and protected species are likely to be low. Planned maintenance or replacement of pipeline sections have the potential to impact habitats and protected species, most likely in the form of habitat maintenance/control. However, impacts are likely to be highly localised and should be mitigated by Ecological Method Statements and in person Ecological Clerk of Works (EcoW).

4.2.3.3 Indicative Water Treatment Works Site

Construction

4.52. No statutory designated nature conservation sites or ancient woodland would be impacted by works to construct the new WTW. Thompsons Wood LWS is located 0.17km to the east of the Indicative WTW Site and could be negatively impacted due to disturbance.

4.53. Works to construct the new WTW have the potential to impact protected and priority species. Protected species with a potential to be present within the Indicative WTW Site include but may not be limited to badgers, bats, hazel dormice, reptiles, GCN and breeding birds, and may all be negatively impacted by construction works.

Operation

4.54. During operation, the new WTW would potentially increase lighting to the surrounding habitats, with exterior lights being installed. This could have adverse effects on crepuscular and nocturnal species, for example bats, barn owl etc. There would also be a potential increase in noise and disturbance to the surrounding habitats. These forms of disturbance could act to deter protected and priority species from the immediate area, causing further loss of usable habitat and hence increasing habitat loss, fragmentation and severance.

4.2.3.4 Drinking Water Transfer Main Route Corridor

Construction

4.55. Technical Supporting Document B2, Habitats Regulations Assessment, contains the results of the HRA undertaken for the Beckton Reuse Indirect Option. The Stage 1 Screening Assessment identified potential Likely Significant Effects for Wormley-Hoddesdonpark Woods SAC. The Stage 2 AA identified no adverse effects on the integrity of this therefore this European Site has not been considered further.

4.56. The Drinking Water Transfer Main Route Corridor is within 0.08km of Northaw Great Woods SSSI and Northaw Great Wood Country Park LNR. Construction work could negatively impact upon the sites, including the diverse breeding bird community that they support, due for example to loss of supporting habitat, disturbance due to noise, vibration light and presence of people. It is assumed that a CEMP would be in place, and it is anticipated that with standard mitigation measures in place during construction (EcoW presence, clearance of habitat outside the bird breeding season, control of disturbance etc), there would be no adverse effects on the integrity of these sites.

4.57. A number of non-statutory SINCs and LWSs could be directly impacted during construction, with several being bisected by the Drinking Water Transfer Main Route Corridor. These include Gunpowder Park LWS, Lea Valley SINC of Metropolitan Importance, New River SINC of Metropolitan Importance, Tolmers Park LWS, Wood N. of Postern Gate LWS, Woodland Strip N. of School Camp LWS, Hell Wood LWS and Coldharbour Plantation & Broombarns Wood LWS. Any vegetation removal during the construction phase could have a negative impact on these sites. Disturbance due to excessive noise, vibration, lighting and the presence of people, and pollution events could also adversely affect these habitats.

4.58. No other statutory or non-statutory designated sites are likely to be negatively impacted due to the distance from the Drinking Water Transfer Main Route Corridor and the lack of an impact pathway.

4.59. No ancient woodland would be directly impacted by works to construct the Drinking Water Transfer Main.

4.60. Where open cut excavation is proposed, several priority habitats could be bisected including good quality semi-improved grassland and deciduous woodland, which all have the potential to be negatively impacted by construction works.

4.61. Works to construct the Drinking Water Transfer Main have the potential to impact protected and priority species along the length of the route corridor, including where the Drinking Water Transfer Main Route Corridor crosses or is in close proximity to watercourses, including the River Lee, Turkey Brook and Cuffley Brook. Protected species with the potential to be present include (but are not limited to) badgers, bats, hazel dormice, widespread reptiles, GCN and breeding birds. Habitat loss, habitat severance and fragmentation, and disturbance, could affect these protected species, if present. Other protected species with the potential to be present along the pipeline route include otter and water vole. These species have the potential to be present at the river crossing locations. As described in Paragraph 2.32, trenchless techniques are proposed to cross major watercourses, which is likely to reduce impacts during construction. However, works are likely be required to facilitate this, and as such, potential negative impacts via disturbance and local habitat loss may occur if these species are present.

Operation

4.62. Planned maintenance or replacement of pipeline sections have the potential to impact habitats and protected and priority species, however impacts are likely to be highly localised and should be mitigated by Ecological Method Statements and in person EcoW.

4.2.3.5 Brookmans Park Service Reservoir Connection

Construction

4.63. No designated sites, ancient woodland or priority habitat would be directly impacted by the construction works for the Brookmans Park Service Reservoir Connection.

4.64. Construction works have the potential to impact protected species within the existing Brookmans Park Service Reservoir site, for example due to habitat loss and severance, disturbance due excessive noise, vibration, lighting and the presence of people, and due to pollution events. Notable species with the potential to be present include (but are not limited to) badgers, bats, hazel dormice, widespread reptile species, and breeding birds. Depending on the nature of the construction works, these species may all be negatively impacted by construction works. Habitat loss, habitat severance and fragmentation, and disturbance could all affect protected species if present.

Operation

4.65. The Brookmans Park Service Reservoir Connection would take place within an existing service reservoir, therefore, during operation, it is not expected that there would be any adverse impacts on species or habitats in its vicinity.

4.2.3.6 Drinking Water Transfer Main to North Mymms Route Corridor

Construction

4.66. Water End Swallow Holes SSSI is located 0.12km to the west of the Drinking Water Transfer Main to North Mymms Route Corridor therefore construction works have the potential to negatively impact the statutory designated nature conservation site. However, as described in Section 2.3, below ground structures would be constructed such that they would not form a preferential pathway for pollution to groundwater or cause alterations in groundwater flow or levels.

4.67. The Drinking Water Transfer Main to North Mymms Route Corridor bisects the Meadow N. of Peplins Wood LWS and construction work here could negatively impact upon the site for example due to habitat loss and severance, disturbance due excessive noise, vibration, lighting and the presence of people, and due to pollution events. There are potential impacts on areas of ancient woodland immediately adjacent to the Drinking Water Transfer Main to North Mymms Route Corridor, including Brick Kiln Wood and Peplin's Wood. The Drinking Water Transfer Main to North Mymms Route Corridor also bisects deciduous woodland priority habitat and Ray Brook, and so construction could potentially result habitat loss and

fragmentation, disturbance, pollution, etc.

4.68. A number of non-statutory designated nature conservation sites could be directly impacted during construction, with several being bisected by the Drinking Water Transfer Main to North Mymms Route Corridor. These include The Legg North LWS, Peplin's Wood LWS, Meadow N. of Peplins Wood LWS, Potterells Wood LWS, Grassland N. of Potterells Wood LWS and Brick Kiln Wood (nr Brookmans Park) LWS. Any vegetation removal during the construction phase could have a negative impact on these sites. Disturbance due to excessive light, noise vibration and the presence of people, and pollution events, could also cause adverse effects.

4.69. No other statutory or non-statutory designated nature conservation sites are likely to be negatively impacted due to the distance from the Drinking Water Transfer Main to North Mymms Route Corridor (see Appendix B) and the lack of an impact pathway.

4.70. Construction works have the potential to impact protected and priority species within the Drinking Water Transfer Main to North Mymms Route Corridor. Protected species with the potential to be present include (but are not limited to) badgers, bats, hazel dormice, widespread reptiles, GCN and breeding birds. Depending on the nature of the construction works, these species may all be negatively impacted by construction works, due to excessive noise, vibration, lighting and the presence of people, and due to pollution events for example. Habitat loss, habitat severance and fragmentation, and disturbance could all affect protected species if present.

4.71. Other protected species with the potential to be present along pipeline route include otter and water vole; these species have the potential to be present in Ray Brook and any associated ditches. There is the potential for these species to utilise the area of proposed works for foraging activities.

Operation

4.72. Planned maintenance has the potential to impact habitats and protected species, however impacts are likely to be highly localised and likely mitigated by Ecological Method Statements and in person EcoW.

4.2.3.7 North Mymms Booster Station Connection

Construction

4.73. No designated sites, ancient woodland or priority habitat would be directly impacted by the construction works at the existing North Mymms booster pumping station.

4.74. Construction works have the potential to impact protected species within the existing North Mymms booster pumping station site. Notable species with the potential to be present include (but are not limited to) badgers, bats, hazel dormice,

widespread reptiles, and breeding birds. Depending on the nature of the construction works, these species may all be negatively impacted by construction works. Habitat loss, habitat severance and fragmentation, and disturbance could all affect protected species if present.

Operation

4.75. The North Mymms Booster Station Connection would take place within an existing site, therefore, during operation, it is not expected that there would be any adverse impacts on species or habitats in its vicinity.

4.2.4 Recommended mitigation and enhancement opportunities

4.76. Good practice is to apply the mitigation hierarchy. That is to first avoid, mitigate and finally, as the last option, compensate for biodiversity losses. If compensating for losses within the development footprint is not possible or does not generate the most benefits for nature conservation, then biodiversity losses can be offset by providing gains elsewhere. This is the first principle in the Biodiversity Net Gain Good Practice Principles for Development[27].

4.77. In order to mitigate potential issues arising from the Beckton Reuse Indirect Option on biodiversity, where possible, the transfer mains should be routed to avoid ancient woodland, non-statutory designated nature conservation sites, priority habitats, and those habitats that provide higher/better potential for protected and priority species. If this cannot be accommodated, trenchless techniques should be considered to allow the pipeline to cross under these protected areas. Where this is not possible, compensatory habitat would be required.

4.78. As described in Section 2.3, it is assumed that a CEMP would be developed at an appropriate stage to ensure that environmental risks are managed. Once more information is known about the ecological constraints on site through survey work undertaken at a subsequent project stage, detailed mitigation and enhancement measures should be developed to reduce disturbance during the construction stage, and protected species licences should be obtained, where required.

4.79. The Beckton Reuse Indirect Option falls partially within a Nature Recovery Network with two Natural England Network Enhancement Zones and one Network Expansion Zone. Therefore, there are opportunities to incorporate the network enhancement zone into the landscape and ecology post-construction enhancement/habitat creation and restoration proposals within these locations. Biodiversity enhancements are considered within Chapter 16, Natural capital and biodiversity net

[27] Chartered Institute of Ecology and Environmental Management (CIEEM) Biodiversity Net Gain: Good Practice Principles for Development. Available at: https://cieem.net/resource/biodiversity-net-gain-good-practice-principles-for-development/ [Accessed April 2022]

gain and Chapter 17, Wider benefits.

4.3 Aquatic ecology

4.3.1 Methodology

4.3.1.1 Study area and sources of information

4.80. The desk-based assessment focused on the transfer route corridors, location of associated infrastructure and the surface water bodies within a 1km area (see Figure 4.1: Statutory designated nature conservation sites and Figure 4.2: Non-statutory designated nature conservation sites). Where it was recognised that impacts could extend beyond the proposed study areas due to potential indirect impacts, the assessment boundaries were extended accordingly to address the geographic extent of such potential impacts.

4.81. The proposed infrastructure and transfer corridor interacts with three surface water Management Catchments: Colne, London and the Upper Lee and three Operational Catchments: Colne, Lower Lee Rivers and Lakes and Upper Lee. The option interacts with six WFD Surface water bodies within these catchments including one Surface Water Transfer.

4.82. Table 4.9 outlines the baseline data sources which were collated and considered in the desk-based assessment.

Table 4.9: Sources of information (aquatic ecology)

Data collected	Source
Aquatic ecology data	Environment Agency Ecology and Fish Data Explorer data[28] and Fisheries Classification Scheme 2 (FCS2)[29] data Monitoring Programme data; including fish, invertebrates, macrophytes, diatoms, and multi-purpose eDNA monitoring[30] for the River Lee
Land cover data including statutory designated nature conservation sites and Priority Habitat Inventory	Natural England UK Government – MAGIC Maps Website[20] / the NBN Atlas[21] / local authority information on BAP priority habitats and species

[28] Environment Agency (2021) Ecology and Fish Data Explorer [online]. Available at: https://environment.data.gov.uk/ecology/explorer/ [Accessed on: 25/11/2021].
[29] WFD-UKTAG (2008) Rivers Assessment Methods Fish Fauna: Fisheries Classification Scheme 2. Available at: https://wfduk.org/resources%20/river-fish [Accessed on: 22/02/2022].
[30] Data are also available for the River Lee as part of TWUL's AMP6 Flow Investigations

Data collected	Source
Descriptions / designations of statutory designated nature conservation sites (and candidate designated sites)	Natural England/Joint Nature Conservation Committee (JNCC)
Biodiversity Action Plan (BAP) priority habitats and species	UK Government – MAGIC Maps Website[20] / the NBN Atlas[21] / local authority information on BAP priority habitats and species

4.3.2 Approach to impact appraisal

4.83. A qualitative approach was undertaken to evaluate the aquatic ecology of the study area and assess where there was potential for the Beckton Reuse Indirect Option (infrastructure and transfer corridor) to result in impacts on key aquatic features. Where there was potential for significant impacts, recommendations have been made for further surveys, as appropriate, to be undertaken at a subsequent project stage.

4.84. Several data sources (see Table 4.9) were reviewed to identify available baseline ecological data within the study area and further develop the baseline understanding developed at Gate 1.

4.85. Two types of data were used to build an understanding of the baseline aquatic ecology, community and population sensitivities across the study area. This included community biological metrics and species records.

4.86. The predicted direction and magnitude of receptor change associated with each pathway (see Table 4.10) is reported within the assessment, based on the definitions outlined in Table 4.11. The assessment of effects considers the likely embedded (i.e. design) mitigation and 'standard' mitigation, prior to any further mitigation and/or compensation (see Section 2.3).

Table 4.10: Relevant pathways and receptors considered in the assessment

Component	Receptor(s)	Pathway
Indicative Intake Location	Lea Navigation Enfield Lock to Tottenham Locks (GB106038027950)	Construction related impacts such as pollution incidents, local increases in sediment/siltation, temporary disturbance as a result of noise and vibration, etc. Operational impacts have been assessed as part of the London Effluent Reuse EAR. Maintenance could be required, including backflushing or 'airburst'.
Indicative Raw Water Pumping Station	Lea Navigation Enfield Lock to Tottenham Locks (GB106038027950)	Construction related impacts such as pollution incidents, local increases in sediment/siltation, temporary disturbance as a result of noise and vibration, etc. It is unknown whether the component requires washout/maintenance points. Should these be required, this could result in water quality and flow changes during maintenance.
Indicative Water Treatment Works Site	Black Ditch a tributary of the Lea Navigation Enfield Lock to Tottenham Locks (GB106038027950)	Construction related impacts such as pollution incidents, local increases in sediment/siltation, temporary disturbance as a result of noise and vibration, etc. It is unknown whether the component requires washout/maintenance points. Should these be required, this could result in water quality and flow changes during maintenance.
Drinking Water Transfer Main Route Corridor	Lea Navigation (Fieldes Weir to Enfield Lock) (GB106038077851) Small River Lee (and tributaries) (GB106038033200) Turkey Brook and Cuffley Brook (GB106038033180) New River (GB806100111) Cuffley Brook River Colne (east source stream) Ray Brook	Construction related impacts such as pollution incidents, local increases in sediment/siltation, temporary disturbance as a result of noise and vibration, etc. It is unknown whether the component requires washout/maintenance points. Should these be required, this could result in water quality and flow changes during maintenance.

Component	Receptor(s)	Pathway
	Colne (upper east arm including Mimshall Brook) GB106039029850	
Brookmans Park Service Reservoir Connection	River Colne (East Source Stream) a tributary of the Colne (upper east arm including Mimshall Brook) GB106039029850	Construction related impacts such as pollution incidents, local increases in sediment/siltation, temporary disturbance as a result of noise and vibration, etc.
North Mymms Booster Station Connection	Ray Brook a tributary of the Colne (upper east arm including Mimshall Brook) GB106039029850	Construction related impacts such as pollution incidents, local increases in sediment/siltation, temporary disturbance as a result of noise and vibration, etc.

Table 4.11: Gate 2 assessment of potential effects for aquatic ecology

Description of potential effect
Major beneficial change in aquatic ecological community receptors, with the potential to improve the overall ecological integrity of the reach.
Minor beneficial change in aquatic ecological community receptors, unlikely to affect the overall ecological integrity of the reach.
No or negligible change in aquatic ecological community receptors.
Minor adverse change in aquatic ecological community receptors, unlikely to affect the overall ecological integrity of the reach.
Major adverse change in aquatic ecological community receptors, with the potential to reduce the overall ecological integrity of the reach.

4.3.2.1 Assumptions and limitations

4.87. This chapter presents a purely desk-based assessment, and as such, it does not include any field-based evidence of sensitivity of any watercourses. Protected species records were also informed by open-source data.

4.88. Available data were mostly available for large water bodies. As such, no data were available for the smaller tributaries associated with the various components. This includes the Black Ditch (a tributary of the River Lee) which will be directly associated with the construction and operation of the new WTWs. Additional information regarding the baseline data limitations are provided in Section 4.3.3.

4.89. Data for the macrophyte and phytobenthos communities were particularly limited within the study area with the sensitivity of these elements informed by a single site on major watercourses only.

4.90. As noted in Section 2.1, the source of water for the Beckton Reuse Indirect Option is the River Lee. However, the natural flow in the river is insufficient and so operation of the scheme will be dependent on recycled water being fed into the river from the Beckton Water Recycling option of the London Effluent Reuse SRO. Any impacts related to the provision of the source water are considered in the EAR for the London Effluent Reuse SRO.

4.91. Raw water for the Beckton Reuse Indirect Option will be abstracted from the River Lee. The concept design proposes a passive wedge wire screen located in the riverbed. The necessary equipment for backflushing or 'airburst' will be housed away from the riverbank to ensure that there is a minimum of visible intrusion at the intake site

4.92. Any discharge from the new WTW would be treated to a standard agreed with the regulatory authority at less than the agreed maximum rate so as to not cause any potential impacts to water quality of the receiving water body.

4.93. Assumptions regarding the construction methodology and embedded mitigation measures (including measures related to INNS and biosecurity) are provided in Section 2.3.

4.3.3 Understanding the baseline

4.3.3.1 Statutory and non-statutory designated nature conservation sites

4.94. While several designated nature conservation sites (statutory and non-statutory) have been identified within the study area, most of the sites are designated for terrestrial habitats and species. The relevant sites are listed in Section 4.2.2 and are presented in Figure 4.1: Statutory designated nature conservation sites and Figure 4.2: Non-statutory designated nature conservation sites. Where internationally designated terrestrial habitat and species are dependent on aquatic features, these have been assessed in more detail within Technical Supporting Document B2, Habitats Regulations Assessment.

4.95. Two statutory designated nature conservation sites have been identified as important with regards to aquatic features. As noted above, the Beckton Reuse Indirect Option could affect the Cornmill Stream and Old River Lea SSSI. The SSSI is a freshwater habitat with one of the most diverse invertebrate faunas in Essex. The site supports an outstanding assemblage of dragonflies and damselflies (Odonata); eighteen species have been recorded. The Old River Lea is one of only two known localities in Essex for the uncommon and nationally declining white-legged damselfly (*Platycnemis pennipes*). Other Odonata include the variable damselfly (*Coenagrion pulchellum*), the red-eyed damselfly (*Erythromma najas*) and the ruddy darter (*Sympetrum sanguineum*).

4.96. The slow-moving streams support a rich and varied aquatic and marginal flora. Associated with this habitat is one of the richest gastropod molluscan faunas in the county including two vulnerable species of freshwater snail and other invertebrates including a rare sawfly and a rare soldier fly.

4.97. Upstream of the study area, parts of the Lee Valley SPA and Ramsar site also extend into the Small River Lee and the Flood Relief Channel.

4.3.3.2 Fish community and notable species

4.98. Baseline data for the fish community were available for several sites within the study area from the Environment Agency's Fish and Ecology data explorer, although the data were limited to the larger watercourses (e.g. the main River Lee). The WFD status of the waterbodies range from Bad to Moderate (also see Technical Supporting Document B3, Water Framework Directive Compliance Assessment).

4.99. The available data suggests a diverse fish community with a total of 36 species recorded within the study area between 2000 and 2022. This includes three species of conservation importance, including bullhead (*Cottus gobio*), European eel (*Anguilla anguilla*) and brown / sea trout (*Salmo trutta*). The latter has been observed most frequently at the Environment Agency's Fishers Green on the River Lee. There are also records (very low abundances) of brook lamprey (*Lampetra planeri*) from a site on the River Lee and Old River Lea (see Table 4.12).

4.100. Data were also available from surveys completed in 2021 on the River Lee (downstream of the existing intake). This included electro-fishing surveys and seine netting surveys.

4.101. The available baseline data suggest a fish community that is fairly tolerant to environmental change when considering the tolerances of the fish community as identified as part of the Fisheries Classification Scheme (FCS2)[31].

[31] WFD UK Tag (2008). UKTAG Rivers Assessment Methods Fish Fauna (Fisheries Classification Scheme 2 (FCS2)) by Water Framework Directive - United Kingdom Technical Advisory Group (WFD-UKTAG). ISBN: 978-1-906934-09-5

4.102. The data also indicates that the fish community is dominated by taxa with a preference for slow flowing water. The watercourses within the study area are dominated by coarse fish communities with taxa such as roach (*Rutilus rutilus*), perch (*Perca fluviatilis*) dace (*Leuciscus leuciscus*), chub (*Squalius cephalus*), stone loach (*Barbatula barbatula*), common bream (*Abramis brama*) and ruffe (*Gymnocephalus cernuus*) prevalent in high abundances.

Table 4.12: Summary of baseline fish community

Receptor(s)	Baseline summary
Lea Navigation Enfield Lock to Tottenham Locks (GB106038027950)	The fish element has not been classified for this water body. The fish community consist mostly of coarse fish species and with a preference for slow flowing water. The fish community is considered to be generally tolerant to environmental changes. There are historical records of European eel within this water body.
Black Ditch, a tributary of the Lea Navigation Enfield Lock to Tottenham Locks (GB106038027950)	The fish element has not been classified for this water body. There are no open-source data available for this water body. The sensitivity of the fish community is unknown. Given the geographical location and connectivity to the River Lee, it is assumed that the fish community is similar to the fish community of the River Lee.
Lea Navigation (Fieldes Weir to Enfield Lock) (GB106038077851)	The fish element has been classified as Poor. The fish community consist mostly of coarse fish species and have a preference for slow flowing water. The fish community is considered to be generally tolerant to environmental changes. There are historical records of European eel and bullhead within this water body.
Small River Lee (and tributaries) (GB106038033200)	The fish element has been classified as High. Data are not available for the reaches associated with the construction activities or the reaches immediately downstream. Sensitivity is inferred from data further upstream. The fish community consist mostly of coarse fish species and have a preference for slow flowing water. The fish community is considered to be generally tolerant to environmental changes. There are historical records of European eel and bullhead within this water body.
Turkey Brook and Cuffley Brook (GB106038033180)	The fish element has been classified as Good. Data are available for several survey locations, downstream of the proposed construction activities. The fish community consist mostly of coarse fish species and have a preference for slow flowing water. The fish community is considered to be generally tolerant to environmental changes. There are historical records of European eel and bullhead within this water body.

Receptor(s)	Baseline summary
New River (GB806100111)	The ecology element has been classified as Moderate (overall). There were no fisheries data available for this water body.
River Colne (East Source Stream), a tributary of the Colne (upper east arm including Mimshall Brook) GB106039029850	The fish element has not been classified for this water body. There are no opensource data available for this water body. The sensitivity of the fish community is unknown. Given the geographical location and connectivity to the River Colne, it is assumed that the fish community is similar to the fish community of the River Colne.
Ray Brook, a tributary of the Colne (upper east arm including Mimshall Brook) GB106039029850	The fish element has not been classified for this water body. There are no opensource data available for this water body. The sensitivity of the fish community is unknown. Given the geographical location and connectivity to the River Colne, it is assumed that the fish community is similar to the fish community of the River Colne.
Colne (upper east arm including Mimshall Brook) GB106039029850	The fish element has been classified as Bad. Data are only available for one survey location, downstream of the proposed construction activities. The fish community consist mostly of coarse fish species and have a preference for slow flowing water. Only four species have historically been observed at the survey location, including bullhead.

4.103. Aquatic INNS species that are prevalent within the study area include Crucian carp (*Carassius Carassius*), topmouth gudgeon (*Pseudorasbora parva*) and golden goldfish (*Carassius auratus*). It is noted that topmouth gudgeon was confined to a single pond in Enfield which was treated with piscicide by the Environment Agency.

4.104. The INNS assessment is detailed in Chapter 15, Invasive non-native species risk assessment. It is noted that some species, such as the Crucian carp are considered 'naturalised' throughout the UK.

4.3.3.3 Macroinvertebrate community and notable species

4.105. Baseline data for the macroinvertebrate community were available for several sites within the study area from the Environment Agency's Fish and Ecology data explorer. The WFD status of the waterbodies range from Poor to Good (also see Technical Supporting Document B3, Water Framework Directive Compliance Assessment).

4.106. Data from the biological metrics for the macroinvertebrate community indicates that the communities across all the associated watercourses were dominated by taxa with a moderate to high tolerance for pollution (see Table 4.13). There was some variation in the metrics with the results indicating slightly higher sensitivities in larger watercourses (such as the River Lee).

4.107. The biological metric score also indicated that, overall, the macroinvertebrate communities were dominated by species with a preference for moderate to slow flowing water and were not considered sensitive to reductions in flow velocities.

Table 4.13: Summary of baseline macroinvertebrate community

Receptor(s)	Baseline summary
Lea Navigation Enfield Lock to Tottenham Locks (GB106038027950)	The macroinvertebrate element has been classified as Moderate. Data are available for two survey locations. The Whalley Hawkes Paisley Tigg (WHPT) Average Score Per Taxon (ASPT) scores for the survey locations range from 3.6 - 4.0. Lotic Invertebrate Flow Evaluation (LIFE) scores range from 5.9 – 6.3 and Proportion of Sediment-sensitive Invertebrates (PSI) scores range from 10.3 – 15.5. Overall, the macroinvertebrate community is considered tolerant to pollution with a preference for slow flowing water and are indicative of a heavily silted riverbed.
Black Ditch, a tributary of the Lea Navigation Enfield Lock to Tottenham Locks (GB106038027950)	There is no survey data available for this watercourse. Based on the geographical location it is assumed that the macroinvertebrate community is tolerant to pollution and not sensitive to any flow changes.
Lea Navigation (Fieldes Weir to Enfield Lock) (GB106038077851)	The macroinvertebrate element has been classified as Good. Data are only available for one survey locations in the vicinity of the construction activities. The WHPT ASPT scores for the survey location range from 4.3-4.5. LIFE scores range from 6.2 – 6.3 and PSI scores range from 25.2-26.1. Overall, the macroinvertebrate community is considered tolerant to pollution with a preference for slow flowing water and are indicative of a heavily silted riverbed.
Small River Lee (and tributaries) (GB106038033200)	The macroinvertebrate element has been classified as Moderate. Data are only available for one survey locations in the vicinity of the construction activities, noting that the site has been survey on numerous occasions. The WHPT ASPT scores for the survey location range from 2.7-3.9. LIFE scores range from 5.0 – 6.0 and PSI scores range from 2.8-20.1. Overall, the macroinvertebrate community is considered tolerant to pollution with a preference for slow flowing water and are indicative of a heavily silted riverbed.

Receptor(s)	Baseline summary
Turkey Brook and Cuffley Brook (GB106038033180)	The macroinvertebrate element has been classified as Moderate. Data are available for several locations in the vicinity of the construction activities with an extensive historical record. The WHPT ASPT scores for the survey location range from 3.1-4.5. LIFE scores range from 5.8 – 7.0 and PSI scores range from 7.1-40.7. Overall, the macroinvertebrate community is considered tolerant to pollution with a preference for slow to moderately fast flowing water and are indicative of a heavily silted to moderately silted riverbed. Data are also available for the Ponsbourne Brook (a tributary of the Turkey Brook which will directly impacted by constructing activities. The data also indicates that the macroinvertebrate communities of this watercourse is considered tolerant to pollution with a preference for slow flowing water.
New River (GB806100111)	The ecology element has been classified as Moderate (overall). There were no macroinvertebrate data available for this water body.
River Colne (East Source Stream), a tributary of the Colne (upper east arm including Mimshall Brook) GB106039029850	The macroinvertebrate element has not been classified for this watercourse. Data were available for two survey locations. The data indicates that the macroinvertebrate communities of this watercourse is considered tolerant to pollution with a preference for slow flowing water and a moderately sedimented riverbed. WHPT ASPT scores ranged from 2.5-3.7, LIFE scores ranged from 5.4-6.4 and PSI scores ranged from 10.0-33.3.
Ray Brook, a tributary of the Colne (upper east arm including Mimshall Brook) GB106039029850	The macroinvertebrate element has not been classified for this watercourse. Data were available for two survey locations. The data indicates that the macroinvertebrate communities of this watercourse is considered tolerant to pollution with a preference for slow flowing water and a moderately sedimented riverbed. WHPT ASPT scores ranged from 3.3-4.1, LIFE scores ranged from 5.6-6.5 and PSI scores ranged from 9.2-36.1.
Colne (upper east arm including Mimshall Brook) GB106039029850	The macroinvertebrate element has been classified as Poor. Data are available for one survey location downstream of the construction activities. The WHPT ASPT scores for the survey location range from 3.6-4.0. LIFE scores range from 5.7-6.5 and Proportion of Sediment-sensitive Invertebrates (PSI) scores range from 8.7-24.2. Overall, the macroinvertebrate community is considered tolerant to pollution with a preference for slow flowing water and are indicative of a heavily silted to moderately silted riverbed.

4.108. Limited species data were available for the desktop review (with data mostly limited to family level). From the limited data, notable macroinvertebrates that were identified included the banded demoiselle (*Calopteryx splendens*) and blue-tailed damselfly (*Ischnura elegans*) and the soldier fly (*Oxycera morrisii).* Taxa associated with the Cornmill Stream and Old River Lea SSSI were not observed in the species recorded.

4.3.3.4 Macrophyte community and notable species

4.109. Limited open-source baseline data were available for the macrophyte communities of the watercourses associated with the Beckton Reuse Indirect Option. The WFD status (macrophyte and phytobenthos combined) of the waterbodies range from Bad to Moderate (Also see Technical Supporting Document B3, Water Framework Directive Compliance Assessment).

4.110. Data were available from targeted surveys in 2020 and 2021 to inform the baseline macrophyte community associated with the London Effluent Reuse SRO. The available data indicated that the macrophyte community includes Kneiff's feather-moss (*Leptodictyum riparium*), fool's watercress (*Apium nodiflorum*), floating sweet-grass (*Glyceria fluitans*), reed sweet-grass (*Glyceria maxima*), common duckweed (*Lemna minor*), water mint (*Mentha aquatica*), water forget-me-not (*Myosotis scorpioides*), yellow water-lily (*Nuphar lutea*), fennel pondweed (*Stuckenia pectinata*), watercress (*Nasturtium officinale agg*.) and common club-rush (*Schoenoplectus lacustris*).

4.111. The available biological metrics suggest a macrophyte community indicative of eutrophic water with a high tolerance to changes in nutrient concentrations (see Table 4.14). This is considered typical for the water bodies within the study area. The data also indicated that the macrophyte community was dominated by taxa with a preference for slow flowing/standing water.

4.112. Several non-native species were recorded from the associated watercourses, including least duckweed (*Lemna minuta*), Himalayan balsam (*Impatiens glandulifera*), floating pennywort (*Hydrocotyle ranunculoides*) giant hogweed (*Heracleum mantegazzianum*) and Nuttall's waterweed (*Elodea nuttallii*).

Table 4.14: Summary of baseline macrophyte community

Receptor(s)	Baseline summary
Lea Navigation Enfield Lock to Tottenham Locks (GB106038027950)	The macrophyte and phytobenthos element (combined) has been classified as Moderate. Data are limited to one survey location with River Macrophyte Nutrient Index (RMNI) scores indicative of eutrophic conditions.

Receptor(s)	Baseline summary
Black Ditch, a tributary of the Lea Navigation Enfield Lock to Tottenham Locks (GB106038027950)	No macrophyte or phytobenthos data are available for this water body.
Lea Navigation (Fieldes Weir to Enfield Lock) (GB106038077851)	The macrophyte and phytobenthos element (combined) has been classified as Good. Data are limited to one survey location with RMNI scores indicative of eutrophic conditions.
Small River Lee (and tributaries) (GB106038033200)	The macrophyte and phytobenthos element (combined) has been classified as Moderate. Data are limited to one survey location with RMNI scores indicative of eutrophic conditions.
Turkey Brook and Cuffley Brook (GB106038033180)	The macrophyte and phytobenthos element (combined) has been classified as Moderate. Data are available for survey location with RMNI scores indicative of eutrophic conditions.
New River (GB806100111)	The ecology element has been classified as Moderate (overall). There were no macrophyte or phytobenthos data available for this water body.
River Colne (East Source Stream), a tributary of the Colne (upper east arm including Mimshall Brook) GB106039029850	The water body has not been classified for the macrophyte and phytobenthos element. No macrophyte or phytobenthos data are available for this water body.
Ray Brook, a tributary of the Colne (upper east arm including Mimshall Brook) GB106039029850	The water body has not been classified for the macrophyte and phytobenthos element. Macrophyte or phytobenthos data are available for one survey location with RMNI scores indicative of eutrophic conditions.
Colne (upper east arm including Mimshall Brook) GB106039029850	The macrophyte and phytobenthos element (combined) has been classified as Poor. Data are limited to once survey location with RMNI scores indicative of eutrophic conditions.

4.3.3.5 Diatom/phytobenthos community

4.113. The WFD status (macrophyte and phytobenthos combined) of the waterbodies ranged from Bad to Moderate (see Technical Supporting Document B3, Water Framework Directive Compliance Assessment). Limited baseline data were available for the phytobenthos communities of the watercourses associated with the Beckton Reuse Indirect Option.

As per the macrophyte data, the available biological metric data for the diatom/phytobenthos community suggests a community that is indicative of eutrophic (high nutrient) water quality conditions (see Table 4.15).

Table 4.15: Summary of baseline diatom / phytobenthos community

Receptor(s)	Baseline summary
Lea Navigation Enfield Lock to Tottenham Locks (GB106038027950)	The macrophyte and phytobenthos element (combined) has been classified as Moderate. Data are limited to one survey location with Trophic Diatom Index (TDI) scores indicative of eutrophic conditions.
Black Ditch, a tributary of the Lea Navigation Enfield Lock to Tottenham Locks (GB106038027950)	No phytobenthos data are available for this water body.
Lea Navigation (Fieldes Weir to Enfield Lock) (GB106038077851)	The macrophyte and phytobenthos element (combined) has been classified as Good. Data are limited to one survey location with TDI scores indicative of eutrophic conditions.
Small River Lee (and tributaries) (GB106038033200)	The macrophyte and phytobenthos element (combined) has been classified as Moderate. Data are limited to one survey location with TDI scores indicative of eutrophic conditions.
Turkey Brook and Cuffley Brook (GB106038033180)	The macrophyte and phytobenthos element (combined) has been classified as Moderate. Data are available for one survey location with TDI scores indicative of eutrophic conditions.
New River (GB806100111)	The ecology element has been classified as Moderate (overall). There were no macrophyte or phytobenthos data available for this water body.
River Colne (East Source Stream), a tributary of the Colne (upper east arm including Mimshall Brook) GB106039029850	The water body has not been classified for the macrophyte and phytobenthos element. No phytobenthos data are available for this water body.
Ray Brook, a tributary of the Colne (upper east arm including Mimshall Brook) GB106039029850	The water body has not been classified for the macrophyte and phytobenthos element. No phytobenthos data are available for this water body.
Colne (upper east arm including Mimshall Brook) GB106039029850	The macrophyte and phytobenthos element (combined) has been classified as Poor. No phytobenthos data are available for this water body.

4.3.4 Appraisal outcomes

4.114. The assessment of effects associated with recycled water being fed into the River Lee, and the associated abstraction nearby, has been assessed as part of the London Effluent Reuse SRO assessments. As such, only the construction related activities have been assessed in this section.

4.115. No internationally statutory designated nature conservation sites would be directly impacted by works to construct the Beckton Reuse Indirect Option. The designated nature conservation sites which include aquatic communities as the qualifying/notifiable features are the Cornmill Stream and Old River Lea SSSI and the Lee Valley SPA and Ramsar site. The sites are located upstream of the proposed transfer corridor and would not be affected by the construction activities.

4.116. The assessment of the potential impacts on the aquatic communities has considered several mitigation measures as listed in Section 2.3 and Section 4.3.5.

4.3.4.1 Indicative Intake Location and Indicative Raw Water Pumping Station Site

Construction

4.117. During construction, there is a risk of construction related impacts on the aquatic communities associated with the river (Lea Navigation Enfield Lock to Tottenham Locks). The construction related impacts include localised impacts on water quality due to increased sediment loads and/or pollution incidents. Temporary disturbance of fish communities (including migratory species such as European eel) could also occur.

4.118. Overall, the aquatic communities associated with the construction activities are considered to be tolerant and impacts are considered temporary and reversible. Any impacts on the aquatic communities are therefore expected to be short term, with no or negligible change in aquatic ecological community receptors expected.

Operation

4.119. The source of water for the Beckton Reuse Indirect Option is the River Lee. However, the natural flow in the river is insufficient and so operation of the scheme will be dependent on recycled water being fed into the river from the Beckton Water Recycling option of the London Effluent Reuse SRO.

4.120. The operational impacts on the River Lee have been assessed as part of the London Effluent Reuse SRO. The operation of the Beckton Reuse Indirect Option, therefore, assumes that sufficient water will be available for the abstraction and that impacts on the aquatic communities are considered negligible.

4.121. As noted in Section 2.1, backflushing or 'airburst' may be required for maintenance of the intake. Such 'airburst' could result in localised impacts on water quality through the re-suspension of fine material and water quality impacts where water may have become stagnant within the intake pipe.

4.122. The aquatic communities associated with the Lea Navigation Enfield Lock to Tottenham Locks are considered to be tolerant and impacts are considered temporary and reversible. Any impacts on the aquatic communities are therefore expected to be short term, with no or negligible change in aquatic ecological community receptors.

4.123. The timing of the 'airbursts' are important as the baseline community includes European eel and avoiding the peak upstream migration period of juvenile eel (spring) would further mitigate against the potential impacts associated with the maintenance of the intake.

4.3.4.2 Raw Water Transfer Main Route Corridor

Construction

4.124. During construction, there is a risk of construction related impacts on the aquatic communities associated with the River Lee (Lea Navigation Enfield Lock to Tottenham Locks) and the Black Ditch (a tributary of the River Lee). The construction related impacts include localised impacts on water quality due to increased sediment loads and/or pollution incidents. Temporary disturbance of fish communities (including migratory species such as European eel could also occur.

4.125. Overall, the aquatic communities associated with the construction activities are considered to be tolerant, and impacts are considered temporary and reversible. Any impacts on the aquatic communities are therefore expected to be short term, with no or negligible change in aquatic ecological community receptors.

4.126. There is some uncertainty with regards to the impacts on the Black Ditch as there is no data available for this watercourse. It has been assumed that the sensitivity of the aquatic communities are similar to those communities that are present in the River Lee (tolerant to pollution and not considered sensitive to flow).

Operation

4.127. Operational impacts are not considered likely following construction. During maintenance of the infrastructure, there is a risk that washout from the Raw Water Transfer Main could discharge into nearby water bodies resulting in changes in water quality and flow. It has been assumed that maintenance work would be completed with consideration of the Environment Agency's Pollution Prevention Guidance Notes. Any changes are therefore considered temporary and reversible and

negligible overall.

4.3.4.3 Indicative Water Treatment Works Site

Construction

4.128. The construction works for this component are associated with the Black Ditch (a tributary of the River Lee). There are no ecological data available for this watercourse. As such, it has been assumed that the sensitivity of the watercourse is similar to the River Lee.

4.129. Overall, the aquatic communities associated with the construction activities are considered to be tolerant, and impacts are considered temporary and reversible. Any impacts on the aquatic communities are therefore expected to be short term, with no or negligible change in aquatic ecological community receptors.

Operation

4.130. The operation of the treatment works could impact the Black Ditch (a tributary of the River Lee). There is no ecological data available for this watercourse. As such, it has been assumed that the sensitivity of the watercourse is similar to the River Lee.

4.131. During operation, any effluent discharge could impact on the receiving environment and the associated aquatic communities. Overall, the aquatic communities associated with the operational activities are considered to be tolerant to changes in water quality.

4.132. It is also recommended that a closed loop system be put into place for the new WTW to capture any potential contaminants from the treatment process. As such, there is no impact pathway applicable to the operation of this component.

4.3.4.4 Drinking Water Transfer Main Route Corridor and Drinking Water Transfer Main to North Mymms Route Corridor

Construction

4.133. During construction, there is a risk of construction related impacts on the aquatic communities associated with numerous water bodies. This includes the River Lee, the Black Ditch (a tributary of the River Lee), the Turkey and Cuffley Brook, the Small River Lee (and tributaries), the New River, the River Colne (east source stream) Ray

Brook and the River Colne (upper east arm including Mimshall Brook).

4.134. As noted in Section 2.3, main rivers would be crossed via micro-tunnel. All other rivers would be crossed using an open cut method across the road with traffic management. Where watercourses would not be micro-tunnelled, it is assumed they will be flumed during construction. However, works are likely be required to facilitate this, and as such, potential negative impacts via disturbance and local habitat loss may occur. This would include localised impacts on water quality due to increased sediment loads and/or pollution incidents.

4.135. Overall, the aquatic communities associated with the construction activities are considered to be tolerant and impacts are considered temporary and reversible. Any impacts on the aquatic communities are therefore expected to be short term, with no or negligible change in aquatic ecological community receptors.

Operation

4.136. Operational impacts are not considered likely following construction. During maintenance of the infrastructure, there is a risk that washout from the Drinking Water Transfer Main or Drinking Water Transfer Main to North Mymms could discharge into nearby water bodies resulting in changes in water quality and flow. It has been assumed that maintenance work will be completed with consideration of the Environment Agency's Pollution Prevention Guidance Notes. Any changes are therefore considered temporary and reversible and negligible overall. It is noted that any water discharged from the washout / maintenance points will be treated.

4.3.4.5 North Mymms Booster Station Connection

Construction

4.137. During construction, there is a risk of construction related impacts on the aquatic communities associated with the Ray Brook. The construction related impacts include localised impacts on water quality due to increased sediment loads and/or pollution incidents.

4.138. Overall, the aquatic communities associated with the construction activities are considered to be tolerant and impacts are considered temporary and reversible. Any impacts on the aquatic communities are therefore expected to be short term, with no or negligible change in aquatic ecological community receptors.

Operation

4.139. Operational impacts are not considered likely following construction. During maintenance of any infrastructure impacts are likely to be negligible.

4.3.5 Recommended mitigation

4.140. As stated in Paragraph 4.76, good practice is to apply the mitigation hierarchy. That is to first avoid, mitigate and finally as the last option compensate for biodiversity losses. If compensating for losses within the development footprint is not possible or does not generate the most benefits for nature conservation, then biodiversity losses can be offset by providing gains elsewhere. This is the first principle in the Biodiversity Net Gain Good Practice Principles for Development.

4.141. Appropriate precautions should be taken when working in any channels or adjacent to watercourses, to appropriately manage flood risk and the potential for deposition of silt or release of other forms of suspended material or pollution within the water column.

4.142. Water extracted from the ground during construction should be treated to a standard agreed with the regulatory authority before discharging at less than the agreed maximum rate to the water environment.

4.143. It is recommended that a closed loop system be put into place for the new WTW to capture any potential contaminants from the treatment process.

4.144. Any discharge from commissioning lagoons should be treated to a standard agreed with the regulatory authority at less than the agreed maximum rate so as to not cause any potential impacts to water quality of the receiving water body.

4.145. Crossings of main rivers should be via micro-tunnel. Where watercourses cannot be micro-tunnelled, it is recommended that they are flumed during construction. This will be a short term construction activity (i.e. less than seven days), which will ensure the watercourse is returned to its natural function following installation of the pile section.

4.146. It is assumed that a CEMP would be developed at an appropriate stage to ensure that environmental risks such as uncontrolled discharges from construction are minimised and that Emergency Response Plans are in place in the event of an incident. Best practice pollution prevention will be followed for all construction works.

4.147. There is still a risk of flooding during the construction phase near any watercourse and it is recommended that works within the river during forecasts of wet weather or issued flood warnings should be avoided.

4.4 Summary of main findings and recommendations for future technical work

4.4.1 Terrestrial ecology

4.148. The Beckton Reuse Indirect Option has the potential to directly impact Chingford Reservoir SSSI and the Lea Valley IBA and indirectly affect Northaw Great Woods SSSI and Northaw Great Wood Country Park LNR during construction. A CEMP should be in place, and it is anticipated that with mitigation measures in place during construction, there would be no adverse effects on the integrity of these sites.

4.149. A number of non-statutory designated nature conservation sites could be negatively impacted during construction including the Lea Valley SINC of Metropolitan Importance, and Woodlands Farm Meadows, Wood, South of Barn Hill Wood and Barn Hill Wood LWSs, which could be negatively impacted due to disturbance during construction of the Raw Water Transfer Main, and Thompsons Wood LWS, which could be which could be negatively impacted due to disturbance during construction of the Indicative WTW Site.

4.150. The Gunpowder Park LWS, Lea Valley SINC of Metropolitan Importance, New River SINC of Metropolitan Importance, Tolmers Park LWS Wood N. of Postern Gate LWS, Woodland Strip N. of School Camp LWS, Hell Wood LWS and Coldharbour Plantation & Broombarns Wood LWS would potentially be directly impacted due to open cut excavation for the Drinking Water Transfer Main, and the Legg North LWS, Peplin's Wood LWS, Meadow N. of Peplins Wood LWS, Potterells Wood LWS, Grassland N. of Potterells Wood LWS and Brick Kiln Wood (nr Brookmans Park) LWS could be directly impacted during construction of the Drinking Water Transfer Main to North Mymms.

4.151. No other statutory or non-statutory sites are likely to be negatively impacted due to the distance from the pipeline route and the lack of an impact pathway.

4.152. There are potential impacts on areas of ancient woodland immediately adjacent to the Drinking Water Transfer Main to North Mymms Route Corridor, including Brick Kiln Wood and Peplin's Wood.

4.153. Coastal and floodplain grazing marsh priority habitat present would be negatively impacted by vegetation removal during construction work for the River Lee Intake and the Raw Water Pumping Station. Where open cut excavation is proposed for the transfer mains, several priority habitats could be bisected including good quality semi-improved grassland and deciduous woodland, which all have the potential to be directly impacted by construction works.

4.154. The Beckton Reuse Indirect Option has the potential to impact protected and priority species, including where the transfer mains cross watercourses, including the River Lee, Turkey Brook, New River Canal and Ray Brook. Notable species with the potential to be present include (but are not limited to) badgers, bats, hazel dormice,

reptiles, GCN, and breeding birds. If present, these species may be adversely affected by construction works through disruption to commuting opportunities and routes. There could also be indirect effects due to disturbance from construction plant and machinery, the presence of people, lighting, creation of dust etc.

4.155. Other protected species with the potential to be present include otter and water vole. These species have the potential to be present at the river crossing locations. Trenchless techniques are proposed to cross the watercourses, which is likely to reduce impacts during construction. However, works are likely be required to facilitate this, and as such, potential negative impacts via disturbance and local habitat loss may occur if these species are present.

4.156. Planned maintenance or replacement of pipeline sections during operation have the potential to impact habitats and protected species, however impacts are likely to be highly localised and likely to be sufficiently mitigated by Ecological Method Statements and ecological supervision.

4.157. During operation, the new WTW could cause disturbance to protected and priority species through increasing lighting to the surrounding habitats, which could affect bats and barn owls, and potential increases in noise and disturbance to the surrounding habitats.

4.158. In order to mitigate potential issues arising from construction of the Beckton Reuse Indirect Option on biodiversity, the transfer mains should be routed to avoid ancient woodland, non-statutory designated nature conservation sites, priority habitats, and those habitats that provide higher/better potential for protected and priority species. If this cannot be accommodated, trenchless techniques should be considered to allow the pipeline to cross under these areas. Where this is not possible, compensatory habitat would be required.

4.159. It should be noted that the proposed protected and priority species suggested as being present are likely to be amended following completion of surveys and should not be considered final. Surveys are recommended at a subsequent project stage both to refine habitat mapping and identify the presence of protected species. Surveys should be phased in nature and proportionate to the level of design.

4.160. A Preliminary Ecological Appraisal (PEA) is recommended at a subsequent project stage to assess the likelihood of protected species and habitats being present. As part of this, protected and priority species data would be obtained from biological records centres and site visits undertaken to ground truth the findings of the desk based habitat mapping before a survey programme for protected species and habitats is established to inform an Ecological Impact Assessment to assess impacts to the qualifying features of designated sites, habitats and protected species, and inform scheme design evolution and mitigation measures. The timing of surveys would vary depending on the protected species in question, as optimum windows for differing species vary.

4.4.2 Aquatic ecology

4.161. Considering the micro-tunnelling technique prosed for the construction process, and the mitigation measured proposed, no or negligible change in aquatic ecological community receptors are expected.

4.162. Walkovers of the potential crossing points are recommended to further inform the scope of the mitigation measures that may be required. Limited data was available for the desktop assessment of selected aquatic features, notably macrophyte and phytobenthos communities and targeted surveys will be required to inform the baseline sensitivity of the associated watercourses.

4.163. No data were available to inform the sensitivity of the Black Ditch. This watercourse is associated with the construction and operation of WTWs.

4.164. It is also recommended that a closed loop system be put into place for the new WTW to capture any potential contaminants from the treatment process.

5 Soils

5.1 Introduction

5.1. This chapter presents a desk-based assessment undertaken to identify potential impacts on soils from the transfer route corridors and above ground infrastructure including the WTW. The objectives of the desk-based assessment were to establish the soils baseline associated with the Beckton Reuse Indirect Option, identify constraints and opportunities, and identify the issues that may require further investigation at a subsequent project stage. Land quality has also been considered in relation to potential land contamination.

5.2. The need to consider soils and land quality is driven by legislation (Part II A of the Environmental Protection Act (EPA), 1990, although numerous other subsidiary Regulations are also relevant) and national planning policy (draft NPS for Water Resource Infrastructure[18] (Section 4.10, Land use including open space, green infrastructure and Green Belt) and NPPF[19] (Section 15, conserving and enhancing the natural environment), paragraphs 174 and 183-184).

5.3. Impacts on food production as a result of the loss of agricultural land are considered in the NCA presented in Chapter 16, Natural capital and biodiversity net gain.

5.2 Methodology

5.2.1 Study area and sources of information

5.4. The desk-based assessment focused on the transfer route corridors, location of associated infrastructure and the surrounding area within 200m.

5.5. Table 5.1 outlines the baseline data sources which were collated and considered in the desk-based assessment.

Table 5.1: Sources of information (soils)

Data collected	Source
Land use	MAGIC map[20]
Agricultural land classification (ALC)	Provisional ALC data (Natural England)[32] Post-1988 publicly available ALC data (Natural England)[33] Predictive BMV Land Maps (Natural England)[34]
Soil type and properties	Soilscapes viewer, Land Information System (LandIS)[35] British Geological Survey (BGS) Onshore GeoIndex – borehole data[36]
Geology and superficial deposits	British Geological Survey of England and Wales, 1:50,000, Sheet 256, North London, Solid & Drift, 2006 British Geological Survey of England and Wales, 1:50,000, Sheet 239, Hertford, Solid & Drift, 1978 BGS Onshore GeoIndex[36]
Climatological data	Climatological Data for ALC handbook (1989)[37]
Soil hydrology	Cranfield University, UK[38]
Flood risk	Information on flood risk was derived from Section 6.4, Flood Risk, to ensure consistency in data collection and subsequent assessment.

[32] Natural England. (2020) Provisional Agricultural Land Classification (ALC). Available at: https://data.gov.uk/dataset/952421ec-da63-4569-817d-4d6399df40a1/provisional-agricultural-land-classification-alc [Accessed April 2022]
[33] Natural England. (2021) Agricultural Land Classification (ALC) Grades - Post 1988 Survey (polygons). Available at: https://data.gov.uk/dataset/c002ceea-d650-4408-b302-939e9b88eb0b/agricultural-land-classification-alc-grades-post-1988-survey-polygons [Accessed April 2022]
[34] Natural England. (2017) Likelihood of Best and Most Versatile Agricultural Land. Available at: http://publications.naturalengland.org.uk/category/5208993007403008 [Accessed April 2022]
[35] Cranfield Soil and AgriFood Institute. Soilscapes. Available at: http://www.landis.org.uk/soilscapes/index.cfm [Accessed April 2022]
[36] British Geological Survey. (2022) GeoIndex Onshore. Available at: https://mapapps2.bgs.ac.uk/geoindex/home.html?_ga=2.129380744.505609546.1642073666-2029197738.1642073666 [accessed April 2022]
[37] The Meteorological Office. (1989) Climatological Data for Agricultural Land Classification Available at: http://publications.naturalengland.org.uk/publication/6493605842649088 [Accessed April 2022]
[38] Cranfield University. Soil Data. Available at: Soil Data - Cranfield Mapshop (blueskymapshop.com) [Accessed April 2022]

Data collected	Source
Land quality	Groundsure Reports & GIS data pack

5.2.2 Approach to impact appraisal

5.2.2.1 Land use

5.6. Using data from MAGIC map[20], current land uses of potentially affected areas were reported to identify features pertinent to soil resources and soil management planning.

5.7. A summary of recent and historical land uses is provided in Section 5.3.1, based on review of the Groundsure Reports and GIS data pack obtained.

5.2.2.2 Agricultural land classification

5.8. Soils are considered a natural non-renewable resource that has relevance to water holding capacity, agricultural output, habitat and biodiversity capital, construction, carbon store, climate change and more.

5.9. Fundamental to this is the ALC framework[39], which categorises agricultural land quality in England and Wales into five provisional grades based on local climatological data and anticipated soil properties (from soil association mapping[40]). This provides a basis for retaining land of higher quality for agricultural use where possible (grades 1-3), whilst prioritising lower quality land (grades 4 and 5) for construction. Provisional ALC maps are based on sparse soil data and are useful as a strategic guide, but can be inaccurate, particularly at the local level. A detailed ALC survey would provide evidence for refining provisional ALC mapping and for subdividing grade 3 into grades 3a and 3b. This is a significant step as grades 1-3a are classed as Best and Most Versatile (BMV) land, defined by the ALC framework as land which is considered 'the most flexible, productive and efficient in response to inputs and which can best deliver future crops for food and non-food uses.' In line with the NPPF[19], the Government and planning authorities have a commitment to retain within agricultural use wherever possible.

5.10. ALC defines cropping potential of land depending on physical and chemical

[39] Ministry of Agriculture, Fisheries and Food. (1988) Agricultural Land Classification of England and Wales Revised guidelines and criteria for grading the quality of agricultural land.
[40] Cranfield University. (2021) Soils guide. Available at: https://www.cranfield.ac.uk/themes/environment-and-agrifood/landis/soils-guide [Accessed April 2022]

properties:

- Grade 1 (excellent quality agricultural land)
- Grade 2 (very good quality agricultural land)
- Grade 3 (good or moderate quality agricultural land)
- Subgrade 3a (good quality agricultural land)
- Subgrade 3b (moderate quality agricultural land)
- Grade 4 (poor quality agricultural land)
- Grade 5 (very poor quality agricultural land)

5.11. Provisional ALC data from Natural England was used in conjunction with ALC data collected post-1988 if available to predict the grade of land impacted by the Beckton Reuse Indirect Option.

5.12. Use of BMV agricultural land (ALC Grades 1, 2, 3a) should be minimised where possible, in favour of land in areas of poorer soil quality (ALC Grades 3b, 4 and 5).

5.13. It is important to note that the provisional Natural England ALC dataset, does not differentiate between Grades 3a and 3b as this is can only be established by a detailed ALC survey.

5.2.2.3 Soil type and properties

5.14. Digitised soil type and properties data from Cranfield University (e.g. texture, permeability) inform soil profile depth and resilience to damage during handling. The information aids assessment of design options, further investigative requirements such as field surveys, and contributes to soil management planning during construction activities.

5.15. Geological borehole data from the BGS Onshore GeoIndex[36] can corroborate information on soil properties from the Land Information System (LandIS)[35].

5.2.2.4 Geology

5.16. Site geology influences soil formation and characteristics. As above, this information aids assessment of design options, further investigative requirements such as field surveys, and contributes to soil management planning during construction activities.

5.2.2.5 *Climatological data*

5.17. Climate influences soil formation, properties and the agricultural potential of land. Key factors include altitude, average annual rainfall and field capacity days. Climatological data is key for providing guidance on soil handling and ALC grade assessment.

5.2.2.6 *Flood risk*

5.18. Flood risk is relevant because soils function as water stores for flood attenuation. The requirement for contractors to monitor and manage flood risk may affect agriculture and soil resources during construction. Areas were categorised into flood zones 1-3, flood storage areas and areas benefiting from flood defences.

5.2.2.7 *Land quality*

5.19. A high level land quality assessment has been undertaken for the Raw and Drinking Water Transfer Mains, Indicative Intake Location and Indicative Raw Water Pumping Station Site, and the new WTW sites. . This involved review of readily available information in the form of Groundsure reports and GIS data pack including recent and historical land use as well as geological mapping and publicly available borehole records.

5.20. The assessment of potential land contamination is based on current guidance documents related to Part II A of the EPA. Particular reference is made to Construction Industry Research and Information Association (CIRIA) Report C552 and to the Model Procedures for the Management of Land Contamination, LCRM (Defra/ Environment Agency). Following procedure in the LCRM, a key element of a Preliminary Risk Assessment is development of a conceptual model. The conceptual model is described in terms of the contaminant sources, transport pathways and possible receptors that may be present, and the potential 'pollutant linkages' between them, as defined in the relevant legislation and guidance. These activities are described in CIRIA C552 as ‘hazard identification’.

5.21. Based on the historical and current industrial land uses, the potential sources of contaminants and contaminants of concern have been identified. Initial conceptual site models (CSMs) have been developed whereby potential sources, pathways, receptors and potential pollutant linkages have been identified. Where a source, relevant pathway and receptor are present, a pollutant linkage is considered to exist whereby there is a circumstance through which environmental harm could occur and a potential environmental liability is considered to exist.

5.22. The following CSM assumptions have been made with regards to the proposed construction:

- Management of waste materials on site will be in accordance with the Definition of Waste: Code of Practice (DoW CoP) which may require a Materials Management Plan (MMP) if material re-use is proposed on site.
- A robust CEMP will be developed and adopted during the construction works to manage any leaks, spills or potential dust generation.
- Risks to construction workers from contact with contaminated soils, groundwater or leachate (dermal or inhalation of dust/ vapours) will be addressed through Construction Design Management (CDM) process and potential Control of Substances Hazardous to Health (COSHH) risk assessments.
- Stockpiling of contaminated soils will be avoided where possible. Where stockpiling is necessary, the material will be segregated and stockpiled on impermeable hardstanding or sheeting and covered to prevent spreading. Risk assessment will then be undertaken to establish whether materials can be re-used or require treatment or off-site disposal.

5.23. Preliminary Qualitative Risk Assessments should be carried out at a subsequent project stage whereby for each potential pollutant linkage identified within the conceptual models, the potential risk is evaluated for ecological receptors, construction/maintenance workers and the final end users. This is based on the probability of the pollution event, and the severity it may have on site users and the environment. The Preliminary Qualitative Risk Assessments should be updated at subsequent project stages, as more information and understanding is obtained through the risk assessment process.

5.2.3 Assumptions and limitations

5.24. Site surveys were not undertaken as part of the desk-based assessment and confirmation of such desk study outputs would be achieved through a subsequent detailed field survey if required at a subsequent project stage.

5.25. The outputs of the desk-based assessment were limited without the detailed data provided by an ALC or Soil Resources Survey but informed the need for future surveys and a Soil Management Plan, where required at a subsequent project stage.

5.3 Understanding of the baseline

5.3.1 Current and historical land use

5.26. The predominant current and historical land uses for the components of the Beckton Reuse Indirect Option are summarised in the following sections.

5.27. The Indicative Intake Location and Indicative Raw Water Pumping Station Site are located on developed land which historically comprised part of the Luthers Farm estate prior to becoming a plant nursery in the early 1900 at the time when the River Lee was channelised and King George's Reservoir was constructed. Historical land uses within 250m of the sites include nurseries, unspecified factory, chemical works, electrical substation, unspecified disused mill, garages and several unspecified tanks. Recent land use in the vicinity of the sites includes construction plant, electrical substation, vehicle repair, testing and services, second hand vehicles, petrol and fuel station reclamation and disposal and a tank.

5.28. The Raw Water Transfer Main Route Corridor is predominantly located within undeveloped land and agricultural fields.

5.29. The Indicative WTW Site is predominantly located within a developed area with commercial premises (plant nurseries). Plant nurseries were constructed on site to the north of Mott Street around 1915, which then extended to the south by 1935. Historical land uses/ surface ground workings recorded on site include unspecified commercial/ industrial premises, smithy, tanks and a pond. Within 250m of the Indicative WTW Site, historical land uses included smithy, nurseries, iron works, abattoir, pipeline station, electricity substation and the Royal Small Arms Factory Enfield. Recent land uses within 250m include tank, vehicle parts and accessories, electricity substation, vehicle repair, testing and services and vehicle components.

5.30. The eastern extent of the Drinking Water Transfer Main Route Corridor predominantly passes through developed land in an urban setting. There are several localised areas of historical surface ground workings, recent industrial land use and historical industrial land use along the alignment which tend to be concentrated in the more built-up areas, except for the historical surface ground workings recorded along the route within Gunpowder Park. Historical land uses along the eastern extent of the route include nurseries, tanks, unspecified factory, unspecified commercial/ industrial, research establishment, unspecified heap, unspecified pit, The Royal Small Arms Factory Enfield, pumping station, STW, railway sidings and station, garages, substation and steam mill. The route passes through an historical landfill site and an EA licensed waste site. There are several further historical landfill sites and an authorised landfill site located within 500m of the route. Recent industrial land use includes tanks, electricity substations, masts, pylons, satellite dish, motoring businesses including repair and servicing, hire services and engineering services.

5.31. The western extent of the Drinking Water Transfer Main Route Corridor and the Drinking Water Transfer Main to North Mymms Route Corridor predominantly pass through undeveloped land and agricultural fields with occasional localised areas of historical surface ground workings/ industrial land uses including unspecified ground works, refuse heaps, cuttings, an old brick field, smithy, WTW and nurseries.

5.32. The Brookmans Park Service Reservoir Connection and North Mymms Booster Station Connection are both within existing facilities and therefore within developed land.

5.3.2 Designated geological sites

5.33. There are two geological SSSIs within 2km of the Drinking Water Transfer Main Route Corridor; these are shown on Figure 4.1: Statutory designated nature conservation sites. Water End Swallow Holes SSSI are the only major sinkholes in chalk which are a permanent feature of the landscape, and they constitute the drainage outlet for the largest enclosed karstic basin in England. The site covers a group of more than 15 sinkholes where two streams drain from the London Clay and sink very close to the boundary of the outcrop of the chalk. At times of flood a lake with surface overflow accumulates in the sinkhole basin, but it eventually drains back into the natural sinks. Castle Lime Works Quarry covers a disused and partly backfilled chalk quarry where one face has been retained to show the chalk/soil interface. This reveals extensive piping in the top of the chalk resulting from solution at the Chalk – Tertiary sediment interface. Believed to have formed during the Tertiary and Pleistocene, it is the finest exposure of clay-filled pipes in the Chalk Karst of England.

5.34. The geological SSSIs would not be impacted during construction and are not considered further in this appraisal.

5.35. No Regionally Important Geological Sites (RIGS) have been identified.

5.3.3 Geology

5.36. Tables 5.2 and 5.3 summarise the identified bedrock and superficial deposits for the Beckton Reuse Indirect components, with the anticipated ground conditions detailed in the following sections. The aquifer classification is also presented in these tables in accordance with the classifications in Table 5.4. Bedrock geology is shown on Figure 5.1 and superficial geology is shown on Figure 5.2.

Table 5.2: Identified bedrock

Component	Bedrock	Description	Aquifer classification
Indicative Intake location Raw Water Transfer Main Route Corridor Indicative WTW Site Drinking Water Transfer Main Route Corridor Brookmans Park Service Reservoir Pumping Station Drinking Water Transfer Main to North Mymms Route Corridor	London Clay Formation	Mainly comprises bioturbated or poorly laminated, blue-grey or grey-brown, slightly calcareous, silty to very silty clay, clayey silt and sometimes silt, with some layers of sandy clay.	Unproductive
Drinking Water Transfer Main Route Corridor Drinking Water Transfer Main to North Mymms Route Corridor	Lambeth Group	Vertically and laterally variable sequences mainly of clay, some silty or sandy, with some sands and gravels, minor limestones and lignites and occasional sandstone and conglomerate.	Secondary A
Drinking Water Transfer Main to North Mymms Route Corridor North Mymms Booster Station Connection	Lewes Nodular Chalk Formation and Seaford Chalk Formation (undifferentiated)	Lewes Nodular Chalk Formation: Hard to very hard nodular chalks and hardgrounds (which resist scratching by finger-nail) with interbedded soft to medium hard chalks (some grainy) and marls; some griotte chalks. Seaford Chalk Formation: Firm white chalk with conspicuous semi-continuous nodular and tabular flint seams.	Principal

Table 5.3: Identified superficial deposits

Component	Superficial deposits	Description	Aquifer classification
Indicative Intake Location Raw Water Transfer Main Route Corridor Drinking Water Transfer Main Route Corridor	Alluvium	Unconsolidated clay, silt, sand and gravel deposited by a river, stream or other body of running water as a sorted or semi-sorted sediment in the bed of the stream or on its floodplain or delta, or as a cone or fan at the base of a mountain slope.	Secondary A
Indicative WTW Site	None	No superficial deposits mapped.	None
Drinking Water Transfer Main Route Corridor	Dollis Hill Gravel Member	Gravel, sandy and clayey in part, with some laminated silty beds. Sand and gravel, locally with lenses of silt, clay or peat and organic material.	Secondary A
Drinking Water Transfer Main Route Corridor	Enfield Silt Member	Varies from silt to clay, commonly yellow-brown and massive.	Unproductive
Drinking Water Transfer Main Route Corridor	Kempton Park Gravel Member	Sand and gravel, locally with lenses of silt, clay or peat.	Secondary A
Drinking Water Transfer Main Route Corridor	Lowestoft Formation	Chalky till with outwash sands and gravels, silts and clays. The till is characterised by its chalk and flint content.	Secondary Undifferentiated
Drinking Water Transfer Main Route Corridor	River Terrace Deposits	Sand and gravel, locally with lenses of silt, clay or peat.	Secondary A
Drinking Water Transfer Main Route Corridor	Taplow Gravel Member	Sand and gravel, with possible lenses of silt, clay or peat.	Secondary A

Component	Superficial deposits	Description	Aquifer classification
Drinking Water Transfer Main to North Mymms Route Corridor	Kesgrave Catchment Subgroup	Mainly gravels characterised by quartz and quartzite from the Triassic, Carboniferous and Devonian rocks. The members comprise bodies of cross-bedded and massive, moderately sorted sand and gravel.	Secondary A

5.37. The anticipated ground conditions at the Indicative Intake Location and Indicative Raw Water Pumping Station Site have been determined on a review of available BGS borehole logs and geological mapping. Fill (Made Ground) and/ or Alluvium is anticipated to a depth of between 2 and 5m bgl overlying the bedrock London Clay Formation. The Lambeth Group is expected at a depth of around 25m bgl overlying the White Chalk Subgroup. Shallow perched groundwater is possible within the Made Ground/ Alluvium.

5.38. A review of existing BGS borehole logs and geological mapping for the Indicative WTW Site indicates the anticipated ground conditions to comprise a potential variable thickness of Infilled Ground (Made Ground) and superficial River Terrace Deposits, although superficial deposits are not shown on mapping they are present in the nearest BGS boreholes. The bedrock geology comprises the London Clay Formation overlying the Lambeth Group from approximately 27m bgl which in turn overlies the White Chalk Subgroup. Shallow groundwater is likely if River Terrace Deposits are present.

5.39. The anticipated ground conditions underlying the Raw and Drinking Water Transfer Main Route Corridors have been determined based on geological mapping and existing BGS borehole logs. Made Ground/ Worked Ground/ Infilled Ground can be expected in built up areas and areas of recent/ historical industrial land use as well as where the alignment passes across/ adjacent to existing infrastructure. Geological mapping indicates minimal superficial cover over large sections of the alignment. Where present, superficial deposits predominantly comprise River Terrace Deposits, Glacial Sand and Gravel and Glacial Till with Alluvium present around the River Lee. The superficial deposits overlie the bedrock London Clay Formation for the majority of the route corridor. Locally along the western extent of the route, the superficial deposits are underlain by the Lambeth Group with the Lowes Nodular Chalk Formation and Seaford Chalk Formation (undifferentiated) encountered close to the ground surface in the vicinity of the North Mymms Booster Station Connection.

Table 5.4: Aquifer classification summary

Aquifer designation	Definition
Principal	Layers of rock or drift deposits with high fracture permeability, which allows them to store and procure high amounts of water.
Secondary A	Permeable layers that can support local water supplies and may contribute to base flow in rivers.
Secondary B	Lower permeability layers that may store and yield limited amounts of groundwater through fissures and openings.
Secondary (undifferentiated)	Not possible to be designated Secondary A or Secondary B status. Have minor value.
Unproductive	Largely unable to procure usable water and are unlikely to have any associated Groundwater Dependent Ecosystems.

Source: British Geological Society (2022)

5.3.4 Climatological data

5.40. Published climatological data shows a similar average annual rainfall across the Beckton Reuse Indirect Option with rainfall slightly increasing from south (600mm) to north (670mm) and field capacity days[41] also increasing from south (116) to north (135).

5.3.5 Soil type and properties

5.3.5.1 Soil association and hydrology

5.41. Digitised soil type data was obtained from Cranfield University. The soil associations identified within the components of the Beckton Reuse Indirect Option are presented in Table 5.5.

[41] The term 'field capacity days' refers to the number of days per year that agricultural land is at field capacity i.e. near saturation point.

Table 5.5: Identified soil associations

Component	Soil association	Description	Soil type hydrology
Drinking Water Transfer Main Route Corridor	Beccles 3	Slowly permeable seasonally waterlogged fine loamy over clayey soils and similar soils with only slight seasonal waterlogging. Some calcareous clayey soils especially on steeper slopes.	Slowly permeable, seasonally waterlogged soils over slowly permeable substrates with negligible storage capacity.
Drinking Water Transfer Main Route Corridor Drinking Water Transfer Main to North Mymms Route Corridor	Essendon	Slowly permeable seasonally waterlogged coarse loamy over clayey soils. Associated with similar fine loamy over clayey and fine silty over clayey soils.	Slowly permeable, seasonally waterlogged soils over slowly permeable substrates with negligible storage capacity.
Indicative Intake Location Raw Water Transfer Main Route Corridor Drinking Water Transfer Main Route Corridor	Fladbury 1	Stoneless clayey soils, in places calcareous variably affected by groundwater. Flat land Risk of flooding.	Soils seasonally waterlogged by fluctuating groundwater and with relatively slow lateral saturated conductivity.
Drinking Water Transfer Main Route Corridor	Hamble 2	Deep stoneless well drained silty soils and similar soils affected by groundwater, over gravel locally. Usually flat land.	Free draining permeable soils in unconsolidated loams or clays with low permeability and storage capacity.
Drinking Water Transfer Main Route Corridor	Waterstock	Deep permeable mainly fine loamy soils variably affected by groundwater. Some deep well drained fine and coarse loamy soils.	Free draining permeable soils in unconsolidated loams or clays with groundwater at less than 2m from the surface.

Component	Soil association	Description	Soil type hydrology
Indicative Intake Location Raw Water Transfer Main Route Corridor Indicative WTW Site Drinking Water Transfer Main Route Corridor Drinking Water Transfer Main to North Mymms Route Corridor	Windsor	Slowly permeable seasonally waterlogged clayey soils mostly with brown subsoils. Some fine loamy over clayey and fine silty over clayey soils and, locally on slopes, clayey soils with only slight seasonal waterlogging.	Slowly permeable, seasonally waterlogged soils over impermeable clay substrates with no storage capacity.

5.3.5.2 Soil organic carbon

5.42. Digitised average soil organic carbon data was obtained from Cranfield University, which presented carbon (%) at depths of 0-30cm, 30-100cm and 100-150cm for the Beckton Reuse Indirect Option components.

5.43. Across the majority of the Beckton Reuse Indirect Option, the soil organic carbon is very low to high within 0-30cm, very low to normal between 30cm and 150cm and very low to low between 100-150cm. No peaty soils were identified.

5.3.6 Agricultural land classification

5.44. Provisional ALC data and detailed ALC records (from soil surveys undertaken post-1988) along the transfer route corridors and the Indicative WTW Site is summarised as follows and shown on Figure 5.3: Agricultural land classification.

5.45. The Indicative Intake location, Raw Water Transfer Mian Route Corridor and the Indicative WTW Site are within Grade 3 agricultural land according to the provisional ALC.

5.46. In its eastern section, the Drinking Water Transfer Main Route Corridor is within non-agricultural and urban land according to the provisional ALC with some areas classed as Grade 3 according to the detailed ALC. As the Drinking Water Transfer Main Route Corridor travels westwards, the majority of the route is within Grade 3 agricultural land according to the detailed ALC. The Drinking Water Transfer Main to North Mymms Route Corridor is within Grade 3 agricultural land according to the provisional ALC.

5.4 Appraisal outcomes

5.4.1 Potential impacts on function or quality of soil resource

5.47. The Beckton Reuse Indirect Option would predominantly involve the installation of an underground water transfer pipeline, with the construction of a new WTW. To facilitate this, areas for temporary construction compounds would also be needed along the route, as well as for associated above ground infrastructure including the Raw Water Pumping Station and new WTW. The transfer route corridors and the Indicative WTW Site are situated in agricultural land predominantly classified as ALC Grade 3 (provisional), or in undeveloped non-agricultural land, and developed non-agricultural and urban land. The Raw Water Pumping Station is on non-agricultural land.

5.48. For the construction of the Raw Water Transfer Main, Drinking Water Transfer Main, Drinking Water Transfer Main to North Mymms and any associated temporary compounds, it is not anticipated that there would be a permanent loss of topsoil/subsoil resource (from agricultural and non-agricultural land where present). It is anticipated that topsoil/subsoil strip would be conducted prior to trenching works to install the pipelines, or construction works for the compounds. These soils should be appropriately stockpiled and managed prior to reinstatement upon the completion of pipe installation for a particular section or the use of a temporary compound.

5.49. Should the pipeline be installed by trenchless techniques, topsoil/subsoil stripping is not anticipated. Topsoil/subsoil resource may not be present where the pipeline and temporary construction compounds are constructed in non-agricultural land/urban area or along a road, as it may have been previously stripped off and/or Made Ground is present.

5.50. Permanent land-take is anticipated within the Indicative Raw Water Pumping Station Site and the Indicative WTW Site. Topsoil/subsoil strip is anticipated to precede construction works and would present a permanent loss of topsoil/subsoil resource (where present) from the stripped area. Soil resource from areas of permanent land-take should firstly be considered for reuse within the scheme, which may be areas of

landscape planting or use as landscape bunds. If this is not viable and/or there is excess soil quantities, topsoil/subsoil may be sold for use in other construction projects or industries. It should be stated that landfilling of soil resource should be the last resort, as this would represent the permanent loss of stripped topsoil/subsoil resource from the scheme.

5.4.2 Potential impact on agricultural land classified as 'best and most versatile'

5.51. Based on the provisional ALC data, the Beckton Reuse Indirect Option components are situated in Grade 3 land, non-agricultural land or urban land. Note that the provisional ALC data does not subdivide Grade 3 into 3a (representing best and most versatile land) and 3b (not presenting best and most versatile land). Where detailed ALC survey is available, agricultural land has been classified as Grade 2 and 3a.

5.52. Where detailed ALC survey is available, some areas of the Drinking Water Transfer Main Route Corridor have been classified as 3b (in the northern section of the route corridor between Goffs Oak and the Brookmans Park Service Reservoir Connection).

5.53. Based on the available ALC data, the anticipated length (L) and area (A) of ALC classifications associated with the Indicative Intake Location, Raw Water Transfer Main, Indicative WTW Site, Drinking Water Transfer Main and Drinking Water Transfer Main to North Mymms, including indicative temporary compound areas are presented in Table 5.6 below. This high-level assessment assumes a working width of 50m following the alignment of the transfer route corridors. As the Brookmans Park Reservoir Connection and North Mymms Booster Station Connection are on existing operational sites, and not likely to result in loss of agricultural land, these have not been included in this table.

Table 5.6: Total landtake of agricultural land

Total ALC Landtake	ALC grades							
	3		3b		Agricultural Land Total		Non-Agricultural or Urban	
	L (km)	A (ha)	L (km)	A (ha)	L (km)	A (ha)	L (km)	A (ha)
Indicative Intake location and Raw Water Pumping Station	0	4.8	0	0	0	4.8	0	0

Total ALC Landtake	ALC grades							
	3		3b		Agricultural Land Total		Non-Agricultural or Urban	
	L (km)	A (ha)	L (km)	A (ha)	L (km)	A (ha)	L (km)	A (ha)
Raw Water Transfer Main Route Corridor	1.7	8.5	0	0	1.7	8.5	0	0
Indicative WTW Site	0	22.0	0	0	0	22.0	0	0
Drinking Water Transfer Main Route Corridor	13.9	69.5	0.7	3.5	14.6	73.0	4.4	22
Drinking Water Transfer Main to North Mymms Route Corridor	4.0	20.0	0	0	4.0	20.0	0	0
TOTAL	19.6	124.8	0.7	3.5	20.3	128.3	4.0	22

5.4.3 Potential land quality impacts (Conceptual Site Models)

5.54. Based on the identified historical and current land uses within the components of the Beckton Reuse Indirect Option and within the surrounding areas, potential sources of contaminants and contaminants of concern have been identified. The potential sources, pathways and receptors of contamination have been identified in the CMSs. These are summarised in the following sections for each component.

