Slade Brook NFM

Natural Flood Management Feasibility Report

Draft Report

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Contract

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JBA Project Code	2023s1222

This report describes work commissioned by the Environment Agency, by an instruction dated 19th September 2023. The Client's representative for the contract was Andy Sadler of the Environment Agency. Ryan Jennings and Jennine Evans of JBA Consulting carried out this work.

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The methodology adopted and the sources of information used by JBA in providing its services are outlined in this Report. The work described in this Report was undertaken between October 2023 and March 2024 and is based on the conditions encountered and the information available during the said period. The scope of this Report and the services are accordingly factually limited by these circumstances.

Unless otherwise stated in this Report, the assessments made assume that the sites and facilities will continue to be used for their current purpose without significant changes.

Where field investigations are carried out, these have been restricted to a level of detail required to meet the stated objectives of the services. The results of any measurements taken may vary spatially or with time and further confirmatory measurements should be made after any significant delay in issuing this Report.

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Abbreviations

mAOD	metres Above Ordnance Datum
NGR	National Grid Reference
PBDE	Polybrominated Diphenyl Ethers
RBD	River Basin District
RFD	Reasons For Deterioration
RNAG	Reasons For Not Achieving Good
SWMI	Surface Water Management Issues
WFD	Water Framework Directive

Definitions

Within this report, JBA have used the following terms to specify the intervention methods being used on the ground, these include:

- Working with Natural Processes (WwNP)
- Nature Based Solutions (NBS)
- Natural Flood Management (NFM)

Within the report, each of these terms are used. WwNP/NBS focuses on managing, restoring, and emulating a more naturally functioning catchment and river system.

NFM applies the WwNP approach to implement specific features across catchments to intercept, slow and store floodwaters.

Nature Based Solutions in this context are interventions that mimic natural processes and include restoring hydrological function of soils, tree planting, NFM structures, attenuation features, woodland management, mire restoration, floodplain reconnection and potentially beavers.

This report quotes the frequency of a flood in terms of an annual exceedance probability (AEP), which is 100/return period (years). A return period is defined as the average time between years with at least one larger flood. AEPs can be helpful when presenting results to members of the public who may associate the concept of return period with a regular occurrence rather than an average recurrence interval. The table below is provided to enable quick conversion between return periods and annual exceedance probabilities.

Table 1-1: AEP/Return Period Conversion

Return period (years)	2	5	10	20	25	30	50	75	100	200	1000
AEP	0.5	0.2	0.1	0.05	0.04	0.033	0.02	0.013	0.01	0.005	0.001
AEP (%)	50	20	10	5	4	3.3	2	1.3	1	0.5	0.1

Executive Summary

This project was commissioned to assess and develop potential river restoration opportunities for the Slade Brook and Loddington Arm (Ise), Kettering. Opportunities were pursued that would provide improvements for water quality, in-channel conditions, riparian habitat, floodplain reconnection and Natural Flood Management (NFM).

Opportunities should seek to address and improve Water Framework Directive (WFD) pressures failures of both the Slade Brook and Loddington Arm (Ise).

Several reports have been completed in this project as defined:

- This Report – NFM Feasibility including desk based NFM assessment, catchment character and a hydraulic modelling summary.
- Appendix A – Hydraulic modelling technical report including updated hydrology (ENV6006464R-JBAU-XX-01-AS-HM-0014-S3-P01-SladeBrook_2D-NFM-HydraulicModelling)
- Appendix B – NFM, geomorphological and ecological walkovers were completed on 12/12/2023 and 12/03/2024 (ENV6006464R-JBAU-XX-01-AS-EN-0010-S3-P01-SladeBrook_NFMWalkoverAssessment)
- Appendix C – Heritage baseline scoping assessment (ENV6006464R-JBAU-XX-01-AS-HE-0006-S3-P01-Slade_Brook_Heritage_Baseline_Scoping)

5 options have been selected for the NFM short list priority. These include:

- Site 3 - Glendon Wood leaky barriers
- Site 4 - Prologis Park river restoration
- Site 9 - Land at Coppicemoor Spinney / DS - wetland design and wet woodland.
- Coppicemoor Brook near Middle Ground Spinney - river restoration/floodplain reconnection.
- Coppicemoor Brook near Underwood Hill Spinney - Leaky Barriers.

All 5 sites showed significant flood peak reductions in Kettering when simulated through the JFlow model. More information on these specific sites is detailed in the Short List, Design and Access Statement – Appendix D (ENV6006464R-JBAU-XX-01-DS-C-0030-A2-P02-NFMShortList_DesignAccess_0324)

In order to pursue these opportunities into future projects next steps have been considered in Table 6 1, which are underpinned by the constraints that have been outlined for each of the site's opportunities throughout the Slade Brook catchment. These next steps include a mixture of suggestions of further work and investigations that would need to be undertaken in order to allow these opportunities to progress.

- Undertake landowner, stakeholder and community engagement to gain a wider understanding as to the likelihood of implementation of the features.
- Review the features to be implemented and agree outline designs (and subsequently detailed designs where necessary) with appropriate levels of modelling.
- Understand and assign maintenance requirements and responsibility of assets to an appropriate authority.

- Apply for necessary planning and consenting permissions, with a suitable level of consideration for wider environmental issues such as ecology, carbon, water quality, landscape and heritage.
- Further analysis on the East Brook watercourse may provide additional flood risk benefits for Kettering. This has not been analysed within this project given the urban nature and culverted watercourse. A SUD's scheme here may work well in this catchment.

1 Introduction

1.1 Purpose of this report

This feasibility study aims to hydrologically assess the Slade Brook catchment and River Ise at Kettering to identify sites suitable for NFM (Natural Flood Management) opportunities that also delivers additional benefits of ecological improvements, addresses WFD failing or deteriorating elements and increases carbon sequestration. This project will seek to identify areas where sustainable interventions can be implemented such as floodplain reconnection, woodland planting or add in-channel features like leaky dams to positively reduce the flood risk to properties in the Kettering area. The aim is to identify sites where schemes can be delivered that will work in-combination and demonstrate a positive benefit for both flood risk and ecological improvement.

This report will cover:

- Catchment character,
  - Including Hertiage - **Appendix C - ENV6006464R-JBAU-XX-01-AS-HE-0006-S3-P01-Slade_Brook**_Heritage_Baseline_Scoping
- Desk Based NFM Assessment,
- Walkover and Opportunities Discussion - **Appendix B** - ENV6006464R-JBAU-XX-01-AS-EN-0010-S3-P01-SladeBrook_NFMWalkoverAssessment
- 2D NFM Hydraulic Modelling - **Appendix A** - ENV6006464R-JBAU-XX-01-AS-HM-0014-S3-P01-SladeBrook_2D-NFM-HydraulicModelling
- Conclusion and Next Steps

2 Catchment Character

2.1 Introduction

The approach used to complete the catchment character assessment of the Slade Brook study catchment is to firstly develop an understanding of the hydrology of the catchment. This is achieved by assessing the hydrology, geology, land use, historical mapping, aerial imagery and any other relevant literature for the catchment. Then drawing on the information gathered in the assessment to develop an understanding of the key functions and processes which are affecting the WFD pressures of the watercourse.

2.2 Hydrological understanding of the catchment

More information is provided in Appendix A [1] - Appendix A - ENV6006464R-JBAU-XX-01-AS-HM-0014-S3-P01-SladeBrook_2D-NFM-HydraulicModelling.

The Slade Brook catchment is 33.6km^2, with 16.2km of main channel before flowing into the Ise - Lower watercourse. The areas of interest for this commission are shown in Figure 2-1. The catchment rises in Foxhall/Harrington, within a confined valley which disconnects the Slade Brook hydraulically from the Ise and Brampton Branch. The headwaters are confined within a gentle valley, then the Slade Brook navigates in a straight planform through a gentle but defined valley through the rural land between Foxhall/Harrington, past Rothwell and through the town of Kettering. In the reaches upstream of Kettering, the floodplain is disconnected and drained for agriculture. In Kettering, the urban reaches of the Slade Brook are straightened, trapezoidal. The channels are very confined with properties and roads often developed up to the bank top of the watercourse (Figure 2-1), preventing connectivity to its floodplain or space for natural processes or habitat. The annual average rainfall (1991-2020) is 608.63mm which is lower than both the England South regional and UK averages (Table 2-1).

Large waterbodies can be found in the Slade Brook and Ise catchments. In the downstream reach of the Slade Brook, there is a wildlife lake next to Kettering Conference Centre, also locally known as Kettering Leisure Village. This lake is created by a large concrete dam, Figure 2-2, which impounds the flow upstream. The lake is beginning to succeed as the sediment is trapped behind the dam. The flow can vary and is responsive to flood events as the dam level is constant and the flow overtops the dam. However, this is likely depriving downstream reaches of sediment.

In addition to the wildlife lake, there are two reservoirs in the upper Ise catchment. Both Thorpe Malsor and Cransley reservoirs are under private ownership and their current operating procedures are unknown except that the flows are regulated from these two reservoirs. These regulated flows provide a steady and constant flow with little variation.

1 ENV6006464R-JBAU-XX-01-AS-HM-0014-A2-P02-SladeBrook_2D-NFM-HydraulicModelling

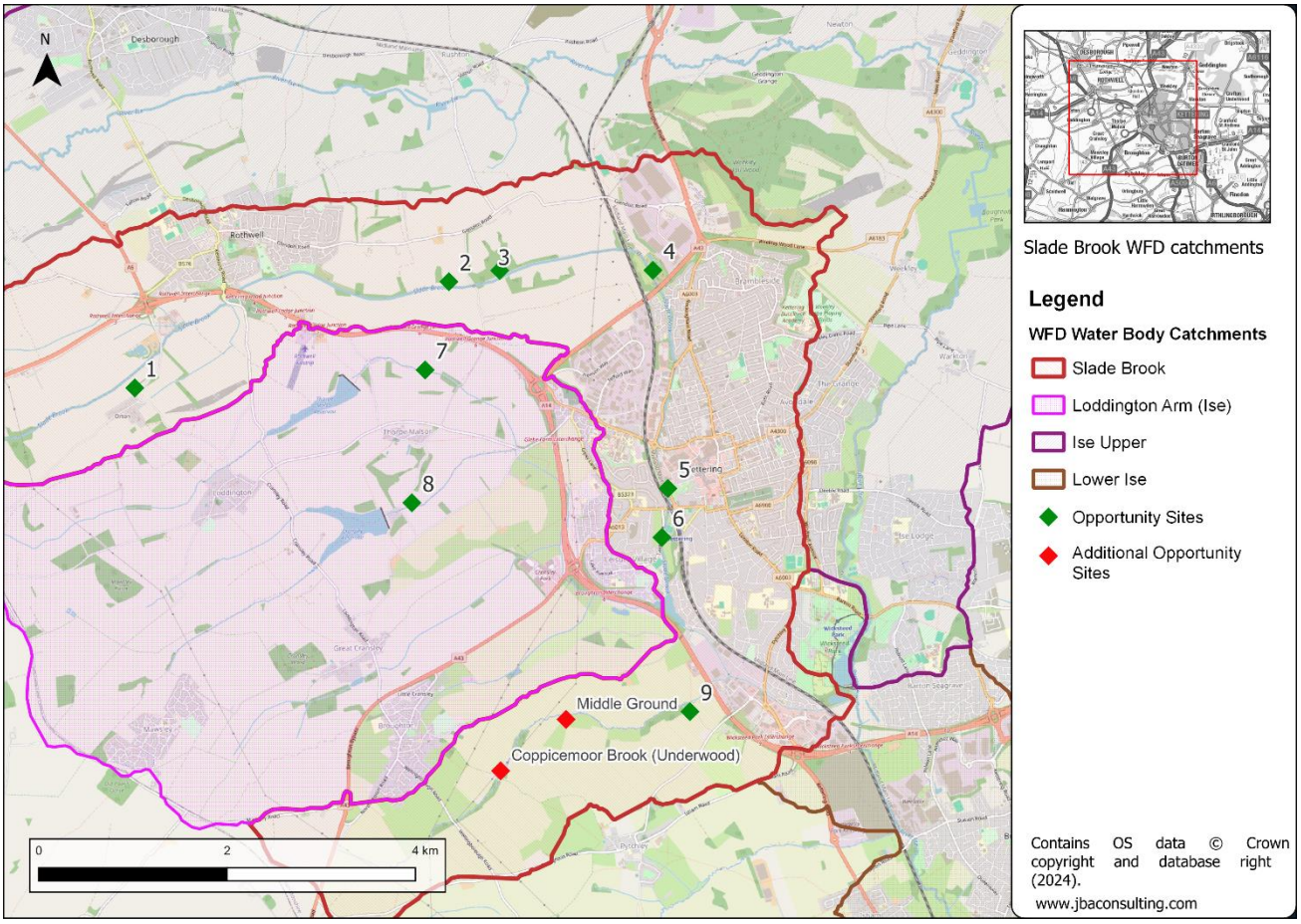

Figure 2-1 Proposed site locations for the Slade Brook NFM project.

Figure 2-2 The dam impounding the flow of the Slade Brook at Kettering Conference Centre for a wildlife lake.

Table 2-1 Average annual rainfalls

Location	Bedford (nearest rain gauge)	England South regional average	UK average
Average annual rainfall 1991-2020 (mm) 2*	626.91	808.04	1162.93

2.2.1 Risk of surface water flooding

The risk of surface water flooding in the Slade Brook and Loddington Arm (Ise) catchment predominantly follows the same path as the watercourses. The key areas for concern are the areas at risk of surface water flooding in Kettering. Natural flood management measures should aim to reduce the risk of flooding to homes and businesses within the town.

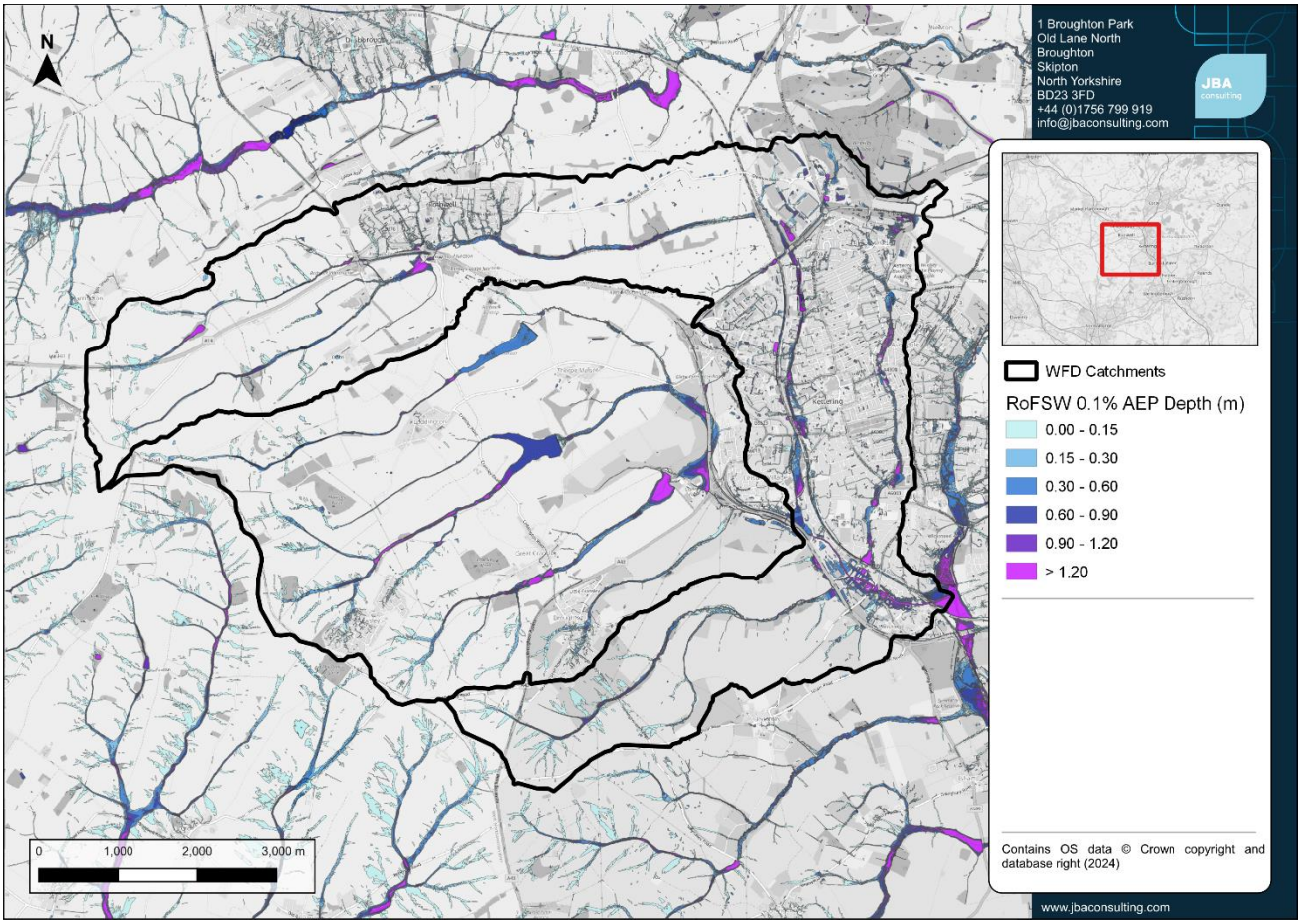

Figure 2-3 Risk of surface water flooding for the Slade Brook and Loddington Arm (Ise) catchments.

2.3 Ecology

2 https://www.metoffice.gov.uk/research/climate/maps-and-data/uk-climate-averages/gcr9j7q0s

There are no statutory designated nature conservation sites along Slade Brook, the closest being Southfield Farm Marsh SSSI located near the Slade Brook's confluence with the River Ise. Deciduous woodland priority habitat is located in several areas along Slade Brook. Bat and Great Crested Newt mitigation licences have been granted for the disturbance of resting sites within Kettering adjacent to the river corridor. A full desk study is provided in Section 3.3, with site specific ecology referenced in Section 4 (NBS/NFM Walkover and Opportunities).

2.4 Heritage Baseline Scoping

The following data sources were consulted in the production of a Heritage Baseline scoping document (Appendix C [3] - Appendix C - ENV6006464R-JBAU-XX-01-AS-HE-0006-S3-P01-Slade_Brook_Heritage_Baseline_Scoping):

- National Heritage List for England (Historic England Dataset); and
- West Northamptonshire Historic Environment Record (HER) data search

The document outlines considerable sections of the catchment which maybe sensitive in regard to the proximity of heritage assets. This section of the Heritage assessment has been expanded in Section 4.1- NFM Heritage Assessment post NFM analysis to identify in detail, the likelihood of sensitivity around specific NFM proposals.