5.4.3.1 *Indicative Intake Location and Indicative Raw Water Pumping Station Site*

5.55. Potential sources of contaminants and contaminants of concern identified for the Indicative Intake Location and Indicative Raw Water Pumping Station Site are detailed in Table 5.7 below.

Table 5.7: Potential contaminants of concern – River Lee Intake and Raw Water Pumping Station

Source	Potential contaminants of concern
Current on-site sources: Made Ground • Likely to be associated with the construction of King George Reservoir and culverting of the River Lee.	Heavy metals, inorganics, organics, total petroleum hydrocarbons (TPH) poly-aromatic hydrocarbons (PAHs).
Historic on-site sources: Plant nursery Unspecified tank	Heavy metals, inorganics, organics, PAH, Asbestos Containing Material (ACM). TPH, PAH
Current off-site sources: Industrial land use • Construction plant, electrical substation, vehicle repair, testing and servicing, second hand vehicles, petrol and fuel station, recycling, reclamation and disposal, tank.	Heavy metals, inorganics, organics, TPH, PAH, Polychlorinated biphenyl (PCBs), ACM.

5.56. Sources, pathways and receptors for the River Lee Intake and Raw Water Pumping Station are summarised below.

On-site sources

- S1: Contaminants associated with Made Ground recorded on site in BGS boreholes (between 2 and 5m) and onsite uses as a nursery and presence of tank.
- S2: Ground gas generation associated with a substantial thickness of made ground and potential Alluvium.

Off-site sources

- S3: Contaminants associated with off-site industrial land uses (vehicle repair, fuel stations, recycling centre).

Pathways

- P1: Human uptake pathways

- Direct soil and dust ingestion
- Skin contact with soils and dust
- Inhalation of outdoor vapours
- P2: Horizontal and vertical migration of volatile vapours resulting from potential on/off site fuel spillages and/or made ground
- P3: Horizontal and vertical migration of ground gas resulting from potential on site made ground
- P4: Horizontal and vertical migration of contaminants in the unsaturated zone
- P5: Horizontal and vertical migration of contaminants in the saturated zone
- P6: Migration of contaminants along engineered preferential pathways (shaft, buried pipelines, service trenches)
- P7: Surface run-off along roads, pavements and other surfaces

Receptors

- R1: Construction workers
- R2: Final end users (maintenance workers / site personnel)
- R3: Final end users (off site residential / commercial / recreational)
- R4: Groundwater in the Lambeth Group / White Chalk Subgroup (Principal aquifer)
- R5: Surface water features (River Lea located immediately west of site and King George Reservoir)
- R6: Source Protection Zone 1 (Inner Catchment) and 2 (Outer Catchment)
- R7: Buried Structures and infrastructure

5.4.3.2 River Lee Intake and Raw Water Pumping Station

5.57. Potential sources of contaminants and contaminants of concern identified for the Indicative WTW site are detailed in Table 5.8 below.

Table 5.8: Potential contaminants of concern – Indicative WTW

Source	Potential contaminants of concern
Current on-site sources:	
Plant nursery	Heavy metals, inorganics, organics, PAH, ACM
Tank	TPH, PAH

Source	Potential contaminants of concern
Historic on-site sources: Nursery, unspecified commercial/ industrial, smithy, historical tanks.	Heavy metals, inorganics, organics, PAH, PCBs, ACM, TPH, PAH
Current off-site sources: Industrial land use • Tank, vehicle parts and accessories, electricity substation, vehicle repair, testing and servicing, vehicle components.	Heavy metals, inorganics, organics, PAH, PCBs, ACM.
Historic off-site sources: Industrial land use • Smithy, nurseries, iron works, unspecified commercial/ industrial, unspecified tank, pipeline station, abattoir, electricity substation, The Royal Small Arms Factory Enfield 277m northwest.	Heavy metals, inorganics, organics, PAH, PCBs, microbial contaminants (e.g., pathogens) and ACM.

5.58. Sources, pathways and receptors for the Indicative WTW Site are summarised below:

On-site sources

- S1: Potential Made Ground/ Infilled Ground associated with past and present land uses (nursery / tanks).

Off-site sources

- S2: Contamination from offsite industrial land uses (tanks, substation, vehicle workshops)

Pathways

- P1: Human uptake pathways
- Direct soil and dust ingestion
- Skin contact with soils and dust
- Inhalation of vapours
- P2: Horizontal and vertical migration of any volatile vapours / ground gas resulting from potential on/off Made Ground/ Infilled Ground
- P3: Horizontal and vertical migration of contaminants in the unsaturated zone
- P4: Horizontal and vertical migration of contaminants in the saturated zone
- P5: Migration of contaminants along engineered preferential pathways (piles, buried pipelines, service trenches)

- P6: Surface run-off along roads, pavements and other surfaces

Receptors

- R1: Construction workers
- R2: Final end users (WTW site staff)
- R3: Final end users (off site residential / commercial / recreational)
- R4: Groundwater in the River Terrace Deposits (if present)
- R5: Surface water features (tributary of the River Lea passing though the site parallel and to the south of Mott Street)
- R6: Buried structures and infrastructure

5.4.3.3 Raw and Drinking Water Transfer Main Route Corridors

5.59. Potential sources of contamination and contaminants of concern identified for the Raw and Drinking Water Transfer Main Route Corridors are detailed in Table 5.9 below.

Table 5.9: Potential contaminants of concern – Raw and Drinking Water Transfer Main Route Corridor

Source	Potential contaminants of concern
Current on-site sources:	
Landscaped ground/ infilled ground • Surface ground workings	Heavy metals, inorganics, organics, TPH, PAHs, volatile and semi-volatile organic compounds (SVOCs and VOCs) and ACMs. Elevated concentrations of carbon dioxide (CO2) and methane (CH4), and depleted concentrations of oxygen (O2).
Industrial on-site uses	
• Plant nurseries	Heavy metals, inorganics, organics, PAHs and ACMs.
• Hire services, repair and servicing, railway station, engineering services, water tower, chimney, motoring services, tank, substations, masts, pylons, satellite dish, business park, M25 motorway, A10, railway line.	Heavy metals, inorganics, organics, TPH, PAHs, SVOCs, VOCs.
EA Licensed Waste Site	
• The London Composting Company	Bioaerosols, organics.

Source	Potential contaminants of concern
Historic on-site sources: Military land • The Royal Small Arms Factory Industrial land uses • Research Establishment • Sewage works (settling tanks, sludge beds, humus tank, filter beds, pumping station) • Unspecified heaps, unspecified pit, old brick field, unspecified works, cuttings • Nurseries, tanks • Factory, commercial/ industrial, garage, substation, steam mill, smithy Historical landfill • Former Enfield Sewage Works (household, industrial, inert, liquid sludge)	Explosives, unexploded ordnance, ACM, metal powders, solvents, paints, fuel and lubricating oils Heavy metals, inorganics, organics, TPH, PAHs, SVOCs, VOCs, PCBs, microbial contaminants (e.g. pathogens) and ACMs. Heavy metals, inorganics, organics, TPH, PAHs, SVOCs and VOCs and ACM. Elevated concentrations of carbon dioxide (CO_2) and methane (CH_4), and depleted concentrations of oxygen (O_2).
Current off-site sources: Historical landfill Authorised landfill	Heavy metals, inorganics, organics, TPH, PAHs, SVOCs and VOCs and ACM. Elevated concentrations of carbon dioxide (CO2) and methane (CH4), and depleted concentrations of oxygen (O2).

5.60. Sources, pathways and receptors for the Raw Water and Drinking Water Transfer Main Route Corridor are summarised below.

On-site sources

- S1: Potentially contaminated Made Ground associated with historical and current land uses (railway line, engineering services, motoring services, substations, sewage works, garage, factory, commercial/ industrial)
- S2: Potentially Infilled Ground/ Landscaped Ground associated with historical surface ground workings (unspecified pit, old brick field, unspecified workings, cuttings) and historical landfill (former Enfield Sewage Works)

- S3: Potentially high levels of heavy metals and organic compounds associated with plant nurseries
- S4: Contaminants associated with historical military land (The Royal Small Arms Factory)
- S5: Ground gas generation from historical landfill on-site (Former Enfield Sewage Works) and off-site landfills
- S6: Potentially bioaerosols from EA Licensed Waste Site (The London Composting Company)
- S7: Ground gas generation associated with Alluvium

Off-site sources

- S8: Adjacent historical landfill sites - Eleanor Cross Road (closest 260m N), Enfield Crematorium (closest 110m S), Town Mead (460m N), Aylands Open Space (480m W) and authorised landfill site – Twigden Homes Ltd (250m W) and associated ground gas risk
- S9: Contaminants associated with offsite industrial land uses

Pathways

- P1: Human uptake pathways
- Direct soil and dust ingestion (outdoors)
- Skin contact with soils and dust
- Inhalation of outdoor vapours
- P2: Horizontal and vertical migration of any volatile vapours resulting from potential on/ off site fuel spillages and/ or made ground/ landfills
- P3: Horizontal and vertical migration of any ground gas resulting from potential on/off site infilled ground/ landscaped ground and/or landfills
- P4: Horizontal and vertical migration of contaminants in the unsaturated zone
- P5: Horizontal and vertical migration of contaminants in the saturated zone
- P6: Migration of contaminants along engineered preferential pathways (buried pipeline and service trenches)

Receptors

- R1: Construction workers
- R2: Final end users (maintenance workers)
- R3: Final end users (off site residential / commercial / recreational)
- R4: Groundwater in the Kempton Park Gravel/ Taplow Gravel Member/ Dollis Hill Gravel/ Sand and Gravel of uncertain age/ Kesgrave Catchment Subgroup (Secondary A Superficial aquifers)

- R5: Groundwater in the Lewes Nodular Chalk Formation and Seaford Chalk Formation (Principal Bedrock Aquifer) and in the Lambeth Group (Secondary A Bedrock Aquifer)
- R6: Surface water features (River Lea/ Small River Lea/ King George's Reservoir/ un-named river adjacent to Mott Street/ Turkey Brook/ New River/ Cuffley Brook/ Roy Brook/ drainage ditches)
- R7: Source Protection Zone I (Inner Protection), Zone II (Outer Protection) or Zone III (Total Catchment)
- R8: Buried Structures and infrastructure i.e. pipeline material

5.4.3.4 Main identified impacts to land quality

5.61. It is considered for the Indicative Intake Location and Indicative Raw Water Pumping Station Site, as well as the Indicative WTW Site, the risks identified in the CSM would be adequately mitigated using the process in LCRM.

5.62. There may be significant negative impact to land quality and human health where the Drinking Water Transfer Main Route Corridor passes through an existing landfill site. Impacts may include creating preferential pathways for contaminants to groundwater or surface water as well for ground gas away from the existing landfill, impacts on human health due to direct contact with contaminated material and inhalation of landfill gas, production of waste requiring treatment and/ or removal. Temporary impacts during construction would include production of potentially contaminated dust from excavation of waste.

5.5 Recommended mitigation

5.5.1 Soils

5.63. Recommended measures to mitigate potential issues with regards to soils are as follows:

- A detailed soil survey (soil resource survey and/or agricultural land classification survey) to confirm the soil resources present, map the distribution of soil types and establish the land grade (if ALC survey is chosen), and inform a soil management plan.

- A soil management plan:
  - Provides guidance for the stripping, stockpiling, maintenance, reinstatement and aftercare of the soil resources in accordance with Defra[42] and British Standards soil guidance[43,44].
  - The soil management plan should include pre-construction planning, site preparation, field tests, and the methodology, monitoring and guidance for soil stripping, stockpiling, reinstatement and aftercare.

5.5.2 Land quality

5.64. Recommended measures to mitigate potential issues with regards to land quality are as follows:

- The assessment and possibly the remediation of land contamination would be a requirement of the planning process to ensure that the site is suitable for its proposed use under the NPPF. The LCRM guidance details the steps that would need to be followed as the scheme is progressed through the development and planning process. These steps include the production of a PRA and completion of an appropriate ground investigation, tiered stages of risk assessments together with an assessment of unacceptable pollutant linkages. Where such linkages are found then a remediation options appraisal and strategy will be produced.
- Any remediation works required to manage contamination risk will be agreed with the relevant Local Planning Authority and Environment Agency. Remediation will need to be completed and verified before completion of the project.
- Risks during construction will also be mitigated through use of a CEMP which details the measures that will need to be taken to ensure that construction works themselves do not introduce new contamination into the site; and also how to manage pre-existing contamination that could be encountered. Together the CEMP and LRCM process comprise embedded mitigation measures that deal with temporary and permanent effects respectively.

[42] Department for Environment, Food & Rural Affairs. (2009) Construction Code of Practice for the Sustainable Use of Soils on Construction Sites. London: Defra.
[43] British Standards Institution. (2015) BS 3882:2015 Specification for topsoil. London: BSI Standards Limited.
[44] British Standards Institution. (2013) BS 8601:2013 Specification for subsoil and requirements for use. London: BSI Standards Limited.

5.6 Summary of main findings and recommendations for future technical work

5.6.1 Soils

5.65. The Beckton Reuse Indirect Option is within developed and undeveloped land. The Indicative Intake Location, Indicative Raw Water Pumping Station Site and Raw Water Transfer Main Route Corridor are within undeveloped land and agricultural fields. The Indicative WTW Site is predominantly located within a developed area with commercial premises but also covers undeveloped land and agricultural fields. The Drinking Water Transfer Main Route Corridor and the Drinking Water Transfer Main to North Mymms Route Corridor predominantly pass through undeveloped land and agricultural fields.

5.66. Soil along the transfer route corridor's eastern end and western two-thirds is anticipated to predominantly be comprised of a slowly permeable seasonally waterlogged fine loamy over clayey soil. Soil associated with flat land adjacent to the River Lee is anticipated to comprise a stoneless clayey soil which is seasonally waterlogged by fluctuating groundwater. West of the River Lee, soil is anticipated to be a deep permeable mainly fine loamy soil becoming a deep stoneless well drained silty soil as the alignment progresses westwards, with these soils are free draining permeable soils in unconsolidated loams or clays.

5.67. Ground disturbance in the form of topsoil/subsoil stripping can adversely affect soil quality during the construction process through inappropriate handling during stripping, stockpiling and reinstatement. This can impact soil function which could ultimately affect crop/vegetation growth.

5.68. For temporary works, it is anticipated that the majority of stripped topsoil/subsoil resource would be reinstated. A volume of subsoil may be permanently lost from the volume of strip that is associated with space occupied by underground pipelines. These soils should be appropriately stockpiled and managed prior to reinstatement upon the completion of pipe installation for a particular section.

5.69. For permanent land-take, topsoil/subsoil strip is anticipated to precede construction works and would present a permanent loss of topsoil/subsoil resource (where present) from the stripped area.

5.70. Soil resource from areas where reinstatement is not possible should firstly be considered for reuse within the scheme. If this is not viable and/or there are excess soil quantities, topsoil/subsoil may be sold for use in other construction projects or industries. It should be stated that landfilling of soil resource should be the last resort, as this would represent a permanent loss of stripped topsoil/subsoil resource from the stripped area .

5.71. Based on the provisional ALC data, the Beckton Reuse Indirect Option components are situated in Grade 3 land, non-agricultural land or urban land. Note that the provisional ALC data does not subdivide Grade 3 into 3a (representing best and most versatile land) and 3b (not presenting best and most versatile land).

5.72. Where detailed ALC survey is available, some areas of the Drinking Water Transfer Main Route Corridor have been classified as Grade 3b (in the northern section of the route corridor between Goffs Oak and Brookmans Park Service Reservoir.

5.73. It is recommended that a detailed soil survey (soil resource survey and/or ALC survey) is undertaken at a subsequent project stage to confirm soil resources present. The findings should inform a soil management plan which should provide guidance for stripping, stockpiling, maintenance, reinstatement and after care of soil resources. During construction activities, it is recommended that a qualified soil scientist undertake on-site monitoring visits to ensure the best practice and guidance as stated in the soil management plan is followed.

5.6.2 Land quality

5.74. Based on the identified historical and current land uses within the components of the Beckton Reuse Indirect Option and within the surrounding areas, there is the potential for contamination to be present within the ground and groundwater underlying the sites as well as potential ground gas, particularly within the western extent of the Drinking Water Transfer Main Route Corridor where the route passes through an historical landfill site and close to surrounding historical landfill sites.

5.75. Consultation would be required with the landowner, local authorities and the Environment Agency, at a subsequent project stage, with regard to potential routing through landfill and associated risks. Design details of the historical landfill should be requested from the Local Authority (if these exist) to enable further assessments to be carried out to ensure that risks from the pipeline acting as an additional pathway to human health and controlled waters are mitigated. In addition, early consultation should be initiated to determine options for discharge/ treatment of potentially contaminated groundwater.

5.76. Where the Drinking Water Transfer Main Route Corridor passes through a landfill site, the feasibility of undertaking ground investigation should be considered. Additional health and safety/ chemical and geotechnical testing and aquifer protection measures will be required along with other requirements for drilling and/ or construction on a site where landfilling is present.

5.77. Once further assessments have been carried out at a subsequent project stage, detailed geotechnical and geo-environmental Preliminary Risk Assessments should be completed, and the envisaged land quality mitigation measures reviewed to understand whether these are sufficient to mitigate the potential impacts to

acceptable levels and therefore confirm the feasibility or not of the preferred route. As part of the Preliminary Risk Assessments, ground investigation aims would be determined.

5.78. A site-specific geotechnical and geo-environmental ground investigation would be the key mitigation in reducing the uncertainty associated with the majority of the identified risks for the preferred route. It is envisaged that a preliminary phase of ground investigation works would provide initial information to assist in the development and delivery of the next project stage which includes finalised feasibility, pre-planning investigations and planning applications. A detailed phase of ground investigation would be required at a later stage in the project delivery.

5.79. Management of waste materials on site would be in accordance with the DoW CoP which may require a MMP if material re-use is proposed on site. Further risk assessment would be required at subsequent project stages to determine the materials suitability for use. Some waste materials may not be suitable for reuse and will require disposal to landfill.

5.80. Consideration would need to be given to the potential requirement for pre-treatment of excavated material should existing landfill material be excavated as part of the construction works requiring disposal.

6 Water

6.1 Introduction

6.1. This chapter presents a desk-based assessment undertaken to identify potential impacts on water from the transfer route corridors and above ground infrastructure including the WTW. The objectives of the desk-based assessment were to establish the baseline associated with the Beckton Reuse Indirect Option, identify constraints and opportunities, and identify the issues that may require further investigation at a subsequent project stage.

6.2. The need to consider water is driven by national planning policy (draft NPS for Water Resource Infrastructure[18] (Section 4.15, Water quality and resources and 4.8, Flood Risk) and NPPF[19] (Section 14, Meeting the challenge of climate change, flooding and coastal change), paragraphs 159-169, and Section 15, Conserving and enhancing the natural environment, paragraph 174).

6.3. Technical Supporting Document B3, Water Framework Directive Compliance Assessment, contains the results of the WFD assessment undertaken for the Beckton Reuse Indirect Option. This has formed the basis of the aquatic environment appraisal. Consideration has been given to groundwater in Section 6.3 and a desk-based assessment on flood risk is presented in Section 6.4.

6.2 Aquatic environment appraisal

6.4. As described in Section 3.2, Technical Supporting Document B3, Water Framework Directive Compliance Assessment, contains the results of the informal WFD assessment undertaken for the Beckton Reuse Indirect Option.

6.5. The Level 1 basic screening assessment was completed to determine which activities have the potential to impact the surface water bodies. The Level 1 – basic screening assessment identified that the Beckton Reuse Indirect Option interacts with seven WFD Surface water bodies within these catchments including one Surface Water Transfer.

6.6. The Level 1 – basic screening of the ACWG assessment has identified one surface water body which has an activity impact score greater than 1 for the Beckton Reuse Indirect option: Lea Navigation Enfield Lock to Tottenham Locks (GB106038027950). This water body was carried forward for a Level 2 – detailed screening assessment.

6.7. Based on the design assumptions outlined in Section 2.3, there will be no potential for deterioration of any WFD elements as a result of the Beckton Reuse Indirect Option; passing Objective 1. There will be no potential for the Beckton Reuse Indirect Option to result in any WFD status not achieving their objectives, therefore passing Objective 2. Therefore, this option is considered to be compliant with the WFD at this stage.

6.8. No statutory designated sites would be directly impacted by works to construct the Beckton Reuse Indirect Option. The only designated site which includes aquatic communities as the qualifying/notifiable features is the Cornmill Stream and Old River Lea SSSI. The site is located upstream of the proposed transfer corridor and will not be affected by the construction activities.

6.9. During construction there is a risk of impacts on the aquatic communities associated with the transfer corridor. The risk related to construction impacts such as pollution incidents, local increases in sediment/siltation, temporary disturbance as a result of noise and vibration, etc.

6.10. As noted in Section 2.3, main rivers would be crossed via micro-tunnel. All other roads would be crossed using an open cut method across the road with traffic management. Where watercourses would not be micro-tunnelled, it is assumed they will be flumed during construction. This will be a short term construction activity (i.e. less than seven days), which will ensure the watercourse is returned to its natural function following installation of the pile section.

6.11. It is assumed that several mitigation measures will be implemented during the construction activities. This includes those best practice measures as listed in Section 2.3.

6.12. Any impacts on the aquatic communities are therefore expected to be short term and reversible. As such, no or negligible change in aquatic ecological community receptors are expected.

6.3 Groundwater

6.13. Bedrock geology and superficial deposits are provided in Section 5.3.3, with the Beckton Reuse Indirect Option affecting Principal, Secondary A, Secondary B and Unproductive aquifers. Risks to groundwater during construction were considered in Section 5.4.3.

6.14. Source Protection Zones (SPZ) are defined by the Environment Agency around large groundwater abstractions. They are zones which show the level of risk to the source from contamination, from any activity in these areas. Construction within SPZs requires additional assessment and potentially mitigation to ensure no adverse impacts on public water supplies. The Indicative Intake Location and Indicative Raw

Water Pumping Station Site, Drinking Water Transfer Main Route Corridor, Drinking Water Transfer Main to North Mymms Route Corridor and North Mymms Booster Station Connection are located within areas defined as SPZ1 and SPZ2. The Raw Water Transfer Main Route Corridor is within SPZ2. The Indicative WTW Site and Brookmans Park Service Reservoir Connection are not located within SPZs. Prior to construction, a hydrogeological risk assessment would be required for works within SPZ1 or 2.

6.15. Groundwater Dependent Terrestrial Ecosystems (GWDTE), like wetlands, flushes and fens are environments reliant upon groundwater for their continued success and health. This makes them particularly sensitive to hydrological and ecological changes caused as a result of new developments that disrupt existing groundwater flow, such as pipelines. No GWDTE would be impacted during construction.

6.16. Groundwater has been considered as part of the WFD assessment with two WFD groundwater bodies being considered. Neither of these groundwater bodies were carried through to the Level 2 – detailed screening assessment as the activities associated with the Beckton Reuse Indirect Option did not result in an impact score greater than 1. This is a result of the embedded mitigation and design assumptions. Namely:

- The pipe depth will not exceed be 8 m below existing ground level.
- Any below ground structures will be constructed to ensure no impact to groundwater flow or quality.
- Any shafts or retaining walls which extend further than 8 m below existing ground level are in excess of 500 m from any GWDTEs.

6.17. This has resulted in no further requirements for assessment of groundwater flow under the WFD at this stage. If any of the design assumptions or mitigation measures change, this will be reconsidered at subsequent project stages.

6.4 Flood risk

6.4.1 Methodology

6.18. The desk-based assessment focused on the transfer route corridors, location of associated infrastructure and the surrounding area within 1km. Where impacts could extend beyond 1km, the study area was extended.

6.19. The watercourses included in the study area are the River Lee, River Colne and the following tributaries of these rivers, as shown on Figure 6.1: Flood risk and main river network interactions.

- Cuffley Brook – Approximately 8.5km long watercourse flowing north to south from Newgate Street to its confluence with Turkey Brook near Waltham Cross.
- Turkey Brook – Approximately 11.8km long watercourse flowing eastward from Potters Bar to its confluence with the River Lee near Waltham Cross.
- Ray Brook - Approximately 4km long watercourse flowing west to east joining Mimmshall Brook at Water End.

6.20. Table 6.1 outlines the baseline data sources which were collated and considered in the desk-based assessment.

Table 6.1: Sources of information (flood risk)

Data collected	Source
Surface water	
Detailed river network	Environment Agency
Groundwater	
Geology of bedrock and superficial deposits	British Geological Society
Aquifer properties	British Geological Society
Interactive groundwater vulnerability map	Defra
Flood risk	
Flood map for planning	Environment Agency
Historical flooding incidents	Lead local flood authorities, Environment Agency
Long term flood risk information (surface water, river flooding)	Environment Agency
Flood risk from reservoirs	Environment Agency
Flood protection infrastructure/ measures	Environment Agency
Detailed 2D River Lee modelling and mapping	Environment Agency
Upper River Colne modelling and mapping study	Environment Agency
Topography	
LiDAR data	Environment Agency

6.21. The assessment on flood risk was limited by the availability of the data in the study area. The quality of the model results available for the study area also limited the understanding on the risk from flooding. The assumptions inherent in the models used to produce flood risk information, such as flood extents, flood depths, levels and flows followed through to the model outputs used for the study. These assumptions needed to be understood and considered when assessing the data.

6.22. Historical records on flooding and anecdotal information can be limited and it cannot be assumed that where there is no historical information available, flooding has not occurred in the past. Likewise photographs and records of flooding may not always capture the peak of a flood event or give a clear indication on the cause of flooding, and this was considered when reviewing the information.

6.23. When considering the impacts of climate change, there are assumptions in the projections used and how this translates to an impact on peak flow, sea level rise and rainfall rates.

6.4.2 Understanding of the baseline

6.4.2.1 Environment Agency flood zone

6.24. The Environment Agency provides the 'Flood Map for Planning'[45] which displays the Environment Agency Flood Zones as defined in Table 6.2. It should be noted that the boundaries of the Flood Zones are indicative and do not consider any man-made structures such as railway embankments, roads and flood defences

Table 6.2: Flood Zone descriptions

Flood Zone	Description	Annual Exceedance Probability
Flood Zone 1 – Low Probability	Land assessed as having a less than 1 in 1000 annual probability of river or sea flooding in any year.	<0.1% sea or river flooding
Flood Zone 2 – Medium Probability	Land assessed as having between a 1 in 100 and 1 in 1000 annual probability of river flooding, or between a 1 in 200 and 1 in 1000 annual probability of sea flooding in any year.	1% - 0.1% river flooding 0.5% - 0.1% sea flooding

[45] Environment Agency Flood Map for Planning. Available at: https://flood-map-for-planning.service.gov.uk/ [Accessed May 2022]

Flood Zone	Description	Annual Exceedance Probability
Flood Zone 3a – High Probability	Land assessed as having a 1 in 100 or greater annual probability of river flooding, or a 1 in 200 or greater annual probability of flooding from the sea in any year.	>1% river flooding >0.5% sea flooding
Flood Zone 3b – Functional Floodplain	Land where water has to flow or be stored.	Identified in the Strategic Flood Risk Assessment as the 5% AEP or Flood Zone 3a where detailed modelling is not available.

Source: Environment Agency (2022) Flood Warning Information Service: Long term flood risk information.

6.25. Table 6.3 provides a summary of the fluvial flood risk for each of the components of the Beckton Reuse Indirect Option according to the Environment Agency's Flood Map for Planning[45]. Figure 6.1: Flood risk and main river network interactions shows the extent of Flood Zones 2 and 3 in relation to the Beckton Reuse Indirect Option.

Table 6.3: Fluvial flood risk from Environment Agency flood map for planning[45]

Component	Fluvial Flood Risk
Indicative Intake Location Indicative Raw Water Pumping Station Site Raw Water Transfer Main Route Corridor	The Indicative Intake location, Indicative Raw Water Pumping Station Site and part of the Raw Water Transfer Main Route Corridor sit within Flood Zone 2 and 3.
Indicative WTW Site	The Indicative WTW Site sits within Flood Zone 1 and is therefore considered to be at low risk from fluvial flooding.
Brookmans Park Service Reservoir Connection	The Brookmans Park Service Reservoir is located within Flood Zone 1 and therefore is considered to be at low risk from fluvial flooding.
Drinking Water Transfer Main Route Corridor	The main sources of fluvial flood risk along the Drinking Water Transfer Main Route Corridor is from the River Lee its associated tributaries; Turkey Brook, and Cuffley Brook. The most noticeable interaction with Flood Zone 3 is where the Drinking Water Transfer Main Route Corridor crosses any watercourses along the route corridor.

Component	Fluvial Flood Risk
Drinking Water Transfer Main to North Mymms	The main sources of fluvial flood risk along the Drinking Water Transfer Main to North Mymms Route Corridor is from the River Colne and its associated tributary, Ray Brook. The most noticeable interaction with Flood Zone 3 is where the Drinking Water Transfer Main to North Mymms Route Corridor crosses the Ray Brook.
North Mymms Booster Station Connection	The main source of fluvial flood risk to the North Mymms Booster Station Connection is from the River Colne and its associated tributary, Ray Brook.

6.4.2.2 Historical flooding

6.26. The Environment Agency has provided information on recorded historical flood events in the area. Historical flooding has been identified in the area of the Indicative Intake Location during the flood event of 1947.

6.27. A review of online news and anecdotal evidence has highlighted examples of several key flood events in Waltham Abbey including events in 1903, 1947, 1982 and 2000.

6.28. There are no instances of historical flooding recorded at the Indicative WTW Site, along the Drinking Water Transfer Main Route Corridor or at Brookmans Park Service Reservoir.

6.29. Table 6.4 provides a summary of historical flooding for each of the components of the Beckton Reuse Indirect Option.

Table 6.4: Recorded historical flooding

Component	Historical flooding
Indicative Intake Location Indicative Raw Water Pumping Station Site Raw Water Transfer Main Route Corridor	The Environment Agency identified one historical flood event in 1947 affecting the Indicative Intake Location and Indicative Raw Water Pumping Station Site. The online evidence does not identify instances of flooding at the Indicative Intake Location and Indicative Raw Water Pumping Station Site or the respective reach of the River Lee flood relief channel but does identify periods of fluvial and pluvial flood risk in the wider catchment, especially in the centre of Waltham Abbey.

Component	Historical flooding
Indicative WTW Site	The online evidence does not identify instances of flooding at the Indicative WTW Site or the respective reach of River Lee flood relief channel but does identify periods of fluvial and pluvial flood risk in the wider catchment, especially in the centre of Waltham Abbey.
Brookmans Park Service Reservoir Connection	There is no recorded flood history from the Environment Agency at Brookmans Park Service Reservoir.
Drinking Water Transfer Main Route Corridor	There is no recorded flood history from the Environment Agency along the Drinking Water Transfer Main Route Corridor.
Drinking Water Transfer Main to North Mymms North Mymms Booster Station Connection	There is no recorded flood history from the Environment Agency along the Drinking Water Transfer Main to North Mymms Route Corridor or within the site of the North Mymms Booster Station Connection.

6.4.2.3 Modelled river levels

6.30. Modelled water levels of the River Lee have been obtained from the Environment Agency.

6.31. The Environment Agency commissioned CH2M Hill in 2014 to undertake the River Lee 2D Flood Mapping Study with the objective being to predict fluvial flood risk throughout the complex River Lee systems between Hertford and its confluence with the River Thames at Bow Creek.

6.32. The modelled flood extents have been provided by the Environment Agency for the 50%, 20%,10%, 5%, 2%, 1.3%, 1%, 1%+20%CC, 0.5% and 0.1% Annual Exceedance Probability (AEP) events for the modelled baseline scenario.

6.33. Halcrow was commissioned in 2010 to undertake the 1D-2D Upper Colne Strategic Flood Risk Management (SFRM) study. The principal objective of the study was to develop a robust hydrological and hydraulic model for the Upper Colne and its tributaries. The key outputs were peak channel water levels and flood maps, which are to be used in strategy studies including National Flood Risk Assessment (NaFRA).

6.34. The modelled flood extents include the 50% AEP, 20% AEP, 10% AEP, 5%AEP, 2%AEP, 1%AEP, 1%AEP+25%CC, 0.5% AEP and 0.1%AEP events for the baseline scenario.

6.35. The Indicative Intake Location and Indicative Raw Water Pumping Station Site are shown to be partially at risk of fluvial flooding from the River Lee for the design events modelled.

6.36. The Raw Water Transfer Main Route Corridor and Indicative WTW Site are not shown to be at risk of fluvial flooding from the River Lee for the design events modelled.

6.37. The Drinking Water Transfer Main Route Corridor and Drinking Water Transfer Main to North Mymms Route Corridor is at risk of fluvial flooding where it crosses watercourses. This is described in more detail in Section 6.4.3.2.

6.4.2.4 Surface water flood risk

6.38. Surface water (pluvial) flooding happens when rainwater does not drain away through the normal drainage systems or soak into the ground, but ponds or flows over the ground instead. Managing the risk of flooding from surface water is the responsibility of Lead Local Flood Authorities (LLFAs). In this instance, the LLFAs are Hertfordshire County Council, London Borough of Enfield, Epping Forest District Council and Essex County Council.

6.39. Each council has a published Strategic Flood Risk Assessment (SFRA) which examines different aspects of flooding including surface water flooding. All councils have requirements to assess, management and mitigate surface water flooding in respect to new development.

6.40. The Environment Agency's 'Long term flood risk' map[46] includes information regarding the risk of flooding from surface water, indicating areas with a 'high', 'medium', 'low' and 'very low' flood risk. These are defined in Table 6.5.

Table 6.5: Surface water flood risk categories

Category	Description	Annual Exceedance Probability
Very low risk	Each year the area has a chance of surface water flooding of less than 0.1%.	<0.1% (1 in 1000 year) of surface water flooding.
Low risk	Each year the area has a chance of surface water flooding of between 0.1 and 1%.	1% -0.1% (1 in 100 –1 in 1000 year) surface water flooding.
Medium risk	Each year the area has a chance of surface water flooding of between 1 and 3.3%.	3.3 –1% (1 in 75 -1 in 100 year) surface water flooding.

[46] GOV.UK Check the long term flood risk for an area in England. Available at: https://www.gov.uk/check-long-term-flood-risk [Accessed May 2022]

Category	Description	Annual Exceedance Probability
High risk	Each year the area has a chance of surface water flooding of greater than 3.3%.	>3.3% (up to 1 in 75 year) surface water flooding.

Source: Environment Agency (2022) Flood Warning Information Service: Long term flood risk information.

6.41. Table 6.6 provides a summary of the surface water flood risk for each of the components of the Beckton Reuse Indirect Option according to the Environment Agency's Long term flood risk map. Figure 6.2: Surface water flood extents shows the surface water flood extents in relation to the Beckton Reuse Indirect Option.

Table 6.6: Surface water flood risk

Component	Surface water flood risk
Indicative Intake Location	Low
Indicative Raw Water Pumping Station Site	Medium
Raw Water Transfer Main Route Corridor	High to Very Low
Indicative WTW Site	Low
Brookmans Park Service Reservoir Connection	Very low
Drinking Water Transfer Main Route Corridor	High to very low
Drinking Water Transfer Main to North Mymms Route Corridor	High to very low
North Mymms Booster Station Connection	Very low

6.4.2.5 Sewer flood risk

6.42. Sewer flooding can be caused by blocked pipes, extreme weather and prolonged rainfall, insufficient land drainage and surcharges from private sewers or drains.

6.43. Hertfordshire County Council (2019[47]) state that sewer systems are typically designed and constructed to accommodate rainfall events with a 3.3% AEP or greater (i.e. storm events up to the 30-year return period). Therefore, rainfall events with a return period greater than 30-years (3.3% AEP) would be expected to result in surcharging of some of the sewer systems.

6.44. Climate change is anticipated to increase the potential risk from sewer flooding as summer storms become more intense and winter storms more prolonged.

6.45. Essex County Council (2018) SFRA[48] identify that it is the responsibility of the risk management authority, in this case Thames Water and Affinity Water, to manage and maintain existing sewer networks.

6.46. The transfer mains would be under the jurisdiction of Affinity Water. The transfer mains have been sized to maintain velocities and minimise the deposition of sediment. It is unlikely that in the future the transfer mains would require flushing or swabbing. The transfer mains would be inspected and maintained through the use of access chambers.

6.4.2.6 Groundwater flood risk

6.47. Groundwater flooding occurs when groundwater levels rise above surface elevations and is most likely to occur in low-lying areas underlain by permeable rocks (aquifers).

6.48. Bedrock geology and superficial deposits (see Section 5.3.3) can be useful indicators of available groundwater. Geological formations have varying ability to store and procure water due mostly to the permeability of the rock or unconsolidated deposit in question and these are classified as shown in Table 5.4.

6.49. In co-operation with the Environment Agency, DEFRA has produced UK coverage of groundwater vulnerability[49]. The Drinking Water Transfer Main Route Corridor as predominantly 'Unproductive' and 'Low' risk of groundwater flooding. The only area designated as 'Medium – Low' risk of groundwater flooding is the Waltham Cross area to the east boundary of the Drinking Water Transfer Main Route Corridor Option.

6.50. As defined by the BGS, areas of 'medium' vulnerability are 'areas that offer some groundwater protection.' The definition for medium can also be applied to 'medium-low.' Unproductive areas are 'comprised of rocks that have negligible significance for

[47] Hertfordshire County Council (2019) LFRMS 2: A strategy for the management of local sources of flood risk. Available at: https://www.hertfordshire.gov.uk/media-library/documents/environment-and-planning/water/flood-risk-management/lfrms-for-hertfordshire-full-report.pdf [Accessed May 2022]
[48] Essex County Council (2018) South Essex Level 1 Strategic Flood Risk Assessment. Available at: South Essex Strategic Flood Risk Assessment Level 1.pdf (southend.gov.uk) [Accessed May 2022]
[49] DEFRA (2022) Interactive groundwater vulnerability map. Available at: https://magic.defra.gov.uk/MagicMap.aspx [Accessed May 2022]

water supply or baseflow to rivers, lakes and wetlands.'

6.51. Hertfordshire County Council (2019[47]) state that the presence of the chalk aquifer in Hertfordshire and other under groundwater bearing areas such as the river gravel deposits mean that there is potential for groundwater flooding. Two entries of groundwater flooding were identified by Hertfordshire County Council in 2000/1 and 2013/14, both are described as extreme events, however the location of the flood events have not been listed and therefore are unknown.

6.52. There are no known incidents of groundwater flooding within the components of the Beckton Reuse Indirect Option. It is considered that groundwater flooding could pose a risk in the east section of the Drinking Water Transfer Main Route Corridor.

6.4.2.7 Reservoir, canal and other sources of artificial flooding

6.53. Artificial flood sources include raised channels, canals, or storage features such as ponds and reservoirs.

6.54. The failure of a reservoir has the potential to cause catastrophic damage due to the sudden release of large volumes of water. The local planning authority would need to evaluate the potential damage to buildings or loss of life in the event of dam failure, compared to other risks, when considering development downstream of a reservoir.

6.55. The Environment Agency has produced 'Reservoir Flood Maps' based on hydraulic modelling to deliver a 'Dry day' and 'Wet day' scenario.

- The 'Dry-day' scenario predicts the flooding that would occur if the dam or reservoir failed when rivers are at normal levels.
- The 'Wet day' scenario predicts how much worse the flooding might be if a river is already experiencing an extreme natural flood.

6.56. There are several lakes, lagoons and reservoirs along the course of the River Lee, most noticeably King George V reservoir. The Environment Agency's Risk of Flooding from Reservoirs Map shows that the Indicative Intake Location, Indicative Raw Water Pumping Station Site and part of the Drinking Water Transfer Main Route Corridor through Waltham Cross and Waltham Abbey would be at risk of flooding. This is illustrated on Figure 6.3: Risk of flooding from reservoirs.

6.57. The Lee Navigation channel runs north to south through the Epping Forest District Council administrative area, parallel to the River Lee and is under the jurisdiction of the Canal and River Trust (CRT) which is the navigation authority. CRT inspects, maintains and operates the water control structures within its ownership primarily to meet its statutory obligation to maintain navigation. CRT is not a Risk Management Authority. Primary responsibility for land drainage and flood prevention rest with

private parties. CRT does not have any specific statutory responsibilities in relation to flooding and, therefore, its responsibilities are those of an owner and operator of its canals and other waterways.

6.4.3 Appraisal outcomes

6.4.3.1 Sequential Test

6.58. As set out in the NPPF[19], the aim of the Sequential Test is to steer new development to areas with the lowest probability of flooding. Annex 3 of the Flood risk and coastal change Planning Practice Guidance (PPG)[50] defines WTWs as 'less vulnerable,' and it is considered that the Indicative Intake location, Indicative Raw Water Pumping Station Site and transfer mains are defined as 'water compatible.' These are defined in the PPG as follows:

- 'Less vulnerable' developments can be constructed in Flood Zone 3a without the application of an Exception test. Construction in Flood Zone 3b is strictly prohibited.
- 'Water compatible' developments are appropriate in Flood Zone 3b, and application of the Exception Test is not required. It should be noted however that:

'Water-compatible developments in Flood Zone 3b, should be designed and constructed to:

- remain operational and safe for users in times of flood
- result in no net loss of floodplain storage
- not impede water flows and not increase flood risk elsewhere.'

6.59. The aim therefore is to assess the asset locations with respect to flood risk for its planned lifetime, and to demonstrate that the development does not increase flood risk elsewhere.

6.4.3.2 Fluvial flood risk

6.60. The Indicative Intake Location is within Flood Zones 2 and 3 and part of the Indicative Raw Water Pumping Station Site is within Flood Zone 2, and therefore are at risk of fluvial flooding. The Raw Water Transfer Main Route Corridor is not within Flood

[50] GOV.UK, Flood risk and coastal change. Available at: https://www.gov.uk/guidance/flood-risk-and-coastal-change [Accessed May 2022]

Zones 2 and 3.

6.61. The Indicative WTW Site is located within Flood Zone 1 and not shown to be at risk of fluvial flooding from the River Lee for the design event model. They are therefore considered to be at low risk of fluvial flooding.

6.62. The Drinking Water Transfer Main Route Corridor and Drinking Water Transfer Main to North Mymms Route Corridor are at risk of fluvial flooding where they cross watercourses. It is assumed that no-dig methods would be utilised for major river crossings and that there would be no displacement of fluvial flooding as the pipeline would be located underground. The key crossing points are as follows:

- River Lee Navigation and River Lee Flood Relief Channel approximately 0.5km south of the M25 (micro-tunnelled).
- Turkey Brook crossing to the east of the A10 (micro-tunnelled).
- New River Canal to the west of the A10 (micro-tunnelled).
- Ray Brook crossing at Water End; fluming of the channel at this section would be required.

6.63. Although the Drinking Water Transfer Main would not cross the Cuffley Brook, the route corridor is within Flood Zone 3.

6.64. It is assumed that the placement of the Drinking Water Transfer Main and Drinking Water Transfer Main to North Mymms would not have consequential effects on the displacement of fluvial flooding as the pipelines would be located underground. Care should be taken when installing the Drinking Water Transfer Main and Drinking Water Transfer Main to North Mymms as to not impact upon the watercourses they cross.

6.65. It is recommended that during construction any excavated material is located away from identified areas of flood risk, especially if it is spoiled, so it does not block local drains or potentially lead to contamination.

6.66. It is also recommended that works within the river during forecasts of wet weather or issued flood warnings should be avoided. Therefore, construction timings should be considered in greater detail during the design development stage.

6.67. It is noted that Cuffley Brook and Ray Brook are not included in either the CH2M Hill (2014) River Lee study or Halcrow's (2010) Upper Colne study. Both watercourses are shown to exhibit flooding according to the Environment Agency's Flood Zones at the crossings examined above. It is recommended that if available models of these watercourses exist, they should be examined at a subsequent project stage to understand the full hydrological risk during construction, including the impact these watercourses, if flumed, would have on localised flooding. Access to these models would also provide more detail in understanding the water levels for the different AEP events and assist in identifying potential constraints to development.

6.68. Brookmans Park Service Reservoir is located within Flood Zone 1 is therefore at low risk of fluvial flooding.

6.69. The North Mymms Booster Station Connection is partly within Flood Zones 2 and 3, and therefore at risk of fluvial flooding. The North Mymms Booster Station Connection would be to an existing pumping station and minimal works are anticipated to facilitate this. Therefore the North Mymms Booster Station Connection is unlikely to have consequential effects on the displacement of fluvial flooding.

6.4.3.3 Surface water flood risk

6.70. New developments have the potential to cause an increase in downstream flood risk due to increased runoff rates and volumes. All above ground infrastructure would result in land use changes resulting from installation of impermeable surfaces. The change in surface water would need to be assessed at a subsequent project stage and, if appropriate, controlled.

6.71. The Indicative Intake Location is at low risk of surface water flooding. However, the Indicative Raw Water Pumping Station Site is within a medium surface water flood risk area. The pumping station location is partly within a brownfield site currently in commercial use with a hard standing surface. It is assumed that the location already has a drainage system in place. The Environment Agency surface water flood mapping assess how water moves across the ground; it does not take into consideration already established drainage system. It is recommended that a drainage assessment is made at a subsequent project stage at the Indicative Raw Water Pumping Station Site to examine the current drainage capabilities.

6.72. The Indicative WTW Site is within a low surface water flood risk area. It should be noted that there is a small pond to the west outside the boundary of the Indicative WTW Site. The extent of the surface water flood risk does not reach the boundary of the Indicative WTW Site however, it is recommended that this is investigated further at a subsequent project stage as the pond could potentially be a source of flooding.

6.73. The Raw Water Transfer Main Route Corridor varies from very low to high surface water flood risk.

6.74. The Indicative WTW Site has underlying clay which would impede the infiltration of surface water and could result in pooling or standing water during precipitation events. The presence of underlying clayey soils suggests that surface water accumulation could be a problem in the area, and that sustainable drainage arrangements would be required to manage surface water from the Indicative WTW Site as to not exacerbate flooding to the surrounding areas.

6.75. Under the guidance of the Epping Forest District Council (2015[51]) (as local flood authority), displacement of surface water flood risk needs to be managed. They also advise that for development over 235m² of impermeable area, a full Flood Risk Assessment (FRA) would need to be submitted along with details of the proposed surface water management strategy. This would need to be undertaken at a subsequent project stage.

6.76. Epping Forest District Council[51] state that surface water should be discharged in one of three ways.

- Runoff should be first restricted to the greenfield 1 in 1-year runoff rate during all events up to and including the 1 in 100-year rainfall event with climate change.
- If point one is not possible then discharge rates can be limited to a range of equivalent greenfield discharge rates. For example, the 1 in 1-year storm event would be limited to the 1 in 1-year greenfield run off rate, the 1 in 30-year storm event would be limited to the 1 in 30-year storm event and the 1 in 100-year rate would be limited to the 1 in 100-year storm event (inclusive of a climate change allowance). If this alternative approach is used, then there should also be an inclusion of long-term storage.
- Discharge location is to a tidal estuary then it is accepted that discharge rates are unrestricted. However, evidence should be provided to ensure that the surface water would be managed during a tide locking scenario. This should be demonstrated by showing that the surface water can be managed for a 1 in 100-year pluvial storm event plus climate change and a 1 in 20 year fluvial/tidal storm event coinciding.

6.77. It is recommended that when installing a sustainable drainage system, the first two points above are considered for implementation in the design.

6.78. If point two is considered as part of the design, then it would be necessary to provide additional mitigation for the impact of increased volumes of water leaving the site. This could be achieved through the use of online long-term storage.

6.79. The surface water flood risk of the Drinking Water Transfer Main Route Corridor and Drinking Water Transfer Main to North Mymms Route Corridor varies from Very Low to High. It is assumed that during the operation of the Drinking Water Transfer Main and Drinking Water Transfer Main to North Mymms Route Corridor, surface water flood risk would not be affected as the development is underground. It is recommended that during the construction phase, care is taken to ensure stockpiled materials are not washed into local drains, as they could cause blockages which could lead to localised flooding. It is also recommended that any excavated material is located away from areas of flood risk, especially if it is spoiled, so it does not block

[51] Epping Forest District Council (2015) Level 1 Strategic Flood Risk Assessment Update. Available at: https://www.efdclocalplan.org/wp-content/uploads/2018/02/EB909-Level-1-Strategic-Flood-Risk-Assessment-SFRA-Update-URS-2015.pdf [Accessed May 2022]

local drains or potentially lead to contamination.

6.80. The Brookmans Park Service Reservoir Connection and the North Mymms Booster Pumping Station Connection are shown to be at a very low risk of surface water flooding. No impacts are anticipated during construction or operation.

6.4.3.4 Groundwater flood risk

6.81. Groundwater flooding would not preclude development of the River Lee Intake , Raw Water Pumping Station, Raw Water Transfer Main, Indicative WTW site or Brookmans Service Reservoir Connection unless there was a demonstrated history of relatively frequent and problematic flooding at these locations. As described in Section 6.4.2.6, there have been no incidents of flood events

6.82. The bedrock geology is largely of the London Clay Formation throughout the Drinking Water Transfer Main Route Corridor and Drinking Water Transfer Main to North Mymms Route Corridor. There are beds of chalk identified at Brookmans Park. Hertfordshire County Council[47] state that the presence of the chalk aquifer in Hertfordshire, and other under groundwater bearing areas such as the river gravel deposits, mean that there is potential for groundwater flooding. Chalk aquifers can take several months to become saturated and do not react quickly to intense rainfall, however once the groundwater level has reached the surface, flooding can last several months. Two entries of groundwater flooding have been identified by Hertfordshire County Council in 2000/1 and 2013/14, both are described as extreme events, however the locations of the flood events have not been listed and are therefore unknown. It is reasonable to assume that the areas underlain by chalk are likely to be susceptible to groundwater flooding and that the risk of groundwater flooding is therefore expected to be high with a prolonged duration of flooding. Hertfordshire County Council has also identified that groundwater flooding may also impact on other underground infrastructures. It is recommended that borehole logs or an available groundwater model are requested at a subsequent project stage to assess the risk of groundwater flooding on development of the Drinking Water Transfer Main within chalk bedrock areas.

6.4.3.5 Reservoir, canal and other sources of artificial flooding

6.83. The Environment Agency's Risk of Flooding from Reservoirs Map shows that the Indicative Intake Location, Indicative Raw Water Pumping Station Site and part of the Drinking Water Transfer Main Route Corridor through Waltham Cross and Waltham Abbey would be at risk of flooding from artificial sources and reservoir flooding. The consequences of flooding from reservoirs are very high, however the inspection and maintenance regime under the Reservoirs Act (1975) means that the probability of

occurrence of flooding from these sources is considered low.

6.84. The Lee Navigation has been identified as a potential flood risk due to its course running parallel with the River Lee. No information has been provided about the operation of the canal and therefore cannot be examined as part of this assessment, however the main risk would be due to a breach of the canal during the construction period. It is considered that this risk would be very low.

6.4.4 Recommended mitigation

6.4.4.1 Management of fluvial flood risk during construction

6.85. Land within the Indicative Raw Water Pumping Station Site that would be used as a temporary construction compound to store materials and equipment for the development of the River Lee Intake and Raw Water Pumping Station is not at fluvial flood risk and is therefore considered to be suitable for the storage of materials and equipment.

6.86. Land within the Indicative WTW Site that would be used as a temporary construction compound to store materials and equipment for the development of the WTW is not at fluvial flood risk and is therefore considered to be suitable for the storage of materials and equipment. It is recommended that materials are stored away from the areas shown to be within Flood Zone 2.

6.87. There are Flood Alert Areas on the watercourses of the River Lee, Turkey Brook, Cuffley Brook, Ray Brook and River Colne, and it is recommended that construction teams sign up to the Environment Agency's flood alert system. An alert through the system warns of the possibility of flooding and make the necessary preparations.

6.88. Sections of the Raw Water Transfer Main Route Corridor, Drinking Water Transfer Main Route Corridor and Drinking Water Transfer Main to North Mymms Route Corridor are at fluvial flood risk, and there is a risk of flooding during the construction phase. It is recommended that measures are implemented when working next to watercourses and works within the river during forecasts of wet weather or issued flood warnings should be avoided. This should inform construction timings during the design development stage.

6.89. Preparation should be taken during the receipt of a flood alert to secure all construction locations and the equipment from the possibility of severe flooding. On site personnel should be made aware of flood risk and an evacuation plan directing staff away from areas where there is a flood risk should be implemented on receipt of a flood alert or warning.

6.4.4.2 *Management of fluvial flood risk during operation*

6.90. Pipeline maintenance access points should be located in areas where there is low risk of flooding to ensure that they are accessible at all times and ensure pipe design and cover is enough to withstand seepage from flooding into the pipes.

6.91. Assessment of fluvial flood risk at the Indicative WTW Site and Indicative Raw Water Pumping Station Site showed that these locations neither have a history of flooding nor are at risk of fluvial flooding up to the 0.1%. It is therefore not considered at this stage that mitigation of fluvial flood risk is required.

6.4.4.3 *Management of surface water flood risk during construction*

6.92. It is recommended that care is taken during construction when storing equipment and materials to prevent stockpiled materials and other items being washed into local drains, as these could cause blockages, which could lead to localised flooding. In particular, it is recommended that materials for construction of the River Lee Intake and Raw Water Pumping Station are stored away from the surface water flood extents.

6.4.4.4 *Management of surface water flood risk during operation*

6.93. In accordance with the NPPF[19], paragraph 167, point C, new assets would need to incorporate sustainable drainage systems, unless there is clear evidence that this would be inappropriate.

6.94. Both Epping Forest District Council and Hertfordshire County Council identify the discharge hierarchy for new developments, stating that discharge hierarchy should be appropriately assessed and the selected discharge point for proposed SuDS must be justified. The primary aim is that runoff should be first restricted to the greenfield 1 in 1-year runoff rate during all events up to and including the 1 in 100-year rainfall event with climate change.

6.95. A sustainable drainage system would therefore be required for the Indicative Raw Water Pumping Station and Indicative WTW Site. It is recommended that the implemented drainage system is capable of capturing all excess surface water as a result of the scheme.

6.96. It is also recommended that a closed loop system be put into place for the new WTW to capture any potential contaminants from the treatment process.

6.4.4.5 Management of groundwater flood risk

6.97. For the Drinking Water Transfer Main Route Corridor, in the vicinity of Brookman's Park, it is recommended that a request is placed for an available groundwater model at a subsequent project stage to determine the groundwater risk of the chalk aquifer on underground pipe equipment. It is also recommended that groundwater risk is implemented into the design of the Drinking Water Transfer Main at this location to ensure that equipment is not affected.

6.5 Summary of main findings and recommendations for future technical work

6.5.1 Aquatic environment appraisal

6.98. Based on the design assumptions outlined in Section 2.3, there will be no potential for deterioration of any WFD elements as a result of the Beckton Reuse Indirect Option. There will be no potential for the Beckton Reuse Indirect Option to result in any WFD status not achieving their objectives. Therefore, this option is considered to be compliant with the WFD at this stage.

6.99. The assessment of effects associated with recycled water being fed into the river, and the associated abstraction, will be assessed as part of the London Effluent Reuse SRO assessments. As such, only the construction related activities were assessed.

6.100. During construction there is a risk of impacts on the aquatic environment associated with the transfer corridor. The risk relates to construction impacts such as pollution incidents, local increases in sediment/siltation, temporary disturbance as a result of noise and vibration, etc. It is assumed that several mitigation measures will be implemented during the construction activities. This includes those best practice measures as listed in Section 2.3. Any impacts on the aquatic environment are therefore expected to be short term and reversible. As such, no or negligible change is expected.

6.5.2 Groundwater

6.101. The Beckton Reuse Indirect Option affects Principal, Secondary A, Secondary B and Unproductive aquifers.

6.102. The Indicative Intake Location and Indicative Raw Water Pumping Station Site, Drinking Water Transfer Main Route Corridor, Drinking Water Transfer Main to North Mymms Route Corridor and North Mymms Booster Station Connection are located within areas defined as SPZ1 and SPZ2. The Raw Water Transfer Main Route Corridor

is within SPZ2. The Indicative WTW Site and Brookmans Park Service Reservoir Connection are not located within SPZs. Construction within SPZs requires additional assessment and potentially mitigation to ensure no adverse impacts on public water supplies. Prior to construction, a hydrogeological risk assessment would be required for works within SPZ1 or 2.

6.103. Neither of the groundwater bodies considered in the Level 1 – basic screening assessment were carried through to the Level 2 – detailed screening assessment. This has resulted in no further requirements for assessment of groundwater flow under the WFD at this stage. If any of the design assumptions or mitigation measures change, this will be reconsidered at subsequent project stages.

6.5.3 Flood risk

6.104. Examination of fluvial flood risk from the Environment Agency's Flood Zone maps and modelled river levels indicates that the Indicative Intake Location is within Flood Zones 2 and 3 and part of the Indicative Raw Water Pumping Station Site is within Flood Zone 2, and therefore are at risk of fluvial flooding. The Indicative Intake Location is at low risk of surface water flooding. However, the Indicative Raw Water Pumping Station Site is within a medium surface water flood risk area.

6.105. Examination of fluvial flood risk from the Environment Agency's Flood Zone maps and modelled river levels indicates that the Raw Water Transfer Main Route Corridor is not within Flood Zones 2 and 3 and surface water flooding. The Raw Water Transfer Main Route Corridor is considered to be at low risk of groundwater flooding and is not at risk of flooding from reservoir, canal and or other sources of artificial flooding.

6.106. Examination of fluvial flood risk from the Environment Agency's Flood Zone maps and modelled river levels indicates that the Indicative WTW Site is at low risk of fluvial flooding. A small part of the Indicative WTW Site is considered to be at high risk of surface water flooding. A sustainable drainage system would therefore be required for the Indicative WTW Site and the Raw Water Pumping Station, and it is recommended that a closed loop system be put into place for the new WTW to capture any potential contaminants from the treatment process.

6.107. The Indicative WTW Site is considered to be at low risk of surface water flooding. Care should be taken with the storage of equipment and materials to ensure stockpiled materials and other items are not washed into local drains to prevent blockages which could lead to localised flooding.

6.108. The Indicative WTW Site is considered to be at low risk of groundwater flooding and is not at risk of flooding from reservoir, canal and or other sources of artificial flooding.

6.109. The Drinking Water Transfer Main Route Corridor is at risk of fluvial flooding from the River Lee and Colne and associated tributaries where the pipeline crosses the watercourses. It is assumed that predominantly no-dig methods would be utilised for major river crossings and that there would be no displacement of fluvial flooding as the pipeline would be underground. There is still a risk of flooding during the construction phase near any watercourse and it is recommended that works within the river during forecasts of wet weather or issued flood warnings should be avoided. Therefore, construction timings should be considered during the design development stage. Pipeline maintenance access points should be located in areas where there is low risk of flooding to ensure that they are accessible at all times and ensure pipe design and cover is enough to withstand seepage from flooding into the pipes.

6.110. In the vicinity of Brookmans Park, the Drinking Water Transfer Main Route Corridor bedrock geology is chalk. It is recommended that a groundwater model is requested at a subsequent project stage to assess the risk of groundwater flooding on the development of the Drinking Water Transfer Main Route Corridor within chalk bedrock areas. It is also recommended that groundwater risk is taken into consideration during design of the Drinking Water Transfer Main, and groundwater designs are implemented to assist with protection the asset.

6.111. The Indicative Intake Location, Indicative Raw Water Pumping Station Site and part of the Drinking Water Transfer Main Route Corridor through Waltham Cross and Waltham Abbey are shown to be at risk from reservoir, canal and or other sources of artificial flooding. The consequences of flooding from reservoirs are very high, however the inspection and maintenance regime under the Reservoirs Act (1975) means that the probability of occurrence of flooding from these sources is considered low.

6.112. The Brookmans Park Service Reservoir Connection is considered to be at low risk of fluvial and surface water flooding, is considered to be at low risk of groundwater flooding and is not considered to be at risk of flooding from reservoir, canal and or other sources of artificial flooding.

6.113. The North Mymms Booster Station Connection is partly within Flood Zones 2 and 3, and therefore considered to be at risk of fluvial flooding. The North Mymms Booster Station Connection would be to an existing pumping station and minimal works are anticipated to facilitate this. Therefore the North Mymms Booster Station Connection is unlikely to have consequential effects on the displacement of fluvial flooding.

7 Air quality

7.1 Introduction

7.1. This chapter presents a desk-based assessment undertaken to identify potential air quality impacts on sensitive receptors from the construction and operation of the transfer corridors and above ground infrastructure including the WTW associated with the Beckton Reuse Indirect Option. The objectives of the desk-based assessment were to establish the baseline air quality associated with the Beckton Reuse Indirect Option, identify constraints and opportunities, and identify the issues and features that may require further investigation at a subsequent project stage.

7.2. The need to consider air quality is driven by legislation[52] and national planning policy (draft NPS for Water Resource Infrastructure[18] (Section 4.2, Air Quality) and NPPF[19] (Section 15, conserving and enhancing the natural environment), paragraph 186).

7.2 Methodology

7.2.1 Study area and sources of information

7.3. For possible dust generating activities during construction, the desk-based assessment identified the number of sensitive receptors in the area surrounding the Raw Water and Drinking Water Transfer Main Route Corridors, Drinking Water Transfer Main to North Mymms Route Corridor and associated infrastructure (River Lee Intake, Raw Water Pumping Station, Indicative WTW Site and Brookmans Park Service Reservoir Connection) up to a distance of 350m. This is in line with the Institute of Air Quality Management (IAQM) construction dust guidance[53].

7.4. The review of baseline conditions considered publicly available air quality data up to a distance of 1km from the Raw Water Main Route Corridors, Drinking Water Transfer Main Route Corridor and Drinking Water Transfer Main to North Mymms Route Corridor and anticipated construction works areas and associated

[52] Air Quality Standards Regulations 2010, Air Quality Standards (amendment) Regulations 2016, Air Quality (Amendment of Domestic Regulations) (EU Exit) Regulations 2019 Environment (Miscellaneous Amendments) (EU Exit) Regulations 2020, Air Quality (England) Regulations 2000, Air Quality (England) (Amendment) Regulations 2002, Environment Act 1995 (Part IV)
Environment Act 2021 (Schedule 11), Environmental Protection Act 1990 (section 79(1)(d))
[53] Institute of Air Quality Management (2014) Guidance on the assessment of dust from construction and demolition. Available at: http://iaqm.co.uk/wp-content/uploads/guidance/iaqm_guidance_report_draft1.4.pdf [Accessed April 2022]

infrastructure. If no representative data was found within this distance, data from a wider area was reviewed and presented if it was considered representative.

7.5. Table 7.1 outlines the baseline data sources collated and considered in the desk-based assessment.

Table 7.1: Sources of information (air quality)

Data collected	Source
Locations of AQMA and Clean Air Zones (CAZ)	Local authority and Defra mapping
Publicly available air quality data (Local authority and Defra air quality monitoring data, Defra background maps, PCM model)	Local authority monitoring data (published in Annual Status Reports) Defra air quality monitoring data Defra PCM model/background maps
Human health, dust soiling and ecological receptor locations within 350m of transfer route corridors and associated infrastructure	OS mapping (AddressBase) Natural England mapping

7.2.2 Approach to impact appraisal

7.6. The desk-based assessment used a qualitative approach to appraise the Beckton Reuse Indirect Option and identify where there is potential for air quality impacts. This included consideration of existing pollutant concentrations (from publicly available sources) in the vicinity of the Beckton Reuse Indirect Option as well as its proximity to:

- AQMA and Clean Air Zones (CAZ)
- Sensitive human health receptors
- Sensitive receptors to dust soiling
- Sensitive ecological receptors (relevant designated nature conservation sites)

7.7. Based on these findings, high-level mitigation measures were identified.

7.8. The sensitivity of receptors based on dust soiling and risks to human health within this appraisal has been based on the definitions provided with the IAQM guidance[53], which are presented in Table 7.2 below.

Table 7.2: Sensitivities of human health receptors to dust soiling effects and health effects

Receptor sensitivity	Dust soiling	Human health
High sensitivity receptor – surrounding land where:	Users can reasonably expect enjoyment of a high level of amenity; or the appearance, aesthetics or value of their property would be diminished by soiling; and the people or property would reasonably be expected to be present continuously, or at least regularly for extended periods, as part of the normal pattern of use of the land. Indicative examples include dwellings, museums and other culturally important collections, medium and long term car parks and car showrooms.	Locations where members of the public are exposed over a time period relevant to the air quality objective (for example, in the case of the 24-hour objectives, a relevant location would be one where individuals may be exposed for eight hours or more in a day). Indicative examples include residential properties. Hospitals, schools and residential care homes should also be considered as having equal sensitivity to residential areas for the purposes of this assessment.
Medium sensitivity receptor	Users would expect to enjoy a reasonable level of amenity, but would not reasonably expect to enjoy the same level of amenity as in their home; or the appearance, aesthetics or value of their property could be diminished by soiling; or the people or property wouldn't reasonably be expected to be present here continuously or regularly for extended periods as part of the normal pattern of use of the land. Indicative examples include parks and places of work.	Locations where the people exposed are workers, and exposure is over a time period relevant to the air quality objective (for example, in the case of the 24-hour objectives, a relevant location would be one where individuals may be exposed for eight hours or more in a day). Indicative examples include office and shop workers.

Receptor sensitivity	Dust soiling	Human health
Low sensitivity receptor	The enjoyment of amenity would not reasonably be expected; or property would not reasonably be expected to be diminished in appearance, aesthetics or value by soiling; or there is transient exposure, where the people or property would reasonably be expected to be present only for limited periods of time as part of the normal pattern of use of the land. Indicative examples include playing fields, farmland (unless commercially-sensitive horticultural), footpaths, short term car parks and roads.	Locations where human exposure is transient. Indicative examples include public footpaths, playing fields, parks and shopping streets.

7.9. Table 7.2 above provides examples of high, medium and low sensitivity human health receptors. However, at this stage, only the following receptor types have been considered and included in this assessment, due to data availability:

- Residential properties
- Medical centres
- Education facilities
- Places of worship
- Allotments / community growing spaces
- Offices
- Golf courses
- Leisure centres
- Public gardens/parks
- Play spaces
- Playing fields
- Farm buildings

- Industrial properties

7.10. The presence of any other types of human health receptors would be considered at a later stage.

7.11. The following sensitive ecological receptor types have also been considered:

- SAC
- SPA
- Ramsar sites
- SSSI
- NNR
- LNR
- Ancient woodland
- Non-statutory designated nature conservation sites

7.12. Priority habitats have not been considered as they are not classified as a designated site, in accordance with IAQM guidance[54].

7.13. Of the ecological receptor types listed above, six (SAC, SSSI, NNR, LNR, ancient woodland and non-statutory designated nature conservation sites) are located within 350m of the Beckton Reuse Indirect Option and are therefore included in this assessment.

7.2.3 Assumptions and limitations

7.14. No formal construction dust assessment (following the methodology outlined in the IAQM guidance) has been undertaken at this stage and therefore only high-level construction dust mitigation measures have been identified. No assessment of potential construction traffic effects has been undertaken as information on vehicle numbers or access routes are not available at this stage.

7.15. The most recent year of monitoring data available from local authorities is for 2020, however data from 2020 has the potential to be impacted by effects associated with the coronavirus (Covid-19) pandemic, such as a reduction in traffic movements resulting in reduced monitored pollutant concentrations. Therefore, data from 2020 may not be representative of existing concentrations so 2019 data has been used to inform the baseline for this assessment. It is therefore assumed that 2019 data is

[54] IAQM (2020) A guidance to the assessment of air quality impacts on designated nature conservation sites. Available at: https://iaqm.co.uk/text/guidance/air-quality-impacts-on-nature-sites-2020.pdf [Accessed April 2022]

representative of current conditions.

7.16. The desk-based assessment was qualitative and therefore no atmospheric dispersion modelling or scheme-specific monitoring surveys was undertaken.

7.17. The following elements were excluded from the desk-based assessment:

- Identification of potential construction traffic effects as a result of the Beckton Reuse Indirect Option – as construction vehicle numbers and access routes have not yet been finalised at this stage. The Environmental Protection UK (EPUK)/IAQM guidance[55] indicates that an assessment of traffic emissions is likely to be required where a development generates an additional annual average flow of greater than 25 Heavy Duty Vehicles[56] (HDVs) per day or greater than 100 Light Duty Vehicles (LDVs) per day on local roads within an AQMA and greater than 100 HDVs per day or greater than 500 LDVs per day on local roads outside an AQMA. Considering the nature of the scheme and the number of staff required, it is unlikely that the LDV and/or the HDV flows would exceed these thresholds during the construction phase and that an assessment of traffic emissions would be required. However, this should be confirmed at a subsequent project stage once, construction vehicle numbers have been finalised and are available.
- Identification of potential construction effects associated with Non-road Mobile Machinery (NRMM) and site traffic. It is stated in IAQM guidance[53] that 'they are unlikely to make a significant impact on local air quality, and in the vast majority of cases they will not need to be quantitatively assessed'. Therefore, given the nature of the scheme, it is unlikely that emissions from NRMM and site traffic would affect local air quality and as such their impacts on air quality have not been considered in this appraisal. Nonetheless it should be noted that NRMM would still be required to meet the relevant emission standards for NRMM.
- Identification of potential operational traffic effects as a result of the Beckton Reuse Indirect Option – as, based on current information, the scheme is anticipated to generate an additional annual average flow of one to three HDVs per day throughout its operation, which is well below the EPUK/IAQM screening threshold of 100 HDVs per day. As such, the impacts on air quality associated from vehicles associated with the Beckton Reuse Indirect Option during its operation are unlikely to require an assessment of traffic emissions and have not been considered further at this stage. This should be confirmed at a subsequent project stage, once operational vehicle numbers have been finalised and are available.
- Identification of potential operational effects associated with standby generators required for the associated infrastructure (Raw Water Pumping Station and new

[55] Environmental Protection UK and Institute of Air Quality Management (2017), 'Land-Use Planning and Development Control: Planning for Air Quality'

[56] HDVs are defined as freight vehicles of more than 3.5 tonnes (trucks) or passenger transport vehicles of more than 8 seats (buses and coaches).

WTW) as these are unlikely to result in air quality impacts during normal operation since the generators would only be used for emergencies (i.e. during periods when mains electricity supply to the respective sites (Raw Water Pumping Station and WTW) was disrupted). If an emergency were to occur, the generators would likely operate for a short period of time until the power supply to the respective sites was restored. Outside emergency operation, the standby generators would only operate during maintenance/testing, which is anticipated to have a duration of less than 50 hours a year. Therefore, given the limited number of operating hours associated with the standby generators during normal operation, the impacts on air quality are likely to be minimal so have not been considered in this appraisal. However, this should be reviewed once the location, operating profile and design of the associated infrastructure for the Beckton Reuse Indirect Option has been finalised.

7.3 Understanding of the baseline

7.3.1 Air Quality Management Areas

7.18. The closest AQMAs to each of the Beckton Reuse Indirect Option components are detailed in Table 7.3.

Table 7.3: Closest AQMAs to the Beckton Reuse Indirect Option

AQMA name	Details
Enfield AQMA	The Drinking Water Transfer Route Corridor is located with this AQMA, which is a parish-wide AQMA located within London Borough of Enfield's administrative area. The Indicative Intake location is approximately 15m to the east of the AQMA at its closest point and the Indicative WTW Site is approximately 700m to the east of the AQMA as its closest point. The AQMA was declared in 2001 for exceedances of the annual mean NO_2 and 24-hour mean particulate matter (PM_{10}) objectives.
Hertsmere AQMA No. 5	The Brookmans Park Service Reservoir Connection is located approximately 3.5km to the north of this AQMA at its closest point, which is located within Hertsmere Borough Council's administrative area. The AQMA was declared in 2005 for exceedances of the annual mean NO_2 objective.
Hertsmere AQMA No. 3	Sections of the Drinking Water Transfer Main to North Mymms Route Corridor are located approximately 3km northeast from this AQMA, which is located within Hertsmere Borough Council's administrative area. The AQMA was declared in 2003 for exceedances of the annual mean NO_2 objective.

7.3.2 Clean Air Zones

7.19. The Beckton Reuse Indirect Option passes through the administrative areas of four local authorities; Welwyn Hatfield Borough Council, Broxbourne Borough Council, London Borough of Enfield and Epping Forest District Council. None of these local authorities have, or are currently proposing to have, a CAZ. However, it should be noted that there are proposals for the Ultra Low Emission Zone in London to cover the whole of Greater London from August 2023, which includes the London Borough of Enfield.

7.3.3 Local authority monitoring data

7.3.3.1 Nitrogen dioxide monitoring

7.20. Monitoring of NO_2 is undertaken within the administrative area of each of the four local authorities that the Beckton Reuse Indirect Option passes through.

7.21. The following NO_2 monitoring is undertaken by each of the local authorities:

- Welwyn Hatfield Borough Council undertakes NO_2 monitoring across two automatic monitoring stations and 51 diffusion tube sites.
- Broxbourne Borough Council undertakes NO_2 monitoring at 38 diffusion tube sites.
- London Borough of Enfield undertakes NO_2 monitoring across four automatic monitoring stations and 10 diffusion tube sites.
- Epping Forest District Council undertakes NO_2 monitoring at 45 diffusion tube sites.

7.22. Local authority monitoring sites within the study area (within 1km of the Beckton Reuse Indirect Option) include:

- One automatic monitoring station within London Borough of Enfield's administrative area, which only measures NO_2.
- 18 diffusion tube sites, of which 9 are within the Broxbourne Borough Council administrative area, one within London Borough of Enfield, four within Welwyn Hatfield Borough Council and four within Epping Forest District Council.

7.23. Data from the diffusion tube sites show that between 2018 and 2020, NO_2 concentrations were compliant with the annual mean objective at all the monitoring sites in nearby suburban/urban background locations. This is the type of location that is representative of the Indicative Intake location, Indicative Raw Water Pumping

Station, Indicative WTW Site, Raw Water Transfer Main Route Corridor, the majority of the Drinking Water Transfer Main Route Corridor, and the Drinking Water Transfer Main to North Mymms Route Corridor.

7.24. Further to this, between 2018 and 2020, annual mean NO_2 concentrations were compliant with the annual mean objective at all but two roadside sites. These two roadside sites are located in urban areas approximately 275m-340m away from the Drinking Water Transfer Main Route Corridor. Of these two monitoring sites, only one recorded annual mean NO_2 concentrations above 40µg/m3 in 2019, which is the latest year with representative monitoring data available. However, this site is not considered to be a site of relevant exposure for the annual mean NO_2 objective, as it is not at a location where members of the public would be regularly exposed (such as at home).

7.25. The results of an automatic monitoring site within the London Borough of Enfield administrative area show that NO_2 concentrations are well below the annual and 1-hour mean NO_2 objectives between 2018 and 2020 at this automatic monitoring station, which is in an urban background location.

7.3.3.2 Particulate matter monitoring

7.26. Monitoring of particulate matter (PM) is undertaken within the administrative area of each of the four local authorities that the Beckton Reuse Indirect option passes through.

7.27. The following PM monitoring is undertaken by each of the local authorities:

- Welwyn Hatfield Borough Council undertakes $PM_{2.5}$ monitoring across two automatic monitoring stations.
- London Borough of Enfield undertakes PM_{10} monitoring across four automatic monitoring stations.

7.28. No representative PM monitoring data is available in the vicinity of the Beckton Reuse Indirect Option and the closest automatic PM monitoring station is approximately 6.8km to the south west.

7.3.4 Defra background mapping

7.29. Defra provides mapped future year projections of background pollution concentrations for NO_X, NO_2, PM_{10} and $PM_{2.5}$ for each 1 km grid square across the UK for all years between 2018 to 2030[57]. Future year projections have been developed

[57] Defra Background maps (2018) [Online] Available at: https://uk-air.defra.gov.uk/data/laqm-background-maps [Accessed April 2022]

from the base year of the background maps, which is currently 2018. The maps include a breakdown of background concentrations by emission source, including road and industrial sources, which have been calibrated against 2018 (the baseline year) UK monitoring data.

7.30. Table 7.4 presents the minimum and maximum background concentrations across the 1 km grid squares containing the Beckton Reuse Indirect Option for the current year of 2022. The minimum and maximum background concentrations are all below the relevant objectives.

Table 7.4: Defra projected background concentrations of NO_2, NO_x, PM_{10} and $PM_{2.5}$ for the Beckton Reuse Indirect Option components in 2022 (ug/m^3)

Component	Minimum and maximum 2022 background concentrations (µg/m^3)			
	NO_2	NO_x	PM_{10}	$PM_{2.5}$
Indicative Intake Location Indicative Raw Water Pumping Station	14.9-15.7	20.6-21.9	15.1-15.5	10.1-10.2
Raw Water Transfer Main Route Corridor	14.9-15.7	20.6-21.9	15.1-16.1	10.1-10.4
Indicative WTW Site	13.9-15.1	18.9-20.8	15.5-16.5	10.2-10.4
Drinking Water Transfer Main Route Corridor	9.6-19.2	12.6-27.3	13.6-17.3	9.1-11.3
Brookmans Park Service Reservoir Connection	10.3-10.7	13.5-14.1	14.6-14.6	9.3-9.4
Drinking Water Transfer Main to North Mymms Route Corridor North Mymms Booster Station Connection	10.3-12.7	13.5-17.0	14.1-15.1	9.3-9.7

Source: https://uk-air.defra.gov.uk/data/laqm-background-maps?year=2018

7.3.5 PCM model

7.31. The PCM model presents the projected roadside NO_2 concentrations for approximately 9,000 modelled road links across UK and is used by Defra to report compliance with limit values transposed into UK law from EU Directive 2008/50/EC[58]. The PCM model provides NO_2 concentrations at locations 4m from the road, and projections are available for all years from 2019 to 2030 from the base year of 2018.