2.5 Historical analysis

By interrogating the Ordnance Survey (One Inch, 1885-1900) historic maps of the catchment, a noticeable increase in urban areas has occurred, primarily the loss of open agricultural fields and woodlands however even in the 1888-1900 map the Slade Brook is confined by roads and buildings within the urban area. The channel was historically straightened through the main project area (Figure 2-4) but no reference to the natural conditions of the channel can be found. The channel is largely confined by the topography, so there is little room for the channel to meander outside of its valley (Figure 2-5).

There are potential opportunities to restore paleochannels at Site 8 but otherwise there is limited opportunity for channel realignment to historic channels.

3 ENV6006464R-JBAU-XX-01-AS-HE-0006-S3-P01-Slade_Brook_Heritage_Baseline_Scoping

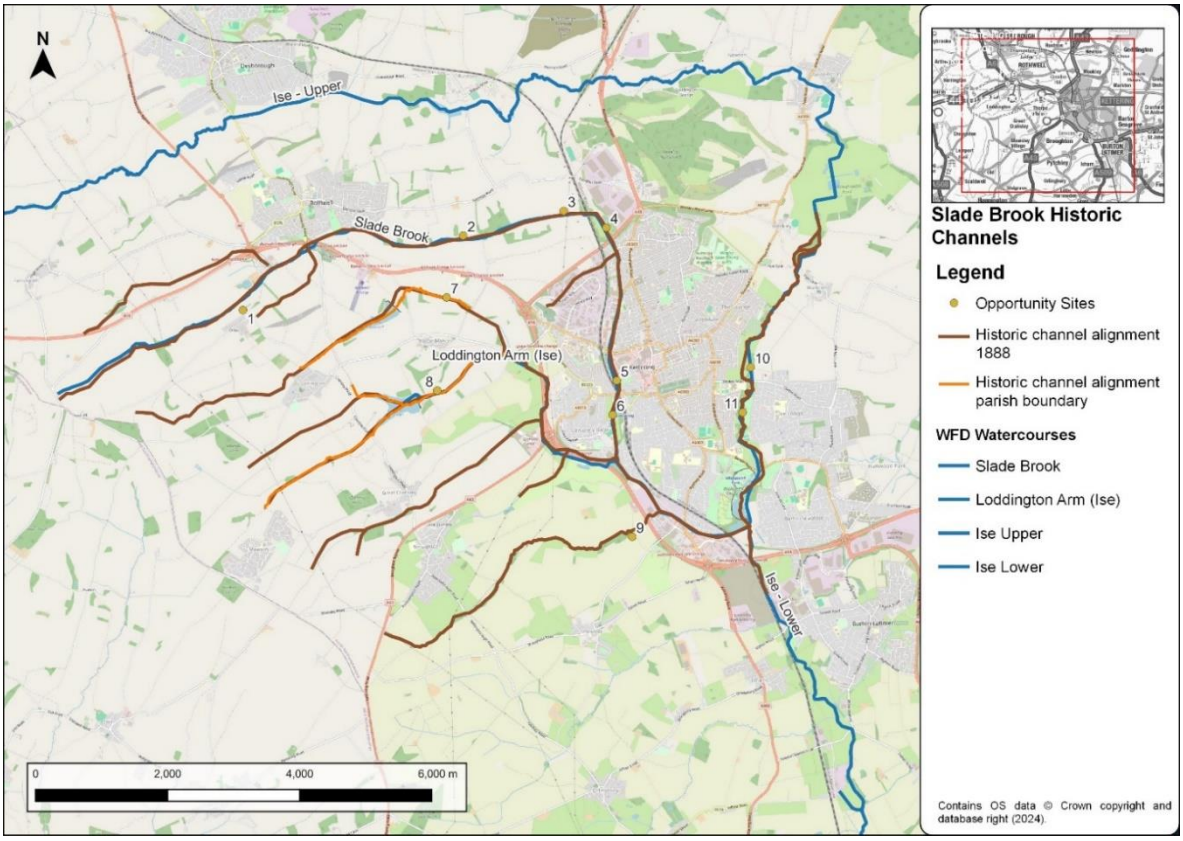

Figure 2-4 Historical alignment of the Slade Brook

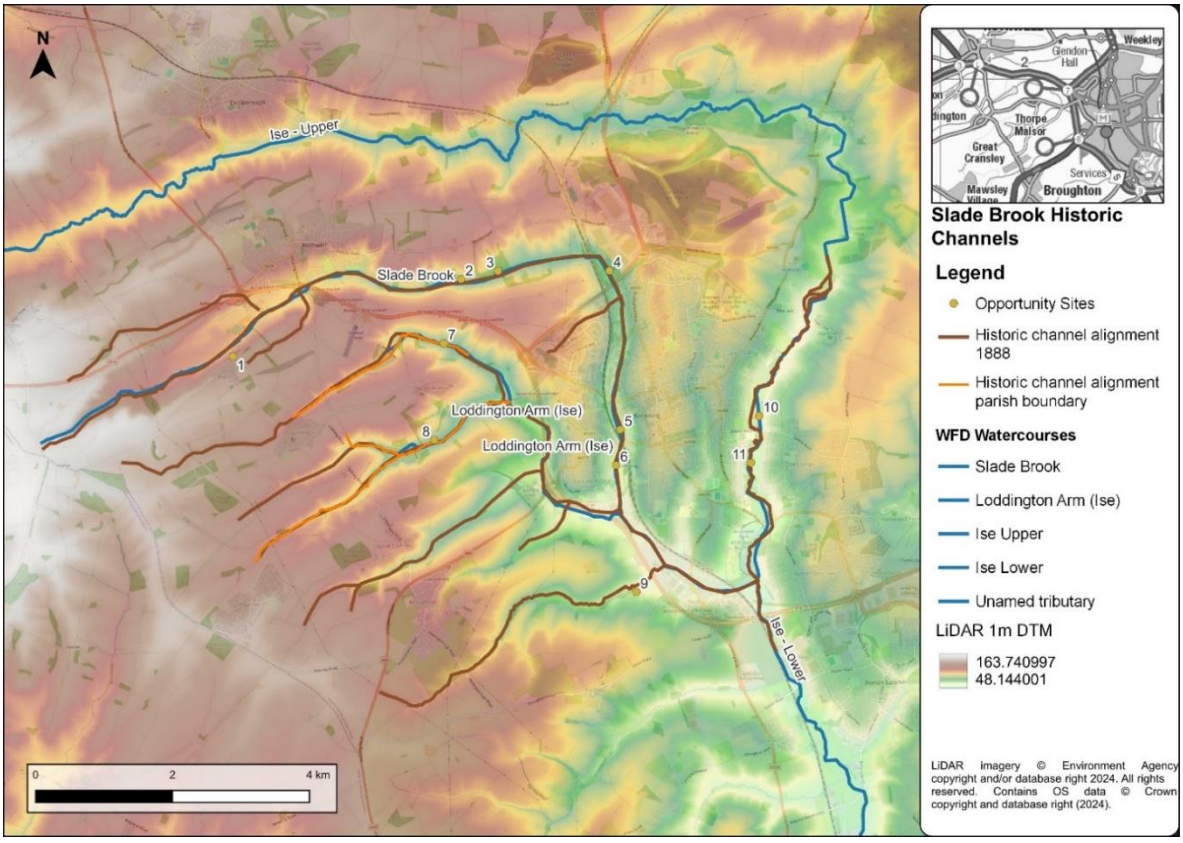

Figure 2-5 Historical alignment of the Slade Brook with LiDAR

2.6 WFD status and pressures

This project covers both the Slade Brook water body (GB105032045170) and the Loddington Arm (Ise) Water Body (GB105032045150).

2.6.1 The Slade Brook

The Slade Brook water body (GB105032045170) is not designated as a heavily modified watercourse. The water body is currently at 'Moderate' ecological status due to moderate monitored status for Macrophytes and Phytobenthos combines and Macrophtes sub-element (Table 2-2).

The reasons for not achieving good status (RNAGS) for Slade Brook water body are listed in

Table 2-4 and the objectives to improve the ecological status of the water body are listed in Table 2-5. The pressures affecting the failing elements have been listed as 'Disproportionately expensive: Disproportionate burdens' and low confidence to address these by the objective of good status by 2027.

Table 2-2 WFD classifications for Slade Brook water body (GB105032045170)

Classification Item	2022 (Cycle 3)
Ecological	Moderate
Biological quality elements	Moderate
Fish	Good
Macrophytes and Phytobenthos Combined	Moderate
Macrophytes Sub Element	Moderate
Physico-chemical quality elements	Good
Ammonia (Phys-Chem)	High
Biochemical Oxygen Demand (BOD)	High
Dissolved oxygen	High
Phosphate	Good
Temperature	High
pH	High
Hydromorphological Supporting Elements	Supports good
Hydrological Regime	Supports good
Chemical	Does not require assessment
Priority hazardous substances	Does not require assessment
Benzo(a)pyrene	
Dioxins and dioxin-like compounds	
Heptachlor and cis-Heptachlor epoxide	
Hexabromocyclododecane (HBCDD)	
Hexachlorobenzene	
Hexachlorobutadiene	
Mercury and Its Compounds	
Perfluorooctane sulphonate (PFOS)	
Polybrominated diphenyl ethers (PBDE)	
Priority substances	Does not require assessment
Cypermethrin (Priority)	
Fluoranthene	
Other Pollutants	Does not require assessment

Table 2-3 Investigations into Classification Status by the Environment Agency

Classification Element	Cycle	Year	Status	Outcome
Macrophytes and Phytobenthos Combined	2	2015	Moderate	Certain there is not a problem
Phosphate	2	2016	Good	Quite certain there is a problem

Table 2-4 Reasons for nor achieving good status (RNAGS) and Significant Water Management Issues (SWMI) for the Slade Brook water body.

SWMI	Activity	Category	Classification Element
Diffuse source	Poor Livestock Management	Agriculture and rural land management	Phosphate
Diffuse source	Urbanisation - urban development	Urban and transport	Phosphate
Diffuse source	Poor nutrient management	Agriculture and rural land management	Phosphate
Point source	Sewage discharge (continuous)	Water Industry	Phosphate
Unknown (pending investigation)	Unknown (pending investigation)	Sector under investigation	Perfluorooctane sulphonate (PFOS)
measures delivered to address reason, awaiting recovery	Not applicable	No sector responsible	Polybrominated diphenyl ethers (PBDE)
measures delivered to address reason, awaiting recovery	Not applicable	No sector responsible	Mercury and Its Compounds
Natural	Natural conditions - other	No sector responsible	Macrophytes and Phytobenthos Combined

Table 2-5 Objectives for Slade Brook water body.

Classification Item	Status	Year	Reasons
Ecological	Good	2015	
Biological quality elements	Good	2015	
Fish	Good	2015	
Macrophytes and Phytobenthos Combined	Good	2015	
Physico-chemical quality elements	Good	2015	
Ammonia (Phys-Chem)	Good	2015	
Dissolved oxygen	Good	2015	
Phosphate	Good	2015	
Temperature	Good	2015	

Classification Item	Status	Year	Reasons
pH	Good	2015	
Hydromorphological Supporting Elements	Supports good	2015	
Hydrological Regime	Supports good	2015	
Supporting elements (Surface Water)	Not assessed	2015	
Specific pollutants	Not assessed	2015	
Chemical	Good	2063	Natural conditions: Chemical status recovery time; Technically infeasible: No known technical solution is available
Priority hazardous substances	Good	2063	Natural conditions: Chemical status recovery time; Technically infeasible: No known technical solution is available
Benzo(a)pyrene	Good	2015	
Dioxins and dioxin-like compounds	Good	2015	
Heptachlor and cis-Heptachlor epoxide	Good	2015	
Hexabromocyclododecane (HBCDD)	Good	2015	
Hexachlorobenzene	Good	2015	
Hexachlorobutadiene	Good	2015	
Mercury and Its Compounds	Good	2040	Natural conditions: Chemical status recovery time
Perfluorooctane sulphonate (PFOS)	Good	2039	Technically infeasible: No known technical solution is available
Polybrominated diphenyl ethers (PBDE)	Good	2063	Natural conditions: Chemical status recovery time
Priority substances	Good	2015	
Cypermethrin (Priority)	Good	2015	
Fluoranthene	Good	2015	
Other Pollutants	Does not require assessment	2015	

2.6.2 The Loddington Arm (Ise)

The Loddington Arm (Ise) water body (GB105032045150) is designated as heavily modified watercourse. The watercourse is currently at 'moderate' ecological status due to 'poor' monitored status of Macrophytes Sub Element (Table 2-6). This watercourse has remained at moderate ecological status, but the Ammonia (Phys-Chem) status has declined from high to good since Cycle 2 in 2019.

The reasons for not achieving good status (RNAGS) for Loddington Arm (Ise) water body are listed in Table 2-6 and the objectives to improve the ecological status of the water body are listed in Table 2-7. The pressures affecting the failing elements have been listed as Disproportionately expensive: Disproportionate burdens and Natural conditions: Chemical status recovery time; No known technical solution is available.

Table 2-6 WFD classifications for Loddington Arm (Ise) water body (GB105032045150)

Classification Item	2022 (Cycle 3)
Ecological	Moderate
Biological quality elements	High
Fish	Not assessed
Macrophytes and Phytobenthos Combined	
Macrophytes Sub Element	Poor
Physico-chemical quality elements	Moderate
Ammonia (Phys-Chem)	Good
Biochemical Oxygen Demand (BOD)	High
Dissolved oxygen	High
Phosphate	Moderate
Temperature	High
pH	High
Hydromorphological Supporting Elements	Supports Good
Hydrological Regime	Supports Good
Chemical	Does Not Require Assessment
Priority hazardous substances	Does Not Require Assessment
Benzo(a)pyrene	
Dioxins and dioxin-like compounds	
Heptachlor and cis-Heptachlor epoxide	
Hexabromocyclododecane (HBCDD)	
Hexachlorobenzene	
Hexachlorobutadiene	
Mercury and Its Compounds	
Perfluorooctane sulphonate (PFOS)	
Polybrominated diphenyl ethers (PBDE)	

Classification Item	2022 (Cycle 3)
Priority substances	Does not require assessment
Cypermethrin (Priority)	
Fluoranthene	
Other Pollutants	Does not require assessment

Table 2-7 Reasons for nor achieving good status (RNAGS) and Significant Water Management Issues (SWMI) for the Loddington Arm (Ise) water body (GB105032045150).

SWMI	Activity	Category	Classification Element
Diffuse source	Poor Livestock Management	Agriculture and rural land management	Phosphate
Diffuse source	Transport Drainage	Urban and transport	Phosphate
Diffuse source	Poor nutrient management	Agriculture and rural land management	Phosphate
Point source	Sewage discharge (continuous)	Water Industry	Phosphate
Unknown (pending investigation)	Unknown (pending investigation)	Sector under investigation	Perfluorooctane sulphonate (PFOS)
Physical modification	Other (not in list, must add details in comments)	Recreation	Mitigation Measures Assessment
measures delivered to address reason, awaiting recovery	Not applicable	No sector responsible	Polybrominated diphenyl ethers (PBDE)
measures delivered to address reason, awaiting recovery	Not applicable	No sector responsible	Mercury and Its Compounds

Table 2-8 Objectives for Loddington Arm (Ise) water body

Classification Item	Status	Year	Reasons
Ecological	Moderate	2015	Disproportionately expensive: Disproportionate burdens;
Disproportionately expensive: Unfavourable balance of costs and benefits			
Biological quality elements	Good	2015	

Classification Item	Status	Year	Reasons
Invertebrates	Good	2015	
Macrophytes and Phytobenthos Combined	Not assessed	2015	Disproportionately expensive: Unfavourable balance of costs and benefits
Physico-chemical quality elements	Moderate	2015	Disproportionately expensive: Unfavourable balance of costs and benefits
Ammonia (Phys-Chem)	Good	2015	
Dissolved oxygen	Good	2015	
Phosphate	Moderate	2015	Disproportionately expensive: Unfavourable balance of costs and benefits
Temperature	Good	2015	
pH	Good	2015	
Hydromorphological Supporting Elements	Supports good	2015	
Hydrological Regime	Supports good	2015	
Supporting elements (Surface Water)	Good	2027 - Low confidence	Disproportionately expensive: Disproportionate burdens
Mitigation Measures Assessment	Good	2027 - Low confidence	Disproportionately expensive: Disproportionate burdens
Specific pollutants	Not assessed	2015	
Chemical	Good	2063	Natural conditions: Chemical status recovery time;
Technically infeasible: No known technical solution is available			
Priority hazardous substances	Good	2063	Natural conditions: Chemical status recovery time;
Technically infeasible: No known technical solution is available			
Benzo(a)pyrene	Good	2015	
Dioxins and dioxin-like compounds	Good	2015	

Classification Item	Status	Year	Reasons
Heptachlor and cis-Heptachlor epoxide	Good	2015	
Hexabromocyclododecane (HBCDD)	Good	2015	
Hexachlorobenzene	Good	2015	
Hexachlorobutadiene	Good	2015	
Mercury and Its Compounds	Good	2040	Natural conditions: Chemical status recovery time
Perfluorooctane sulphonate (PFOS)	Good	2039	Technically infeasible: No known technical solution is available
Polybrominated diphenyl ethers (PBDE)	Good	2063	Natural conditions: Chemical status recovery time

2.6.3 Summary

Opportunities should seek to address and improve WFD pressures failures of both the Slade Brook and Loddington Arm (Ise). In summary the pressures and failures for the Slade Brook water body are:

- Macrophytes and Phytobenthos Combined
- Macrophytes Sub Element
- Phosphates
  - Agriculture
  - Water Industry (Sewage treatment works)
  - Urban development

And the pressures and failures for the Loddington Arm (Ise) water body are:

- Macrophytes Sub Element
- Ammonia (Phys-Chem)
- Phosphate
  - Agriculture and rural land management
  - Water Industry (Sewage treatment works)
  - Physical Modifications
  - Urban development

It is possible that NFM and WwNP measures may benefit water-quality and therefore could help improve the ecological status of the rivers and waterbodies. NFM and WwNP also generally maintains or improves the biodiversity of an area, and therefore could further improve the ecological status of the area. It is also possible that NFM and WwNP measures may help improve the chemical status of the rivers by slowing rapid hydrological surface pathways which can rapidly transport chemical pollutants into the stream network before they can degrade. Such features might also retain sediment on the land which these contaminants are attached or bonded to. Certain NFM features may also help bind soils

contaminated with these chemical compounds and slow or stop them from reaching the stream network – potentially improving the chemical water-quality status.

3 Desk Based NBS/NFM Assessment

3.1 Geology

The geology within the catchment is part of the Great Oolite Group, Inferior Oolite Group and the Lias Group. These groups are a combination of Middle and Lower Jurassic. A variety of Formations and Members make up these catchments, comprised of:

- Northampton Sand Formation (ironstone, ooidal)
- Stamford Member (sandstone and siltstone)
- Whitby Mudstone Formation (mudstone)
- Grantham Formation (sandstone, siltstone and mudstone)
- Lower Lincolnshire Limestone Member (limestone)
- Rutland Formation (mudstone)
- Wellingborough Limestone Member (limestone and mudstone)
- Blisworth Limestone Formation (limestone)

Known superficial deposits within the catchments include alluvium, alluvial fan deposits, river terrace deposits, glaciofluvial deposits, head, till, Grendon member and Oadby member. Further information is available in Appendix A - Appendix A - ENV6006464R-JBAU-XX-01-AS-HM-0014-S3-P01-SladeBrook_2D-NFM-HydraulicModelling.

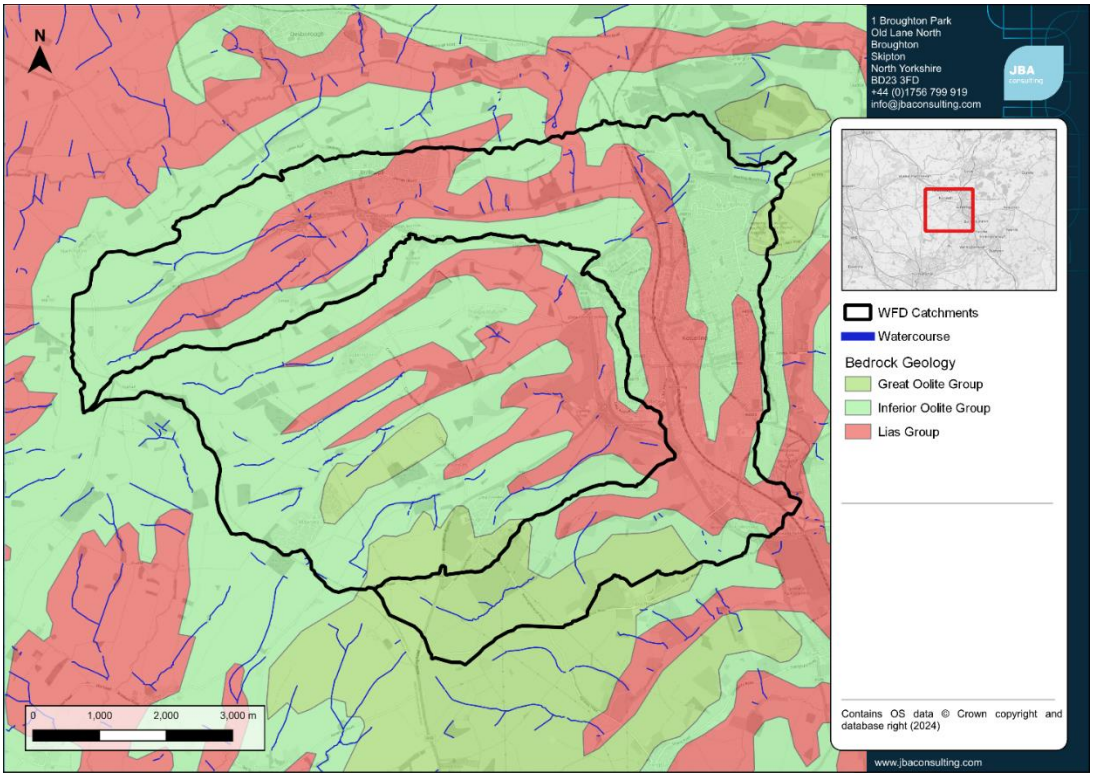

Figure 3-1 Geology in the Slade Brook and Loddington Arm (Ise) catchments.

3.2 Working with Natural Processes

During the initial desk-based assessment of potential for NFM, the Working with Natural Processes (WwNP) potential area maps suggested floodplain reconnection south of Rothwell adjacent to the A14 and to the west of the trainline running through Kettering near the train station and Pytchley Lodge Road. Floodplain woodlands are suggested in Glendon, the south or Thorpe Malsor and in Great Cransley. The riparian woodland potential is suggested along a vast majority of the watercourses and runoff attenuation features and wider catchment woodland is suggested across many arable and improved grassland fields.

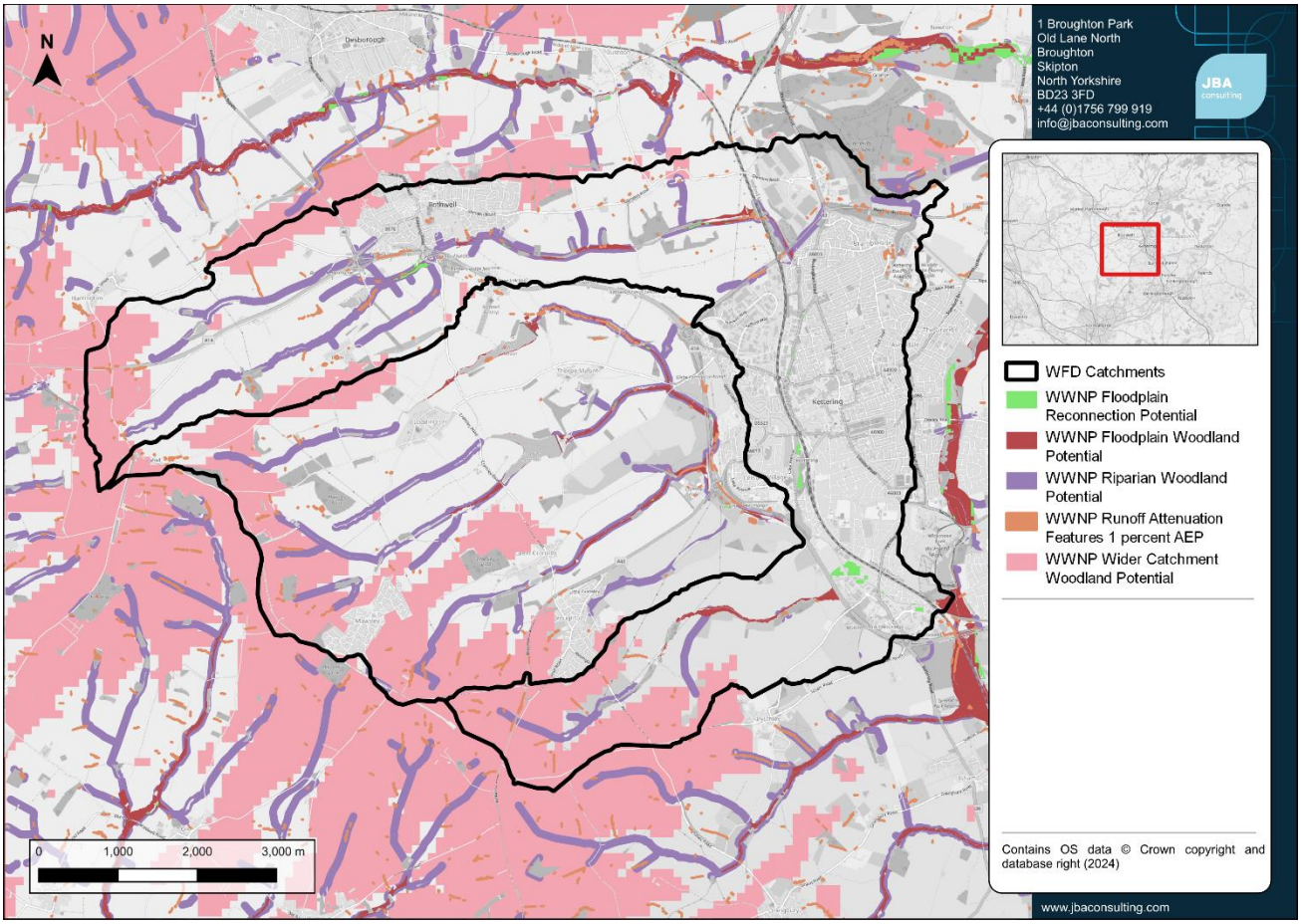

Figure 3-2 Working with Natural Processes potential for the Slade Brook and Loddington Arm (Ise) catchments.

There are many plausible options for NFM within the Slade Brook catchment. In the headwater-like areas, especially in the western sections such as the upper Slade Brook or upstream of Cransley/Thorpe Malsor Reservoirs, headwater management techniques are potentially a viable option. Several of these headwater areas contain steeper gradients, causing the channels around to be deeply eroded into the landscape and considerably incised. These eroded river channels are likely fast responding, increasing flood-risk. Such river networks tend to be highly erosive, and therefore likely contribute towards local erosion and downstream siltation issues. This erosive and rapidly responding river network potentially worsen water-quality issues downstream, as the streams are both erosive so can

erode and entrain sediment, but also are rapidly responding, and therefore contaminants have a reduced amount of time to degrade before being transferred downstream.

There are numerous potential options for NFM in these headwater areas. Leaky barriers, or similar features, are plausible options to be assessed for these rapidly responding headwater streams. Leaky barriers act as a physical barrier to water within the stream channel and can therefore delay the movement of water downstream. These leaky barriers can be designed to only start taking effect during certain river discharges, and can allow water (and any entrained fish, invertebrates etc.) to pass unhindered during lower flows. Such leaky barriers can be made of a variety of materials, such as heather, wood, turf, stone etc. (sometimes called turf dam, stone dam etc.) and can be made of local materials. Leaky barriers can be placed both within stream channels, as well as surface gulleys, and therefore are often applicable across a range of areas. These features not only reduce flood-risk, but may offer additional ecosystem services, such as the creation of habitats or improving biodiversity.

Large sections of the headwaters are also lacking tree or shrub cover. This lack of vegetative cover likely reduces surface roughness, likely resulting in surface and near-surface hydrological pathways which are less likely to be slowed and/or infiltrated into the ground, causing rapid hydrological responses and elevated flood-risk. Areas which lack vegetation, in particular trees, likely have reduced interception and evapotranspiration losses, resulting in increased hydrological inputs through rainfall and resultantly faster and larger hydrological responses and increased flood risk. The lack of trees and vegetation in places also likely decreases localised infiltration capacity and permeability of the soil, further encouraging rapid surface hydrological pathways which increase flood risk and amplify water quality issues, as well as potentially increasing the risk of soil erosion issues.

Moorland NFM options could also including increasing the vegetative cover in areas where this is lacking. There are numerous methods of doing this. This could be via the planting of trees or rough vegetation, the inoculation of sphagnum mosses in certain areas, reducing/restricting livestock and grazing pressures etc. These options combine to allow the vegetation in an area to (re-)grow - increasing permeability and evapotranspirative losses, likely reducing overall flood-risk. Increased vegetation may also both uptake any excess nutrients e.g., phosphorus or nitrates which may be lost downstream, and they may also intercept rapid surface hydrological pathways e.g., overland-flow, which rapidly transport these contaminants, improving local and downstream water-quality, alongside the flood-risk benefits. Increased vegetation also offer a host of additional ecosystem services, such as improvements to biodiversity, habitat creation, carbon capture, reduced soil erosion, and more.

The reduction or restricting of grazing in these headwater areas may be an additional NFM option. Grazing likely reduces the infiltration capacity and permeability of the soil, encouraging rapid surface hydrological pathways which likely contribute towards flood-risk, water-quality degradation, and soil erosion issues. Grazing pressures also likely reduce the establishment of vegetation, causing the issues highlighted above.

Another option for NFM in upland areas could be to add storage features. These act to attenuate stormflows by physically storing water during storm events, therefore reducing the amount of water that is transferred downstream. These must be positioned correctly in a catchment to work effectively and can also take up considerable areas of a catchment. These also offer benefits such as habitat creation and biodiversity improvements. Such features may also improve the resilience towards droughts. Storage features tend to be costly to install however, often involve large-scale projects, and also may have issues with filling/emptying timing.

Areas that are used for agriculture, such as pastures or arable fields, may also be enhanced by NFM measures. Agricultural soil management techniques and selective/modified farming practices looks to be plausible options in several of the sub-catchments. Agricultural soil management interventions (features/practices) could include converting stone-walls to hedgerows, increasing the number of field boundaries such as hedgerows, the inclusion of field-margins, as well as across-slope woodlands, buffer strips or hedgerows (possibly on flow paths). Additional interventions could include aeration/sward lifting/ subsoiling, contour cultivation (if applicable and safe to do so), traffic and tramline management, modified grazing and stock management practices, and field gate location management. These interventions would likely increase infiltration, permeability, roughness, interception, and/or evapotranspiration. This would ultimately reduce flood-risk, and potentially improve water-quality issues within the sub-catchments. Many of these interventions also provide additional ecosystem services, such as for habitat creation, carbon capture, recreation and culture etc.

An increased amount of catchment and riparian woodlands would also likely improve infiltration, permeability, interception, and evapotranspiration, especially given the lack of woodland cover in certain sections of certain sub-catchments. This may benefit fluvial flood-risk but could also reduce the risk of surface water flooding. Given the increased urbanisation of the area post-1937 and loss of certain permeable soils, woodlands and trees may be particularly important to increase the permeability of area and to reduce surface and near-surface drainage pathways.

Increasing floodplain reconnection may be another widely applicable option for the watercourses within the Slade Brook. Floodplain reconnection involves allowing water to overflow the banks of the channel and reconnect with the floodplain in certain locations that do not contain expensive infrastructure, causing inundation. Floodplain reconnection can remove considerable amounts of water from the channel, reducing flood-risk downstream. This technique also tends to increase biodiversity in an area through habitat and wetland creation. The floodplain used as part of this can also still be retained for certain uses e.g., agriculture. Floodplain reconnection can be done in many ways, and can involve the re-meandering of streams, or the reprofiling of the stream area.

Floodplain restoration is a related technique to floodplain reconnection (and can include floodplain reconnection) that could be used in several areas of the catchment. This encompasses several techniques, such as the planting of riparian/floodplain woodlands or vegetation, which can act to both slow flow, leaving the channel, as well as intercept or slow

pathways entering the channel. Floodplain restoration, much like floodplain reconnection, often encompasses additional ecosystem services described above.

Alterations to the general land-use of the catchment can also reduce flood-risk, whilst maintaining or improving additional ecosystem services. A promising example of this for the catchment area would be through various formats of woodland creation - such as catchment, cross-slope etc. Increased woodland cover increases evapotranspiration, increases surface roughness and permeability etc. (see above). An increased amount of woodland cover therefore reduces flood-risk, alongside providing additional benefits e.g., habitat creation, carbon capture etc.

In urban areas within the Slade Brook boundary and Kettering, urban NFM measures could be applied. This includes measures such as sustainable drainage systems (SuDS), increased woodland and green-space creation, infiltration devices, reducing impermeable surfaces, pervious paving, swales, green rooves, and many others. These systems work to reduce flood-risk to urban areas, with additional potential benefits to water-quality and other ecosystem services. Urban NFM however, often must operate within restricted spaces, often where land is very expensive, and therefore may have limited application.

3.3 Ecology

A desk-based assessment was undertaken to identify previous records for protected and notable species with records obtained from Northamptonshire Biodiversity Records Centre. For the purpose of this project, only species associated with the river corridor or with potential to be impacted by the proposals have been included. A lack of records does not confirm species absence as it could be a lack of recording in these areas.

3.3.1 Mammals

There are few records of Otter *Lutra lutra* and Water Vole *Arvicola amphibius* with none found in proximity to the shortlisted options. Both species have been recorded on Slade Brook, however most of the records are along the River Ise. Badger *Meles meles* are frequent throughout the catchment with Brown Hare *Lepus europaeus* and Hedgehog *Erinaceus europaeus* also present.

3.3.2 Amphibians, Reptiles and Crustaceans

Great Crested Newt *Triturus cristatus* have been recorded, particularly around Broughton. There are few Common Toad *Bufo bufo* records within the wider landscape. There are scattered records of Grass Snake *Natrix helvetica* along the river corridor. There are five records of White-clawed crayfish all within the River Ise between Newton and Rushton although these are now known to have been absent since 2010.

3.3.3 Birds

Red Kite *Milvus milvus*, Barn Owl *Tyto alba*, Skylark *Alauda arvensis*, and various priority waders, ducks, gulls and wetland passerines have been recorded within the wider landscape.

3.3.4 Invertebrates

There are a considerable number of Lepidoptera records around Kettering, accounting for long-term regular moth recorders in the area. There are few Hemiptera, Coleoptera, Diptera, Odonata and Hymenoptera records. Species of note include White-letter Hairstreak *Satyrium w-album*, *Bagous limosus*, *Hydaticus seminiger*, Scarce Chaser *Libellula fulva*, *Dicranomyia lucida*, *Helius pallirostris*, Fen Snout *Nemotelus pantherinus*, *Pherbellia argyra*, *Pherbellia dorsata*, *Psacadina verbekei*, *Vanoyia tenuicornis*.

3.3.5 Plants and Bryophytes

There are a variety of priority and locally scarce plants and mosses, most of which are records pre-dating the year 2000. Species of note include Tufted Sedge *Carex elata*, Tawny Sedge *Carex hostiana*, Flea Sedge *Carex pulicaris*, Round-fruited Rush *Juncus compressus*, Orpine *Sedum telephium* and Smooth Brome *Bromus racemosus.*

4 NBS/NFM Walkover and Opportunities Summary

NFM, Geomorphological and ecological walkovers were completed on 12/12/2023 and 12/03/2024.

On the 12/12/2023 walkover the weather was cold with temperatures of 5 - 8 °C, the sky was grey with some drizzle and patches of rain. River levels were raised due to high rainfall and frequent storm events experienced throughout the autumn. The water level was falling but measured at 0.3m at 10:15am which is within the normal range of 0.08m to 1.30m for the River Ise level at Slade Brook (https://riverlevels.uk/ise-barton-seagrave-slade-brook).

On the 12/03/2023 walkover the weather was cold with temperatures of 7 - 12 °C, in the morning there was heavy rain which slowly broke up through the day and was sunny in the late afternoon. River levels were high at 0.26mAOD which is within the normal range for the River Ise level at Slade Brook.

This project was commissioned to assess and develop potential river restoration opportunities for the Slade Brook and Loddington Arm (Ise), Kettering. Opportunities were pursued that would provide improvements for water quality, in-channel conditions, riparian habitat, floodplain reconnection and NFM.

These opportunities are underpinned with baselines that were developed from both site walkovers and desk-top studies. The baselines in this report cover geomorphology and ecology. Constraints were also identified through assessments of land use and geological /

ecological constraints. Previous reports from EA, SC and the CVPC were assessed for opportunities and constraints that have been identified previously.