7.32. In general, predicted NO_2 concentrations decline into the future, mainly in response to cleaner vehicles and technologies, and actions in Air Quality Action Plans by local and combined authorities. The most recent PCM model was published in 2020 and the projections represent the projected concentrations assuming no further action beyond the air quality measures that were committed by the reference year (2018).

7.33. The closest PCM link to each of the components has been presented below in Table 7.5. The greatest 2022 annual mean NO_2 concentration of 34.0µg/m^3 is predicted on the A10, which intersects the Drinking Water Transfer Main Route Corridor. This concentration is well below the annual mean limit value of 40µg/m^3 for NO_2.

Table 7.5: Predicted annual mean NO_2 concentrations on PCM links closest to the Beckton Reuse Indirect Option components

Component	PCM road link	Details
Indicative Intake Location	A1055 Census ID (802058392)	The predicted concentration at this link for 2022 is 30.0µg/m^3.
Indicative Raw Water Pumping Station Site		
Raw Water Transfer Main Route Corridor		
Indicative WTW Site		
Drinking Water Transfer Main Route Corridor	A10 Census ID: (802056187)	The predicted concentration at this link for 2022 is 34.0µg/m^3.
	A1010 Census ID: (802017429)	The predicted concentration at this link for 2022 is 22.9µg/m^3.
	A1055 Census ID: (802016617)	The predicted concentration at this link for 2022 is 26.2µg/m^3.
	A1055 Census ID: (802058392)	The predicted concentration at this link for 2022 is 30.0µg/m^3.

[58] European Union. (April 2008) Directive on Ambient Air Quality and cleaner Air for Europe, Directive 2008/50/EC Official Journal, vol. 152, pp. 0001-0044

Component	PCM road link	Details
Brookmans Park Service Reservoir Pumping Station	A1000 Census ID: (802038128)	The predicted concentration at this link for 2022 is 20.1µg/m^3.
Drinking Water Transfer Main to North Mymms Route Corridor		

7.4 Appraisal outcomes

7.4.1 Nitrogen dioxide

7.34. The annual mean objective may be exceeded in regions of the Drinking Water Transfer Main Route Corridor that are located close to the roadside within Enfield AQMA, which was declared for exceedances of the annual mean NO_2 and 24-hour mean PM_{10} objectives.

7.35. However, the Beckton Reuse Indirect Option is not expected to have a significant impact on air quality in these regions, as construction and operational vehicle flows are unlikely to be above the screening threshold of 100 HDVs and/or 500 LDVs.

7.36. Further to this, exceedances of the NO_2 objectives are unlikely to occur in suburban and urban background locations, where the Indicative Intake Location, Indicative Raw Water Pumping Station Site, Indicative WTW Site, Raw Water Transfer Main Route Corridor, the majority of the Drinking Water Transfer Main Route Corridor and the Drinking Water Transfer Main to North Mymms Route Corridor are located.

7.4.2 Particulate matter

7.37. Exceedances of the PM_{10} and $PM_{2.5}$ objectives are not expected to occur in any location.

7.4.3 Dust soiling and health effects

7.38. Table 7.6 provides a summary of the human health and ecological receptors within 350m of the components of the Beckton Reuse Indirect Option. These receptors could be impacted as a result of construction activities.

Table 7.6: Dust soiling and health effects – sensitive human health and ecological receptors within 350m of the Beckton Reuse Indirect Option components

Component	Human health receptors within 350m	Ecological receptors within 350m
Indicative Intake Location Indicative Raw Water Pumping Station Site	High sensitivity: Between 10 and 100 residential properties and two nurseries Medium sensitivity: Leisure centres Low sensitivity: industrial properties and farm buildings	One SSSI Two non-statutory designated nature conservation sites
Raw Water Transfer Main Route Corridor	High sensitivity: Over 100 residential properties and three nurseries Medium sensitivity: offices and public parks/gardens Low sensitivity: industrial properties	One area of ancient woodland One SSSI Four non-statutory designated nature conservation sites
Indicative WTW Site	High sensitivity: Over 100 residential properties Medium sensitivity: offices and public parks/gardens Low sensitivity: industrial properties	One area of ancient woodland Two non-statutory designated nature conservation sites

Component	Human health receptors within 350m	Ecological receptors within 350m
Drinking Water Transfer Main Route Corridor	High sensitivity: Over 100 residential properties, between 10 and 100 education facilities, less than 10 places of worship and less than 10 medical facilities. Medium sensitivity: offices, leisure centres, allotments, public parks/gardens, play spaces and golf courses. Low sensitivity: playing fields, industrial properties and farm buildings.	Four areas of ancient woodland Two SSSIs One LNR One NNR One SAC 17 non-statutory designated nature conservation sites
Brookmans Park Service Reservoir Connection	High sensitivity: between 10 and 100 residential properties Medium sensitivity: offices Low sensitivity: industrial properties	None
Drinking Water Transfer Main to North Mymms Route Corridor	High sensitivity: Over 100 residential properties, two schools, a university, place of worship and a general practice surgery/clinic Medium sensitivity: offices, leisure centres and a golf course Low sensitivity: industrial properties, farm buildings and a playing field	Two areas of ancient woodland One SSSI Eight non-statutory designated nature conservation sites
North Mymms Booster Station Connection	High sensitivity: between 10 and 100 residential properties Medium sensitivity: offices Low sensitivity: industrial properties	One area of ancient woodland One SSSI Two non-statutory designated nature conservation sites

7.5 Recommended mitigation

7.39. The following generic mitigation measures should be implemented for the Beckton Reuse Indirect Option, as a minimum, to reduce adverse impacts on air quality associated with construction dust. These mitigation measures are based on highly recommended measures for low-risk sites in the IAQM guidance[53]. More stringent mitigation measures may be proposed at a subsequent project stage once a more detailed air quality assessment has been undertaken:

- Communication and site management
  - Display the name and contact details of person(s) accountable for air quality and dust issues on the site boundary.
  - Display the head or regional office contact information.
  - Record all dust and air quality complaints, identify causes and take appropriate measures to reduce emissions in a timely manner and record the measures taken.
  - Make a complaint log available to the planning authority, when requested.
  - Record any exceptional incidents that cause dust and or air emissions, either on or off site, and the action taken to resolve the situation in the log book.
- Monitoring
  - Carry out regular site inspections, record inspection results and make an inspection log available to the planning authority, when requested.
  - Increase the frequency of site inspections by the person accountable for air quality and dust issues on site when activities with a high potential to produce dust are being carried out and during prolonged dry or windy conditions.
- Preparing and maintaining the site
  - Plan site layout so that machinery and dust causing activities are located away from receptors as far as possible.
  - Erect solid screens or barriers around dusty activities or the construction site boundary that are at least as high as any stockpiles.
  - Avoid site runoff of water or mud.
  - Ensure all vehicles switch off engines when stationary – no idling vehicles.
  - Avoid the use of diesel- or petrol-powered generators and use mains electricity or battery powered equipment, where practicable.
- Operations
  - Only use cutting, grinding or sawing equipment fitted or in conjunction with suitable dust suppression techniques such as water sprays or local extraction.

- Ensure an adequate water supply on the site for effective dust/ particulate matter suppression/ mitigation using non-potable water, where possible and appropriate.
- Use enclosed chutes and conveyors and covered skips.
- Minimise drop heights from conveyors, loading shovels, hoppers and other loading or handling equipment and use fine water sprays on such equipment wherever available.
- No bonfires and burning of waste materials.

7.40. As discussed in Section 7.2.3, the impacts associated with standby generators have not been assessed at this stage, in part because it has been assumed that the impact on air quality would be mitigated within their design. Specifically, it is assumed that the generators would be designed to optimise dispersion of pollutants. For example, the generators should be designed with a sufficient stack height and should not have rain caps or cowls attached, which could impede the exhaust flow.

7.6 Summary of main findings and recommendations for future technical work

7.41. All of the Beckton Reuse Indirect Option components except the Drinking Water Transfer Main Route Corridor are located outside an AQMA. There are no CAZs in the vicinity. However, it should be noted that there are proposals for the Ultra Low Emission Zone in London to cover the whole of Greater London from August 2023, which includes the London Borough of Enfield.

7.42. The assessment indicates that the NO_2, PM_{10} and $PM_{2.5}$ objectives may be exceeded in regions of the Drinking Water Transfer Main Route Corridor that are located close to the roadside within Enfield AQMA, which was declared for exceedances of the annual mean NO_2 and 24-hour mean PM_{10} objectives. Exceedances of the objectives are unlikely to occur in suburban and urban background locations, where the Indicative Intake Location, Indicative Raw Water Pumping Station Site, Indicative WTW Site, Raw Water Transfer Main Route Corridor, Drinking Water Transfer Main to North Mymms Route Corridor pipeline and majority of the Drinking Water Transfer Main Route Corridor are located.

7.43. There are sensitive human and ecological receptors within 350m of the Beckton Reuse Indirect Option, which could be impacted as a result of construction activities. Therefore, a number of construction dust mitigation measures have been recommended in accordance with the IAQM guidance[53]. A dust risk assessment should be undertaken at a subsequent project stage, once more information is available to determine the construction dust risk at these sensitive receptors, and whether additional construction dust mitigation is required.

7.44. The air quality impacts associated with vehicle traffic during the construction phase and the impacts from the standby generators should also be assessed once further details of these activities are available. If significant effects are predicted as result of these activities, additional mitigation may be required.

7.45. The impacts on air quality associated with vehicles during operation are not anticipated to be significant as, based on current information, the Beckton Reuse Indirect Option would generate an additional annual average flow of one to three HDVs per day throughout its operation, which is well below the EPUK/IAQM screening threshold of 25 HDVs per day on average each year.

7.46. The impacts associated with standby generators during operation have not been assessed, in part because it has been assumed that the impact on air quality would be mitigated within their design. Specifically, it is assumed that the generators would be designed to optimise dispersion of pollutants. For example, the generators should be designed with a sufficient stack height and should not have rain caps or cowls attached, which could impede the exhaust flow.

8 Climatic factors

8.1 Introduction

8.1. This chapter presents a desk based assessment undertaken to identify potential climatic risks from the construction and operation of the transfer corridors and above ground infrastructure including the WTW.

8.2. The need to consider climatic factors is driven by legislation (Paris Agreement 2015 and Climate Change Act 2008), Government policy (National Adaptation Programme[59]) and national planning policy (draft NPS for Water Resource Infrastructure[18] (Section 3.7, Climate change adaptation) and NPPF (Section 14, Meeting the challenge of climate change, flooding and coastal change[19]).

8.3. Technical Supporting Document A3b, Carbon Strategy Report, should be referred to for estimated capital and operational carbon impacts, whole life carbon emissions and carbon mitigation strategies. A summary is provided in in Section 8.3 of this chapter.

8.2 Climate change risk assessment

8.2.1 Methodology

8.4. The project is anticipated to be operational from 2039 and the WRSE Regional Plan considers a design life to 2100, so therefore the assessment presents projections for the end of the century, covering the period 2080-2099. The climate change risk assessment presented in this chapter is intended to be a high-level screening exercise which assesses the main risks to the scheme assets based on climate projections for a time horizon of 2080-2099. The hazards included in this stage of assessment include; high temperatures, low temperatures, high rainfall, flooding and drought. Hazards such as extreme events (snowfall) have not been considered at this screening stage. Further assessment should be completed at subsequent project stages to include a full range of hazards.

[59] Defra (2018) The National Adaptation Programme and the Third Strategy for Climate Adaptation Reporting: Making the country resilient to a changing climate. Available at: https://www.gov.uk/government/publications/climate-change-second-national-adaptation-programme-2018-to-2023 [Accessed April 2022]

8.5. The construction phase has not been fully assessed as the construction methods are unknown at this stage. A high-level overview of construction impacts has been provided in Section 8.2.3. Further climate related impacts on construction due to extreme weather events should be considered and addressed by measures in the CEMP at a subsequent project stage.

8.2.1.1 Study area and sources of information

8.6. The climate change risk assessment focused on the area surrounding the route transfer corridors and associated infrastructure including the WTW. Current climate data describes the wider region surrounding the Beckton Reuse Indirect Option and future climate identifies changes to the climate.

8.7. Table 8.1 outlines the baseline data sources collated and considered.

Table 8.1: Sources of information (climatic factors)

Data collected	Source
Current climate conditions	Met Office UKCP18 Land Observations (Regional) Met Office Regional Climates UK[60]
Future climate projections (temperature and precipitation)	Met Office UKCP18 Probabilistic Projections (Regional) Met Office UKCP18 Global Projections (Regional) (applicable to wind speed only)
Flood risk maps	Environment Agency Flood Risk Maps (see Chapter 6)

8.2.1.2 Approach to impact appraisal

8.8. A qualitative approach was taken to appraise the Beckton Reuse Indirect Option and identify where there is potential for physical climate risks to affect the scheme. This included consideration of future climate conditions in the area surrounding the scheme up to the end of the century based on operation starting in 2034 and a design horizon to 2100 as planned for in the WRSE Regional Plan.

[60] Met Office Regional Climates UK, Eastern England. Available at: https://www.metoffice.gov.uk/binaries/content/assets/metofficegovuk/pdf/weather/learn-about/uk-past-events/regional-climates/eastern-england_-climate---met-office.pdf [Accessed April 2022]

8.9. Potential climate risks relevant to the Beckton Reuse Indirect Option were identified and the likelihood and severity of each climate risk scored. The combination of likelihood and severity provides a risk rating for each climate impact (risk = likelihood x severity). Where the risk rating is greater than 5, mitigation measures are identified to reduce the risk, and the residual likelihood and severity of the climate risk is re-rated after mitigation to ensure the residual risk is at an acceptable level. The method is based on the Environment Agency Climate Change Risk Assessments (CCRAs)[61] for permitting purposes and has been used for similar schemes. This is a sound approach for conducting a high level physical climate change risk assessment and is good practice.

8.10. The scoring criteria for severity and likelihood of impact are below:

- Severity of impact:
  - Severe risk: short-term, acute risk to operations resulting in permanent compliance breach(es).
  - Medium risk: short-term, acute risk to operations resulting in multiple temporary compliance breaches.
  - Mild risk: short-term, acute risk to operations resulting in single temporary compliance breach.
  - Minor risk: short or long-term risk resulting in additional measures for compliance.
- Likelihood of impact:
  - Highly likely: event appears very likely in the short term and almost inevitable over the long term, or there is evidence of the event already happening.
  - Likely: it is probable that an event will occur, or circumstances are such that the event is not inevitable, but possible in the short term and likely over the long term.
  - Low likelihood: circumstances are such that an event could occur, but it is not certain even in the long term that an event would occur, and it is less likely in the short term.
  - Unlikely: circumstances are such that it is improbable the event would occur even in the long term.

Table 8.2: Climate risk score calculation

	Severe risk (Score= 4)	Medium risk (Score = 3)	Mild risk (Score = 2)	Minor risk (Score = 1)
Highly Likely (Score = 4)	16	12	8	4

[61] Environment Agency Climate Change Risk Assessment: https://www.gov.uk/guidance/adapting-to-climate-change-risk-assessment-for-your-environmental-permit [Accessed April 2022]

	Severe risk (Score= 4)	Medium risk (Score = 3)	Mild risk (Score = 2)	Minor risk (Score = 1)
Likely (Score = 3)	12	9	6	3
Low Likelihood (score = 2)	8	6	4	2
Unlikely (Score = 1)	4	3	2	1

8.11. The risk categories are as follows:

- 12 to 16: high
- 8 to 9: moderate to high
- 4 to 6: moderate to low
- 1 to 3: low

8.2.1.3 Assumptions and limitations

8.12. The baseline for the future climate relies on the outputs from climate models, referred to as projections and obtained from a third-party source (the UK Met Office). Climate projections are not predictions or forecasts but projections of future climate under a range of hypothetical emissions scenarios and assumptions. The results, therefore, from the experiments performed by climate models cannot be Drinking as exact or factual, rather they are projections. Projections exclude outlying 'surprise' or 'disaster' scenarios in the literature and any scenario necessarily includes subjective elements. Generally, there is a higher level of confidence in temperature projections than those for precipitation and other variables and the degree of uncertainty associated with all climate change projections increases for projections further into the future. The climate change risk assessment would need to be updated periodically throughout the project lifecycle to ensure that all data is valid and the most up to date version.

8.13. The assessment is based on an operational design horizon to 2100, which is common across the WRSE Regional Plan. This may not be the same as the operational life of the specific assets that will be constructed and appraised in other parts of the Gate 2 feasibility work. However, the period to 2100 is considered appropriate for the assessment of climatic factors relevant to the scheme.

8.14. Cumulative assessment of climate change impacts is not covered at this stage. The assessment focuses on identifying and screening the high level physical climate risks to the main assets of the scheme. Further assessment will be carried out at subsequent project stages, including in-combination impacts of climate change with other topics.

8.2.2 Understanding of the baseline

8.2.2.1 Current climate

8.15. The majority of the route corridor is located within the Met Office eastern region of England, with a section located in the southern (London) region. The eastern region has been selected for the assessment, as the majority of the scheme is located in this region and the temperatures are similar to the southern (London) region. This region is subject to continental weather influences that bring cold spells in winter and hot, humid weather in summer. High level climate observations[60] for this region over a 30-year period between 1981-2010 are presented in Table 8.3.

Table 8.3: Observed climate conditions

Climate variables	Climate observations
Temperature	Mean annual temperatures in the region vary between 9.5°C and 10.5°C. Extreme minimum temperatures typically occur in December or January. January is the coldest month with mean daily minimum temperature close to 1°C. July is the warmest month with mean daily temperature of between 20°C and 23°C across the region. Extreme maximum temperatures typically occur in July or August and are usually associated with heat waves lasting several days.

Climate variables	Climate observations
Rainfall	There is a much more even distribution of rainfall throughout the year than in most other parts of the UK. This is mainly due to a combination of the 'rain-shadow' effect for winter Atlantic depressions produced by the high ground to the west and a higher frequency of convective rainfall in summer. Across most of the region there are, on average, about 30 rain days (rainfall greater than 1 mm) in winter (December to February) and less than 25 days in summer (June to August). Although rainfall is generally low, there have been some noteworthy severe storms. The number of thunderstorms in a year can make a significant contribution to the total annual rainfall. They can occur at any time of year but are more frequent during the summer months. Over East Anglia, Lincolnshire and Humberside the average number of days of thunder per year is about 15 although there is considerable variability from year to year. For example, Cambridge recorded 2 days of thunder in 1997, 7 in 1998 and 22 in 1999. The region can be subject to dry periods that place demands on water supplies and require conservation measures.
Wind	Eastern England is one of the more sheltered parts of the UK, since the windiest areas are to the north and west, closer to the track of Atlantic storms. The strongest winds are associated with the passage of deep depressions across or close to the UK. The frequency of depressions is greatest during the winter months so this is when the strongest winds normally occur. Much of East Anglia and Lincolnshire has no more than 2 days of gale each year, but exposed coasts average about 5 gales each year. The strongest gust recorded in Eastern England was 87 knots at Shoeburyness (Landwick) in Essex. Eastern England has the greatest frequency of tornadoes in the UK. It will typically last for a few minutes, track across the land for 2 to 5 km and have a diameter of 20 to 100 metres. On average, 33 tornados are reported each year in the UK although the number can vary significantly from year to year. Coastal areas experience sea breezes from late spring through the summer and will often reach London.
Sunshine	On average, December is the month with the least sunshine and July is the sunniest. Compared to coastal resorts in SW England, the Norfolk coast has about 10% less sunshine hours throughout the year. Low cloud from the North Sea can affect the coast especially in spring and summer. Across the region, annual averages range from about 1450 hours over much of Lincolnshire and East Yorkshire to over 1600 hours in east Norfolk, Suffolk and Essex.
Snowfall	The average number of days with snow falling each year ranges from under 20 in the south-east of the area to over 30 on higher ground. The average number of days with snow lying is less, varying from about 6 to 15.

8.16. Table 8.4 shows the observed climate baseline for the eastern region for 1981-2000. These are determined using the observations from the Met Office UKCP18 database at a regional level. Summer is defined as the months of June, July and August. Winter is defined as the months of December, January and February.

Table 8.4: Observed climate baseline

Climate variables	Baseline (1981-2000)
Mean annual temperature (°C)	9.9
Mean summer temperature (°C)	16.1
Maximum summer temperature (°C)	21.1
Mean winter temperature (°C)	4.2
Minimum winter temperature (°C)	1.3
Mean summer precipitation (mm/summer month)	50.7
Mean winter precipitation (mm/winter month)	47.9
Mean annual wind speed (m/s)	4.3

8.17. The Environment Agency flood maps (see Chapter 6, Water) were used to determine the extent of current flooding. The Drinking Water Transfer Main Route Corridor and Drinking Water Transfer Main to North Mymms Route Corridor pass through areas of existing Flood Zone 2 and 3, including at the River Lee crossing, Turkey Brook crossing, Cuffley Brook crossing and Ray Brook crossing. The Raw Water Transfer Main Route Corridor and Indicative WTW Site is within Flood Zone 1, and the Indicative Intake Location and Indicative Raw Water Pumping Station sit within Flood Zone 2 and 3 (see Section 6.4.2).

8.18. Historic weather events that have occurred in the region include:

- Drought in 2010-2012 in eastern England resulting in difficult farming conditions, low river and groundwater levels and fires.
- Snow and low temperatures in February 2018 resulting in travel disruption and power cuts.
- Eight named storms over the 2018/2019 winter bringing high winds and heavy rainfall, resulting in travel disruption, flooding and power cuts.
- Heatwave in August 2020 with temperatures reaching 34˚C, resulting in fires, heat-related health issues, and thunderstorms.

- Storm Eunice in February 2022 resulting in damages to buildings, fallen trees and flooding.
- Heatwave in July 2022 with temperatures reaching 39.9°C, resulting in heat-related health issues, fires, and travel disruption.
- Drought in July/August 2022 resulting in difficult farming conditions, low river and groundwater levels, untreated sewer discharges to water bodies, and fires.

8.2.2.2 Climate projections

8.19. The UKCP18 probabilistic projection dataset[62] developed by the Met Office Hadley Centre has been used to obtain future climate projections for eastern England. A baseline period of 1981-2000 has been used and the RCP8.5[63] emission scenario has been selected based on a precautionary approach. Three probabilities of change have been selected to show the ranges of outcomes; low, central and high change corresponding to 10th percentile, 50th percentile and 90th percentile, respectively.

8.20. The project is anticipated to be operational from 2039 and the WRSE Regional Plan considers a design life to 2100, so therefore the assessment presents projections to the end of the century, covering the period 2080-2099. Climate projections for east England are presented in Table 8.5.

[62] The UKCP18 product selected for use in this assessment is the probabilistic projections. Probabilistic projections present a range of values for climate variables, based on the output of multiple runs of multiple climate models. Met Office, UKCP18 Guidance: How to use the UKCP18 land projections. Available at: https://www.metoffice.gov.uk/binaries/content/assets/metofficegovuk/pdf/research/ukcp/ukcp18-guidance---how-to-use-the-land-projections.pdf. [Accessed April 2022]

[63] Representative Concentration Pathways (RCP8.5) are a method for capturing the assumptions about the economic, social and physical changes within a set of scenarios. Different pathways result in a different range of global mean temperature increases over the 21st century. Met Office, UKCP18 Guidance: Representative Concentration Pathways. Available at: https://www.metoffice.gov.uk/binaries/content/assets/metofficegovuk/pdf/research/ukcp/ukcp18-guidance---representative-concentration-pathways.pdf. [Accessed April 2022]

Table 8.5: Climate projections

Climate variables	Baseline (1981-2000)	Projected change 10th % 2080-2099 (RCP8.5)	Total projected (RCP8.5)	Projected change 50th % 2080-2099 (RCP8.5)	Total projected (RCP8.5)	Projected change 90th % 2080-2099 (RCP8.5)	Total projected (RCP8.5)
Mean annual temperature (ºC)	9.9	+2	11.9	+4.1	14.0	+6.2	16.1
Mean summer temperature (ºC)	16.1	+2.7	18.8	+5.3	21.4	+7.9	24
Maximum summer temperature (ºC)	21.1	+2.7	23.8	+5.9	27	+9.3	30.4
Mean winter temperature (ºC)	4.2	+1.5	5.7	+3.6	7.8	+5.8	10
Minimum winter temperature (ºC)	1.3	+1.4	2.7	+3.6	4.9	+6.3	7.6
Mean summer precipitation (mm/summer month)	50.7	-72%	14.2	-37%	31.9	-1%	50.2
Mean winter precipitation (mm/winter month)	47.9	-1%	47.4	+22%	58.4	+50%	71.9

Climate variables	Baseline (1981-2000)	Projected change 2080-2099 (RCP8.5)[64]	Total projected (RCP8.5)
Mean annual wind speed (m/s)	4.3	-0.26	4.04

8.21. The UKCP18 projections indicate that in the period 2080-2099, temperatures in eastern England are projected to increase across the year. Precipitation is projected to vary seasonally, with an increase in winter and decrease in summer. Although summers are projected to become drier overall, more intense rainfall events are anticipated. Although winters are projected to become warmer overall, extreme low temperature events are anticipated to still occur. These projections are generally aligned to those identified across the UK where summers are projected to be hotter and drier, and winters wetter and warmer.

8.2.3 Appraisal outcomes

8.22. Appendix C presents the results of the risk assessment for a range of physical climate risks for the Beckton Reuse Indirect Option. A summary of the highest scoring risks is provided below.

8.23. Impacts of higher summer temperatures include the potential that pipe / cabling material would be exposed to increased solar radiation (UV) and may deteriorate at a faster rate, cracking, strength loss and more rapid deterioration of concrete due to high temperatures. Additionally, there is the potential for pipejack / microtunnels crossings made from concrete to face cracking, strength loss and rapid deterioration due to high temperatures. As well as this, there is the potential that chemical and mechanical processes/equipment may exceed their operational temperature limit resulting in shut down and brake pressure tank capacity not able to cope with increased demand in the future due to increases in temperature.

[64] Wind speed projections are only accessed at the global projections (regional) dataset up to 2100 (cannot be accessed using the probabilistic projections). There are no percentage probabilities with this dataset, and so is presented in a separate table to the rest of the climate variables. Met Office, UKCP18 Factsheet: Wind. Available at: https://www.metoffice.gov.uk/binaries/content/assets/metofficegovuk/pdf/research/ukcp/ukcp18-fact-sheet-wind_march21.pdf [Accessed April 2022]

8.24. Impacts of extreme low-temperature events include the potential that pipe and cabling material would be exposed to air frost and extreme cold temperatures/ice leading to deterioration of materials.

8.25. Higher annual and winter rainfall and more extreme rainfall events throughout the year may impact the Beckton Reuse Indirect Option as high rainfall levels can cause swelling of the ground surrounding the pipe and lead to instability, risk of corrosion of pipe and cable materials. The Indicative Intake Location and Indicative Raw Water Pumping Station Site, and the parts of the Drinking Water Transfer Main Route Corridor are within areas of existing Flood Zone 2 and 3. The Drinking Water Transfer Main Route Corridor and Drinking Water Transfer Main to North Mymms Route Corridor passes through Flood Zone 2 and 3 in the River Lee crossing, Turkey Brook crossing, Cuffley Brook crossing and Ray Brook crossing. Flood risk in this area is likely to be exacerbated with higher winter rainfall and more extreme rainfall events throughout the year and may cause ground instability and issues with access to the pipes. Flood water may seep into the pipe and contaminate supply, however this is low risk as it is a buried pipe. It is also possible that flooding events could raise river levels and damage the pipe jack/micro tunnelling if there is not enough clearance.

8.26. Drier summers can impact soil, drought may have an impact on the stability/properties. There is a risk of ground cracking/shrinkage due to drought and can cause instability issues. Shrinkage and desiccation of ground leading to cracks, strength loss and instability, which may affect the foundations of the pipejack / microtunnel crossings and the Indicative WTW Site. If there is a drought, site operations at the Indicative WTW Site may be affected as the site uses potable water.

8.27. The construction phase of the scheme will be impacted by climate change and as such consideration of the impacts and mitigations are to be included in the CEMP. As the construction methods are unknown at this stage, it is not possible to provide a detailed assessment of impacts and mitigations. A high-level list of potential construction impacts and mitigations for all assets in the scheme (pipeline, WTW works, and raw water pumping station) are provided in Table 8.6.

Table 8.6: Potential construction impacts and mitigation measures

Potential impact	Potential mitigation measures
Flooding and heavy rain	
Programme delays due to increased frequency of site shutdowns	Contractor to be on Flood Watch at all times and to have a Flood Response Plan prepared for the construction phase Contingency plans for situations where flooding leads to restricted site access or key staff being unable to get to work, leading to construction delays.

Potential impact	Potential mitigation measures
Damage to equipment (plant, power generators, site cabins) and construction	Contingency plans for situations where storms, high winds or flooding lead to loss of mains power supply or communications, and the identification of safety critical and construction programme consequences.
Dangerous working conditions for staff (ground instability)	Workforce health and safety plans and welfare management systems to be put in place by the contractor, including details to be outlined within works plans and task briefs as appropriate. These should consider flooding which may lead to injury to construction staff due to slips and falls, especially for construction staff working in exposed locations at a distance from welfare facilities.
Site surface run-off (pollutants) contaminating rivers and groundwater	Procedures and precautions to be implemented in case of flooding, including temporary demobilisation plans. These procedures should consider prolonged and intense rainfall events that may lead to staff safety risks or pollution risks where construction materials (e.g. dust, contaminants, metals, or oils) have potential to runoff into watercourses. This should consider likely surface water runoff routes and plans for the protection of plant such as fuel storage and materials stockpiles or demobilisation of vehicles and items of mobile plant.
Additional costs to repair damages following flooding/heavy rainfall	Procedures and precautions to be implemented in case of flooding, including temporary demobilisation plans. Ensuring that all plant is stored in an area of site that is less susceptible to flooding to limit the equipment damage. Utilise sand bags on site and temporary flood prevention.
Wet conditions causing issues with earthworks and compaction methods	Flooding and high rainfall will affect the earthworks. Ensure that procedures are in place to demobilise construction vehicles. Use trenchless technology where possible to install the pipeline to minimise the impacts of a flood/heavy rainfall on the construction. This will also limit the impact of the scheme on the flood risk in the area.
Heatwaves and drought	
Dry conditions causing issues with earthworks and compaction methods	Hot temperatures and drought causes the soil moisture content of the soil to decrease, leading to issues with earthworks and compaction. Ensure that bowsers are on site to enable compaction works to continue.
Lack of potable water on site due to increase in demand	Prepare contingency plans for water shortages to ensure that a supply of water is available.

Potential impact	Potential mitigation measures
Dangerous working conditions for staff (heat-related injuries)	Workforce health and safety plans and welfare management systems to be put in place by the contractor, including details to be outlined within works plans and task briefs as appropriate. These should consider high temperatures, which may lead to risks of heatstroke, especially for construction staff working in exposed locations at a distance from welfare facilities.
Operating temperatures of construction equipment exceeded (plant, power generators)	Ensure cooling procedures are in place and utilised to enable continued operation of machinery (coolant, air circulation, shade).
Extreme weather (storms, wind, ice)	
Additional costs to repair damages following storms/wind	Procedures and precautions to be implemented in case of extreme weather, including temporary demobilisation plans. Ensuring that all plant is stored in an area of site that is less susceptible to wind to limit the equipment damage.
Site equipment (plant, power generators) freezing	Contingency plans for situations where freezing temperatures including battery warmers and oil heaters.
Icy/snow conditions causing issues with earthworks and compaction methods	Icy and snowy conditions will affect the earthworks. Ensure that procedures are in place to demobilise construction vehicles.
Programme delays due to increased frequency of site shutdowns	Contingency plans for situations where extreme weather leads to restricted site access or key staff being unable to get to work, leading to construction delays.
Dangerous working conditions for staff (risk of airborne debris)	Workforce health and safety plans and welfare management systems to be put in place by the contractor, including details to be outlined within works plans and task briefs as appropriate. These should consider both low temperatures, snow and ice which may lead to injury to construction staff due to slips and falls, especially for construction staff working in exposed locations at a distance from welfare facilities.

8.2.4 Recommended mitigation

8.28. It is recommended that the risks identified above are mitigated by considering the changes in climate in the designs of the pipeline and assets at a subsequent project stage. This includes planning for a higher range of thermal variation, increased flood risk and ground movement.

8.29. Design related mitigation measures could be implemented to reduce the impact of the Beckton Reuse Indirect Option on the climate including the following.

- Structural elements to be designed to include thermal expansion and greater thermal variation specification to account for climate change.
- Pipe design and choice of materials to consider temperature variation.
- Materials selection and specification to consider future temperatures. Monitor and adjust the curing process of the concrete accordingly in order to minimise the risk of high temperatures on the deterioration rate of the structure.
- Include greater thermal variation in design and specification of equipment to account for the extremes in temperature. Consider alternative treatment methods.
- Consider nature based solutions to provide shade and reduce temperature.
- Locate pipeline access points in areas where there is low risk of flooding. Ensure pipe design and cover is enough to withstand seepage from flooding into the pipes.
- Ensure that ground movements are monitored and repaired when necessary to avoid further damage. Consider the changes in soil moisture in the pipe bedding material specification.
- Additional protective measures to be implemented to ensure that the pipes and cabling are sufficiently protected to reduce the corrosion rates. Selection of materials to consider future rainfall regime.
- Ensure that drainage capacity is designed to limit the flooding at the structure and account for future increased rainfall. Ensure that the foundations are not susceptible to seepage due to poor drainage.
- Ensure that design takes into consideration the raised river levels during flood events.
- Consider increasing the stormwater storage capacity and retention period in future to cope with extreme rainfall events if necessary.
- Temporary flood protection e.g. demountable barriers. Consider need for permanent flood walls around the site. Monitor changes to local river levels.

8.3 Carbon footprinting assessment

8.30. Technical Supporting Document A3b, Carbon Strategy Report, should be referred to for estimated capital and operational carbon impacts, whole life carbon emissions and carbon mitigation strategies. A summary is provided in this section.

8.3.1 Methodology

8.31. Technical Supporting Document A3b, Carbon Strategy Report set out the methodology for the carbon assessment undertaken for Gate 2. In summary, PAS 2080 principles were used in the approach to carbon management, which included understanding the baseline carbon impact of the scheme through quantifying its carbon impact, using a quantified assessment to establish carbon hotspots and then prioritising design mitigation efforts at the carbon hotspot areas.

8.32. Efforts have been prioritised to reduce emissions rather than focus on an emissions mitigation plan. It is acknowledged that a significant proportion of emissions in construction and operation are considered Scope 3 emissions and outside of the direct control of the companies and designers delivering the Beckton Reuse Indirect Option. However, it is also acknowledged that there is a significant opportunity to work with the supply chain prior to the delivery of the scheme to support accelerated decarbonisation of external systems and supply chains to help reduce the carbon impact of the scheme. The IEMA emissions reduction hierarchy [65] has been followed to identify opportunities to mitigate carbon impacts of the scheme. This aligns well with the carbon reduction hierarchy from PAS2080 and helps focus efforts on reducing emissions rather than offsetting them.

8.33. The carbon mitigation strategy has focussed efforts during Gate 2 on areas where the largest and most efficient reductions can be made. This has been informed through updating the baseline quantification with the latest design information for the scheme to identify the key capital and operational carbon hotspots for the scheme.

8.34. The mitigation efforts have been split into two areas:

- Opportunities directly under the control of the design team, including areas which can reduce emissions through design decisions that can be embedded and costed into the scheme.

[65] Institute of Environmental Management and Assessment (2020) Pathways to Net Zero: Using the IEMA GHG Management Hierarchy. Available at: https://www.iema.net/resources/reading-room/2020/11/26/pathways-to-net-zero-using-the-iema-ghg-management-hierarchy-november-2020 [Accessed August 2022]

- Longer term opportunities where the scheme and sector can influence external systems and supply chains to decarbonise major components of the scheme – these longer-term mitigation opportunities have been covered by a collaborative project commissioned by the All Company Working Group (ACWG) which has identified a consistent view across SROs how these external systems may decarbonise in the future to inform future decarbonisation potential and engagement priorities for individual SROs.

8.35. An assessment of carbon contributions and opportunities for net zero was undertaken at Gate 1, which resulted in identifying the options with the highest carbon footprints. For RAPID Gate 2, the following have been undertaken:

- Develop overall evidence-based carbon reduction strategy, that will continue to update assessments and challenge hotspots at later Gate stages
- Carbon design challenge workshops
- Identification of carbon mitigation measures to embed into current design
- Develop carbon mitigation plan for subsequent project stages

8.3.2 Appraisal outcomes

8.36. Whole life carbon emissions were assessed over 80 years, to include a 6-year planning and development period followed by a 5-year construction period ending in 2033. Operational carbon and capital carbon replacement emissions are assumed to start after the 5-year construction period. Table 8.7 summarises the estimated whole life carbon impacts of the Beckton Reuse Indirect Option.

8.37. Full details of the carbon values are reported in Technical Supporting Document A3b, Carbon Strategy Report.

Table 8.7: Summary of the whole life carbon emissions for the Beckton Reuse Indirect Option

	50Ml/d	% of total emissions*	100Ml/d	% of total emissions*
Capital (tCO2e)	45,700	56%	65,000	39%
Capital replacements (tCO2e)	25,500	31%	38,200	23%
Operational power (tCO2e)	9,700	12%	57,100	38%
Operational chemicals (tCO2e)	160	0.2%	340	0.2%

	50Ml/d	% of total emissions*	100Ml/d	% of total emissions*
Land use change (tCO2e)	860	1%	860	0.5%
Total (tCO2e)	81,920		161,500	

* Columns do not add up to 100% due to rounding of values

8.38. The majority of the capital carbon sits within the construction associated with the transfer pipelines and WTW. The capital carbon emissions associated with pipeline construction result predominantly from the embodied carbon (Scope 3) of the pipe material itself, with backfill/reinstatement (Scope 3) being the next hotspot followed by the emissions from excavation (Scope 1 for the contractor), all contributing less than 20% of emissions. The capital carbon emissions for the WTW were driven by aspects of the treatment process that comprise of predominantly civil components such as potable water storage, and tanks for processes like UV treatment and filtration. These assets are dominated by concrete and steel reinforcement in the structures, at this stage the embodied carbon of these materials (Scope 3) has been estimated based on typical UK concrete mixes and standard reinforcement quantities. Power consumption for pumping is the significant contributor to operational emissions.

8.39. Full details of the carbon hotspots are reported in Technical Supporting Document A3b, Carbon Strategy Report.

8.3.3 Recommended mitigation

8.40. Capital and operational carbon mitigation strategies are presented in Technical Supporting Document A3b, Carbon Strategy Report, and a summary is provided below.

8.3.3.1 Capital carbon mitigation opportunities

8.41. The Beckton Reuse Indirect Option has varying opportunities for carbon reduction in the design of the scheme, which are outlined below together with the relevant stage in the IEMA carbon reduction hierarchy.

- [Substitute] Material selection: This accounts for around half of capital emissions. Ductile Iron (DI) has a relatively high carbon intensity per metre unit

length of pipe material compared to steel and composite pipes, such as glass fibre reinforced plastic (GRP). This should be explored at subsequent project stages.

- [Reduce] Water treatment works: Although overall land requirement of the WTW has increased, where possible, processes have been optimised from Gate 1 to reduce the land footprint, such as use of lamella clarifiers from dissolved air flotation. However there is opportunity to optimise the design of chosen construction material to reduce use of high carbon materials such as concrete or allow for lower carbon materials at subsequent project stages.
- [Reduce] Pipe size (diameter): The pipeline diameter has been optimised and selected on 100% utilisation at 100% capacity. There is the opportunity for further review at subsequent project stages, which could result in a smaller diameter pipe leading to capital carbon savings through both material (embodied) and installation savings.
- [Reduce] Infrastructure crossings: The number of open cut crossings has been minimised predominantly to reduce disruption to the traffic network and the riverine environment. Major crossings would be trenchless (micro-tunnelling) with shafts at either end of the crossing. Based on current information, there are deemed to be no feasible alternative installation methods. However, consideration could be given at subsequent project stages to not installing dual tunnels at every trenchless crossing.
- [Substitute] Backfill and reinstatement: Where possible, use of as-dug material would be used for backfilling. To not overstate the carbon savings, the Gate 2 carbon assessment has assumed imported backfill for the pipe surround and as-dug material for the remaining trench, except where traversing through contaminated ground (where all backfill is assumed to be imported). Once further detail is known at subsequent project stages, an updated assessment of the imported material required for the pipeline should be made and could potentially lead to carbon savings.
- [Substitute] Electricity supply provision: At Gate 2, pumping stations have been designed to have dual supply. There is the opportunity to optimise this to single supply for the high and low-lift pump stations. This could be explored at a subsequent project stage where discussions need to account for the risk to the operation of the scheme and the balance of carbon emissions associated with bringing standby generators.
- [Reduce] Waste minimisation: Adopting construction techniques, e.g. modular or off-site manufacture options could help reduce the amount of waste associated with construction projects, whilst potentially reducing carbon emissions, improving health and safety and overall operational performance of assets. Having a robust waste management plan and engaging other potential users of surplus excavations could help reduce emissions associated with waste disposal.

8.42. The route of the Beckton Reuse Indirect Option pipeline is deemed to be the shortest practicable and is unlikely to change significantly in subsequent project stages.

8.3.3.2 Operational carbon mitigation opportunities

8.43. Operational carbon mitigation will largely depend on procurement partners and supply chain. As with the capital carbon, hotspot analysis was conducted at Gate 1 based on various assumptions.

8.44. Reducing operational carbon will be based on the following hotspot mitigation areas.

- Sweetening flow scenario: Testing low flow scenarios to allow for a reduction in minimum flow could offer carbon savings through reduction in chemical and energy requirements. However, any reduction in the minimum flow to supply provided by the Beckton Reuse Indirect Option would need to be made up for by increasing the supply from other sources. The net reduction in operational carbon or the network, would therefore be less than the savings presented for the Beckton Reuse Indirect Option.
- Optimising energy efficiency and maintenance activities to prolong asset life/ performance: Capital replacements form a sizeable proportion of the carbon footprint, and therefore exploring materials and plants which last longer could provide carbon savings. For example, consideration could be given to utilising new LED UV lamps, which have a lower energy consumption and longer design lives.
- Low carbon power generation and decarbonised electricity procurement choices: Organisations can procure green electricity through their suppliers, which when market-based reporting can be used to zero out the power generation emissions of grid electricity. This requires the purchase of Renewable Energy Guarantees of Origin (REGO) certificates and comes at a premium over standard electricity tariffs in most cases.
- Renewable energy generation: There are opportunities to generate renewable energy through installation of solar panels and wind turbines across the Beckton Reuse Indirect Option. Areas considered to date have been:
  - Solar panels installed on the process units of the WTW provided the technology improves to reduce leakage issues with tank roofs as has been noticed in previous projects. Hence this relies on technology developments to enable the opportunity.
  - Wind turbines at the service reservoir in the vicinity of Brookmans Park since it is on elevated ground; however, this is not a prospect solely for T2AT and should explored with other stakeholders at subsequent project stages.

8.4 Summary of main findings and recommendations for future technical work

8.4.1 Climate change risk assessment

8.45. The main climatic risks are:

- Flood risk being exacerbated by climate change and negatively impacting the pipeline;
- Higher temperatures and drought, leading to desiccation of soil, loss of strength, ground movement and damage to the new WTW and Raw Water Pumping Station foundations and pipeline bedding;
- New WTW and Raw Water Pumping Station operational temperature limits being exceeded leading to shut downs.

8.46. It is recommended that these measures are mitigated by considering the changes in climate in the designs of the pipeline and assets. This includes planning for a higher range of thermal variation, increased flood risk and ground movement.

8.4.2 Carbon footprinting assessment

8.47. The Beckton Reuse Indirect Option would have both capital and operational carbon emissions. The majority of the capital carbon sits within the construction associated with the transfer pipelines and WTW. The capital carbon emissions associated with pipeline construction result predominantly from the embodied carbon of the pipe material itself, with backfill/reinstatement and excavation also contributing to emissions. The capital carbon emissions for the WTW were driven by aspects of the treatment process that comprise of predominantly civil components such as potable water storage, clarifiers and filtration. Power consumption for pumping is the significant contributor to operational emissions.

8.48. Capital carbon mitigation opportunities include material selection, optimising the design of the WTW to reduce use of high carbon materials, reducing pipe size diameter, consideration given to not installing dual tunnels at every trenchless crossing, reviewing backfill and reinstatement to reduce the amount of imported material required, consideration given to single rather than dual supply for pumping stations and waste minimisation, e.g. through use of modular or off-site manufacture options.

8.49. Operational carbon mitigation opportunities include reducing operational carbon at carbon hotspot areas such as optimising energy efficiency and maintenance activities to prolong asset life/ performance, low carbon power generation and decarbonised

electricity procurement choices and renewable energy generation.

9 Landscape

9.1 Introduction

9.1. This section presents a desk-based assessment undertaken to describe the landscape baseline for the Beckton Reuse Indirect Option based on published data. On the basis of the baseline, potential landscape impacts were identified for the transfer corridors and above ground infrastructure including the WTW. Potential impacts on protected trees were also considered.

9.2. The need to consider landscape and arboriculture is driven by national planning policy (draft NPS for Water Resource Infrastructure[18] (Section 4.9, Landscape and visual impacts) and NPPF (Section 15, Conserving and enhancing the natural environment, paragraphs 174 and 180[19]).

9.2 Methodology

9.2.1 Study area and sources of information

9.3. The landscape desk-based assessment focused on the transfer route corridors, location of associated infrastructure and the surrounding area within a maximum 1km distance of the Beckton Reuse Indirect Option. It is considered that 1km is sufficient for this stage as the desk based assessment focusses on landscape.

9.4. Protected trees were considered within 100m of the transfer route corridors and associated above ground infrastructure to identify potential design conflicts with arboricultural features.

9.5. The baseline data sources which were collated and considered in the desk-based assessment include, but are not limited to, those set out in Table 9.1 below.

Table 9.1: Sources of information (landscape)

Data collected	Source
Designations including National Park, Area of Outstanding Natural Beauty (AONB), Ancient woodland, agricultural land classifications, areas of high landscape value	Natural England, local planning authorities

Data collected	Source
Historic environment including conservation areas, listed buildings, scheduled monuments, Registered Parks and Gardens Parks Historic landscape characterisation historic hedgerows, historic field patterns	Information on the assets that are relevant to the historic environment DBA were sourced from the historic environment DBA team, to ensure consistency. Information on assets not relevant to the historic environment DBA team were sourced from aerial photography, historic maps, published historic landscape character documentation.
Public rights of way (PRoWs) including footpaths, bridleways, cycle paths	Local planning authorities, SUSTRANS, OS mapping
Published landscape and townscape character assessments and National Landscape Character Area Profiles	Local planning authorities, GOV.UK
Topography	LiDAR data from the Environment Agency database
Tranquillity and light pollution data	Council for Protection of Rural England (CPRE)
Existing vegetation	Aerial photography, OS mapping
Green infrastructure including country parks, formal parks, areas of recreation green space	OS Mapping, Local plans and local planning authorities
Ancient and Veteran Trees	Ancient Tree Inventory
Tree Preservation Orders (TPOs)	Local Planning Authorities

9.2.2 Approach to impact appraisal

9.6. The methodology was based on the Guidelines for Landscape and Visual Impact Assessment Third Edition (GLVIA 3), published by the Landscape Institute and Institute of Environmental Management and Assessment in 2013.

9.7. The desk based landscape baseline study considered the constituent elements, features and other factors that contribute to existing landscape character within the study area including:

- the physical influences on the landscape resource, including topography, geology, soils, microclimate, water bodies and water courses;

- the influence of human activity, including land use, open space, transport routes, PRoWs, national trails, historic green lanes, land management, the character of settlement and buildings and the pattern and type of fields and enclosure;
- the aesthetic and perceptual aspects of the landscape, including scale, complexity, openness, tranquillity, and wildness; and
- heritage features, including conservation areas, listed buildings, registered parks and gardens and other elements contributing to historic landscape character.

9.8. The findings were reviewed in conjunction with published landscape character assessments, to identify local landscape character areas.

9.9. The appraisal recognised the difference between impacts occurring at the construction phase and those occurring at the operational phase

9.10. Where appropriate, high-level mitigation measures were suggested to avoid or reduce potential impacts.

9.2.3 Assumptions and limitations

9.11. The information presented within this desk based assessment was sourced via the most up-to-date online records and from project data available at the time of writing. TPO data was sourced from Local Planning Authorities and where this was not possible, via the most up-to-date online records. Since this is a desk-based study, the findings can only be based on the information available at the time of the study and it is assumed that the information sourced is accurate.

9.12. A site survey was not undertaken as part of this desk-based assessment.

9.13. A Zone of Theoretical Visibility (ZTV) map was not produced as part of this desk-based assessment as there is insufficient design information to model the ZTV at this stage.

9.14. Consideration of visual amenity in this desk based assessment identified protected and designated views within the study area. A high level visual baseline is given in Section 9.3.4 to identify the nature of visual receptors in the study area. However, visual amenity for individual and groups of receptors including residential, recreational and workplace receptors has not been considered. An assessment of visual amenity to inform a more detailed assessment would require more detailed design information, production of a ZTV and confirmation by site survey would follow at a subsequent project stage.

9.3 Understanding of the baseline

9.3.1 Landscape designations

9.15. There are no statutory landscape designations within the study area. There are a number of nature conservation and heritage designations within the study area including registered parks and gardens, conservation areas, sites of special scientific interest and scheduled monuments. Landscape assets and designations relevant to defining landscape character are presented on Figure 9.1: Landscape Assets and Designations and where relevant, referred to in the local landscape character area descriptions in the sections below. Descriptions of the other designations within the study area can be found in Chapter 4, Biodiversity, Flora and Fauna, Chapter 10, Historic Environment, Chapter 12, Population and Human Health and Chapter 13, Material Assets.

9.3.2 National Character Areas

9.16. The Beckton Reuse Indirect Option lies within the Northern Thames Basin National Character Area (NCA 111: Northern Thames Basin)[66].

9.17. The Northern Thames Basin forms the rising land above the low-lying marshy landscapes adjoining the coast and estuaries of the Greater Thames Estuary. Chalk geology commonly underpins this National Character Area and the neighbouring Chilterns and South Suffolk and North Essex Claylands National Character Area to the west and north. Directly south is the Inner London NCA on the banks of the Thames where the river valley widens out into a broad flood plain.

9.18. The London Basin Chalk aquifer, which underlies much of the western section of the Northern Thames Basin National Character Area, is the principal aquifer supplying water to Inner London. The Chalk is confined in the basin by the overlying Tertiary formations of London Clay, which means recharge largely occurs in the extensive Chalk outcrop of the Northern Thames Basin and into the Chilterns National Character Area to the north and the North Downs to the south.

9.19. The landscape becomes extensively urbanised towards the Inner London National Character Area and includes major transport links from outside the area such as the East Coast mainline railway, M11 which connects to London and Cambridgeshire, the M1 which passes north-west through the Chilterns to the Midlands beyond, and the M25 which provides circular access to all parts of London and the south. Important A roads providing wide physical links include the A12 and A120 and the A1(M).

[66] National Character Area Profile 115: Thames Valley – NE379. Available at: https://nationalcharacterareas.co.uk/thames-valley/ [Accessed October 2022]

9.20. Many watercourses feed in or flow from surrounding areas, often along courses incised into boulder clays or tills, for instance the Ver and Lea from the westerly Chilterns National Character Area which flow into Hertfordshire before joining the Thames in inner London. These, along with others, form a series of river valleys draining south to the Thames and east to the North Sea and Thames Estuary.

9.21. The following key characteristics are identified in the National Character Area description.

- The landform is varied with a wide plateau divided by river valleys.
- The prominent hills and ridges of the 'Bagshot Hills' are notable to the north-west and extensive tracts of flat land are found in the south.
- Characteristic of the area is a layer of thick clay producing heavy, acidic soils, resulting in retention of considerable areas of ancient woodland.
- Areas capped by glacial sands and gravels have resulted in nutrient-poor, free-draining soils which support remnant lowland heathlands, although these are now small. Areas that have alluvial deposits present are well drained and fertile.
- The water bearing underlying Chalk beds are a main source of recharge for the principal London Basin Chalk aquifer.
- A diverse landscape with a series of broad valleys containing the major rivers Ver, Colne and Lea, and slightly steeper valleys of the rivers Stour, Colne and Roman. Numerous springs rise at the base of the Bagshot Beds and several reservoirs are dotted throughout the area.
- The pattern of woodlands is varied across the area and includes considerable ancient semi-natural woodland. Hertfordshire is heavily wooded in some areas as are parts of Essex, while other areas within Essex are more open in character. Significant areas of wood pasture and pollarded veteran trees are also present.
- The field pattern is very varied across the basin reflecting historical activity.
- Mixed farming, with arable land predominating in the Hertfordshire plateaux, parts of the London Clay lowlands and Essex heathlands. Grasslands are characteristic of the river valleys throughout.
- The diverse range of semi-natural habitats include ancient woodland, lowland heath and floodplain grazing marsh and provide important habitats for a wide range of species including great crested newt, water vole, dormouse and otter.
- Rich archaeology including sites related to Roman occupation, with the Roman capital at Colchester and City of St Albans (Verulamium) and links to London. Landscape parklands surrounding 16th- and 17th-century rural estates and country houses built for London merchants are a particular feature in Hertfordshire.
- the medieval pattern of small villages and dispersed farming settlement remains central to the character of parts of Hertfordshire and Essex. Market towns have expanded over time as have the London suburbs and commuter settlements.

- brick-built dwellings are characteristic from the late 17th century onwards. Prior to this dwellings and farm buildings tended to be timber built with weatherboarding, now mainly painted white but traditionally black or tarred, and whitewashed plaster walls.

9.3.3 Local Landscape Character Assessments

9.22. Local landscape character assessments were reviewed for East Hertfordshire[67], Epping Forest[68], the Lea Valley[69] and London Natural Signatures[70]. The landscape character areas relevant to the Beckton Reuse Indirect Option are presented in Table 9.2, Table 9.3 and Table 9.4 respectively, and shown on Figure 9.2: Epping Forest, Hertfordshire and London Natural Signatures Landscape Character Areas, and Figure 9.3: Lee Valley Landscape Character Assessment.

Table 9.2: East Hertfordshire Landscape Character Assessment (2004)

Landscape Character Area	Key characteristics
Theobald's Estate	• Discrete woodlands and estate farmland – Wooded arable farmland is widespread across the area, especially in the west. Within the woodlands of the estate, there are ornamental species such as rhododendrons, lime and horse chestnut. The hedgerows of the area are typically common elm but also consist of brambles and dog roses. • Geometric field pattern – The large fields are consistent in shape, due to the former park and are regularly broken up by organic woodland shapes. • Undulating landform – The area is part of the gently undulating South Hertfordshire plateau – a subsection of the North Thames basin. There is a change of soils across the area from slowly permeable clay over tertiary clay in the west, via loamy or clayey soils over chalky till to deep stoneless well-drained silty soils over aeolian silty drift in the east.

[67] Hertfordshire County Council Landscape Character Assessment, prepared for East Hertfordshire District Council. Available at: https://www.hertfordshire.gov.uk/services/recycling-waste-and-environment/landscape/landscape-character-assessment.aspx [Accessed April 2022]
[68] Epping Forest Landscape Studies, Landscape Character Assessment, prepared by Chris Blandford Associates. Available at: https://docslib.org/doc/5310363/epping-forest-landscape-studies-landscape-character-assessment-chris-blandford-associates-jan-2010 [Accessed April 2022]
[69] Lee Valley Regional Park Landscape Strategy, April 2019. Available at: https://www.enfield.gov.uk/__data/assets/pdf_file/0019/5950/cd-43-lvrp-landscape-character-assessment-part-3-improving-enfield.pdf [Accessed April 2022]
[70] Natural England (2011) London's Natural Signatures. Available at: http://publications.naturalengland.org.uk/publication/6540238365130752 [Accessed April 2022]

Landscape Character Area	Key characteristics
	• Long straight boundaries – Farmland and parkland are typical on both sides of the M25 corridor. The area is rich in historic interest, but it is not immediately obvious in the landscape. • Transport infrastructure – With permeant noise, movement and light, the M25 is major influence along the southern boundary.
Cheshunt Common	• Strongly undulating open arable farmland – predominately the fields are geometric and of medium scale. The monoculture reinforces the drama. • In the north of the area there is one block of woodland. • No settlements – only one farm. • Cuffley Brook runs north–south and run to join the River Lee. • Transport – the only road in the area is the B156. A railway creates a strong western boundary.
Ponsbourne and Tolmers Parkland Estates	• Open, strongly undulating farmland. • Views framed by woodlands. • Parkland pasture. • Exotic tree species located in the parkland which have spilled into the wider landscape – Wellingtonia. The local trees are oak and ash with hawthorn, field maple and blackthorn hedgerows. Hedges are larger in this area – ether medium or tall. • There are very few roads in this area and no settlements.
Northaw Great Wood	• The country park is an ancient woodland with occasional glades. To the north-west of the park, there are plantations. • Parts of the woodland, Northaw Great Wood is an SSSI for its oak/hornbeam community, woodland pasture and heathland. • The woodland features distinctive swallow holes in the northern area • Distinctive gravel soil underfoot – London clay. • Strong boundary to arable fields in the north. • Strongly undulating terrain. • Tranquil. • East-facing slope with eastward flowing Grimes Brook, which flows to the River Lee.
Northaw Common Parkland	• As part of the South Hertfordshire plateau, the topography is mainly gently undulating but features prominent slopes. • Tight circles of Scots Pine, limes and oaks planted in open parkland, which is the main landcover. • The soils are generally base-poor overlain with fine loamy soils and some calcareous clays.

Landscape Character Area	Key characteristics
	• Land use is primarily horse pasture Fences are prominent throughout the area. • Restricted views and limited public access. • Ridgelines crossing the area and vale 'bowls'. • Hornbeam pollards.
Mimmshall Valley	• Arable field patterns of small oak/ash woodland blocks and fenced pastures. • Field boundaries are typically indicated with hedges of predominantly hawthorn, elder or elm. • Major transport corridor - The A1(M) and the railway define this area to east and west. • Water related features - Water End Swallow Holes (SSSI) are major sinkholes in chalk and a permanent landscape feature. The site, which is the largest in England, consists of a group of more than 15 sinkholes where two streams drain from the London clay and sink very close to the boundary of chalk outcrop. • Permeable clayey soils mostly have brown subsoils and li over tertiary clays, resulting in seasonal waterlogging. • Valley slopes and floor - high points run through the central area.
North Mymms Common and Newgate Street Farmed Plate	• Narrow flat ridge above strongly undulating slopes. • Small to medium sized open, arable fields. • Poor draining soil. • Farmland is typically indicated with elm hedgerows and standard oaks. • Electricity pylons.
Thunderfield Ridges	• Small-scale co-axial field system within extensive woodland fringe – each field forms a narrow north-south rectangle. • Distinction between pasture and woodland on the slopes and built development on the narrow flat ridges (20th century) or in the valley (pre-20th century). • System of east-west narrow ridges with small streams in the narrow valley bottoms, echoed in the alignment of roads and fields. • Linked blocks of ancient woodland. • Small scale and very rural. • Very limited views within area, except from ridges. • Impact of built development on southern part of area. • Extensive north-easterly views.

Landscape Character Area	Key characteristics
Little Berkham Settled Plateau	• Gently undulating plateau. • Settlements at the end of each finger – some with older 19th and 20th century buildings. • Small to medium arable fields. • Loamy over clayey soils – slowly permeable and seasonally waterlogged. • Many ponds due to the poor drainage. • Tall elm hedges can be found around the settlements and small copses of oak, ash and sycamore are common throughout the area.
Brickedon Wooded Slopes	• Extensive and interlocking broadleaf woodland – a mix of ancient and secondary woodland. The species are predominantly oak, hornbeam, ash and some elm. • Strongly undulating north-facing landform with many minor valleys. • Intricate road system – winding and undulating roads linking small villages. • Clay soils over tertiary clay - slowly permeable and seasonally waterlogged. • Most land is screened from view by vegetation. • Farmland is mainly pastoral fields, with some arable lands – field sizes are irregular small or medium fields. • Field boundaries are prominent by various types of hedges – thorn, oak and ash. Hedgerow trees are either mature oak or young mature ash.
Potters Bar Parkland	• Relic estate planting and landscape features. • Relic estate architecture. • Extensive areas of recreation. • Urban edge influences. • Ridgelines and valleys. • Open views. • Mixed farming.

Table 9.3: Epping Forest Landscape Character Assessment (2010)

Landscape Character Area	Key characteristics
Rammey Marsh	• The site can be distinguished between the east and west marshes separated by the course of the River Lee - the east marsh includes a short section of the River Lee and has more varied habitats with a richer biodiversity that the western mars.

Landscape Character Area	Key characteristics
	• Flat floodplain with elevated topography in the north on a former landfill site with an exposed character and strong influences from the M25 motorway and long views across the valley. • A low-lying mosaic of meadow and amenity grassland on former floodplain, subject to gravel extraction with recreational access provided along mown pathways. • A low-lying mosaic of meadow and amenity grassland and a sense of enclosure with historic features at Enfield Locks providing a point of interest. • Semi-enclosed restored marshland in the south with mature willow trees along the perimeter creating a more secluded character compared to the more open landscape to the north. • Lines of electricity pylons within the wider, flat floodplain of the River Lee are dominant vertical elements, visible within most views across the area. • Sense of tranquillity within this landscape is disturbed by noise and movement associated with the M25 road corridor which crosses the area. • Recreational use, including angling on the river and Navigation with moorings for canal boats plus access points from the residential areas to the west connecting to the recreational resources of the wider Lee Valley and Gunpowder Park. • A general absence of settlement within the area. • Views north and south along the corridor of the River Lee Navigation are contained by mature vegetation along the canal sides. • Glimpsed views of the slopes of Gunpowder Park and the wooded ridgeline of Epping Forest outside the Park forms an important skyline to the east which contrasts with intensely urbanised areas often visible to the south and west. • Vegetation also generally limits views east-west across the valley corridor and views to adjacent Landscape Character Areas. • The key ecological features within this area are the flooded former gravel pits and an associated patchwork of wetlands and grassland which provide key habitats for birds. In addition to this, mature trees also contribute to the ecological network of habitats. There are no designated sites of international or national nature conservation value; however there is one County Wildlife Site.
Lippitts and Daws Hills	• A series of pronounced hills are key features within this landscape, covered by a patchwork of arable and pastoral fields. • To the east, views into the Lea Valley contribute to recognisable sense of place, whilst to the west, views to Epping Forest Ridge provide orientation. • A relatively strong sense of tranquillity throughout the area. • Small to medium sized patches of woodland are landscape features.

Landscape Character Area	Key characteristics
	• Several minor roads and lanes cross the area west-east and connect Epping Forest in the west to the Lea Valley in the east.

Table 9.4: Lea Valley Landscape Character Assessment (2019)

Landscape Character Area	Key characteristics
B1: King George's and William Girling Reservoirs	• Large, elevated reservoirs retained by steep, grassed embankments forming prominent vertical features in the valley landscape. • Small areas of reclaimed former marshlands on the fringes now used for formal and informal recreation. • The waterways of the River Lee Navigation and River Lee, often lined with mature trees (which frame long views and provide a sense of enclosure) form important linear features through the area. • The wooded ridgeline of Epping Forest to the east of the LVRP forms an important skyline which contrasts with the expanses of intensely urbanised areas visible to the south and west. • A fragmented and interrupted character created by reservoir embankments and main road corridors which cross the valley with public access largely restricted to the narrow navigation corridor along the western edge and small areas of playing fields to the east. • Extensive views from the elevated valley sides including Mansfield Hill to the east over areas of open water and a wooded valley floor backed by dense urban and industrial development. • A landscape of variable scale from the very large scale, reflective expanses of the reservoirs, massively engineered embankments and small, intimate areas of neglected 'leftover' landscapes created by the severances introduced by the reservoirs and transport corridors. • A more urban/industrial character is created by industrial and utilities infrastructure and associated visual intrusions. • Views across the open water from 'borrowed' landscape features such as the topography at Mansfield Hill, are especially important. • Areas of remaining small scale landscape which have not been disturbed by large scale infrastructure are important as little remains of the original landscape pattern.

Landscape Character Area	Key characteristics
	• The gentle landform of the valley sides to the east, the largely undeveloped skylines formed by the wooded ridges and small hills enclosing the valley to the east. • The substantial areas of artificial embanked reservoir landforms, forming undeveloped skylines. • The few semi-natural areas on the valley floor and the existing framework of trees and remaining riverine features. • The generally small to medium scale landscape comprises a complex mosaic of both channelled and naturalised rivers and navigations, wetlands, meadows and woodland. • Views to and from 'borrowed' landscape features such as the rolling, rural hills to the east and wooded ridges associated with Epping Forest.
H1: Gunpowder Park	• Parkland comprising 115 hectares of regenerated green space on the site formerly used for large scale munitions production, with parts of the former agricultural landscape still evident in the field pattern in the south. • Occupying a gently sloping valley side, extending from the flat valley floor east and rising to approximately 30m AOD. • Mixture of open meadows and agricultural fields interwoven with coppice blocks and scrub on valley sides and smaller scale, more enclosed mosaic of water-filler gravel pits, reed swamp, wet grasslands and wet woodland within the valley floor. • Few features or remnants of the Royal Ordinance munitions works evident – a landscape shaped by the remediation works rather than the original Ordinance Site established in the 1885 as an extension to the Royal Gunpowder Mills (LCA E1 Royal Gunpowder Mills). • Crossed by several ditches, including the 'Black ditch' along the north boundary, formally used to transport goods to the ordinance factory from the Lea and one of the few features remaining of the works apart from three pill boxes which also remain in-situ. • Evidence of remedial and decontamination works including distinctive earthwork features (created above capped contaminated areas to allow tree planting) and pools and wetlands created in Ossier Marsh from the removal of contaminated land. • Wide views available from more elevated and open valley sides to the east of the park, extending along the valley to the cityscape of east London in the far distance. • Open rolling farmland forms a rural setting to the east, with low wooded ridgelines in the distance at Epping Forest forming an important skyline in the distance – in contrast with the urban areas visible to the north and west.

Landscape Character Area	Key characteristics
	• Encompassing a wide range of habitats, reflecting a transition from wooded valley sides and grassland to the wetlands and riparian habitats of the valley floor - providing important biodiversity and nature conservation interest. • Designated as a SINC and as part of the Sewardstone and Ossier County Wildlife Site – the wet woodland on Ossier Marsh of particular note as one of the few remaining areas in the Lee Valley. • Constant noise from the M25 audible throughout the area. • Limited visual connection with the waterways of the Rammey Marsh Flood Relief Channel which follows the western boundary due to presence of trees and scrub, although weirs and bridge crossings providing visual interest locally. • Network of paths, cycle paths, trails, and boardwalks within the Park allow access to and exploration of the different areas, with wider links established west to Enfield Island Village, south to Sewardstone and north to Meridian Village.
C1: Rammey Marsh	• A low-lying mosaic of meadow and amenity grassland on former floodplain, subject to gravel extraction with recreational access provided along mown pathways. • The site can be distinguished between the east and west marshes separated by the course of the River Lee - the east marsh includes a short section of the River Lee and has more varied habitats with a richer biodiversity that the western marsh. • Flat floodplain with elevated topography in the north on a former landfill site with an exposed character and strong influences from the M25 motorway and long views across the valley. • Semi-enclosed restored marshland in the south with mature willow trees along the perimeter creating a more secluded character compared to the more open landscape to the north. • The waterways of the River Lee Navigation and River Lee, often lined with mature trees provide a sense of enclosure and form important linear features through the area with historic features at Enfield Locks providing a point of interest. • An important site for biodiversity including pyramidal orchid and a colony of bee orchid, birds and mammals, reflected in its designation as a Site of Importance for Nature Conservation. • Glimpsed views of the slopes of Gunpowder Park and the wooded ridgeline of Epping Forest outside the Park forms an important skyline to the east which contrasts with intensely urbanised areas often visible to the south and west.

Landscape Character Area	Key characteristics
	• Recreational use, including angling on the river and Navigation with moorings for canal boats plus access points from the residential areas to the west connecting to the recreational resources of the wider Lee Valley and Gunpowder Park. • Large scale buildings and pylons outside the marshes punctuate the skyline in wide, elevated views in the north.

Table 9.5: London Natural Signatures Landscape Character Assessment (2011)

Landscape Character Area	Key Characteristics
Lea River Valley	• Extensive floodplain meadows – wet grasslands, with remnant water channels, grading to marsh and open water. • Wet woodland and scrub as a backdrop to the open wetlands. • Meandering watercourses, with curving bands of woodland and individual lines of trees. • Quarrying and the creation of reservoirs. • Curvilinear hedgerows and woodland marking the upper limit of the floodplain. • Reedbeds.
Finchley Ridge	• Ancient woodlands with subtle variations in woodland structure – some areas with rich ground flora and an open structure (below canopy views); others with dense understorey; and others under coppice management. • Hornbeam coppice. • Ancient woodbanks and ditches. • Open scrubby slopes with long views. • Ridgetop woodland as a focus for views.

9.3.4 Visual baseline

9.23. The study area is divided into two distinct areas: the southern section lies within the urban area of greater London, and the northern section lies beyond the M25 corridor and has a more rural character. As such, visual receptors are typical of the urban and urban/rural interface and include (but are not limited to) the following:

- Residential receptors: residents within Greater London, in outlying settlements, villages and in isolated properties.
- Recreational receptors: users of public rights of way, long distance footpaths, promoted routes, cycle ways (including local routes and those within the National Cycle Network), visitors to country parks, recreational users of the waterways including boaters and people engaging in outdoor recreation at formal sports facilities.
- Transport receptors: users of the local and national road network including motorways and people travelling by rail.
- Employment and education receptors: people working and those attending education establishments in the study area.

9.24. These are the types of visual receptors that would be considered and potentially taken through to assessment at a subsequent project stages, once more detailed design information is available. The scoping of visual receptors to be included in the assessment would be informed through the production of a ZTV, site visit and in consultation with key stakeholders.

9.3.5 Protected trees

9.25. One area of ancient woodland is within proximity to the Raw Water Transfer Route Corridor. The Drinking Water Transfer Main Route Corridor and the Drinking Water Transfer Main to North Mymms Route Corridor are adjacent to areas of ancient woodland. There is no ancient woodland within 100m of the Indicative Intake Location, Indicative Raw Water Pumping Station Site, Indicative WTW Site or Brookmans Park Service Reservoir Connection.

9.26. Based on the information available, two Ancient or Veteran Trees were identified within proximity to Drinking Water Transfer Main Route Corridor. No Ancient or Veteran Trees were identified within 100m of the Indicative Intake location, Indicative Raw Water Pumping Station Site, Raw Water Transfer Main Route Corridor, Indicative WTW Site, Brookmans Park Service Reservoir Connection or the Drinking Water Transfer Main to North Mymms Route Corridor.

9.27. There are several conservation areas within proximity to the Beckton Reuse Indirect Option. Turkey Street Conservation Area and Forty Hill Conservation area are within the Drinking Water Transfer Main Route Corridor. There are no conservation areas within 100m of the Indicative Intake location, Raw Water Transfer Main Route Corridor, Indicative WTW Site, Brookmans Park Reservoir Pumping Station or the Drinking Water Transfer Main to North Mymms Route Corridor.

9.28. There is one TPO within proximity to the Indicative Intake Location. There are several TPOs within the Raw Water Transfer Main Route Corridor in the Sewardstone Road area. There are several TPOs within the Drinking Water Transfer Main Route Corridor along the extent of the route. There are also several TPOs within the Drinking Water Transfer Main to North Mymms Route Corridor within the Brookmans Park area. There are no TPOS within proximity to the Indicative WTW Site.

9.4 Appraisal outcomes

9.4.1 Indicative Intake Location and Indicative Raw Water Pumping Station Site

9.29. Table 9.6 presents the potential landscape effects during construction and operation for the Indicative Intake Location and Indicative Raw Water Pumping Station Site.

9.30. During construction of the River Lee Intake and Raw Water Pumping Station, the proposed works could directly impact one TPO group and would be in close proximity to several other TPOs. Trees should be physically inspected via a walkover assessment by a qualified arboriculturist to determine the level of impact, if any, to the trees.

Table 9.6: Potential landscape effects – Indicative Intake Location and Indicative Raw Water Pumping Station Site

Key landscape sensitivities	Potential effects on landscape character during construction		Potential effects on landscape character during operation
• London's Green Belt • Lies within the Rammey Marsh LCA. • Proximity to an area of Special Landscape Character (Enfield Borough Council). • Woodland, meadow, amenity grassland and scattered trees within the River Lee floodplain. • Hedgerows and trees along field boundaries connecting the woodland blocks at Lee Valley Campsite and north of Luthers Farm. • Residential receptors on A112 Sewardstone Road • Recreational visitors to the River Lee and users of PRoWs. • Important local view on elevated land at Barn Hill to the east, as identified by Enfield Borough Council.	• Temporary closure of PRoW where it crosses the Indicative Intake Location. • A reduction in landcover value due to the removal of woodland, meadow, amenity grassland and scattered trees within the River Lee floodplain and along field boundaries within the Indicative Raw Water Pumping Station Site. • An adverse change to landscape character in proximity to the River Lee due to the presence of construction activity within the open, green and undeveloped river floodplain. The river corridor is currently screened from housing, light industrial buildings, road infrastructure and business units on the A112 Sewardstone Road, by	• A reduction in landcover value due to the permanent loss of vegetation from within the Indicative Raw Water Pumping Station Site. • A permanent adverse change to landscape character of the river corridor in this location as the introduction of new infrastructure elements would replace riparian vegetation, meadows and amenity grassland in proximity to the River Lee and would have an urbanising influence on the undeveloped character of the river floodplain. • A permanent adverse change to the landscape setting of the River Lee, area of Special Landscape Character (Enfield Borough Council) and PRoWs due to the presence of the	• Removal of vegetation to the east of the Indicative Raw Water Pumping Station Site may open up views of construction activity and the operational WTW for residents on the A112 Sewardstone Road. • High potential for views of permanent new infrastructure elements from the elevated viewpoint on Barn Hill identified by Enfield Borough Council and for walkers along the London Loop to the east. • Introduction of uncharacteristic construction activity and permanent infrastructure elements into linear views along the undeveloped River Lee corridor for recreational users.

Key landscape sensitivities	Potential effects on landscape character during construction		Potential effects on landscape character during operation
	trees and woodland within the river floodplain. Removal of this screening vegetation and the introduction of construction activity would have an urbanising effect on the river corridor. • Loss of recreational space adjacent to the River Lee. • Potential change to the setting of the area of Special Landscape Character (Enfield Borough Council) due to the presence of construction activity. • A potential reduction in tranquillity due to the presence of construction activity within the green belt and river corridor.	new intake on the bank of the River Lee. • A reduction in landcover value due to the loss of vegetation within areas previously occupied by the temporary construction compound.	

9.4.2 Raw Water Transfer Main Route Corridor

9.31. Table 9.7 presents the potential landscape effects during construction and operation for the Raw Water Transfer Main Route Corridor.

9.32. There are several TPOs within the Raw Water Transfer Main Route Corridor. Trees should be physically inspected via a walkover assessment by a qualified arboriculturist to determine the level of impact, if any, to the trees.

9.33. The Raw Water Transfer Main Route Corridor is within proximity of one area of ancient woodland (Thompson's Wood) although direct impacts are unlikely to occur.

Table 9.7: Potential landscape effects – Raw Water Transfer Main Route Corridor

Key landscape sensitivities	Potential effects on landscape character during construction	Potential effects on landscape character during operation
Landform		
NCA 111: Northern Thames Basin • Landform is varied with a wide plateau divided by river valleys. • Broad valleys. Rammey Marsh LCA • Flat floodplain with elevated topography in the north on a former landfill site with an exposed character and strong influences from the M25 motorway. Lippitts and Daws Hills LCA • Pronounced hills.	• There is the potential for the character of the low lying landform along the edge of the broad River Lee valley to be temporarily altered by the presence of construction activity including excavation within a wide corridor of land and the presence of construction compounds and temporary soil stockpiles.	• It is assumed that land would be reinstated following construction.
Land cover/use		
NCA 111: Northern Thames Basin	• The introduction of construction compounds, machinery	• The pipeline route would be evident in the landscape where

Key landscape sensitivities	Potential effects on landscape character during construction	Potential effects on landscape character during operation
• Field pattern is very varied across the basin reflecting historical activity. • Mixed farming, with arable land predominating in the Hertfordshire plateaux. • London suburbs. Rammey Marsh LCA • A low-lying mosaic of meadow and amenity grassland on former floodplain, subject to gravel extraction with recreational access. • Lines of electricity pylons within the wider, flat floodplain of the River Lee. • A general absence of settlement. Lippitts and Daws Hills LCA • Patchwork of arable and pastoral fields. • Small to medium sized patches of woodland. • Several minor roads and lanes cross the area west-east.	(including pipe jacks), fencing, lighting in the winter months and construction activity have the potential to temporarily change the largely undeveloped character of this area of green belt. • Temporary change in land use to accommodate construction activity. • An adverse change to the structure of the landscape due to loss of vegetation on the boundaries of the varied small to medium scale fields which would alter the field pattern.	vegetation has been removed at field boundaries and easements prevent the replanting of hedgerows. This would alter the existing field pattern and reducing landcover value.
Vegetation and water		
NCA 111: Northern Thames Basin • Pattern of woodlands is varied across the area and includes considerable ancient semi-natural woodland. • Diverse range of semi-natural habitats include ancient woodland. Rammey Marsh LCA • A low-lying mosaic of meadow and amenity grassland.	• Large scale excavation has the potential to result in the loss of scrub vegetation, hedgerows along field boundaries and woodland most notably a wide belt of woodland within the River Lee corridor which separates the undeveloped river	• Potential permanent loss of trees and woodland within the pipeline easement.