More detailed site-specific information is provided in Appendix B [4] - Appendix B - ENV6006464R-JBAU-XX-01-AS-EN-0010-S3-P01-SladeBrook_NFMWalkoverAssessment

Through this process, pressures were identified for this watercourse from both historic and recent uses of the watercourse.

From the pressures described above the criteria for opportunities this project focused on were:

- Improving public access and reducing pressures on the banks,
- Increasing connectivity to floodplains,
- Improving or create wet woodlands,
- Increasing water retention in the upper catchment,
- Increasing resilience to prolonged dry weather,
- Improving in-channel flow diversity,
- Improving in-channel habitat,
- Improving riverbed conditions.
- Reducing agricultural input and pollutants.

Opportunities were pursued that would provide improvements for water quality, in-channel conditions, riparian habitat, floodplain reconnection and NFM. This section focuses on the opportunities for Natural Flood Management within the upper catchment.

These opportunities are underpinned with baselines that were developed from both site walkovers and desk-top studies. The baselines in this report cover natural flood management. Constraints were also identified through assessments of land use and geological / ecological constraints.

Figure 4-1 outlines the opportunities across the catchment as identified from this walkover. These include:

- 66,608m² area with potential for leaky barriers
- 6,264m² of runoff attenuation features
- 330m of raised track
- 1,738m² of ridge and furrow bunds
- 34,667m² of riparian buffers
- 207,560m² of soil improvement
- 28,059m² of wetland creation
- 18,558m² of woodland planting

4 ENV6006464R-JBAU-XX-01-AS-EN-0010-S3-P01-SladeBrook_NFMWalkoverAssessment

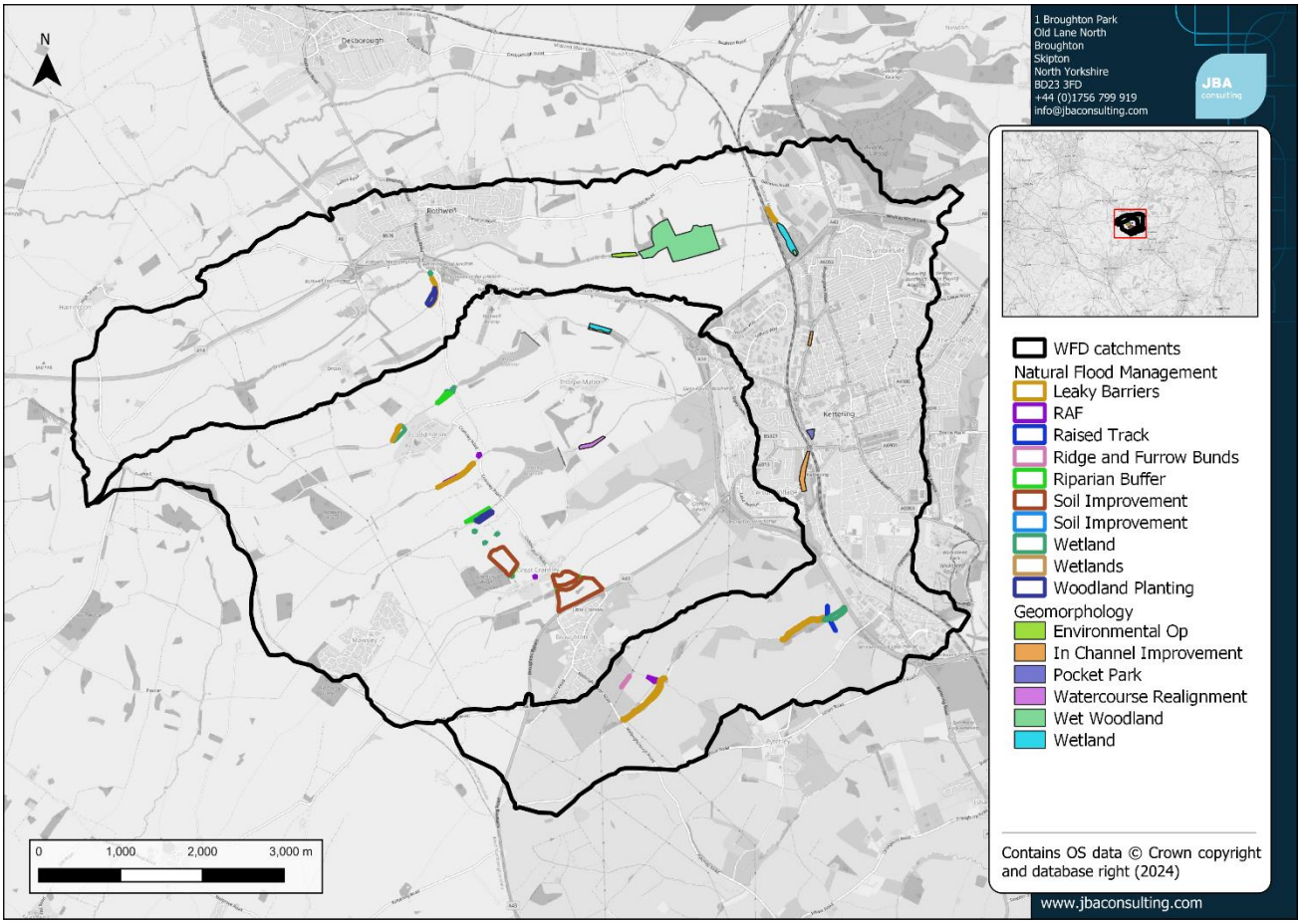

Figure 4-1: Potential Geomorphology and NFM options following site walkover.

4.1 NFM Heritage Assessment

This section of the Heritage assessment has been expanded post NFM analysis to identify in detail, the likelihood of sensitivity around specific NFM proposals. More information is provided in Figure 4-2 and - Appendix C - ENV6006464R-JBAU-XX-01-AS-HE-0006-S3-P01-Slade_Brook_Heritage_Baseline_Scoping [4].

In general, the heritage assessment has not identified any option which would fundamentally damage/disturb an existing heritage feature. The majority of the NFM potential features have been classified as low risk in relation the nearby heritage asset. Some have been identified as medium risk and therefore may require a further detailed inspection.

A more detailed desk-based assessment would be needed to assess the potential impacts on the historic environment with regards to any future work.

With regards to the proposed works in Glendon Wood, it is recommended that consultation with the County Archaeologist at North Northamptonshire County Council is undertaken, to discuss any potential archaeological impacts on Glendon Hall Park in future work.

With regards to the proposed works in Prologis Park, Coppicemoor Spinney, Coppicemoor Brook: Middle Ground and Coppicemoor Brook: Underwood Hill there is no heritage that will be impacted. Therefore, there are no recommendations for future work.

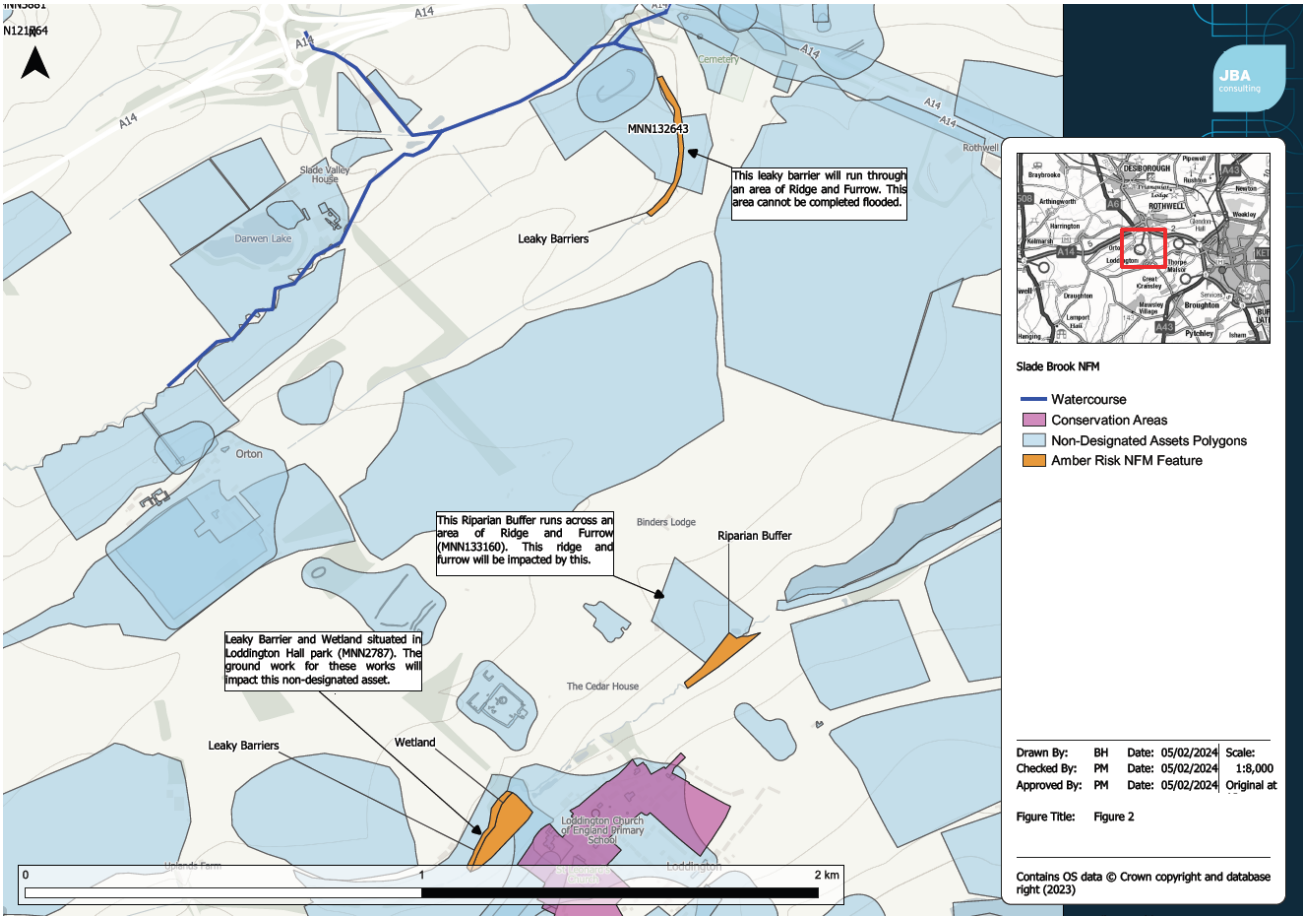

Figure 4-2: NFM heritage sensitivity assessment. Full figures available in Appendix C [4]

5 2D Hydraulic Modelling

5.1 Updated catchment hydrological assessment.

JFlow® 2D rainfall runoff modelling was completed following identification of potential NFM areas from the initial desk-based assessment and site visit. JFlow® is a 2D hydrodynamic modelling software used to predicted surface water flood risk and depths. A baseline and NFM scenario were simulated to quantify the potential benefits that NFM could have in the Slade Brook catchment. More information Appendix A [1] - Appendix A - ENV6006464R-JBAU-XX-01-AS-HM-0014-S3-P01-SladeBrook_2D-NFM-HydraulicModelling

5.2 Baseline model results.

To understand the accuracy and uncertainty of the baseline Slade Brook model, the model results were compared to ReFH2 flow estimates and the recorded flow gauge data

(recorded at 32019 - Slade Brook at Kettering). These have all been used to calibrate the baseline Slade Brook 2D model.

As can be seen in Figure 5-1, the observed hydrograph has a steep rising limb and longer and shallower falling limb. The observed hydrograph shape is relatively wide and round. By comparison, the modelled hydrograph rising limb is slightly steeper than the observed, and falling limb starts at a similar rate of recession but soon becomes steeper than the observed event. This contrast between the modelled and observed hydrograph is likely because baseflow has not been represented in the 2D JFlow model. Inputs from baseflow likely elongate the hydrograph and reduce the gradient of the rising and falling limb in the observed data. The catchment is moderately permeable, meaning there are likely some steady baseflow inputs to channel flows. A simplified approach has been used in the modelling and baseflows are not represented however despite this, there is still a relatively good fit with the observed hydrograph.

The watercourse in the downstream location has been significantly modified with the urban nature and Kettering Conference Centre wildlife lake. In addition to the lake there are two reservoirs in the upper catchment. Both Thorpe Malsor and Cransley reservoirs are under private ownership and there current operating procedures are unknown. For this assessment it is assumed that the reservoirs are full for the flood risk modelling (assuming the worst case for flooding with minimal storage available).

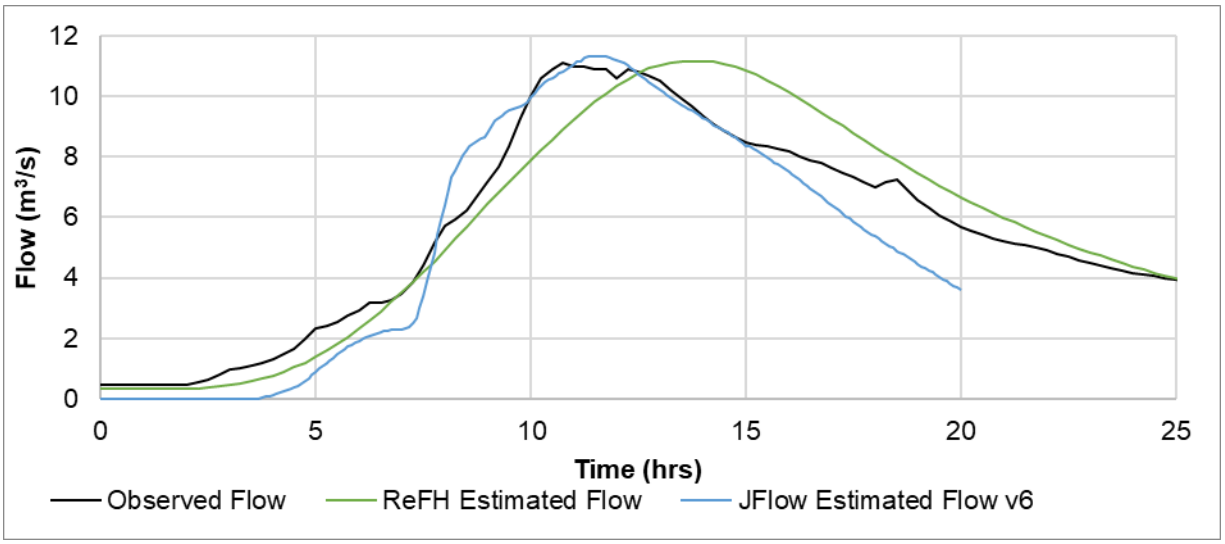

Figure 5-1: A comparison of hydrograph shape from observed flow data at the Slade Brook at Kettering flow gauge and modelled flows from the hydraulic model.

5.2.1 March 2016 hydrograph analysis

Upstream of A509 in Kettering Slade Brook is joined by East Brook Culvert and Coppicemoor Brook (West), (Figure 5-6). At this location both the East Brook and Coppicemoor Brook peak earlier than the Slade Brook (Figure 5-2). This suggests that delaying either of these tributaries through the use of NFM may be detrimental and increase flood risk by synchronising the time to peak. Further delaying the reducing the Slade Brook could improve flood risk by desynchronising the peaks further.

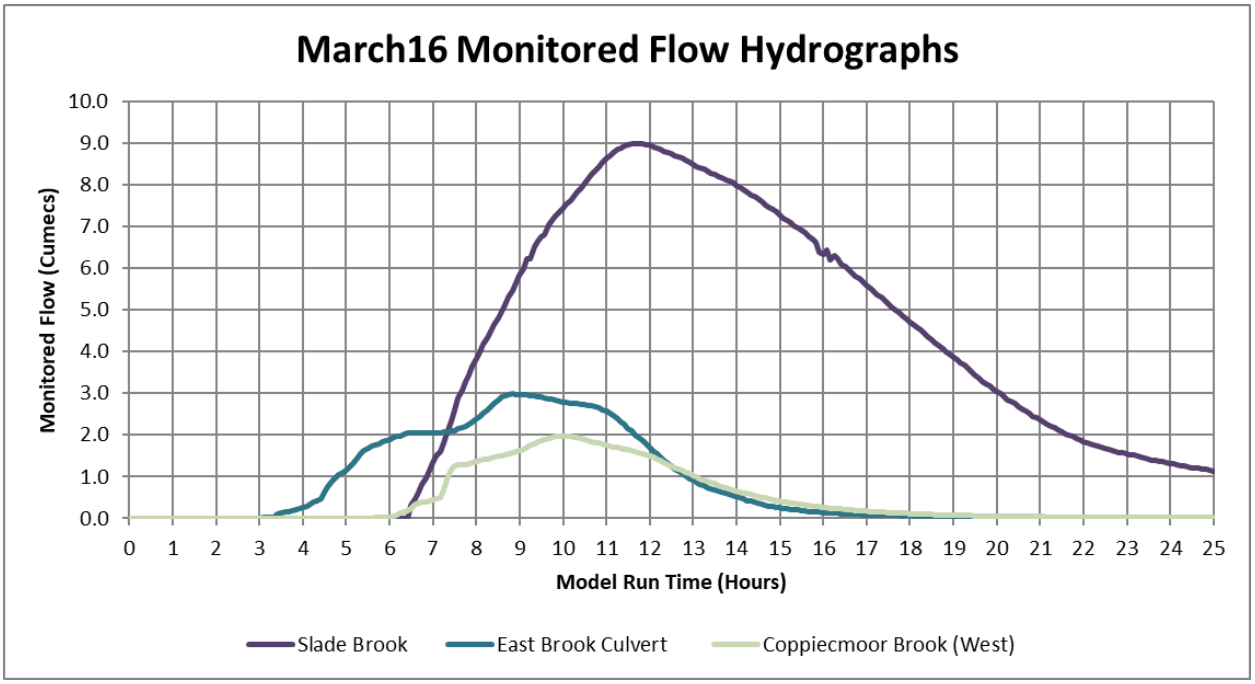

Figure 5-2: Slade Brook JFlow hydrograph analysis - upstream of A509.

A large flood storage reservoir at Kettering Conference Centre has two inflows. Slade Brook from the North and Loddington Arm from the West (Figure 5-6). At this location both Slade Brook and Loddington Arm are synchronised resulting in one single larger peak flow downstream (Figure 5-3). To note there is relatively minimal flood storage available within the flood storage reservoir due to sedimentation build up.

Loddington Arm's hydrograph shows the effects of both Cransley Reservoir and Thorpe Malsor Reservoir and Cransley Brook (upstream of Kettering Conference Centre Lake), (Figure 5-6). The hydrographs peak is flattened given the available storage in the upper catchment. For reference the Loddington Arm is 26.5km² (larger than the Slade Brook at this point (20.7km²).