Key landscape sensitivities	Potential effects on landscape character during construction	Potential effects on landscape character during operation
• Semi-enclosed restored marshland in the south with mature willow trees along the perimeter creating a more secluded character. • Lippitts and Daws Hills LCA • Small to medium sized patches of woodland.	floodplain and the residential and infrastructure development to the east.	
Characteristic views		
• Important local views from elevated land at Barn Hill identified by Enfield Borough Council. Rammey Marsh LCA • Views north and south along the corridor of the River Lee Navigation are contained by mature vegetation along the canal sides. • Glimpsed views of the slopes of Gunpowder Park and the wooded ridgeline of Epping Forest forms an important skyline to the east. • Views for residents on A112 Sewardstone Road. • Views from footpaths including the London Loop.	• High potential for views of construction activity on the lower lying river floodplain from the elevated viewpoint on Barn Hill and for walkers along the London Loop to the east. • Introduction of construction activity into linear views along the River Lee corridor. • Removal of vegetation within the floodplain has the potential to open up views to housing, infrastructure and light industrial uses on the A112 Sewardstone Road for recreational users along the River Lee. • Construction activity has the potential to change the character of views to the east for	• High potential for views of permanent new infrastructure elements from the elevated viewpoint on Barn Hill identified by Enfield Borough Council and for walkers along the London Loop to the east; • Permanent loss of vegetation for example where easements prevent replanting, would be noticeable within views.

Key landscape sensitivities	Potential effects on landscape character during construction	Potential effects on landscape character during operation
	residents on A112 Sewardstone Road and footpath users. • Skyline views maybe interrupted by taller construction machinery.	
Perceptual and experiential qualities		
Rammey Marsh LCA • Semi-enclosed restored marshland in the south with mature willow trees along the perimeter creating a more secluded character compared to the more open landscape to the north. • Sense of tranquillity within this landscape is disturbed by noise and movement associated with the M25 road corridor which crosses the area. Lippitts and Daws Hills LCA • To the east, views into the Lea Valley contribute to recognisable sense of place, whilst to the west, views to Epping Forest Ridge provide orientation.	• Construction activity has the potential to temporarily reduce tranquillity in the vicinity of the construction work; • The secluded character of the largely undeveloped river floodplain may also be adversely affected by construction activity.	• Operational activity has the potential to permanently reduce tranquillity in the vicinity of permanent above ground structures.
Landscape assets/designations		
• London's Green Belt • PRoWs including the London Loop	• Potential loss of open space during construction. • Potential temporary diversion or closure of footpaths and cycleways that intersect with the pipeline corridor.	• The assumption is that all PRoWs would be open following completion of the construction phase of the works.

9.4.3 Indicative Water Treatment Works Site

9.34. Based on the information available, no arboricultural constraints in relation to protected trees have been identified for the Indicative WTW Site.

9.35. Table 9.8 presents the potential landscape effects during construction and operation for the Indicative WTW Site.

9.36. Based on the information available, no arboricultural constraints in relation to protected trees have been identified for the Indicative WTW Site.

Table 9.8: Potential landscape effects – Indicative Water Treatment Works Site

Key landscape sensitivities	Potential effects on landscape character during construction	Potential effects on landscape character during operation	Additional Notes
• London's Greenbelt. • Lies partly within the Rammey Marsh LCA and partly in the Lippitts and Daws Hills LCA. • Located in the broad Lee River Valley immediately west of a small hill at Thompsons Wood. • The northern section and a portion of the south are currently undeveloped areas of land. • Mature tree belts around the existing glass houses.	• Loss of open land within the green belt. • A potential reduction in tranquillity due to the presence of construction activity within the green belt. • Loss of woodland and scrub vegetation within the site boundary, reducing landcover value.	• Permanent loss of tree belts and scrub woodland within the footprint of the site.	• Potential for views of construction activity and the permanent works from residential receptors nearby, although garden vegetation is likely to provide a good level of screening and much of the site is set back from the road. • The hill at Thompsons Wood has the potential to provide screening of the proposed works from the raised land to the east. • The permanent new infrastructure elements would

Key landscape sensitivities	Potential effects on landscape character during construction	Potential effects on landscape character during operation	Additional Notes
• Scrub woodland in the northern section of the site. • A small watercourse running parallel to Mott Street. • Proximity to Gunpowder Park (Country Park) and Thompson's Wood (ancient woodland). • Residential receptors on A112 Sewardstone Road, Butlers Drive, Mott Street and The Grange.			be located on areas of previously developed land. The scale of new development would be in keeping with the scale of the existing development.

9.4.4 Drinking Water Transfer Main Route Corridor

9.37. Table 9.9 and Table 9.10 present the potential landscape effects during construction and operation for the Drinking Water Transfer Main Route Corridor. For the purpose of describing effects on landscape character, the Drinking Water Transfer Main Route Corridor has been split into two sections: Indicative WTW Site to M25 Crossing and M25 Crossing to Brookmans Park Service Reservoir.

9.38. There are several TPOs within the Drinking Water Transfer Main Route Corridor and pipeline construction works could directly impact trees within the Turkey Street and Forty Hill Conservation Areas. The Drinking Water Transfer Main Route Corridor is within proximity to four areas of ancient woodland and two Ancient and Veteran trees, although the latter are within the grounds of Myddleton House Gardens and therefore unlikely to be directly impacted. Trees should be physically inspected via a walkover assessment by a qualified arboriculturist to determine the level of impact, if any, to the trees.

Table 9.9: Potential landscape effects – Drinking Water Transfer Main Route Corridor (Indicative WTW Site to M25 crossing)

Key landscape sensitivities	Potential effects on landscape character during construction	Potential effects on landscape character during operation
Landform		
NCA 111: Northern Thames Basin • Landform is varied with a wide plateau divided by river valleys. • Broad valleys. Rammey Marsh LCA (Epping Forest & Lea Valley) • Flat floodplain with elevated topography in the north on a former landfill site. Gunpowder Park (Lea Valley) • A gently sloping valley side, extending from the flat valley floor. • Distinctive earthwork features (created above capped contaminated areas to allow tree planting). Theobolds Estate LCA (Hertfordshire) • Undulating landform.	• There is the potential for the character of the broad flat floodplain of the River Lee, valley sides and undulating landform of the plateau to the west to be temporarily affected by the presence of construction activity including excavation within a wide corridor of land, and the presence of construction compounds and temporary soil stockpiles.	• It is assumed that landform would be reinstated to its former levels following construction.
Land cover/use		
NCA 111: Northern Thames Basin • Field pattern is very varied across the basin reflecting historical activity. • Mixed farming, with arable land predominating in the Hertfordshire plateaux.	• The introduction of construction compounds, machinery (including pipe jacks), fencing, lighting in the winter months and construction activity have the potential to temporarily change the existing character and	• The pipeline route would be evident in the landscape where mature vegetation has been removed and where easements do not allow for replanting. • Loss of field boundary vegetation would alter the existing field

Key landscape sensitivities	Potential effects on landscape character during construction	Potential effects on landscape character during operation
• Landscape parklands surrounding 16th- and 17th-century rural estates and country houses. • Medieval pattern of small villages and dispersed farming settlement remains central to the character of parts of Hertfordshire and Essex. • London suburbs. Rammey Marsh LCA (Epping Forest & Lea Valley) • A low-lying mosaic of meadow and amenity grassland on former floodplain, subject to gravel extraction with recreational access. • Lines of electricity pylons within the wider, flat floodplain of the River Lee. • A general absence of settlement. • Recreational use, including angling on the river and Navigation. Gunpowder Park (Lea Valley) • Parkland comprising 115 hectares of regenerated green space on the site formerly used for large scale munitions production, with parts of the former agricultural landscape still evident in the field pattern in the south. • Mixture of open meadows and agricultural fields interwoven with coppice blocks and scrub on valley sides and smaller scale, more enclosed mosaic of water-filler gravel pits, reed swamp, wet grasslands and wet woodland within the valley floor. Lea River Valley (London Natural Signatures) • Extensive floodplain meadows. Theobolds Estate LCA (Hertfordshire)	recreational value of the landscape surrounding the River Lee, including Gunpowder Park, and Whitewebbs Park. • Much of the landscape has a suburban/light industrial use between the A112 and the A10 to the south of the M25. • Temporary change in land use within the greenbelt to accommodate construction activity. • Construction activity may temporarily affect the setting of Whitewebbs ancient woodland. • Adverse effects for the setting of the landscape parkland at Capel Manor College.	pattern to the north of Whitewebbs Park and reduce landcover value. • Potential for permanent loss of mature vegetation within parkland at Capel Manor College, Gunpowder Park and Whitewebbs Park and meadow and amenity grass within the River Lee corridor, which would reduce landcover value.

Key landscape sensitivities	Potential effects on landscape character during construction	Potential effects on landscape character during operation
• Discrete woodlands and estate farmland. • Geometric field pattern. • Transport infrastructure.		
Vegetation and water		
NCA 111: Northern Thames Basin • Considerable areas of ancient woodland. • Pattern of woodlands is varied across the area and includes considerable ancient semi-natural woodland. • Diverse range of semi-natural habitats include ancient woodland, lowland heath and floodplain grazing marsh. Rammey Marsh LCA (Epping Forest & Lea Valley) • A low-lying mosaic of meadow and amenity grassland. • Semi-enclosed restored marshland in the south with mature willow trees along the perimeter creating a more secluded character. Gunpowder Park (Lea Valley) • Mixture of open meadows and agricultural fields interwoven with coppice blocks and scrub on valley sides and smaller scale, more enclosed mosaic of water-filler gravel pits, reed swamp, wet grasslands and wet woodland within the valley floor. • Crossed by several ditches, including the 'Black ditch'. • Pools and wetlands created in Ossier Marsh from the removal of contaminated land.	• Large scale excavation has the potential to result in the loss of woodland, marshland, meadow, wet grasslands and wet woodland within the pipeline corridor. • Removal of riparian vegetation resulting in a change to the character of the watercourses, including the River Lee, River Lee Navigation, Turkey Brook and Cuffley Brook. • Removal of screening vegetation along existing road and rail corridors e.g. the M25, A10, has the potential to increase the prominence of these elements within the landscape; • Removal of roadside vegetation within residential areas would	• The pipeline corridor would be evident where vegetation has been removed. • Potential permanent loss of trees and woodland within the pipeline easement. • Potential change to the character of river corridors due to the presence of a culvert where crossings are proposed over watercourses. • Removal of screening vegetation along existing road and rail corridors e.g. the M25, A10, has the potential to increase the prominence of these elements within the landscape.

Key landscape sensitivities	Potential effects on landscape character during construction	Potential effects on landscape character during operation
• Transition from wooded valley sides and grassland to the wetlands and riparian habitats of the valley floor. Lea River Valley (London Natural Signatures) • Wet grasslands, with remnant water channels, grading to marsh and open water. • Wet woodland and scrub as a backdrop to the open wetlands. • Meandering watercourses, with curving bands of woodland and individual lines of trees. • Curvilinear hedgerows and woodland marking the upper limit of the floodplain. Finchley Ridge (London Natural Signatures) • Ancient woodlands with subtle variations in woodland structure. Theobolds Estate LCA (Hertfordshire) • Wooded arable farmland is widespread across the area.	adversely change the character of the townscape.	
Characteristic views		
Rammey Marsh LCA (Epping Forest & Lea Valley) • Views north and south along the corridor of the River Lee Navigation are contained by mature vegetation along the canal sides. • Glimpsed views of the slopes of Gunpowder Park and the wooded ridgeline of Epping Forest forms an important skyline to the east. Gunpowder Park (Lea Valley) • Wide views available from more elevated and open valley sides to the east of the park.	• Construction activity within the River Lee valley has the opportunity to alter characteristic views from the river towpath, from within Gunpowder Pak valley sides and along the river corridor. • Several Important Local Views have been identified by Enfield	• Permanent loss of vegetation for example where easements prevent replanting, would be noticeable within views, particularly where vegetation is mature and has a screening function. • Loss of existing screening vegetation along road and rail

Key landscape sensitivities	Potential effects on landscape character during construction	Potential effects on landscape character during operation
• Low wooded ridgelines in the distance at Epping Forest forming an important skyline in the distance. • Limited visual connection with the waterways of the Rammey Marsh Flood Relief Channel due to presence of trees and scrub. Finchley Ridge (London Natural Signatures) • Open scrubby slopes with long views. • Ridgetop woodland as a focus for views.	BC within and beyond the study area. The characteristics of these views have the potential to be altered by the presence of construction activity and loss of mature vegetation. • Removal of vegetation within the floodplain and around Innova Business Park, has the potential to open up views to infrastructure and light industrial for recreational users along the River Lee. • Removal of existing screening vegetation along road and rail corridors e.g. the M25 and A10 has the potential to open up views of vehicle and train movements for visual receptors.	corridors e.g. the M25 and A10 has the potential to open up views of vehicle and train movements for visual receptors.
Perceptual and experiential qualities		
Rammey Marsh LCA (Epping Forest & Lea Valley) • Semi-enclosed restored marshland in the south with mature willow trees along the perimeter creating a more secluded character compared to the more open landscape to the north.	• Construction activity has the potential to further reduce tranquillity in the vicinity of the construction work, particularly where construction takes place away from the largely built up	• Operational activity has the potential to permanently reduce tranquillity in the vicinity of permanent above ground structures.

Key landscape sensitivities	Potential effects on landscape character during construction	Potential effects on landscape character during operation
• Sense of tranquillity within this landscape is disturbed by noise and movement associated with the M25 road corridor which crosses the area. Theobalds Estate LCA (Hertfordshire) • With permeant noise, movement and light, the M25 is major influence along the southern boundary. • The area is rich in historic interest, but it is not immediately obvious in the landscape.	areas and infrastructure e.g. within the River Lee corridor, at Gunpowder Park and adjacent to Whitewebbs Park. • Removal of existing screening vegetation along road and rail corridors e.g. the M25 and A10 has the potential to increase the prominence of these elements within the landscape and reduce tranquillity.	• There may be an adverse effect on tranquillity in operation as vegetation removed in construction along road and rail corridors, has the potential to increase the prominence of these elements within the landscape and reduce tranquillity.
Landscape assets/designations		
• London's Greenbelt. • Areas of Special Character including the Lee Valley Reservoirs and Theobolds Estate South. • PRoWs including: – NCN route 1 – The London Loop – Hertfordshire Chain Walk	• Potential loss of open space during construction • The introduction of construction activity including machinery and stockpiles may potentially adversely affect the key characteristics of the area of special character including historic landscape and rural character. • Potential temporary diversion or closure of footpaths and cycleways that intersect with the route corridor.	• Potential to permanently adversely affect the key characteristics of the area of special character including historic landscape and rural character, with the loss of key areas of vegetation and introduction of permanent above ground structures. • The assumption is that all PRoWs and cycle routes would be open following completion of the construction phase of the works.

Table 9.10: Potential landscape effects – Drinking Water Transfer Main Route Corridor (M25 Crossing to Brookmans Park Service Reservoir Connection)

Key landscape sensitivities	Potential effects on landscape character during construction	Potential effects on landscape character during operation
Landform		
NCA 111: Northern Thames Basin • Landform is varied with a wide plateau divided by river valleys. Theobolds Estate LCA (Hertfordshire) • Undulating landform. Cheshunt Common LCA (Hertfordshire) • Strongly undulating open arable farmland. Ponsbourne and Tomlers Parkland Estates LCA (Hertfordshire) • Open, strongly undulating farmland • North Mymms Common and Newgate Street Farmed Plate (Hertfordshire) • Narrow flat ridge above strongly undulating slopes.	• There is the potential for the character of the wide plateau, river valley along Cuffley Brook, undulating farmland and along the ridgeline to be temporarily altered by the presence of construction activity, including excavation, within a wide corridor of land, and the presence of construction compounds and temporary soil stockpiles. • The character of the ridgeline may be adversely affected by the presence of large-scale construction machinery and construction compounds.	• It is assumed that land would be reinstated to its former levels following construction.
Land cover/use		
NCA 111: Northern Thames Basin • Field pattern is very varied across the basin reflecting historical activity.	• The introduction of construction compound, machinery (including pipe jacks), fencing, lighting in the winter months and construction activity have the potential to	• Potential for permanent loss of vegetation including woodland and along field boundaries which would alter the pattern

Key landscape sensitivities	Potential effects on landscape character during construction	Potential effects on landscape character during operation
• Mixed farming, with arable land predominating in the Hertfordshire plateaux. • Landscape parklands surrounding 16th- and 17th-century rural estates and country houses. • Medieval pattern of small villages and dispersed farming settlement remains central to the character of parts of Hertfordshire and Essex. Theobolds Estate LCA (Hertfordshire) • Discrete woodlands and estate farmland. • Geometric Field Pattern. • Transport infrastructure. Cheshunt Common LCA (Hertfordshire) • Open arable farmland – predominately the fields are geometric and of medium scale. The monoculture reinforces the drama; • No settlements – only one farm. Ponsbourne and Tomlers Parkland Estates LCA (Hertfordshire) • Open, strongly undulating farmland. • Parkland pasture. • Very few roads in this area and no settlements. North Mymms Common and Newgate Street Farmed Plate LCA (Hertfordshire) • Small to medium sized open, arable fields	temporarily change the existing character of the arable and parkland landscape along a wide corridor of land within the green belt. • Potential for wide swathes of woodland to be lost during construction, permanently altering landscape character. • Temporary change in land use within the greenbelt to accommodate construction activity. • Potential alteration of historic field patterns and the landscape setting of historic assets. • Construction traffic movements would be uncharacteristic of this area due to the lack of roads and settlements and could lower tranquillity.	of landscape and reduce landcover value.
Vegetation and water		

Key landscape sensitivities	Potential effects on landscape character during construction	Potential effects on landscape character during operation
NCA 111: Northern Thames Basin • Considerable areas of ancient woodland. • Remnant lowland heathlands. • Pattern of woodlands is varied across the area and includes considerable ancient semi-natural woodland. • Diverse range of semi-natural habitats include ancient woodland, lowland heath and floodplain grazing marsh. Theobolds Estate LCA (Hertfordshire) • Wooded arable farmland is widespread across the area. Cheshunt Common LCA (Hertfordshire) • Cuffley Brook runs north–south and run to join the River Lee. • In the north of the area there is one block of woodland. Ponsbourne and Tomlers Parkland Estates LCA (Hertfordshire) • Exotic tree species located in the parkland which have spilled into the wider landscape – Wellingtonia. The local trees are oak and ash with hawthorn, field maple and blackthorn hedgerows. Hedges are larger in this area – ether medium or tall. North Mymms Common and Newgate Street Farmed Plate LCA (Hertfordshire) • Elm hedgerows and standard oaks	• This is a well wooded landscape with little development. Large scale excavation has the potential to result in the loss of arable farmland, woodland and field boundary vegetation within the pipeline corridor. • Potential removal of riparian vegetation along Cuffley Brook and along tributaries. • Potential removal of screening vegetation along existing road and rail corridors e.g. the M25, which may open up views of vehicle and train movements for visual receptors.	• Potential permanent loss of trees and woodland within the pipeline easement. • Removal of screening vegetation along existing road and rail corridors e.g. the M25, may open up views of vehicle and train movements for visual receptors. • Potential permanent loss of riparian vegetation along Cuffley Brook and along tributaries.
• Characteristic views		
Ponsbourne and Tomlers Parkland Estates LCA (Hertfordshire)	• There is the potential for construction activity, compounds	• Loss of existing screening vegetation along infrastructure

Key landscape sensitivities	Potential effects on landscape character during construction	Potential effects on landscape character during operation
• Views framed by woodlands	and stockpiles to adversely affect characteristic rural views to and from the ridgeline and from PRoWs. • The potential removal of woodland to the north of Goffs Oak /Cuffley Hill and intervening vegetation to the west would alter key characteristics of the view and would open up views to construction activity for residents. • The potential loss of existing screening vegetation along infrastructure elements (such as the M25 and railway corridors) has the potential to increase the prominence of these elements in the landscape and open up views for visual receptors.	elements (such as the M25 and rail corridors) has the potential to open up views for visual receptors. • Loss of woodland would alter the character of existing views for users of PRoWs. • Potential permanent loss of woodland to the north of Goffs Oak would change the character of existing views for residents.
Perceptual and experiential Qualities		
Theobolds Estate LCA (Hertfordshire) • With permanent noise, movement and light, the M25 is major influence along the southern boundary. • The area is rich in historic interest, but it is not immediately obvious in the landscape.	• Construction activity has the potential to temporarily reduce tranquillity in areas away from existing infrastructure elements and settlement edges and along PRoWs.	• Removal of vegetation around existing infrastructure (such as the M25 and rail corridors) has the potential to increase the prominence of these elements in the landscape.

Key landscape sensitivities	Potential effects on landscape character during construction	Potential effects on landscape character during operation
Landscape assets/designations		
• London's Greenbelt • PRoWs including: – Hertfordshire Chain Walk – Hertfordshire Way	• Potential loss of open space during construction. • Potential temporary diversion or closure of footpaths that intersect with the route corridor.	

9.4.5 Brookmans Park Service Reservoir Connection

9.39. The Beckton Reuse Indirect Option would not require any changes to the Brookmans Park Service Reservoir therefore there are no anticipated landscape effects.

9.40. Based on the information available, no arboricultural constraints in relation to protected trees have been identified for the Brookmans Park Service Reservoir Connection.

9.4.6 Drinking Water Transfer Main to North Mymms Route Corridor

9.41. Table 9.11 presents the potential landscape effects during construction and operation of the Drinking Water Transfer Main to North Mymms Route Corridor.

9.42. There are TPOs within the Drinking Water Transfer Main to North Mymms Route Corridor. The Drinking Water Transfer Main to North Mymms Route Corridor is immediately adjacent to two areas of ancient woodland, Peplin's Wood and Brick Kiln Wood. Trees should be physically inspected via a walkover assessment by a qualified arboriculturist to determine the level of impact, if any, to the trees.

Table 9.11: Potential landscape effects – Drinking Water Transfer Main to North Mymms Route Corridor

Key landscape sensitivities	Potential effects on landscape character during construction	Potential effects on landscape character during operation
Landform		
NCA 111: Northern Thames Basin • Landform is varied with a wide plateau divided by river valleys. • Broad valleys. North Mymms Common and Newgate Street Farmed Plate LCA (Hertfordshire) • Narrow flat ridge above strongly undulating slopes. Potters Bar Parklands LCA (Hertfordshire) • Ridgelines and valleys. Mimmshall Valley LCA (Hertfordshire) • Valley slopes and floor – high points run through the central area.	• There is the potential for the character of the wide plateau, river valley along Water End, the undulating farmland and along the ridgeline to be altered by construction activity including excavation, within a wide corridor of land, the presence of temporary soil stockpiles and the siting of construction compounds. • There is the potential for the character of the ridgeline to be altered by the presence of large-	• It is assumed that land would be reinstated following construction.

Key landscape sensitivities	Potential effects on landscape character during construction	Potential effects on landscape character during operation
	scale construction machinery and construction compounds.	
Land cover/use		
NCA 111: Northern Thames Basin • Field pattern is very varied across the basin reflecting historical activity. • Mixed farming, with arable land predominating in the Hertfordshire plateaux. • Landscape parklands surrounding 16th- and 17th-century rural estates and country houses. • Medieval pattern of small villages and dispersed farming settlement remains central to the character of parts of Hertfordshire and Essex. North Mymms Common and Newgate Street Farmed Plate LCA (Hertfordshire) • Small to medium sized open, arable fields. Potters Bar Parklands LCA (Hertfordshire) • Relic estate planting and landscape features. • Extensive areas of recreation. • Urban edge influences. • Mixed farming. Mimmshall Valley LCA (Hertfordshire) • Arable field patterns of small oak/ash woodland blocks and fenced pastures.	• The introduction of construction compounds, machinery (including pipe jacks), fencing, lighting in the winter months and construction activity have the potential to temporarily change the largely undeveloped character of this area of green belt. • Temporary change in land use to accommodate construction activity. • The introduction of construction compound, machinery (including pipe jacks), fencing, lighting in the winter months and construction activity have the potential to temporarily change the existing character of the arable landscape and the setting of existing settlements e.g. Bell Bar and Brookmans Park along a wide corridor of land.	• Potential for permanent loss of vegetation including woodland/ancient woodland and along field boundaries which would alter the pattern of landscape and reduce landcover value.

Key landscape sensitivities	Potential effects on landscape character during construction	Potential effects on landscape character during operation
	• Potential for wide swathes of woodland including ancient woodland to be lost in construction, permanently altering the character of the landscape. • Temporary change in land use within the greenbelt to accommodate construction activity. • Potential alteration of historic field patterns and the landscape setting of historic assets.	
Vegetation and water		
NCA 111: Northern Thames Basin • Considerable areas of ancient woodland. • Remnant lowland heathlands. • Pattern of woodlands is varied across the area and includes considerable ancient semi-natural woodland. • Diverse range of semi-natural habitats include ancient woodland, lowland heath and floodplain grazing marsh. North Mymms Common and Newgate Street Farmed Plate LCA (Hertfordshire) • Elm hedgerows and standard oaks.	• Large scale excavation has the potential to result in the loss of ancient woodland e.g. Brick Kiln Wood and Peplin's Wood, woodland and hedgerows within the pipeline corridor, which would adversely affect landscape character. • Potential removal of vegetation along existing road and rail corridors e.g. Bulls Lane, Bell Lane and A1000 Great North	• Potential permanent loss of trees and woodland within the pipeline easement. • Potential permanent loss of ancient woodland at Brick Kiln Wood and Peplin's Wood. • Potential change to the character of Bulls Lane, Bell Lane and A100 Great North Road due to the loss of roadside vegetation. • Removal of screening vegetation along existing road and rail

Key landscape sensitivities	Potential effects on landscape character during construction	Potential effects on landscape character during operation
Mimmshall Valley LCA (Hertfordshire) • Small oak/ash woodland blocks. • Hedges of predominantly hawthorn, elder or elm.	Road, has the potential to increase the prominence of these elements within the landscape. • Removal of riparian vegetation along Ray Brook changing the character of the watercourse.	corridors e.g. A1000 Great North Road, and A1000 Great North Road, has the potential to increase the prominence of these elements within the landscape. • Potential introduction of culverts at the crossing of Ray Brook.
Characteristic views		
Potters Bar Parklands LCA (Hertfordshire) • Open views	• Construction activity has the opportunity to alter characteristic open views across Potters Bar parklands LCA. • There is the potential for construction activity, compounds and stockpiles to adversely affect characteristic rural views to and from the higher ground and from PRoWs. • Removal of intervening vegetation would alter key characteristics of the view for residents on Bulls Lane, Bell Lane and A1000 Great North Road and would potentially open up views to construction activity.	• Removal of vegetation along road and rail corridors e.g. Bulls Lane, Bells Lane and the A1000 Great North Road has the potential to permanently change the character of the view for visual receptors. • Removal of existing screening vegetation along road and rail corridors e.g. the A1000 Great North Road, has the potential to open up views of moving vehicles and trains, and change the character of the view for visual receptors.

Key landscape sensitivities	Potential effects on landscape character during construction	Potential effects on landscape character during operation
	• Removal of existing screening vegetation along road and rail corridors e.g. the A1000 Great North Road, has the potential to open up views of moving vehicles and trains for visual receptors.	
Perceptual and experiential qualities		
North Mymms Common and Newgate Street Farmed Plate LCA (Hertfordshire) • Electricity pylons. Potters Bar Parklands LCA (Hertfordshire) • Urban edge influences. Mimmshall Valley LCA (Hertfordshire) • Major transport corridor – The A1(M) and the railway define this area to east and west.	• Construction activity has the potential to temporarily reduce tranquillity in areas away from built up areas e.g. along PRoWs. • Removal of existing screening vegetation along road and rail corridors e.g. the A1000 Great North Road has the potential to increase the prominence of these elements within the landscape and reduce tranquillity.	• There may be an adverse effect on tranquillity in operation as vegetation removed in construction along road and rail corridors, has the potential to increase the prominence of these elements within the landscape and reduce tranquillity.

Key landscape sensitivities	Potential effects on landscape character during construction	Potential effects on landscape character during operation
Landscape assets/designations		
• London's Green Belt • PRoWs including NCN Route 12	• Potential loss of open space during construction. • Potential temporary diversion or closure of footpaths and cycleways that intersect with the route corridor.	

9.4.7 North Mymms Booster Station Connection

9.43. The Beckton Reuse Indirect Option would not require any changes to the booster pumping station in the vicinity of North Mymms therefore there are no anticipated landscape effects.

9.44. Based on the information available, no arboricultural constraints in relation to protected trees have been identified for the North Mymms Booster Station Connection.

9.5 Recommended mitigation and enhancement opportunities

9.5.1 Landscape mitigation

9.45. Table 9.12 presents recommended mitigation for potential landscape effects.

Table 9.12: Recommended mitigation for potential landscape effects

Component	Recommended mitigation for potential effects
Indicative Intake Location and Indicative Raw Water Pumping Station Site	• Avoid development and building within the river floodplain particularly in close proximity to area of Special Landscape Character (London Borough of Enfield). • Locate construction compounds adjacent to existing infrastructure and away from undeveloped areas e.g. arable/pastoral fields and the river floodplain. • Arrange the construction compound and permanent site footprint to sit within existing field boundaries to minimise vegetation loss and retain the existing field patterns within the landscape. • Retain existing vegetation where possible to help contain landscape and visual effects. • Align breaks in field boundaries and intake from the River Lee at existing less vegetation points. • Reinstate vegetation including scrub, woodland and meadow lost during construction.
Raw Water Transfer Main Route Corridor	Landform • Return the landform to the existing levels following construction. • Land cover / use:

Component	Recommended mitigation for potential effects
	• Reduce the working corridor width at field boundaries and arrange construction works to sit within the existing field boundaries in order to maintain existing land use and pattern of the landscape. • Locate construction compounds adjacent to existing infrastructure and away from undeveloped areas e.g. arable/pastoral fields and the river floodplain. • Restore land to its former use following construction. Vegetation and water • Adjust the pipeline route to avoid removal of vegetation and avoid root protection zones where possible. • Adjust the pipeline route to cross the field boundaries where there is little or no vegetation. • Replace vegetation removed during construction. • Narrow the working corridor where crossing vegetated areas in order to reduce vegetation loss. • Link mitigation woodland and other screen planting to existing nearby woodland belts and vegetation to aid landscape integration. Characteristic views • Adjust the pipeline route to avoid removal of vegetation and root protection zones to retain screening effect of existing vegetation. • Perceptual and experiential qualities: • Locate construction compounds adjacent to existing infrastructure and away from undeveloped areas e.g. arable/pastoral fields and the river floodplain. • Minimise lighting in construction and operation to avoid introducing additional lighting into unlit areas e.g. the river floodplain; • Locate pipelines away from PRoWs which would greatly reduce perceptual and experiential value for footpath users, albeit temporarily. • The removal of vegetation along PRoWs may permanently lower perceptual and experiential value for footpath users. • The removal of screening vegetation along existing infrastructure and detracting elements should be avoided and, if not possible to avoid, reinstated and enhanced following construction. Landscape assets/designations • Keep working width to a minimum and restore landscape to its former use following construction. • Locate construction compounds adjacent to existing infrastructure and away from undeveloped areas e.g. arable/pastoral fields and the river floodplain.

Component	Recommended mitigation for potential effects
	• Provision of managed access or a diversion of PRoWs during construction. • Avoid prolonged closure of footpaths.
Indicative WTW Site	• Avoid construction of permanent structures on undeveloped land in the green belt. • Refine the site boundary and location of proposed permanent infrastructure elements to avoid removal of trees and vegetation within the proposed site. • Careful siting of the construction compound to avoid loss of vegetation. • Replace all trees and vegetation removed during construction. • Use earthworks in association with woodland planting to screen the proposed works from residential receptors.
Drinking Water Transfer Main Route Corridor (Indicative WTW Site to M25 Crossing)	Landform • Return the land to the existing levels following construction. • Land cover / use: • Allow for changes to the width of the working corridor to maintain existing land use and patterns of vegetation, in particular parkland landscape and field boundary vegetation. • Locate construction compounds in areas of low landcover value. • Improve landcover value by planting new areas of vegetation including woodland and hedgerows. • Restore land to its former use following construction. • Reinstate field boundaries where removed. Vegetation and water • Adjust the pipeline route to avoid removal of vegetation and avoid root protection zones where possible. • Adjust the pipeline route to cross the watercourse where there is little or no vegetation. • Avoid running parallel to watercourses for long stretches. • Replace vegetation removed during construction. • Narrow the working corridor where crossing vegetated areas in order to reduce vegetation loss. • Sympathetic design of pipeline intersection points with existing watercourses to minimise visual impact. • Link mitigation woodland and other screen planting to existing nearby woodland belts and vegetation to aid landscape integration and connectivity of green infrastructure. • Avoid removal of trees within the road and rail corridors.

Component	Recommended mitigation for potential effects
	Characteristic views • Avoid removal of vegetation within the river corridor and floodplain. • Avoid removal of existing screening vegetation around infrastructure and light industrial elements. Perceptual and experiential qualities • Avoid routing the pipelines through recreational landscapes, including Gunpowder Park and Whitewebbs Park. • Locate construction compounds adjacent to existing infrastructure elements and away from less developed areas e.g. recreational routes, parks, the river floodplain, woodland. • Locate pipelines away from PRoWs which would greatly reduce perceptual and experiential value for footpath users, albeit temporarily. • The removal of vegetation along PRoWs may permanently lower perceptual and experiential value for footpath users. • The removal of screening vegetation along existing infrastructure and detracting elements should be avoided and, if not possible to avoid, reinstated and enhanced following construction. • Minimise lighting in construction and operation to avoid introducing additional lighting in the vicinity of residential receptors. Landscape assets/designations • Keep working width to a minimum and restore landscape to its former use following construction. • Locate construction compounds adjacent to existing infrastructure and away from undeveloped areas e.g. parkland landscape, the river floodplain, ancient woodland. • Preserve and enhance the key characteristics of the areas historic landscape and rural character. • Provision of managed access or a diversion of PRoWs during construction. • Avoid prolonged closure of footpaths.
Brookmans Park Service Reservoir Connection	Landform • Return the land to the existing levels following construction. Land cover / use • Avoid crossing areas of woodland especially ancient woodland; • Careful siting of construction traffic routes to minimise landscape and visual impacts of traffic movements and reduction in tranquillity. • Allow for changes to the width of the working corridor to maintain existing land use and in particular vegetation cover and field boundary vegetation.

Component	Recommended mitigation for potential effects
	• Locate temporary construction compounds in areas of low landcover value. • Improve landcover value by planting new areas of vegetation including woodland and hedgerows. • Restore land to its former use following construction. • Reinstate field boundaries where removed. Vegetation and water • Avoid construction within areas of ancient woodland or within root protection zones. • Adjust the pipeline route to avoid removal of vegetation and avoid root protection zones where possible. • Adjust the pipeline route to cross the watercourse where there is little or no vegetation. • Avoid running parallel to watercourses for long stretches. • Replace vegetation removed during construction. • Narrow the working corridor where crossing vegetated areas in order to reduce vegetation loss. • Sympathetic design of pipeline intersection points with existing watercourses to minimise visual impact. • Link mitigation woodland and other screen planting to existing nearby woodland belts and vegetation to aid landscape integration. Characteristic views • Avoid siting construction compounds at prominent locations on the ridgeline. • Avoid siting construction compounds close to the edge of the settlement at Goffs Oak. • Avoid removal of woodland to the north of Goffs Oak / Cuffley Hill. • Avoid removal of existing screening vegetation around infrastructure elements. Perceptual and experiential qualities • Locate construction compounds adjacent to existing infrastructure elements and away from recreational routes and residential receptors. • Locate pipelines away from PRoWs which would greatly reduce perceptual and experiential value for footpath users, albeit temporarily. • The removal of vegetation along PRoWs may permanently lower perceptual and experiential value for footpath users. • The removal of screening vegetation along existing infrastructure and detracting elements should be avoided and, if not possible to avoid, reinstated following construction.

Component	Recommended mitigation for potential effects
	• Minimise lighting in construction and operation to avoid introducing additional lighting in the vicinity of residential receptors. Landscape assets/designations • Keep working width to a minimum and restore landscape to its former use following construction. • Provision of managed access or a diversion of PRoWs during construction. • Avoid prolonged closure of footpaths.
Drinking Water Transfer Main Route Corridor (M25 Crossing to Brookmans Park Service Reservoir)	None
Drinking Water Transfer Main to North Mymms Route Corridor	Landform • Return the land to the existing levels following construction. Land cover / use • Avoid crossing areas of woodland especially ancient woodland. • Allow for changes to the width of the working corridor to maintain existing land use and in particular vegetation cover and field boundary vegetation. • Locate construction compounds in areas of low landcover value. • Improve landcover value by planting new areas of vegetation including woodland and hedgerows. • Restore land to its former use following construction. • Reinstate field boundaries and vegetation at settlement edges where removed. Vegetation and water • Avoid removal of trees within ancient woodland at Brick Kiln Wood and Peplin's Wood. • Avoid removal of trees within the road and rail corridors. • Replace vegetation removed during construction. • Narrow the working corridor where crossing vegetated areas in order to reduce vegetation loss. • Link mitigation woodland and other screen planting to existing nearby woodland belts and vegetation to aid landscape integration. Characteristic views • Avoid siting construction compounds at prominent locations on higher ground.

Component	Recommended mitigation for potential effects
	• Avoid removal of existing screening vegetation around infrastructure elements. Perceptual and experiential qualities • Locate construction compounds adjacent to existing infrastructure elements and away from recreational routes and residential receptors; • Locate pipelines away from PRoWs which would greatly reduce perceptual and experiential value for footpath users, albeit temporarily. • The removal of vegetation along PRoWs may permanently lower perceptual and experiential value for footpath users. • The removal of screening vegetation along existing infrastructure and detracting elements should be avoided and, if not possible to avoid, reinstated and enhanced following construction. • Minimise lighting in construction and operation to avoid introducing additional lighting in the vicinity of residential receptors. Landscape assets/designations • Keep working width to a minimum and restore landscape to its former use following construction. • Locate construction compounds adjacent to existing infrastructure and away from undeveloped areas e.g. parkland landscape, the river floodplain, ancient woodland. • Provision of managed access or a diversion of PRoWs during construction. • Avoid prolonged closure of footpaths and cycle routes.
North Mymms Booster Station Connection	None

9.5.2 Mitigation for protected trees

9.46. Ancient woodland is irreplaceable and so the loss or deterioration resulting from the development is not currently considered an option. Therefore, compensation measures are not considered as part of the assessment at this stage.

9.47. Guidance[71] states that for ancient woodlands, ancient trees, and veteran trees, developments should have a buffer zone of at least 15 metres from the boundary of the woodland to prevent significantly damaging the root system (known as the root protection area, RPA). For ancient or veteran trees (including those on the woodland boundary), the buffer zone should be at least 15 times larger than the diameter of the tree. The buffer zone should be a minimum of 5 metres from the edge of a tree canopy if that area is larger than 15 times the diameter of the closest tree stem. Where assessment shows other impacts are likely to extend beyond this distance, a larger buffer zone is likely to be needed.

9.48. Buffer zones should be created around the areas of ancient woodland where they are in close proximity to the footprint of construction works. The buffer zones should be 5 metres from the edge of the tree's canopy if that area is larger than 15 times the tree's diameter. Where a buffer zone cannot be created then a walked inspection should be undertaken to determine the level of impact and consultation undertaken with the Local Planning Authority.

9.49. Where possible, the Drinking Water Transfer Main Route Corridor should be rerouted to avoid trees within conservation areas. Where this is not practicable, consultation with the Local Planning Authority would be required. Where works may enter the RPA of trees in conservation areas, these areas should be physically inspected via a walkover assessment by a qualified arboriculturist to determine the level of impact.

9.50. For works in conflict or close to TPOs, above ground infrastructure site layout should be designed, and the Raw and Drinking Water Transfer Main Route Corridors rerouted, to avoid works close to TPOs. Where this is not possible, RPAs of the trees are to firstly be avoided, if this is not practicable and TPOs are within 15m of the works footprint, any RPAs are to be protected by barriers. All protective barriers should be installed prior to works commencing and maintained for the duration of the construction works in accordance with BS 5837:2012.

9.5.3 Enhancement opportunities

9.51. Table 9.13 presents potential landscape enhancement opportunities that should be explored as the design develops at a subsequent project stage.

[71] Natural England and Forestry Commission (2022) Ancient woodland, ancient trees and veteran trees: advice for making planning decisions. Available at: https://www.gov.uk/guidance/ancient-woodland-ancient-trees-and-veteran-trees-advice-for-making-planning-decisions [Accessed April 2022]

Table 9.13: Potential landscape enhancement opportunities

Component	Enhancement opportunities
Indicative Intake Location and Indicative Raw Water Pumping Station Site	• Look for opportunities to reduce the proportion of hard surfacing to soft landscape to increase the landcover value within the proposed temporary and permanent sites. • Look for opportunities to strengthen the green corridor and enhance landcover value. • Allow for rewilding of the temporary site following the completion of the construction phase to enhance landcover and biodiversity value.
Raw Water Transfer Main Route Corridor	• Opportunities to enhance nearby hedgerows, riparian vegetation and strengthen connections within the blue-green network. • Opportunities to enhance nearby sections of the long distance footpaths in terms of planting, resurfacing, information boards, way markers and social enhancements.
Indicative WTW Site	None
Drinking Water Transfer Main Route Corridor (Indicative WTW Site to M25 Crossing)	• Opportunity to enhance the setting of Whitewebbs Wood ancient woodland. • Opportunities to enhance nearby hedgerows, riparian vegetation and strengthen connections within the blue-green network. • Opportunities to improve local views and further screen infrastructure elements such as the M25. • Opportunities to enhance nearby sections of the long distance footpaths in terms of planting, resurfacing, information boards, way markers and social enhancements.
Brookmans Park Service Reservoir Connection	None
Drinking Water Transfer Main Route Corridor (M25 Crossing to Brookmans Park Service Reservoir)	• Opportunity to enhance the setting of ancient woodland at Great/Broombarns Wood. • Opportunities to enhance nearby hedgerows, riparian vegetation and strengthen connections within the blue-green network. • Opportunities to enhance nearby sections of the long distance footpaths in terms of planting, resurfacing, information boards, way markers and social enhancements.

Component	Enhancement opportunities
Drinking Water Transfer Main to North Mymms Route Corridor	• Opportunity to enhance the setting Brick Kiln Wood and Peplin's Wood ancient woodland. • Opportunities to enhance nearby hedgerows and strengthen connections within the blue-green network. • Opportunities to enhance nearby sections of the long distance footpaths in terms of planting, resurfacing, information boards, way markers and social enhancements.
North Mymms Booster Station Connection	None

9.6 Summary of main findings and recommendations for future technical work

9.52. Construction of the River Lee Intake would require the temporary closure of a PRoW and, together with construction of the Raw Water Pumping Station, has the potential to change the setting of the area of Special Landscape Character (London Borough of Enfield) and reduce tranquillity within the green belt and river corridors due to the presence of construction activity. Removal of trees and woodland within the floodplain would open views from the river corridor to the light industrial buildings, road infrastructure and business units on the A112 Sewardstone Road.

9.53. Construction of the Raw Water Transfer Main, Drinking Water Transfer Main and Drinking Water Transfer Main to North Mymms has the potential to result in a temporary change to the land use and to the varied landforms of the recreational landscape of the River Lee valley and Hertfordshire Plateau, due to large scale excavation and stockpiling of materials within the working corridor, all of which lies within the London Green Belt. The temporary diversion or closure of footpaths and cycleways, including the London Loop, NCN route 1, Hertfordshire Chain Walk, Hertfordshire Way and NCN route 12, would temporarily reduce recreational connectivity.

9.54. Construction of the Raw Water Transfer Main, Drinking Water Transfer Main and Drinking Water Transfer Main to North Mymms has the potential to result in the loss of vegetation both in the working corridor and where temporary construction compounds are located. This is of particular concern along watercourses, field boundaries and where vegetation has a screening effect, for example in screening existing roads (such as the M25 and A1000) and rail infrastructure. There is potential for loss of vegetation and disturbance to the setting of ancient woodlands at Whitewebbs Wood, Cattlegate Wood, Hook Wood, Great/Broombarns Woods, Peplin's Wood and Brick Kiln Wood. Perceptual and experiential value may be

adversely affected in the vicinity of PRoWs and residential properties as a result of the presence of construction activity which may result in a reduction in tranquillity of the landscape.

9.55. There is potential for permanent loss of areas of woodland and riparian vegetation along the River Lee, Black Ditch, River Lee Navigation, Small River Lee, Turkey Brook, Cuffley Brook, Northaw Brook and Ray Brook and the introduction of man-made culverts at the intersection of the pipeline with these watercourses, which unless designed sympathetically, would locally detract from the character of the river corridors. Removal of roadside vegetation, most notably along the M25 corridor and A1000 Great North Road, has the potential to open up views of detracting elements for residential and recreational receptors. Removal of roadside vegetation and trees within residential areas would result in an adverse effect on the townscape character.

9.56. Although the pipeline would be buried below the surface of the ground, the pipeline corridor may be evident where vegetation is lost during construction along watercourses and PRoWs, in particular where vegetation such as trees and woodland cannot be replaced because it falls within the pipeline easement. This may result in a permanent change to the character along stretches of watercourses and PRoWs, which may in turn affect their perceptual and experiential value for users of the PRoWs and waterside footpaths.

9.57. Construction of the new WTW would involve the removal of areas of existing vegetation and, as a result, there would be localised, adverse landscape effects. The Indicative WTW Site is proposed on a site predominantly of existing industrial/commercial use and the introduction of a new WTW would not be considered a notable change in land use within the landscape context.

9.58. The study area is divided into two distinct areas: the southern section lies within the urban area of greater London, and the northern section lies beyond the M25 corridor and has a more rural character. As such, visual receptors are typical of the urban and urban/rural interface and include (but are not limited to) residential receptors; recreational receptors, including users of public rights of way, cyclists, visitors to country parks, recreational users of the waterways and people engaging in outdoor recreation at formal sports facilities; transport receptors, including users of the road and rail networks; and employment and education receptors. These types of visual receptors would be considered and potentially taken through to assessment at a subsequent project stages, once more detailed design information is available.

9.59. Construction of the Raw Water Transfer Main, Drinking Water Transfer Main and Drinking Water Transfer Main to North Mymms has the potential to impact protected trees including those within conservation areas and with TPOs.

9.60. There are wider opportunities within the Beckton Reuse Indirect Option to enhance landcover value and strengthen the blue-green network, for example through use of re-wilding techniques in the restoration of temporary compound areas and use of mitigation planting to link existing green infrastructure elements across the wider

landscape.

9.61. Recommended future technical work at a subsequent project stage includes the following:

- Refining the pipeline construction corridor and location of above ground structures to reduce the likely loss of vegetation and impact to sensitive landscape features.
- Once the location of above ground structures has been refined, a ZTV should be produced to aid identification of possible visual receptors.
- Site visits should be to be carried out along the refined pipeline route corridor to confirm the findings of this desk based assessment and the ZTV.
- Design landscape mitigation to integrate the above ground structures into the landscape and replace any vegetation removed during construction within the working corridor.
- To support to the detailed design phase of the Beckton Reuse Indirect Option, it is recommended that a full BS5837:2012 survey is conducted at a subsequent project stage, and an arboricultural impact assessment and tree protection plan produced. Where sensitive sites cannot be avoided, extra mitigation is likely to be required to minimise impacts during the construction phase.

10 Historic environment

10.1 Introduction

10.1. This chapter presents the results of a desk-based assessment undertaken to identify potential impacts on heritage assets from the transfer route corridors and above ground infrastructure including the WTW. The objectives of the desk-based assessment were to set out the characteristics of the historic environment and the key heritage assets associated with the Beckton Reuse Indirect Option, identify constraints and opportunities, and identify the issues and heritage assets that may require further investigation at a subsequent project stage.

10.2. The need to consider the historic environment is driven by legislation (Ancient Monuments and Archaeological Areas Act 1979 and Planning (Listed Buildings and Conservation Areas) Act 1990) and planning policy, including the draft NPS for Water Resource Infrastructure[18] (Section 4.7, Historic Environment) and NPPF[19] (Section 16 (conserving and enhancing the historic environment), paragraphs 189-208).

10.2 Methodology

10.2.1 Study area and sources of information

10.3. The desk-based assessment focused on the transfer route corridors, location of associated infrastructure and the surrounding area within 500m for designated heritage assets, and 200m for non-designated heritage assets. This search radius was considered sufficient to produce a comprehensive baseline and allowed for an understanding of the archaeological potential and historic significance to be established, and subsequently for appropriate mitigation to be recommended. Where heritage assets with the study areas are identified as being subject to potential impacts, consideration of those impacts also included the impacts on setting, which may extend beyond the extent of the study areas described above.

10.4. Table 10.1 outlines the baseline data sources which were collated and considered in the desk-based assessment.

Table 10.1: Sources of information (historic environment)

Data collected	Source
Historic environment – designated assets	
World Heritage Sites	• National Heritage List for England (NHLE) data download[72]
Listed buildings	
Scheduled monuments	
Registered parks and gardens	
Registered historic battlefields	
Conservation areas	
Historic environment – non-designated assets	
Locally listed buildings	Local Planning Authorities
Non-designated heritage assets	• Datasets held by the Greater London Historic Environment Record (GLHER), Hertfordshire and Essex Historic Environment Record (HER). • National Mapping Programme data • Historic maps • LiDAR data from the Environment Agency database • The British Geological Society (BGS)

10.2.2 Approach to impact appraisal

10.5. The desk-based assessment used a qualitative approach to appraise the Beckton Reuse Indirect Option and identify where there is potential for historic environment impacts, recognising the difference between impacts occurring at the construction phase and those occurring at the operational phase.

10.6. An understanding of the value of heritage assets was required to assess the potential impact of the Beckton Reuse Indirect Option on the historic environment. Where the value of heritage assets was discussed, the following criteria was used:

[72] Historic England, Open Data from Historic England. Available at: https://historicengland.org.uk/listing/the-list/data-downloads/ [Accessed April 2022]

- High Value – a designated heritage asset of potentially national importance, including scheduled monuments, grade I and grade II* registered parks and gardens and grade I and II* listed buildings and structures.
- Moderate Value – a heritage asset of regional importance, including non-designated assets, conservation areas and listed buildings and registered parks and gardens with a grade II designation.
- Low value – non designated assets of local importance or no notable significance.

10.2.3 Assumptions and limitations

10.7. Information provided by the HER can be limited because it depends on previous opportunities for research, fieldwork and discovery. Where nothing of historic interest was shown in a particular area, this could have been down to lack of targeted research or investigation rather than the genuine absence of sub-surface archaeological deposits.

10.8. Documentary sources are rare before the medieval period, and many historic documents are inherently biased. Older primary sources often fail to accurately locate sites and interpretation can be subjective.

10.9. Historic maps provide a glimpse of land-use at a specific moment. It is therefore possible that short-term structures or areas of land-use are not shown and therefore not recorded within this assessment.

10.3 Understanding of the baseline

10.3.1 Designated assets

10.10. There are no World Heritage Sites located within the 500m study area.

10.11. There are three Scheduled Monuments within 500m of the Drinking Water Transfer Main Route Corridor (Elsyng Palace, World War II Heavy Anti-aircraft gunsite at Burnt Farm Camp and Coldharbour Moat), as shown on Figure 10.1: Designated heritage assets. All Scheduled Monuments are considered of high heritage value because of their archaeological importance on a national scale.

10.12. There are two Grade II Registered Parks and Gardens within 500m of the Drinking Water Transfer Main Route Corridor (Forty Hall and Myddleton House), as shown on Figure 10.1: Designated heritage assets. Grade I and Grade II* Registered Parks and Gardens are considered of high heritage value because of their heritage importance

on a national scale. Grade II Registered Parks and Gardens are considered of medium heritage value because of their heritage importance on a regional scale.

10.13. There are 60 Listed Buildings located within the 500m study area, with the majority of these within 500m of the Drinking Water Transfer Main Route Corridor, as shown on Figure 10.1: Designated heritage assets. Grade I and Grade II* Listed Buildings are considered of high heritage value because of their heritage importance on a national scale. Grade II Listed Buildings are considered of medium heritage value because of their heritage importance on a regional scale.

10.14. There are two conservation areas within the 500m study area, as shown on Figure 10.1: Designated heritage assets. These are Turkey Street and Forty Hill. All conservation areas are considered of moderate heritage value because of their heritage importance on a regional scale.

10.3.2 Non-designated assets

10.15. There are 138 non-designated assets within the 200m study area, as mapped by Epping Forest District Council, and in the Essex HER, the GLHER and Hertfordshire HER.

10.3.2.1 Locally listed buildings

10.16. There is one Locally Listed Building within the 200m study area, as designated by Epping Forest District Council. The Clock House is located to the south of the Indicative Raw Water Pumping Station Site and Raw Water Transfer Main Route Corridor.

10.3.2.2 Lea Valley West Bank Archaeological Priority Area (Greater London)

10.17. The Drinking Water Transfer Main Route Corridor crosses the north of the Lea Valley Archaeological Priority Area (APA), HER ref: DLO35151, on an east-west alignment. The area is recognised as one with extensive river valley deposits with high prehistoric and paleoenvironmental potential.

10.3.2.3 Whitewebbs Hill, Bulls Cross and Forty Hill (Greater London)

10.18. The Drinking Water Transfer Main Route Corridor crosses the Whitewebbs Hill, Bulls Cross and Forty Hill APA (HER ref. DLO35150), running almost perpendicular with the APA's northern border. The area is recognised as a multi-period site including Ermine

Street (Roman road), medieval manors, post medieval Elsynge Palace and Flash Road Aqueduct (scheduled monument), Clay Hill and Forty Hill settlements.

10.3.2.4 Areas of archaeological interest (Broxbourne Borough Council)

10.19. The Broxbourne Local Plan[73] (Policy number HA9) has highlighted 34 Areas of Archaeological Interest throughout the borough, three of which fall within 200m of the Drinking Water Transfer Main Route Corridor:

- Area 30: The historic farm site of Burnt Farm
- Area 23: Remains of a lodge to Theobalds Park
- Area 19: World War II military remains of national importance

10.3.3 Archaeological potential

10.20. The area around the Lea Valley West Bank APA has been flagged as having high potential for archaeological remains of prehistoric date, particularly where the Drinking Water Transfer Main Route Corridor runs through undeveloped land such as Gunpowder Park. Remains would likely comprise evidence of prehistoric exploitation of the River Lee as well as paleoenvironmental remains preserved in the waterlogged deposits of alluvium. There is a moderate potential for prehistoric remains across the rest of the Raw and Drinking Water Transfer Main Route Corridors; prehistoric activity has been recorded as part of multiperiod sites across the study area, although there is less recorded evidence towards the north west of the Drinking Water Transfer Main Route Corridor.

10.21. The former Roman Road Ermine Street exited Londinium at Bishopsgate and was the main road from London to Lincoln and York, and roughly follows the same alignment as Bull's Cross. This area also falls within the Whitewebbs Hill, Bulls Cross and Forty Hill APA, an area designated for its high potential for archaeology, Ermine Street included. There is therefore a high potential for evidence of the road itself, or for smaller roadside settlements or activity. Small settlements were common along the main Roman Roads leading into London, providing the city with agricultural produce from its rural outskirts. Across the rest of the Drinking Water Transfer Main Route Corridor, Roman activity has been recorded as part of multi-period sites, and so in undeveloped areas, the potential for Roman remains is moderate.

10.22. There is generally a low potential for remains of early medieval date. Evidence for early medieval activity in the study area is limited to a sunken Saxon building in the

[73] Broxbourne Borough Council (2020) Broxbourne Local Plan. Available at: https://www.broxbourne.gov.uk/downloads/file/1813/local-plan-2018-2033 [Accessed April 2022]

area of the Drinking Water Transfer Main Route Corridor that is now largely developed.

10.23. There is a moderate potential for remains of a medieval date. Medieval remains have been recorded as part of multiperiod sites across the Drinking Water Transfer Main Route, and the Whitewebbs Hill, Bulls Cross and Forty Hill APA recognises the potential for medieval manors in the east of the study area. A possible moated medieval manor has also been identified at Coldharbour Farm towards the western end of the Drinking Water Transfer Main Route Corridor. Medieval agricultural practices such as ridge and furrow survive as earthworks and cropmarks at a number of locations across the Drinking Water Transfer Main Route Corridor and will still survive well in undeveloped areas.

10.24. There is a high potential for remains of post-medieval date across the Raw and Drinking Water Transfer Main Route Corridors. The HER has recorded several assets of post-medieval date including post-medieval manors and estates within 200m of the Raw and Drinking Water Transfer Main Route Corridors and phased post-medieval development has been recorded in archaeological excavations at various locations within the 200m study area. A large portion of the Drinking Water Transfer Main Route Corridor passes through Hatfield Great Park (HER no. MHT6510), a very large former deer park, evidence for which may survive as buried features in undeveloped areas of the route corridor.

10.25. There is a high potential for modern remains within Drinking Water Transfer Main Route Corridor, where the Hertfordshire HER maps several heritage assets of a military nature, including anti-tank obstacles, anti-tank ditches and pillboxes. Modern remains of wartime date are considered to be of limited archaeological significance as they provide an insight to the local methods of defence during this period.

10.4 Appraisal outcomes

10.4.1 Indicative Intake Location and Indicative Raw Water Pumping Station Site

10.4.1.1 Construction

10.26. No designated heritage assets are anticipated to be directly impacted during construction phase of the River Lee Intake and Raw Water Pumping Station. However, construction activities have the potential to temporarily alter the setting of Luthers Grade II* Listed Building through noise, visual and light intrusion. The locally listed building Clock House is considered to be sufficiently screened by vegetation and development to not be impacted by the construction of the River Lee Intake.

10.27. The construction phase has the potential to permanently impact archaeological remains, if present, by severely truncating them or removing them entirely. This might include evidence for the early prehistoric exploitation of the Lea Valley.

10.4.1.2 Operation

10.28. Any above ground structures associated with Indicative Intake Location and the Raw Water Pumping Station have the potential to permanently and adversely alter the setting of Luthers Grade II* Listed Building, through visual intrusion. Otherwise, there are no anticipated impacts to heritage assets whilst these assets are in operation.

10.4.2 Raw Water Transfer Main Route Corridor

10.4.2.1 Construction

10.29. No designated heritage assets are anticipated to be directly impacted by the construction of the Raw Water Transfer Main. However, construction activities have the potential to temporarily alter the settings of listed buildings through noise, visual and light intrusion, particularly those that are intervisible with the Raw Water Transfer Main Route Corridor.

10.30. The depth of the open cut trench is anticipated to be excavated to a depth of 0.9 to 1.2m, depending on the current land use. This would remove all potential archaeological remains within its footprint, particularly in undeveloped areas where archaeology is likely to survive relatively close to the surface, and particularly in areas that have been recognised by the local authority as having a high archaeological potential.

10.31. Any top soil strip involved with the installation of compound and welfare sites along the pipeline route also has the potential to remove archaeological remains that survive close to the surface.

10.4.2.2 Operation

10.32. Any above ground structures associated with the pipeline have the potential to permanently and adversely alter the setting of listed buildings that are intervisible with them, through visual intrusion. Otherwise, there are no anticipated impacts to heritage assets whilst the Raw Water Transfer Main is in operation.

10.4.3 Indicative Water Treatment Works Site

10.4.3.1 Construction

10.33. No designated heritage assets are anticipated to be directly impacted by the construction of the Indicative WTW Site. However, there would be very minor changes to the setting of the Grade II listed Netherhouse Farmhouse as a result of the construction phase of WTW site CON_01 through noise intrusion caused by construction activities.

10.34. The groundworks involved in the construction phase of the Indicative WTW Site have the potential to permanently impact archaeological remains, if present, by severely truncating them or removing them entirely. This might include remains of a deserted medieval settlement, should they survive, as mapped in this location by Essex HER.

10.4.3.2 Operation

10.35. The presence of the new WTW site is anticipated to result in minimal changes to the setting of the Grade II listed Netherhouse Farmhouse whilst in operation, assuming that the new WTW infrastructure does not exceed the height of the buildings that currently separate the Indicative WTW Site and the listed building.

10.36. There would be no further impact to archaeological remains during the operation of the Indicative WTW Site.

10.4.4 Drinking Water Transfer Main Route Corridor

10.4.4.1 Construction

10.37. No designated heritage assets are anticipated to be directly impacted during construction of the Drinking Water Transfer Main. However, construction activities have the potential to temporarily alter the settings of listed buildings and Registered Parks and Gardens and Scheduled Monuments through noise, visual and light intrusion, particularly those that are intervisible with the Drinking Water Transfer Main Route Corridor.

10.38. The Drinking Water Transfer Route Corridor passes through Forty Hill Conservation Area and Turkey Street Conservation Area, as designated by London Borough of Enfield. Whilst nothing of historic interest relating to the conservation areas would be directly impacted during construction of the pipeline, their settings would be changed through visual and noise intrusion as a result of construction activities.

10.39. The depth of the open cut trench is anticipated to be excavated to a depth of 0.9 to 1.2m, depending on the current land use. This would remove all potential archaeological remains within its footprint, particularly in undeveloped areas where archaeology is likely to survive relatively close to the surface.

10.40. Any top soil strip involved with the installation of compound and welfare sites along the Drinking Water Transfer Main Route Corridor also has the potential to remove archaeological remains that survive close to the surface.

10.4.4.2 Operation

10.41. Any above ground structures associated with the Drinking Water Transfer Main Route Corridor have the potential to permanently and adversely alter the setting of listed buildings, conservation areas, Registered Parks and Gardens and Scheduled Monuments that are intervisible with them, through visual intrusion. Otherwise, there are no anticipated impacts to heritage assets whilst the Drinking Water Transfer Main is in operation.

10.4.5 Brookmans Park Service Reservoir Connection

10.4.5.1 Construction

10.42. No designated heritage assets are anticipated to be impacted during construction of the Brookmans Park Service Reservoir Connection.

10.43. Brookmans Park Service Reservoir Connection falls within the southern boundary of Hatfield Great Park, a historic asset mapped by the Hertfordshire HER. The Beckton Reuse Indirect Option would not require any changes to the Brookmans Park Service Reservoir. Minor construction works to facilitate the Brookmans Park Service Reservoir Connection have the potential to permanently impact archaeological remains, if present, by severely truncating them or removing them entirely.

10.4.5.2 Operation

10.44. There are no anticipated impacts to heritage assets whilst the Brookmans Park Service Reservoir Connection is in operation.

10.4.6 Drinking Water Transfer Main to North Mymms Route Corridor

10.4.6.1 Construction

10.45. No designated heritage assets are anticipated to be directly impacted by the construction of the Drinking Water Transfer Main to North Mymms. However, construction activities have the potential to temporarily alter the settings of Listed Buildings and through noise, visual and light intrusion, particularly those that are intervisible with the Drinking Water Transfer Main to North Mymms Route Corridor.

10.46. The depth of the open cut trench is anticipated to be excavated to a depth of 0.9 to 1.2m, depending on the current land use. This would remove all potential archaeological remains within its footprint, particularly in undeveloped areas where archaeology is likely to survive relatively close to the surface.

10.47. Any top soil strip involved with the installation of compound and welfare sites along the pipeline route also has the potential to remove archaeological remains that survive close to the surface.

10.4.6.2 Operation

10.48. Any above ground structures associated with the pipeline have the potential to permanently and adversely alter the setting of listed buildings that are intervisible with them, through visual intrusion. Otherwise, there are no anticipated impacts to heritage assets whilst the Drinking Water Transfer Main to North Mymms is in operation.

10.4.7 North Mymms Booster Station Connection

10.4.7.1 Construction

10.49. The Beckton Reuse Indirect Option would not require any changes to the North Mymms booster pumping station. Minor construction works to facilitate North Mymms Booster Station Connection have the potential to permanently impact archaeological remains, if present, by severely truncating them or removing them entirely.

10.4.7.2 Operation

10.50. There are no anticipated impacts to heritage assets whilst the North Mymms Booster Station Connection is in operation.

10.5 Recommended mitigation and enhancement opportunities

10.5.1 Mitigation

10.51. The following are potential avoidance, mitigation, and compensation measures that could be implemented to address the potential impacts.

10.52. Design considerations should aim to minimise change within the setting of designated heritage assets, with particular consideration to listed buildings which fall within or immediately adjacent to the Beckton Reuse Indirect Option.

10.53. Strategic planting and other landscaping between the Indicative WTW Site and designated assets may soften the visual impact, especially in conjunction with design measures for the buildings. However, a number of these designated assets are located in open landscape and excessive planting may have an adverse effect on their character. The visual impact should be softened as much as possible by introducing landscaping features such as bunds; however, the mitigation factor which would have the greatest effect on reducing the potential for impact is the design, height and massing of the buildings and structures within the new WTW site.

10.54. Buildings or structures over 10m within the new WTW site should be designed to be the minimal feasible height, to further reduce impact on the setting of heritage assets. The exterior of tall elements should be designed to retreat into the landscape, for example by using gradated painting.

10.55. Archaeological investigation would be required at a subsequent project stage. The extent of this investigation would be dependent on the results of further assessment and site survey, as well as consultation with the relevant stakeholders. This is likely to include geophysical survey and archaeological trial trenching as a minimum. Archaeological investigation, importantly, does not amount to mitigation as the remains would still be removed during construction; the potential for impact to the buried archaeological remains is therefore the same. However, this does not undermine the importance of undertaking archaeological investigation.

10.56. Geophysical survey, trial trenching and/or other survey may identify areas of greater archaeological potential or specific remains of moderate value within the site area. This may allow for the targeting of building and service locations to reduce impact on buried archaeology. However, as the landscape contains a high density of remains

and the historic environment is not the only factor of consideration in the scheme design, this is unlikely to materially reduce the potential for impact.

10.6 Summary of main findings and recommendations for future technical work

10.57. There are 60 Listed Buildings, three Scheduled Monuments, two conservation areas and two Registered Parks and Gardens within 500m of the Beckton Reuse Indirect Option. There are no World Heritage Sites within this area. No direct effects on the designated heritage assets in the study area are anticipated. The presence of the new WTW is anticipated to result in minimal changes to the setting of Netherhouse Farmhouse Grade II Listed Building whilst in operation, assuming that the new WTW infrastructure does not exceed the height of the buildings that currently separate the Indicative WTW Site and the listed building.

10.58. There are 138 non-designated heritage assets within 500m of the Beckton Reuse Indirect Option, as mapped by Epping Forest District Council, the GLHER, Essex HER and Hertfordshire HER. Data within these HERs, along with archaeological excavation reports, has identified a generally high potential for archaeological remains of all periods, with the exception of early medieval. Archaeological potential is less understood along the northern extent of the transfer route corridors, in light of the paucity of archaeological investigation in this area.

10.59. The excavation required for the Raw Water Transfer Main, Drinking Water Transfer Main and Drinking Water Transfer Main to North Mymms and above ground infrastructure, including the Raw Water Pumping Station and new WTW would severely truncate, or remove entirely, potential archaeological remains.

10.60. Further assessment at a subsequent project stage would refine the need for archaeological investigation, in consultation with local archaeological advisors. A programme of geophysical survey in undeveloped areas, and test pitting in developed areas, would help identify the presence of archaeological remains. Should remains of potential high significance be identified, a diversion of the pipeline route should be considered, to facilitate preservation in situ. The results of the survey or test pitting would enable a programme of targeted archaeological investigation to be developed, such as targeted trial trench evaluation, to ensure no significant archaeological remains are removed without adequate record.

11 Noise

11.1 Introduction

11.1. This section presents the results of a desk-based assessment undertaken to identify potential noise and vibration impacts on sensitive receptors from the transfer route corridors and above ground infrastructure including the WTW. The objectives of the desk-based assessment were to establish an outline of the baseline noise environment associated with the Beckton Reuse Indirect Option, to the extent possible based on available data, identify the noise and vibration sensitive receptors, identify constraints and opportunities, and identify the issues that may require further investigation at a subsequent project stage.

11.2. The need to consider noise and vibration is driven by legislation (Environmental Protection Act 1990) and national planning policy (draft NPS for Water Resource Infrastructure[18] (Section 4.11, Noise and Vibration), NPPF[19] (Section 8, Promoting Healthy and Safe Communities) and the Noise Policy Statement for England[74] (NPSE).

11.2 Methodology

11.2.1 Study area and sources of information

11.3. The desk-based assessment focused on the transfer route corridors, location of associated infrastructure and the surrounding area within 300m where only daytime impacts are expected and 600m where night-time impacts may occur.

11.4. Potential vibration impacts were considered to a distance of 50m.

11.5. Table 11.1 outlines the baseline data sources which were collated and considered in the desk based assessment.

[74] Defra (2010) Noise Policy Statement for England (NPSE). Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/69533/pb13750-noise-policy.pdf [Accessed April 2022]

Table 11.1: Sources of information (noise and vibration)

Data collected	Source
Baseline Noise Data	Extrium Defra Noise Mapping Website Extrium > England Noise and Air Quality Viewer
Publicly available baseline noise data	Previous publicly available planning applications for proposed sites near the Beckton Reuse Indirect Option.
Receptor locations within 300m of the pipeline and above ground infrastructure	OS mapping, publicly available satellite imagery This was undertaken alongside Community and Health and Air Quality desk based assessments, to ensure a consistent set of receptors were used across the assessments.
Noise Action Planning Important Areas Round 3 England (2022)	Defra Noise Action Planning Important Areas Round 3 England[75]
Construction Plant Noise Levels	British Standard 5228-1:2009+A1:2014 entitled 'Code of practice for noise and vibration control on construction and open sites – Part 1: Noise
Construction Plant Vibration Levels	British Standard 5228-1:2009+A1:2014 entitled 'Code of practice for noise and vibration control on construction and open sites – Part 2: Vibration
Construction Methodology	Concept Design Team and experience from previous similar projects

11.2.2 Approach to impact appraisal

11.6. The desk based assessment for noise and vibration used a qualitative approach to appraise the Beckton Reuse Indirect Option and identify where there was potential for impacts and the likely mitigation that would be required.

[75] Defra Noise Action Planning Important Areas Round 3 England. Available at: https://www.data.gov.uk/dataset/948d6c4c-772e-4f55-9f39-97508e1cc701/noise-action-planning-important-areas-round-3-england [Accessed August 2022]

11.2.2.1 Operational noise

11.7. Once operational, the majority of the Beckton Reuse Indirect Option components would generate no noise. Any noise created would be generated by the above ground facilities. The nature of these facilities is fairly common place and well understood, and controlling noise from them is relatively routine and achieved by enclosure within buildings, acoustic enclosures, acoustic louvers and duct silencers for ventilation systems, vibration isolation and acoustic barriers etc. During the design process, noise limits would be set based on measured background noise levels and the above ground facilities would be designed to comply with those limits.

11.8. Therefore, for the purposes of the desk based assessment noise predictions from the above ground facilities have not been made. It has been assumed that they would be designed to meet the relevant planning criteria which are outlined below.

11.9. The aims of the NPSE[74] are:

'Through the effective management and control of environmental, neighbour and neighbourhood noise within the context of Government policy on sustainable development:

- avoid significant adverse impacts on health and quality of life;
- mitigate and minimise adverse impacts on health and quality of life; and
- where possible, contribute to the improvement of health and quality of life.'

11.10. Within the aims of the NPSE the key phrases 'significant adverse' and 'adverse' are introduced. NPSE refers to established concepts from toxicology to introduce the following terms:

- No Observed Effect Level (NOEL), the level below which no effect can be detected;
- Lowest Observable Adverse Effect Level (LOAEL), the level above which adverse effects on health and quality of life can be detected; and,
- Significant Observed Adverse Effect Level (SOAEL), the level above which significant adverse effects on health and quality of life occur.

11.11. No single objective noise measure defines a value of SOAEL that is applicable to all sources in all situations and no prescribed value is given for SOAEL in NSPE[74]. Instead NPSE acknowledges that it is "likely to be different for different noise sources, for different receptors and at different times". Local planning authorities are expected to produce their own guidance and values for LOAEL and SOAEL based on the principles of the NPSE.

11.12. In setting LOAEL and SOAEL many planning authorities make reference to or expect a parallel assessment in terms of BS4142:2014. Using BS4142, the level of sound from proposed new plant, the 'rating level', would be predicted in terms of the A-weighted

equivalent continuous sound level dBLAeq, and compared to the existing background sound level, in terms of LA90. The LA90 is to be representative of the period being assessed. If the new sound source is impulsive, intermittent, or tonal in nature, then a penalty is added to the 'rating level' to account for the character of the noise.

11.13. The outcome of the assessment is defined in BS4142:2014 with the following points that relate to the difference between the background noise level and the 'rating noise level':

- Typically, the greater this difference, the greater the magnitude of the impact.
- A difference of around +10 dB or more is likely to be an indication of a significant adverse impact, depending on the context.
- A difference of around +5 dB is likely to be an indication of an adverse impact, depending on the context.
- The lower the rating level is relative to the measured background sound level, the less likely it is that the specific sound source will have an adverse impact or a significant adverse impact. Where the rating level does not exceed the background sound level, this is an indication of the specific sound source having a low impact, depending on the context, which was informed using BS8233.

11.14. This type of assessment would be used in deriving noise limits for the above ground facilities which would be used as design constraints and would therefore ensure that no noise impacts would occur due to the operation of these facilities.

11.2.2.2 Construction noise

11.15. The most geographically extensive impacts resulting from the Beckton Reuse Indirect Option are likely to result from construction rather than operation. Potential construction impacts were appraised qualitatively with reference to B25228 Code of Practice for Noise and Vibration Control on Construction and Open Sites, Part 1 (noise) and Part 2 (vibration).

11.16. Appraisal of the potential impact of construction noise was done based on the ABC method from BS5228 Part 1 – where professional judgement may be used to identify the ambient noise level category based upon desktop review of the environment around the receptor using aerial photography, available noise mapping. The ABC method states the following:

'Table E.1 shows an example of the threshold of potential significant effect at dwellings when the site noise level (the noise level generated by the construction site), rounded to the nearest decibel, exceeds the listed value. The table can be used as follows: for the appropriate period (night, evening/weekends or day), the ambient noise level is determined and rounded to the nearest 5 dB.'

11.17. The receptor is then assigned a Category. The appropriate category is determined using the following three conditions:

- Category A: threshold values (Table 4.1 column 2) to use when ambient noise levels (when rounded to the nearest 5 dB) are less than 65 during Day, 55 during Evening and 45 at Night.
- Category B: threshold values (Table 4.1 column 3) to use when ambient noise levels (when rounded to the nearest 5 dB) are the same as 65 during Day, 55 during Evening and 45 at Night.
- Category C: threshold values (Table 4.1 column 4) to use when ambient noise levels (when rounded to the nearest 5 dB) are higher than 65 during Day, 55 during Evening and 45 at Night.

11.18. The category value is then compared with the predicted level of construction noise generated by the site. If the site noise level exceeds the appropriate category value, then a potential significant effect is indicated. The assessor then needs to consider other project-specific factors, such as the number of receptors affected and the duration and character of the impact, to determine if there is a significant effect.

11.2.3 Assumptions and limitations

11.19. At this stage, the actual construction methodology is not known, and noise level outline predictions were therefore based on construction methodologies from similar projects. The actual construction methodology used to construct the Beckton Reuse Indirect Option may be different.

11.20. At this stage, noise predictions cannot take account of all the factors which affect sound propagation such as; terrain screening, screening due to buildings, detailed ground absorption, etc. Predictions used in the appraisal assumed flat ground.

11.21. Baseline noise data was taken from Defra noise mapping which is based on computer noise modelling of road and rail traffic. The traffic data used will now be dated and terrain and building data used in the modelling was necessarily of low resolution. This modelling can only be viewed, therefore, as indicative.

11.22. Defra noise modelling only covers areas near motorways trunk roads and rail lines. Coverage of the Beckton Reuse Indirect Option is therefore incomplete.

11.23. Vibration impacts are extremely difficult to predict accurately even with a detailed construction methodology. With only an outline construction methodology, vibration predictions are indicative.

11.24. It is assumed that all works would take place during daytime. It is expected that ambient noise levels in most areas where construction would take place would be

below the Category A values which is 65dBA for daytime. Therefore, the threshold of noise impact would be 65dBA at most locations.

11.25. Exceptions to this may occur where the receptor is near roads such as the M25 and A10 which generate a high ambient noise level, in which case the noise category may be B or C and therefore the Threshold for significant Noise Impact may be 70dBA or 75dBA.

11.26. Vibration impacts are extremely difficult to predict accurately even with a detailed construction methodology. With only an outline construction methodology vibration predictions are indicative at this stage.

11.27. The Raw Water Transfer Main, Drinking Water Transfer Main and Drinking Water Transfer Main to North Mymms have been considered on the basis that the route corridor is fixed within certain limits but that the pipeline alignment may be varied within these limits. Based on plant used for similar projects the distance at which the threshold of significant noise impact has been calculated based on flat ground. As a guiding principle therefore the pipeline alignment should be placed at least 85m away from any receptor where normal open trench methods are used. Where trenchless techniques are used the launch pit should be at least 130m from the nearest receptor. Where this cannot be achieved within the corridor this is highlighted below in Section 11.4 as a potentially significant impact.

11.3 Understanding of the baseline

11.28. The majority noise sensitive receptors are residential premises. Other noise sensitive receptors include schools, nurseries, churches, hospitals, ecological receptors, and public open spaces, including PRoWs. Commercial receptors are considered less sensitive and have not been included here unless they also include residences such as farms and small family businesses. Potentially affected noise sensitive receptors are presented in Table 11.2. Please note that impacts on ecological receptors are considered in Chapter 4: Biodiversity, flora and fauna.

Table 11.2: Potentially affected noise sensitive receptors and baseline noise description for components of the Beckton Reuse Indirect Option

Component	Receptors within 300m buffer	Baseline noise description
Indicative Intake Location and Indicative Raw Water Pumping Station Site	Between 10 and 100 residential properties and two nurseries One SSSI One IBA	Residential/light industrial area, traffic noise from A112

Component	Receptors within 300m buffer	Baseline noise description
	Two non-statutory designated nature conservation sites PRoWs	
Raw Water Transfer Main Route Corridor	Over 100 residential properties and three nurseries One SSSI One IBA Four non-statutory designated nature conservation sites Public parks/gardens PRoWs	Residential/light industrial area, traffic noise from A112
Indicative WTW Site	Over 100 residential receptors Two non-statutory designated nature conservation sites Public parks/gardens PRoWs	Residential/light industrial area, traffic noise from A112
Drinking Water Transfer Main Route Corridor	Over 4,000 residential receptors and between 10 and 100 education facilities, less than 10 places of worship and less than 10 medical facilities Two SSSIs, one LNR, one NNR and one SAC 17 non-statutory designated nature conservation sites Allotments, public parks/gardens, play spaces, playing fields and golf courses PRoWs	Traffic noise from M25 Business park, traffic noise from M25 Light industrial noise from business park Residential area, commercial and traffic noise from A1010 and A10 Rural, traffic noise from M25 Residential/Rural area, traffic noise from Cuffley Hill Rural area, traffic noise from B158 Residential area, traffic noise from Great North Road
Brookmans Park Service Reservoir Connection	Less than 10 residential receptors PRoWs	Residential area, traffic noise from Great North Road
Drinking Water Transfer Main to North Mymms Route Corridor	Over than 100 residential receptors, two schools, a university, place of worship and a general practice surgery/clinic	Rural/ Residential area Rural area, traffic noise from A1

Component	Receptors within 300m buffer	Baseline noise description
	One SSSI Eight non-statutory designated nature conservation sites Golf course and playing field PRoWs	
North Mymms Booster Station Connection	Less than 10 residential receptors One SSSI Two non-statutory designated nature conservation sites PRoWs	Rural/ Residential area Rural area, traffic noise from A1

11.29. There are a number of Noise Important Areas (NIAs) within 300m of the Beckton Reuse Indirect Option. These are summarised in Table 11.3. NIAs are locations where the highest 1% of noise levels at residential locations can be found.

Table 11.3: Noise Important Areas within 300m buffer of the Beckton Reuse Indirect Option

Component	NIAs within 300m	Reason for NIA designation
Indicative Intake Location and Indicative Raw Water Pumping Station Site	Within 300m of NIA: 13505 Within 300m of NIA: 14750	Road noise (A112) Road noise (A112)
Raw Water Transfer Main Route Corridor	Within 300m of NIA: 13505 Within 300m of NIA: 14750 Within 300m of NIA: 14749	Road noise (A112) Road noise (A112) Road noise (A112)
Indicative WTW Site	Intersects NIA: 14749 Intersects NIA: 5714	Road noise (A112) Road noise (A112)
Drinking Water Transfer Main Route Corridor	Intersects NIA: 5714 Within 300m of NIA: 838 Within 300m of NIA: 1315 Within 300m of NIA: RI_180 Within 300m of NIA: 1186* Within 300m of NIA: 5716	Road noise (A112) Road noise (A121) Road noise (M25) Rail noise Road noise (M25) Road noise (M25)

Component	NIAs within 300m	Reason for NIA designation
Brookmans Park Service Reservoir Connection	None	N/A
Drinking Water Transfer Main to North Mymms Route Corridor	None	N/A
North Mymms Booster Station Connection	None	N/A

11.4 Appraisal outcomes

11.4.1 Indicative Intake Location and Indicative Raw Water Pumping Station Site

11.4.1.1 Construction

11.30. The Indicative Intake Location and Indicative Raw Water Pumping Station Site is located near Sewardstone in a semi-rural area but with light industrial units and residential dwellings along the A112. There are residential dwellings within 50m of the Indicative Raw Water Pumping Station Site. It is likely therefore that dwellings along the A112 in Sewardstone would be subject to temporary construction noise impacts. In addition, there is a PRoW running adjacent to the Indicative Intake Location.

11.31. Preliminary assessment of construction traffic indicates vehicles would access the Indicative Intake Location and Indicative Raw Water Pumping Station Site via the A112. Construction traffic routes are however not fully developed. There is potential for temporary adverse impacts at a small number of noise sensitive receptors located along the A112. The A112 to the south of the site at the junction of the A1037 carried approx. 11,307 vehicles per day in 2019. It is therefore likely that noise impacts due to construction traffic would be small depending on the time of day and the relative concentration of construction traffic.

11.32. Several construction phases would result in larger increases in construction traffic (e.g. during concrete pours) however the duration of these activities is unlikely to result in significant adverse effects due to construction traffic. Impacts are subject however to design of the construction routes.

11.4.1.2 Operation

11.33. The majority of the buried pipeline along the route would make no noise when installed and operational.

11.34. The Raw Water Pumping Station would be carefully designed with noise emissions in mind such that no adverse noise impact occurs. This would require these facilities to be designed such that the Rating Noise level emitted would be at or below, depending on local authority requirements, the local background LA90 at the receptor when assessed using BS 4142:2014+A1:2019 Methods for rating and assessing industrial and commercial sound. This would require a baseline noise survey to be conducted at residential receptors at a subsequent project stage to determine the background noise levels and inform detailed design.

11.35. Methods which would be employed to mitigate noise emitted by above ground facilities include:

- Acoustic enclosure of plant;
- Acoustic louvres, ducts silencers and plena for ventilation paths to enclosures and buildings;
- Vibration isolation of plant;
- Acoustic barriers.

11.36. All of these means of noise mitigation have been used extensively and are well understood and therefore any potential adverse noise impacts can be designed out. Given the relative proximity of residential receptors in Sewardstone, it is recommended that that a baseline noise survey should be conducted in the area at a subsequent project stage. The background level data obtained should then be used as a design constraint for the River Lee Intake and Raw Water Pumping Station.

11.37. Operational HDV movements are not likely to result in significant additional daily vehicle movements therefore changes in road traffic using the existing road network due to additional vehicle movements are unlikely to result in adverse noise effects.

11.4.2 Raw Water Transfer Main Route Corridor

11.4.2.1 Construction

11.38. Where the Raw Water Transfer Main Route Corridor is located away from noise sensitive receptors, the potential construction noise and vibration impacts would be minimised. However, temporary adverse impacts could occur where construction activities, including construction of the pipeline, is unavoidable close to noise sensitive receptors.

11.39. It has been assumed that where the route corridor is wide enough, the pipeline alignment can be located more than 85m from noise sensitive receptors and adverse noise effects can be largely avoided.

11.4.2.2 Operation

11.40. The buried pipeline along the Raw Water Transfer Main Route Corridor would make no noise when installed and operational.

11.41. Noise sources associated with operation of pipelines, or ancillary pumping stations along the pipeline, have the potential to result in adverse effects if located near to noise sensitive receptors. At this stage it is not known where these additional fixed plant items would be located, or noise levels generated by these elements.

11.4.3 Indicative WTW Site

11.4.3.1 Construction

11.42. There are residential dwellings in close proximity to the Indicative WTW Site. It is recommended that baseline noise surveys should be conducted and an assessment of temporary construction noise impacts be conducted at a subsequent project stage.

11.43. Preliminary assessment of construction traffic indicates vehicles would access the Indicative WTW Site via the A112. Construction traffic routes are however not fully developed. There is potential for temporary adverse impacts at a small number of noise sensitive receptors located along the A112. The A112 to the south of the site at the junction of the A1037 carried approx. 11,307 vehicles per day in 2019. It is therefore likely that noise impacts due to construction traffic would be small depending on the time of day and the relative concentration of construction traffic.

11.4.3.2 Operation

11.44. The new WTW would be carefully designed with noise emissions in mind such that no adverse noise impact occurs. This would require these facilities to be designed such that the Rating Noise level emitted would be at or below, depending on local authority requirements, the local background LA90 at the receptor when assessed using BS 4142:2014+A1:2019 Methods for rating and assessing industrial and commercial sound. This would require a baseline noise survey to be conducted at residential receptors at subsequent project stages at potentially affected to determine the background noise levels.

11.45. Methods which would be employed to mitigate noise emitted by above ground facilities include:

- Acoustic enclosure of plant;
- Acoustic louvres, ducts silencers and plena for ventilation paths to enclosures and buildings;
- Vibration isolation of plant;
- Acoustic barriers.

11.46. All of these means of noise mitigation have been used extensively and are well understood and therefore any potential adverse noise impacts can be designed out.

11.47. Operational HDV movements are not likely to result in significant additional daily vehicle movements therefore changes in road traffic using the existing road network due to additional vehicle movements are unlikely to result in adverse noise effects.

11.4.4 Drinking Water Transfer Main Route Corridor

11.4.4.1 Construction

11.48. Where the pipeline corridor is located away from noise sensitive receptors, the potential construction noise and vibration impacts are minimised. However, temporary adverse impacts could occur where construction activities, including construction of the pipeline, is unavoidable close to noise sensitive receptors.

11.49. It has been assumed that where the route corridor is wide enough the pipeline alignment can be located more than 85m from a noise sensitive receptor and adverse noise effects can be largely avoided. At this stage, it is considered that this would be possible for the majority of the Drinking Water Transfer Main Route Corridor and adverse noise effects can be largely avoided. However, it is not possible for the Drinking Water Transfer Main to be located over 85m away from noise sensitive receptors in some residential areas within Enfield where the pipeline is proposed to be aligned along roads and therefore there may be temporary noise effects.

11.4.4.2 Operation

11.50. The buried pipeline along the Drinking Water Transfer Main Route Corridor would make no noise when installed and operational.

11.51. Noise sources associated with the operation of pipelines, or ancillary pumping stations along the pipeline, have the potential to result in adverse effects if located near to noise sensitive receptors. At this stage it is not known where these additional

fixed plant items would be located, or noise levels generated by these elements.

11.4.5 Brookmans Park Service Reservoir Connection

11.4.5.1 Construction

11.52. The required construction works for the Brookmans Park Service Reservoir Connection are subject to detailed design and may comprise modifications to the existing pipework within the existing site boundary. It is anticipated that any temporary land required would be accommodated within the construction working width for the Drinking Water Transfer Main. There are residential receptors within proximity and, depending on the extent and nature of the construction works, there may be some temporary construction noise impacts in this location.

11.4.5.2 Operation

11.53. It is not anticipated that any modifications to the service reservoir in the vicinity of Brookmans Park would make any additional noise to the existing site.

11.4.6 Drinking Water Transfer Main to North Mymms Route Corridor

11.4.6.1 Construction

11.54. Where the pipeline corridor is located away from noise sensitive receptors, the potential construction noise and vibration impacts are minimised. However, temporary adverse impacts could occur where construction activities, including construction of the pipeline, is unavoidable close to noise sensitive receptors.

11.55. It has been assumed that where the route corridor is wide enough the pipeline alignment can be located more than 85m from a noise sensitive receptor. At this stage, it is considered that this would be possible for the Drinking Water Transfer Main to North Mymms Route Corridor and therefore adverse noise effects can be largely avoided.

11.4.6.2 Operation

11.56. The buried pipeline along the Drinking Water Transfer Main to North Mymms Route Corridor would make no noise when installed and operational.

11.57. Noise sources associated with the operation of pipelines, or ancillary pumping stations along the pipeline, have the potential to result in adverse effects if located near to noise sensitive receptors. At this stage it is not known where these additional fixed plant items would be located, or noise levels generated by these elements.

11.4.7 North Mymms Booster Station Connection

11.4.7.1 Construction

11.58. The required construction works for the North Mymms Booster Station Connection are subject to detailed design and may comprise modifications to the existing pipework. There are residential receptors within proximity and, depending on the extent and nature of the construction works, there may be some temporary construction noise impacts in this location.

11.4.7.2 Operation

11.59. It is not anticipated that any modifications to the booster pumping station in the vicinity of North Mymms would make any additional noise to the existing site.

11.5 Recommended mitigation

11.5.1 Construction noise mitigation

11.60. Where significant adverse noise and/or vibration impacts are identified for works within the construction phase cannot be avoided, appropriate mitigation measures should be applied including the use of Best Practicable Means (BPM) in accordance with BS5228-1&2:2009+A1:2014 guidance. Mitigation may comprise a number of measures including management of construction hours, selection of low noise and vibration construction plant, use of screening (enclosures, barriers, or bunds), noise and vibration monitoring.

11.61. Mitigation of construction traffic would include implementation of a Construction Management Plan.

11.62. Recommended mitigation measures are discussed below.

- Select a pipeline alignment to be at least 85m from dwellings and 130m from where trenchless techniques occur.

- Use any excess excavated material to construct temporary or permanent noise bunds where noise impacts are predicted.
- The effects of construction noise and vibration can be mitigated by good public relations and community liaison. Residents who are kept aware of the reasons for construction works, the expected duration of elevated noise or vibration and the date at which it will stop are more accepting of it than if the noise commences without warning or explanation and appears to be continuing for an indefinite period.
- BPM in terms of considerate working should be employed at all times. A letter box drop, and dedicated site contact for the public with a complaints handling procedure would also be put in place. The impact on noise sensitive receptors within the vicinity of the Scheme can be controlled when undertaken in accordance with good practice as set out in BS5228 parts 1 and 2.
- Typical means by which noise and vibration may be minimised include the following:
  - Selecting quiet equipment.
  - Ensure equipment is maintained, in good working order, and is used in accordance with the manufacturer's instructions.
  - Members of the construction team should be trained and advised on quiet working methods.
  - Equipment should not be left running unnecessarily.
  - Equipment should be fitted with silencers or mufflers.
  - Use plant enclosures whenever feasible.
  - Careful orientation of plant with directional features.
  - Materials should be lowered instead of dropped from height.
  - Inform nearby noise sensitive receptors in advance of construction activities and keep them up to date with progress and changes.
  - Give nearby noise sensitive receptors a site contact telephone number; the contact should liaise with residents and maintain good rapport.
  - Temporary noise barriers should be used where practicable.
  - Effective construction programme management with the aim of minimising the duration of construction near any particular receptor.

11.5.2 Mitigation for above ground infrastructure

11.63. Mitigation of operational noise would be applied through design to minimise potential adverse noise impacts at the nearest noise sensitive receptors. Measures may include selection of plant and equipment, location and orientation of fixed plant

items and use of screening (e.g., acoustic enclosures, barriers or bunds).

11.64. Other above ground facilities may be acoustically screened form residential receptors by earth bunds where feasible. These bunds may be placed early in the construction process such that they screen construction noise as well as later operational noise. Although narrow bands of tree planting has negligible effect on noise propagation, it does have a psychological benefit in that if the noise source is not visible it is perceived to be quieter to some extent.

11.65. Acoustic design input should be obtained during the design stages of the pumping station. The noisiest equipment should be located centrally within the site and very noisy equipment should be contained within substantial buildings/enclosures (not GRP kiosks) with ventilation paths Drinking with acoustic louvres, duct silencers.

11.6 Summary of main findings and recommendations for future technical work

11.6.1 Construction

11.66. By careful design, the noise impact of the Beckton Reuse Indirect Option could be minimised. The alignment of the Raw Water Transfer Main, Drinking Water Transfer Main and Drinking Water Transfer Main to North Mymms should be chosen to be at least 85m from noise sensitive receptors (130m where trenchless techniques occur) in order to minimise significant adverse noise impacts. This can be achieved along the vast majority of these corridors although there are some areas within Enfield where this is would not be possible and temporary noise effects may occur.

11.67. There are noise sensitive receptors within close proximity to the Indicative Raw Water Pumping Station Site and the Indicative WTW Site. It is likely therefore that there would be temporary construction noise impacts.

11.68. Once the final alignments of the transfer mains have been agreed, the areas where residual construction noise impacts may occur should be identified and the noise mitigation options to be included in a Construction Noise Management Plan considered.

11.69. At this stage, it is considered likely that baseline noise surveys and construction noise assessments would be required at a subsequent project stage since the potential for construction noise impacts has been identified.

11.6.2 Operational noise

11.70. All operational noise impacts for above ground infrastructure should be designed out through a number of methods including acoustic enclosure of plant, acoustic louvres, ducts silencers and plena for ventilation paths to enclosures and buildings, vibration isolation of plant and acoustic barriers, where required. All of these means of noise mitigation have been used extensively and are well understood and therefore any potential adverse noise impacts can be designed out.

11.71. At this stage, it is considered likely that baseline noise surveys and operational noise assessments would be required at a subsequent project stage since the potential for noise impacts has been identified. This would determine the background noise levels and inform detailed design. If required, baseline noise monitoring should be undertaken in order to set noise limits in accordance with BS4142: 2014 for operational noise in the area of all of the above ground facilities. Once the noise baseline has been established use the derived criteria as design constraints for these facilities.

12 Population and human health

12.1 Introduction

12.1. This chapter presents the results of a desk-based assessment undertaken to identify potential impacts on sensitive receptors from the transfer route corridors and above ground infrastructure including the WTW. The objectives of the desk-based assessment were to identify the key receptors and resources features associated with the Beckton Reuse Indirect Option, identify constraints and opportunities, and identify the issues that may require further investigation at a subsequent project stage.

12.2. The need to consider population and human health is driven by planning policy, including the draft NPS for Water Resource Infrastructure[18] (Section 4.10, Land use including open space, green infrastructure and Green Belt and 4.13, Socio-economic impacts) and NPPF[19] (Section 8 (promoting healthy and safe communities), Section 12 (achieving well-designed places), Section 15 (conserving and enhancing the natural environment), paragraph 185)).

12.2 Methodology

12.2.1 Study area and sources of information

12.3. The desk based assessment focused on the transfer route corridors, and the location of associated infrastructure. The study area for this topic is the route environmental corridors and a 500m buffer around the route environmental corridors and associated infrastructure.

12.4. Where sensitive receptors (specifically education and healthcare facilities) or regional tourist attractions, lie outside of this study area, but are accessed by communities using routes within the study area (that may be disturbed as part of construction works within the transfer route corridors), these facilities were identified.

12.5. Table 12.1 outlines the baseline data sources which were collated and considered in the desk based assessment.

Table 12.1: Sources of information (population and human health)

Data collected	Source
Housing and private property	Google Maps and OS AddressBase
Businesses	OS OpenMap and Google Maps
Community facilities, focusing on schools and education facilities; hospitals and medical facilities; are homes and places of worship	OS OpenMap
Open space and recreation, focusing on national and regional trails; recreational facilities; allotments and regional tourist attractions	OS OpenMap
Population and health statistics	English Indices of Multiple Deprivation (IMD) 2019[76] – for the measurement and comparison of relative levels of deprivation (poverty – total IMD and individual domains for Health, Employment and Living Environment Public Health England data sets Office for National Statistics (ONS) data sets on demography

12.2.2 Approach to impact appraisal

12.6. The desk based assessment used a qualitative approach to appraise the Beckton Reuse Indirect Option and identify where there was potential for community and health impacts and the likely mitigation that was required.

12.7. The appraisal identified the likely impacts on community and health resources / receptors including:

- Land requirement – a temporary or permanent (or both) requirement for land affecting resources.
- Change in access – a temporary or permanent (or both) restriction in access, either directly affecting a resource (such as a trail) or affecting the ability of a resource to function (e.g. customers being able to access a business, or

[76] Ministry of Housing, Communities & Local Government (2019) English indices of deprivation 2019. Available at: https://www.gov.uk/government/statistics/english-indices-of-deprivation-2019 [Accessed May 2022]

children/staff being able to access a school). This could also include positive changes where new or enhanced facilities are provided.

- Change in amenity – a temporary or permanent (or both) change in the environmental conditions (e.g. noise, air quality, visual impacts, presence of HGV traffic) which may affect the enjoyment of residential property, neighbourhoods, community and recreational facilities.

12.8. The appraisal considered the greatest impacts to be where:

- A residential property is demolished or a business cannot continue to function.
- A community facility or recreational facility cannot function or a new / enhanced facility is provided
- Impacts occur over a long period (e.g. over a year) and/or affect an activity that is undertaken frequently (e.g. daily trip to school).
- Limited accessible alternatives are available.
- A large number of people are affected or those with vulnerabilities are affected.

12.2.3 Assumptions and limitations

12.9. The assessment was limited to desk-based activities only and no site visits to ground-truth data. No surveys (e.g. telephone surveys or email questionnaires) were undertaken.

12.3 Understanding of the baseline

12.10. The Indicative Intake Location and Indicative Raw Water Pumping Station Site are within 500m of residential properties and businesses located within the Sewardstone area. The Indicative Intake location and Indicative Raw Water Pumping Station Site are not within 500m of any community facilities. The Indicative Raw Water Pumping Station Site is within an area of private property, which is also a business.

12.11. The Raw Water Transfer Main Route Corridor is within 500m of settlements including residential properties and businesses. The closest communities with the potential to be impacted by construction activities are located in the Sewardstone and Waltham Abbey areas. The Raw Water Transfer Main Route Corridor is not within 500m of any community facilities.

12.12. The Indicative WTW Site is within 500m of the Waltham Abbey area including residential properties, businesses and Gunpowder Park. The Indicative WTW Site is not within 500m of any community facilities.

12.13. The Drinking Water Transfer Main Route Corridor runs through settlements located within 500m containing housing and private property, businesses and community facilities (including schools, a cemetery, a leisure centre, a post office and a church). The closest communities the potential construction activities would be located to are within the Waltham Cross, Enfield, Bullsmoor, Whitewebbs, Burnt Farm Ridge, Goffs Oak, Cuffley, Cheshunt and Newgate Steet areas.

12.14. The Drinking Water Transfer Main Route Corridor crosses sports fields and a play space, bisects a number of transport routes and PRoWs and is within 500m of several open spaces and recreational facilities, including Whitewebbs Park and Golf Course, Tottenham Hotspur Training Centre, Elsinge Golden Jubilee Park and Gunpowder Park.

12.15. The Brookmans Park Service Reservoir Connection is within 500m of housing and private property, business and community facilities (including a school) within the Brookmans Park area.

12.16. The Drinking Water Transfer Main to North Mymms Route Corridor runs through settlements located within 500m containing housing and private property, businesses and community facilities (including schools and a church). The closest communities the potential construction activities are located in are within the Water End, Brookmans Park and Welham Green area.

12.17. The Drinking Water Transfer Main to North Mymms Route Corridor bisects PRoWs running alongside the East Coast Mainline and is within 500m of several open spaces and recreational facilities including Brookmans Park Golf Club and Tennis Courts and playing fields.

12.18. Health indicators for the population within the local authority areas in which the Beckton Reuse Indirect Option and a 500m buffer is located were analysed (Welwyn Hatfield District Council, Borough of Broxbourne, London Borough of Enfield and Epping Forest District Council). Based upon the available data, all the local authorities perform relatively well on key public health indicators. Life expectancy (for both genders) is slightly higher across all areas compared to the England average. The under-75 mortality rates (from all causes and cancer) are less than the national rates for all local authorities. The under-75 mortality rates (from cardiovascular diseases) are less than the national rates for all local authorities except for Broxbourne. The percentage of people in employment is higher for all the local authorities when compared to the England rate except for Hertsmere and Enfield. The All ages killed and seriously injured (KSI) rate is higher than the national rate in Hertsmere and Epping Forest. The percentage of people in employment is higher than the national average for all local authorities except Hertsmere and Enfield.

12.19. The English Indices of Multiple Deprivation (IMD) 2019 are commonly used for the measurement and comparison of relative levels of deprivation (poverty). For all local authorities except London Borough of Enfield, a large proportion of residents are in the fifth least to least deprived deciles in the country.

12.20. Deprivation data for total IMD and health deprivation and disability, employment deprivation, and living environment deprivation indicate that none of the Lower-layer Super Output Areas (LSOAs) within the local authorities are within the most deprived 10% nationally for health deprivation and disability although a small percentage of LSOAs in Hertsmere Borough Council and Enfield Council fall within the most deprived 10% nationally for IMD total and employment, as well as Epping Forest District for living environment.

12.4 Appraisal outcomes

12.21. The potential impacts on housing and private property, businesses, community facilities and open space and recreation were considered. For each component of the Beckton Reuse Indirect Option, a summary of the main findings is provided.

12.4.1 Indicative Intake Location and Indicative Raw Water Pumping Station Site

12.22. The Indicative Intake Location and Indicative Raw Water Pumping Station Site are within private property, and temporary and permanent land requirements are therefore anticipated to directly affect private property and business activities during construction.

12.23. The Indicative Intake Location and Indicative Raw Water Pumping Station Site are within 500m of residential properties and businesses within the Sewardstone area, therefore there may be a temporary change in environmental conditions in this area as a result of a combination of noise, air quality, visual impacts or presence of HGV vehicles during construction.

12.24. No impacts on housing, private property, businesses, community facilities or areas of open space and recreation are anticipated during operation.

12.4.2 Raw Water Transfer Main Route Corridor

12.25. The Raw Water Transfer Main Route Corridor temporary and permanent land requirements are not anticipated to directly affect housing or private property.

12.26. The Raw Water Transfer Main Route Corridor bisects fours businesses. Construction and operation would require temporary acquisition of land currently used by these businesses.

12.27. The Raw Water Transfer Main Route Corridor is within 500m of residential properties and businesses within the Sewardstone and Waltham Abbey area, therefore there may be a temporary change in environmental conditions in this area as a result of a combination of noise, air quality, visual impacts or presence of HGV vehicles during construction.

12.28. The Raw Water Transfer Main bisects two PRoWs within the Sewardstone area. Construction may cause temporary closure and/or diversion of these PRoWs.

12.29. No impacts on housing, private property, businesses, community facilities or areas of open space and recreation are anticipated during operation as the pipeline would be underground, and land temporarily required to construct the pipeline would be reinstated.

12.4.3 Indicative WTW Site

12.30. Temporary and permanent land requirements are not anticipated to directly affect housing, private property, community facilities or open space and recreation for the Indicative WTW Site.

12.31. The Indicative WTW Site is located on the current sites for existing businesses. This would require permanent acquisition of land currently used by these businesses.

12.32. Potential amenity impacts on residential, business and open space and recreational (including Gunpowder Park) receptors as a result of changes in environmental conditions are anticipated during construction.

12.33. Depending on the design of the new WTW, there may be a change in environmental conditions during operation for residential and private properties and businesses as a result of a combination of noise, air quality, visual impacts or presence of HGV vehicles. It is not expected that the new WTW would impact Gunpowder Park during operation.

12.4.4 Drinking Water Transfer Main Route Corridor

12.34. Temporary and permanent land requirements are not likely to directly affect housing and private property within the Drinking Water Transfer Main Route Corridor.

12.35. Depending on the construction methodology, there may be a change in environmental conditions for communities within 500m of the Drinking Water Transfer Main Route Corridor as a result of a combination of noise, air quality, visual impacts or presence of HGV vehicles.

12.36. Agricultural land may be temporarily acquired to construct the raw water pipeline. No others impacts on businesses are anticipated as a result of temporary land requirements or potential changes to access. However, depending on the construction methodology, there may be a change in environmental conditions for businesses in these locations as a result of a combination of noise, air quality, visual impacts or presence of HGV vehicles.

12.37. In relation to community facilities, the Drinking Water Transfer Main to North Mymms Route Corridor runs through the sports facilities and a play space, which may require temporary closure and/or relocation. The pipeline bisects several transport routes which may require temporary road closures during construction. Depending on the construction methodology, there may be a change in environmental conditions for areas of community facilities as a result of a combination of noise, air quality, visual impacts or presence of HGV vehicles.

12.38. In relation to open space and recreation, the Drinking Water Transfer Main to North Mymms Route Corridor runs through sports fields and a play space which may require temporary closure of the facilities and therefore construction could directly impact this facility. The Drinking Water Transfer Main to North Mymms Route Corridor bisects several PRoWs within the Enfield, Bullsmoor, Whitewebbs, Cuffley and Newgate Street areas including the PRoW along the River Lee Navigation. Construction may cause temporary closure and/or diversion of these PRoWs. Depending on the construction methodology, there may be a change in environmental conditions for areas of open space and recreation as a result of a combination of noise, air quality, visual impacts or presence of HGV vehicles.

12.39. No impacts on housing, private property, businesses, community facilities or areas of open space and recreation are anticipated during operation as the pipeline would be underground and land temporarily required to construct the pipeline would be reinstated.

12.4.5 Brookmans Park Service Reservoir Connection

12.40. As Brookmans Park Service Reservoir is an existing facility, temporary and permanent land requirements are not anticipated to directly affect housing, private property, businesses, community facilities or areas of open space and recreation. Depending on the construction works required at Brookmans Park Service Reservoir, there may be amenity impacts on receptors within 500m as a result of changes in environmental conditions. There may be increased construction traffic activity in and around the area although this is not anticipated to impact the access to, or function of businesses in this area.

12.41. No impacts on housing, private property, businesses, community facilities or areas of open space and recreation are anticipated during operation as the extent of the changes to the current Brookmans Park Service Reservoir are limited.

12.4.6 Drinking Water Transfer Main to North Mymms Route Corridor

12.42. Temporary and permanent land requirements are not likely to directly affect housing and private property within the Drinking Water Transfer Main Route Corridor.

12.43. Depending on the construction methodology, there may be a change in environmental conditions within communities within 500m of the Drinking Water Transfer Main to North Mymms Route Corridor as a result of a combination of noise, air quality, visual impacts or presence of HGV vehicles.

12.44. Agricultural land may be temporarily acquired to construct the raw water pipeline. No others impacts on businesses are anticipated as a result of temporary land requirements or potential changes to access. However, depending on the construction methodology, there may be a change in environmental conditions for businesses in these locations as a result of a combination of noise, air quality, visual impacts or presence of HGV vehicles.

12.45. In relation to community facilities, the Drinking Water Transfer Main to North Mymms Route Corridor bisects transport routes, as well as the East Coast Main Line, which may require temporary road/rail closures and could cause temporary traffic delays in these areas. Depending on the construction methodology, there may be a change in environmental conditions for areas of community facilities as a result of a combination of noise, air quality, visual impacts or presence of HGV vehicles.

12.46. In relation to open space and recreation, the Drinking Water Transfer Main to North Mymms Route Corridor bisects PRoWs through Brookmans Park, Peplin's Wood and connecting Welham Green to Water End. Construction may cause temporary closure and/or diversion of these PRoWs. Depending on the construction methodology, there may be a change in environmental conditions for areas of open space and recreation as a result of a combination of noise, air quality, visual impacts or presence of HGV vehicles.

12.4.7 North Mymms Booster Station connection

12.47. As the existing booster pumping station is an existing facility, temporary and permanent land requirements are not anticipated to directly affect housing, private property, businesses, community facilities or areas of open space and recreation. Depending on the construction works required for the North Mymms Booster Station Connection, there may be amenity impacts on receptors within 500m as a result of changes in environmental conditions. There may be increased construction traffic activity in and around the area although this is not anticipated to impact the access to, or function of businesses in this area.

12.48. No impacts on housing, private property, businesses, community facilities or areas of open space and recreation are anticipated during operation as the extent of the changes to the current North Mymms Booster Station are limited.

12.5 Recommended mitigation and enhancement opportunities

12.5.1 Mitigation

12.49. To avoid or mitigate potential disruption and disturbance to communities during construction and operation of the Beckton Reuse Indirect Option, best practice mitigation should be implemented. This includes:

- Setting out how engagement with local communities would be undertaken during construction, including with the country park should temporary land acquisition and closure of parts of the country park be required during construction.
- Implementation of specific measures in relation to air quality and noise to reduce impacts on neighbouring residential communities, particularly for sensitive community resources such as educational facilities, health facilities and care homes.
- Developing mitigation for local road closures and diversions when details are known regarding timing and duration of closure.
- The above ground assets should have landscaping, air quality and noise mitigation included in their design, in order to limit the potential indirect impacts from noise and air pollution on properties and businesses and open spaces.
- Sensitive layout and siting of potential construction compounds that take into consideration the potential impacts from noise, traffic, air quality and visual effects on communities.
- Maintenance or diversion of key routes used by the community such as footpaths and pedestrian and cycling routes (refer to Section 13.2.4).

12.5.2 Enhancement opportunities

12.50. Potential programmes and initiatives that could be implemented as part of the Beckton Reuse Indirect Option to deliver public value include providing educational programmes on water at local educational facilities, placing particular emphasis on the benefits of water transfers and the necessity to implement sustainable water infrastructure solutions.

12.51. More widely, socio-economic benefits could accrue through:

- Job and training opportunities, particularly in the construction sector. This would occur primarily during the construction period through supply chain benefits

generated by the Beckton Reuse Indirect Option, 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 would provide social value to local communities in executing construction works or operation and maintenance contracts.

12.52. There are also opportunities to enhance areas of open space and recreational routes along the route which may be impacted as a result of construction of the Beckton Reuse Indirect Option.

12.6 Summary of main findings and recommendations for future technical work

12.53. The Beckton Reuse Indirect Option is located within 500m of housing and private property, businesses, community facilities and areas of open space and recreation. The Indicative Raw Water Pumping Station Site and Indicative WTW Site are within areas of private property, which are also businesses. The Raw Water Transfer Main Route Corridor, Drinking Water Transfer Main Route Corridor and Drinking Water Transfer Main to North Mymms Route Corridor cross agricultural land and bisect areas of open space and recreation, including a country park and several PRoWs.

12.54. Health indicators for the population within the three local authority areas in which the Beckton Reuse Indirect Option is located were also analysed. Life expectancy (for both genders) is slightly higher across all areas compared to the England average. The under-75 mortality rates (from all causes and cancer) are less than the national rates for all local authorities. With the exception of Enfield, a large proportion of residents living within 500 m of the Beckton Reuse Indirect Option live in the fifth least to least deprived deciles in the country.

12.55. There are anticipated to be a range of community and human health impacts affecting housing and private property, businesses and open space and recreation as a result of the Beckton Reuse Indirect Option during both construction and operation. These impacts include permanent land requirements affecting existing businesses, and temporary land requirements affecting a country park, PRoW closure and travel disruption. Depending on the construction methodologies, there may also be a change in environmental conditions as a result of a combination of noise, air quality, visual impacts or presence of HGV vehicles.

12.56. To avoid or mitigate potential disruption and disturbance to communities during construction and operation of the Beckton Reuse Indirect Option, best practice mitigation should be implemented during construction.

12.57. Further assessment is recommended at a subsequent project stage to understand the timing and extent of the population and human health impacts and whether the impacts are temporary or permanent.

13 Material assets

13.1 Introduction

13.1. This chapter presents the results of a desk-based assessment undertaken to identify potential impacts on material assets from the transfer corridors and above ground infrastructure including the WTW. The objectives of the desk-based assessment were to identify the key material assets associated with the Beckton Reuse Indirect Option, identify constraints and opportunities and identify the issues and features that may require further investigation at a subsequent project stage.

13.2. This chapter is split into two sections. Section 13.2 considers transport related material assets while Section 13.3 considers all other material assets.

13.2 Transport and access

13.3. This section presents the desk-based assessment undertaken to identify the transport and access constraints and opportunities for the Beckton Reuse Indirect Option. The desk-based assessment identifies the transport infrastructure, road, rail, water, and PRoWs likely affects to users in the study area.

13.4. The need to consider transport and access is driven by legislation and national planning policy (draft NPS for Water Resource Infrastructure[18] (Section 4.14, Traffic and Transport) and NPPF[19] (Chapter 9, Promoting sustainable transport).

13.2.1 Methodology

13.2.1.1 Study area and sources of information

13.5. The desk-based assessment focused on the transfer route corridors and location of associated infrastructure for the Beckton Reuse Indirect Option.

13.6. Table 13.1 outlines the baseline data sources which were collated and considered in the desk based assessment.

Table 13.1: Sources of information (transport and access)

Data collected	Source
Major Roads – A roads	Ordnance Survey Open data
Major Roads - Motorways	Ordnance Survey Open data
Railway lines	Ordnance Survey Open data
National Cycle Network	Sustrans[77]
National Trails	Natural England
PRoWs	GIS data from Local Planning Authorities (Enfield London Borough Council, Epping Forest District Council and Broxbourne District Council)
Navigable waterways	Ordnance Survey mapping

13.2.1.2 Approach to impact appraisal

13.7. The desk-based assessment used a qualitative approach to appraise the Beckton Reuse Indirect Option and identify where there was potential for impacts on transport infrastructure (such as the strategic road network, PRoWs, etc) and the potential mitigation that would be required. It also identified opportunities for sustainable travel to those areas through identifying cycling, bus and rail proximities.

13.8. Impacts were scored using a high level assessment. The criteria assessed the challenges surrounding accessing the site from the local highway network and the National Highways Strategic Route Network (SRN)[78] and diversions of PRoWs/roads required due to proposed site compounds or water treatment facilities. Opportunity scoring criteria assessed the sites accessibility to connecting sustainable transport routes such as cycle routes, train stations and bus stops.

13.9. Based upon high level estimates of HGVs and staff vehicles that may be required during the construction and operational phases of the Beckton Reuse Indirect Option (see Section 13.2.3.1), at this stage, it is not considered that the vehicles volumes generated would present additional constraints to the road network, and, as described in Section 13.2.3, the majority of roads are anticipated to provide practical options. Where access difficulties have been identified, these, together with further assessment of sensitive receptors would need to be investigated at subsequent

[77] Sustrans' Open Data Portal. Available at: https://data-sustrans-uk.opendata.arcgis.com/ [Accessed April 2022]
[78] National Highways: Roads we manage. Available at: https://highwaysengland.co.uk/about-us/our-roads/ [Accessed April 2022]

project stages, with reference to the Institute of Environmental Assessment 1993 (now the Institute of Environmental Management and Assessment) guidelines and Design Manual for Roads and Bridges (DMRB) Guidance Notes LA 101 (Introduction to Environmental Assessment) 2019, LA 103 (Scoping Projects for Environmental Assessments) 2020 and LA 104 (Environmental Assessment and Monitoring) 2020.

13.10. The scoring methodology that that was applied in Sections 13.2.3.2 to 13.2.3.4 can be found in Table 13.2. A higher score representing fewer constraints and/or greater potential opportunity. At this stage of review, no weighting was given to any of the constraints or opportunities.

Table 13.2: Scoring methodology for transport and access

Scoring	Description
1	High risk, mitigation unlikely
2	Higher risk but could be partly mitigated
3	Medium risk but can be mitigated
4	Lower risk, likely that mitigation would overcome impacts.
5	No impact

13.2.1.3 Proximity to Strategic Road Network

13.11. The distance from the SRN, which consists of motorways and major A roads, was considered. This determines the most appropriate route to a site location for the import of material to the site. The scoring for each range band is based on professional judgement of acceptability in terms of distance from the SRN in this location. The method of scoring has been determined where 1 represents greater than 50km away from an SRN and 5 represents less than 1km, the full breakdown of the scoring can be found in Table 13.3 below.

Table 13.3: Scoring methodology for proximity to Strategic Road Network

Scoring	Description
1	>50km
2	40-50km
3	20-39km
4	1-19km

Scoring	Description
5	<1km

13.2.1.4 Proximity to public rights of way

13.12. The criteria for PRoWs shown in Table 13.4 was based around a distance which can be reached within five minutes using a comfortable walking pace of around 5kph for the average person. This is based on the guidance in LTN 1/20 that references a walking speed of 1.2 m/s, around 4.4 kph, which has been rounded up to 5kph for the purpose of this assessment.

13.13. A person walking at a speed of around 5kph would cover around 400m in 5 minutes. A 5-10 minute walk is a distance of around 400-800m, a 10-15 minute walk is around 800-1200m. A distance of greater than 1200m away or greater is deemed to be over a 15 minute walk. The measure is used to determine if site is well located for walking or if a diversion due to the development of infrastructure could cause a significant impact on walking in the area.

Table 13.4: Scoring methodology for proximity to public rights of way

Scoring	Distance / time
1	>1200m / Diversion required
2	800-1200m
3	400-800m
4	<400m

13.2.1.5 Local road suitability

13.14. This criterion focussed on the suitability of non-major roads/local roads once the vehicles have egressed from the SRN. This is important as it has the potential to highlight problematic infrastructure such as width, height and weight restrictions and also sensitive receptors so suitable diversion(s) can be made without negatively impacting the local network. This assessment does not consider characteristics such as the on-street parking situation, this would need to be identified by a site visit, to determine what days and times the streets/traffic are most affected by on-street parking. This also could involve a parking survey completed by an independent traffic survey company at a subsequent project stage.

13.15. The scoring criteria and application to individual bands was based on professional judgement and experience of highway and traffic management schemes. The criteria are presented in Table 13.5.

Table 13.5: Scoring methodology for local road suitability

Scoring	Description
1	Height and width restrictions
2	Narrow roads (one way traffic) / poor condition roads
3	Single carriageway, medium condition
4	Dual carriageway, wide, good condition

13.2.1.6 Proximity to public transport

13.16. In terms of railway station and bus stop distances, a standard has been published by Transport for London (TfL) for Public Transport Accessibility Level (PTAL) guidance[79]. This data has been used to inform the scoring criteria for railway station and bus stop proximity as shown in Table 13.6.

13.17. At an average walking speed of 5kph, the railway criteria 4 states a 12 minute walk (1000m maximum) is the highest acceptable limit when walking to a station whereas the bus stop criteria 4 acceptable distance limit is considerably lower at around five minutes (less than 400m). This is due to the fact that bus stops occur far more frequently along a route compared to the railway stations and bus stops are typically used to travel shorter distances thus requiring them to be closer to be attractive to use.

Table 13.6: Scoring methodology for proximity to public transport

Scoring	Distance (railway station)	Distance (bus)
1	>8000m	>3000m
2	5000-8000m	1000-3000m
3	1000-5000m	400-1000m
4	<1000m	<400m

[79] Transport for London (2010) Measuring Public Transport Accessibility Levels. Available at: https://s3-eu-west-1.amazonaws.com/londondatastore-upload/PTAL-methodology.pdf [Accessed April 2022]

13.2.1.7 Proximity to cycle network

13.18. The criteria for proximity to the cycle network were based around a distance which can be reached within five minutes using the assumption that the average cycling speed is 25kph[80]. Therefore, a distance of 2km of less could be cycled in less than 5 minutes. Less than 6000m would be around 15 minutes and reasonably practicable to undergo a cycle ride using pavements and roadsides. 6000-9000m is around 22 minutes and unreasonable distance to cover to reach a designated cycle route. Anything over 9000m was deemed as impractical to the average cyclist and be attributed the lowest score. The criteria are presented in Table 13.7.

Table 13.7: Scoring methodology for proximity to cycle network

Scoring	Distance / Time
1	>9000m
2	6000-9000m
3	2000-6000m
4	<2000m

13.2.1.8 Assumptions and limitations

13.19. No surveys or site visits were undertaken as part of this work.

13.20. Only publicly available data sets were used, alongside the available mapping and aerial imagery to determine high level transport impacts and receptors.

13.21. This assessment focused on the initial pipeline route and corridor estimates for compound and working widths, materials for pipe bedding, temporary road surfacing, and staff numbers . Assumptions with regard to construction material volumes and operational requirements were based upon information provided by the Concept Design team.

13.22. Consideration of impacts on future (i.e. yet to be built) transport infrastructure would be considered at subsequent stages of the project.

[80] This is based on LTN 1/20 guidance of an absolute minimum design speed of 20 kph.

13.2.2 Understanding of the baseline

13.23. The Indicative Intake Location, Indicative Raw Water Pumping Station Site, Raw Water Transfer Main Route Corridor and Indicative WTW Site are located in the vicinity of Sewardstone Road (A112) and can be accessed by junction 26 of the M25. The Indicative WTW Site is within 150m of PRoWs routing through Gunpowder Park to the west and connecting with the River Lee Navigation.

13.24. The nearest railway station is Enfield Lock, located in the London Borough of Enfield situated between Brimsdown and Waltham Cross, around 2km west of the Indicative WTW Site and less than 1km from the Drinking Water Transfer Main Route Corridor. Enfield Lock Railway Station is on the West Anglia Main Line, served by the national rail service and is operated by Greater Anglia.

13.25. The nearest National Cycle Network (NCN) route to the Indicative Intake Location, Indicative Raw Water Pumping Station Site, Raw Water Transfer Main Route Corridor and Indicative WTW Site is NCN Route 1, which intersects and runs perpendicular to the M25. NCN Route 1 is located around 2km west of the Indicative WTW Site.

13.26. The Drinking Water Transfer Main Route Corridors run roughly parallel to the M25 from junction 23 with the A1(M) at South Mimms to past junction 25 with the A10 at Waltham Abbey. The key access points from the SRN for the Drinking Water Main Route Corridor would be from junctions 23 to 26, utilising the primary road.

13.27. The nearest railway stations to the Drinking Water Transfer Main Route Corridors are Turkey Street, Cuffley and Brookmans Park, all within 2km, and there are several bus stops within 1-2km. NCN routes 1 and 12 are within proximity to some sections of the Drinking Water Transfer Main Route Corridors, and there are several PRoWs bisected and within proximity.

13.2.3 Appraisal outcomes

13.2.3.1 Construction and operational vehicle movements

13.28. Current construction methodology indicates around 100 HGV and 220 LGV vehicle movements per day are anticipated for the temporary construction compounds and around 50 staff vehicle movements. Further refinement would be required at later stages of development to determine peak periods of activity and how HGV, LGV and workforce vehicle trips are managed or reduced to mitigate impacts on the road network.

13.29. During operation of the new WTW, between one and three additional HGVs are anticipated per day (i.e. between two and six HGV vehicle movements) and up to 30 staff vehicle movements per day. Additionally, these HGV/workforce assumptions

are also applied to the other components of the Beckton Reuse Indirect Option as HGV figures are expected to be low.

13.30. Based upon high level estimates of HGVs, LGVs and staff vehicles that may be required during the construction and operational phases of the Beckton Reuse Indirect Option, at this stage, it is not considered that the vehicles volumes generated would present additional constraints to the road network.

13.2.3.2 Construction access for the Raw and Drinking Transfer Mains, including the River Lee Intake and Raw Water Pumping Station

Strategic Road Network (SRN)

13.31. All of the indicative locations for temporary construction compounds identified were considered to have a score of 4 (lower risk) in terms of their proximity to SRNs as they all were less than 20km away from an SRN junction; however, no locations were within 1km of an SRN. It is anticipated that both eastbound and westbound vehicles would use the M25. The vehicles would be expected to predominantly choose either J25 or J26 to access and egress the M25. With respect to the western section of the transfer route, it is expected that the A1 Junction 2 would be used to access the sites.

Public rights of way

13.32. The majority of indicative locations for temporary construction compounds identified were considered to have a score of 4 (lower risk) in terms of their proximity to PRoWs as each one was less than 400m from a PRoW. Although this provides a potential opportunity in terms of adequate public accessibility to these sites, it also provides a constraint when undergoing development works where construction areas may impact on nearby PRoWs.

13.33. Around half of the PRoWs identified within 400m are within 50m or less of the indicative locations for temporary construction compounds. Consideration would need to be made to maintain walking routes around the indicative locations for temporary construction compounds and ensure they are accessible and safe to use.

Local road suitability

13.34. This criterion focussed on the construction vehicle accessibility level to the indicative locations for temporary construction compounds once they have egressed from the SRN or from site. The majority of roads that were assessed provided practical options such as the A10 (three lanes in both directions), dual carriageway of Lieutenant Ellis Way and single carriageways of Dowding Way (A121), Sewardstone Road (A112) and Mollison Avenue. The majority of roads scored a 4 (lower risk) or 5 (no impacts)

13.35. The main notable issues identified were the railway bridge along Darnicle Hill (no height restriction sign) (scoring a 2, higher risk), weak bridge and a 'no access for construction vehicles' sign along Hawkshead Lane, 7.5T weights limit along Kentish Lane (scoring a 1, higher risk) and a narrow bridge at the Warrengate Road/Bradmore Lane junction (scoring a 2, higher risk).

13.36. The desk-based assessment has also highlighted potential access issues for some of the indicative locations for temporary construction compounds. For example, a private access road, for which access would need to be attained prior to the commencement construction works, and therefore scoring a 3 (medium risk).

Proximity to public transport

13.37. The majority of the indicative locations for temporary construction compounds are considered to score a 3 (medium risk) in terms of proximity to a railway station with only one area being in close proximity to Brookmans Park Railway Station, making it a potential destination for workers to choose the train as the mode of transport to get to work compared to opting for private transport.

13.38. Bus stop services offer good proximity to the indicative locations for temporary construction compounds with most sites being a 1-2km walking distance away (and therefore scoring a 2 (higher risk) or 3 (medium risk). However, one of the indicative locations for temporary construction compounds, near the Brookmans Park Service Reservoir Connection is more isolated from bus routes (and therefore scoring 1 (higher risk).

Proximity to cycle network

13.39. The desk-based assessment has highlighted that NCN routes 1 and 12 offer good connections with the majority of locations of the indicative locations for temporary construction compounds scoring a 3 (medium risk) or 4 (lower risk) in terms of proximity to the cycle network. Along the Drinking Water Transfer Main Route Corridor, to the north of the M25, access to the indicative locations for temporary construction compounds are considered medium to higher risk as the NCN routes 1 and 12 are further away and therefore scoring a 2 (higher risk).

13.2.3.3 Intersections of the Raw and Drinking Transfer Main Route Corridors with existing transport infrastructure

Railway lines

13.40. The Raw Water Transfer Main Route Corridor does not intersect any railway lines. The Drinking Water Transfer Main Route Corridor crosses the West Anglia Main Line between Waltham Cross and Enfield Lock, Lea Valley line by Turkey Street and the

East Coast Main Line by Cuffley Station. The Drinking Water Transfer Main to North Mymms Main Route Corridor crosses the East Coast Main Line between Welham Green and Brookmans Park.

Navigable waterways

13.41. The Drinking Water Transfer Main Route Corridor intersects the River Lee Navigation.

Public rights of way

13.42. The Raw Water Transfer Main Route Corridor intersects three PRoWs, the Drinking Water Transfer Main Route Corridor intersects one PRoW and the Drinking Water Transfer Main to North Mymms Route Corridor intersects five PRoWs. The vast majority of PRoWs run perpendicular to the route corridors, meaning only a small section of the PRoW would need to be temporarily diverted or controlled to maintain the pedestrian route during construction.

Highways and local roads

13.43. The Raw Water Transfer Main Route Corridor intersects one single carriageway local road.

13.44. The Drinking Water Transfer Main Route Corridor and Drinking Water Transfer Main to North Mymms Route Corridor intersect with numerous highways and local roads. The majority of these are single carriageways or narrow access tracks and there is one section where the Drinking Water Transfer Main Route Corridor crosses the M25 where there are six lanes to cross, although it is assumed that a trenchless technique would be used in this location.

Cycle networks

13.45. The Raw Water Transfer Main Route Corridor and Drinking Water Transfer Main to North Mymms Route Corridor do not intersect any National Cycle Networks.

13.46. The Drinking Water Transfer Main Route Corridor intersects NCN route 1.

13.2.3.4 Indicative Water Treatment Works Site

Strategic Road Network

13.47. The Indicative WTW Site is considered to have a score of 4 (lower risk) in terms of proximity to the SRN as it is less than 20km away from an SRN Junction. Both the northbound and southbound vehicles would use the M25, Junction 26.

Public rights of way

13.48. The Indicative WTW Site is within 150m of two PRoWs and therefore scored a 4 (lower risk). Although the proximity of PRoWs provides a potential opportunity in terms of accessibility to the sites, it also provides a reason for particular caution when undergoing development works to ensure that construction impacts are contained within the site boundary.

Local road suitability

13.49. This criterion focussed on the construction vehicle accessibility level to site once they have egressed from the SRN or from site. The desk-based assessment indicated that the majority of roads provided practical options such as the single carriageways of Dowding Way (A121) and Sewardstone Road (A112). However, temporary local road closures may be required during construction. At this stage, it is considered that the local roads offer suitable conditions for construction vehicles for the Indicative WTW Site and therefore scored a 4 (lower risk).

Proximity to public transport

13.50. The Indicative WTW Site scored a 3 (medium risk) in relation to its proximity to the closest railway station and higher risk in relation to its proximity to bus stops where the nearest bus stops are 1.9km away.

Proximity to cycle network

13.51. The Indicative WTW Site is considered to score a 4 (lower risk) in relation to its proximity to the cycle network as NCN route 1 offers good connections for cycling.

13.2.4 Recommended mitigation

13.52. To avoid or mitigate potential disruption to transport infrastructure during construction and operation of the Beckton Reuse Indirect Option, mitigation should be implemented. This includes:

- Phased diversion for footpaths which intersect the Raw Water Transfer Main Route Corridor, Drinking Water Transfer Main Route Corridor and Drinking Water Transfer Main to North Mymms Route Corridor so PRoWs remain accessible at all times.
- where possible the implementation of a Traffic Management Plan during construction
- Engagement with National Highways to confirm the engineering method where the pipeline intersects with the M25.

- Engagement with Network Rail to progress an Asset Protection Agreement or Basic Asset Protection Agreement where the pipeline intersects with the West Anglia Main Line between Waltham Cross and Enfield Lock, Lea Valley Line at Turkey Street Station, East Coast Main Line at Cuffley Station and between Welham Green and Brookmans Park.
- Engagement with the Canal and River Trust to confirm the engineering method for crossing the River Lee Navigation.
- A temporary diversion for NCN route 1 may be required and/or a localised traffic management programme implemented to control the flows of vehicles around the NCN during construction.
- Pursuant to the consenting process, a Transport Assessment would be undertaken and supporting documents such as a Construction Traffic Management Plan, Travel Plan and Servicing and Delivery Plan would be produced detailing how transport impacts are mitigated and managed.

13.3 Other material assets

13.53. There is no specific legislation for the assessment of impacts on material assets. The need to consider material assets is driven by national planning policy (draft NPS for Water Resource Infrastructure[18] (Section 4.10, Land use including open space, green infrastructure and Green Belt) and NPPF[19] (Chapter 10, High quality communications, and Chapter 17, Facilitating the sustainable use of minerals)).

13.3.1 Methodology

13.54. The desk-based assessment was based upon a mapping exercise to identify key material assets present in the study area and an assessment as to the potential for the Beckton Reuse Indirect Option to affect material assets.

13.55. For construction, the desk based assessment focused on the transfer route corridors, location of the associated infrastructure and surrounding area within 200m. There is no guidance on buffer areas but 200m was chosen based on previous projects and the nature of material asset features.

13.56. Table 13.8 outlines the baseline data sources which were collated and considered in the desk based assessment. There is no set definition of what is covered under material assets, therefore, the SEPA guidance on SEA[81] and materials assets has been

[81] Scottish Environment Protection Agency (SEPA) Strategic Environmental Assessment

used as a basis. The transport infrastructure considered in Section 13.2 has not been repeated in this section.

Table 13.8: Sources of information (other material assets)

Data collected	Source
Infrastructure relating to energy and heat generation and distribution	
Power lines	National Grid[82]
Power plants (coal, nuclear, EfW)	Open Power System Data[83]
Large-scale renewables – wind farms, solar farms, hydroelectric	Open Power System Data[84]
Existing water / wastewater infrastructure	
Treatment works/reuse plants Reservoirs (including service reservoirs)	Thames Water and Affinity Water
Transport	
Airports / Airfields	Ordnance Survey mapping
Waste Management	
Landfill sites – authorised (type)	Environment Agency
Waste management facilities including recycling centres, energy from waste plants, incinerators	Local Authority data – Mineral and Waste Plans Aerial mapping
Minerals	
Quarries	Onshore Geoindex[36]

SEPA Guidance Note 4: Guidance on consideration of material assets in Strategic Environmental Assessment. Available at: https://www.sepa.org.uk/media/219432/lups-sea-gu4-consideration-of-material-assets-in-sea.pdf [Accessed April 2022]

[82] National Grid Network route maps. Available at: https://www.nationalgrid.com/uk/electricity-transmission/network-and-infrastructure/network-route-maps [Accessed April 2022]

[83] Open Power System Data. 2020. Data Package Conventional power plants. Version 2020-10-01. https://doi.org/10.25832/conventional_power_plants/2020-10-01. (Primary data from various sources, for a complete list see URL) [Accessed April 2022]

[84] Open Power System Data. 2020. Data Package Renewable power plants. Version 2020-05-20. https://doi.org/10.25832/renewable_power_plants/2020-05-20. (Primary data from various sources, for a complete list see URL) [Accessed April 2022]

Data collected	Source
Mineral Safeguarding Areas / Mineral Allocation Sites	Local Authority data – Mineral and Waste Plans

13.57. The material assets considered were limited by the availability of data on certain assets. Where possible open-source datasets were used but there were some assets where information was not publicly available or was not available due to lack of records or confidentiality. In these cases, any baseline data gaps were identified.

13.58. Several assets that could be considered under material assets are instead covered under different topics for example, community assets are included under Chapter 12, Population and Human Health. Natural material assets such as woodland and agricultural land are covered under Chapter 4, Biodiversity, Flora and Fauna, Chapter 9, Landscape and Chapter 5, Soils, respectively.

13.3.2 Understanding of the baseline

13.59. Powerlines, powerplants, cabling and large scale renewables assets were reviewed. The assets identified were within the Drinking Water Transfer Main Route Corridor and include two intersections with overhead powerlines.

13.60. There is one relevant WTW within the study area: the existing North Mymms WTW, and two reservoir assets: the King George V Reservoir and the existing service reservoir in the vicinity of Brookmans Park.

13.61. The Beckton Reuse Indirect Option would cross numerous water mains within the Thames Water and Affinity Water networks.

13.62. There is one allocated waste site (Sopers Road, Cuffey) and two licensed waste sites within the study area. There is also one historical landfill site, the former Enfield sewage works within the study area.

13.63. Sections of the Drinking Water Transfer Main Route Corridor and Drinking Water Transfer Main to North Mymms Route Corridor are within adopted and emerging sand and gravel mineral safeguarding areas[85,86]. No allocated minerals sites have been identified within the study area.

[85] Hertfordshire County Council Local Aggregates Assessment 2021. Available at: https://www.hertfordshire.gov.uk/media-library/documents/environment-and-planning/planning/planning-in-hertfordshire/final-laa-2021-002.pdf [Accessed May 2022]
[86] Essex County Council Minerals Policies Map. Available at: https://images.ctfassets.net/knkzaf64jx5x/3kRWyM7PIyxdi1ccSCRb3Z/8b8c8d6e33e65d4673e5bdf376b185aa/policies-map.jpg 2014 [Accessed May 2022]

13.64. There are no aviation assets within the study area.

13.3.3 Appraisal outcomes

13.65. Construction of the Raw and Drinking Water Transfer Main would require excavation and depending on the height of machinery required to excavate, there may be impacts on the power lines present within the study area. This may present potential safety hazards which may result in a power outage and damaged cables.

13.66. Construction activities may impact the existing Brookmans Park Service Reservoir and North Mymms booster pumping station. Temporary disturbance may occur when the pipelines are connected to these assets but disruption should be minor and short-lived. No impacts are anticipated on King George V Reservoir.

13.67. There would be no direct impacts on the operation of authorised landfills or waste management facilities.

13.68. No impacts on material assets are anticipated during operation.

13.3.4 Recommended mitigation

13.69. In order to mitigate potential issues arising from the Beckton Reuse Indirect Option on material assets, mitigation measures should be implemented such as selection of appropriate machinery for the pipeline excavation in proximity to any power lines and use of covers such as netting below power lines to reduce potential power outages.

13.70. Engagement should be undertaken with the Minerals and Waste Authority on sections of the Drinking Water Transfer Main Route Corridor Drinking Water Transfer Main to North Mymms Route Corridor that traverse strategic areas of minerals.

13.4 Summary of main findings and recommendations for future technical work

13.71. The Beckton Reuse Indirect Option has the potential to affect other material assets during construction and operation including transport, energy, water and wastewater, waste and minerals infrastructure.

13.72. Based upon high level estimates of HGVs and staff vehicles that may be required during the construction and operational phases of the Beckton Reuse Indirect

Option, at this stage, it is not considered that the vehicles volumes generated would present additional constraints to the road network, and the majority of roads are anticipated to provide practical options such as the A10 (three lanes in both directions), dual carriageway of Lieutenant Ellis Way and single carriageways of Dowding Way (A121), Sewardstone Road (A112) and Mollison Avenue. Potential issues have been identified in some areas, for example, a private access road, for which access would need to be attained prior to the commencement construction works. These access issues would need to be investigated at subsequent project stages.

13.73. The Raw and Drinking Water Transfer Main Route Corridors intersect with PRoWs and there are PRoWs in proximity to indicative locations for temporary construction compounds, the Indicative Intake Location, Indicative Raw Water Pumping Site and the Indicative WTW Site. Although this provides a potential opportunity in terms of adequate public accessibility to these sites, it also provides a constraint when undergoing development works where construction areas may impact on nearby PRoWs. It is recommended that consideration is given to maintaining walking routes around the temporary construction compounds and ensuring they are accessible and safe to use.

13.74. The Drinking Water Transfer Main Route Corridor intersects with National Cycle Network (NCN) route 1. Consequently, appropriate mitigation is likely to be required, potentially including a temporary diversion.

13.75. The Drinking Water Transfer Main Route Corridor crosses the West Anglia Main Line, Lea Valley Line, East Coast Main Line, River Lee Navigation and highways and local roads, as well as NCN route 1. Engagement would be required with the relevant stakeholders including National Highways, Network Rail and Canal and River Trust.

13.76. The Beckton Reuse Indirect Option has the potential to affect other material assets during construction including potential safety hazards from overhead powerlines, and strategic areas of minerals. During operation, there is potential for temporary disruption during maintenance work.

13.77. Recommended areas for future technical work at a subsequent project stage are summarised below:

- Review any changes to the conceptual design following Gate 2 in terms of access routes to the indicative locations for temporary construction compounds, pipeline crossings and HGV/workforce access for the new WTW.
- Review construction HGV and workforce numbers and programme once known to determine construction flows to assess future potential impact on roads.
- Review construction vehicle types once known to enable access roads and site access point suitability to be assessed.
- Collect baseline traffic data, depending on the expected volume of vehicles and the programme. Traffic surveys are only likely to be required at specific junctions.

The scope of traffic surveys and need for modelling would be subject to engagement with the highway authorities.

- Update review of local authority local plans / transport schemes to understand potential cumulative effects from other projects to determine the modelling extents and junction analysis required.
- Pursuant to the consenting process, a Transport Assessment would be undertaken and supporting documents such as a Construction Traffic Management Plan, Travel Plan and Servicing and Delivery Plan would be produced detailing how transport impacts are mitigated and managed.

14 Potential cumulative effects

14.1 Introduction

14.1. An initial cumulative effects assessment has been undertaken and is presented in Technical Supporting Document B4, Strategic Environmental Assessment Review. It is understood that if the Beckton Reuse Indirect Option is selected as an option in the WRSE Regional Plan, as well as Thames Water WRMP24 and Affinity Water WRMP24, it will be subject to an in-combination effects assessment with the other selected options, neighbouring water companies plans and neighbouring regional plans. Until the WRSE Best Value Regional Plan has been developed and agreed, it is not known when the Beckton Reuse Indirect Option would be implemented, and therefore, which other developments could act in-combination with it.

14.2 Plans, programmes and projects considered

14.2. The following plans, programmes and projects have been considered within the cumulative effects assessment:

- Other SROs
- Other water company schemes
- Local Development Frameworks
- Development Consent Orders for Nationally Significant Infrastructure Projects
- Relevant Transport and Works Act Orders
- Relevant planning applications

14.3 Strategic Resource Options

14.3. As described in Section 4.3, the source of water for the Beckton Reuse Indirect Option is the River Lee. However, the natural flow in the river is insufficient and so operation of the scheme will be dependent on recycled water being fed into the river from the London Effluent Reuse SRO. The operation of the Beckton Reuse Indirect Option, therefore, assumes that sufficient water will be available for the abstraction and that impacts on the aquatic communities are considered negligible. Cumulative effects with the London Effluent Reuse SRO are unlikely during construction or operation since, as described in Section 4.3, impacts on the aquatic communities for

the Beckton Reuse Indirect Option are considered negligible.

14.4. There are no other SROs geographically near to the Beckton Reuse Indirect Option and therefore effects during construction are unlikely to occur. Cumulative operational effects with other SROs are unlikely.

14.4 Other water company schemes

14.5. Thames Water and Affinity Water have confirmed that there are no other relevant water company schemes that would need to be considered.

14.5 Local development frameworks

14.5.1 Policy WAL E8 – Epping Forest Local Plan (2011-2033), Epping Forest District Council

14.6. Epping Forest Local Plan (2011-2033) includes a 40,000m^2 employment allocation site located north of the A121. The plan period for this development is up to 2038 and as such, there is potential for construction works to overlap with potential for cumulative effects from noise, dust, light and vibration pollution. The following designated sites were considered: Stream and Old River Lea SSSI, Turnford & Cheshunt Pits SSSI, Epping Forest SAC, Epping Forest SSSI, Lee Valley SPA and Lee Valley Ramsar. The HRA Stage 2 AA identified transmission pathways but concluded that no adverse effects on the integrity of Lee Valley SPA and Lee Valley Ramsar are likely if the suggested mitigation measures are observed. Therefore, no cumulative effects are anticipated.

14.7. During construction there is the potential for temporary cumulative effects to local community from noise and air pollution as well as effects on access to facilities, potential receptors include King Harold School and Abbey Garden and residential areas in Waltham Abbey.

14.8. There is potential for cumulative effects on SPZs resulting from construction with both developments intersecting the same SPZ.

14.9. The closest element of the Beckton Reuse Indirect Option to the development is the pipeline which would not be visible to the nearby residential receptors and would not have any operational noise impacts on nearby residential receptors. The development has not predicted any other significant adverse residual effects, and it is considered unlikely that when combined with the Beckton Reuse Indirect Option, the reported effects would result in significant cumulative effects upon operation.

14.5.2 Waltham Abbey North Masterplan – Policies WAL T1, R1, R2 & R3 – Epping Forest Local plan (2011-2033), Epping Forest District Council

14.10. Waltham Abbey North Masterplan Area is allocated to accommodate 612 homes. The plan period for this development is up to 2038 and as such, there is potential for construction works to overlap. During the construction period, depending on the timings of construction, there is potential for cumulative effects from noise, dust, light and vibration pollution on the following designated sites: Cornmill Stream and Old River Lea SSSI, Waltham Abbey SSSI, Turnford & Cheshunt Pits SSSI. The HRA Stage 2 Appropriate Assessment identified transmission pathways but concluded that no adverse effects on the integrity of Lee Valley SPA and Lee Valley Ramsar are likely if the suggested mitigation measures are observed. Therefore, no cumulative effects are anticipated.

14.11. The development of the allocated sites within Waltham Abbey have the potential to result in air pollution that could impact upon air quality in the district, including Epping Forest. The Beckton Reuse Indirect Option is not expected to exceed air quality objectives. However, should construction activities overlap, adequate traffic planning with regulators should be implemented to minimise risks of cumulative effects on air quality.

14.12. There is potential for construction activities to have cumulative effects on the local community from noise and air pollution as well as effects on access to facilities. Potential receptors identified include King Harold School and Abbey Garden and residential areas in Waltham Abbey.

14.13. There are areas of Flood Zone 2 and 3 within 1km of Areas WAL T1, R1, R2 & R3 – Epping Forest Local Plan (2011-2033) and the transfer corridors for the Beckton Reuse Indirect Option. There are not anticipated to be cumulative construction or operational effects related to flood risk.

14.14. The closest element of the Beckton Reuse Indirect Option to the development is the pipeline which would not be visible to the nearby residential receptors and would not have any operational noise impacts on nearby residential receptors. The development has not predicted any other significant adverse residual effects, and it is considered unlikely that there would be significant cumulative effects when combined with the Beckton Reuse Indirect Option.

14.5.3 Policy CH1 – Local Plan 2018-2033 Policy CH1 – Local Plan 2018-2033, Broxbourne District Council

14.15. Chestnut Lakeside will be developed as a new mixed use urban village to accommodate 1,750 homes. Cheshunt Lakeside development is over 2km North of the Beckton Reuse Indirect Option, however, the development is less than 400m

from Lee Valley SPA. The HRA carried out by the council indicated the plan was likely to have an adverse effect on the qualifying interests of the SPA (Bittern, Gadwall and Shoveler). The HRA AA undertaken for the Beckton Reuse Indirect Option identified transmission pathways but concluded that no adverse effects on the integrity of Lee Valley SPA and Lee Valley Ramsar if the suggested mitigation measures are observed. Therefore, no cumulative effects are anticipated with implementation of appropriate mitigation.

14.16. There is potential for cumulative effects from construction resulting from noise and air pollution, with temporary impacts on residential areas within Waltham Cross. The closest element of the scheme to the development is the pipeline which would not be visible to the nearby residential receptors and would not have any operational noise impacts on nearby residential receptors. The development has not predicted any other significant adverse residual effects, and it is considered unlikely that there would be significant cumulative effects when combined with the Beckton Reuse Indirect Option.

14.5.4 Policy CH2 – Local Plan 2018-2033, Policy CH2 – Local Plan 2018-2033, Broxbourne District Council

14.17. Policy CH2 – Local Plan 2018-2033 Rosedale Park will be developed as a series of interlinked new suburban parkland communities to accommodate 800 homes. The planned period for this development is up to 2038, there is therefore potential for construction works to overlap.

14.18. There is potential for temporary cumulative effects resulting from noise, dust, light and vibration pollution on the following LWS: Meadow of Tudor Village LWS, Longmead Farm Meadows LWS, Albury Fields LWS, Poyndon Farm LWS. Noise and air pollution during construction may also have temporary cumulative effects on residential areas in Goff's Oak and community facilities including a sports ground, church and two schools.

14.19. The closest element of the Beckton Reuse Indirect Option to the development is the pipeline which would not be visible to the nearby residential receptors and would not have any operational noise impacts on nearby residential receptors. The development has not predicted any other significant adverse residual effects, and it is considered unlikely that there would be significant cumulative effects when combined with the Beckton Reuse Indirect Option.

14.5.5 Policy PB2 – Draft Local Plan, Hertsmere Borough Council, Broxbourne District Council

14.20. The former Potters Bar Golf Course is proposed for development. The new development will provide a sustainable new neighbourhood delivering around 500 new homes. The plan period for this development is up to 2038, there is therefore potential for construction works to overlap.

14.21. There are areas of Flood zone 2 and 3 that are within 1km of PB2 and the pipeline element of the Beckton Ruse Indirect Option. There is not anticipated to be cumulative construction or operational effects related to flood risk.

14.22. There is potential for cumulative effects on SPZs resulting from construction with both developments intersecting the same SPZ.

14.23. The closest element of the Beckton Reuse Indirect Option to the development is the pipeline which would not be visible to the nearby residential receptors and would not have any operational noise impacts on nearby residential receptors. The development has not predicted any other significant adverse residual effects, and it is considered unlikely that there would be significant cumulative effects when combined with the Beckton Reuse Indirect Option.

14.5.6 Policy PB3 – Draft Local Plan, Hertsmere Borough Council

14.24. Land to the south of Potters Bar is proposed for development for around 900 new homes. There is potential for construction works to overlap however, the plan is over 2km from any designated sites and over 3.5km from proposed construction sites associated with the Beckton Reuse Indirect Option. No notable cumulative effects on any other sensitive receptors are anticipated during construction or operation.

14.5.7 Policy NS1 – Draft Local Plan, Hertsmere Borough Council

14.25. The NS1 Plan period is up to 2038. There is an area of Green Belt Land within Shenley Parish being considered for a New Garden Village with leisure, educational, employment and business facilities. Initially, 2,400 homes are proposed, with capacity for up to 6,000 homes.

14.26. During the construction period, depending on the timings of construction, there is potential for cumulative effects from noise, dust, light and vibration pollution on the following designated sites: Redwell Wood SSSI and Colney Heath LNR.

14.27. There is potential for cumulative effects on SPZs resulting from construction with both developments intersecting the same SPZ.

14.28. The closest element of the Beckton Reuse Indirect Option to the development is the pipeline which would not be visible to the nearby residential receptors and would not have any operational noise impacts on nearby residential receptors. The development has not predicted any other significant adverse residual effects, and it is considered unlikely that there would be significant cumulative effects when combined with the Beckton Reuse Indirect Option.

14.5.8 Other developments

14.29. The following developments are identified to have overlapping construction periods with the Beckton Reuse Indirect Option and were therefore considered within the cumulative assessment:

- 2013/3223 (London Borough Hackney) – mixed use development
- HGY/2021/3175 (London Borough Haringey) – mixed use development
- Policy SA13 – Draft Local Plan (London Borough Enfield) – site allocation for residential development
- Policy SA15 – Draft Local Plan (London Borough Enfield) – site allocation for mixed use development
- Policy SA19 – Draft Local Plan (London Borough Enfield) – site allocation for mixed use development
- Policy SA01 – Proposed Submission Waltham Forest Local Plan Part 2 - London Borough Waltham Forest – site allocation for mixed use development
- Policy SA02 – Proposed Submission Waltham Forest Local Plan Part 2 - London Borough Waltham Forest – site allocation for new neighbourhood
- Policy SA03 – Proposed Submission Waltham Forest Local Plan Part 2 - London Borough Waltham Forest – site allocation for mixed use development
- Policy SA16 - Proposed Submission Waltham Forest Local Plan Part 2 - London Borough Waltham Forest – site allocation for new hospital
- Policy SA19 – Proposed Submission Waltham Forest Local Plan Part 2 - London Borough Waltham Forest – site allocation for mixed use development
- Policy SA38 – Proposed Submission Waltham Forest Local Plan Part 2 - London Borough Waltham Forest – site allocation for mixed use development

14.30. No cumulative effects were identified for construction or operational phases. The developments are within 3km of Lee Valley SPA and Ramsar. The Stage 2 HRA Appropriate Assessment conducted for Beckton Reuse Indirect Option identified no adverse effects on the integrity of the Lee Valley SPA and Lee Valley Ramsar if appropriate mitigation is implemented. Therefore, no adverse effects on the integrity of the European Sites are considered likely either alone or in-combination. The distance between the developments and the Beckton Reuse Indirect Option are also significant enough that no other common receptors were identified with potential for cumulative effects.

15 Invasive non-native species risk assessment

15.1 Introduction

15.1.1 Key legislation

15.1. The translocation of INNS is subject to regulation under the following national legislation:

- 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 INNS (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 (WFD) (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, 2015)[87].

[87] WFD-UKTAG (2015). UK Technical Advisory Group on the Water Framework Directive. Revised classification of aquatic alien species according to their level of impact. Public working draft.

15.1.2 Assessment objectives

15.2. The overall aim of this assessment is to determine the potential increase in INNS risk arising from the Beckton Reuse Indirect Option. This overall aim was underpinned by the following objectives:

- To establish if the scheme would introduce a hydrological connection between previously isolated catchments.
- To identify INNS within an appropriate study area to understand the current INNS distribution.
- To outline the legislative context of INNS risk assessment.
- To use the SRO Aquatic INNS Risk Assessment Tool (SAI-RAT) developed by APEM Ltd on behalf of the Environment Agency[88] to quantify the INNS risk associated with the scheme based on the conceptual design information currently available.
- To review potential biosecurity options for implementation by the client and other relevant stakeholders to mitigate the INNS risk associated with the scheme.

15.2 Methodology

15.2.1 Study area

15.3. As outlined in Section 2.1, the Beckton Reuse Indirect Option involves the transfer of water from a new intake on the River Lee to the existing Brookmans Park Service Reservoir via a new WTW, then onto North Mymms. For the purposed of the INNS Risk Assessment, the Beckton Reuse Indirect Option has been divided into three sections which have been assessed separately in the risk assessment tool.

- Section 1: An approximately 1.2km pipeline transfer of raw water from a new intake on the River Lee to the new WTW at the Indicative WTW Site.
- Section 2: Pipeline transfer of drinking water from the Indicative WTW Site to the existing Brookmans Park Service Reservoir. Transfer distance is approximately 20km and crosses under the River Lee and Lee Navigation canal.
- Section 3: An approximately 2.8km pipeline transfer of drinking water from the existing Brookmans Park Service Reservoir to a booster pumping station in the vicinity of North Mymms.

[88] APEM Ltd (2021). SRO Aquatic INNS Risk Assessment Tool (SAI-RAT) – User Guide. Produced on behalf of the Environment Agency.

15.4. The Environment Agency guidance for SRO INNS risk assessments[88] specifies that the study area should be a 1km buffer zone either side of the proposed water transfer route.

15.2.2 High-level screening related to Environment Agency guidance

15.5. The Environment Agency position statement *Managing the Risk of Spread of Invasive Non-Native Species Through Raw Water Transfers*[89] outlines the organisation's position on how it will manage INNS risks associated with raw water transfers. The key points of relevance to this report are as follows:

- The focus of the Environment Agency'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 Environment Agency will use to decide whether subsequent mitigation is required, to ensure the risk of INNS transfer is not significantly increased.

15.6. The Beckton Reuse Indirect Option was screened to determine if it would create a link between isolated catchments, as mapped in the Environment Agency document Invasive Non-Native Species Isolated Catchment Mapping[90].

15.2.3 Invasive non-native species records

15.7. Open-source macroinvertebrate, macrophyte and fish data for the period 1965 to 2022 were obtained for the study area from the Environment Agency Ecology and Fish Data Explorer app[91] and the NBN Atlas online records[21]. The data were screened against Schedule 9 of the Wildlife and Countryside Act 1981 (as amended) and WFD-

[89] Environment Agency (2017). Managing the Risk of Spread of Invasive Non-Native Species Through Raw Water Transfers. Position 1321_16.
[90] Environment Agency (2018). Invasive Non-Native Species Isolated Catchment Mapping. Prepared by Wallingford HydroSolutions Ltd.
[91] Environment Agency Ecology and Fish Data Explorer app. Available at: https://environment.data.gov.uk/ecology/explorer/ [Accessed April 2022]

UKTAG guidance[92] to identify INNS present within the study area.