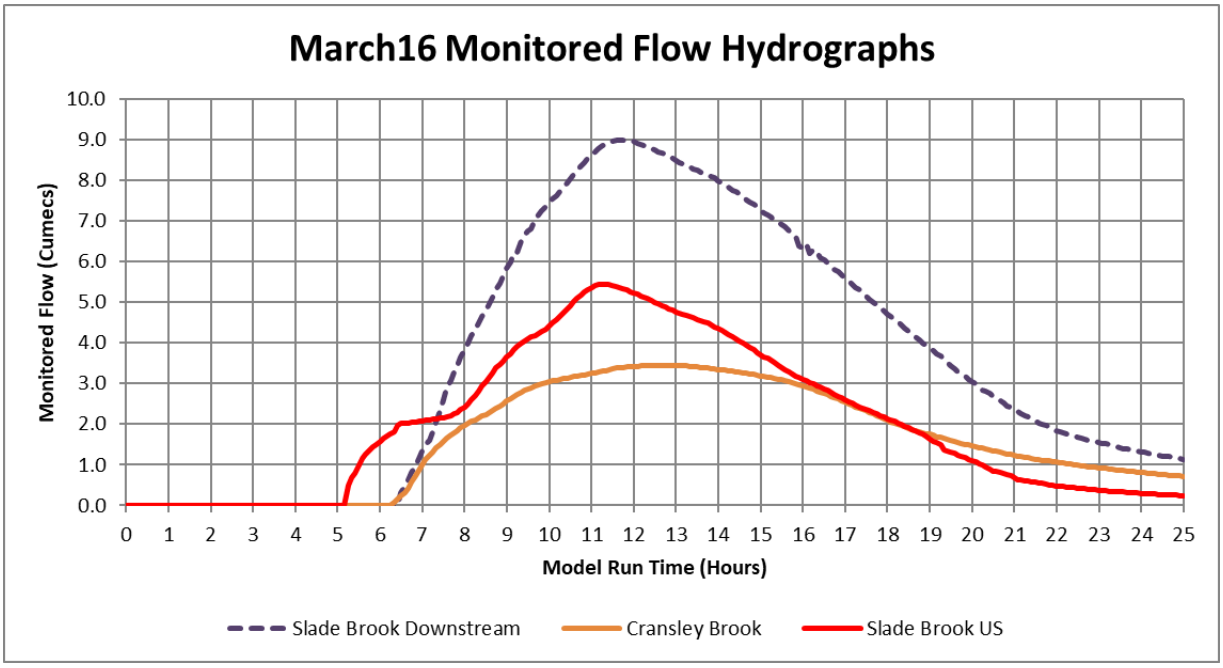

Figure 5-3: Slade Brook JFlow hydrograph analysis - upstream of Kettering Conference Centre Lake. Purple dashed line shows the outflow from the lake at this location.

There are four watercourses which make up the Loddington Arm. Broughton Drain and Cransley Brook peak earlier than outflow from Thorpe Malsor and Cransley Reservoir (Figure 5-6). The hydrographs peak for both reservoir outflows are flattened given the available storage in the upper catchment. NFM measures on the Broughton Brook and Cransley Drain are recommended to reduce the peak flow and ideally increase the time peak difference between the two drains (Figure 5-4).

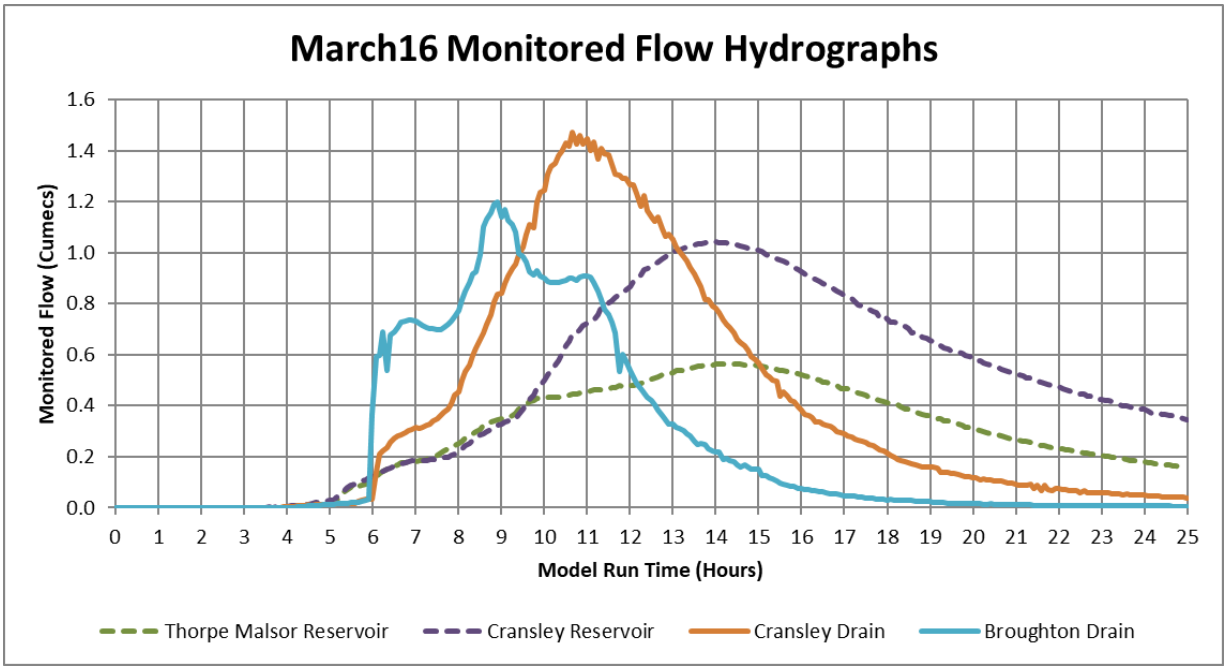

Figure 5-4: Loddington Arm JFlow hydrograph analysis. Dashed lines show the outflow from the Reservoirs at this location.

In the upper catchment of Slade Brook (south of Rothwell/upstream of A14) 4 tributaries join together (Figure 5-6). At this location the Orton Drain (South), Slade Valley House Drain, Harrington Drain (North West) and the Upstream Slade Brook (West) are synchronised. Reducing the peak flow and desynchronising the Upstream Slade Brook and Harrington Drain would likely have the greatest NFM benefits in this location.

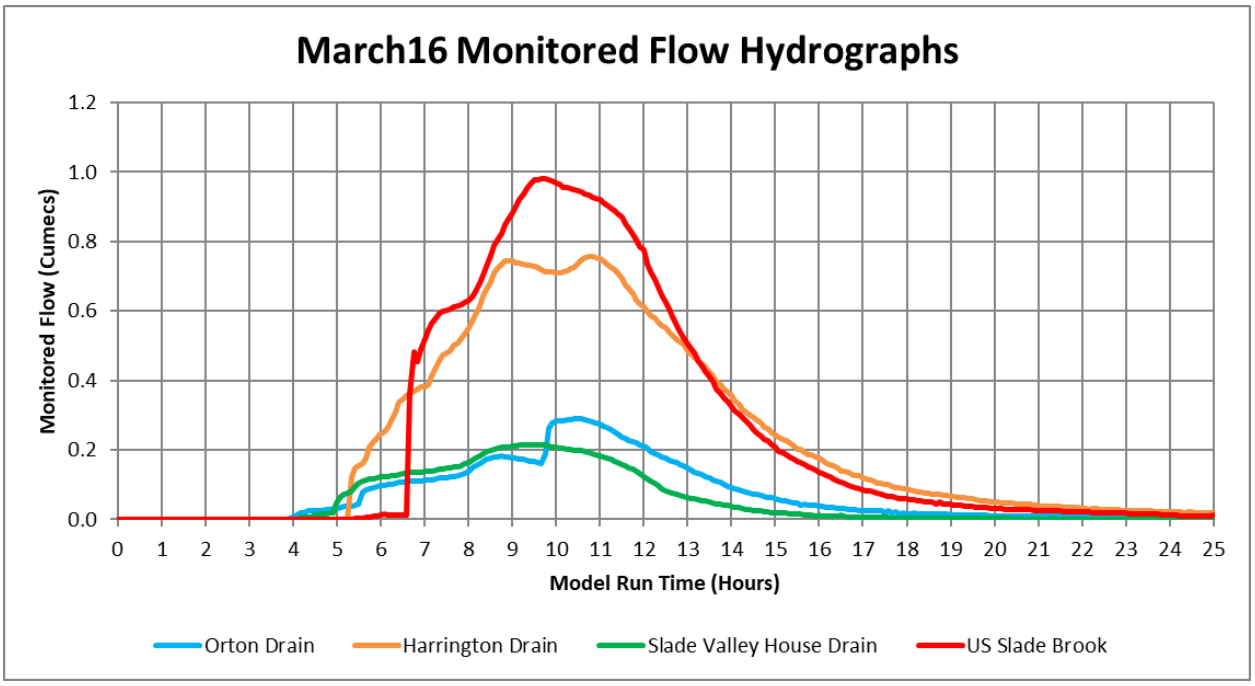

Figure 5-5: Upstream Slade Brook JFlow hydrograph analysis.

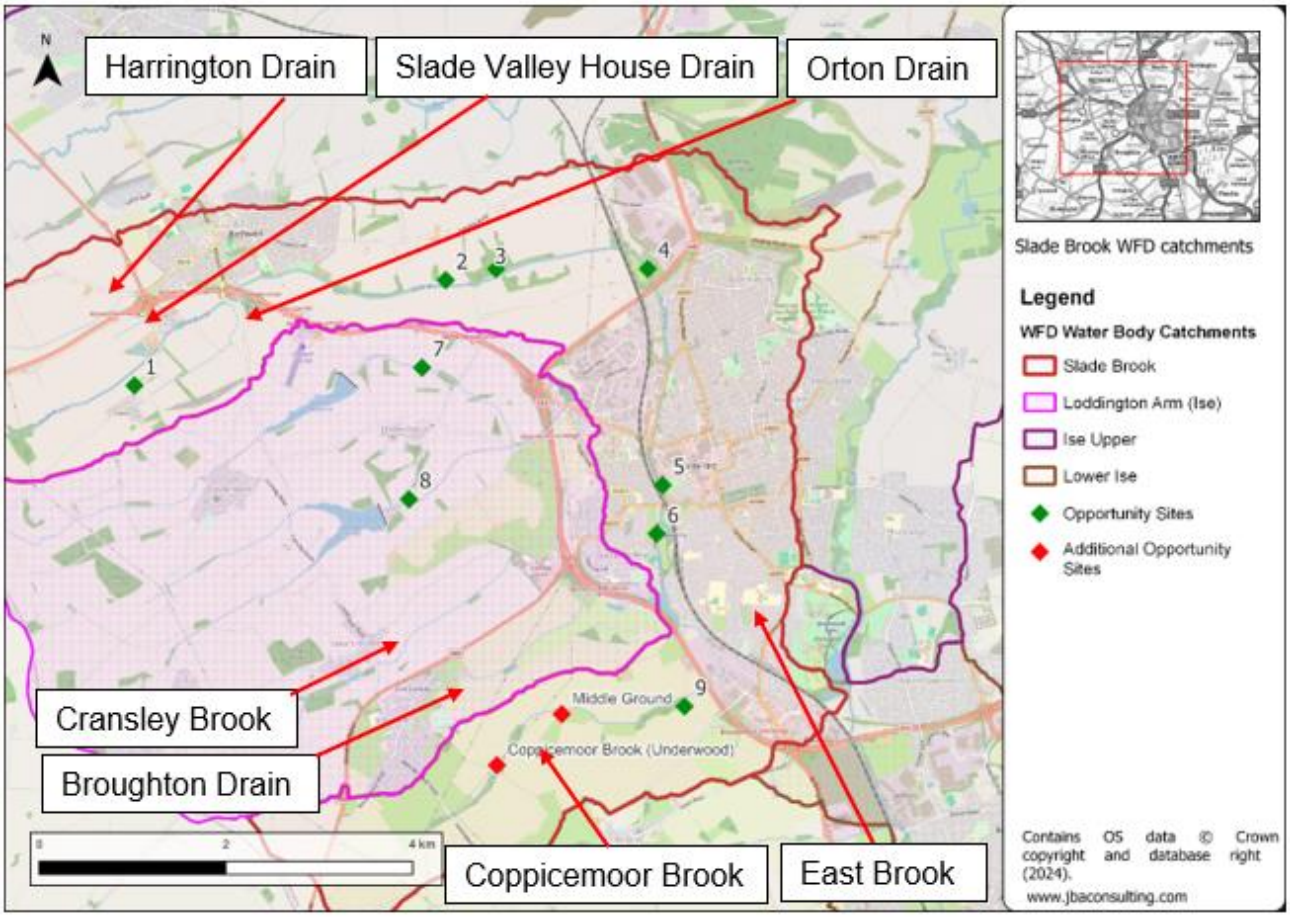

Figure 5-6: Watercourses in the Slade Brook.

5.2.2 Potential locations to target NFM.

Using the hydrograph analysis in section 0 (

March 2016 hydrograph analysis) and flow path analysis from JFlow. Several locations have been suggested for further NFM potential investigation.

Existing woodland and storage lakes at Home Farm, Great Cransley maybe a prime location for Leaky Barriers and increasing floodplain storage on Cransley Brook (Figure 5-7).

Land upstream of the confluence of Broughton Drain and Loddington Arm shows large potential for floodplain reconnection and storage (Figure 5-8). The drain in this location has been historically modified (straightened). The Broughton Drain is likely to have water quality issues given the drainage from the village of Broughton and presence of a water treatment works upstream of this location.

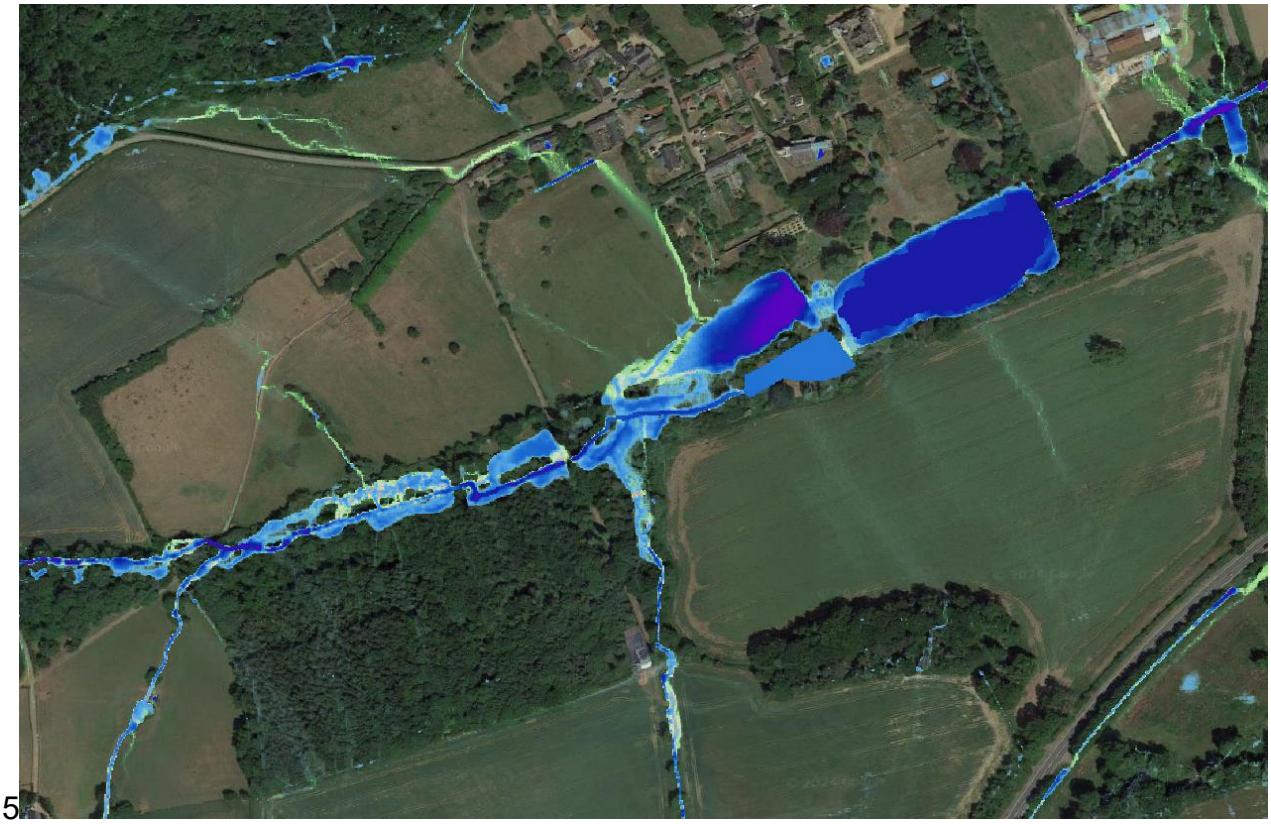

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Figure 5-7: Cransley Hall - JFlow Max Flow path analysis for the RP20 flood event.