15.2.4 Ricardo PLC field surveys

15.8. In support of the T2AT SRO, aquatic ecological monitoring was undertaken by Ricardo PLC in 2021, with additional surveys planned in 2022. Field surveys and environmental deoxyribonucleic acid (eDNA) samples for INNS were undertaken at 13 locations within the vicinity of the scheme. Twelve of the 13 survey sites were reservoirs, which are not planned to be utilised as part of the T2AT SRO. However, the level of connection between the River Lee and the adjacent reservoirs has not been established. Therefore, it was assumed INNS could be transferred between these sites.

15.9. Further detail of the field surveys, including methods and locations is included in Appendix D.1. The field survey results are discussed in Section 15.3.

15.2.5 Risk assessment

15.10. The SAI-RAT used for this investigation was developed by APEM Ltd on behalf of the Environment Agency[88]. The tool builds upon other assessment tools such as the Northumbrian Water Group (NWG) raw water transfer assessment tool and the Wessex Water asset assessment tool, to provide a standardised approach to quantifying the INNS risk associated with SROs.

15.11. Risk assessments are processes by which the level of risk presented by certain hazards can be assessed, where hazards are anything that can cause harm. The level of risk is typically the combination of the chance and extent of the harm which could be caused. In the case of this tool, the hazard is the potential movement of INNS along key pathways, and the risk is the chance of that movement occurring combined with the extent of the harm this could cause.

15.12. The tool takes a pragmatic pathway and source-pathway-receptor model approach to the assessment of INNS risk relating to assets and water transfers. An extended functional group mechanism has been included in the tool to account for future risks rather than only examining species known to be currently present within the vicinity of transfer routes and assets. These functional groups are listed in Table 15.1.

[92] WFD-UKTAG (2015). UK Technical Advisory Group on the Water Framework Directive. Revised classification of aquatic alien species according to their level of impact. Public working draft.

Table 15.1: INNS functional groups

Animals	Plants
Mobile, juveniles < 1mm, eggs	Seed, aquatic, annual
Sessile, juveniles < 1mm, eggs	Vegetative, aquatic, annual
Mobile, juveniles > 1mm, eggs	Seed + vegetative, aquatic, annual
Sessile, juveniles > 1mm, eggs	Seed, riparian, annual
Mobile, juveniles < 1mm, no eggs	Vegetative, riparian, annual
Sessile, juveniles < 1mm, no eggs	Seed + vegetative, riparian, annual
Mobile, juveniles > 1mm, no eggs	Seed, aquatic, perennial
Sessile, juveniles > 1mm, no eggs	Vegetative, aquatic, perennial
	Seed + vegetative, aquatic, perennial
	Seed, riparian, perennial
	Vegetative, riparian, perennial
	Seed + vegetative, riparian, perennial
	Seed, aquatic + riparian, annual
	Vegetative, aquatic + riparian, annual
	Seed + vegetative, aquatic + riparian, annual
	Seed, aquatic + riparian, perennial
	Vegetative, aquatic + riparian, perennial
	Seed + vegetative, aquatic + riparian, perennial

15.13. The risk assessment matrix tool takes the form of a Microsoft Excel spreadsheet, into which data and information about SRO water transfers and asset options are entered by the assessor to automatically generate a risk score. Risk scores are presented as a percentage of the highest potential score, with a higher score signifying an increased risk of introducing and transferring INNS. Risk scores are categorised as Low, Medium or High, as shown in Table 15.2.

Table 15.2: Risk score categories

Percentage (%)	Category
0-33	Low
34-66	Medium
67-100	High

15.14. Detailed instructions for use of the tool are provided in the SRO Aquatic INNS Risk Assessment Tool (SAI-RAT) – User Guide (APEM Ltd, 2021). Tool input data is provided in Appendix E.

15.2.6 Biosecurity assessment

15.15. The SAI-RAT includes a high-level, qualitative assessment of biosecurity measures. Following input of proposed water transfer and new asset details to the tool, various biosecurity measures are presented based on the identified pathways of INNS spread. Each of the presented biosecurity measures in the tool are assigned a confidence rating of either High, Medium or Low based on their overall robustness at reducing risk in relation to the corresponding pathway and recreational activities occurring.

15.2.7 Thames raw water transfer INNS risk assessment methodology

15.16. An investigation to understand potential pathways of introduction and spread of INNS within the Thames raw water transfer network was undertaken by Atkins SNC-Lavalin Group[93] on behalf of Thames Water. As the scope of this investigation

[93] Atkins SNC-Lavalin Group 2022. Thames Water AMP7 Invasive and Non-Native Species (INNS) WINEP. TWUL INNS Raw Water Transfer Risk Assessment Report.. 5204636 / WIP / 029

included the River Lee, the results of these assessments are relevant to the Beckton Reuse Indirect Option and were therefore reviewed to inform the INNS Risk Assessment.

15.17. A total of 71 individual risk assessments were undertaken based on 82 transfers (note some transfers were grouped under one assessment due to common sources and receptors). These assessments used an updated version of an INNS risk assessment tool developed by NWG, termed the raw water risk assessment tool (RW-RAT). The RW-RAT was used to provide a score for the 'inherent',' adjusted' and 'weighted' INNS risks.

15.18. The inherent risk score reflects the high-level inherent INNS risk associated with a raw water transfer. This is based on the type of transfer, it's frequency of use, and the distance (in relation to WFD waterbodies) and volume of water transfer.

15.19. The adjusted risk score accounts for factors that may exacerbate or mitigate the risk of INNS transfer via a raw water transfer. The adjusted risk score is calculated by applying multipliers to the inherent risk scores, for each given exacerbating and mitigating factor.

15.20. The INNS weighted risk score accounts for any known INNS at the transfer source and is categorised from low to very high, based on the legislative status of INNS as assigned within the RW-RAT.

15.2.8 Constraints and limitations

15.21. The SAI-RAT used in this assessment quantifies the risk associated with the operational phase of a water transfer option, rather than the construction phase. The Beckton Reuse Indirect Option would involve the construction of a new pipeline, which poses the risk of INNS being spread through the movement of personnel, vehicles and equipment to and from construction sites, as well as the excavation and disposal of materials (e.g., sediment and vegetation). As the design is further developed, construction-phase risks relating to INNS should also be considered, and any identified mitigation measures included in a CEMP to be prepared at a subsequent project stage, as set out in Section 2.3.

15.22. The data and information entered into the INNS risk assessment tool were based on the latest available conceptual design. As the conceptual design is still in development, these details may be subject to change. The INNS risk assessment should be revised throughout the design process. For example, at the time of assessment the number of washout/maintenance points along the pipeline sections of the transfer route could not be confirmed. These should be factored into the risk assessment when they are incorporated into the design.

15.3 Results

15.3.1 High-level screening related to Environment Agency guidance

15.23. The transfer source, the River Lee falls within area 76 of the Environment Agency's *Invasive Non-Native Species Isolated Catchment Mapping v3* (Environment Agency, 2018). This area is classified as 'Canal – CRT', meaning that it is connected to navigable canals controlled by the Canal and River Trust. As the transfer receptor, North Mymms Booster Station Connection is also located within the same area as the transfer source, it is concluded that the Beckton Reuse Indirect Option would not create a link between 'isolated' catchments.

15.24. The Environment Agency guidance for raw water transfers states: 'where catchments are already connected, a risk assessment will be required, which the Environment Agency will use to decide whether subsequent mitigation is required, to ensure the risk of INNS transfer is not significantly increased.' The INNS risk assessment presented in this report fulfils this requirement at Gate 2. The output suggests that the Beckton Reuse Indirect Option would not significantly increase the risk of INNS transfer. However, this conclusion is subject to the assumptions and limitations detailed in Section 15.2.8 and should be taken under advisement from the Environment Agency.

15.3.2 Invasive Non-Native Species records

15.25. A total of thirty-three invasive distinct non-native aquatic and riparian taxa were identified in the Environment Agency and NBN Atlas records for the study area. Five invasive fish species were identified in the records, including the High Impact common carp (*Cyprinus carpio*) and topmouth gudgeon (*Pseudorasbora parva*). Twelve invasive macroinvertebrate species have been recorded in the study area, of which four are High Impact species. Sixteen invasive aquatic and riparian plant species have been recorded, including seven High Impact species.

15.26. Most species records within the study area have occurred within the last 10 years, with the exception of Crucian carp (*Carassius Carassius*) and Signal crayfish (*Pacifastacus leniusculus*) which have been recorded within the last 15 years. Overall, these records indicate that the prevalence of non-native plants and invertebrates has been increasing since 1965, with a surge in occurrences in the 2010s. The prevalence of non-native fish species is relatively unchanged.

15.27. Further detail of the INNS records within 1km of the transfer routes is included in Appendix D.1.

15.3.3 Ricardo PLC field survey results

15.28. Twenty-three INNS fish, macroinvertebrates and macrophytes were recorded during surveys. High Impact macroinvertebrate species included signal crayfish (*Pacifastacus leniusculus*), demon shrimp (*Dikerogammarus haemobaphes*), bloody-red mysid (*Hemimysis anomala*), quagga mussel (*Dreissena bugensis*) and zebra mussel (*Dreissena polymorpha*). High Impact macrophyte species included Canadian waterweed (*Elodea canadensis*), Nuttall's waterweed (*Elodea nuttallii*) and floating pennywort (*Hydrocotyle ranunculoides*). In addition, High Impact riparian species giant hogweed (*Heracleum mantegazzianum*) and Japanese knotweed (*Fallopia japonica*) were also recorded. Positive eDNA samples were collected for High Impact carp species. The greatest number of INNS was recorded at sites LRUS-031 and LRUS-032, with ten species recorded at each site. Nine non-native species were recorded on the River Lee approximately 800m from the proposed extraction point (site LRUS-017).

15.29. Further detail of the field survey results is included in Appendix D.2.

15.3.4 Species distribution

15.30. A summary of the distribution of invasive non-native species found during Environment Agency record searches and during field surveys by Ricardo is presented below in Table 15.3.

15.31. Note the INNS records identified using NBN Atlas were not included in this summary as individual grid references were not available.

15.32. Although not explicitly accounted for within the risk assessment tool, changes in flow to the River Lee may create more favourable conditions for some non-native species or alter their dispersal.

15.33. The detection of several species within the river system and many of the surveyed reservoir suggests a high level of connectivity between these waterbodies, and therefore a high probability of future invasion and transmission of new species.

Table 15.3: Summary of species distribution within study area

Species	Legislative status	Taxon group	Location of records	Distribution
Common [wild] carp *Cyprinus carpio*	UKTAG-High[94]	Bony fish	River Lee River Lee Navigation Turkey Brook Lockwood Reservoir	Several records of common carp were found throughout the study area and this variety may be well established within the area.
Crucian carp *Carassius caraccius*	UKTAG-Unknown	Bony fish	River Lee Navigation Turkey Brook	Crucian carp was recorded at one site on the River Lee Navigation and one site on the Turkey Brook. Other records were found in isolated ponds. This species may have limited distribution within the local river system.
Feral [brown] goldfish/ golden goldfish *Carassius auratus*	UKTAG-High	Bony fish	Turkey Brook	Goldfish was recorded at one site on the Turkey Brook. This is unlikely an established population and is potentially a release of domestic animals.
Mirror carp *Cyprinus carpio*	UKTAG-High	Bony fish	River Lee Navigation	Mirror carp was recorded at two sites on the River Lee Navigation. This variety may have limited distribution throughout the local river system, though could be more widespread.
Topmouth gudgeon *Pseudorasbora parva*	UKTAG-High	Bony fish	Turkey Brook Cuffley Brook	Several records of topmouth gudgeon recorded along Cuffley Brook and Turkey Brook[95] suggesting this species is well established in this location.

[94] WFD-UKTAG listed INNS, categorised as High / Medium / Low / Unknown Impact
[95] The latest record is from 2014.

Species	Legislative status	Taxon group	Location of records	Distribution
Zander *Sander lucioperca*	UKTAG-Moderate WACA 1981 Sch. 9[96]	Bony fish	River Lee Navigation	Two records of zander were found in the River Lee Navigation. This species may have a limited distribution within the local river system, though could be more widespread.
Rainbow Trout *Oncorhynchus mykiss*	UKTAG-Low	Bony fish	Walthamstow 4 Reservoir High Maynard Reservoir	Rainbow trout was found in field surveys in two adjacent reservoirs. It is likely this species has a very limited distribution in the study area.
Bladder snail *Physella acuta*	UKTAG-Unknown	Mollusc	Turkey Brook River Lee Navigation River Lee West Warwick Reservoir East Warwick Reservoir Low Maynard Reservoir Lockwood Reservoir Banbury Reservoir Walthamstow 4 Reservoir Walthamstow 2/3 Reservoir Walthamstow 5 Reservoir Reservoir Walthamstow 1 High Maynard Reservoir	Four records of bladder snail were found in the River Lee Navigation and the Turkey Brook, Field studies identified this species in all locations including the River Lee, suggesting this species is well established in this location.

[96] Listed on Schedule 9 of the Wildlife & Countryside Act 1981

Species	Legislative status	Taxon group	Location of records	Distribution
			William Girling Reservoir King George V Reservoir	
Bloody-red mysid *Hemimysis anomala*	UKTAG-High	Crustacean	River Lee Navigation East Warwick Reservoir Low Maynard Reservoir	Bloody-red mysid was found at one site on the River Lee Navigation. Field surveys also found this species at two reservoir sites. This indicates this species may have a limited distribution in the study area, though could be more widespread.
Caspian mud-shrimp *Chelicorophium curvispinum*	UKTAG-Unknown	Crustacean	River Lee Navigation River Lee	Caspian mud shrimp was found at two sites on the River Lee Navigation and during field surveys on the River Lee. The species is likely to be relatively widespread within the river system where suitable habitat exists.
Demon shrimp *Dikerogammarus haemobaphes*	UKTAG-High	Crustacean	River Lee River Lee Navigation East Warwick Reservoir Low Maynard Reservoir Lockwood Reservoir Banbury Reservoir Walthamstow 4 Reservoir Walthamstow 2/3 Reservoir Walthamstow 5 Reservoir	Demon shrimp was found at two sites on the River Lee Navigation and during field surveys on the River Lee and several adjacent reservoirs. Demon shrimp is a prolific invader and is at risk of further spread within the local river system.

Species	Legislative status	Taxon group	Location of records	Distribution
			Reservoir Walthamstow 1 High Maynard Reservoir William Girling Reservoir King George V Reservoir	
Freshwater bivalve *Dreissenidae sp.*	UKTAG-Unknown	Mollusc	River Lee Navigation Low Maynard Reservoir Walthamstow 4 Reservoir Walthamstow 5 Reservoir Reservoir Walthamstow 1	There are two records of *Dreissenidae sp*. In the River Lee Navigation and four positive identifications of this species in the field. *Dreissenidae sp*. Are prolific invaders and are at risk of further spread within the local river system.
Freshwater gastropod *Physella sp.*	UKTAG-Unknown	Mollusc	River Lee Navigation River Lee West Warwick Reservoir East Warwick Reservoir Low Maynard Reservoir Lockwood Reservoir Banbury Reservoir Walthamstow 4 Reservoir Walthamstow 2/3 Reservoir Walthamstow 5 Reservoir Reservoir Walthamstow 1	Three records of *Physella sp*. were found on the River Lee Navigation. Field surveys found *Physella sp*. at every survey location. It is likely *Physella* (including *Physella acuta* and/or *Physella gyrina*) are well established within the area.

Species	Legislative status	Taxon group	Location of records	Distribution
			High Maynard Reservoir William Girling Reservoir King George V Reservoir	
New Zealand mud snail *Potamopyrgus antipodarum*	UKTAG-Moderate	Mollusc	Turkey Brook Potters Bar Brook Northaw Brook Cuffley Brook River Lee Navigation River Lee West Warwick Reservoir East Warwick Reservoir Low Maynard Reservoir Lockwood Reservoir Banbury Reservoir Walthamstow 4 Reservoir Walthamstow 2/3 Reservoir Walthamstow 5 Reservoir Reservoir Walthamstow 1 High Maynard Reservoir William Girling Reservoir King George V Reservoir	New Zealand mud snail was recorded in several rivers within the study location and was found at every site during field surveys. It is likely this species is well established in the local river system.

Species	Legislative status	Taxon group	Location of records	Distribution
Northern river crangonyctid *Crangonyx pseudogracilis*	UKTAG-Low	Crustacean	Turkey Brook River Lee Navigation	Four records for Northern river crangonyctid were found in close proximity on the Turkey Brook and River Lee Navigation. However, as this species is difficult to distinguish from Florida crangonyctid, it may be more widespread in the local river system as records for *Crangonyx pseudogracilis/floridanus* exist in several rivers.
Northern river/Florida crangonyctid *Crangonyx pseudogracilis/floridanus*	UKTAG-Unknown	Crustacean	River Lee River Lee Navigation Cuffley Brook Turkey Brook West Warwick Reservoir East Warwick Reservoir Low Maynard Reservoir Walthamstow 4 Reservoir Walthamstow 2/3 Reservoir Walthamstow 5 Reservoir Reservoir Walthamstow 1 High Maynard Reservoir William Girling Reservoir King George V Reservoir	Northern river/Florida crangonyctid were recorded in several rivers within the study location and was found at several adjacent reservoirs during field surveys. It is likely this species is well established in the local river system.

Species	Legislative status	Taxon group	Location of records	Distribution
Oblong orb mussel *Sphaerium transversum*	UKTAG-Unknown	Mollusc	River Lee Navigation	Oblong orb mussel was recorded at one site on the River Lee Navigation. This species may have limited distribution throughout the local river system.
Signal crayfish *Pacifastacus leniusculus*	UKTAG-High WACA 1981 Sch. 9 EU species of special concern[97] IAS Order 2019 Sch. 2[98]	Crustacean	River Lee Navigation High Maynard Reservoir King George V Reservoir	Signal crayfish was recorded at one site on the River Lee Navigation and was found in the High Maynard Reservoir and King George V Reservoir during field surveys. The species is likely to be well established in the local river system, and possibly within the local reservoirs. It is a high impact invader and there is a risk of further spread to any waterbodies which have not yet been colonised.
Zebra mussel *Dreissena polymorpha*	UKTAG-High	Mollusc	River Lee Navigation West Warwick Reservoir East Warwick Reservoir Low Maynard Reservoir Lockwood Reservoir	Zebra mussel was found at two sites on the River Lee Navigation and in several adjacent reservoirs during field surveys. The species appears to be widespread within the local river system and reservoirs and is a high impact invader so there is within a risk of

[97] Invasive Non-Native Species (Amendment etc.) (EU Exit) Regulations 2019 – listed as an 'invasive alien species of union concern'
[98] Listed on Schedule 2 of the Invasive Alien Species (Enforcement and Permitting) Order 2019

Species	Legislative status	Taxon group	Location of records	Distribution
			Banbury Reservoir Walthamstow 4 Reservoir Walthamstow 2/3 Reservoir Walthamstow 5 Reservoir Reservoir Walthamstow 1 King George V Reservoir	spread to any waterbodies not yet colonised.
Polychaete worm *Hypania invalia*	UKTAG-Unknown	Annelid worm	River Lee	*Hypania invalida* was found during field surveys on the River Lee. No other records were found indicating this species may have a limited distribution in the study system.
Oligochaete worm *Branchiura sowerbyi*	UKTAG-Unknown	Oligochaete worm	Lockwood Reservoir	*Branchiura sowerbyi* was found in field surveys in one adjacent reservoir. The species has a very limited distribution in the study area.
Quagga mussel *Dreissena bugenis*	UKTAG-High	Mollusc	West Warwick Reservoir East Warwick Reservoir Low Maynard Reservoir Lockwood Reservoir Banbury Reservoir Walthamstow 4 Reservoir Walthamstow 2/3 Reservoir Walthamstow 5 Reservoir	Quagga mussel was found during field surveys of all reservoirs surveyed. No records were found within river systems, however as quagga mussel is a high impact invader, there is a risk these species could spread further depending on the level of connection between the River Lee and adjacent reservoirs.

Species	Legislative status	Taxon group	Location of records	Distribution
			Reservoir Walthamstow 1 High Maynard Reservoir William Girling Reservoir King George V Reservoir	
Freshwater gammarid *Cryptorchestia cavimana/garbinii agg.*	UKTAG-Unknown	Crustacean	Banbury Reservoir Walthamstow 4 Reservoir Walthamstow 5 Reservoir	*Cryptorchestia cavimana/garbinii agg*. was found in field surveys in three adjacent reservoirs. It is likely this species has a very limited distribution in the study area
Side swimmer *Gammarus tigrinus*	UKTAG-Unknown	Crustacean	West Warwick Reservoir East Warwick Reservoir Lockwood Reservoir Reservoir Walthamstow 1 High Maynard Reservoir William Girling Reservoir	*Gammarus tigrinus* was found in field surveys in six adjacent reservoir. The species is likely to be relatively widespread within the area, where suitable habitat exists.
Himalayan Balsam *Impatiens glandulifera*	UKTAG - High EU species of special concern WACA 1981 Sch. 9 IAS Order 2019 Sch. 2	Flowering plant	Turkey Brook River Lee Mimmshall Brook River Lee Navigation	Records of Himalayan balsam were found on several rivers in the study and the species may therefore be relatively widespread along local watercourses.

Species	Legislative status	Taxon group	Location of records	Distribution
Least duckweed *Lemna minuta*	UTAG-Unknown	Flowering plant	River Lee River Lee Navigation	Several records of least duckweed were found on the River Lee and River Lee Navigation and the species may therefore be relatively widespread within local watercourses.
Nuttall's pondweed *Elodea nuttallii*	UKTAG-High EU species of special concern WACA 1981 Sch. 9 IAS Order 2019 Sch. 2	Flowering plant	River Lee West Warwick Reservoir East Warwick Reservoir Low Maynard Reservoir Walthamstow 4 Reservoir Walthamstow 2/3 Reservoir Walthamstow 5 Reservoir Reservoir Walthamstow 1 High Maynard Reservoir King George V Reservoir River Lee, upstream of Thames Water King George V reservoir intake	Several records of Nuttall's pondweed found on River Lee and field studies indicate this species is prevalent in adjacent reservoirs, therefore the species is likely to be relatively widespread within the study area where suitable habitat exists.
Orange balsam *Impatiens capensis*	UKTAG-Low	Flowering plant	River Lee	Two records of Orange balsam found within close proximity on the River Lee. This species may not be prevalent throughout the study area.

Species	Legislative status	Taxon group	Location of records	Distribution
Sweet flag *Acorus calamus*	UKTAG-Low	Flowering plant	River Lee Walthamstow 2/3 Reservoir	Two records of Sweet flag were found within close proximity on the River Lee, and one from an adjacent reservoir. This species may not be very prevalent throughout the study area.
Canadian waterweed *Elodea canadensis*	UKTAG-Moderate WACA 1981 Sch. 9	Flowering plant	River Lee	Canadian waterweed was recorded on the River Lee during field surveys approximately 800m upstream of the abstraction point. It is a High Impact species, which risks further spread to any area is has not already colonised.
Floating pennywort *Hydrocotyle ranunculoides*	UKTAG-High EU species of special concern WACA 1981 Sch. 9 IAS Order 2019 Sch. 2	Flowering plant	River Lee	Floating pennywort was recorded on the River Lee during field surveys approximately 800m upstream of the abstraction point. As floating pennywort is a High Impact species, there is a risk changes to flow may create a more favourable habitat facilitate further spread downstream.
Japanese knotweed *Fallopia japonica*	UKTAG – High WACA 1981 Sch. 9	Flowering plant	West Warwick Reservoir Walthamstow 2/3 Reservoir	Japanese knotweed was recorded at two reservoir sites during field surveys though may not be particularly widespread within the study area.
Giant hogweed	UKTAG – High	Flowering plant	West Warwick Reservoir Walthamstow 2/3 Reservoir	Giant hogweed was recorded at two reservoir sites during field surveys though may not be

Species	Legislative status	Taxon group	Location of records	Distribution
Heracleum mantegazzianum	WACA 1981 Sch. 9			particularly widespread within the study area.

15.3.5 Risk assessment

15.3.5.1 Water transfer risk

15.34. The INNS risk assessment results for the sections of the Beckton Reuse Indirect Option as derived from the Environment Agency SAI-RAT are summarised in Table 15.4 below. It should be noted that these scores do not take into account any engineering interventions that may be required as mitigation to prevent the spread of INNS.

Table 15.4: INNS risk assessment scores for water transfers

Transfer section name	Transfer section description	Risk score (%)	Risk score category
Section 1	River Lee Flood Relief Channel to the new WTW via new pipeline	35.60	Medium
Section 2	New WTW to Brookmans Park Service Reservoir via new pipeline	27.98	Low
Section 3	Brookmans Park Service Reservoir to booster pumping station in the vicinity of North Mymms via new pipeline	30.38	Low

15.35. Of the three water transfer sections, Section 1 was found to have the highest associated INNS risk with a score of 35.60%, which falls into the Medium risk category. Section 2 of the transfer generated the lowest risk score at 27.98%, which falls into the Low risk category. Section 3 also falls into the Low risk category with a risk score of 30.38%.

15.36. Section 1 generated the highest risk score as it involves the transfer of raw water from the source river, whereas drinking water is transferred along Sections 2 and 3. Although raw water is not intentionally discharged to an open waterbody at any point along Section 1 of the transfer route, a higher score is assigned to account for the risk of INNS introduction to the environment via leaks or washout of raw water from the pipeline, or movement of INNS due to operational procedures (e.g., contamination of personnel clothing, equipment or vehicles that come into contact with raw water). INNS have been identified in the source waters of the River Lee (see Sections 15.2.2 and 15.2.3). As the River Lee is accessible to the public and is used by local angling clubs, there is risk of further INNS introduction to the source waters and consequently to Section 1 of the transfer.

15.37. Sections 2 and 3 of the transfer contain drinking rather than raw water, which accounts for the low risk scores generated for these two sections compared to Section 1. The slight difference in risk score between Section 2 and Section 3 can be accounted for by the difference in transfer distance and highest order site designation within 1km of the receptor site. The INNS risk presented by Section 2 and 3 is considered to be negligible as there is no opportunity for raw water to be discharged into the environment.

15.3.5.2 Asset risk

15.38. The INNS risk assessment results of the assets as derived from the Environment Agency tool are summarised in Table 15.5 below.

Table 15.5: INNS risk assessment scores for assets

Asset name	Risk score (%)	Risk score category
River Lee Intake	17.25	Low
Raw Water Pumping Station	15.32	Low
New WTW	18.39	Low

15.39. All of the proposed assets generated a 'Low' risk score for introducing and spreading INNS. The new WTW scored slightly higher due to the higher frequency of maintenance and removal of waste sludge onto land. However as all assets form sealed structures, contact with raw water is not planned as part of routine operation. Suggested biosecurity measures may not reduce this risk further and is discussed in more detail in Section 15.3.6.

15.3.5.3 Overall risk

15.40. The overall INNS risk associated with the Beckton Reuse Indirect Option was found to be Low at 24.15%, with both the raw water transfer element and the asset element assessed as Low risk. A full breakdown is provided in Table 15.6.

Table 15.6: Overall risk scores associated with the Beckton Reuse Indirect Option

Component	Average risk score (%)	Risk score category
Water transfers	31.32	Low
New assets	16.99	Low
Overall	24.15	Low

15.3.6 Biosecurity assessment

15.41. The risk assessment tool identified a range of biosecurity measures to mitigate the risk associated with key pathways of INNS spread that would be introduced by the proposed water transfers and assets. Potential biosecurity measures specific to pipeline transfers are presented in Table 15.7.

15.42. Only Section 1 of the transfer would benefit from biosecurity or mitigation measures as the only section which would involve the transfer of raw water. Such measures would likely have minimal benefit as the risk would be related to rare accidental leaks of raw water from the closed system. As Section 2 and 3 transfer drinking water through a closed system, biosecurity and mitigation are not necessary as the risk posed by INNS is negligible.

Table 15.7: Potential biosecurity measures for pipeline transfers

Biosecurity measure	Description	Confidence
Biosecurity strategy	Biosecurity measures incorporated into water company standard operating procedure.	Medium

Biosecurity measure	Description	Confidence
Chlorination	Chlorination of transferred water using hypochlorite, chlorine gas or chlorine dioxide. Suggested pipeline concentration of 1mg Cl/L over 10 days of continuous dosing.	High
Chemical treatment	Could include coagulation and flocculation, OZONE treatment, pH or salinity alteration, or application of an herbicide.	High
Anti-fouling paints	Paint applied to surfaces of pipeline to create toxic/unfavourable substrate for bio-fouling INNS.	Medium
UV treatment	UV is transmitted through water as it flows through a specialised chamber. The radiation damages cells and DNA and causes mortality in the exposed organisms.	Medium
Active filtration	Active filtration using screen filters, bed filters or other pumped filtration methods.	Medium
Passive filtration	Installation of fish screens, rundown screens or conveyor screens to prevent the passage of suspended matter and organisms.	Low
Raw water transfer (RWT) flows	Periodically stopping the flow of water and allowing the RWT to fully dry out would kill any aquatic INNS that have entered the RWT. A period of 2 weeks drying time would be sufficient to kill most aquatic INNS. Only feasible for small RWT and pipelines.	Medium

Biosecurity measure	Description	Confidence
Integrated/combination treatment	Combinations of filter-active treatment methods and chemical treatment.	High

15.43. Angling by members and day ticket holders is conducted on the River Lee and is likely controlled by either the Canal and River Trust or an angling club; therefore, such organisations provide a mechanism for disseminating biosecurity information and influencing practices. As shown in below in It is possible that the Canal and River Trust, the Environment Agency and angling clubs, would be best placed to advise on mitigation options which are likely to be adopted. It is recommended that Thames Water and Affinity Water engage with third party organisations at a subsequent project stage to select biosecurity measures and consider implementation of company-wide INNS strategies.

15.44. Table 15.8, there are a number of potential biosecurity options which are likely to vary in their feasibility and effectiveness. This assessment indicates that live bait restrictions, and either prevention or thorough drying of equipment being transported between waterbodies would be the most effective measures. It is however uncertain how feasible such options may be. It is possible that the Canal and River Trust, the Environment Agency and angling clubs, would be best placed to advise on mitigation options which are likely to be adopted. It is recommended that Thames Water and Affinity Water engage with third party organisations at a subsequent project stage to select biosecurity measures and consider implementation of company-wide INNS strategies.

Table 15.8: Potential biosecurity measures for angling

Biosecurity measure	Description	Confidence
Check, clean, dry (CCD)	Promotion of CCD protocol amongst recreational user of the canal network.	Medium
Biosecurity strategy	Biosecurity strategy developed by canal recreational user groups.	Medium
Event management	A reduction in the number of events or scale of events. Increased biosecurity during events.	Medium
Site-specific recreational equipment	Equipment not to be transported between waterbodies. Use restricted to one site to prevent spread of INNS.	High

Biosecurity measure	Description	Confidence
Live bait restrictions	Either prohibiting the use of live bait entirely, or managing live bait use, ensuring source from site only.	High
Equipment and personal protective equipment (PPE) cleaning (dry)	Installation of waterless cleaning stations. May involve the use of brushes to decontaminate dirty equipment.	Low
Static water wash equipment and PPE (cold)	Water < 35°C to aid manual removal of INNS (ambient temperature water will not cause mortality of INNS). May involve use of dip tank.	Low
Static water wash equipment and PPE (hot)	A temperature of > 35°C for 15 minutes, or > 45°C for 1 second has been proven effective against many invasive invertebrate species. May involve use of dip tank.	Medium
Drying	Allowing equipment to completely dry ensures that hitchhiker INNS are rendered non-viable. Providing a drying room or other designated area on site for this purpose would allow PPE to be stored and dried at the same location.	High

15.45. The overall INNS risk associated with the operation of assets is low as staff and equipment entering the raw water is not planned as part of routine operation. The greatest risks identified within the risk assessment are associated with the introduction of INNS from outside sources such as on personnel and vehicles entering the site and INNS being transferred from the asset. The proposed Beckton Reuse Indirect WTW also poses an additional risk of INNS transfer through removal of waste sludge from the site onto land. As the assets involved in the transfer are intended to be sealed, the likelihood of INNS transmission through the pathways identified within the risk assessment is negligible and implementation of biosecurity measures would likely have negligible risk reduction benefit. Medium and High confidence measures should be considered if the evolving design involves a point in the system being temporarily or permanently unsealed; however based on current design this is not considered to be the case.

15.46. Table 15.9 shows potential biosecurity measures which could be incorporated during scenarios where there may be a risk of INNS transmission and introduction.

Table 15.9: Potential biosecurity measures for implementation at assets

Biosecurity measure	Description	Confidence
Check, clean, dry (CCD)	Promotion of CCD protocol amongst WTW personnel.	Medium
Biosecurity strategy	Biosecurity strategy developed by water company.	Medium
Site-specific operational equipment	Provision of site-specific operational equipment (e.g., pontoons, buoys, vehicles) to reduce the inter-site movement of INNS.	High
Equipment and personal protective equipment (PPE) cleaning (dry)	Installation of waterless cleaning stations. May involve the use of brushes to decontaminate dirty equipment.	Low
Static water wash equipment and PPE (cold)	Water < 35°C to aid manual removal of INNS (ambient temperature water will not cause mortality of INNS). May involve use of dip tank.	Low
Static water wash equipment and PPE (hot)	A temperature of > 35°C for 15 minutes, or > 45°C for 1 second has been proven effective against many invasive invertebrate species. May involve use of dip tank.	Medium
Running water (cold)	Running water can be effective against invertebrate INNS. However, efficacy (mortality endpoint) is reduced in comparison to pressurised water. Efficacy is dependent on the method and effort of cleaning.	Low
Running water (hot)	Running water can be effective against invertebrate INNS; however, efficacy (mortality endpoint) is reduced in comparison to pressurised water. Efficacy is dependent on the method and effort of cleaning.	Medium
PPE cleaning (dry)	Boot brushing/cleaning stations are a simple approach to decontamination of footwear.	Low

Biosecurity measure	Description	Confidence
PPE cleaning (dip tank or sink, cold)	A dip tank or sink to allow total immersion of PPE. Brushes and cleaning tools would be a requirement. Ambient temperature water will not cause direct mortality in INNS (unless of much different salinity), so cleaning relies on manual action (scrubbing and drying). Wastewater would be contaminated, so appropriate disposal needed.	Low
PPE cleaning (dip tank or sink, hot)	A dip tank or sink to allow total immersion of PPE. A temperature of >35°C for 15 minutes, or >45°C for 1 second has been proven effective against many INNS. The efficacy of hot water against INN plant species (mortality endpoint) is not as high as for invertebrates, so it is important that equipment is treated for sufficient time; immersion of equipment at 50°C for 5 minutes is recommended to achieve high INNS plant mortality.	Medium
Pressure wash (cold)	High-pressure cold water can be effective against invertebrate INNS. However, efficacy (mortality endpoint) is reduced in comparison to pressurised hot water. Efficacy is dependent on the method of application of the spray, regarding duration and distance from surface.	Low
Pressure wash (hot)	High-pressure, hot water can be very effective against invertebrate INNS. However, the efficacy is dependent on the method of application of the spray, regarding duration and distance from surface.	Medium
Drying	Allowing equipment to completely dry ensures that hitchhiker INNS are rendered non-viable. Providing a drying room or other designated area on site for this purpose would allow PPE to be stored and dried at the same location.	High

15.3.7 Thames raw water transfer INNS risk assessment results

15.47. During the risk assessment undertaken by Atkins SNC-Lavalin Group, the Lee Valley area was identified as a high risk point within the network due to several raw water transfers crossing this area. The River Lee Intake falls within this area, however as this report assessed only pre-existing transfers within the Thames Water network, no RWT assessed within this report is directly applicable to the Beckton Reuse Indirect Option but has been used to inform where additional risk may occur. Within the risk assessment, intakes from rivers have consistently been identified as the highest risk due to abstraction of water directly from a high risk source, where the risk of INNS introduction and transfer is high. The Lee Valley was a high scoring location in terms of INNS weighted risk score, with several higher risk INNS present in the area. Existing transfers within the Lee Valley also scored highly for inherent risk and adjusted risk due to large continuous transfers and frequent recreation in the area. As the source is acknowledged as the first point in which an INNS may enter the Thames Water network, mitigation at the source should be prioritised as this can immediately reduce the risk throughout the rest of the transfer. From a high level review, several key potential mitigation options which could be feasibly applied throughout the general Thames Water network area have been identified below:

- Fine screens and filters – e.g. sand filters, Mecana cloth filters, microstrainers, although these may not be feasible for large volume transfers
- Changes to the operation of transfers, including dewatering and cleaning
- UV treatment
- Thermal treatment
- INNS monitoring programme

15.4 Summary of main findings and recommendations for future technical work

15.48. The following conclusions have been drawn from the results of the INNS risk assessment:

- The Beckton Reuse Indirect Option would not introduce a new hydrological connection between previously isolated catchments as assessed by Environment Agency's Invasive Non-Native Species Isolated Catchment Mapping v3.
- The transfer route was broken down into three sections for the risk assessment based on the source, pathway and receptor: Section 1, a short raw water pipeline transfer from the River Lee Intake to the new WTW; Section 2, a 20km pipeline transfer of drinking water from the new WTW to existing Brookmans Park SR, and Section 3, a short pipeline transfer of drinking water from Brookmans Park SR to the existing North Mymms booster pumping station.

- A large range of aquatic and riparian INNS have been identified within the study area, including within the River Lee and reservoirs in the vicinity. This suggests a high level of connectivity and risk of future invasion and transmission of INNS.
- Despite the prevalence of INNS in the area, there is a very low risk that the Beckton Reuse Indirect Option would facilitate their spread as Sections 2 and 3 transfer drinking water through a closed system, therefore eliminating the risk of further INNS translocation.
- The INNS risk for Section 1 of this scheme is higher than for Section 2 and Section 3, on account of the transfer involving raw water abstracted from the River Lee rather than drinking water. This poses a risk of INNS spread to previously un-infested waterbodies if raw water leaks from the pipeline or during occasional pipeline washout.
- Changes in flow to the River Lee may create more favourable conditions for some non-native species or alter their dispersal.
- INNS risk associated with the new assets was assessed as being Low. However, it is thought that the movement of personnel and vehicles from the WTW following contact with raw water would be the most likely pathway of INNS spread associated with the Beckton Reuse Indirect Option.
- Section 1 would have minimal benefit from the implementation of biosecurity measures in reducing the risk relating to the rare event of water leakage. The most effective and appropriate biosecurity measures suggested to reduce the risk of INNS transference and introduction through pathways include the use of chemical treatment and chlorination, UV treatment application of antifouling paint and various types of filtration, all of which have High and Medium confidence. However, implementation of these measures may be considered disproportionate in relation to the risk.
- As Section 2 and 3 of this transfer would involve drinking water, there would be negligible risk of INNS transfer and further biosecurity/mitigation measures would have no tangible benefit.
- The INNS risk associated with the proposed new assets (River Lee Intake, Raw Water Pumping Station and the new WTW) was assessed as being Low. The assets are designed to move water within a sealed system; therefore it is considered unlikely that additional biosecurity measures would reduce risk further.
- This risk assessment considers operational risk only. Consideration of biosecurity measures during construction is also recommended at a subsequent project stage. Engagement with third parties may identify measures which are most appropriate.

15.4.1 Further investigative actions

15.49. The data and information input to the INNS risk assessment tool were based on the latest available conceptual design. It is recommended that the INNS risk assessment is reviewed at a subsequent project stage to account for any changes that may introduce INNS risk. As the design is further developed, construction-phase risks relating to INNS should also be considered, and any identified mitigation measures included in a CEMP to be prepared at a subsequent project stage, as set out in Section 2.3.

15.4.2 Biosecurity and mitigation

15.50. Measures to mitigate the INNS risk associated with water transfers and assets have not yet been incorporated into the design. Biosecurity measures would have minimal benefit for Section 1 of the transfer (due to the transfer of raw water). It is recommended that the design team review whether it would be feasible and proportionate to apply Medium and High confidence measures to further reduce risk at a subsequent project stage.

15.51. Consideration of biosecurity measures during construction is also recommended at a subsequent project stage. Engagement with third parties may identify measures which are most appropriate during the construction and operational phases. The implementation of company-wide INNS strategies is also recommended.

16 Natural capital and biodiversity net gain

16.1 Introduction

16.1. This chapter presents the findings from the NCA and BNG calculations undertaken for the Beckton Reuse Indirect Option.

16.2. Natural capital refers to the elements of the natural world that provide benefits to society and includes aspects such as woodland, grassland, freshwater, marine, urban greenspace and wetland habitats.

16.3. The benefits that are provided to humans by the natural environment vary from regulating services such as natural flood management to cultural services such as recreational value.

16.4. BNG refers specifically to the combination of habitats present within a site and their ability to support biodiversity. Each habitat is given a distinct score that relates to its area, condition, distinctiveness and connectivity. The change in habitat due to the construction and operation of the regional plan options informs the overall BNG score and whether they are likely to contribute to a net gain in biodiversity.

16.5. At Gate 1, a BNG, NCA and ecosystems services assessment was carried out. This assessment used the most-up-to-date guidance available at the time to undertake the assessment, The Biodiversity 2.0 Metric. In July 2021, Defra and Natural England launched The Biodiversity 3.0 Metric[99]. The Biodiversity 3.0 metric presents significant improvements for measuring and accounting for nature losses and gains. The Biodiversity 3.0 metric has been used for this Gate 2 assessment, and therefore replaces the assessment carried out at Gate 1. Defra and Natural England have since published the Biodiversity 3.1 Metric[100], in July 2022.

16.6. The T2AT SRO is committed to achieving a minimum 10% biodiversity net gain, which would be reviewed when the precise regulatory and legislative requirements are known (e.g. under the Environment Act 2021[101]. Opportunities were identified to achieve this for the Beckton Reuse Indirect Option, however specific habitat mitigation and enhancement proposals would be set out at a subsequent project stage.

[99] Natural England, 2021. ARCHIVE SITE for the Biodiversity Metric 2.0 and the Biodiversity Metric 3.0. Available at: http://nepubprod.appspot.com/publication/5850908674228224?_sm_au_=iVVPNqtWD1q4R02FB4M2vK7TFvCft [Accessed: May 2022]

[100] Natural England, 2022. The Biodiversity Metric 3.1 (JP039). Available at: http://nepubprod.appspot.com/publication/6049804846366720 [Accessed: August 2022]

[101] Environment Act 2021, c.30. Available at: https://www.legislation.gov.uk/ukpga/2021/30/contents/enacted [Accessed: April 2022]

16.2 Structure of this chapter

16.7. This chapter presents the NCA, BNG, and opportunities relating to the Beckton Reuse Indirect Option. There are five parts to this chapter.

- Methodology – Definition of how the NCA and BNG has been assessed.
- Assumptions and limitations – A list of assumptions and limitations that are applicable to the results.
- The Gate 2 NC and BNG Assessment Findings – Outputs of the NCA and BNG and description of optimised routes. Assessments have been undertaken in line with the methodology found in the WRSE Regional Plan Environmental Assessment Methodology Guidance[16].
- Results and opportunities – Summaries of the assessment and the potential opportunities to achieve a minimum 10% net gain in BNG as well as improve the overall provision of ecosystem services provided by natural capital.
- Recommendations for future technical work – Developed design, finalised feasibility, pre-planning investigations and planning investigations.

16.3 Methodology

16.3.1 Defining the natural capital baseline

16.3.1.1 Zone of Influence

16.8. The Zone of Influence (ZoI) was defined as the area of receiving (i.e. a watercourse receiving a discharge) or providing (i.e. an aquifer where abstraction would occur) environment with the potential to be altered or changed as a result of the Beckton Reuse Indirect Option.

16.9. The transfer pipelines would be installed primarily using open cut excavation. To provide sufficient working space to construct the pipeline a temporary working area would be required, which could include the temporary removal of natural capital stocks within that area. For areas where the pipeline would be constructed in open field, or areas not otherwise limited by physical constraints such as nearby buildings, it has been assumed that the working width would extend a maximum of 25m on both sides of the pipeline, resulting in a total working width of 50m. The assumed temporary works area has been reduced in built-up areas for the natural capital assessment to ensure that impacts on natural capital stocks are not overstated (e.g.

to avoid natural capital stocks that are separated from the working area by above ground permanent structures such as buildings). It has therefore been assumed that for built-up areas, the temporary works area would extend a maximum of 10m on both sides of the pipeline, resulting in a total width of 20m. The natural capital stocks that are both temporarily and permanently impacted by the construction of permanent aboveground infrastructure and the temporary works area required to construct the pipeline are included within the ZoI. At a subsequent project stage, the ZoI would need to be further refined with the availability of greater design detail and site survey data.

16.3.1.2 Developing a natural capital baseline

16.10. A natural capital baseline was developed for the Beckton Reuse Indirect Option. This baseline was developed using open-source data as described in the NECR285 National Natural Capital Atlas[102] to generate a natural capital account of the stocks within the ZoI. The list of stocks considered within the accounts and the methodology for mapping them are provided in Appendix F. The methodology used to map natural capital utilises the same breakdown of stocks as the NECR285 National Natural Capital Atlas where possible. However, the list has been supplemented with additional abiotic stocks and key habitats that are vital such as chalk streams and rivers.

16.11. The natural capital baseline reports the total quantity of each stock within the study area, and where suitable, an indication of natural capital condition.

16.3.2 Overview assessment methodology: natural capital assessment

16.12. An NCA has been undertaken in accordance with the Environment Agency's Water resources planning guideline supplementary guidance – Environment and society in decision-making[103] (WRPG supplementary guidance) and Enabling a Natural Capital Approach (ENCA)[104] requirements. ENCA is recommended for use by HM Treasury's Green Book: appraisal and evaluation in central government (2020)[105] and

[102] Natural England (2020). National Natural Capital Atlas: Mapping Indicators (NECR285). Available at: http://publications.naturalengland.org.uk/publication/4578000601612288 [Accessed April 2022]
[103] Environment Agency (2020) Water resources planning guideline supplementary guidance – Environment and society in decision-making.
[104] Defra (2021). Enabling a Natural Capital Approach guidance. Available online at: https://www.gov.uk/government/publications/enabling-a-natural-capital-approach-enca-guidance/enabling-a-natural-capital-approach-guidance [Accessed April 2022].
[105] HM Treasury (2020) The Green Book Central Government Guidance On Appraisal And Evaluation. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/938046/The_Green_Book_2020.pdf [Accessed April 2022].

represents supplementary guidance to the Green Book[106]. In August 2021, ENCA updated its guidance. The approach for Gate 2 is to update the NCA in line with this.

16.13. The August 2021 ENCA guidance includes updated values within the Asset Databook and Service Databook. Within the Service Databook, the carbon reduction tab now includes Department for Business, Energy and Industrial Strategy (BEIS) (2021) carbon values – a set of values produced by the Government to be used in policy appraisal and evaluation, reflecting the latest evidence. The climate regulation section of the assessment has been updated in line with this.

16.14. The impact of the Beckton Reuse Indirect Option on the natural capital stocks and indicators of condition was reported for each element quantitatively. This impact was reported for during construction and post construction to give an estimation of the impact of the whole lifecycle of the Beckton Reuse Indirect Option. The results of the stock assessment were reported in total losses and gains within the ZoI.

16.15. The results of the change in natural capital stocks informed the assessment against the six natural capital metrics (also known as ecosystem services) listed below using the Natural England logic chains, shown in Figure 16.1: Ecosystem services valuation logic chain. The cost / benefit assessment was informed by the option type, option description and any embedded mitigation. The outputs of the NCA were compared to the pre-construction provision of impacted services to assess the impact of the Beckton Reuse Indirect Option. Four ecosystem services were monetised, and the results of the assessment reported as a discreet monetary figure (subject to the ecosystem service scoping exercise set out below), water purification was assessed qualitatively, and biodiversity has been assessed via the Biodiversity 3.0 Metric. Water regulation has not been included for assessment to avoid the potential double accounting of benefits with capacity-based and financial assessment, and to align with the WRPG supplementary guidance[103] that recommends not including monetisation of water regulation benefits in decision making.

[106] HM Treasury (2020) Green Book supplementary guidance: climate change and environmental valuation. Available at: https://www.gov.uk/government/publications/green-book-supplementary-guidance-environment [Accessed April 2022].

Figure 16.1 Ecosystem services valuation logic chain

16.16. The metrics used to assess the impact on natural capital include:

- Carbon sequestration (climate regulation)
- Natural hazard management
- Water purification (qualitative assessment only)
- Biodiversity and habitats (assessed as part of the BNG assessment)
- Air pollutant removal
- Recreation and amenity value
- Food production

16.17. Both natural capital assessment strategies, as outlined in the WRPG supplementary guidance[103] and the Defra ENCA[104], discuss taking a proportionate approach to the assessment. It is therefore important to accommodate this when integrating a natural capital approach within the SRO gated process. A natural capital approach has the potential to inform concept design and aid decision making, by quantifying the relative cost benefits and disbenefits of the SROs to aid the initial assessment of the identified strategic solutions.

16.18. During the initial phase of the NCA, all of the six ecosystem services were reviewed and scoped in or out due to the geographical or socio-economic context of the Beckton Reuse Indirect Option and its ZoI. The approach taken to screening individual metrics is provided below.

16.3.2.1 Carbon sequestration (climate regulation)

16.19. The climate regulation metric focuses on carbon sequestration, which can be defined as the capture and secure storage of carbon that would otherwise be emitted to, or remain, in the atmosphere. The carbon sequestration NCA is in addition to construction and operational carbon calculations (see Section 8.3.2) and provides a holistic assessment of carbon emissions for the Beckton Reuse Indirect Option.

16.20. The assessment was determined by land management within the ZoI of the Beckton Reuse Indirect Option which influenced the carbon store for prolonged periods of time and results in a change in net emissions. The estimate of the carbon stocks for the footprint of the Beckton Reuse Indirect Option was based on the area of broad land use types according to literature and research. The estimated carbon stocks for broad habitat types are listed below and the sequestration rates are shown in Table 16.1.

Table 16.1: Carbon sequestration rates for broad habitat types (JBA Consulting)[103,107]

Land use type	C Seq rate (tCO2e/ha/yr)
Woodland – deciduous	4.97
Woodland – coniferous	12.66
Arable land	0.107
Pastoral land	0.397
Peatland – undamaged	4.11
Peatland – overgrazed	-0.1
Peatland – rotationally burnt	-3.66
Peatland – extracted	-4.87
Grassland	0.397
Heathland	0.7
Shrub	0.7
Saltmarsh	5.188
Urban	0
Green Urban	0.397

[107] Alonso, I., Weston, K., Gregg, R. and Morecroft, M. 2012. Carbon storage by habitat - Review of the evidence of the impacts of management decisions and condition on carbon stores and sources. Natural England Research Reports, Number NERR043.

16.21. The carbon sequestration rates were converted to monetary values using standard methods and the BEIS Interim Non-Traded Carbon Values from 2022, shown in Table 16.2. The NCA is based on a 2022 price year; however, it is assumed that adjustments for inflation have been accounted within the annual projections provided by BEIS and therefore the 2022 value presented below has not been adjusted. High series values were used to reflect a conservative estimate for the price of carbon.

Table 16.2: BEIS interim non-traded carbon values for policy appraisal, £/tCO2e (£2020)

Year	Low series	Central series	High series
2020	120	241	361
2021	122	245	367
2022	124	248	373
2023	126	252	378
2024	128	256	384
2025	130	260	390
2026	132	264	396
2027	134	268	402
2028	136	272	408
2029	138	276	414
2030	140	280	420
2031	142	285	427
2032	144	289	433
2033	147	293	440
2034	149	298	447
2035	151	302	453
2036	155	307	460
2037	156	312	467
2038	158	316	474
2039	161	321	482
2040	163	326	489
2041	165	331	496

Year	Low series	Central series	High series
2042	168	336	504
2043	170	341	511
2044	173	346	519
2045	176	351	527
2046	178	356	535
2047	181	362	543
2048	184	367	551
2049	186	373	559
2050	189	378	568

16.3.2.2 Natural hazard management

16.22. Different habitat types have intrinsic flood risk management values by intercepting, storing and slowing water flows. This is known as natural flood management (NFM) and is listed as a policy within the Government's 25 Year Environment Plan[108]. The capacity of habitats to achieve this can be quantified, and then a monetary value can be assigned based on the damage-costs avoided from flooding or replacement costs due to their capacity to regulate flood waters. The capacity for a given natural capital asset to provide a flood regulation service will depend on two factors:

- Its capacity to slow overland flows
- Whether the asset is located in an area of flood risk

16.23. This ecosystem service also applies in urban areas, where vegetation can reduce surface water flooding from heavy rainfall, with benefits to sewerage capacity. Coastal flood risk, which has been predicted to increase with future climate change, is reduced by coastal margin habitats such as saltmarsh.

16.24. The Beckton Reuse Indirect Option was assessed on the ability to positively or negatively impact flood risk through the comparison of pre- and post-construction natural capital stocks and the catchment in which it is located. The assessment is restricted to catchment areas which drain to downstream communities impacted by flooding. These communities were identified using the Environment Agency's Indicative Flood Map[45], which overlays areas at risk of fluvial flooding and the

[108] 25 Year Environment Plan – Policy Paper. GOV.UK. Available at: https://www.gov.uk/government/publications/25-year-environment-plan [Accessed April 2022]

National Receptor Database. The ecosystem service was scoped in for assessment as it was identified that the Beckton Reuse Indirect Option would have a temporary or permanent impact upon the relevant natural capital stocks, such as areas of woodland, located within the floodplain.

16.25. Reduced flood damage to downstream or coastal settlements as a result of reduced magnitude / frequency of flood / storm events; and / or lower sewer capacity or water storage costs was valued in line with Broadmeadow et al, 2018[109]. This assessment was developed to provide indicative national estimates of water regulation services of woodland to inform natural capital accounts, this is based on modelling to estimate the potential volume of flood water avoided by woodland ecosystems in flood risk catchment. The methodology adopts a replacement-cost (rather than damage cost) approach to valuing the flood regulation service of woodland by applying annualised average capital and operating costs of flood reservoir storage that would be required in the absence of the ecosystem service.

16.26. Central estimate of the average annual costs of reservoir floodwater storage is £0.42/m^3. The range is from £0.10 to £1.19/m^3 per year. The central estimate was used to derive an annual average estimate for the flood regulation service of woodland in Great Britain, which was then uplifted to a 2022 price year. These 'replacement costs' can be considered a lower bound of the benefit if it can be assumed that such expenditure would be deemed value for money by the flooding authorities within flood risk catchments in terms of avoided flood damage costs (ENCA[104]).

16.3.2.3 Water purification

16.27. Based on their ecological functioning, different habitat types have varying capacities for absorbing pollutants from a given water source. This service is dependent on the location of the natural capital asset and the nature of the surrounding area. If a natural capital asset has a high capacity to remove pollutants but is not close to a water source, the service will not be provided. Due to this, valuation of the static water purification services of different natural capital assets as part of the NCA was not considered appropriate. A common value for different habitat types could not be applied due to extensive variation in local factors which determine the provisioning of this service.

16.28. To account for the provision of this service within the NCA the impact of the Beckton Reuse Indirect Option associated with the provision or removal of woodland and semi-natural grassland was considered qualitatively and with consideration of the NEVO[110] tool. The tool defines the resulting changes for the following water quality

[109] Broadmeadow, S., Thomas, H., Nisbet, T. and Valatin, G., 2018. Valuing flood regulation services of existing forest cover to inform natural capital accounts. Forest Research.
[110] Luizzo, L., (2019) Natural Environment Valuation Online Tool - Chapter 6a: Water Quantity & Quality Model

variables:

- Dissolved oxygen concentration
- Nitrogen concentration (including organic nitrogen, nitrate, nitrogen dioxide, ammonium)
- Phosphorous concentration (including organic and mineral phosphorous)
- Pesticide concentration (for eighteen different pesticide types

16.29. This approach followed the methodology that if an area of woodland were to be lost, the resultant impacts on water quality can be qualitatively assessed within the ZoI. Any negative changes to the natural capital in theory, reflects the loss of this service within the ZoI.

16.3.2.4 Air pollutant removal

16.30. Air pollution presents a major risk to human health, resulting in premature deaths and reduced quality of life. By removing air pollution, habitats help to lessen these impacts on health and wellbeing. The provisioning of the service is positively related to several key aspects:

- The surrounding area of the natural capital assets with regards to background pollution, especially particulate pollutant
- The quantity and type of natural capital asset, woodland is the major service provider
- The density of population potentially benefiting from reduced exposure; because pollutants are transported, beneficiaries may be downwind of the ecosystem (ENCA[104]).

16.31. The Beckton Reuse Indirect Option was screened against the provision of air pollutant removal according to its location. Air pollutant removal was only considered within built up areas or when the ZoI includes AQMAs. The impact of the Beckton Reuse Indirect Option was assessed according to changes in natural capital stocks within these areas.

16.32. The value provided by natural capital assets was taken from the UK Government's air quality economic assessment methodology[111]. The assessment embeds these values (based on the damage cost approach, i.e. damage to health avoided from reductions in air pollution) and estimates the present value automatically based on the quantitative estimates provided. Indicative average values for air pollution removal in 2015 for different habitats were calculated from aggregate UK values

[111] Jones L., Vieno M., Morton Dan et al. (2017) Developing Estimates For The Valuation Of Air Pollution Removal In Ecosystem Accounts. Final Report For Office Of National Statistics - NERC Open Research Archive

published in February 2019, as shown in Table 16.3.

16.33. The value of each habitat was combined with the changes expected in natural capital stocks to provide a value for the change in service provision. The final impact was reported as a single value that is incorporated within the NCA metric.

Table 16.3: Air pollutant value by habitat type (£2022)

Habitat group	Value (£ per hectare per year)
Urban woodland	942
Rural woodland	299
Urban grassland	182
Enclosed farmland	17
Coastal margins	31

16.3.2.5 Recreation and amenity

16.34. The recreational value of green spaces can be significant. This value reflects both the natural setting and the facilities on offer at the site and often has a strong non-market element. It varies with the type and quality of habitat, location, local population density and the availability of substitute recreational opportunities. Recreational values can be beneficially affected by enhancements in green spaces, or adversely affected by new developments or infrastructure. The wider tourism and outdoor leisure sector is also dependent upon nature to varying degrees (ENCA[104]). This metric depends on the extent to which the natural capital stocks the Beckton Reuse Indirect Option provides would enhance the opportunity for recreation.

16.35. The key parameter needed to estimate in this category is the number of additional or enhanced recreational visits created because of the option. This was estimated using the Outdoor Recreation Valuation Tool (ORVal). ORVal[112] is referenced in HM Treasury Green Book. Random utility / travel cost model of recreational demand for all sites in England and Wales and generates probabilistic predictions of visitor numbers for any publicly accessible outdoor recreation park, path, or beach. It takes account of scarcity of sites and substitution possibilities, as well as travel distances to sites and their attributes. This is useful for baseline initial assessment, accounting, and multiple sites. This should be seen as an estimation in the absence of site-specific

[112] ORVal, Land, Environment Economics and Policy Institute. University of Exeter. Available at: https://www.exeter.ac.uk/research/leep/research/orval/ [Accessed April 2022]

data on visitor numbers.

16.36. Following the development of the natural capital baseline, it was determined that the construction of the Beckton Reuse Indirect Option would not result in the permanent loss of greenspace. Therefore, the change in recreation and amenity services has been scoped out of this assessment.

16.3.2.6 Food production

16.37. Food is produced by a range of ecosystems and in some cases, the food for human consumption is effectively the same as the ecosystem service (e.g., wild fruit, fishing). More often, the provisioning service is a raw material (e.g., crops) that is harvested and processed by humans and produced capital into added value processed food (e.g., bread). The boundary between what is provided by natural capital and the contribution of other forms of capital is often a grey area, e.g., crops require agricultural management; livestock need grassland ecosystems (ENCA[104]).

16.38. Food production has been calculated using the NEVO agricultural model; this is a structural model of agricultural land use and production for Great Britain estimated using Farm Business Survey (2005 – 2011) and June Agricultural Census data. The agricultural land use component in NEVO builds upon the approach developed by Fezzi and Bateman[113]. NEVO was used to assess the impact of the creation or removal of agricultural land for the Beckton Reuse Indirect Option. The change in value of food provision for the footprint of the Beckton Reuse Indirect Option was calculated using this online tool and reported within the NCA.

16.3.3 Overview assessment methodology: biodiversity net gain

16.39. The BNG requirement as outlined in the WRPG[103] stipulates that each SRO should look to maximise BNG. In July 2021, Defra and Natural England launched The Biodiversity 3.0 Metric. The Biodiversity 3.0 Metric presents significant improvements for measuring and accounting for nature losses and gains. It encourages users to create and enhance habitats where they are most needed to help establish or improve ecological networks through rural and urban landscapes. By linking to current and future habitat plans and strategies, including the future Local Nature Recovery Strategies (LNRS), the Biodiversity 3.0 Metric incentivises habitat creation and enhancement where most needed. It also 'rewards' landowners who undertake work early, creating or enhancing habitats in advance, allowing them to generate more biodiversity units from their land. Condition assessment approaches have also been significantly updated and simplified for the Biodiversity

[113] Fezzi, C., Bateman, I., Hadley, D. & Harwood, A. 2019. Natural Environment Valuation Online Tool - Chapter 1: Agriculture Model

3.0 Metric and some key changes made. The metric can support and complement a natural capital approach by providing a consistent method for quantifying impacts on biodiversity, which underpins many other ecosystem services.

16.40. The Government anticipates the Biodiversity 3.0 Metric (and subsequent revisions) to become the industry standard for biodiversity assessments for on-land and intertidal development types in England. As set out in the Environment Act 2021[101], BNG must be measured using a recognised biodiversity metric. The biodiversity metric essentially underpins the Environment Act's provisions for mandatory BNG in England, subject to any necessary adjustments for application to major infrastructure projects. The Environment Act 2021[101] further specifies the requirement of biodiversity reports to include specified quantitative data relating to biodiversity, and as such any tool which evaluation is predominantly qualitative is not recommended.

16.41. The Gate 2 approach has been to use the Biodiversity 3.0 Metric. Any new scheme elements brought into the gated process at this stage have been assessed by the Biodiversity 3.0 Metric, aligning the T2AT SRO with those assessments undertaken to inform the regional planning process and the associated WRMP24s. It should be noted that in April 2022, Defra and Natural England released The Biodiversity 3.1 Metric, providing an update to the Biodiversity 3.0 Metric. The BNG calculation should be revisited and updated using the latest version of the metric at a subsequent project stage.

16.42. A biodiversity baseline has been developed from spatial data sets of habitats inventories to calculate BNG change through land use. The Priority Habitat Inventory and sites with SSSI, SAC, SPA and Ramsar designations were used to identify areas with high biodiversity importance (see Chapter 4: Biodiversity, flora and fauna for data sources). Units have been assigned to the pre-construction land use according to the habitats present in the ZoI. Post construction land use, including any mitigation described in the scheme description, has been used to calculate the post construction score. As this assessment was carried out using only open-source data a precautionary approach has been applied, presuming that where not specifically known, habitats are assigned the moderate habitat score so as not to overstate or understate the likely effects.

16.3.4 Natural capital optimised routes

16.43. As described in Section 2.1, the Beckton Reuse Indirect Option is comprised of a number of key components. The NCA has considered the potential impact of the Indicative Intake Location, Indicative Raw Water Pumping Station Site, Raw Water Transfer Main, Drinking Water Transfer Main and Drinking Water Transfer Main to North Mymms, Indicative WTW Site, the temporary working easement required to facilitate construction, and the indicative locations of temporary construction

compounds.

16.44. The Beckton Reuse Indirect Option has been developed based on series of criteria that consider engineering, environmental, social, and planning constraints. Route corridors for the Raw Water Transfer Main, Drinking Water Transfer Main and Drinking Water Transfer Main to North Mymms have been identified, which are designed to avoid key environmental constraints such as statutory designated nature conservation sites. An indicative route within the wider corridor has been identified taking into account engineering, environmental, social, and planning constraints, for example, avoiding intersecting deciduous woodland priority habitat wherever possible. This route is referred to as the 'Indicative Route' and was assessed as the baseline case.

16.45. As part of the NCA, the Indicative Route was optimised by adjusting it in discrete locations to ensure that the temporary works area, alternating between 10m and 25m along the route, similarly avoids temporary impacts on natural capital assets, wherever possible, while remaining within the wider route corridor. For example, if the route avoided intersecting deciduous woodland priority habitat, but the temporary working easement passes within 25m of the habitat, then the route was realigned further away from that habitat. This resulting route is referred to as the 'NC Optimised Route'. The NC Optimised Route was assessed using the same NC and BNG methodology set out above and the findings are presented in Section 16.5 for comparison against the Indicative Route. It should be noted that for both the Indicative Route and the NC Optimised Route, the assumed temporary works area is considered to be constrained by the route corridors, and therefore, the temporary works area is narrower in discrete locations so that the area, and any associated works, do not extend outside the route corridors.

16.4 Assumptions and limitations

16.46. The following assumptions and limitations are applicable to the results.

Natural capital assessment

- The costs for constructing, operating and maintaining the scheme were not considered within the assessments.
- The provision of public water supply has been excluded from all assessments to avoid potential double accounting of benefits with capacity-based and financial assessment.
- Natural capital stocks identified within the areas allocated for above ground infrastructure have been assumed to be completely lost as a result of the SRO.
- Natural capital stocks presumed temporarily lost are expected to be reinstated/compensated.

- It has been assumed that for each pipeline, the temporary works area required to facilitate construction would extend a maximum of 10m on both sides of the pipe in built-up areas, resulting in a total width of 20m, and would extend a maximum of 25m in open areas not limited by physical constraints, resulting in a total width of 50m.
- The area provided for the temporary works area is assumed to be constrained by the option corridor. Permanent and temporary works are assumed to not extend outside the option corridor.

Biodiversity net gain

- No enhancement of biodiversity post construction was considered. BNG habitat units were assigned to the pre-construction land use according to the habitats present within each option boundary. The post construction land use, including agreed mitigation, was used to calculate the post construction biodiversity score. Where temporary impacts are expected, it is assumed that habitats will be replaced on a like-for-like, and irreplaceable habitats are assumed to be permanently lost.
- The desk-based assessment was carried out using open-source data. As such, a precautionary approach was applied, presuming that where not specifically known, habitats were assigned the maximum habitat score. Habitat identification would need to be refined with habitat survey data at a subsequent project stage to refine the accuracy of the BNG calculations.
- It has been assumed that for each pipeline, the temporary works area required to facilitate construction would extend a maximum of 10m on both sides of the pipe in built-up areas, resulting in a total width of 20m, and would extend a maximum of 25m in open areas not limited by physical constraints, resulting in a total width of 50m.
- The area provided for the temporary works area is assumed to be constrained by the option corridor. Permanent and temporary works are assumed to not extend outside the option corridor.
- The duration of disturbance and timeline for habitat creation has not been included in the assessment. Durations of disturbance, including proposals for creating habitats in advance of disturbance, would need to be refined with greater design detail at subsequent project stages to refine the accuracy of the BNG calculations.

16.5 Natural capital assessment and biodiversity net gain findings

16.47. The NCA and BNG findings are summarised in Tables 16.4 to 16.7, with commentary presented in Section 16.6. A summary of what is included within each table is as follows:

- Table 16.4 shows the predicted impacts on natural capital during and post construction.
- Note: Only those stocks with predicted impacts are listed.
- Table 16.5 summarises the predicted impacts to the provision of ecosystem services screened in for detailed assessment.
- Table 16.6 summarises the predicted impacts to the provision of water purification for the Beckton Reuse Indirect Option, where screened in for qualitative assessment.
- Table 16.7 shows the BNG outputs, including the total net change for habitat and river units where impacted. These outputs have been informed using the predicted impacts on natural capital in Table 16.4.
- Note: At this stage the BNG only takes account of reinstatement and standard mitigation or design assumptions (such as micro-tunnelling for main rivers), not reprovision or additional habitat creation unless outlined in the scheme description.

16.48. Mitigation has only been considered when outlined in the scheme description, or where standard mitigation must be applied. It is recommended that the BNG assessment is revisited as the scheme design develops and habitat survey information is available at a subsequent project stage, and mitigation or enhancement opportunities developed further to achieve a minimum 10% BNG.

16.49. Additionally, where possible, the Beckton Reuse Indirect Option should aim to not only reinstate lost habitat, but also provide a greater or more diverse habitat than is lost, to achieve overall BNG in line with regulatory requirements for BNG at the time of the project consenting. The latter could be achieved by identifying local sites of ecological interest and proposing measures which enhance these features. Further to the above, the calculations would be updated to the BNG 3.1 metric when considering the opportunities for habitat mitigation and enhancement.

Table 16.4: Predicted impacts on natural capital stocks

Natural capital stock	Area of stocks within ZoI pre-construction (Ha)	Stocks present within ZoI during construction (Ha)	Stocks present within ZoI post construction (Ha)	Change (Ha)
Indicative Route				
Coastal floodplain grazing marsh	2.35	0.00	0.60	-1.75
Arable	57.14	0.00	49.46	-7.68

Natural capital stock	Area of stocks within ZoI pre-construction (Ha)	Stocks present within ZoI during construction (Ha)	Stocks present within ZoI post construction (Ha)	Change (Ha)
Pastures	41.46	0.00	39.10	-2.37
Broadleaved, mixed and yew woodland	0.53	0.00	0.30	-0.23
Woodland priority habitat	4.36	0.00	4.36	0.00
Greenspace	5.71	0.00	5.71	0.00
Urban woodland	0.25	0.00	0.25	0.00
Active floodplain	5.85	4.92	5.77	-0.09
Rivers	0.54	0.54	0.54	0.00
Ponds (non-linear)	0.03	0.03	0.03	0.00
NC Optimised Route				
Coastal floodplain grazing marsh	2.34	0.00	0.60	-1.75
Arable	58.13	0.00	50.45	-7.68
Pastures	45.64	0.00	43.25	-2.39
Broadleaved, mixed and yew woodland	0.44	0.00	0.23	-0.21
Woodland priority habitat	2.65	0.00	2.65	0.00
Greenspace	5.71	0.00	5.71	0.00
Urban woodland	0.25	0.00	0.25	0.00

Natural capital stock	Area of stocks within ZoI pre-construction (Ha)	Stocks present within ZoI during construction (Ha)	Stocks present within ZoI post construction (Ha)	Change (Ha)
Active floodplain	5.26	5.16	5.16	-0.10
Rivers	0.53	0.53	0.53	0.00
Ponds (non-linear)	0.03	0.03	0.03	0.00

Table 16.5: Quantitative detailed assessment of the unmitigated predicted impacts on the provision of ecosystem services (£2022[114])

Ecosystem services	Baseline value (£/year)	Estimated value post construction (£/year)	Temporary impact from construction (£/year)	Total future value (£/year)	Overall change in value (£/year)
Indicative Route					
Carbon storage	£17,938.31	£0.00	-£17,938.31	£14,588.88	-£3,349.43
Natural hazard management	£503.07	£0.00	-£503.07	£360.77	-£142.30
Air pollutant removal	£2,676.28	£0.00	-£2,676.28	£2,069.67	-£606.61
Recreation and amenity value[115]	Scoped out	Scoped out	Scoped out	Scoped out	Scoped out
Food production	£134,100.00	£131,200.00	-£2,900.00	£131,200.00	-£2,900.00
Total	£155,217.65	£131,200.00	-£24,017.65	£148,219.31	-£6,998.34

[114] Ecosystem service values have been calculated as the present value for a consistent price year (£2022), where possible. The price of carbon has relied on BEIS annual projections for 2022, as set out in the methodology above.
[115] Scoped out when the option does not cause the permanent loss of greenspace.

Ecosystem services	Baseline value (£/year)	Estimated value post construction (£/year)	Temporary impact from construction (£/year)	Total future value (£/year)	Overall change in value (£/year)
NC Optimised Route					
Carbon storage	£15,274.62	£0.00	-£15,274.62	£12,775.56	-£2,499.07
Natural hazard management	£327.50	£0.00	-£327.50	£228.54	-£98.95
Air pollutant removal	£2,156.92	£0.00	-£2,156.92	£1,688.14	-£468.78
Recreation and amenity value	Scoped out	Scoped out	Scoped out	Scoped out	Scoped out
Food production	£134,100.00	£131,200.00	-£2,900.00	£131,200.00	-£2,900.00
Total	£151,859.04	£131,200.00	-£20,659.04	£145,892.24	-£5,966.80

Table 16.6: Qualitative assessment of the unmitigated predicted impacts on the provision of water purification

Likely baseline provision	Construction impacts	Likely future provision	Overall change in provision
Indicative Route			
The stocks both temporarily and permanently lost likely provide a high provision of the ecosystem service due to the natural capital assets high capacity to store and absorb pollutants and the proximity of the asset to a water source. These stocks include, for example, different types of woodland area and floodplain grazing marsh.	The provision of services would be lost during construction.	The future provision of the ecosystem service provided by the stock would likely be reduced.	The provision of water purification provided by the associated stocks would likely be reduced due to the option.

Likely baseline provision	Construction impacts	Likely future provision	Overall change in provision
NC Optimised Route			
The stocks both temporarily and permanently lost likely provide a high provision of the ecosystem service due to the natural capital assets high capacity to store and absorb pollutants and the proximity of the asset to a water source. These stocks include, for example, different types of woodland area and floodplain grazing marsh.	The provision of services would be lost during construction.	The future provision of the ecosystem service provided by the stock would likely be reduced.	The provision of water purification provided by the associated stocks would likely be reduced due to the option.

Table 16.7: Summary of the unmitigated BNG metric outputs

Route	On-site baseline (biodiversity units)	On-site post intervention (biodiversity units)	Total net unit change (biodiversity units)	Total percentage change
Indicative Route	389.96	260.89	-129.07	-33.10%
NC Optimised Route	387.30	274.71	-112.59	-29.07%

16.6 Results and opportunities

16.6.1 Summary of NCA and BNG assessments

16.6.1.1 Natural capital assessment

16.50. The Beckton Reuse Indirect Option would likely cause the temporary and permanent loss of stocks during construction. Stocks that are likely to be permanently lost include coastal and floodplain grazing marsh, arable land, pasture, active floodplain, and broadleaved, mixed and yew woodland. However, best practice mitigation (such

as the use of trenchless techniques) and reinstatement/compensation of habitat means that some natural capital stocks post construction would have no to little change.

16.51. The transfer routes and associated above ground infrastructure are concept designs at this stage and, through further investigative work at subsequent project stages, the route could be aligned to further minimise the impact upon priority habitat such as coastal and floodplain grazing marsh.

16.52. The NC Optimised Route has reduced the total amount of river length and broadleaved, mixed and yew woodland that is permanently lost when compared to the Indicative Route, with a subsequent reduction in the loss of ecosystem services. As a result of the route optimisation, a greater amount of pasture and floodplain stocks have been lost as a result.

16.6.1.2 Ecosystem services assessment

16.53. The Beckton Reuse Indirect Option is likely to generate the loss of natural capital stocks during construction. However, habitat that is expected to be reinstated/compensated to pre-construction conditions following best practice technique would likely have no permanent impact to the provision of ecosystem services. Broadleaved, mixed and yew, priority, and urban woodland have a significant maturity time with a delay of 30 years. Therefore, this delay is considered within potential future provision of this stock through the ecosystem services assessment. This can be accounted to the tree mortality rate presumed after woodland areas are replanted.

16.54. Construction impacts include the release of CO_2 due to habitat clearance, a reduction in air pollutant removal, a reduction in food production services, a reduction in natural hazard management, and a reduction in water purification services. For those stocks that are temporarily lost, it is expected that the future value is not affected as stocks are assumed to be reinstated.

16.55. As discussed in Section 16.6.1.1, NC Optimised Route has reduced the loss of targeted natural capital stocks, with a subsequent reduction in the loss of those ecosystem services that have been monetised.

16.56. The Beckton Reuse Indirect Option presents an opportunity to improve the existing habitats through post construction remediation and replacement of low value habitats with higher value habitats. The Indicative Route crosses several priority habitats, Network Enhancement Zones, Fragmentation Action Zones, and Network Expansion Zones and is therefore suitable for the planting of new high value habitats.

16.6.1.3 Biodiversity net gain assessment

16.57. Applying the Biodiversity 3.0 Metric, the Indicative Route would result in the loss of approximately 129 BNG habitat units due to the temporary and permanent removal of habitats during construction.

16.58. When compared to the Indicative Route , the NC Optimised Route results in a lower loss of BNG habitat units, with the loss of approximately 113 BNG habitat units due to the temporary and permanent removal of habitats during construction.

16.6.2 Opportunities

16.6.2.1 Mitigation and enhancement opportunities

16.59. Following the BNG and NCA, opportunities should be considered to ensure the natural environment is left in better condition than pre-construction conditions. When considering these opportunities, it is important to note that the construction and operation of the Beckton Reuse Indirect Option may not be required for a considerable period of time. Opportunities for mitigation and enhancement would need to consider the timing of delivery, noting that there may be changes to land use by existing landowners over this period. Therefore, to allow for greater flexibility, the identification of opportunities should be considered within the wider route corridor. This should be achieved by one or both of the following:

- Mitigation: Opportunities to offset the net loss of biodiversity asset(s) and/or Natural Capital stock(s) (ecosystem service).
- Enhancements: Opportunities that, once introduced and established, would result in a net gain to a biodiversity asset and/or Natural Capital stock(s) (ecosystem service).

16.60. As a core principle, where possible, the Beckton Reuse Indirect Option should aim to not only reinstate lost habitat, but also provide a greater or more diverse habitat than is lost, to achieve overall BNG The latter could be achieved by identifying local sites of ecological interest and proposing measures. It could also be achieved by identifying sites with limited biodiversity value and improving these, such as enhancing arable or improved grassland habitats to provide habitats with a higher biodiversity value. Any habitats that are created or enhanced to achieve BNG are required to be secured for 30 years, through management, maintenance, and monitoring.

16.61. A summary of the potential NCA, BNG mitigation and enhancement measures for each sub-component type are outlined in Table 16.8. Further explanation into the potential enhancement measures is provided within the sections below.

Table 16.8: Summary of potential net gain mitigation and enhancement opportunities

Component	Mitigation opportunity	Enhancement opportunity
Raw Water and Drinking Water Transfer Main Route Corridors	Scheme layouts, including the aboveground infrastructure and pipeline alignment, to be amended to avoid the permanent loss of natural capital assets, wherever possible.	Creation of higher value habitat within grassland, arable and pasture natural capital assets onsite to achieve an increase in Biodiversity Units (BU) and work towards a minimum 10% uplift in BNG.
	Schemes to identify area for the creation and/or reinstatement of high value natural capital assets, including: • Coastal and floodplain grazing marsh • Lowland fens • Lowland raised bog • Reedbeds • Blanket bog • Hay meadows • Dwarf shrub heath • Broadleaved, mixed and yew woodland • Coniferous woodland • Bluespace • Greenspace	Habitat creation work within the adjacent priority habitats. Scheme falls within and is in proximity to habitat network zones[116]: • Habitat restoration-creation • Restorable habitat • Fragmentation action zone • Network enhancement zones 1 and 2 • Expansion zone These areas identify specific locations for a range of actions to help improve the ecological resilience for each of the habitats/habitat networks. The scheme should look to identify habitat network zones and priority habitats within the near vicinity and look to improve/create/restore habitats which would help to work towards increasing BU and work towards a minimum 10% uplift in BNG.
	Construction practices to be considered to reduce the amount of clearance required for, especially in areas that include high value natural capital assets (see above for list).	Increase the quality/quantity of freshwater assets, including lakes, ponds located in designated SSSIs, pending detailed assessment of local conditions and available space.

[116] Edwards J, Knight M, Taylor S & Crosher I. E (May 2020) 'Habitat Networks Maps, User Guidance v.2', Natural England.

Component	Mitigation opportunity	Enhancement opportunity
	Directional drilling to be used where possible to avoid loss of high value natural capital assets (see above for list).	Scheme to identify suitable areas offsite for the creation, enhancement and/or restoration in order to develop off-site net gains, working towards achieving a minimum 10% uplift in BNG.
		Identify areas of local peatland restoration.
Scheme elements located along the canals		Possibly create man-made floating wetland islands, enabling plants and microbes to form and attract wildlife both above and below the water's surface and create biochemical and physical processes to improve things such as water quality.
Indicative WTW Site and other scheme elements that contain above ground infrastructure		Seeding of grassland within footprints of the above ground infrastructure, where possible.

16.6.2.2 Nature Recovery Networks and opportunities

16.62. The Government's 25 Year Environment Plan[108] includes provision for an NRN and states that it will deliver on the recommendations of the Lawton Report and that recovering wildlife will require more habitat; in better condition; in bigger patches that are more closely connected. As well as helping wildlife thrive, the NRN could be designed to bring a wide range of additional benefits: greater public enjoyment; pollination; carbon capture; water quality improvements and flood management.

16.63. Natural England has produced a series of habitat network maps to help address the challenges outlined in the Lawton report and believe they should provide a useful baseline for the development of a NRN as required within the 25 Year Environment Plan[108] and Local Nature Recovery Strategies as proposed within the Environment Act[101]. The maps have been created to provide a national overview of the distribution of habitat networks with suggestions for future action to enhance biodiversity, to help stimulate local engagement with partners and to agree local priorities and identify where action might help build more ecologically resilient ecosystems across

landscapes.

- Habitat Creation/Restoration: Areas where work is underway to either create or restore the primary habitat.
- Restorable Habitat: Areas of land, predominantly composed of existing semi-natural habitat where the primary habitat is present in a degraded or fragmented form, and which are likely to be suitable for restoration.
- Network Enhancement Zone 1: Land connecting existing patches of primary and associated habitats which is likely to be suitable for creation of the primary habitat. Factors affecting suitability include proximity to primary habitat, land use (urban/rural), soil type, slope and proximity to coast. Action in this zone to expand and join up existing habitat patches and improve the connections between them can be targeted here.
- Network Enhancement Zone 2: Land connecting existing patches of primary and associated habitats which is less likely to be suitable for creation of the primary habitat. Action in this zone that improves the biodiversity value through land management changes and/or green infrastructure provision can be targeted here.
- Fragmentation Action Zone: Land within Enhancement Zone 1 that connects existing patches of primary and associated habitats which are currently highly fragmented and where fragmentation could be reduced by habitat creation. Action in this zone to address the most fragmented areas of habitat can be targeted here.
- Network Expansion Zone: Land beyond the Network Enhancement Zones with potential for expanding, linking/joining networks across the landscape i.e., conditions such as soils are potentially suitable for habitat creation for the specific habitat in addition to Enhancement Zone 1. Action in this zone to improve connections between existing habitat networks can be targeted here.

16.64. The NCA and BNG assessments consider the impacts of the Beckton Reuse Indirect Option on priority habitat, however there are opportunities for the scheme to support the NRN. For example, where the pipeline is to be constructed within one of the identified habitat zones, reinstatement of land following construction could be linked to the priorities of that area such as habitat creation, restoration, or improvement. To provide an indication of the potential opportunity associated with the Beckton Reuse Indirect Option, the total area of Network Enhancement Zone 1, Network Enhancement Zone 2, Fragmentation Action Zone, and Network Expansion Zone located within the route corridor and in proximity to each corridor (i.e. within 500m of the route corridor) has been summarised in Table 16.9 below. Both the Indicative Route and the NC Optimised Route are located within the wider route corridor, as set out above. Therefore, the NRN areas have been summarised for the wider route corridor (and surrounding 500m area).

Table 16.9: Area of Nature Recovery Network in proximity to the Beckton Reuse Indirect Option

NRN classification	Total NRN area located within, and in proximity to (500m), the Beckton Reuse Indirect Option (Ha)
Network Enhancement Zone 1	114.92
Network Enhancement Zone 2	409.59
Fragmentation Action Zone	44.07
Network Expansion Zone	495.35

16.65. The measures identified by the NCA and BNG assessment can be used to target mitigation and enhancement to support the NRN areas set out above, as well as other local sites of ecological interest. For example, the route corridor extends through the administrative areas of London Borough of Enfield, Essex County Council and Hertfordshire County Council. These local authorities have developed biodiversity action plans, such as the Lee Valley Regional Park's Biodiversity Action Plan 2019-2029[117], that can further help target areas for mitigation and enhancement. These strategies could then be further supplemented with review of other national, regional and local strategies, such as priorities set out by the Chalk Stream River Strategy[118].

16.66. It is recommended that these opportunities are further explored at subsequent project stages. Wider partnership working with landowners, conservation groups and other organisations should be explored to help deliver opportunities for biodiversity enhancement.

16.6.2.3 BNG unit purchase

16.67. BNG can be achieved via a new statutory biodiversity credits scheme. Credits can be bought by developers as a last resort when onsite and local offsite provision of habitat cannot deliver the BNG required. It is important to emphasise that the purchase of BNG units should only be considered as a last resort when alternative methods for habitat provision are not possible for achieving a 10% net gain in

[117] Lee Valley Regional Park Authority. Lee Valley Regional Park's Biodiversity Action Plan 2019-2029. Available at: https://www.leevalleypark.org.uk/biodiversity-action-plan [Accessed June 2022]
[118] Catchment Based Approach (CaBA). Chalk Stream Restoration Strategy 2021 Main Report. Available at: https://catchmentbasedapproach.org/learn/chalk-stream-strategy/ [Accessed September 2022]

biodiversity. The price of biodiversity credits will be set higher than prices for equivalent biodiversity gain on the market and are expected to be purchased through a national register for net gain delivery sites. Natural England is in the process of running pilot schemes to provide a practical insight into the implications of the scheme, which is expected to go live spring 2023. The number of credits required to be purchased to obtain a 10% increase in BNG for each route option has been calculated and presented in Table 16.10 (i.e. how many BNG units are required to offset the loss plus achieve a 10% net gain).

16.68. Habitat creation possibilities, other than unit purchase, to achieve a 10% BNG gain include:

- On-site: Improve the existing habitats on-site through post construction remediation and replacement of low BNG value habitats with higher BNG value habitats
- Off-site: Purchase suitable areas of off-site land within the local area and/or at a regional scale to offset BNG decrease by improving the existing habitats within the off-site land and/or by replacing existing habitats with higher BNG value habitats.
- On-site and off-site: Improve existing habitats and/or replacement of low BNG value habitats with higher BNG value habitats as part of the catchment management options.

Table 16.10: BNG habitat units required to be purchased to achieve 10% net gain

Route option	BNG habitat unit purchase
Indicative Route	168.07
NC Optimised Route	151.32

16.7 Summary of the main findings and recommendations for future technical work

16.69. The NCA, BNG and ecosystem services outputs identified the following:

- NC: The Beckton Reuse Indirect Option would cause the temporary and permanent loss of natural capital stocks.
- BNG: The Beckton Reuse Indirect Option is likely to result in a loss of BNG habitat units due to the temporary and permanent loss of natural capital assets during construction. Mitigation and enhancement opportunities for the scheme have

been suggested in this section, which can work in tandem to reducing the loss of BNG and introducing net gain. It is recommended that these are developed further at subsequent project stages.

- Ecosystem services: The Beckton Reuse Indirect Option presents opportunities to improve the existing habitats along the route through post construction remediation and replacement of low value habitats with higher value habitats.

16.70. The Beckton Reuse Indirect Option would likely cause the temporary and permanent loss of stocks during construction. Stocks that are likely to be permanently lost include coastal and floodplain grazing marsh, arable land, pasture, active floodplain, and broadleaved, mixed and yew woodland. The NC Optimised Route, resulted in a reduction in the quantity of river length temporarily impacted and the quantity of broadleaved, mixed and yew woodland that would be permanently lost as a result of the scheme, while increasing the quantity of pasture and active floodplain lost as a result of the scheme. The NC Optimised Route resulted in greater value retained for those ecosystem services scoped in for quantitative assessment. The NC Optimised Route also resulted in a smaller total quantity of BNG habitats units lost. The feasibility of the NC Optimised Route should be further investigated at subsequent project stages against engineering, environmental, social, and planning constraints, as well as against potential opportunity areas and proposals for environmental net gain.

16.71. The opportunities identified in the BNG/NC assessment have the potential to contribute to government ambitions for environmental net gain. This could take the form of habitat compensation, creation and/or species relocation schemes. Any schemes would need to be taken forward based on a comprehensive understanding on the interaction between natural systems and between natural systems and social uses of land.

16.72. It is recommended that the underlying data sources are confirmed and refined with on-site surveys at a subsequent project stage to provide a more-detailed understanding of habitat condition. Opportunities should also be considered to create and improve habitat on-site and off-site through local schemes, NRNs and wildlife corridors in order to achieve a minimum 10% net gain in BNG units and increase the provision of ecosystem services, therefore aiding in developing more resilient options for the future provision of water for T2AT SRO.

17 Wider benefits

17.1 Introduction

17.1. This chapter summarises the wider benefits that are predicted to arise from implementing the Beckton Reuse Indirect Option. Wider benefits are those areas of environmental and social value that are associated with constructing and operating the scheme. Areas of disbenefit are also considered.

17.2. The consideration of wider benefits draws on the findings of other assessment work to inform the Gate 2 submission, as well as introducing additional information where material in the context of the Beckton Reuse Indirect Option.

17.3. The overall Best Value and solution benefits are presented in the Gate 2 Report.

17.2 Methodology

17.4. This section sets out the methodology for identifying and assessing wider benefits.

17.2.1 Six capitals framework

17.5. There is no specific methodology guiding wider benefits assessments for SROs. Approaches set out in WRMP Guidance[119] (on identifying benefits (both monetary and non-monetary) for customers, environment and society) and Ofwat's Public Value Principles[120] have influenced the methodology. The starting point for the assessment of wider benefits is the Six Capitals framework[121] (see Table 17.1), which is used by organisations, including UK water companies, as a framework for considering social, governance and environmental issues.

[119] Environment Agency, Natural Resources Wales and Ofwat (2022) Water Resources Planning Guideline. Available at: https://www.gov.uk/government/publications/water-resources-planning-guideline/water-resources-planning-guideline [Accessed May 2022]
[120] Ofwat, Ofwat's Public Value Principles. Available at: https://www.ofwat.gov.uk/about-us/our-strategy/ofwats-public-value-principles/ [Accessed May 2022]
[121] Integrated Reporting Framework. Available at: https://www.integratedreporting.org/resource/international-ir-framework/ [Accessed May 2022]

Table 17.1: Six Capitals framework

Capital	Description
Financial	The pool of funds available for use in the production of goods or provision of services, obtained through financing or generated through operations or investments.
Human	People's competencies, capabilities and experiences, and their motivation to innovate.
Manufactured	Manufactured physical objects available to an organisation for use in the production of goods and services.
Intellectual	Organisational, knowledge-based intangible aspects such as intellectual property, systems and procedures.
Social	The institutions and relationships within and between communities, groups of stakeholders and other networks and the ability to share information to improve individual and collective wellbeing
Natural	The physical stocks of renewable and non-renewable resources that provides goods and services of value to society.

17.2.2 Scoping of potential benefits

17.6. The ZoI was defined as the area of receiving (i.e. experiencing a benefit or disbenefit) or providing (i.e. providing workforce) environment with the potential to be altered or changed as a result of the Beckton Reuse Indirect Option.

17.7. A review of the potential wider benefits that are relevant to the Beckton Reuse Indirect Option was undertaken. Table 17.2 sets out the findings of the review.

Table 17.2: Wider benefits scoping

Capital	Description	Applicability to Beckton Reuse Indirect Option	Scoped in to wider benefits
Financial	Economic benefits – Job creation	The Beckton Reuse Indirect Option is expected to generate temporary and permanent employment opportunities. This will bring benefits through the supply chain.	Yes
Financial	Economic benefits – through capital expenditure		

Capital	Description	Applicability to Beckton Reuse Indirect Option	Scoped in to wider benefits
Financial	Economic benefits – through supply chain		
Financial	Economic benefits – increase in tourism related to new recreation assets	The Beckton Reuse Indirect Option would not build or enhance assets that could be used for tourism or recreation. Brookmans Park Service Reservoir is not accessible to the public.	No
Financial	Financial asset value – some properties or premises may experience a change in value due to proximity to the Beckton Reuse Indirect Option	The Beckton Reuse Indirect Option is not likely to increase or decrease the value of property. The implications for businesses / landowners directly affected by the requirement for land are considered separately in the Cost analysis for Gate 2.	No
Social	Health and wellbeing – from access to recreation and / or open space	The Beckton Reuse Indirect Option provides the opportunity to enhance recreation features such as PRoWs.	Yes
Social	Education – opportunities to provide educational resource	The Beckton Reuse Indirect Option would not provide additional educational resources.	No
Social	Social value – quality of life benefits associated with other economic benefits	The Beckton Reuse Indirect Option could provide an opportunity to continue the deployment of apprenticeships.	Yes
Social	Partnerships – working collaboratively with other organisations	The Beckton Reuse Indirect Option provides the opportunity to link with local organisations to deliver benefits, for example, implementing BNG initiatives.	Yes
Natural	Natural capital – any additional benefits in addition to the scope of the NCA (see Chapter 16)	The ability of the Beckton Reuse Indirect Option to contribute to other aspects of natural capital has been reviewed and no additional issues to the NCA have been identified.	No
Natural	Flood risk – any additional benefits derived from decreasing flood risk (see Chapter 6)	The Beckton Reuse Indirect Option is not likely to affect wider flood risk management measures.	No

17.8. The scoping exercise identified that items applicable to financial, social and natural capital were relevant to the assessment, and that items relating to human, manufactured and intellectual capital were not specifically relevant. The items relating to natural capital are already covered and assessed (see Chapters 6: Water and 16: Natural capital assessment and biodiversity net gain) and are therefore not duplicated here.

17.9. In summary, the key issues for the Beckton Reuse Indirect Option are:

- Economic impacts deriving from employment and the benefits through the supply chain;
- Health and well-being benefits occurring from opportunities to enhance local footpaths / PRoWs;
- Ongoing contribution to enabling apprenticeships; and
- Partnership strategy to work with local organisations.

17.10. The detailed methodology for assessing the wider benefits varies for each of these issues and the following section presents these details alongside the results.

17.3 Results

17.11. This section set out the findings from the assessment of wider benefits for employment impacts, health and well-being benefits and apprenticeships. A partnership strategy is set out in Section 17.4.

17.3.1 Employment impacts

17.12. Employment impacts are expected to result in positive outcomes. The beneficiaries are those who are directly employed, as well as indirect and induced impacts on the local economy (goods and services). The number of potential employees is identified for both the construction and operation phases.

17.13. Employment impacts were calculated by applying standard data from the ONS on Gross Value Added (GVA) per worker at the UK level in the production sector, as this includes employment in the utilities and water industries the number of jobs estimated by the client. This gross figure was adjusted for additionality by applying deadweight and displacement. Leakage was considered to be zero as the study area for this analysis is too large for leakage to be likely. This data was adjusted to 2022 prices using Gross Domestic Product (GDP) deflators from HM Treasury. The GVA impact was then modelled over a 30-year appraisal period and the present value of

this benefit was calculated using the standard HMT discount rate of 3.5% per annum. Indirect and induced employment impacts were calculated using a standard multiplier of 1.1 from the HCA (now Homes England) Additionality Guide[122]. GVA per worker data was then applied to the multiplier jobs and discounted.

17.14. For the construction of the Raw Water Transfer Main, Drinking Water Transfer Main and Drinking Water Transfer Main to North Mymms, it is anticipated that approximately 220 full time equivalent staff could be employed. For construction of the Indicative WTW Site, approximately 220 full time equivalent staff could be employed. The construction period is assumed to be 2030-2034.

17.15. The construction jobs could generate positive economic impacts (direct, indirect and induced) of approximately £94 million. However, the assumption here is that construction jobs are likely to be fully displaced from elsewhere. The assumption is based on how construction jobs are supported, in that many construction firms, big and small, would move around between jobs and if they were not working on this, would likely be working on another project elsewhere. The water companies and any contractors would likely be working on other projects or maintenance if it were not for this project being delivered. This would mean that the jobs supported by the delivery of this project would otherwise be supported by another project. As this assessment looks at national level impacts, a conservative assumption that the jobs would not otherwise exist means this financial benefit is therefore not likely to be able to be attributed to the Beckton Reuse Indirect Option.

17.16. For the operational phase, it is anticipated that 15 full time equivalent staff could be employed.

17.17. The operational jobs could generate positive economic impacts (direct, indirect and induced) of approximately £13 million. These jobs could be attributable to the Beckton Reuse Indirect Option and therefore represent a benefit associated with the T2AT SRO.

17.3.2 Health and well-being

17.18. Health and well-being benefits, such as physical and mental health benefits, could accrue through enhancing opportunities for recreation by enhancing local footpaths / PRoWs to enable access and exposure to greenspace. A Public Health England review[123] concluded that people who have greater exposure to greenspace have a

[122] Homes and Communities Agency 'Additionality Guide'. Fourth Edition 2014. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/378177/additionality_guide_2014_full.pdf [Accessed May 2022]

[123] Public Health England (March 2020): Improving access to greenspace- a new review for 2020 [online]. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/904439/Improving_access_to_greenspace_2020_review.pdf [Accessed August 2022]

range of more favourable physiological outcomes. Greener environments are also associated with better mental health and wellbeing outcomes including reduced levels of depression, anxiety, and fatigue, and enhanced quality of life for both children and adults.

17.19. Opportunities to enhance access to greenspace are most likely to occur in areas where construction activity is affecting existing PRoWs. This is likely to benefit local people, although linkages to any national trails could have a wider benefit. No specific proposals have been incorporated into the scheme design at this stage, therefore benefits are qualitative. The benefits would accrue following construction activity. Examples of opportunities include:

- Opportunities to enhance nearby riparian vegetation and strengthen connections within the blue-green network (Raw Water Transfer Main Route Corridor, Drinking Water Transfer Main Route Corridor and Drinking Water Transfer Main to North Mymms Route Corridor).
- Opportunities to enhance nearby sections of the long distance footpaths in terms of planting, resurfacing, information boards, way markers and social enhancements (Raw Water Transfer Main Route Corridor, Drinking Water Transfer Main Route Corridor and Drinking Water Transfer Main to North Mymms Route Corridor).
- Opportunities to enhance the setting of ancient woodland at Whitewebbs Wood and Great/Broombarns Wood (Drinking Water Transfer Main Route Corridor) and at Brick Kiln Wood and Peplin's Wood (Drinking Water Transfer Main to North Mymms).

17.20. The partnership strategy identifies those organisations that could be engaged to help develop and realise these benefits.

17.3.3 Apprenticeships

17.21. Both Thames Water and Affinity Water have existing apprenticeship schemes to assist in introducing people to the workplace and develop skills through a variety of advanced, higher and degree level apprenticeships across a range of roles. As well as benefits to the individual employee, a skilled workforce contribute to increased Human capital of the organisation. The educational / training facility also benefits through running successful apprenticeship programmes (developing knowledge, skills of trainers) and the local employment and economic market also benefit. Although the apprenticeships are timebound for an individual, organisations such as water companies can provide long term career options as a wide range of roles at all levels are available. Water companies also partner with other organisations, such as contractors, and it is therefore likely that apprentices contribute to construction activities.

17.22. As the water companies run the apprenticeship schemes at a corporate level, rather than recruit for specific projects, it is not possible to assign particular numbers of apprentices to the Beckton Reuse Indirect Option.

17.4 Partnership strategy

17.4.1 Introduction

17.23. This section sets out an approach for identifying partners that may benefit from the delivery of the Beckton Reuse Indirect Option.

17.24. As presented in Chapter 16: Natural Capital and Biodiversity Net Gain, to align with the WRPG[103] and RAPID Gate 2 guidance[5], and to ensure the project creates value beyond public water supply, a NCA has been undertaken to understand the benefits that are currently delivered by the Beckton Reuse Indirect Option, as well as the likely impact on those benefits resulting from construction of the scheme. The potential beneficiaries associated with the findings of the NCA represent a group of stakeholders that could have existing aspirations and priorities that align with the Beckton Reuse Indirect Option, and therefore represent an opportunity to collaboratively deliver environmental enhancement through partnership working.

17.4.2 Approach

17.25. The NCA has estimated the impact of the Beckton Reuse Indirect Option natural capital stocks, which has then informed the assessment against six natural capital metrics (also known as ecosystem services). The approach undertaken for the NCA aligns with Defra's ENCA[104]. ENCA is recommended for use by HM Treasury's Green Book: appraisal and evaluation in central government (2020)[105] and represents supplementary guidance to the Green Book[106]. An assessment on biodiversity and habitats has also been undertaken in order to calculate the biodiversity net gain associated with the route options, following Defra and Natural England's Biodiversity 3.0 Metric[99].

17.26. For each natural capital metric, or ecosystem service, ENCA[104] defines the final welfare benefit and the likely beneficiaries of that service. To inform the various types of partners that may benefit from the Beckton Reuse Indirect Option, the final welfare benefit, likely beneficiaries of the service, and a discussion of other types of organisations that are working within the environmental topic area has been provided for each of the ecosystem services assessed as part of the NCA (see Section 17.4.3).

17.27. Consideration of public water supply and the resulting benefits that customers could receive as a result of the Beckton Reuse Indirect Option has been excluded from the consideration of potential partners. It is assumed that these benefits, including any associated changes to deployable output, are captured separate to the partnership strategy and managed by the associated water companies.

17.28. As part of the RAPID gated process, Thames Water and Affinity Water will engage with a number of statutory consultees and regulators, including but not limited to, the Environment Agency, the Drinking Water Inspectorate, Natural England and Ofwat. For the purposes of identifying potential partnerships, these organisations have been excluded, as engagement is expected to be collaborative and iterative throughout the planning process.

17.29. There are a number of constraints to consider when identifying opportunities for environmental and social benefits, such as the budget for delivering the scheme, the amount of benefit technically possible for each type of proposal given existing land uses, land availability, and the trade-off between prioritising certain types of benefits over others. Further to these constraints, the construction and operation of the Beckton Reuse Indirect Option may not be required for a considerable period of time, at which point constraints such as land use or land availability may have changed. As the scheme continues to progress through the gated process, the relevance of these constraints would be considered when identifying and engaging potential partners.

17.4.3 Natural capital benefits and potential partners

17.4.3.1 Carbon sequestration (climate regulation)

17.30. The NCA identified that both the indicative route and the NC Optimised Route would result in the release of CO_2 due to habitat clearance. The reduced capacity for the route to deliver carbon sequestration as an ecosystem service would result from the temporary and permanent loss of associated stocks, followed by replacement of those same stocks through inset re-planting.

17.31. There is an opportunity to reduce the loss in carbon sequestration by replacing low value habitats with higher value habitats, specifically habitats that can act as carbon sinks. For example, cultivars of carbon sequestering grassland and meadows with enhanced root growth, combined with a good soil profile, have the potential to sequester greater amounts of carbon. It is important to note that, when considering natural capital proposals to enhance carbon sequestration benefits, proper consideration should be given to the habitats being lost in favour of higher value habitats, and whether the retention of less carbon-rich but well-established habitats may sometimes be a better option for local biodiversity. Habitat created to compensate for the loss of natural or semi-natural habitat should be of the same broad habitat type unless there is good ecological reasoning to do otherwise, as

espoused by Defra and Natural England's Biodiversity Metric 3.0[99].

17.32. ENCA[104] identifies the final welfare benefit of carbon sequestration as the contribution to meeting national greenhouse gas (GHG) targets to avert damaging climate change, while noting that the resulting benefits of mitigating climate change (such as reducing the severity of extreme weather events) are far broader and uncertain. In the context of meeting GHG targets, the government is the direct beneficiary of reduced emissions, but other beneficiaries include businesses and individuals who demand carbon offsets. Local legislation and policy set out by the Local Planning Authorities impacted by the Beckton Reuse Indirect Option identifies the need to address climate change risks through mitigation and adaptation. Iterative engagement with both the Local Planning Authorities and regulators throughout the planning process would help to identify potential stakeholders with an interest in reducing carbon emissions through increased sequestration. Local business networks, such as the Hertfordshire Local Enterprise Partnership can provide a valuable resource for identifying both local business partners and local initiatives interested in promoting carbon sequestration.

17.33. When considering potential partnerships, it would be useful to also consider potential funding opportunities available to either the scheme or the potential partner. For example, if woodland planting is identified as a potential carbon sequestration opportunity that could be collaboratively delivered with a local partner, then Forestry Commission funding could be available to create a woodland creation plan through the Woodland Creation Planning Grant[124].

17.4.3.2 Natural hazard management

17.34. The NCA identified that both the indicative route and the NC Optimised Route would result in a reduction of natural hazard management due to the temporary and permanent loss of associated stocks with the floodplain. Where stocks are temporarily lost, it is expected that the future value would not be affected as stocks are expected to be reinstated. Any permanent changes to surface water flood risk, for example by the construction of the new WTW as permanent aboveground infrastructure, would be appropriately assessed and mitigated as set out in Section 6.4.4.4.

17.35. There is an opportunity to further reduce the loss in natural hazard management through enhancements, specifically by replacing low value habitats with higher value habitats, that is habitats that can intercept, store and slow water flows. These types of enhancements can provide a flood risk management value. ENCA[104] identifies the final welfare benefit of natural hazard management as reduced flood damage to downstream settlements, noting that downstream households and businesses, as well as water companies and insurance companies are likely to be the key

[124] Forestry Commission 2018. Woodland Creation Planning Grant. Available at: https://www.gov.uk/guidance/woodland-creation-planning-grant [Accessed May 2022]

beneficiaries. Given the linear nature of the Beckton Reuse Indirect Option, with potential enhancements to natural capital stocks being delivered predominately within the transfer main route corridors, the beneficiaries, and potential partners, are likely to be limited to local landowners and businesses located in close proximity downstream.

17.4.3.3 Biodiversity and habitats

17.36. The BNG calculation presented in Section 16.5 shows that both the Indicative Route and the NC Optimised Route would result in a net loss of biodiversity.

17.37. This BNG calculation has considered agreed mitigation and best practice measures for habitat reinstatement and compensation but has not considered any habitat creation or enhancement proposals. As set out in Section 16.5, the SRO could aim to not only reinstate lost habitat, but also provide a greater or more diverse habitat than is lost, to achieve an overall net gain in biodiversity in line with regulatory requirements for BNG. A summary of potential mitigation and enhancement opportunities has been provided in the Section 16.6.2.1.

17.38. The potential mitigation and enhancement opportunities include, for example, habitat creation that increases connectivity between Natural England's Nature Recovery Networks, where the networks overlap with, and are located in proximity to, the route options. It is anticipated that the forthcoming Local Nature Recovery Strategies, as set out by the Environment Act 2021[101], will bring together information on existing priority habitats, as well as the opportunities identified by regional and national networks, to set out the biodiversity priorities for a given strategy area. The local plans for the Local Planning Authorities impacted by the Beckton Reuse Indirect Option emphasise the importance of conserving biodiversity, recognising priority areas with environmental designations, such as LWSs and SINCs, and through local services, such as the Hertfordshire Ecology Advisory Service. The Local Planning Authorities, as well the as regulators with local knowledge of ongoing biodiversity initiatives, would be an important partnership for targeting enhancements in biodiversity.

17.39. ENCA[104] identifies a range of final welfare benefits from enhancements to biodiversity, as biodiversity underpins, to varying degrees, all ecosystem services. For example, biodiversity underpins the provisioning (food production), regulating (carbon sequestration, natural hazard management, air pollutant removal, and water purification), and cultural services (recreation and amenity) set out within this section. The numerous benefits received from conserving and enhancing biodiversity are widely recognised, and in addition to the local authorities and regulators, there are many organisations that work collaboratively on biodiversity conservation activities. For example, a number of organisations are focused on developing multidisciplinary projects to conserve biodiversity, such as the Hertfordshire Local Nature Partnership, the Hertfordshire Local (Wildlife) Sites Partnership, the

Hertfordshire and Middlesex Wildlife Trust, and Essex Wildlife Trust. These organisations are complemented by other organisations that have a greater focus on a particular aspect of conservation, such as the Herts Bird Club, the Hertfordshire and Middlesex Bat Group, and the Herts and Middlesex Badger Group. National organisations can help to connect these local initiatives across the region through, for example, the Forestry Commission, the Woodland Trust, and the RSPB.

17.40. Exploring local partnership opportunities would allow Thames Water and Affinity Water to further identify and engage with landowners and businesses that are similarly interested in conserving biodiversity, as well as potentially provide access to greater amount of local data.

17.4.3.4 Food production

17.41. The NCA identified that both the indicative route and the NC Optimised Route would result in a reduction of food production services due to the permanent loss of associated stocks, replaced by permanent aboveground infrastructure. Where stocks are temporarily lost, it is expected that the future value is not affected as stocks are expected to be reinstated. Arable land and pasture may be temporarily acquired to construct the Drinking Water Transfer Main.

17.42. ENCA[104] identifies the final welfare benefit of food provisioning services as food for human consumption, with the provisioning service providing a direct input into the agricultural sector and food processing. Although the majority of the effects on agricultural stocks are expected to be temporary, there is an opportunity to partner with farmers, local landowners and agricultural businesses to delivery environmental enhancements as the land is reinstated along the pipeline route.

17.43. The UK Agricultural Act 2020[125] sets out the legislative framework for replacing direct payments to farmers in England with a new system of 'public money for public goods.' The aim of the new Environmental Land Management Scheme (ELMS) will be to deliver benefits such as improved air, water and soil quality, increased biodiversity, climate change mitigation, cultural benefits and to protect the historic environment. There is an opportunity to link any ongoing agri-environment schemes along the Drinking Water Transfer Main Route Corridor with the proposed components of the ELMS and identify where environmental enhancements, such as carbon sequestration or habitat creation, may contribute to these schemes. Given the localised nature of the effects on agricultural stocks, the beneficiaries, and potential partners, are likely to be limited to local landowners and businesses located in close proximity to Drinking Water Transfer Main Route Corridor. National organisations, such as the National Farmers Union, Farming and Wildlife Advisory Group or the Country Land and Business Association, may be able to provide support in identifying opportunities for local partnerships or sources of potential funding,

[125] Agriculture Act 2020. Available at: https://www.legislation.gov.uk/ukpga/2020/21/contents/enacted [Accessed May 2022]

such as the Countryside Stewardship scheme.

17.4.3.5 Air pollutant removal

17.44. The NCA identified that both the indicative route and the NC Optimised Route would result in a reduction of air pollutant removal services due to the temporary and permanent loss of associated stocks within built-up areas. Where stocks are temporarily lost, it is expected that the future value is not affected as stocks are expected to be reinstated.

17.45. There is an opportunity to further reduce the loss in air pollutant removal through enhancements, specifically by replacing low value habitats with higher value habitats. In this context, higher value habitats are those that remove harmful air pollutants from the atmosphere, mainly through direct deposition on leaves and bark and through internal absorption of pollutants through stomatal uptake. ENCA[104] identifies the final welfare benefit of air pollutant removal as reduced health costs from lower levels of exposure to pollution, with both individuals and government identified as the key beneficiaries of reduced health costs.

17.46. Given the localised nature of the effects, with potential enhancements to natural capital stocks being delivered predominately within the narrow transfer main route corridor, the beneficiaries, and potential partners, are likely to be focused on Local Planning Authorities, local landowners and businesses located in close proximity to the Beckton Reuse Indirect Option. The local authorities, for example, may have an aspiration to reinstate affected areas with a greater number of street trees. It should be noted that delivering new or enhanced natural capital stocks, such as street trees, in a built-up area may be challenging given the high concentration of local landowners and businesses, and the complications of land ownership that accompanies densely populated areas.

17.4.3.6 Recreation and amenity value

17.47. The NCA scoped out the consideration of recreation and amenity value as the Beckton Reuse Indirect Option is not likely to result in the permanent loss of designated green space, as set out in Section 12.4. However, the Beckton Reuse Indirect Option is likely to result in temporary effects to recreational and landscape features, such as temporary diversion or closure of PRoWs, as well as permanent effects, such as the loss of small areas of vegetation along some footpaths and waterways. Appropriate mitigation is recommended for these effects, and landscape enhancement opportunities are proposed in Section 9.5.3 to strengthen the existing blue-green networks and enhance local footpaths.

17.48. ENCA[104] identifies the final welfare benefits for enabling recreational services as the use values to individuals visiting recreational sites, such as physical and mental

health benefits, noting that the individuals visiting the sites, as well as recreation and tourism related businesses, are likely to be the key beneficiaries. Similar benefits and beneficiaries are identified by ENCA[104] for enabling local environmental amenity, adding that local property prices can often reflect the added amenity value.

17.49. There are a number of local organisations working to maintain and enhance recreational and landscape features within the areas affected by the Beckton Reuse Indirect Option, which may provide an opportunity for developing local partnerships. For example, the GreenArc partnership facilitates collaborative working to support green infrastructure across a large area of southeast England, including the Lee Valley Regional Park and Epping Forest area. In addition to identifying and prioritising areas for enhancement, these partnerships may allow the SRO to support ongoing volunteering opportunities, as well as connect with local volunteering networks, such as the Community Impact Bucks.

17.4.3.7 Water purification

17.50. The NCA identified that both the indicative route and the NC Optimised Route would result in a reduction of water purification services due to the temporary and permanent loss of associated stocks. Where stocks are temporarily lost, it is expected that the future value is not affected as stocks are expected to be reinstated.

17.51. There is an opportunity to further reduce the loss in water purification services through enhancements, specifically by replacing low value habitats with higher value habitats, that is habitats that can absorb pollutants from a given water source. ENCA[104] identifies the final welfare benefit of water quality as recreational benefits for anglers, rowers, and other users of riparian habitat, as well as more general local amenity benefits and lower costs for water treatment.

17.52. In addition to the groups identified for biodiversity and food production, potential partners include The Rivers Trust, and more specifically the Thames River Trust which coordinates partnerships in the area. These wider networks could assist in identifying more local community groups to prioritise for engagement and volunteering opportunities.

17.5 Summary of main findings and recommendations for future technical work

17.53. The main findings from a review of the wider benefits associated with the Beckton Reuse Indirect Option are as follows.

17.54. Beneficial economic impacts associated with new operational phase jobs are expected to generate approximately £13 million (over the 30 year appraisal period).

17.55. Proposals to enhance green infrastructure links and local footpaths could lead to health and well-being benefits. Further work to develop these opportunities and incorporate into the scheme design could be undertaken at a subsequent project stage.

17.56. A draft partnership strategy has been developed as a basis for future engagement with stakeholders in order to help deliver some of the benefits and enhancements from changes to land use and provision of BNG.

18 Summary of main findings and recommendations for future technical work

18.1 Summary of main findings

18.1. This EAR presents the findings of desk-based studies undertaken following the selection of the Beckton Reuse Indirect Option as one of the preferred options for the Thames to Affinity Transfer SRO. A number of constraints and issues for further investigation at a subsequent project stage have been identified; however, the assessments did not identify any environmental risks which could affect the viability of the Beckton Reuse Indirect Option. As stated in Section 1.2, the recommendations outlined in this environmental appraisal do not definitively scope potential environmental effects in or out at this stage; this would be done as part of an EIA scoping process to be undertaken at the appropriate time and based on up to date information at that time.

18.2. Table 18.1 presents the environmental appraisal summary for the Beckton Reuse Indirect Option.

Table 18.1: Environmental appraisal summary

Assessment / topic	Environmental appraisal summary
Informal Habitats Regulations Assessment	Stage 1 Screening: Potential for Likely Significant Effects on Lee Valley SPA/Ramsar and Wormley Hoddesdonpark Woods SAC. Stage 2 AA: No adverse effects on the integrity of Lee Valley SPA/Ramsar or Wormley Hoddesdonpark Woods SAC are expected. In-combination effects assessment not required as no residual effects are expected.
Water Framework Directive Compliance Assessment	Level 1 Screening: One surface water river (Lea Navigation Enfield Lock to Tottenham Locks) had an impact score greater than 1 due to new or increased abstraction. No groundwater bodies were carried through to the Level 2 – detailed screening assessment. Level 2 Screening: Determined that new or increased surface water abstraction activity does not have the potential to deteriorate the WFD elements of the Lea Navigation Enfield Lock to Tottenham Locks water body or prevent it from attaining Good status in the future. The Beckton Reuse Indirect Option is therefore considered to be compliant with the WFD.

Assessment / topic	Environmental appraisal summary
Strategic Environmental Assessment Review	Major positive effects identified on delivering reliable and resilient water supplies. Major negative effects (pre-mitigation) and moderate negative effects (post-mitigation) were identified for biodiversity, flora and fauna for the construction of the Beckton Reuse Indirect Option. Moderate negative effects on carbon emissions during the operational phase. Moderate negative effects (pre-mitigation) and minor negative effects (post-mitigation) were identified for soil, flood risk, air quality, and population and human health for the construction of the Beckton Reuse Indirect Option. Minor negative or neutral effects were identified for the remaining SEA objectives.
Biodiversity, flora and fauna	Potential for direct impacts on Chingford Reservoir SSSI and Lea Valley IBA as a result of construction of the River Lee Intake. Potential for indirect effects on other statutory designated sites including Northaw Great Woods SSSI and Northaw Great Wood Country Park LNR during construction, although neither of these are GWDTE. Direct and indirect negative effects on non-statutory designated sites, including Gunpowder Park LWS, Lea Valley SINC of Metropolitan Importance, New River SINC of Metropolitan Importance, Tolmers Park LWS Wood N. of Postern Gate LWS, Woodland Strip N. of School Camp LWS, Hell Wood LWS and Coldharbour Plantation & Broombarns Wood, and Legg North LWS, Peplin's Wood, Meadow N. of Peplins Wood, Potterells Wood, Grassland N. of Potterells Wood and Brick Kiln Wood (nr Brookmans Park). Potential for impacts on ancient woodland although temporary construction compounds could be sited and the pipeline aligned to avoid these areas. Potential loss of coastal and floodplain grazing marsh and deciduous woodland priority habitat and potential impacts on protected and priority species. For the aquatic environment, the only designated site which includes aquatic communities as the qualifying/notifiable features is the Cornmill Stream and Old River Lea SSSI. The site is located upstream of the proposed transfer corridor and would not be affected by the construction activities. Impacts on the aquatic communities are expected to be short term and reversible. As such, no or negligible change in aquatic ecological community receptors are expected.

Assessment / topic	Environmental appraisal summary
Soils	No direct or indirect impacts on designated geological sites. Potential for permanent loss of Grade 3 agricultural land at the Indicative Intake Location, Indicative Raw Water Pumping Station Site and Indicative WTW Site as above ground infrastructure. Potential for temporary loss of Grade 3 (including 3b) agricultural land due to pipeline construction within the Drinking Water Transfer Main Route Corridor. Potential for contamination due to construction works within historic landfills and other contaminated land.
Water	Construction activity risks such as disturbance resulting from general construction activity of the transfer corridor and crossing of watercourses are anticipated to be managed through mitigation measures. The assessment of effects associated with recycled water being fed into the river, and the associated abstraction, will be assessed as part of the London Effluent Reuse SRO assessments. The Indicative Intake Location and Indicative Raw Water Pumping Station Site, Drinking Water Transfer Main Route Corridor, Drinking Water Transfer Main to North Mymms Route Corridor and North Mymms Booster Station Connection are located within areas defined as SPZ1 and SPZ2, with potential risk of pollution during construction. No further requirements for assessment of groundwater flow under the WFD at this stage as neither of the groundwater bodies considered in the Level 1 – basic screening assessment were carried through to the Level 2 – detailed screening assessment. The Indicative Intake Location is within Flood Zones 2 and 3 and part of the Indicative Raw Water Pumping Station Site is within Flood Zone 2, and therefore considered to be at risk of fluvial flooding. The Indicative WTW is in flood zone 1. The Indicative Intake Location and Indicative WTW Site are considered to be at low risk of surface water flooding. However, the Indicative Raw Water Pumping Station Site is within a medium surface water flood risk area. A closed loop sustainable drainage system would be required for the Raw Water Pumping Station and new WTW to capture potential contaminants from the treatment process. Fluvial flood risk along the Drinking Water Transfer Main Route Corridor and Drinking Water Transfer Main to North Mymms Route Corridor near watercourse crossings would need to be managed during construction.

Assessment / topic	Environmental appraisal summary
Air	Majority of Beckton Reuse Indirect Option is not within AQMAs. Annual mean NO_2, PM_{10} and $PM_{2.5}$ objectives may be exceeded during construction in areas that are located close to the roadside within Enfield AQMA. Operational effects associated with traffic and standby generators for the new WTW are unlikely to exceed air quality objectives.
Climatic factors	Climatic risks include exacerbation of flood risk, higher temperatures and drought leading to change in ground conditions, and exceedance of operational temperature limits leading to shutdowns. Construction carbon emissions associated with the transfer pipelines and WTW. Operational carbon emissions primarily associated with power consumptions for pumping.
Landscape	Potential for permanent change in landscape character along the pipeline route where vegetation, such as trees and woodland, is lost during construction and cannot be replaced because it falls within the pipeline easement. Construction of the new WTW site would involve the removal of areas of existing vegetation and as a result there would be localised, adverse landscape effects. Indicative WTW Site is proposed on a site predominantly of existing industrial/commercial use and the introduction of a new WTW would not be considered a notable change in land use within the landscape context. Potential visual receptors identified including residential, recreational (including users of PRoW and cyclists), users of transport networks and employment and education receptors. Potential impacts on protected trees within proximity to the Drinking Water Transfer Main Route Corridor including within the Turkey Street and Forty Hill Conservation Areas and TPOs. Opportunities to enhance landcover value and strengthen the blue-green network, for example through use of re-wilding techniques in the restoration of temporary compound areas and use of mitigation planting to link existing green infrastructure elements across the wider Lea Valley landscape.

Assessment / topic	Environmental appraisal summary
Historic environment	No direct impacts on designated heritage assets. Potential for above ground structures associated with the River Lee Intake and the Raw Water Pumping Station to permanently and adversely alter the setting of Luthers Grade II* Listed Building, through visual intrusion. Mitigation would be required to reduce impacts. Minimal changes to the setting of Netherhouse Farmhouse Grade II Listed Building whilst in operation, assuming that the new WTW infrastructure does not exceed the height of the buildings that currently separate the Indicative WTW Site and the listed building. High potential for archaeological remains, particularly dating to the prehistoric period. Excavation during construction would severely truncate, or remove entirely, potential archaeological remains.
Noise	Pipeline alignment should be chosen to be at least 85m from noise sensitive receptors (130m where trenchless techniques occur) in order to minimise significant adverse noise impacts. This could be achieved along the vast majority of the Raw Water Transfer Main Route Corridor, Drinking Water Transfer Main Route Corridor and Drinking Water Transfer Main to North Mymms Route Corridor and should be factored into refinement of the pipeline route alignment. There are some areas within Enfield where this would not be possible and temporary noise effects may occur. Construction and operational noise impacts from the River Lee Intake, Raw Water Pumping Station and Indicative WTW are possible due the proximity of noise sensitive receptors and would require mitigation.
Population and human health	Community and human health impacts affecting housing and private property, businesses and open space and recreation during both construction and operation, including land requirements for the Indicative WTW Site affecting existing businesses and temporary land requirements affecting a country park, PRoW closure, travel disruption and a change in environmental conditions as a result of a combination of noise, air quality, visual impacts or presence of HGV vehicles. No permanent loss of housing and private property, community facilities or recreational assets.

Assessment / topic	Environmental appraisal summary
Material assets	It is not considered that the vehicles volumes generated during construction and operation would present additional constraints to the road network. The majority of roads are anticipated to provide practical options for construction access. There are some localised construction access issues to be investigated in further detail at a subsequent project stage. Major infrastructure crossings including M25, West Anglia Main Line, Lea Valley Line, East Coast Main Line and River Lee Navigation would require further investigation and agreement with stakeholders at a subsequent project stage. Potential impacts on existing utilities and strategic mineral resources.
INNS risk assessment	Beckton Reuse Indirect Option would not introduce a new hydrological connection between previously isolated catchments. Very low risk that the Beckton Reuse Indirect Option would facilitate spread of INNS as water transfer is through a closed system. Main risk identified is raw water movement between the source / intake and the new WTW. Minimal benefit from implementation of biosecurity measures and implementation of these measures may be considered disproportionate in relation to the risk. Negligible risk of INNS transfer of drinking water and further biosecurity/mitigation measures would have no tangible benefit. Low risk associated with the new assets as they are designed to move water within a sealed system; unlikely that additional biosecurity measures would reduce risk further.
Natural capital assessment and biodiversity net gain	Potential for temporary loss of natural capital and ecosystem services as a result of the pipeline and permanent loss as a result of above ground components. Transfer routes could be optimised within the current transfer route corridors to reduce the loss of natural capital stocks. Approximately 129 BNG habitat units could be lost due to the temporary removal of habitats during construction. This could be reduced to 113 BNG habitat units through optimisation of the transfer routes.

18.3. Taking into account the key legislation and national planning policy outlined in this EAR, and with the information available at this stage, it is not considered that there any insurmountable environmental issues that should prevent the Beckton Reuse Indirect Option from progressing.

18.4. The key risk is potential indirect effects on statutory designated sites and direct and indirect effects on non-statutory designated sites, ancient woodland, priority habitat and protected species. This would require further consideration in terms of draft NPS Section 4.3[18] and NPPF[19] Section 15 (paragraph 180), which states that *'as a general principle, and subject to the specific policies below, development should avoid significant harm to biodiversity and geological conservation interests and contribute overall to net biodiversity gain. Where significant harm cannot be avoided or mitigated, as a last resort, appropriate compensation measures should be sought to provide net gains for biodiversity.'* Further technical work, including surveys, is recommended at a subsequent project stage to investigate potential impacts, proposed mitigation and proposals for BNG.

18.2 Recommendations for future technical work

18.5. Recommendations for future technical work at a subsequent project stage are presented in this section. The following activities could be prioritised ahead of commencing formal environmental assessment pursuant to the consenting process:

- Stakeholder engagement on the transfer routes and sites, including with statutory environmental stakeholders (Natural England, Environment Agency and Historic England), Local Planning Authorities, including County Archaeologists, and non-statutory environmental stakeholders including Wildlife Trusts.
- Further work on pipeline routing and siting of above ground infrastructure to avoid constraints such as non-statutory designated sites, ancient woodland and priority habitats; this includes investigating the engineering feasibility of the NC Optimised Route and determining future environmental baseline.
- Informing the design to review biosecurity measures and improve resilience to physical climate change risks.
- Further work to understand contamination risks including a geotechnical and geo-environmental ground investigation and a hydrogeological risk assessment to identify risks to SPZs and likely mitigation.
- Scope and undertake surveys and investigations in order to inform design development and EIA scoping, including:
  - Preliminary Ecological Appraisal to identify the targeted ecology surveys required.
  - Continued aquatic ecology and water quality monitoring.
  - Targeted aquatic ecology surveys of the minor water bodies associated with the Drinking Water Main Route Corridors and the new WTW.

  - Targeted walkovers of the watercourse crossing the inform the need for and scope for additional mitigation measures.
  - Preparation of a ZTV to identify visual receptors followed by site visits to confirm the ZTV and identify viewpoints and locations for visually verified views.
  - Initial arboricultural survey to inform ahead of a full BS5837:2012 survey.
  - Historic environment walkovers and engagement with local archaeological advisors to determine the programme of geophysical and intrusive survey required.
  - Transport Assessment Scoping to identify the traffic surveys and assessment required.
- Undertake optioneering on delivering BNG, including identifying specific locations for opportunities and investigating the merits of the timing of interventions and developing partnerships to help deliver some of the benefits and enhancements from changes to land use and provision of BNG.

Appendix A Maps

Figure 2.1: Beckton Reuse Indirect Option key components

Figure 4.1: Statutory designated nature conservation sites

Figure 4.2: Non-statutory designated nature conservation sites

Figure 4.3: Ancient woodland and priority habitats

Figure 5.1: Bedrock geology

Figure 5.2: Superficial geology

Figure 5.3: Agricultural land classification

Figure 6.1: Flood risk and main river network interactions

Figure 6.2: Surface water flood extents

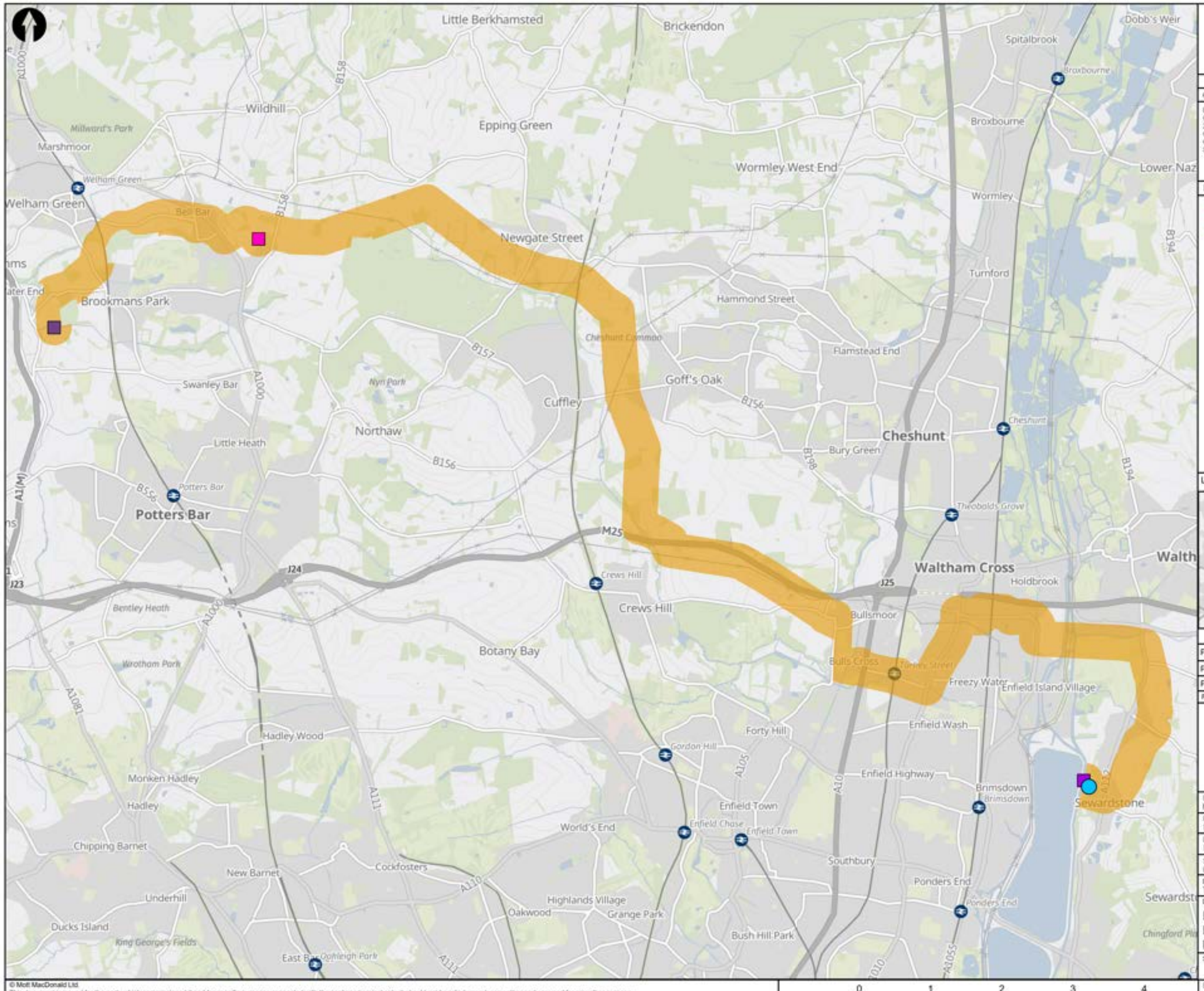
Figure 6.3: Risk of flooding from reservoirs

Figure 9.1: Landscape assets and designations

Figure 9.2: Epping Forest, Hertfordshire and London Natural Signatures Landscape Character Areas

Figure 9.3: Lee Valley Landscape Character Assessment

Figure 10.1: Designated heritage assets



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Legend

Beckton Reuse Indirect Option components
- Indicative Transfer Main Route Corridor
- Indicative Raw Water Pumping Station Site
- River Lee Intake
- Connection into the Affinity Water distribution network 1
- Connection into the Affinity Water distribution network 2

Location Map

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P02	S2	FOR INFORMATION	CD	CLB	CLB	21/09/22
P01	S2	FOR INFORMATION	KL	CLB	CLB	29/06/22

Thames Water
AffinityWater

Location Code: N/A	OS Reference:	Security Reference: STD
Project Group: N/A	Sub Process: N/A	
Location/Town: N/A		
Site Name: Beckton Reuse Indirect		
Project Name: T2AT SRO Gate 2 Environmental Assessments		
Drawing Title: Figure 2.1: Beckton Reuse Indirect Option – key components		
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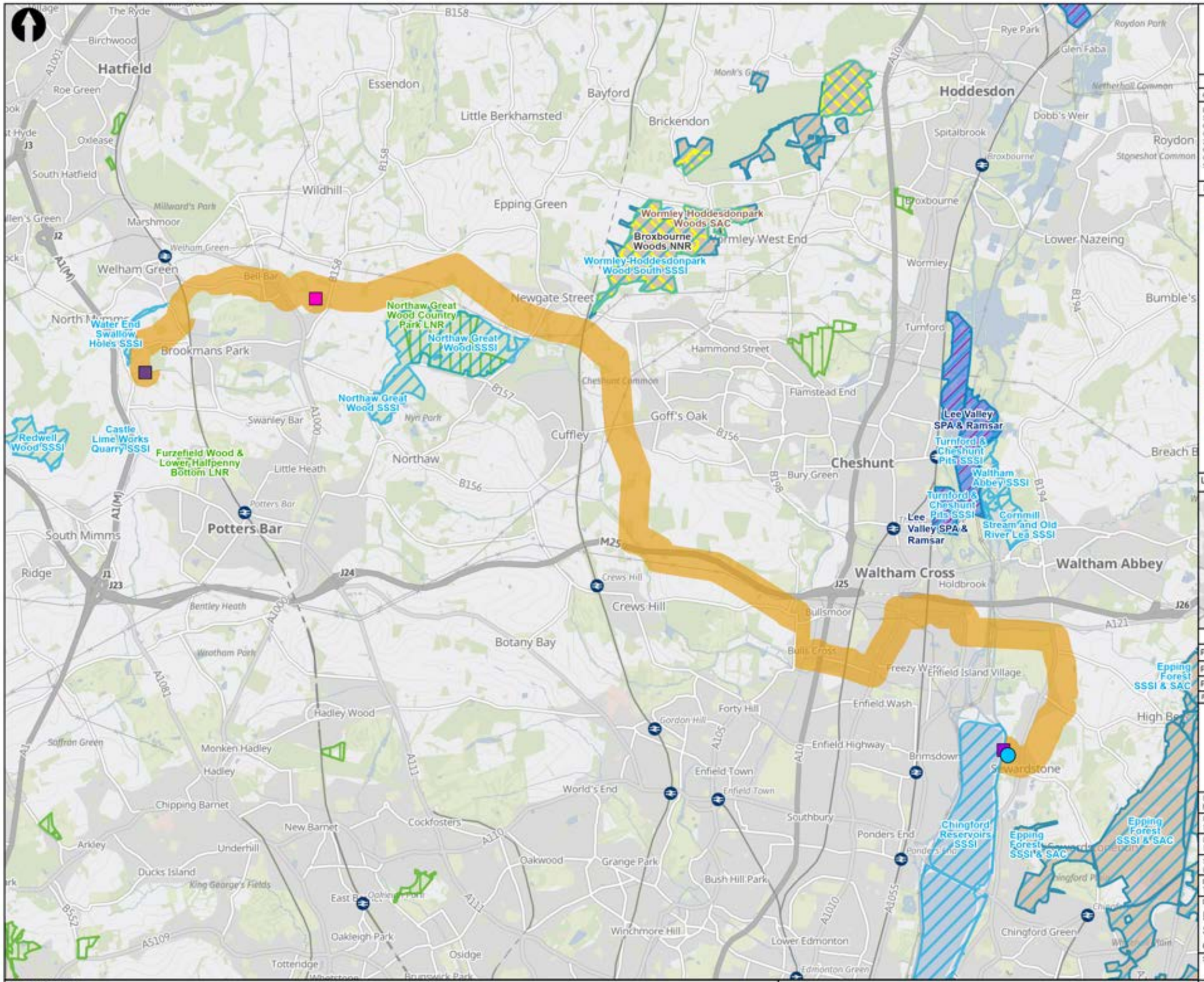

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Legend

Beckton Reuse Indirect Option components

- Indicative Transfer Main Route Corridor
- Indicative Raw Water Pumping Station Site
- River Lee Intake
- Connection into the Affinity Water distribution network 1
- Connection into the Affinity Water distribution network 2
- Special Area of Conservation (SAC)
- Special Protection Area (SPA)
- Site of Special Scientific Interest (SSSI)
- Ramsar
- National Nature Reserve (NNR)
- Local Nature Reserve (LNR)

Location Map

Rev	Status	Suitability description	Author	Ch'k'd	App'd	Date
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P01	S2	FOR INFORMATION	KL	JR	CLB	22/06/22

Thames Water — Affinity Water

Location Code: N/A	OS Reference:	Security Reference: STD
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Location/Town: N/A		
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Project Name: T2AT SRO Gate 2 Environmental Assessments		
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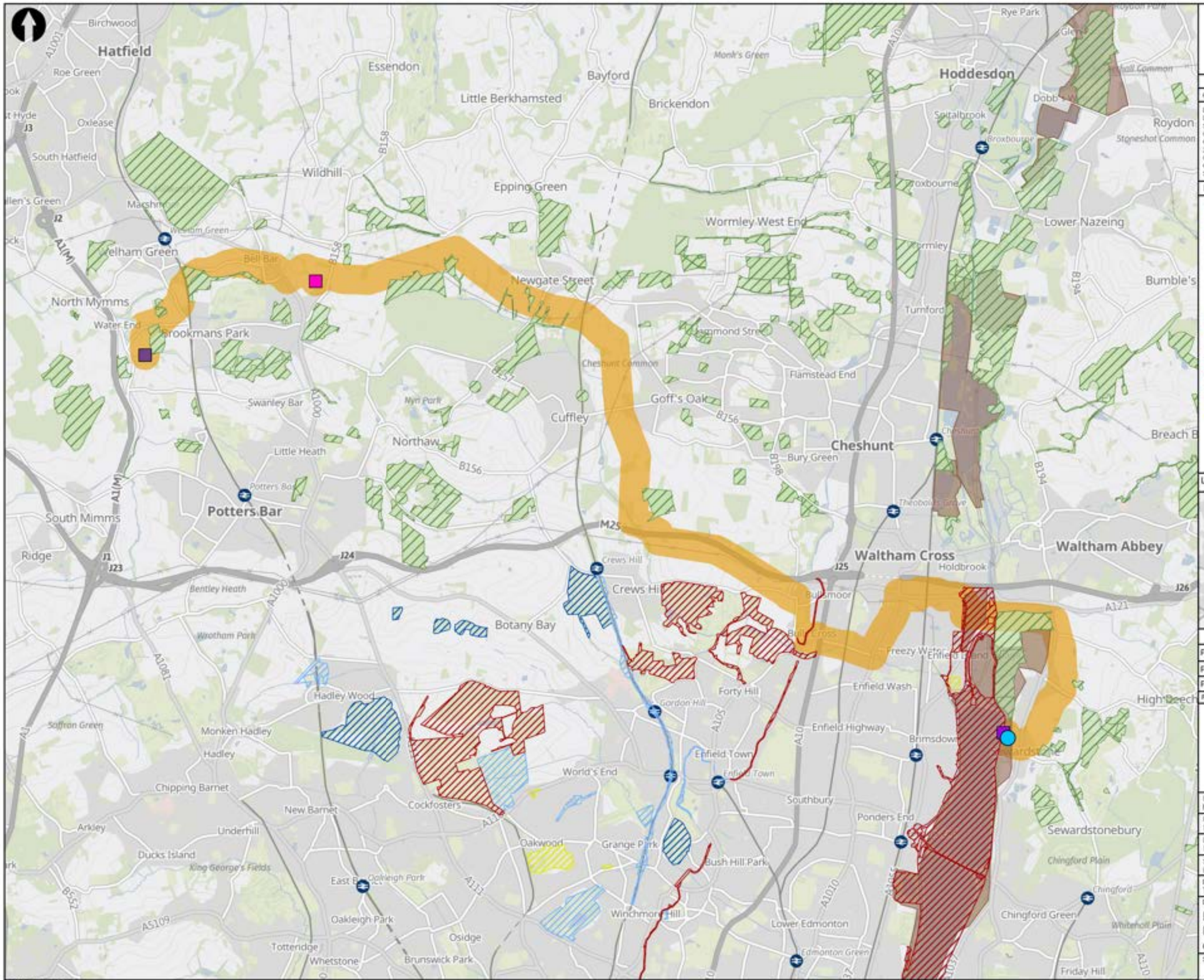

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Legend

Beckton Reuse Indirect Option components
- Indicative Transfer Main Route Corridor
- Indicative Raw Water Pumping Station Site
- River Lee Intake
- Connection into the Affinity Water distribution network 1
- Connection into the Affinity Water distribution network 2
- Local Wildlife Site
- Important Bird Area
- Wildlife Corridor

Sites of Importance for Nature Conservation (SINC)
- Metropolitan Importance
- Borough Importance Grade 1
- Borough Importance Grade 2
- Local Importance

Location Map

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Thames Water — Affinity Water

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Location/Town: N/A		
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Project Name: T2AT SRO Gate 2 Environmental Assessments		
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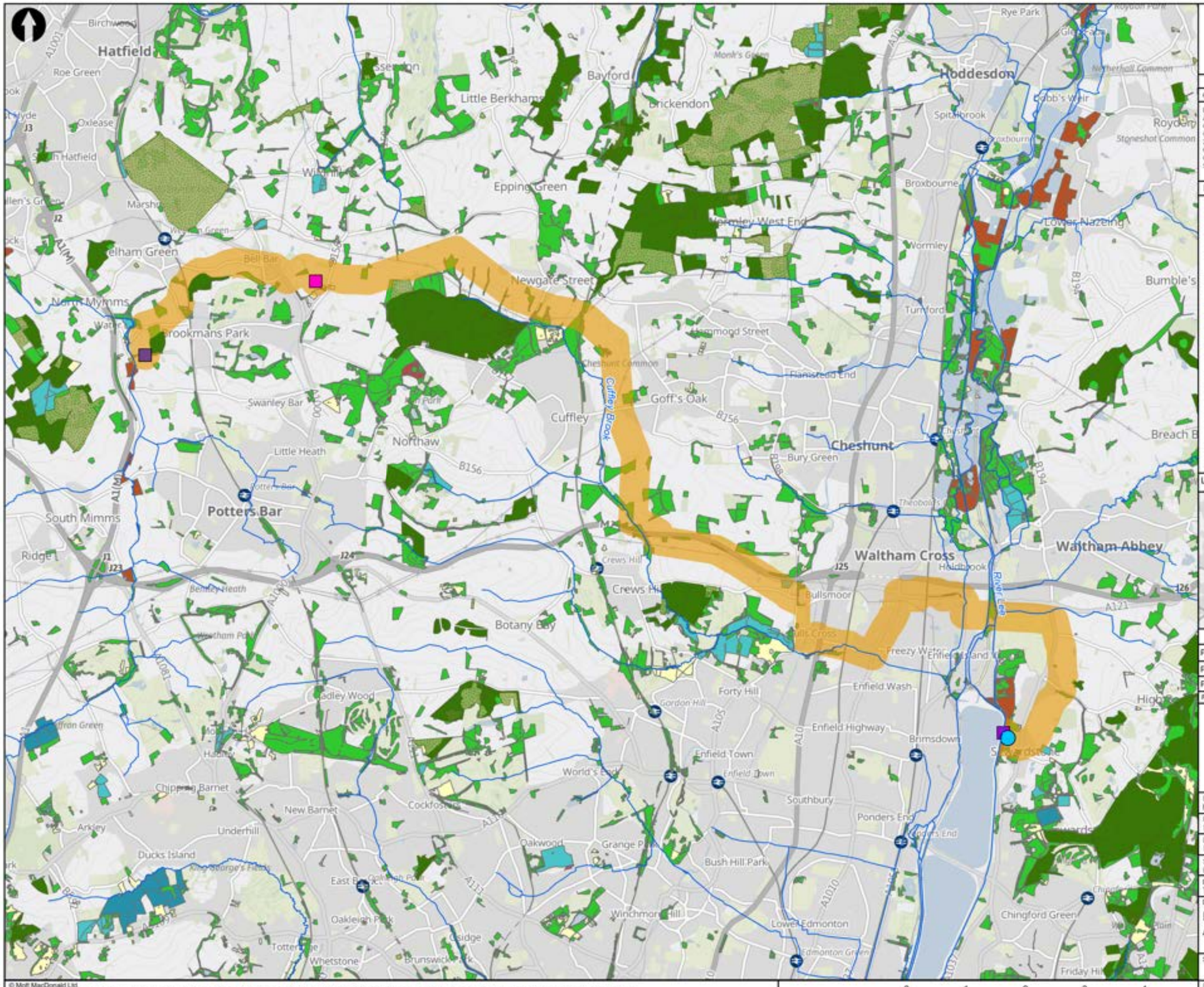

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Legend

Beckton Reuse Indirect Option components
- Indicative Transfer Main Route Corridor
- Indicative Raw Water Pumping Station Site
- River Lee Intake
- Connection into the Affinity Water distribution network 1
- Connection into the Affinity Water distribution network 2
- Main River

Ancient woodland
- Ancient & Semi-Natural Woodland
- Ancient Replanted Woodland

Priority Habitat Inventory
- Coastal and floodplain grazing marsh
- Deciduous woodland
- Good quality semi-improved grassland
- Lowland dry acid grassland
- Lowland fens
- Lowland heathland
- Lowland meadows
- No main habitat but additional habitats present
- Reedbeds
- Traditional orchard

Location Map

Rev	Status	Suitability description	Author	Ch'k'd	App'd	Date
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P01	S2	FOR INFORMATION	KL	JR	CLB	22/06/22

Thames Water — Affinity Water

Location Code: N/A	OS Reference:	Security Reference: STD
Project Group: N/A	Sub Process: N/A	
Location/Town: N/A		
Site Name: Beckton Reuse Indirect		
Project Name: T2AT SRO Gate 2 Environmental Assessments		
Drawing Title: Figure 4.3: Ancient woodland and priority habitats		
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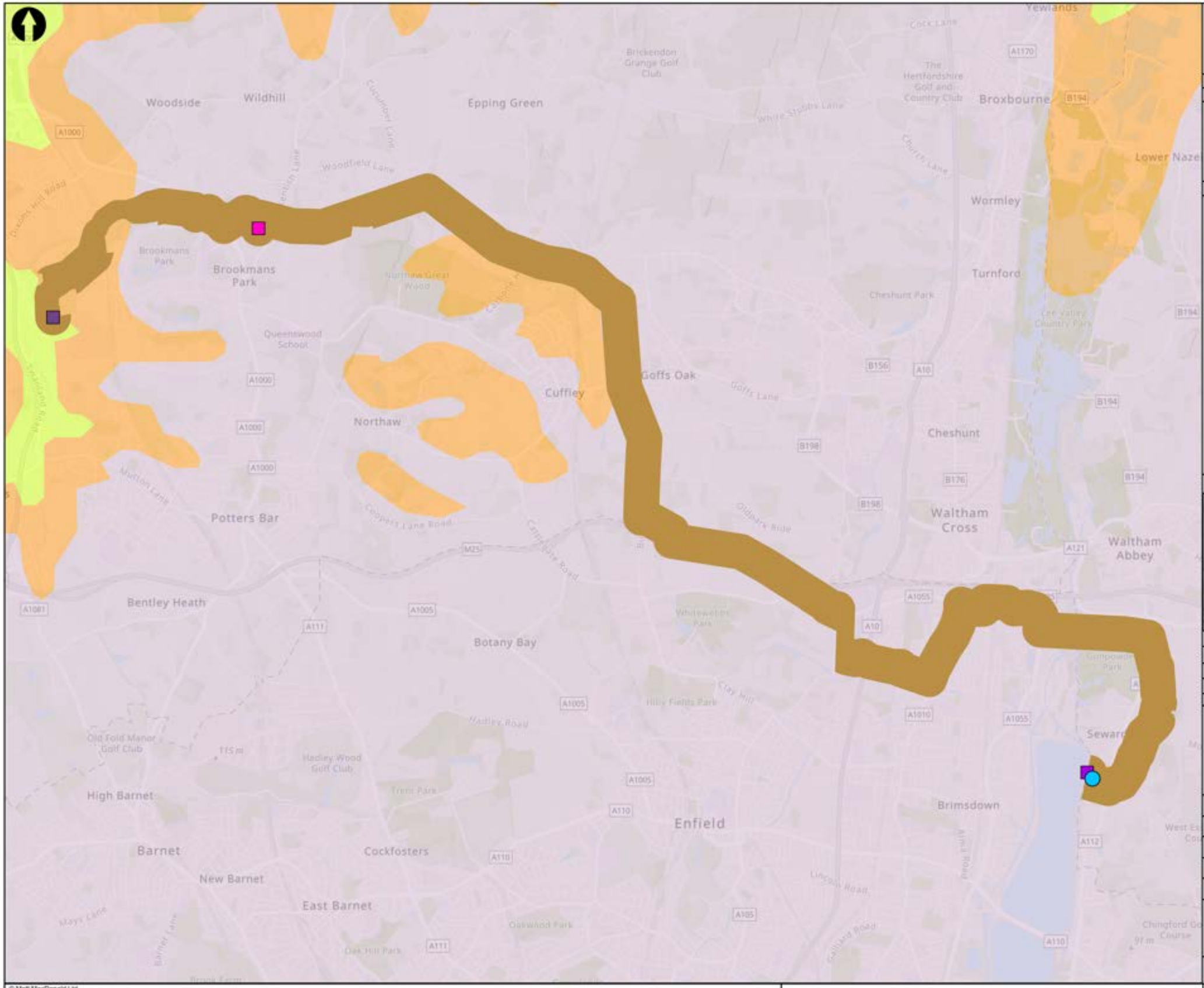

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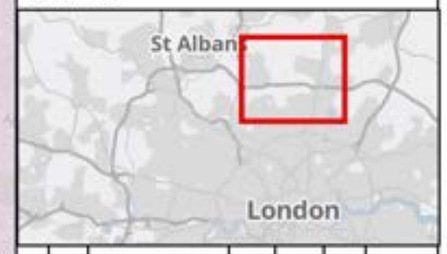
Legend

Beckton Reuse Indirect Option components
- Indicative Transfer Main Route Corridor
- Indicative Raw Water Pumping Station Site
- River Lee Intake
- Connection into the Affinity Water distribution network 1
- Connection into the Affinity Water distribution network 2

Bedrock geology
- Lambeth group - clay, silt, sand and gravel
- Thames group - clay, silt, sand and gravel
- White chalk subgroup - chalk

Location Map



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P01	S2	FOR INFORMATION	CD	CLB	CLB	01/09/22

Thames Water
Affinity Water

Location Code: N/A	OS Reference:	Security Reference: STD
Project Group: N/A	Sub Process: N/A	
Location/Town: N/A		
Site Name: Beckton Reuse Indirect		
Project Name: T2AT SRO Gate 2 Environmental Assessments		
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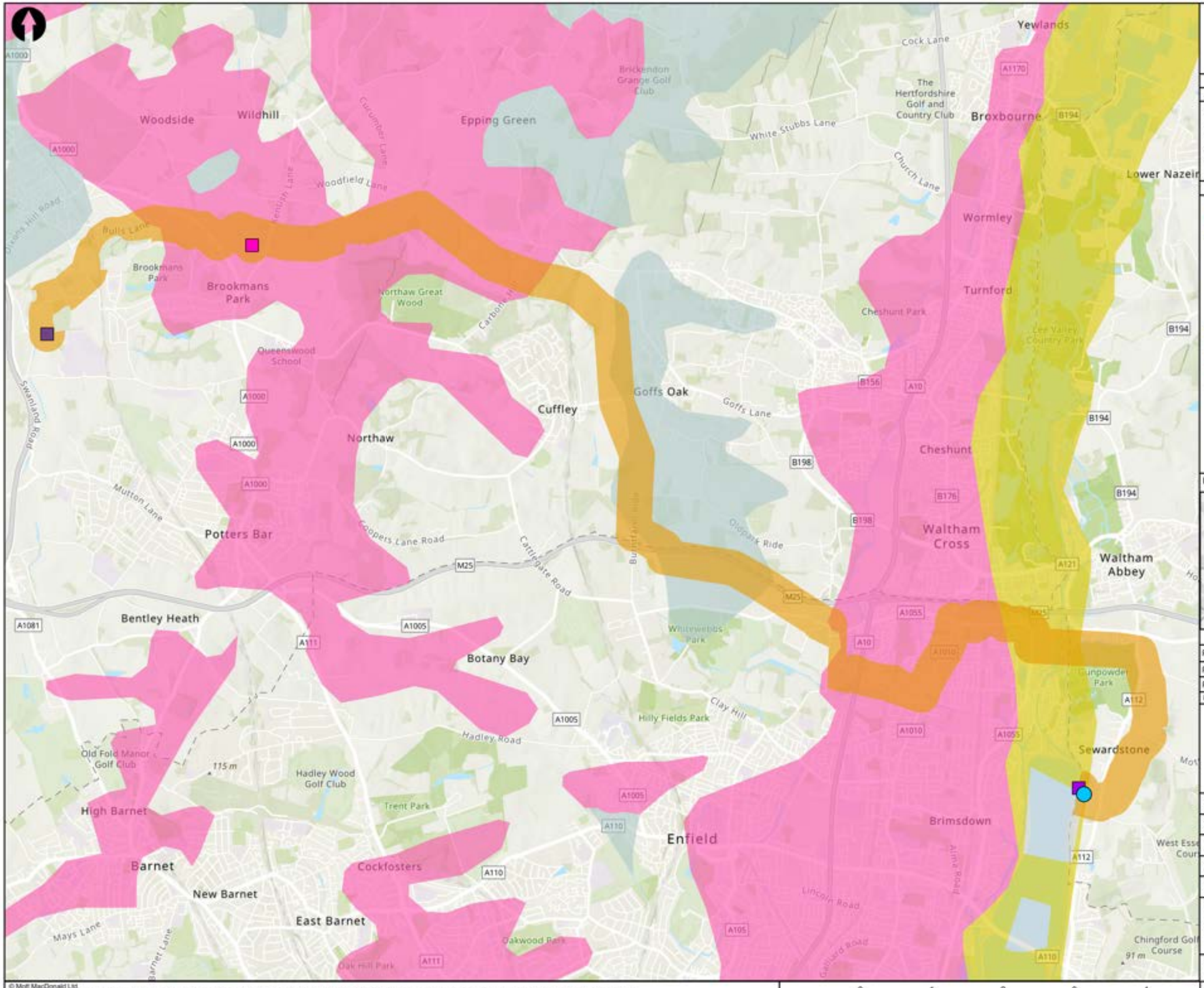

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Legend

Beckton Reuse Indirect Option components
- Indicative Transfer Main Route Corridor
- Indicative Raw Water Pumping Station Site
- River Lee Intake
- Connection into the Affinity Water distribution network 1
- Connection into the Affinity Water distribution network 2