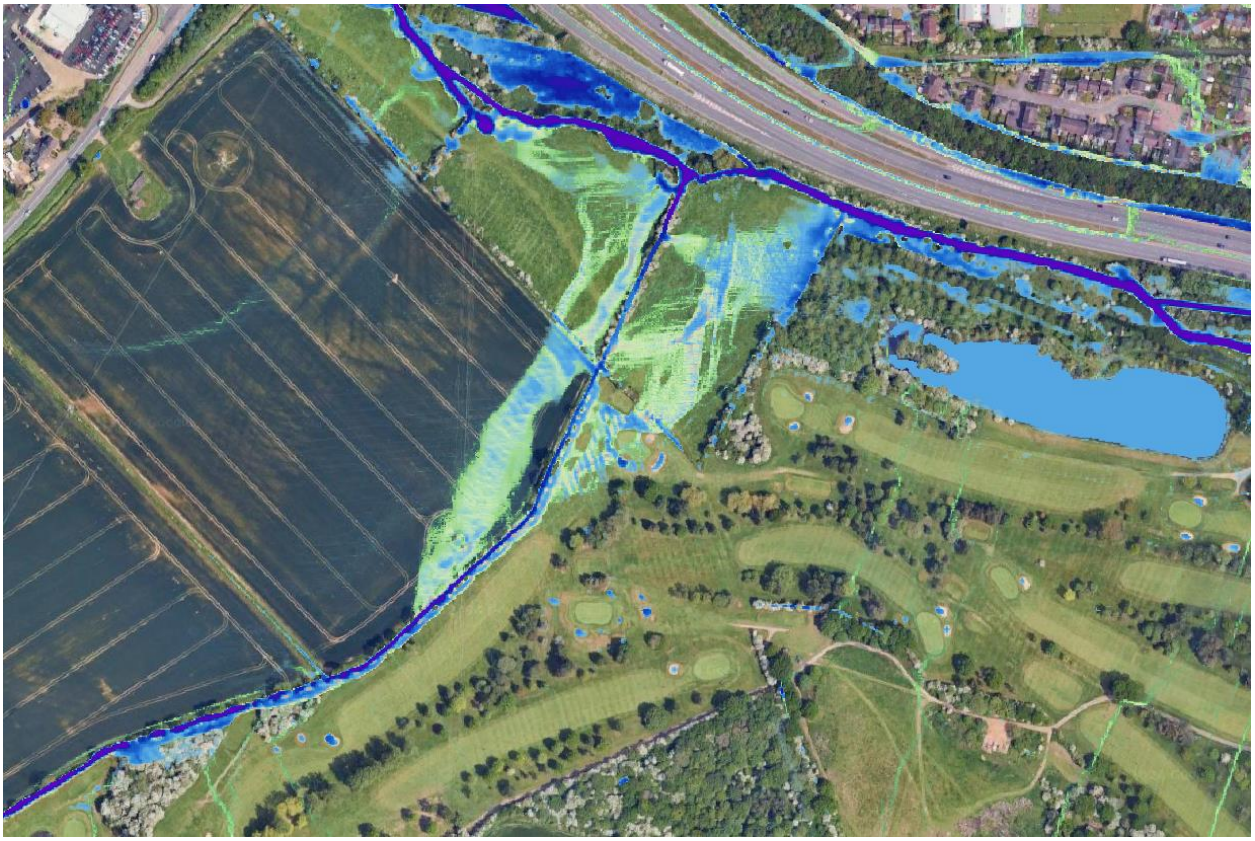


Figure 5-8: Broughton Drain - JFlow Max Flow path analysis for the RP20 flood event.

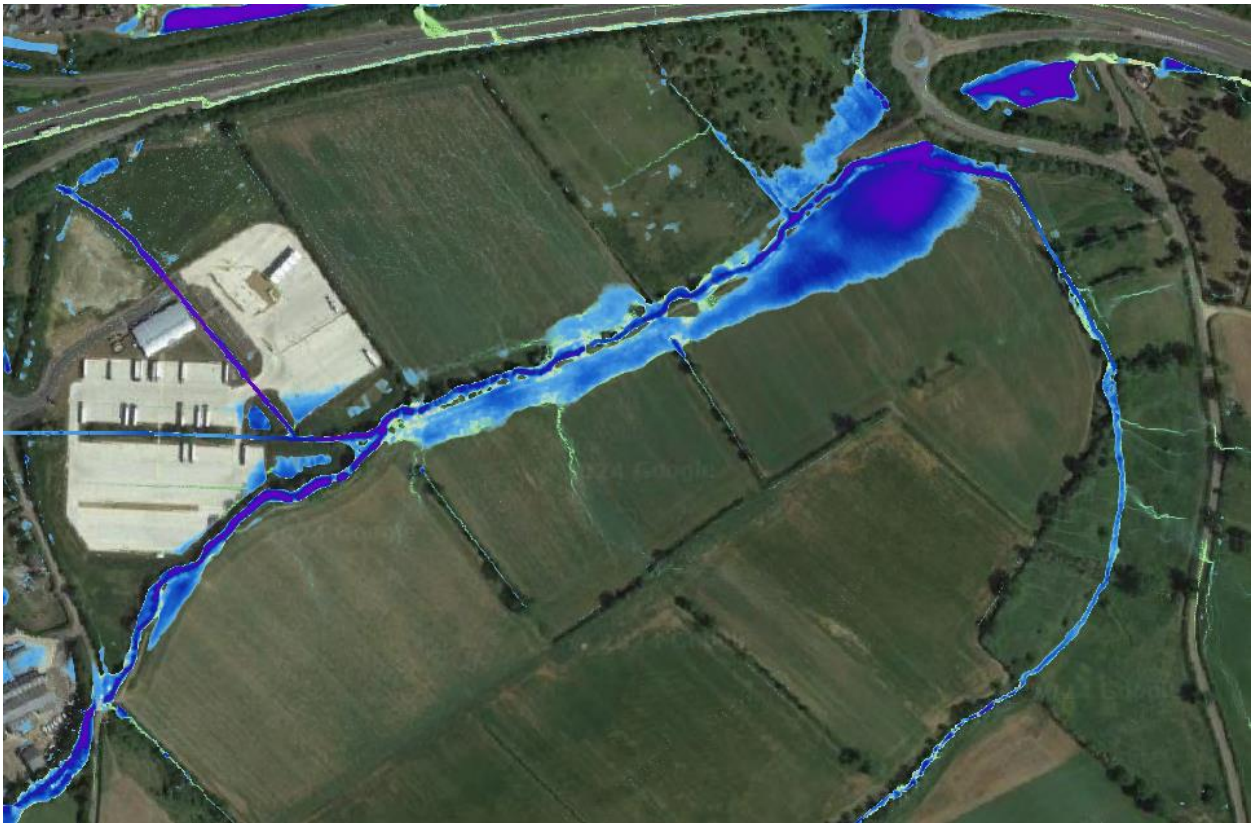


Figure 5-9: Upstream Slade Brook - JFlow Max Flow path analysis for the RP20 event.

Figure 5-10: Harrington Drain - JFlow Max Flow path analysis for the RP20 flood event.

South of Rothwell/upstream of A14 shows large potential for floodplain storage or riparian buffer zone enhancement (Figure 5-9). This location is downstream of the confluence between the synchronised upstream Slade Brook and Harrington Drain.

On Harrington Drain there is potential for leaky barriers or floodplain reconnection upstream of the A14 culvert near Nunnery Farm (Figure 5-10). There is also likely to be inputs into the drain from the A14 and therefore maybe of interest to National Highways for water quality improvements.

Upstream of Cransley reservoir is a lower priority for NFM given the available storage downstream with the reservoir. However, the flow path analysis does suggest some large potential for NFM/Environmental improvements in these locations (Figure 5-11). The drain from Cransley Lodge (Mawsley) has been historically modified and shows potential for restoration. There is also potential to hold water on the upstream side of the disused railway embankment through wetlands. To the North, the main watercourse flows through the Birch and Mawsley Marsh Site of Special Scientific Interest (SSSI). There is large potential to improve the Marsh through re wetting of the floodplain and leaky barriers within the channel. It is likely that drainage from Mawsley would have water quality issues and therefore NBS in this location would improve the water quality and capture of sediment, upstream of the reservoir.

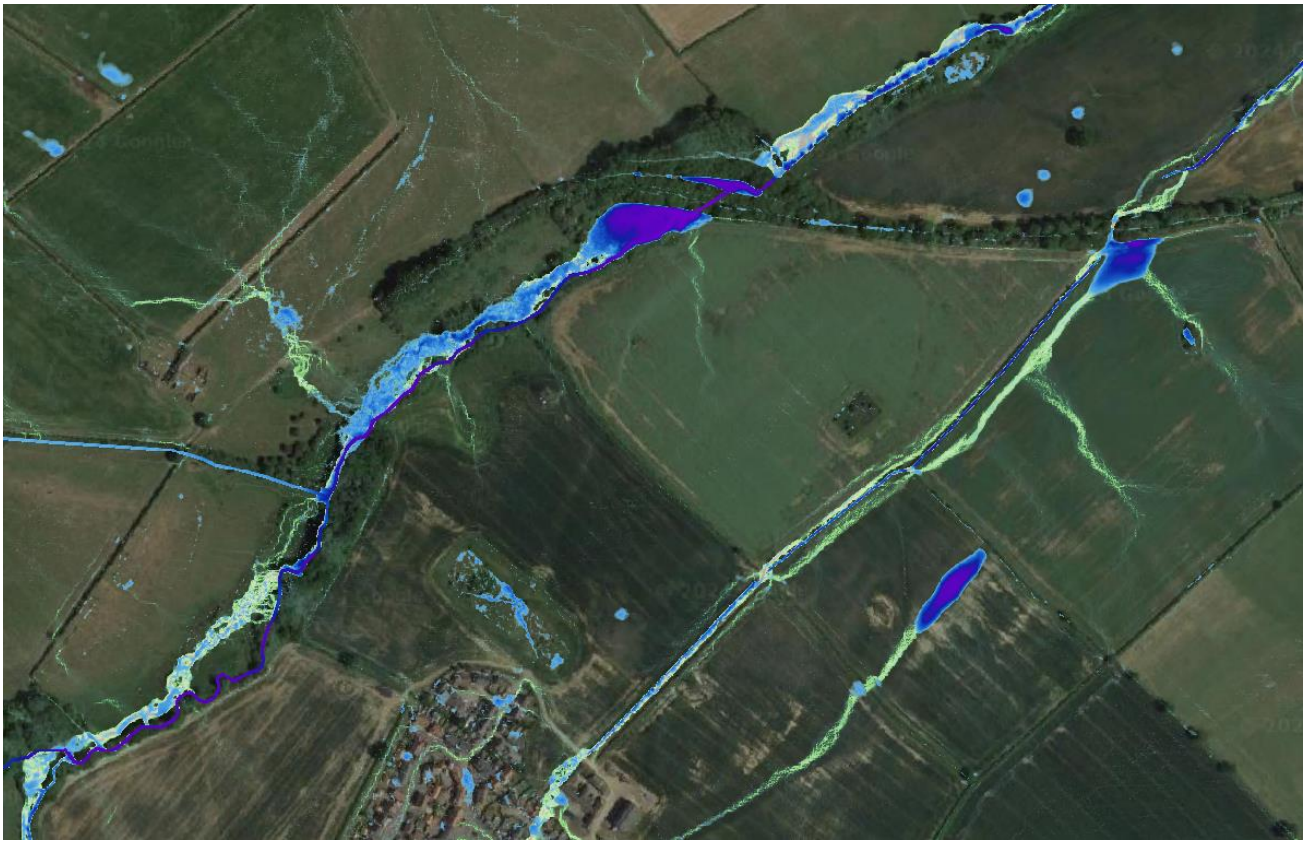


Figure 5-11: Drain upstream of Cransley reservoir - JFlow Max Flow path analysis for the RP20 flood event.

There is also large potential for NFM on land upstream of Coppicemoor Spinney on Coppicemoor Brook (Figure 5-12). The drain in this location has been historically modified and flow path analysis show significant potential for floodplain reconnection.

Figure 5-12: Drain upstream of Coppicemoor Spinney - JFlow Max Flow path analysis for the RP20 flood event.

5.3 Natural Flood Management prioritisation.

Following the desk based NFM assessment and site ground truthing. Several potential options for NFM measures have been identified to help reduce flood risk within the Slade Brook as well as promote environmental improvements. An assessment has been undertaken on these options to highlight the highest priority sites to target NFM implementation. The specific prioritisation is mainly weighted on flood risk reduction initially but also takes into account Heritage, Ecology, Access and Cost.

5.3.1 Long List opportunities

The JFlow® 2D rainfall runoff model was re simulated with the preferred long list NFM options implemented. The NFM potential scenarios were compared against the baseline (pre-NFM interventions) results at each sub-catchment outlet through the use of designated flow monitoring lines. Flow monitoring lines can be used to extract hydrological data at any defined location within the model domain, including the complete flow (discharge) hydrograph. This allows the baseline and post-change models to be compared for each modelled flood event.

This type of modelling enables relative changes to peak flood flows and timing of the peak flow resulting from the introduction of NFM measures in the catchment to be predicted and analysed. The results from this scenario are best used in a comparative way (e.g., baseline condition versus changed condition) rather than using the absolute discharge values.

Table 5-1: Method of implementing NFM opportunities within JFlow® 2D model.

NFM Type	Model Implementation
Reach of leaky barriers/gully blocking	Increase in hydraulic roughness (Manning's n = 0.115 6), this has been used for reaches with high densities of leaky barriers.
Hedgerows (buffered to 2m wide)	Mannings n roughness modification increased to 0.15. Only simulated the slowing of runoff in these locations due to the addition of woodland, rather the smoother baseline surface. Does not consider, increased infiltration, evaporation, transpiration or interception7. Woodland values are for fully mature woodland stands. We appreciate that overland flow velocity can significantly vary across a catchment and seasonally, Bond et al. (2020)8. Both Hedgerows and Woodland have been provided with this same Roughness value.
Woodland	
Storage Features (Offline and Online Ponds / wetlands)	DEM modification reduction between 0.5-1m depending on the areas baseline elevation.
Moorland Restoration	Increase in hydraulic roughness (Manning's n = 0.317). Simulation of increased vegetation coverage (Sphagnum planting, channel reprofiling, bare peat restoration (slowing the flow)).6 9 *Baseline roughness 0.15 increased to 0.317 as per reference.
Floodplain Meadow	Increase in hydraulic roughness (Manning's n = 0.07). Simulation of increased vegetation coverage.

The NFM scenario (Long List) as stated above has been simulated in the JFlow® 2D model upstream of Kettering. The Baseline and NFM hydrographs have been analysed to show

5 Based on the latest NFM research in (Addy & Wilkinson, 2019) - Representing natural and artificial in-channel large wood in numerical hydraulic and hydrological models.

6 E Follett; B Hankin; 2022 - Investigation of effect of logjam series for varying channel and barrier physical properties using a sparse input data 1D network model

7 Wood Wise • Tree and woodland conservation 2022 The Woodland Trust - Page, T., Chappell, N.A., Beven, K.J., Hankin, B., and Kretzschmar, A. (2020) Assessing the significance of wet-canopy evaporation from forests during extreme rainfall events for flood mitigation in mountainous regions of the United Kingdom. Hydrological Processes, 34: 4740–4754.

8 Bond et al. (2020) - Seasonal vegetation and management influence overland flow velocity and roughness in upland grasslands - Stephanie Bond – June 2020

9 Goudarzi Et al 2021 - Blanket Peat Restoration: Numerical Study of the Underlying Processes Delivering Natural Flood Management Benefits – Protect NFM

the potential NFM effect on reducing peak flow at the Slade Brook flow gauge, slightly upstream of the main flooding hotspot as identified by the Environment Agency (upstream of Pytchley Lane - Kettering).

The results showed a reduction in peak flow for the March 2016 (12%). In general, the NFM measures in the upper catchment showed the greatest effect on the rising limb of the hydrograph. Further NFM measures in the upper catchment may have an increased effect on the peak flow.

The larger single peaked design events showed a similar effect. The 2% AEP showed a peak flow reduction of 8% increasing to 10% for the larger 0.5% AEP event. There was an average time delay of 10 mins across all events. This delay to the peak maybe as critical to the local community compared to reducing the peak flow.

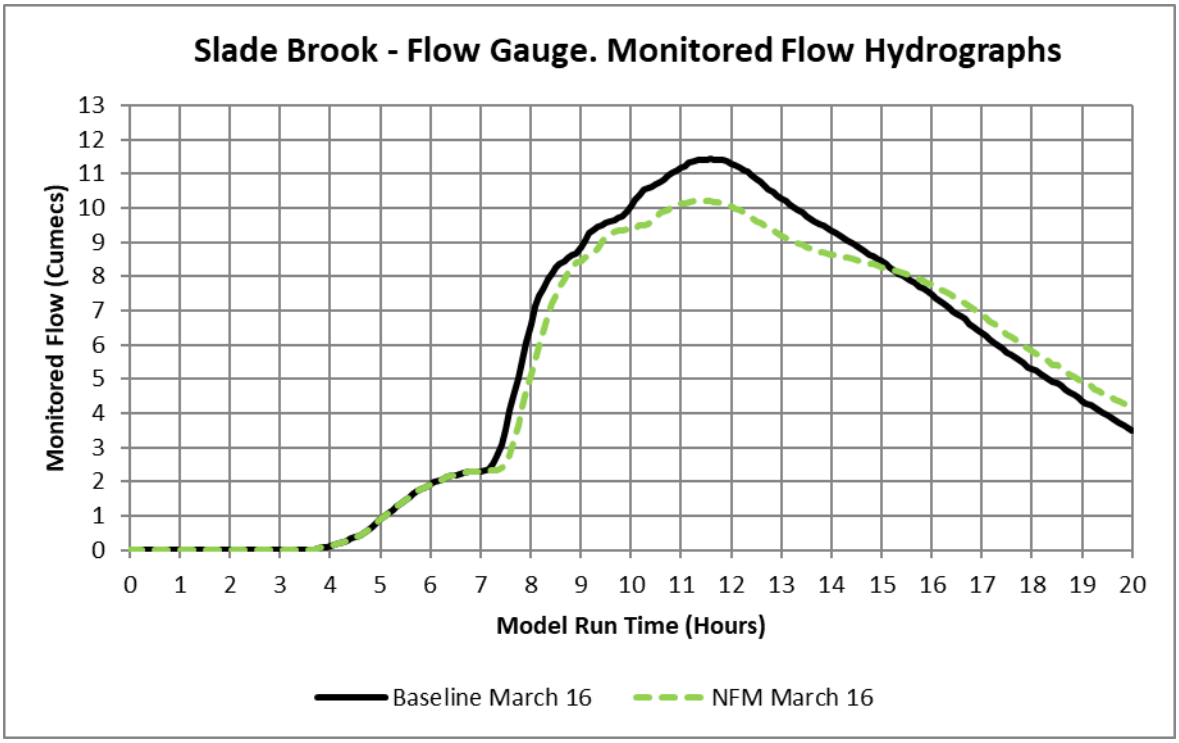


Figure 5-13: JFlow® flow hydrograph analysis at Slade Brook Flow gauge showing Baseline and NFM Long List scenario.

Table 5-2: JFlow® baseline peak flow comparison vs NFM Long List at Slade Brook Flow gauge.

Slade Brook - Flow Gauge	20% AEP	5% AEP	2% AEP	1% AEP	0.5% AEP
Baseline Peak Flow (m3/s)	8.0	11.3	14.0	16.4	19.8
NFM MW Peak Flow (m3/s)	7.2	10.3	12.7	14.5	17.9
Peak Flow Reduction (%)	10.0	8.5	9.0	12.0	9.5
Delay to Peak (mins)	10	-5	10	-30	10

5.3.2 NFM Long List Screening

The table below outlines the screening exercise to review the long list of NBS/NFM measures proposed across the catchment. Several of these options have been identified to be implemented alongside project partners in the future as they would support further environmental enhancement across the site. The key locations have been identified where schemes can be delivered that will work in-combination and demonstrate a positive benefit for both flood risk and ecological improvement.

Table 5-3: NFM Long List Screening - Scores from 1 (Low) - 5 (High)

Long List Screening	Site 1 - Upper Slade Brook Floodplain	Site 2 - Upstream Voilet Lane Floodplain Reconnection	Site 3 - Glendon Wood Leaky Barriers	Site 4 - Prologis Park River Restoration
WFD Benefits	Increased channel morphology and better connection with floodplain as well as reduced input of nutrients and fine sediment from fields (Poaching). Significant improvement for soil management and nutrient management. Increased numbers of ecological niches, important floristically and especially for invertebrates. Macrophytes and Phytobenthos currently 'Moderate'; possibility of supporting moving these to 'Good' and moving overall status to 'Good'. Unknown Scheme, lack of Landowner Engagement	Increased channel morphology and better connection with floodplain as well as reduced input of nutrients and fine sediment from fields (Poaching). Significant improvement for soil management and nutrient management. Increased numbers of ecological niches, important floristically and especially for invertebrates. The measures could improve ecological status and a reduction in fine sediment. Macrophytes and Phytobenthos currently 'Moderate'; possibility of supporting moving these to 'Good' and moving overall status to 'Good'.	The measures could improve ecological status and a reduction in fine sediment. Also help support the reduction of upstream nutrient loads. Increased channel morphology, increased numbers of ecological niches, important floristically and especially for invertebrates. Macrophytes and Phytobenthos currently 'Moderate'; possibility of supporting moving these to 'Good' and moving overall status to 'Good'.	Increased channel morphology and better connection with floodplain. Increased numbers of ecological niches, important floristically and especially for invertebrates. Macrophytes and Phytobenthos currently 'Moderate'; possibility of supporting moving these to 'Good' and moving overall status to 'Good' Slightly restricted floodplain availability given public interaction and footpaths.
Score	2	4	3	3
NFM Benefit	2D JFlow Hydraulic Modelling suggests low NFM benefit for the RP20 design event (<2%)	2D JFlow Hydraulic Modelling suggests low/medium NFM benefit for the RP20 design event (<2%). Close location to flood risk hotspots.	2D JFlow Hydraulic Modelling suggests low/medium NFM benefit for the RP20 design event (>2%). Close location to flood risk hotspots.	2D JFlow Hydraulic Modelling suggests high NFM benefit for the RP20 design event (>5%). Close location to flood risk hotspots.
Score (weighted x2)	1x2 = 2	3x2 = 6	3x2 = 6	5x2 = 10
Whole Life Carbon Emissions	Some loss of carbon from design and construction, however, likely to be matched by growth of riparian	Some loss of carbon from leaky dams, however, likely to be matched by growth of riparian vegetation.	Some loss of carbon from leaky dams, however, likely to be matched by growth of riparian vegetation. Wet Woodland will	Some loss of carbon from design and construction, however, likely to be matched by growth of riparian vegetation.

Long List Screening	Site 1 - Upper Slade Brook Floodplain	Site 2 - Upstream Voilet Lane Floodplain Reconnection	Site 3 - Glendon Wood Leaky Barriers	Site 4 - Prologis Park River Restoration
	vegetation.		have large net gain for Carbon.	
Score	3	4	5	3
Landowner Agreement	Unknown Landowner	Unknown Landowner	Likely to have landowner agreement as there is overall support for the aims of the project. One landownership title.	Prologis owned land with overall support for the aims of the project. One landownership title.
Score	1	1	5	4
Stakeholder Value	No change: no public access.	No change: no public access.	No change: no public access.	Full public access (nearby footpath in view), likely supportive landowner
Score	1	1	1	5
Maintenance	Medium level of long-term maintenance and monitoring required. Access agreement required for future maintenance.	Medium level of long-term maintenance and monitoring required. Access agreement required for future maintenance.	Low level long-term maintenance - higher velocities in channel at this location.	Medium level of long-term maintenance and monitoring required. Access agreement required for future maintenance.
Score	2	2	4	2
Cost (capital works)	Medium/Large Cost, depending on design.	Medium/Large Cost, depending on design.	Low cost, Fencing, Leaky Barriers (Nearby Tree Source)	Likely Large Cost, depending on design.
Score	2	2	5	1
Total Score	13	20	29	28
Decision	**Further assessment required.**	**Further assessment required.**	**Progress to Short List**	**Progress to Short List**

Long List Screening	Site 5 - Meadow Road park - in channel restoration.	Site 6 - Kettering Cricket Club off Lake Avenue - in channel restoration.	Site 7 - Land d/s Thorpe Malsor Reservoir - River Restoration.	Site 7 - Land d/s Cransley Reservoir - River Restoration.
WFD Benefits	The measures could improve ecological status and a reduction in erosion. Also help support the reduction of upstream nutrient loads. Increased channel morphology, increased numbers of ecological niches, important floristically and especially for invertebrates. Macrophytes and Phytobenthos currently 'Moderate'; possibility of supporting moving these to 'Good' and moving overall status to 'Good'.	The measures could improve ecological status and a reduction in erosion. Also help support the reduction of upstream nutrient loads. Increased channel morphology, increased numbers of ecological niches, important floristically and especially for invertebrates. Macrophytes and Phytobenthos currently 'Moderate'; possibility of supporting moving these to 'Good' and moving overall status to 'Good'.	Increased channel morphology and better connection with floodplain as well as reduced input of nutrients and fine sediment from fields (Poaching). Significant improvement for soil management and nutrient management. Increased numbers of ecological niches, important floristically and especially for invertebrates. Unknown controlled flow into site from reservoir, lack of variation in flow. Macrophytes and Phytobenthos currently 'Moderate'; possibility of supporting moving these to 'Good' and moving overall status to 'Good'.	Increased channel morphology and better connection with floodplain as well as reduced input of nutrients and fine sediment from fields (Poaching). Significant improvement for soil management and nutrient management. Increased numbers of ecological niches, important floristically and especially for invertebrates. Unknown controlled flow into site from reservoir, lack of variation in flow. Macrophytes and Phytobenthos currently 'Moderate'; possibility of supporting moving these to 'Good' and moving overall status to 'Good'.
Score	4	4	3	3
NFM Benefit	2D JFlow Hydraulic Modelling suggests low NFM benefit for the RP20 design event (<2%)	2D JFlow Hydraulic Modelling suggests low NFM benefit for the RP20 design event (<2%)	2D JFlow Hydraulic Modelling suggests low NFM benefit for the RP20 design event (<2%). Unknown flows from Reservoir.	2D JFlow Hydraulic Modelling suggests low NFM benefit for the RP20 design event (<2%). Unknown flows from Reservoir.
Score (weighted x2)	1x2 = 2	1x2 = 2	1x2 = 2	1x2 = 2
Whole Life Carbon Emissions	Some loss of carbon from design and construction.	Some loss of carbon from design and construction.	Some loss of carbon from design and construction, however, likely to be matched by growth of riparian vegetation.	Some loss of carbon from design and construction, however, likely to be matched by growth of riparian vegetation.
Score	2	2	3	3

Long List Screening	Site 5 - Meadow Road park - in channel restoration.	Site 6 - Kettering Cricket Club off Lake Avenue - in channel restoration.	Site 7 - Land d/s Thorpe Malsor Reservoir - River Restoration.	Site 7 - Land d/s Cransley Reservoir - River Restoration.
Landowner Agreement	Council Land with overall support for the aims of the project. One landownership title.	Council Land with overall support for the aims of the project. One landownership title.	Likely to have landowner agreement as there is overall support for the aims of the project. One landownership title.	Likely to have landowner agreement as there is overall support for the aims of the project. One landownership title.
Score	5	5	4	4
Stakeholder Value	Full public access (nearby footpath in view), likely supportive landowner	Full public access (nearby footpath in view), likely supportive landowner	No change: no public access.	No change: no public access.
Score	5	1	1	1
Maintenance	Medium level of long-term maintenance and monitoring required. Access agreement required for future maintenance.	Medium level of long-term maintenance and monitoring required. Access agreement required for future maintenance.	Medium level of long-term maintenance and monitoring required. Access agreement required for future maintenance. Unknown scour test requirement from Reservoir	Medium level of long-term maintenance and monitoring required. Access agreement required for future maintenance. Unknown scour test requirement from Reservoir
Score	3	3	1	1
Cost (capital works)	Low/Medium, depending on design. Some care required given location.	Low/Medium, depending on design. Some care required given location.	Medium/Large Cost, depending on design.	Medium/Large Cost, depending on design.
Score	3	3	2	2
Total Score	24	24	16	16
Decision	**Deliver with partner lead. NFM upstream would support this.**	**Deliver with partner lead. NFM upstream would support this.**	**Further assessment required.**	**Further assessment required.**

Long List Screening	Site 9 - Land at Coppicemoor Spinney / DS - Wetland design and wet woodland.	Coppicemoor Brook near Middle Ground Spinney - River Restoration/floodplain reconnection.	Coppicemoor Brook near underwood hill spinney - Leaky Barriers.	Cransley Hall - Wet Woodland
WFD Benefits	The measures could improve ecological status and a reduction in fine sediment. Also help support the reduction of upstream nutrient loads. Increased channel morphology, increased numbers of ecological niches, important floristically and especially for invertebrates. Creation of wet woodland habitat and ponds in this reach should increase the coverage of macrophytes and potentially trap soil particles and so reduce phosphate levels in the watercourse. Macrophytes and Phytobenthos currently 'Moderate'; possibility of supporting moving these to 'Good' and moving overall status to 'Good'.	Increased channel morphology and better connection with floodplain as well as reduced input of nutrients and fine sediment from fields (Poaching). Significant improvement for soil management and nutrient management. Increased numbers of ecological niches, important floristically and especially for invertebrates. The measures could improve ecological status and a reduction in fine sediment. Macrophytes and Phytobenthos currently 'Moderate'; possibility of supporting moving these to 'Good' and moving overall status to 'Good'.	The measures could improve ecological status and a reduction in fine sediment. Also help support the reduction of upstream nutrient loads. Increased channel morphology, increased numbers of ecological niches, important floristically and especially for invertebrates. Macrophytes and Phytobenthos currently 'Moderate'; possibility of supporting moving these to 'Good' and moving overall status to 'Good'.	The measures could improve ecological status and a reduction in fine sediment. Also help support the reduction of upstream nutrient loads. Increased channel morphology, increased numbers of ecological niches, important floristically and especially for invertebrates. Creation of wet woodland habitat and ponds in this reach should increase the coverage of macrophytes and potentially trap soil particles and so reduce phosphate levels in the watercourse. Macrophytes and Phytobenthos currently 'Moderate'; possibility of supporting moving these to 'Good' and moving overall status to 'Good'.
Score	5	4	3	4
NFM Benefit	2D JFlow Hydraulic Modelling suggests high NFM benefit for the RP20 design event (>5%). Close location to flood risk hotspots.	2D JFlow Hydraulic Modelling suggests high NFM benefit for the RP20 design event (>5%). Close location to flood risk hotspots.	2D JFlow Hydraulic Modelling suggests low/medium NFM benefit for the RP20 design event (>2%). Close location to flood risk hotspots.	2D JFlow Hydraulic Modelling suggests low NFM benefit for the RP20 design event (<2%) - upstream of Reservoir.
Score (weighted x2)	5x2 = 10	5x2 = 10	3x2 = 6	1x2 = 2

Long List Screening	Site 9 - Land at Coppicemoor Spinney / DS - Wetland design and wet woodland.	Coppicemoor Brook near Middle Ground Spinney - River Restoration/floodplain reconnection.	Coppicemoor Brook near underwood hill spinney - Leaky Barriers.	Cransley Hall - Wet Woodland
Whole Life Carbon Emissions	Some loss of carbon from leaky dams, however, likely to be matched by growth of riparian vegetation. Wet Woodland will have large net gain for Carbon. Wetland will have large net gain for Carbon.	Some loss of carbon from leaky dams, however, likely to be matched by growth of riparian vegetation.	Some loss of carbon from leaky dams, however, likely to be matched by growth of riparian vegetation.	Some loss of carbon from leaky dams. Wet Woodland will have large net gain for Carbon.
Score	5	4	4	5
Landowner Agreement	Likely to have landowner agreement as there is overall support for the aims of the project. One landownership title. Arable land currently in use.	Unknown Landowner - Land seems to be unused from aerial imagery. Same landowner as Underwood Hill.	Unknown Landowner - Land seems to be unused from aerial imagery. Same landowner as Middle Ground.	Likely to have landowner agreement as there is overall support for the aims of the project. One landownership title.
Score	3	3	3	5
Stakeholder Value	No change: no public access.	No change: no public access.	Full public access (nearby footpath in view).	No change: no public access.
Score	1	1	4	1
Maintenance	Medium level of long-term maintenance and monitoring required. Access agreement required for future maintenance.	Medium level of long-term maintenance and monitoring required. Access agreement required for future maintenance.	Low level long-term maintenance.	Low level long-term maintenance.
Score	3	2	5	4
Cost (capital works)	Low/Medium, depending on design.	Medium/Large Cost, depending on design.	Low cost, Fencing, Leaky Barriers (Nearby Tree Source)	Low/Medium, depending on design, Fencing, Leaky Barriers (Nearby Tree Source)

Long List Screening	Site 9 - Land at Coppicemoor Spinney / DS - Wetland design and wet woodland.	Coppicemoor Brook near Middle Ground Spinney - River Restoration/floodplain reconnection.	Coppicemoor Brook near underwood hill spinney - Leaky Barriers.	Cransley Hall - Wet Woodland
Score	3	2	5	3
Total Score	30	26	30	24
Decision	**Progress to Short List**	**Progress to Short List**	**Progress to Short List**	**Deliver with partner lead**

Long List Screening	Mawsley SSSI - Leaky Barriers	Land US of Cransley Reservoir - Floodplain Storage	Land US of Thorpe Malsor Reservoir - Floodplain Storage	Orton Drain - Upstream of A14 - Leaky Barriers/Woodland Planting
WFD Benefits	The measures could improve ecological status and a reduction in fine sediment. Also help support the reduction of upstream nutrient loads. Increased channel morphology, increased numbers of ecological niches, important floristically and especially for invertebrates. Macrophytes and Phytobenthos currently 'Moderate'; possibility of supporting moving these to 'Good' and moving overall status to 'Good'. Unknown effect on SSSI would require ecological survey's. SSSI status due to be refreshed in Summer 24.	The measures could improve ecological status and a reduction in fine sediment. Also help support the reduction of upstream nutrient loads. Increased channel morphology, increased numbers of ecological niches, important floristically and especially for invertebrates. Creation of wet woodland habitat and ponds in this reach should increase the coverage of macrophytes and potentially trap soil particles and so reduce phosphate levels in the watercourse. Macrophytes and Phytobenthos currently 'Moderate'; possibility of supporting moving these to 'Good' and moving overall status to 'Good'.	The measures could improve ecological status and a reduction in fine sediment. Also help support the reduction of upstream nutrient loads. Increased channel morphology, increased numbers of ecological niches, important floristically and especially for invertebrates. Creation of wet woodland habitat and ponds in this reach should increase the coverage of macrophytes and potentially trap soil particles and so reduce phosphate levels in the watercourse. Potential large benefit of improving Loddington Wetland. Macrophytes and Phytobenthos currently 'Moderate'; possibility of supporting moving these to 'Good' and moving overall status to 'Good'.	The measures could improve ecological status and a reduction in fine sediment. Also help support the reduction of upstream nutrient loads. Increased channel morphology, increased numbers of ecological niches, important floristically and especially for invertebrates. Macrophytes and Phytobenthos currently 'Moderate'; possibility of supporting moving these to 'Good' and moving overall status to 'Good'.
Score	3	5	5	4
NFM Benefit	2D JFlow Hydraulic Modelling suggests low NFM benefit for the RP20 design event (<2%) - upstream of Reservoir.	2D JFlow Hydraulic Modelling suggests low NFM benefit for the RP20 design event (<2%) - upstream of Reservoir.	2D JFlow Hydraulic Modelling suggests low NFM benefit for the RP20 design event (<2%) - upstream of Reservoir.	2D JFlow Hydraulic Modelling suggests low/medium NFM benefit for the RP20 design event (>2%). Close location to flood risk hotspots.
Score (weighted x2)	1x2 = 2	1x2 = 2	1x2 = 2	3x2 = 6

Long List Screening	Mawsley SSSI - Leaky Barriers	Land US of Cransley Reservoir - Floodplain Storage	Land US of Thorpe Malsor Reservoir - Floodplain Storage	Orton Drain - Upstream of A14 - Leaky Barriers/Woodland Planting
Whole Life Carbon Emissions	Some loss of carbon from leaky dams, however, likely to be matched by growth of riparian vegetation. Wet Woodland will have large net gain for Carbon.	Some loss of carbon from leaky dams, however, likely to be matched by growth of riparian vegetation. Wetland will have large net gain for Carbon.	Some loss of carbon from leaky dams, however, likely to be matched by growth of riparian vegetation. Wetland will have large net gain for Carbon.	Some loss of carbon from leaky dams, however, likely to be matched by growth of riparian vegetation.
Score	5	5	4	3
Landowner Agreement	Unknown Landowner	Unknown Landowner - Land seems to be unused from aerial imagery. Maybe for livestock pasture.	Unknown Landowner	Unknown Landowner
Score	1	2	1	1
Stakeholder Value	Full public access (nearby footpath in view).	Full public access (nearby footpath in view).	Full public access (nearby footpath in view).	No change: no public access.
Score	4	4	5	1
Maintenance	Medium level of long-term maintenance and monitoring required. Access agreement required for future maintenance. SSSI surveys	Low level long-term maintenance.	Medium level of long-term maintenance and monitoring required. Access agreement required for future maintenance around Loddington Wetland.	Low level long-term maintenance.
Score	2	5	2	4
Cost (capital works)	Low/Medium, depending on design. SSSI surveys.	Medium/Large Cost, depending on design.	Medium/Large Cost, depending on design.	Low/Medium, depending on design, Fencing, Leaky Barriers (Nearby Tree Source)
Score	3	2	2	3
Total Score	20	25	21	21
Decision	**Further assessment required.**	**Deliver with partner lead**	**Further assessment required.**	**Further assessment required.**

5.4 NFM Short List

As per the screening exercise in section 5.3.2. 5 options have been selected for the NFM short list priority. These include:

- Site 3 - Glendon Wood leaky barriers
- Site 4 - Prologis Park river restoration
- Site 9 - Land at Coppicemoor Spinney / DS - wetland design and wet woodland.
- Coppicemoor Brook near Middle Ground Spinney - river restoration/floodplain reconnection.
- Coppicemoor Brook near Underwood Hill Spinney - Leaky Barriers.