Superficial Geology
- Clay, silt and sand
- Diamicton
- Sand and gravel
- Unknown lithology

Location Map

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Thames Water | Affinity Water

Location Code: N/A	OS Reference:	Security Reference: STD
Project Group: N/A	Sub Process: N/A	
Location/Town: N/A		
Site Name: Beckton Reuse Indirect		
Project Name: T2AT SRO Gate 2 Environmental Assessments		

Drawing Title:
Figure 5.2:
Superficial geology

Scale:	Sheet Size:	Status:
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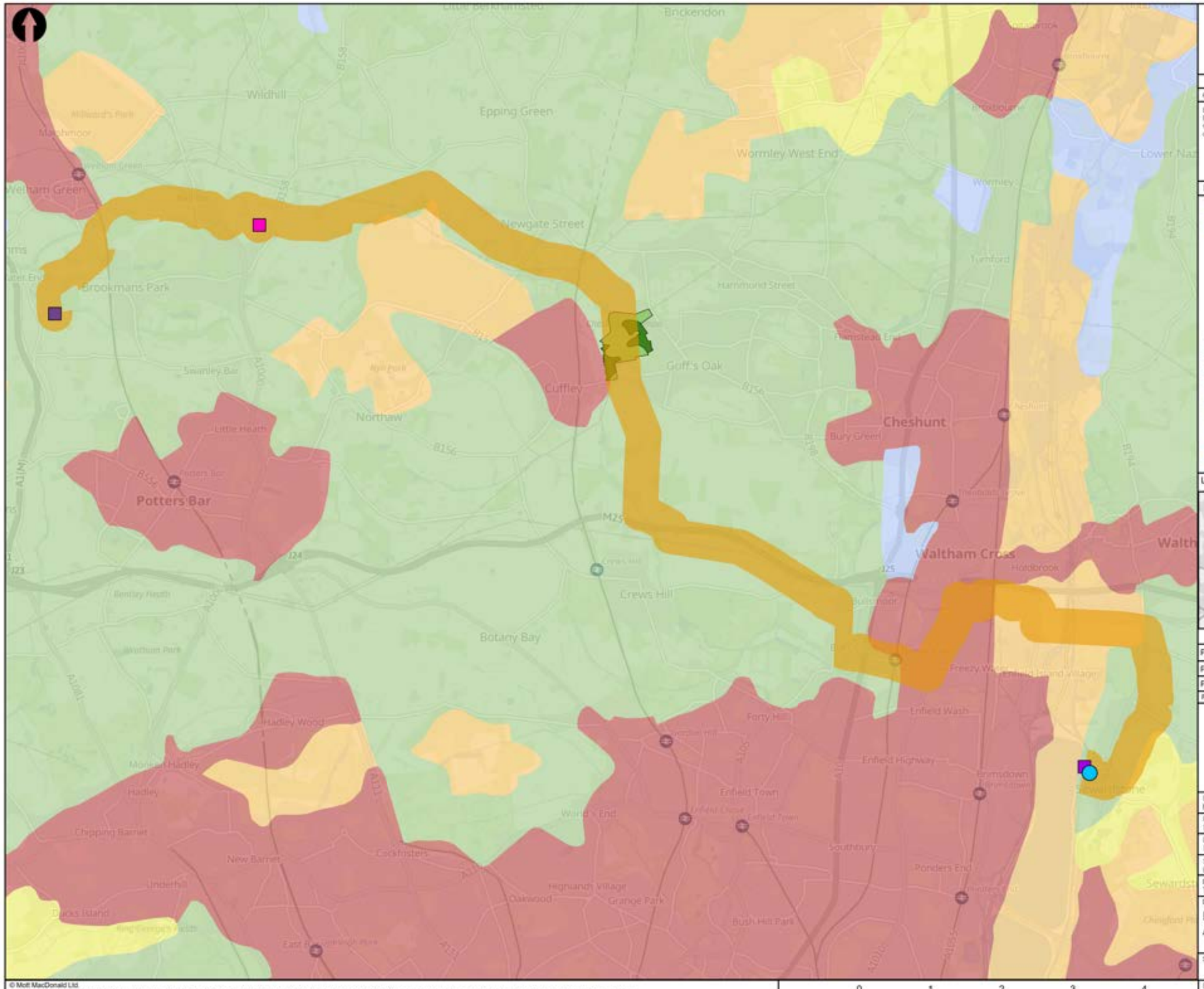

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Legend

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- Indicative Transfer Main Route Corridor
- Indicative Raw Water Pumping Station Site
- River Lee Intake
- Connection into the Affinity Water distribution network 1
- Connection into the Affinity Water distribution network 2

Post 1988 Agricultural Land Classification
- Grade 3a
- Grade 3b

Provisional Agricultural Land Classification
- Grade 2
- Grade 3
- Grade 4
- Non Agricultural
- Urban

Location Map

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P01	S2	FOR INFORMATION	JK	VS	CLB	22/06/22

Thames Water
AffinityWater

Location Code: N/A	OS Reference:	Security Reference: STD
Project Group: N/A	Sub Process: N/A	

Location/Town: N/A

Site Name: Beckton Reuse Indirect

Project Name: T2AT SRO Gate 2 Environmental Assessments

Drawing Title:

Figure 5.3:
Agricultural land classification

Scale:	Sheet Size:	Status:
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Revision: P03

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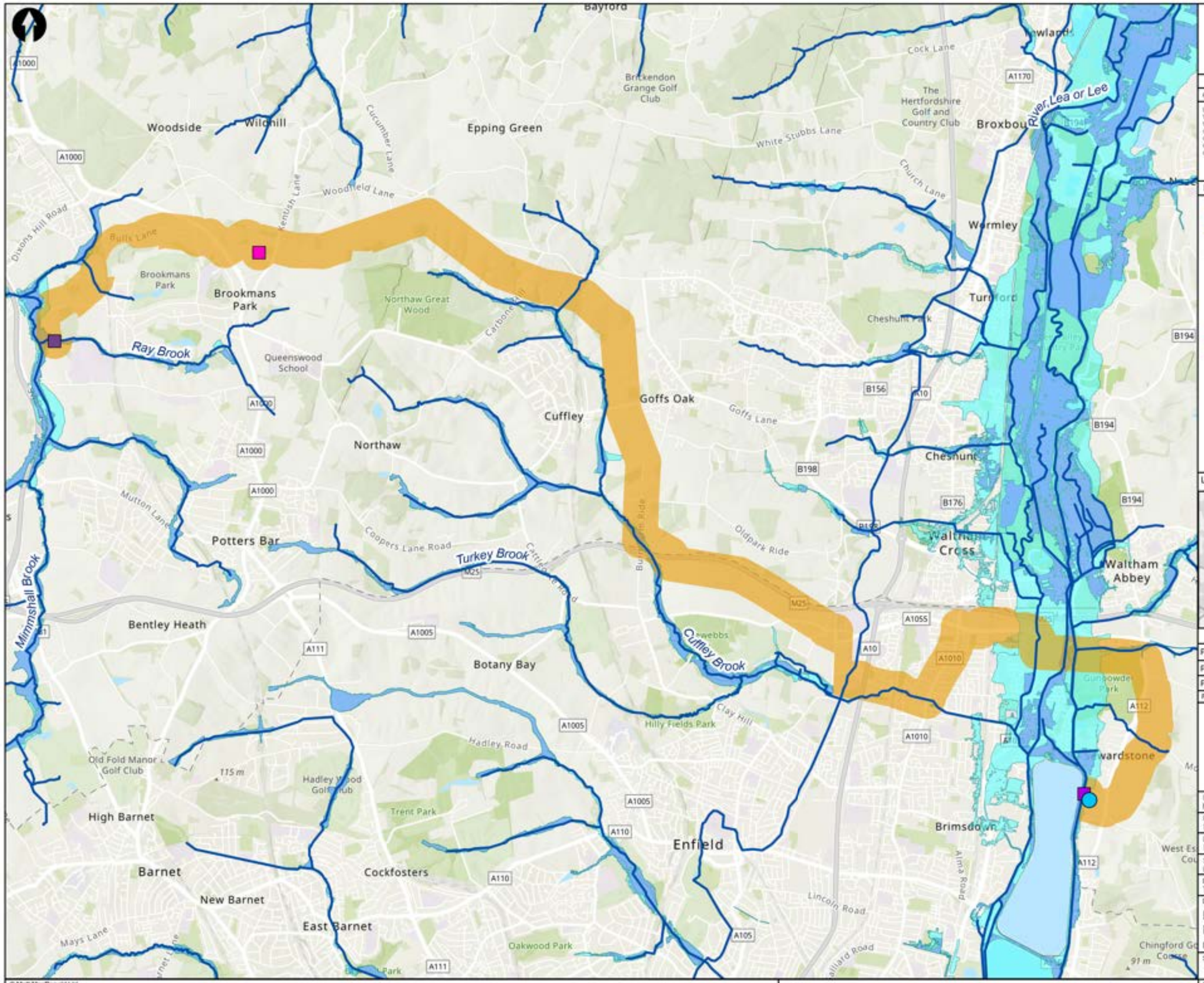

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Legend

Beckton Reuse Indirect Option components
- Indicative Transfer Main Route Corridor
- River
- Indicative Raw Water Pumping Station Site
- River Lee Intake
- Connection into the Affinity Water distribution network 1
- Connection into the Affinity Water distribution network 2
- Flood Zone 2
- Flood Zone 3

Location Map

Rev	Status	Suitability description	Author	Ch'k'd	App'd	Date
P03	S2	FOR INFORMATION	CD	CLB	CLB	18/10/22
P02	S2	FOR INFORMATION	CD	CLB	CLB	21/09/22
P01	S2	FOR INFORMATION	CD	CLB	CLB	01/09/22

Thames Water — Affinity Water

Location Code: N/A	OS Reference:	Security Reference: STD
Project Group: N/A	Sub Process: N/A	
Location/Town: N/A		
Site Name: Beckton Reuse Indirect		
Project Name: T2AT SRO Gate 2 Environmental Assessments		

Drawing Title:
Figure 6.1:
Flood risk zones and main river network interactions

Scale:	Sheet Size:	Status:
1:50,000	A3	S2

Drawing Number: 100383187-023-MMD-00-XX-GIS-Y-0071
Revision: P03

0 1 2 3 4 Kilometres

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Legend

Beckton Reuse Indirect Option components
- Indicative Transfer Main Route Corridor
- Indicative Raw Water Pumping Station Site
- River Lee Intake
- Connection into the Affinity Water distribution network 1
- Connection into the Affinity Water distribution network 2
- Risk of flooding 3.3% annual chance
- Risk of flooding 1% annual chance
- Risk of flooding 0.1% annual chance

Location Map

Rev	Status	Suitability description	Author	Ch'k'd	App'd	Date
P03	S2	FOR INFORMATION	CD	CLB	CLB	18/10/22
P02	S2	FOR INFORMATION	CD	CLB	CLB	21/09/22
P01	S2	FOR INFORMATION	CD	CLB	CLB	01/09/22

Thames Water
AffinityWater

Location Code: N/A	OS Reference:	Security Reference: STD
Project Group: N/A	Sub Process: N/A	
Location/Town: N/A		
Site Name: Beckton Reuse Indirect		
Project Name: T2AT SRO Gate 2 Environmental Assessments		
Drawing Title: Figure 6.2: Surface water flood extents		
Scale: 1:50,000	Sheet Size: A3	Status: S2
Drawing Number: 100383187-023-MMD-00-XX-GIS-Y-0073		Revision: P03

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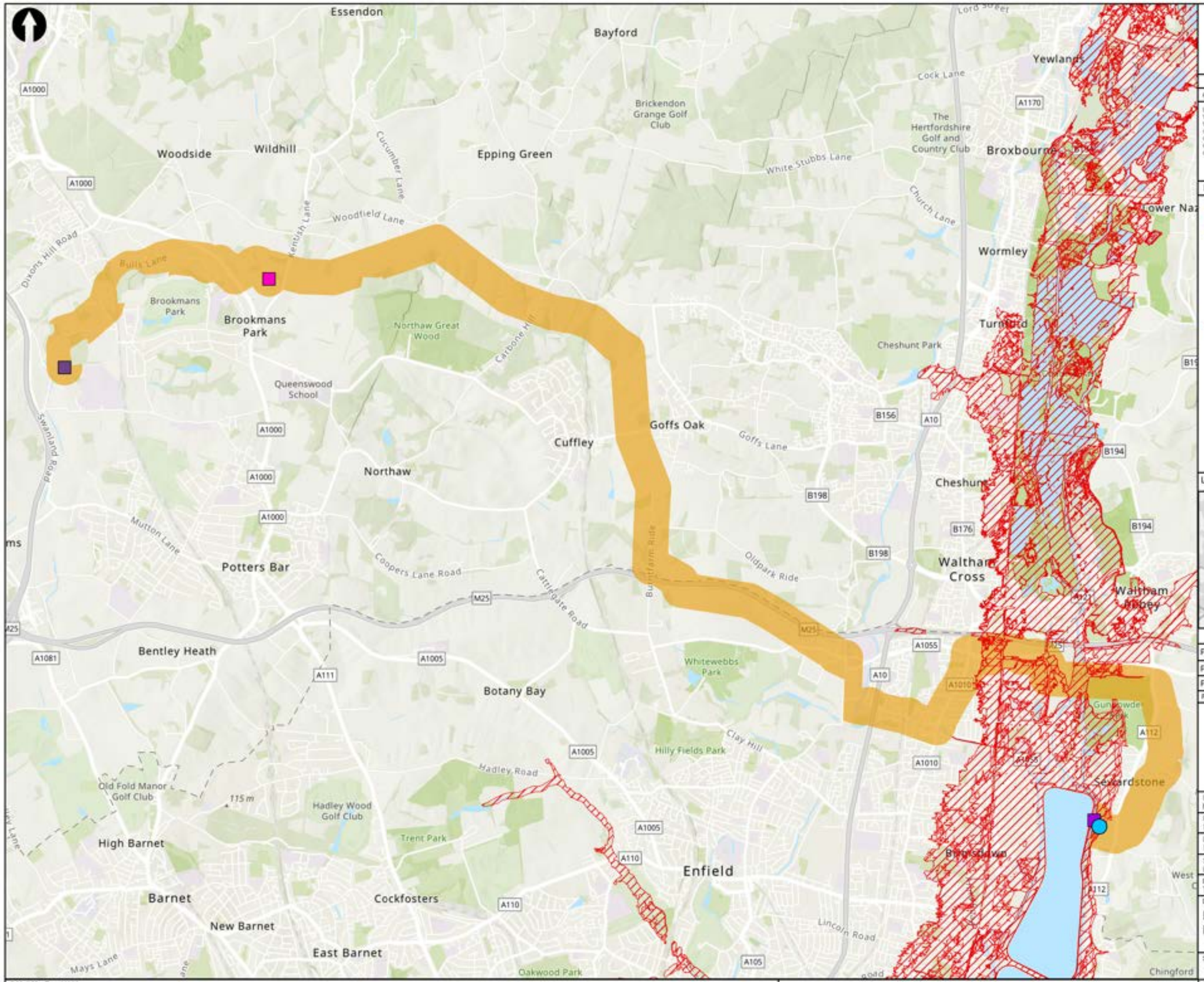

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Legend

Beckton Reuse Indirect Option components
- Indicative Transfer Main Route Corridor
- Indicative Raw Water Pumping Station Site
- River Lee Intake
- Connection into the Affinity Water distribution network 1
- Connection into the Affinity Water distribution network 2
- Reservoir flood extent

Location Map

Rev	Status	Suitability description	Author	Ch'k'd	App'd	Date
P03	S2	FOR INFORMATION	CD	CLB	CLB	18/10/22
P02	S2	FOR INFORMATION	CD	CLB	CLB	21/09/22
P01	S2	FOR INFORMATION	CD	CLB	CLB	01/09/22

Thames Water — Affinity Water

Location Code: N/A	OS Reference:	Security Reference: STD
Project Group: N/A	Sub Process: N/A	
Location/Town: N/A		
Site Name: Beckton Reuse Indirect		
Project Name: T2AT SRO Gate 2 Environmental Assessments		
Drawing Title: Figure 6.3: Risk of flooding from reservoirs		
Scale: 1:50,000	Sheet Size: A3	Status: S2
Drawing Number: 100383187-023-MMD-00-XX-GIS-Y-0077		Revision: P03

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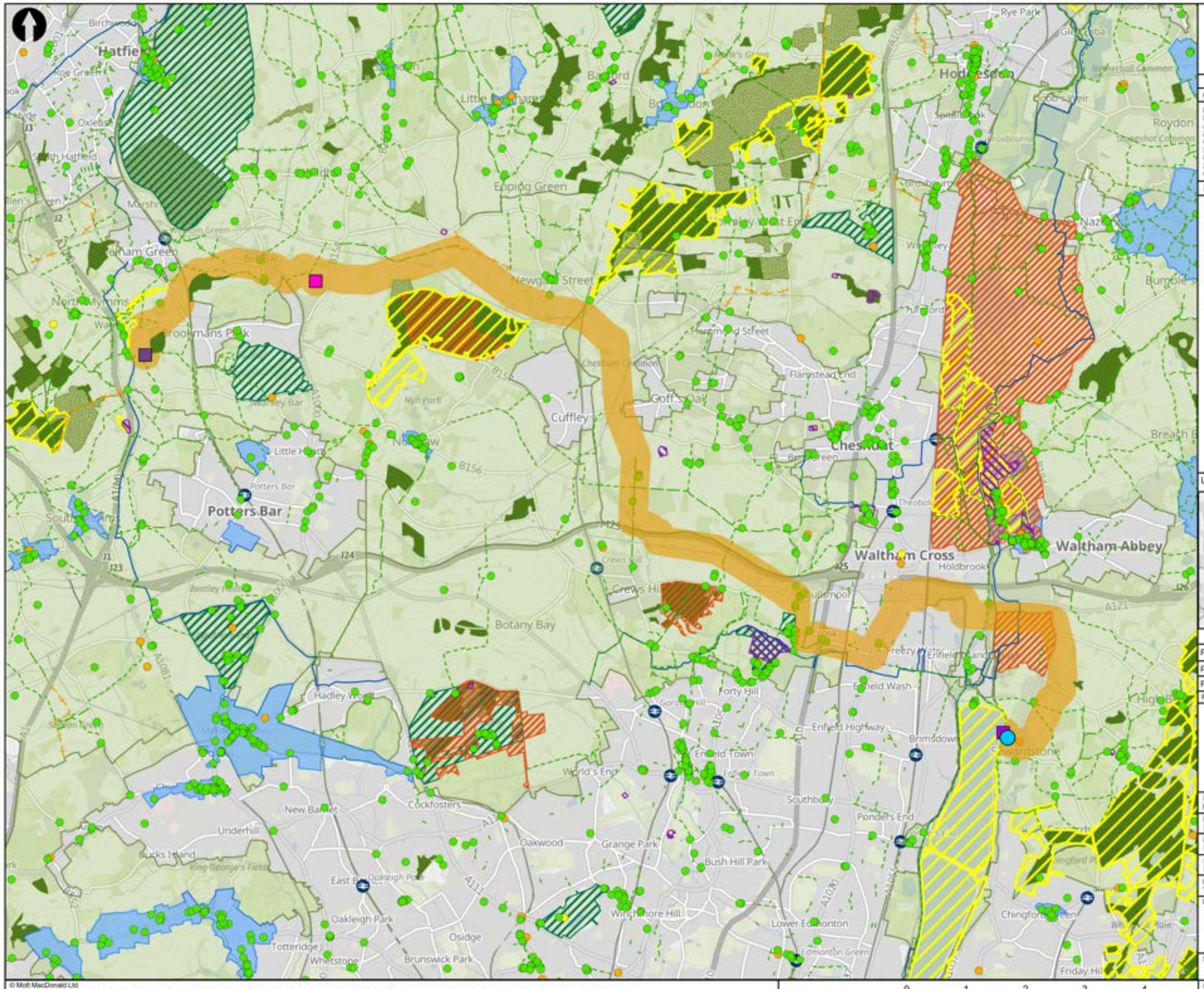

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Legend

Beckton Reuse Indirect Option components
- Indicative Transfer Main Route Corridor
- Indicative Raw Water Pumping Station Site
- River Lee Intake
- Connection into the Affinity Water distribution network 1
- Connection into the Affinity Water distribution network 2
- Byway Open to All Traffic
- Bridleway
- Byway
- Footpath
- Restricted Byway
- Unmetalled Unclassified County Road
- National Cycle Network
- Grade I Listed Building
- Grade II* Listed Building
- Grade II Listed Building
- Site of Special Scientific Interest (SSSI)
- Scheduled monument
- Registered park or garden
- Country park
- Conservation area
- Area of Outstanding Natural Beauty
- Ancient & Semi-Natural Woodland
- Ancient Replanted Woodland
- Green belt

Location Map

Rev	Status	Suitability description	Author	Ch'k'd	App'd	Date
P03	S2	FOR INFORMATION	CD	CLB	CLB	18/10/22
P02	S2	FOR INFORMATION	CD	CLB	CLB	21/09/22
P01	S2	FOR INFORMATION	KL	GL	CLB	22/06/22

Thames Water — Affinity Water

Location Code: N/A	OS Reference:	Security Reference: STD
Project Group: N/A	Sub Process: N/A	
Location/Town: N/A		
Site Name: Beckton Reuse Indirect		
Project Name: T2AT SRO Gate 2 Environmental Assessments		
Drawing Title: Figure 9.1: Landscape assets and designations		
Scale: 1:60,000	Sheet Size: A3	Status: S2
Drawing Number: 100383187-023-MMD-00-XX-GIS-Y-0063		Revision: P03

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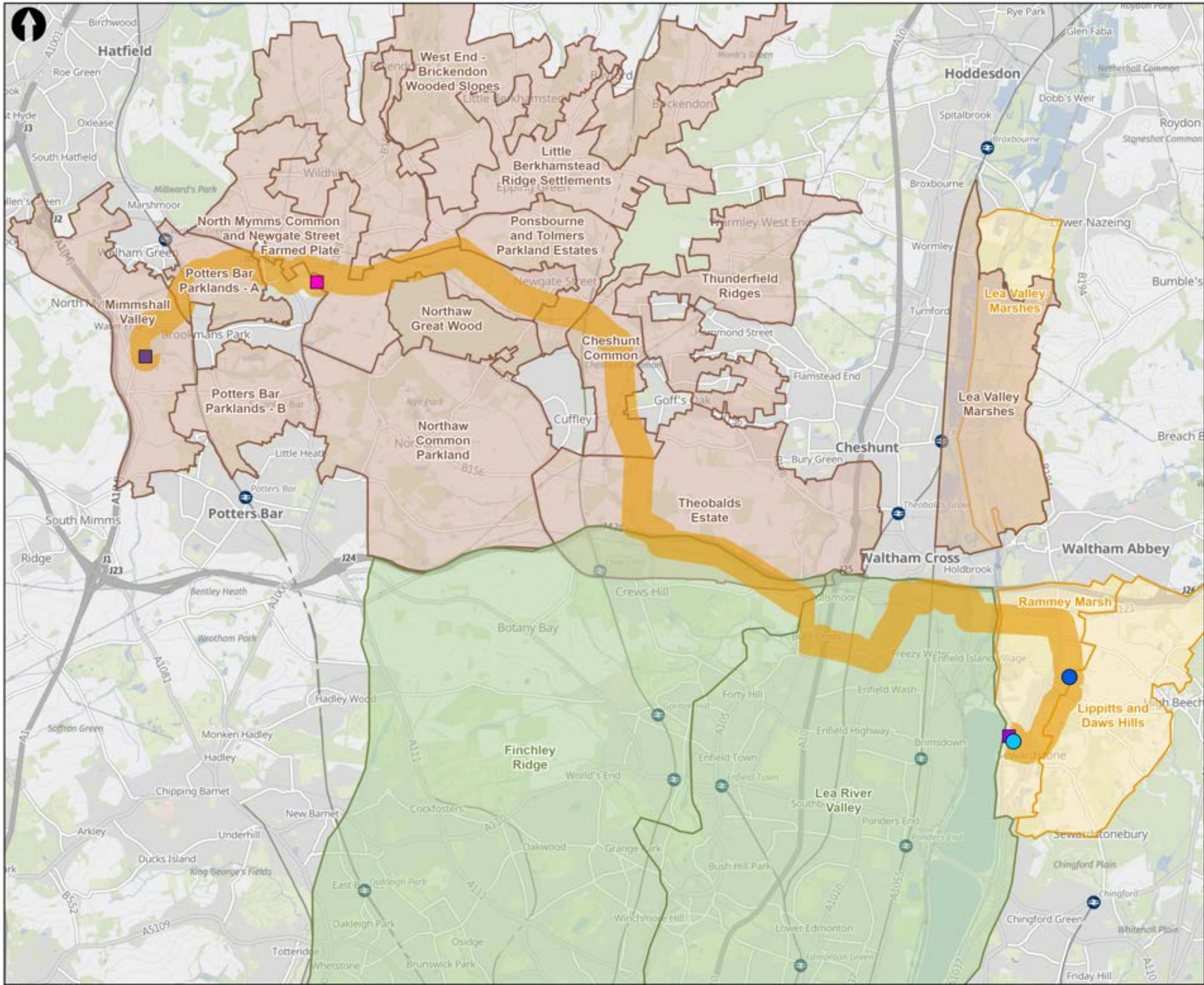

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Legend

Beckton Reuse Indirect Option components
- Transfer Main Route Corridor
- Indicative Raw Water Pumping Station Site
- River Lee Intake
- Connection into the Affinity Water distribution network 1
- Connection into the Affinity Water distribution network 2
- Epping Forest Landscape Character Assessment
- Hertfordshire Landscape Character Assessment
- London Landscape Natural Signatures Landscape Character Assessment

Location Map

St Albans
London

Rev	Status	Suitability description	Author	Ch'k'd	App'd	Date
P03	S2	FOR INFORMATION	CD	CLB	CLB	18/10/22
P02	S2	FOR INFORMATION	CD	CLB	CLB	21/09/22
P01	S2	FOR INFORMATION	KL	GL	CLB	22/06/22

Thames Water | Affinity Water

Location Code: N/A	OS Reference:	Security Reference: STD
Project Group: N/A	Sub Process: N/A	

Location/Town: N/A

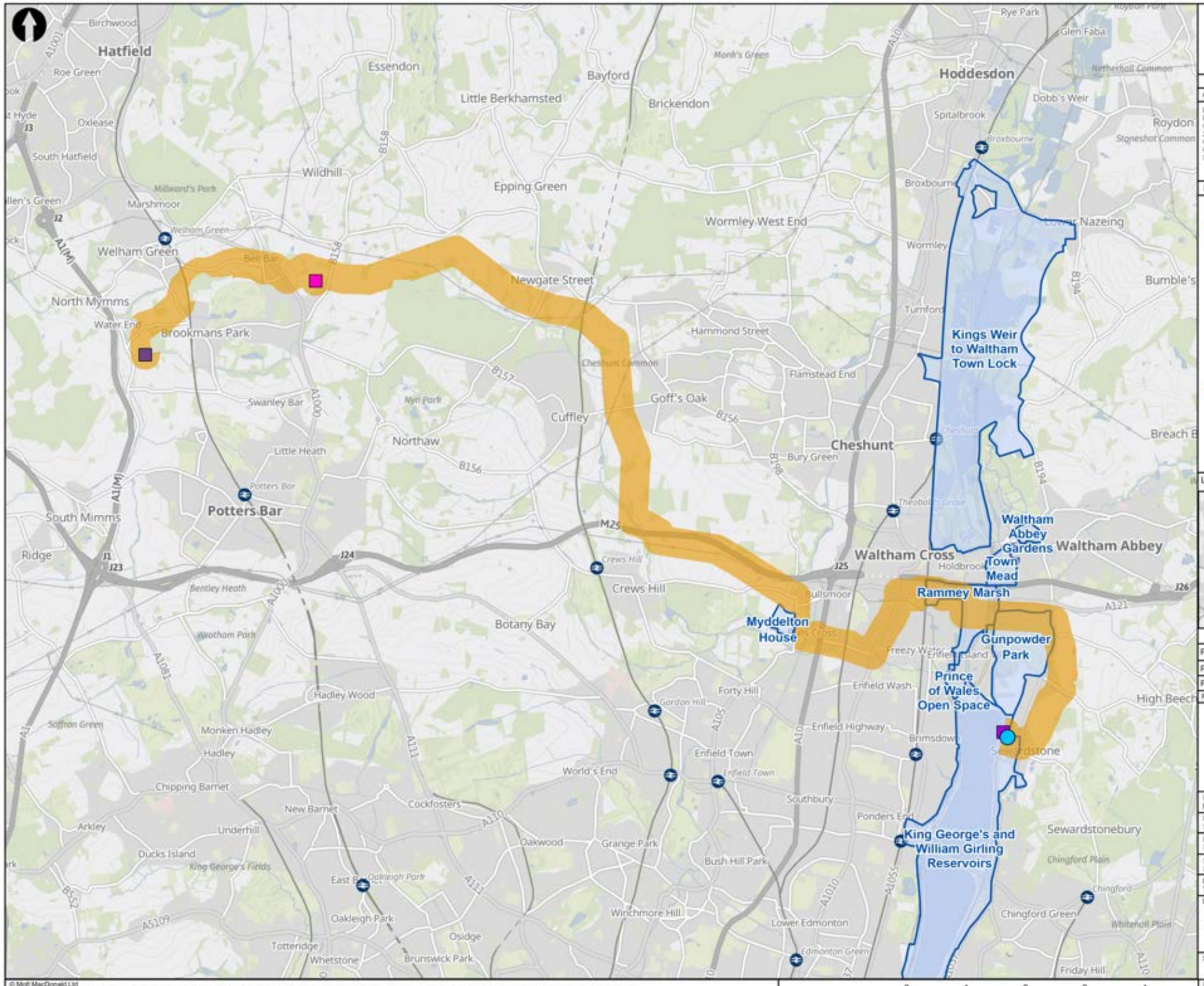
Site Name: Beckton Reuse Indirect

Project Name: T2AT SRO Gate 2 Environmental Assessments

Drawing Title:
Figure 9.2: Epping Forest, Hertfordshire and London Natural Signatures Landscape Character Areas

Scale:	Sheet Size:	Status:
1:60,000	A3	S2

Drawing Number:	Revision:
100383187-023-MMD-00-XX-GIS-Y-0048	P03



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Legend

Beckton Reuse Indirect Option components

- Transfer Main Route Corridor
- Indicative Raw Water Pumping Station Site
- River Lee Intake
- Connection into the Affinity Water distribution network 1
- Connection into the Affinity Water distribution network 2
- Lee Valley Landscape Character Assessment

Location Map

Rev	Status	Suitability description	Author	Ch'k'd	App'd	Date
P03	S2	FOR INFORMATION	CD	CLB	CLB	18/10/22
P02	S2	FOR INFORMATION	CD	CLB	CLB	21/09/22
P01	S2	FOR INFORMATION	KL	GL	CLB	22/06/22

Thames Water — Affinity Water

Location Code: N/A	OS Reference:	Security Reference: STD
Project Group: N/A	Sub Process: N/A	
Location/Town: N/A		
Site Name: Beckton Reuse Indirect		
Project Name: T2AT SRO Gate 2 Environmental Assessments		

Drawing Title:
Figure 9.3: Lee Valley Landscape Character Assessment

Scale:	Sheet Size:	Status:
1:60,000	A3	S2

Drawing Number: 100383187-023-MMD-00-XX-GIS-Y-0055
Revision: P03

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Legend

Beckton Reuse Indirect Option components
- Indicative Transfer Main Route Corridor
- Indicative Raw Water Pumping Station Site
- River Lee Intake
- Connection into the Affinity Water distribution network 1
- Connection into the Affinity Water distribution network 2
- Grade I Listed Building
- Grade II Listed Building
- Grade II* Listed Building
- Scheduled monument
- Registered park or garden
- Conservation area

Location Map

Rev	Status	Suitability description	Author	Ch'k'd	App'd	Date
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P02	S2	FOR INFORMATION	CD	CLB	CLB	21/09/22
P01	S2	FOR INFORMATION	KL	ED	CLB	22/06/22

Thames Water
AffinityWater

Location Code: N/A	OS Reference:	Security Reference: STD
Project Group: N/A	Sub Process: N/A	
Location/Town: N/A		
Site Name: Beckton Reuse Indirect		
Project Name: T2AT SRO Gate 2 Environmental Assessments		

Drawing Title:
Figure 10.1:
Designated heritage assets

Scale:	Sheet Size:	Status:
1:60,000	A3	S2

Drawing Number: 100383187-023-MMD-00-XX-GIS-Y-0064
Revision: P03

0 1 2 3 4 Kilometres

Appendix B Non-statutory designated sites for nature conservation

Name	Designation	Closest distance to Beckton Reuse Indirect Option (km)	Relevant component
Woodlands Farm Meadow	LWS	0	Raw Water Transfer Main Route Corridor
Wood, South of Barn Hill Wood	LWS	0.05	Raw Water Transfer Main Route Corridor
Barn Hill Wood	LWS	0.01	Raw Water Transfer Main Route Corridor
Giwell Park, South	LWS	0.65	Raw Water Transfer Main Route Corridor
Sewardstone Green	LWS	0.35	Raw Water Transfer Main Route Corridor
Lippitts Hill Scrub	LWS	0.71	Raw Water Transfer Main Route Corridor
Aldergrove Wood	LWS	0.75	Raw Water Transfer Main Route Corridor
Carroll's Farm Complex	LWS	0.34	Raw Water Transfer Main Route Corridor
Thompson Wood	LWS	0.02	Raw Water Transfer Main Route Corridor
Day's Farm Paddocks	LWS	0.99	Raw Water Transfer Main Route Corridor
Oak Farm Grassland	LWS	0.94	Raw Water Transfer Main Route Corridor
Sewardstone/Osier Marshes	LWS	0.45	Indicative Raw Water Pumping Station Site
Northfield Marsh	LWS	0.09	Indicative Raw Water Pumping Station Site
Lea Valley	SINC of Metropolitan Importance	0	Intake Location, Indicative Raw Water Pumping Site, Raw Water Transfer Main Route Corridor and Drinking

Name	Designation	Closest distance to Beckton Reuse Indirect Option (km)	Relevant component
			Water Transfer Main Route Corridor
Gunpowder Park	LWS	0	Drinking Water Transfer Main Route Corridor
Cattlins Wood	LWS	0	Drinking Water Transfer Main Route Corridor
Poyndon Farm	LWS	0.94	Drinking Water Transfer Main Route Corridor
Meadow W. of Whitehouse Farm	LWS	0.52	Drinking Water Transfer Main Route Corridor
New River	SINC of Metropolitan Importance	0	Drinking Water Transfer Main Route Corridor
Forty Hall Park & Estate	SINC of Metropolitan Importance	0.1	Drinking Water Transfer Main Route Corridor
Whitewebbs Wood	SINC of Metropolitan Importance	0.5	Drinking Water Transfer Main Route Corridor
Crews Hill to Bowes Park Railsides (SINC of Borough Grade I importance)	SINC of Borough Grade I importance	0.67	Drinking Water Transfer Main Route Corridor
Crews Hill Golf Course (SINC of Borough Grade I importance)	SINC of Borough Grade I importance	0.74	Drinking Water Transfer Main Route Corridor
Kentish Lane Farm Wood (N.E. of Brookmans Park)	LWS	0	Drinking Water Transfer Main Route Corridor
Chestnut Farm Meadows	LWS	0.53	Drinking Water Transfer Main Route Corridor
Warren Wood	LWS	0.77	Drinking Water Transfer Main Route Corridor

Name	Designation	Closest distance to Beckton Reuse Indirect Option (km)	Relevant component
Woodfield Lane Roadside Verge	LWS	0.08	Drinking Water Transfer Main Route Corridor
Hornbeam Lane (Wildhill)	LWS	0.38	Drinking Water Transfer Main Route Corridor
Nine Acre Wood (N.W. of Newgate Street)	LWS	0.45	Drinking Water Transfer Main Route Corridor
Coldharbour Plantation & Broombarns Wood	LWS	0	Drinking Water Transfer Main Route Corridor
Hell Wood	LWS	0	Drinking Water Transfer Main Route Corridor
Woodland W. of Ponsfall Farm	LWS	0.16	Drinking Water Transfer Main Route Corridor
Woodland N. of Postern Gate	LWS	0	Drinking Water Transfer Main Route Corridor
Woodland Strip N. of School Camp	LWS	0	Drinking Water Transfer Main Route Corridor
Tolmers Park	LWS	0	Drinking Water Transfer Main Route Corridor
Meadow S. of Tyler's Causeway	LWS	0.54	Drinking Water Transfer Main Route Corridor
Meadow near Ponsfall Farm	LWS	0.58	Drinking Water Transfer Main Route Corridor
The Warren, Newgate Street	LWS	0.53	Drinking Water Transfer Main Route Corridor
Old Manor Cottage Area, Newgate Street	LWS	0.09	Drinking Water Transfer Main Route Corridor
Home Wood (Cuffley)	LWS	0.07	Drinking Water Transfer Main Route Corridor
Meadow by Long Grove north	LWS	0.32	Drinking Water Transfer Main Route Corridor

Name	Designation	Closest distance to Beckton Reuse Indirect Option (km)	Relevant component
St. Lawrence Farm Field	LWS	0.49	Drinking Water Transfer Main Route Corridor
Calves Croft Wood	LWS	0.64	Drinking Water Transfer Main Route Corridor
Derry's Wood Fields	LWS	0.72	Drinking Water Transfer Main Route Corridor
Meadow by Forest View	LWS	0.25	Drinking Water Transfer Main Route Corridor
Lucasend Farm Pasture W.	LWS	0.62	Drinking Water Transfer Main Route Corridor
Lucasend Farm Meadows N.	LWS	0.81	Drinking Water Transfer Main Route Corridor
Cuffley Station Embankment	LWS	0.23	Drinking Water Transfer Main Route Corridor
Queenswood Home Farm Grove	LWS	0.58	Drinking Water Transfer Main Route Corridor
Grasslands S. of Mymfield	LWS	0.23	Drinking Water Transfer Main Route Corridor, Brookmans Park Service Reservoir Connection and Drinking Water Transfer Main to North Mymms Route Corridor
Meadow N. of Peplins Wood	LWS	0	Drinking Water Transfer Main to North Mymms Route Corridor
Peplins Wood	LWS	0	Drinking Water Transfer Main to North Mymms Route Corridor
The Legg North	LWS	0	Drinking Water Transfer Main to North Mymms Route Corridor
George’s Wood	LWS	0.21	Drinking Water Transfer Main to North Mymms Route Corridor

Name	Designation	Closest distance to Beckton Reuse Indirect Option (km)	Relevant component
Millward's Park	LWS	0.59	Drinking Water Transfer Main to North Mymms Route Corridor
Grubs Lane Marsh	LWS	0.45	Drinking Water Transfer Main to North Mymms Route Corridor
Grasslands by Abdale House	LWS	0.12	Drinking Water Transfer Main to North Mymms Route Corridor
Brick Kiln Wood (nr Brookmans Park)	LWS	0	Drinking Water Transfer Main to North Mymms Route Corridor
Potterells Wood	LWS	0	Drinking Water Transfer Main to North Mymms Route Corridor
Grassland N. of Potterells Wood	LWS	0	Drinking Water Transfer Main to North Mymms Route Corridor
Bush Wood	SINC of Borough Grade I importance	0.91	Drinking Water Transfer Main to North Mymms Route Corridor
Moffats Meadows	LWS	0.85	Drinking Water Transfer Main to North Mymms Route Corridor
Pilvage Wood	LWS	0.97	North Mymms Booster Station Connection

Appendix C Climate change risk assessment

Potential changing climate variable	Asset	A - Impact	B - Likelihood	C - Severity	D - Risk (BxC)	Risk category	E - Mitigation	F - Likelihood (after mitigation)	G - Severity (after mitigation)	H - Residual Risk (FxG)	Risk category
Higher summer temperatures	Underground pipelines / pipe connection	Higher temperatures can lead to expansion and damage to pipes. However, the pipes are buried with suitable cover and are unlikely to be impacted by increase in temperatures.	1	2	2	Low	Structural elements would be designed to include thermal expansion and greater thermal variation specification to account for climate change.	1	1	1	Low
Higher summer temperatures	Overground pipelines/ overground cabling	Pipe and cabling material would be exposed to increased solar radiation (UV) and may deteriorate at a faster rate. Higher temperatures may also cause	2	3	6	Moderate to low	Pipe design and choice of materials to consider higher summer temperatures and greater annual	1	2	2	Low

Potential changing climate variable	Asset	A - Impact	B - Likelihood	C - Severity	D - Risk (BxC)	Risk category	E - Mitigation	F - Likelihood (after mitigation)	G - Severity (after mitigation)	H - Residual Risk (FxG)	Risk category
		increased expansion and damage to overground pipes.					temperature variation. Exposed elements such as air valves and electrical equipment would sit in protective chambers which may provide some protection from solar gain and higher temperatures.				
Higher summer temperatures	Pipejack/ micro tunnels crossing for railway and roads	Cracking, strength loss and more rapid deterioration of concrete due to high temperatures.	2	4	8	Moderate to high	Materials selection and specification to consider future temperatures. Monitor and adjust	1	3	3	Low

Potential changing climate variable	Asset	A - Impact	B - Likelihood	C - Severity	D - Risk (BxC)	Risk category	E - Mitigation	F - Likelihood (after mitigation)	G - Severity (after mitigation)	H - Residual Risk (FxG)	Risk category
							the curing process of the concrete accordingly in order to minimise the risk of high temperatures on the deterioration rate of the structure.				

Potential changing climate variable	Asset	A - Impact	B - Likelihood	C - Severity	D - Risk (BxC)	Risk category	E - Mitigation	F - Likelihood (after mitigation)	G - Severity (after mitigation)	H - Residual Risk (FxG)	Risk category
Higher summer temperatures	Pipejack/micro tunnels crossing for rivers	Cracking, strength loss and more rapid deterioration of concrete due to high temperatures.	2	3	6	Moderate to low	Materials selection and specification to consider future temperatures. Monitor and adjust the curing process of the concrete accordingly in order to minimise the risk of high temperatures on the deterioration rate of the structure.	1	3	3	Low
Higher summer temperatures	New WTW	Chemical and mechanical processes/equipment (chlorine disinfection, pumps, valves) exceed their	2	3	6	Moderate to low	Include greater thermal variation in design and specification of	1	3	3	Low

Potential changing climate variable	Asset	A - Impact	B - Likelihood	C - Severity	D - Risk (BxC)	Risk category	E - Mitigation	F - Likelihood (after mitigation)	G - Severity (after mitigation)	H - Residual Risk (FxG)	Risk category
		operational temperature limit (chlorine works less effectively at high temperatures, generator engine~35˚C) and do not operate as efficiently/shut down.					equipment to account for the extremes in temperature. Consider nature-based solutions to provide shade and reduce temperature.				
Higher summer temperatures	River Lee Intake and Raw Water Pumping Station	Chemical and mechanical processes/equipment exceed their operational temperature limit and shut down.	2	3	6	Moderate to low	Include greater thermal variation in design and specification of equipment to account for the extremes in temperature. Consider	1	3	3	Low

Potential changing climate variable	Asset	A - Impact	B - Likelihood	C - Severity	D - Risk (BxC)	Risk category	E - Mitigation	F - Likelihood (after mitigation)	G - Severity (after mitigation)	H - Residual Risk (FxG)	Risk category
							alternative treatment methods. Consider nature based solutions to provide shade and reduce temperature.				
Extreme low temperature events	Underground pipelines/ connection pipes	The pipes are buried with suitable cover so there is little impact expected. There is a decreased frequency of extreme ground frost, however these events would still occur and could lead to cracking and fracturing of pipes.	2	2	4	Moderate to low	None required.				

Potential changing climate variable	Asset	A - Impact	B - Likelihood	C - Severity	D - Risk (BxC)	Risk category	E - Mitigation	F - Likelihood (after mitigation)	G - Severity (after mitigation)	H - Residual Risk (FxG)	Risk category
Extreme low temperature events	Overground pipelines/ overground cabling	Pipe and cabling material would be exposed to air frost and extreme cold temperatures/ice leading to deterioration of materials	2	3	6	Moderate to low	Pipe design and choice of materials to consider greater annual temperature variation. Exposed elements such as air valves and electrical equipment would sit in protective chambers which may provide some protection from colder temperatures.	2	2	4	Moder ate to low

Potential changing climate variable	Asset	A - Impact	B - Likelihood	C - Severity	D - Risk (BxC)	Risk category	E - Mitigation	F - Likelihood (after mitigation)	G - Severity (after mitigation)	H - Residual Risk (FxG)	Risk category
Higher annual and winter rainfall and more extreme rainfall events throughout the year	Underground pipelines/ connection pipes	The pipeline passes through areas of existing Flood Zone 2 & 3, in the River Lee crossing, Turkey Brook crossing, Cuffley Brook crossing & Ray Brook crossing. Flood risk in these areas is likely to be exacerbated with higher winter rainfall and more extreme rainfall events throughout the year and may cause ground instability and issues with access to the pipes. Flood water may seep into pipe and contaminate supply, however low risk as it is a buried pipe.	3	4	12	High	Locate pipeline maintenance access points in areas where there is low risk of flooding to ensure that they are accessible at all times. Ensure pipe design and cover is enough to withstand seepage from flooding into the pipes.	2	3	6	Moder ate to low

Potential changing climate variable	Asset	A - Impact	B - Likelihood	C - Severity	D - Risk (BxC)	Risk category	E - Mitigation	F - Likelihood (after mitigation)	G - Severity (after mitigation)	H - Residual Risk (FxG)	Risk category
Higher annual and winter rainfall and more extreme rainfall events throughout the year	Underground pipelines/ connection pipes	High rainfall levels can cause swelling of the ground surrounding the pipe and lead to instability.	2	3	6	Moderate to low	Ensure that ground movements are monitored, and repairs made when necessary to avoid further damage. Consider the changes in soil moisture in the pipe bedding material specification.	2	2	4	Moderate to low
Higher annual and winter rainfall and more extreme rainfall events	Overground pipelines/ overground cabling	Risk of corrosion of pipe and cable materials.	2	3	6	Moderate to low	Additional protective measures (such as insulating the cables with cathodic protective	1	2	2	Low

Potential changing climate variable	Asset	A - Impact	B - Likelihood	C - Severity	D - Risk (BxC)	Risk category	E - Mitigation	F - Likelihood (after mitigation)	G - Severity (after mitigation)	H - Residual Risk (FxG)	Risk category
throughout the year							material) would be implemented to ensure that the pipes and cabling are sufficiently protected to reduce the corrosion rates. Selection of materials to consider future rainfall regime.				
Higher annual and winter rainfall and more extreme rainfall events	Pipejack/micro tunnels crossing for railway and roads	Insufficient drainage on the railway and road leading to flooding around base of structure which could cause instability. Extra loading on the structure due to rainfall	2	4	8	Moderate to high	Ensure that drainage capacity is designed to limit the flooding at the structure and account for future	2	2	4	Moder ate to low

Potential changing climate variable	Asset	A - Impact	B - Likelihood	C - Severity	D - Risk (BxC)	Risk category	E - Mitigation	F - Likelihood (after mitigation)	G - Severity (after mitigation)	H - Residual Risk (FxG)	Risk category
throughout the year		and winds which can cause collapse.					increased rainfall. Ensure that the foundations are not susceptible to seepage due to poor drainage.				
Higher annual and winter rainfall and more extreme rainfall events throughout the year	Pipejack/micro tunnels crossing for rivers	Flooding events raising the river levels and damaging the pipe jack/micro tunnel if there is not enough clearance.	3	4	12	High	Ensure that designs take into consideration the raised river levels during floods.	2	3	6	Moderate to low
Higher annual and winter rainfall and more extreme rainfall events	New WTW	The proposed WTW locations are not located in a flood zone so there is low risk that there would be flooding in the future. However, the					None required				

Potential changing climate variable	Asset	A - Impact	B - Likelihood	C - Severity	D - Risk (BxC)	Risk category	E - Mitigation	F - Likelihood (after mitigation)	G - Severity (after mitigation)	H - Residual Risk (FxG)	Risk category
throughout the year		level of flood risk should be kept under review over the lifetime of the assets and as climate changes.									
Higher annual and winter rainfall and more extreme rainfall events throughout the year	River Lee Intake and Raw Water Pumping Station	This is currently surrounded by Flood Zones 2 & 3 to the west. With increased rainfall, flood risk would be exacerbated in these areas and affect the operations of the pumping station.	4	3	12	High	Temporary flood protection e.g. demountable barriers. Consider need for permanent flood walls around the site. Monitor changes to local river levels.	2	2	4	Moderate to low
Drier summers	Underground pipelines/ connection pipes	The soil type that the pipeline route would be built on is primarily sands & gravels and diamicton, so	2	3	6	Moderate to low	Ensure that ground movements are monitored, and repairs made when	1	3	3	Low

Potential changing climate variable	Asset	A - Impact	B - Likelihood	C - Severity	D - Risk (BxC)	Risk category	E - Mitigation	F - Likelihood (after mitigation)	G - Severity (after mitigation)	H - Residual Risk (FxG)	Risk category
	Overground pipelines/ overground cabling	drought may have an impact on the stability/properties of this. There is a risk of ground cracking/shrinkage due to drought and can cause instability issues and weakness.					necessary to avoid further damage. Consider future ground conditions when choosing and specifying pipe materials.				
Drier summers	Pipejack/micro tunnels crossing for railway, roads and rivers	Shrinkage and desiccation of ground leading to cracks, strength loss and instability. Foundations may be affected.	2	3	6	Moderate to low	Consider future ground conditions, temperature, and rainfall regime when designing foundations and specifying foundation depth. Ensure that ground movements are monitored and	1	3	3	Low

Potential changing climate variable	Asset	A - Impact	B - Likelihood	C - Severity	D - Risk (BxC)	Risk category	E - Mitigation	F - Likelihood (after mitigation)	G - Severity (after mitigation)	H - Residual Risk (FxG)	Risk category
							repairs made when necessary to avoid further damage.				
Drier summers	New WTW	WTW site uses potable water on site for processes and site operations may be disrupted if there is a drought. The site would not be affected by Temporary Use Bans (TUBs) or Non-Essential Use Bans (NEUBs), so therefore the likelihood of this is low.	1	3	3	Low	None required.				
Drier summers	New WTW	Parts of the site are located on sand & gravel soils, so there is a minor risk that it may be susceptible to shrinkage which would lead to cracks and weakness.	1	3	3	Low	Consider future ground conditions, temperature and rainfall regimes when designing foundations.	1	2	2	Low

Potential changing climate variable	Asset	A - Impact	B - Likelihood	C - Severity	D - Risk (BxC)	Risk category	E - Mitigation	F - Likelihood (after mitigation)	G - Severity (after mitigation)	H - Residual Risk (FxG)	Risk category
		Foundations may be affected.					Ensure that ground movements are monitored, and repairs made when necessary to avoid further damage.				
Drier summers	River Lee Intake and Raw Water Pumping Station	Site uses potable water on site for processes and site operations may be disrupted if there is a drought. The site would not be affected by Temporary Use Bans (TUBs) or Non-Essential Use Bans (NEUBs), so therefore the likelihood of this is low.	1	4	4	Moderate to low	None required.				

Potential changing climate variable	Asset	A - Impact	B - Likelihood	C - Severity	D - Risk (BxC)	Risk category	E - Mitigation	F - Likelihood (after mitigation)	G - Severity (after mitigation)	H - Residual Risk (FxG)	Risk category
Drier summers	River Lee Intake and Raw Water Pumping Station	Parts of the site are located on clay soils, so therefore susceptible to shrinkage which would lead to cracks and weakness. Foundations may be affected.	2	3	6	Moderate to low	Consider future ground conditions, temperature and rainfall regimes when designing foundations. Ensure that ground movements are monitored and repaired when necessary to avoid further damage.	2	2	4	Moderate to low
Increase in storm intensity	River Lee Intake and Raw Water Pumping Station New WTW	Structural damage resulting from storminess and high winds, including a series of storms occurring in quick succession.	2	3	6	Moderate to low	Ensure that associated buildings are designed as a minimum to withstand wind	2	2	4	Moderate to low

Potential changing climate variable	Asset	A - Impact	B - Likelihood	C - Severity	D - Risk (BxC)	Risk category	E - Mitigation	F - Likelihood (after mitigation)	G - Severity (after mitigation)	H - Residual Risk (FxG)	Risk category
							loadings calculated in accordance with building codes that account for the change in climate and increases in wind gusts. Locate critical infrastructure and staff welfare facilities in areas of the site least likely to suffer storm damage, or provide additional resilience / strengthening measures for situations where a				

Potential changing climate variable	Asset	A - Impact	B - Likelihood	C - Severity	D - Risk (BxC)	Risk category	E - Mitigation	F - Likelihood (after mitigation)	G - Severity (after mitigation)	H - Residual Risk (FxG)	Risk category
							series of storms affects the site.				
Increase in storm intensity	River Lee Intake and Raw Water Pumping Station New WTW	Disruption to utilities, i.e. electricity supply and communications due to increase in lightning strikes, local power outages and storm disruption	2	3	6	Moderate to low	Install back-up generators for any safety critical systems, and ability of the stations to work offline for several days while power supplies are restored.	2	2	4	Moderate to low

Appendix D Invasive non-native species records and surveys

D.1 Environment Agency and NBN Atlas records

The Environment Agency and National Biodiversity Network (NBN) Atlas INNS records for the study area are summarised in Table D.1 (fish), Table D.2 (macroinvertebrates) and Table D.3 (plants).

Table D.1: Non-native fish species identified in Environment Agency and NBN Atlas records within 1km of the Beckton Reuse Indirect route

Common name	Scientific name	Functional group	Legislative status	EA records	NBN Atlas records
Common [wild] carp	*Cyprinus carpio*	Mobile, juvenile >1mm, eggs	UKTAG-High[126]	✓	✓
Common carp varieties	*Cyprinus carpio*	Mobile, juvenile >1mm, eggs	UKTAG-High	✓	
Mirror carp	*Cyprinus carpio*	Mobile, juvenile >1mm, eggs	UKTAG-High	✓	
Crucian carp	*Carassius carassius*	Mobile, juvenile >1mm, eggs	UKTAG-Unknown	✓	
Feral [brown] goldfish	*Carassius auratus*	Mobile, juvenile >1mm, eggs	UKTAG-High	✓	
Golden goldfish	*Carassius auratus*	Mobile, juvenile >1mm, eggs	UKTAG-High	✓	
Topmouth Gudgeon	*Pseudorasbora parva*	Mobile, juvenile >1mm, eggs	UKTAG-High		✓
Zander	*Sander lucioperca*	Mobile, juvenile >1mm, eggs	UKTAG-Moderate WACA 1981 Sch.9[127]	✓	✓

[126] WFD-UKTAG listed INNS, categorised as High / Medium / Low / Unknown Impact
[127] Listed on Schedule 9 of the Wildlife & Countryside Act 1981

Table D.2: Non-native invertebrate species identified in Environment Agency and NBN Atlas records within 1km of the Beckton Reuse Indirect route

Common name	Scientific name	Functional group	Legislative status	EA records	NBN Atlas records
Bladder snail	*Physella acuta*	Mobile, juvenile <1mm, no eggs	UKTAG-Unknown	✓	
Bladder snail	*Physella sp.*	Mobile, juvenile <1mm, no eggs	UKTAG-Unknown	✓	
Bloody-red mysid	*Hemimysis anomala*	Mobile, juvenile >1mm, no eggs	UKTAG-High	✓	
Caspian mud-shrimp	*Chelicorophium curvispinum*	Mobile, juvenile >1mm, no eggs	UKTAG-Unknown	✓	
Demon shrimp	*Dikerogammarus haemobaphes*	Mobile, juvenile >1mm, no eggs	UKTAG-High	✓	✓
Freshwater bivalve	*Dreissenidae sp.*	Sessile, juvenile <1mm, eggs	UKTAG-Unknown	✓	
New Zealand mud snail	*Potamopyrgus antipodarum*	Mobile, juvenile <1mm, no eggs	UKTAG-Moderate	✓	✓
Northern river crangonyctid	*Crangonyx pseudogracilis*	Mobile, juvenile >1mm, no eggs	UKTAG-Unknown	✓	

Common name	Scientific name	Functional group	Legislative status	EA records	NBN Atlas records
Northern river/Florida crangonyctid	*Crangonyx pseudogracilis/ floridanus*	Mobile, juvenile >1mm, no eggs	UKTAG-Unknown	✓	
Oblong orb mussel	*Sphaerium transversum*	Sessile, juvenile <1mm, eggs	UKTAG-Unknown	✓	
Signal crayfish	*Pacifastacus leniusculus*	Mobile, juvenile >1mm, no eggs	UKTAG-High WACA 1981 Sch. 9[128] EU species of special concern[129] IAS Order 2019 Sch. 2[130]	✓	✓
Spiny-cheek crayfish	*Faxonius limosus*	Mobile, juvenile >1mm, no eggs	UKTAG-Moderate		✓
Virile crayfish	*Faxonius virilis*	Mobile, juvenile >1mm, no eggs	UKTAG-High		✓
Wautier's limpet	*Ferrissia (Petancylus)*	Sessile, juvenile <1mm, eggs	UKTAG-Unknown		✓
Zebra mussel	*Dreissena polymorpha*	Sessile, juvenile <1mm, eggs	UKTAG-High	✓	✓

[128] Listed on Schedule 9 of the Wildlife & Countryside Act 1981
[129] Invasive Non-Native Species (Amendment etc.) (EU Exit) Regulations 2019 – listed as an 'invasive alien species of union concern'
[130] Listed on Schedule 2 of the Invasive Alien Species (Enforcement and Permitting) Order 2019

Table D.3 Non-native macrophyte species identified in Environment Agency and NBN Atlas records within 1km of the Beckton Reuse Indirect route

Common name	Scientific name	Functional group	Legislative status	EA records	NBN Atlas records
Canadian waterweed	*Elodea canadensis*	Vegetative, aquatic, perennial	UKTAG-High WACA 1981 Sch. 9		✓
Floating pennywort	*Hydrocotyle ranunculoides*	Seed + vegetative, aquatic, perennial	UKTAG-High EU species of special concern WACA 1981 Sch. 9 IAS Order 2019 Sch. 2		✓
Fringed water-lily	*Nymphoides peltate*	Seed + vegetative, aquatic, perennial	UKTAG-Unknown		✓
Giant hogweed	*Heracleum mantegazzianum*	Seed, riparian, perennial	UKTAG-High WACA 1981 Sch. 9 IAS Order 2019 Sch. 2		✓
Giant knotweed	*Fallopia sachalinensis*	Vegetative, riparian, perennial	UKTAG-High WACA 1981 Sch. 9		✓
Himalayan balsam	*Impatiens glandulifera*	Seed, riparian, annual	UKTAG-High EU species of special concern WACA 1981 Sch. 9 IAS Order 2019 Sch. 2	✓	✓
Least duckweed	*Lemna minuta*	Vegetative, aquatic, perennial	UKTAG-Unknown	✓	✓

Common name	Scientific name	Functional group	Legislative status	EA records	NBN Atlas records
Monkey flower	*Mimulus sp.*	Vegetative, riparian, perennial	UKTAG-Moderate		✓
Montibretia	*Crocosmia pottsii x aurea = C. x crocosmiiflora*	Vegetative, riparian, perennial	UKTAG-Low		✓
Nuttall's waterweed	*Elodea nuttallii*	Vegetative, aquatic, perennial	UKTAG-High EU species of special concern WACA 1981 Sch. 9 IAS Order 2019 Sch. 2	✓	✓
Orange balsam	*Impatiens capensis*	Seed, riparian, annual	UKTAG-Low	✓	✓
Rhododendron	*Rhododendron ponticum*	Seed, riparian, annual	UKTAG-High		✓
Snowberry	*Symphoricarpos albus*	Vegetative, riparian, perennial	UKTAG-Unknown		✓
Sweet flag	*Acorus calamus*	Seed, riparian, annual	UKTAG-Low	✓	
Water fern	*Azolla filiculoides*	Seed, vegetative, aquatic, perennial	UKTAG-High		✓

D.2 Ricardo PLC field survey

D.2.1 Macroinvertebrate surveys

Samples were taken at approximately three sub-sample locations per site during which a visual search, grapnel throws and INNS sampling were undertaken. Macroinvertebrate samples were taken using a three-minute kick/sweep and one-minute manual search across representative habitats. In areas where marginal habitat was poor, a dredge and net sweep was undertaken to collect a mass of material equivalent to that collected by a standard kick sample. In areas where the river channel was wide and deep, an airlift sampler was deployed from a boat to collect samples along a cross section of the river.

D.2.2 Environmental DNA

In addition to the collection of macroinvertebrate samples, eDNA samples were collected at suitable locations to identify the presence of non-native macroinvertebrates and fish. In summary, several sub-samples of water were collected from the identified sample site, combined within a sterile sample bag and then shaken to ensure thorough mixing. Using a syringe, up to 2,000mL of sampled water was filtered through an encapsulated disk filter immediately upon collection until the filter became blocked with sediment and the sampled water was no longer able to pass through. A preservative solution was immediately added to the filter units and they were then sent for laboratory analysis.

D.2.3 Field survey location

Field survey locations are presented in Table D.4.

Table D.4: Field survey locations

Site ID	Grid reference	Site name	Survey date
LRUS-026	TQ 34650 88147	West Warwick Reservoir	30/09/2021
LRUS-027	TQ 34803 88537	East Warwick Reservoir	30/09/2021
LRUS-028	TQ 35171 89472	Low Maynard Reservoir	29/09/2021
LRUS-029	TQ 35294 90352	Lockwood Reservoir	29/09/2021

Site ID	Grid reference	Site name	Survey date
LRUS-030	TQ 36274 91497	Banbury Reservoir	29/09/2021
LRUS-031	TQ 35396 89080	Walthamstow 4 Reservoir	30/09/2021
LRUS-032	TQ 35182 88862	Walthamstow 2/3 Reservoir	30/09/2021
LRUS-033	TQ 35434 88768	Walthamstow 5 Reservoir	30/09/2021
LRUS-034	TQ 34924 88880	Reservoir Walthamstow 1	30/09/2021
LRUS-035	TQ 35527 89876	High Maynard Reservoir	29/09/2021
LRUS-019	TQ 36825 94503	William Girling Reservoir	29/09/2021
LRUS-018	TQ 37171 95946	King George V Reservoir	29/09/2021
LRUS-017	TQ 37360 97993	River Lee, upstream of Thames Water King George V reservoir intake	29/09/2021

D.2.4 INNS field survey results

Results are presented below in Table D.5.

Table D.5: INNS field survey results. Positive eDNA results are marked with (✓)

Species	LR US-026	LR US-027	LR US-028	LR US-029	LR US-030	LR US-031	LR US-032	LR US-033	LR US-034	LR US-035	LR US-019	LR US-018	LR US-017
Bladder snail/tadpole physa *Physella acuta/gyrina agg.*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Species	LR US-026	LR US-027	LR US-028	LR US-029	LR US-030	LR US-031	LR US-032	LR US-033	LR US-034	LR US-035	LR US-019	LR US-018	LR US-017
Bloody-red mysid *Hemimysis anomala*		✓	✓										
Oligochaete worm *Branchiura sowerbyi*				✓									
Canadian pondweed *Chelicorophium curvispinum*													✓
Carp species *Cyprinus carpio*				✓									
Caspian mud shrimp *Chelicorophium curvispinum*													✓
Freshwater gammarid *Crytorchestia cavimana/garbinii agg.*					✓	✓		✓					
Demon shrimp *Dikerogammarus haemobaphes*		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Floating pennywort *Hydrocotyle ranunculoides*													✓
Freshwater bivalve *Dreissena sp.*			✓			✓		✓	✓				

Species	LR US-026	LR US-027	LR US-028	LR US-029	LR US-030	LR US-031	LR US-032	LR US-033	LR US-034	LR US-035	LR US-019	LR US-018	LR US-017
Giant hogweed *Heracleum mantegazzianum*	✓						✓						
Polychaete worm *Hypania invalida*													✓
Japanese knotweed *Fallopia japonica*	✓						✓						
New Zealand mud snail *Potamopyrgus antipodarum*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Northern river/Florida crangonyctid *Crangonyx pseudogracilis/floridanus sens lat.*	✓	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓
Nuttall's pondweed *Elodea nuttallii*		✓	✓			✓	✓	✓	✓	✓		✓	✓
Quagga mussel *Dreissena bugensis*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Rainbow trout *Oncorhynchus mykiss*						✓				✓			

Species	LR US-026	LR US-027	LR US-028	LR US-029	LR US-030	LR US-031	LR US-032	LR US-033	LR US-034	LR US-035	LR US-019	LR US-018	LR US-017
Side swimmer *Gammarus tigrinis*	✓	✓		✓					✓	✓	✓		
Signal crayfish *Pacifastacus leniusculus*										✓		✓	
Sweet flag *Acorus calamus*							✓						
Zebra mussel *Dreissena polymorpha*	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓	

Appendix E Invasive non-native species tool input data

E.1 Tool input data for transfer routes

The information and data entered into the water transfer INNS risk assessment tool for each of the Beckton Reuse Indirect Option transfer routes are detailed in Table E.1.

Table E.1: INNS risk assessment tool water transfer input data

Input variable	Section 1	Section 2	Section 3
Source	River Lee Flood Relief Channel (River Lee Intake)	New WTW	Brookmans Park SR
Source management catchment	London	London	Colne
Source operational catchment	Lee Lower River and Lakes	Lee Lower River and Lakes	Colne
Source type	River	WTW	Sealed water tank
Number of raw water transfers into source	None	None	None
Pathway type	Pipeline	Pipeline	Pipeline
Receptor name	Beckton Reuse Indirect WTW	Brookmans Park SR	North Mymms SR
Receptor easting	538722	526197	523319
Receptor northing	198246	204986	203744
Receptor management catchment	London	Colne	Colne
Receptor orientational catchment	Lee Lower Rivers and Lakes	Colne	Colne
Receptor type	WTW	Sealed water tank	Sealed water tank
Isolated receptor catchment	No	No	No

Input variable	Section 1	Section 2	Section 3
Volumetric rate of transfer (Ml/d)	101-150 Ml/d	101-150 Ml/d	101-150 Ml/d
Frequency of transfer	Year round – continuous, variable flow	Year round – continuous, variable flow	Year round – continuous, variable flow
Distance of transfer (km)	1.1-5	20.1-25	1.1-5
Washout/maintenance points along route*	Unknown	Unknown	Unknown
Source navigable	No	No	No
Pathway navigable	No	No	No
Angling at source	Members and day ticket holders, no matches	No	No
Angling on pathway	No	No	No
Water sports at source	No	No	No
Water sports along pathway	No	No	No
High impact INNS at source	Known to be present	Known to be present	Known to be present
High impact INNS within 1km of pathway	Known to be present	Known to be present	Known to be present
Highest order site designation within 1km of receptor	International	International	National
Presence of priority habitats within 1km of pathway	Known to be present	Known to be present	Known to be present
Presence of priority habitats within 1km of receptor	Known to be present	Known to be present	Known to be present
Other existing connections present	No	No	No

Input variable	Section 1	Section 2	Section 3
between source and receptor			

* Number of washout/maintenance points could not be confirmed at this stage of design. To be accounted for at a later stage.

E.2 Tool input data for new assets

The tool separates the INNS risk associated with water transfers from the INNS risk associated with assets. The information and data entered into the asset INNS risk assessment tool for the River Lee Intake and Raw Water Pumping Station and the new WTW are detailed in Table E.2.

Table E.2: Risk assessment tool new asset input data

Input variable	River Lee Intake	Raw Water Pumping Station	New WTW
Asset type	Intake	Pumping Station	WTW
Asset location	River Lee flood relief channel	Field adjacent to the River Lee flood relief channel	North-east of Mott Street and Sewardstone Road intersection
Asset size (m^2)	500	6300	53000
Existing high impact INNS records on site/area of proposed site	Known to be present	Known to be present	Not surveyed - unknown
Existing priority habitats on site	Known to be present	Known to be present	Known to be present
Frequency of personnel site visits	1.5 (weekly)	2 (daily)	2 (daily)
Frequency of personnel entering or in contact with raw water*	0 (never)	0 (never)	0 (never)
Frequency of road vehicles on site	0.5 (monthly)	2 (daily)	2 (daily)

Input variable	River Lee Intake	Raw Water Pumping Station	New WTW
Frequency of maintenance operations not requiring personnel to enter water	0.5 (monthly)	0.5 (monthly)	2 (daily)
Frequency of maintenance operations requiring personnel to enter water	0 (never)	0 (never)	0 (never)
Transfer of waste sludge to land frequency	0 (never)	0 (never)	2 (daily)
Frequency of recreational activities including angling, water sports and vessels	0 (never)	0 (never)	0 (never)
Mammals/waterfowl onsite frequency	2 (daily)	0 (never)	0 (never)

Appendix F Natural capital stocks and mapping methodology

Broad natural group	Subgroup	Mapping methodology
Freshwater	Active flood plain	Areas at high or medium risks within the Environment Agency's Risk of Flooding from Rivers and Sea dataset.
	Blanket bog	Area of blanket bog mapped using Natural England's Priority Habitat Inventory.
	Chalk rivers*	Mapped using the Environment Agency chalk rivers dataset and mapping intersections with OS watercourse polygons.
	Coastal and floodplain grazing marsh	Area of coastal floodplain and grazing marsh mapped using Natural England's Priority Habitat Inventory.
	Lakes and standing waters	Area of lakes and reservoirs mapped using the Centre for Ecology and Hydrology (CEH)'s UK Lakes Portal dataset.
	Lowland fens	Area of lowland fens mapped using Natural England's Priority Habitat Inventory.
	Lowland raised bog	Area of lowland raised bog mapped using Natural England's Priority Habitat Inventory
	Modified waters e.g. reservoirs	Area of reservoirs mapped by selecting Ordnance Survey (OS) surface water polygons (VectorMap District) that coincide with CEH's Inventory of UK reservoirs (points).
	Other semi-natural habitats	Area of other semi-natural habitat mapped using Natural England's Priority Habitat Inventory (including upland and lowland grasslands, heathland and saltmarsh).
	Ponds and ditches	Mapped by selecting surface waterbodies (from OS VectorMap District) that do not intersect rivers, are smaller than 2ha in size.
	Reedbeds	Area of reedbed habitat mapped using Natural England's Priority Habitat Inventory
	Rivers	Length of rivers mapped using the Environment Agency's Water Framework Directive (WFD) river

Broad natural group	Subgroup	Mapping methodology
		waterbodies dataset (cycle 1, to include coastal streams).
Mountain, Moor and Heath	Blanket bog	Area of blanket bog mapped using Natural England's Priority Habitat Inventory.
	Dwarf shrub heath	Mapped using Natural England's Priority Habitat Inventory ('fragmented heath', 'lowland heathland' and 'upland heathland').
	Inland rock, scree and pavement (AML*)	Area of inland rock and limestone pavement above the moorland line, mapped using CEH's LCM2015 ('inland rock'), Natural England's Priority Habitats Inventory ('limestone pavement') and the Rural Payment Agency (RPA)'s Moorland Line dataset.
	Lakes and reservoirs	Area of lakes and reservoirs above the moorland line, mapped using CEH's UK Lakes dataset, CEH's Inventory of UK reservoirs dataset and RPA's Moorland Line dataset.
	Mountain heath and willow scrub	Area of mountain heath and willow scrub mapped using Natural England's Priority Habitat Inventory.
	Rivers (AML)	Length of rivers mapped using the Environment Agency's WFD river waterbodies dataset and RPA's Moorland Line dataset.
	Semi-natural grassland (AML*)	Area of semi-natural grassland above the moorland line, mapped using Natural England's Priority Habitat Inventory and RPA's moorland line dataset.
	Upland flushes fens and swamps	Area of upland flushes, fens and swamps, mapped using Natural England's Priority Habitat Inventory.
	Wood pasture (AML*)	Area of wood pasture above the moorland line, mapped using Natural England's provisional Wood-Pasture and Parkland BAP Priority Habitat Inventory and RPA's Moorland line dataset.
	Woodland (AML*)	Area of woodland above the moorland line, mapped using Forestry Commission's National Forest Inventory and RPA's moorland line dataset.
Urban	Blue space	Mapped by intersecting OS VectorMap District Surface Water with the Office for National Statistic (ONS)'s Built-Up areas dataset.

Broad natural group	Subgroup	Mapping methodology
	Green space – not semi-natural	Area of urban green space (not semi-natural), mapped using the OS Open Greenspace Layer.
	Open mosaic habitats	Area of open mosaic habitats on previously developed land, mapped using Natural England's draft Open Mosaic Habitat dataset.
	Woodland, scrub and hedge	While urban scrub and hedge are difficult to map at a national scale, the area of urban woodland is mapped here by intersecting the Forestry Commission's National Forest Inventory with ONS Built-Up Areas.
	Semi-natural habitats	Mapped by intersecting Natural England's Priority Habitat Inventory habitats (excluding woodland, good quality semi-improved grassland and traditional orchards) with ONS Built-Up Areas.
Farmland	Arable and rotational leys	Area of arable and rotational leys, and horticulture individually, this map shows the area of arable and horticulture combined. Mapped using UK Land Cover 2018 Sub Classes.
	Horticulture	Area of arable and rotational leys, and horticulture individually, this map shows the area of arable and horticulture combined. Mapped using CEH's Land Cover Map 2015 (LCM2015).
	Improved grassland	Area of improved grassland mapped using CEH's LCM2015.
	Orchards and top fruit	Area of orchards and top fruit mapped using Natural England's Priority Habitat Inventory ('traditional orchards').
Woodland	Ancient woodland	Mapped using Natural England's ancient woodland dataset.
	Broadleaved, mixed and yew woodland	Mapped using Forestry Commission's National Forest Inventory.
	Coniferous woodland	Area of coniferous woodland mapped using Forestry Commission's National Forest Inventory.

Broad natural group	Subgroup	Mapping methodology
	Woodland priority habitats	Mapped using Natural England's Priority Habitat Inventory ('deciduous woodland').
Grasslands	Hay meadows	Area of hay meadow mapped using Natural England's Priority Habitat Inventory ('upland meadow' and 'lowland meadow').
	Other semi-natural grasslands	Area of other semi-natural grassland, mapped using Natural England's Priority Habitat Inventory ('upland calcareous', 'lowland calcareous', 'lowland dry acid', 'good quality semi-improved', 'grass moorland' and 'purple moor grass and rush pasture').
Coastal	Beach	Area of beach mapped using OS VectorMap District ('foreshore'). Note that this dataset includes areas of intertidal sediment as well as beaches.
	Coastal lagoons	Area of coastal lagoons mapped using Natural England's Priority Habitat Inventory ('saline lagoons').
	Mudflats	Area of intertidal mudflats mapped using the EMODnet (Natural England) Intertidal Mudflats dataset.
	Salt marsh	Area of saltmarsh mapped using the Environment Agency's Saltmarsh Extent dataset.
	Sand dunes	Area of sand dunes mapped using Natural England's Priority Habitat Inventory ('coastal dunes').
	Sea cliff	Area of sea cliff habitat mapped using Natural England's Priority Habitat Inventory ('maritime cliff and slopes').
	Shingle	Area of shingle mapped using Natural England's Priority Habitat Inventory ('coastal vegetated shingle').
Marine	Intertidal rock	Area of intertidal rock mapped using Natural England's Open Marine Evidence Base (EUNIS code A1).
	Maerl beds	Area of maerl beds mapped using Natural England's Open Marine Evidence Base (EUNIS code A5.51).
	Reefs	Area of potential reefs mapped using JNCC's Potential Annex 1 Reefs.

Broad natural group	Subgroup	Mapping methodology
	Sea grass beds	Area of seagrass beds mapped using Natural England's Open Marine Evidence Base (EUNIS code A2.61).
	Shallow subtidal sediment	Area of shallow subtidal sediment mapped using JNCC's UKSea Map 2018 (biozone = shallow ircalittoral or infralittoral and substrate = sediment, sand or mud).
	Shelf subtidal sediment	Area of shelf subtidal sediment mapped using JNCC's UKSea Map 2018 (biozone = deep circalittoral and substrate = sediment, sand or mud).
	Subtidal rock	Area of subtidal rock mapped using JNCC's UKSea Map 2018 (substrate = rock).
Soils	Nutrient status of soil	Mean estimates of total nitrogen concentration in topsoil (0-15cm depth) - % dry weight of soil, mapped using data produced from Natural England and CEH's 'Mapping Natural Capital' project (2016).
	Soil carbon/Organic matter	Mean estimates of carbon density in topsoil (0-15cm depth) – tonnes per hectare, mapped using data produced from Natural England and CEH's 'Mapping Natural Capital' project (2016)
	Soil biota	Mean estimates of total abundance of invertebrates in topsoil (0-8 cm depth), mapped using data produced from Natural England and CEH's 'Mapping Natural Capital' project (2016).
Indicators of condition	Natural aquifer function	Area of groundwater catchment with 'good' quantitative status for WFD 2016, mapped using the Environment Agency's WFD data and groundwater catchment boundaries (C2).
	Naturalness of flow regime	The WFD hydrological regime classification describe the naturalness of river flows. This map shows the length of river with 'high' WFD hydrological status in 2016, mapped using the Environment Agency's WFD data and river water bodies (C2).
	Lack of physical modifications of water bodies	Lack of physical modification of rivers, mapped using EA's Reasons for Not Achieving Good Status data (SWMI = 'physical modification'), 2013-2016.
	Presence and frequency of	Mean estimates of number of nectar plant species for bees per 2x2m plot, mapped using data produced

Broad natural group	Subgroup	Mapping methodology
	pollinator food plants	from Natural England and CEH's 'Mapping Natural Capital' project (2016).
	Chemical status of water bodies	River chemical status for WFD 2016, mapped using the Environment Agency's WFD data and river water bodies (C2).

Affinity Water

Thames Water