5.4.1 Slade Brook at A43 downstream of Prologis Park

The NFM scenario (Short List) as stated above has been simulated in the JFlow® 2D model upstream of Kettering as per Section 5.3.1 (Long List opportunities). The Baseline and NFM hydrographs have been analysed to show the potential NFM effect on reducing peak flow. This location is immediately downstream for Site 3 and Site 4. The results also include the benefit from the additional Glendon Hall floodplain works.

The results showed a reduction in peak flow for the 20% AEP of 25% decreasing to 8.5% for the larger 0.5% AEP event. There was a time delay of 60 - 180mins across all events. This delay to the peak maybe as critical to the local community compared to reducing the peak flow.

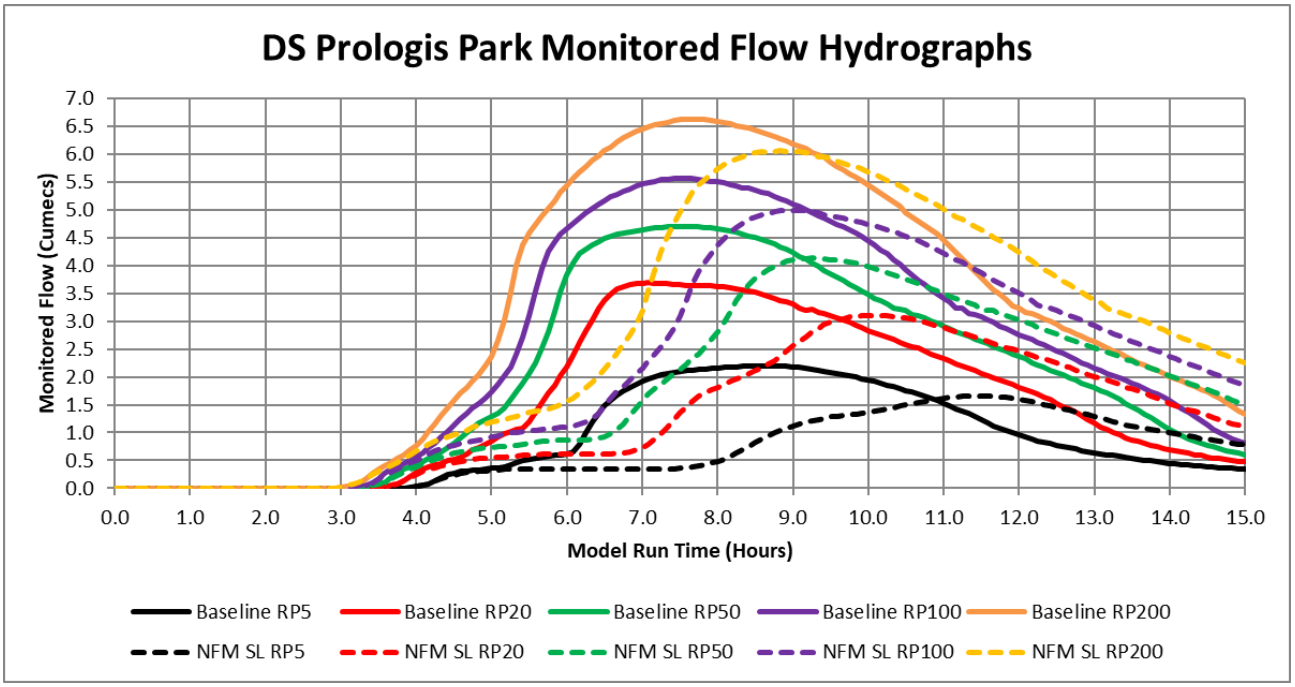


Figure 5-14: JFlow® flow hydrograph analysis at A43 (downstream of Prologis Park) showing Baseline and NFM Short List scenario.

Table 5-4: JFlow® baseline peak flow comparison vs NFM Long List at A43 (downstream of Prologis Park).

Slade Brook - Flow Gauge	20% AEP	5% AEP	2% AEP	1% AEP	0.5% AEP
Baseline Peak Flow (m3/s)	2.2	3.7	4.7	5.6	6.6
NFM MW Peak Flow (m3/s)	1.7	3.1	4.1	5.0	6.0
Peak Flow Reduction (%)	24.5	16.0	12.0	10.5	8.5
Delay to Peak (mins)	170	180	100	85	65

This flow reduction benefit continues through Kettering. For the RP20 this reduction remains at 11% up to the A6013 at Kettering Station. This equates to a max velocity (RP20) reduction of 6% in this reach. As well as a max water level reduction of around 4.5% (0.08m) at Westfield Gardens (in channel - RP20).

5.4.2 Coppicemoor Brook at A14 culvert. Upstream of Orion Way industrial estate.

The NFM scenario (Short List) as stated above has been simulated in the JFlow® 2D model upstream of Kettering as per Section 5.3.1 (Long List opportunities). The Baseline and NFM hydrographs have been analysed to show the potential NFM effect on reducing peak flow. This location is immediately downstream for Site 9 with the benefits of the 2 other sites on Coppicemoor Brook (upstream).

The results showed a large reduction in peak flow for the 20% AEP of 38% decreasing to 11% for the larger 0.5% AEP event. There was a time delay of 30 - 150mins across all events. This delay to the peak maybe as critical to the local community compared to reducing the peak flow.

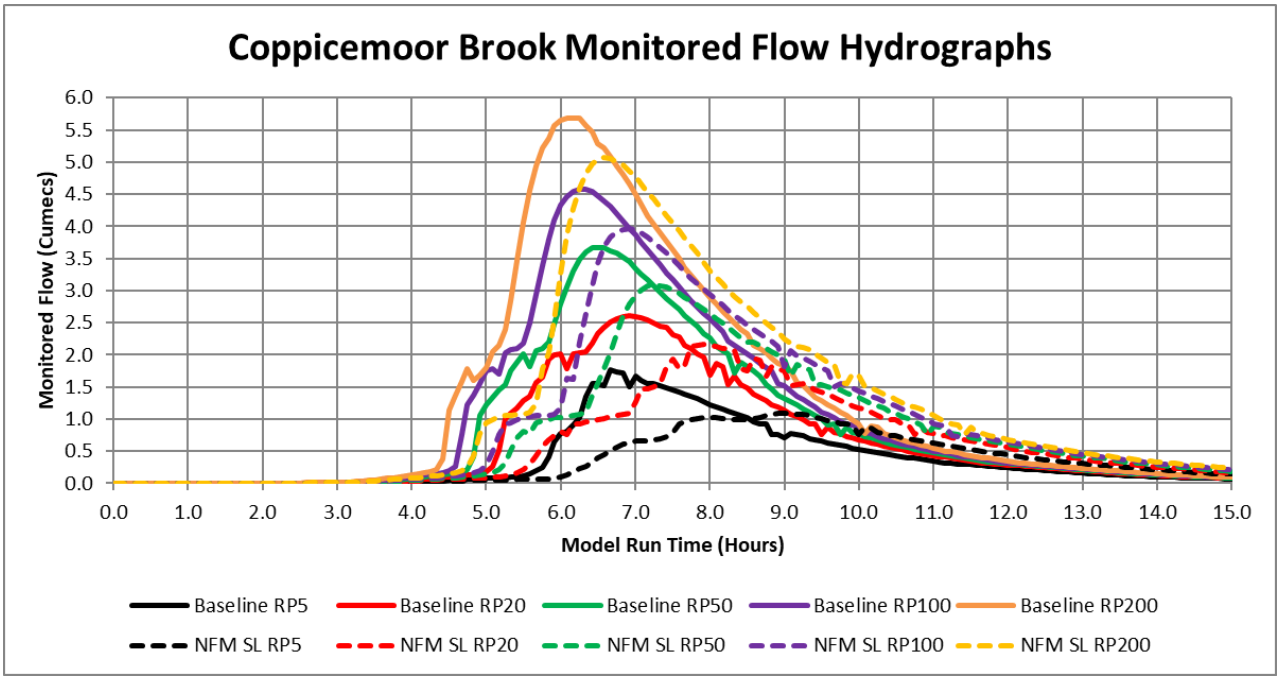


Figure 5-15: JFlow® flow hydrograph analysis at Coppicemoor Brook (A14 culvert) showing Baseline and NFM Short List scenario.

Table 5-5: JFlow® baseline peak flow comparison vs NFM Short List at Coppicemoor Brook (A14 culvert).

Slade Brook - Flow Gauge	20% AEP	5% AEP	2% AEP	1% AEP	0.5% AEP
Baseline Peak Flow (m3/s)	1.8	2.6	3.7	4.6	5.7
NFM MW Peak Flow (m3/s)	1.1	2.2	3.1	4.0	5.1
Peak Flow Reduction (%)	38.0	17.0	16.0	13.0	11
Delay to Peak (mins)	145	60	45	40	30

This flow reduction benefit continues through Kettering. Downstream of the confluence with Slade Brook (240m DS of this location stated above). The RP20 event reduction remains at 8% even with the additional flow from Slade Brook. This equates to a max velocity (RP20) reduction of 7.5% in this reach (Orion Way/Pytchley Lodge Road). As well as a max water level reduction of around 39% (0.06m) at Orion Way (floodplain - RP20).

6 Conclusion and Next Steps

6.1 Concluding summary

This project was commissioned to assess and develop potential river restoration opportunities for the Slade Brook and Loddington Arm (Ise), Kettering. Opportunities were pursued that would provide improvements for water quality, in-channel conditions, riparian habitat, floodplain reconnection and NFM.

Opportunities should seek to address and improve WFD pressures failures of both the Slade Brook and Loddington Arm (Ise). In summary the pressures and failures for the Slade Brook water body are:

- Macrophytes and Phytobenthos Combined
- Macrophytes Sub Element
- Phosphates
    - Agriculture
    - Water Industry (Sewage treatment works)
    - Urban development

It is possible that NFM and WwNP measures may benefit water-quality and therefore could help improve the ecological status of the rivers and waterbodies.

NFM, Geomorphological and ecological walkovers were completed on 12/12/2023 and 12/03/2024. These opportunities are underpinned with baselines that were developed from both site walkovers and desk-top studies. The baselines in this report cover geomorphology and ecology. Constraints were also identified through assessments of land use and geological / ecological constraints. Previous reports from EA, SC and the CVPC were assessed for opportunities and constraints that have been identified previously. The opportunities across the catchment as identified from this walkover include:

- 66,608m² area with potential for leaky barriers
- 6,264m² of runoff attenuation features
- 330m of raised track
- 1,738m² of ridge and furrow bunds
- 34,667m² of riparian buffers
- 207,560m² of soil improvement
- 28,059m² of wetland creation
- 18,558m² of woodland planting

In general, the heritage assessment has not identified any option which would fundamentally damage/disturb an existing heritage feature. The majority of the NFM potential features have been classified as low risk in relation the nearby heritage asset. Some have been identified as medium risk and therefore may require a further detailed inspection. With regards to the proposed works in Prologis Park, Coppicemoor Spinney, Coppicemoor Brook: Middle Ground and Coppicemoor Brook: Underwood's Hill there is no heritage that will be impacted. Therefore, there are no recommendations for future work.

JFlow® 2D rainfall runoff modelling was completed following identification of potential NFM areas from the initial desk-based assessment and site visit. Using the hydrograph analysis and flow path analysis from JFlow. Several locations have been suggested for further NFM potential investigation. These include:

- Existing woodland and storage lakes at Cransley Hall
- Land upstream of the confluence of Broughton Drain and Loddington Arm
- South of Rothwell/upstream of A14 shows large potential for floodplain storage or riparian buffer zone enhancement.
- On Harrington Drain there is potential for leaky barriers or floodplain reconnection upstream of the A14
- Upstream of Cransley Reservoir is a lower priority for NFM given the available storage downstream with the reservoir. However, the flow path analysis does suggest some large potential for NFM/Environmental improvements in these locations. Including at Mawsley Marsh Site of Special Scientific Interest (SSSI).

Following the desk based NFM assessment and site ground truthing. Several potential options for NFM measures have been identified to help reduce flood risk within the Slade Brook as well as promote environmental improvements. An assessment has been undertaken on these options to highlight the highest priority sites to target NFM implementation. The specific prioritisation is mainly weighted on flood risk reduction initially but also takes into account Heritage, Ecology, Access and Cost.

5 options have been selected for the NFM short list priority. These include:

- Site 3 - Glendon Wood leaky barriers
- Site 4 - Prologis Park river restoration
- Site 9 - Land at Coppicemoor Spinney / DS - wetland design and wet woodland.
- Coppicemoor Brook near Middle Ground Spinney - river restoration/floodplain reconnection.
- Coppicemoor Brook near Underwood Hill Spinney - Leaky Barriers.

All 5 sites showed significant flood peak reductions in Kettering when simulated through the JFlow model. More information on these specific sites is detailed in the Short List, Design and Access Statement [10].

6.2 Next steps

In order to pursue these opportunities into future projects next steps have been considered in Table 6-1, which are underpinned by the constraints that have been outlined for each of the site's opportunities throughout the Slade Brook catchment. These next steps include a mixture of suggestions of further work and investigations that would need to be undertaken in order to allow these opportunities to progress.

- Undertake landowner, stakeholder and community engagement to gain a wider understanding as to the likelihood of implementation of the features.

10 ENV6006464R-JBAU-XX-01-DS-C-0030-A2-P02-NFMShortList_DesignAccess_0324

- Review the features to be implemented and agree outline designs (and subsequently detailed designs where necessary) with appropriate levels of modelling.
- Understand and assign maintenance requirements and responsibility of assets to an appropriate authority.
- Apply for necessary planning and consenting permissions, with a suitable level of consideration for wider environmental issues such as ecology, carbon, water quality, landscape and heritage.
- Further analysis on the East Brook watercourse may provide additional flood risk benefits for Kettering. This has not been analysed within this project given the urban nature and culverted watercourse. A SUD's scheme here may work well in this catchment.

Table 6-1 List of next steps for each opportunity identified in this project.

Opportunity	Next steps
Leaky Barrier and Wet Woodland at Site 3 - Glendon Wood	Overall, the site downstream of Violet Lane the Slade Brook runs through a deciduous woodland which mainly consists of Elm with Sycamore Acer pseudoplatanus, Oak Quercus robur, Hawthorn Crataegus monogyna, Elder Sambucus nigra and Ash Fraxinus excelsior. The ground flora included Lesser Celandine Ficaria verna, Dog's Mercury Mercurialis perennis, Garlic Mustard Alliaria petiolata, Lords and Ladies Arum maculatum, Common Nettle Urtica dioica, Current Ribes sp. **Evidence of Badger (latrines and paths) were evident through the woodland**. Hard-core debris has been fly-tipped into the Slade Brook from Violet Lane which it located roughly 10 metres downstream of the Violet Lane culvert. It is recommended that this material is removed from the channel as it is not natural and is causing adverse impacts to the watercourse and stability of the Violet Lane banks. Surface water channels were noted to be freely draining into the Slade Brook. The water is highly turbid and inputting a significant amount of sediment into the channel. An opportunity exists here to partially block the channel with a leaky barrier/dam to slow the flow and store more water on the floodplain, creating a wet woodland. For the leaky barrier in the Slade Brook channel reach it is recommended to undertake the following steps. This is outlined in the Appendix D - ENV6006464R-JBAU-XX-01-DS-C-0030-S2-P01-NFMShortList_DesignAccess_0324 • Landowner and stakeholder engagement. • Depending on scale of opportunities, may require either detailed or geomorphological design. • Flood risk activity Environmental permit.

Opportunity	Next steps
	• INNS survey and the production of an invasive species management plan if required. Including for Badgers. • Requires acquisition of significant timber (e.g. tree trunks and large branches) Possibly available on site through woodland management. • Large woody dams are created by laying two large stacks of tree trunks in a cross formation across the channel. and wherever possible, every single tree trunk/branch used to create a leaky barrier should be long enough to fully span the whole channel width, plus extend a further 1-2m (into the bank) and securely anchored in position, (e.g. using vertical stakes and pins or lashing fixing them to other trees). Access restrictions through existing wet woodland should be reviewed to support the design.
River restoration at Site 4 Prologis/Linear Park Walking Paths	The banks are lined with trees and scrub including Willows, Hawthorn, Blackthorn Prunus spinosa, Oak, Great Willowherb Epilobium hirsutum and Pendulous Sedge Carex pendula, which provide a mosaic of shade for the channel. The vegetation interacts with the surface water by trailing into the water and stirring up the surface flow. Further downstream there does appear to be a two-stage channel with a berms or benching running throughout the reach. It's not clear whether this is natural or as a result of modification or maintenance. The banks and riparian habitats are suitable for supporting Water Vole. For the channel restoration in this location, it is recommended to undertake the following steps. This is outlined in the Appendix D - ENV6006464R-JBAU-XX-01-DS-C-0030-S2-P01-NFMShortList_DesignAccess_0324 • Landowner and stakeholder engagement. Including public interaction. • Topographical surveys. • Depending on scale of opportunities, may require either detailed or geomorphological design. • Flood risk activity Environmental permit. • Installation of Boardwalks and management plan for existing footpaths. • Possible planning permission needed. If needed, then EIA may also be needed.
Coppicemoor Brook at site 9 and upstream - wetland	Downstream the flow was rapid and flumed through a straightened and trapezoidal channel. The channel was lined with Hawthorn, Willows, Oak, Sycamore, Elder and Ash trees,

Opportunity	Next steps
and leaky barriers.	with Rosebay Willowherb Chamaenerion angustifolium forming marginal vegetation. Vegetation was able to interact with the channel and the current cover upstream likely creates a mosaic of light and shade of the channel however it is possible that the channel becomes choked with vegetation in the summer. **There were also many badger burrows and evidence of their activity along the banks.** For the leaky barrier in the Slade Brook channel reach it is recommended to undertake the following steps. This is outlined in the Appendix D - ENV6006464R-JBAU-XX-01-DS-C-0030-S2-P01-NFMShortList_DesignAccess_0324 • Landowner and stakeholder engagement. • Depending on scale of opportunities, may require either detailed or geomorphological design. • Flood risk activity Environmental permit / Ordinary Watercourse Application • INNS survey and the production of an invasive species management plan if required. Including for Badgers.
Across the catchment Riparian buffer improvements	Riparian buffer strips should be 5-10m wide and may require fencing to exclude livestock from the riverbanks. These planted areas can be enhanced into hedgerows which are natural weather barriers, protecting crops, soils and livestock, provide ideal habitat for farmland birds and wildlife species, but also perform a natural flood management function by trapping and slowing water flow. Consideration should be given for access to the vegetated buffer strip for maintenance of the vegetation and any in stream features. There could be a designated narrow access route from one side of the stream only where larger woody material (e.g. trees/shrubs) is excluded. Therefore, access is available for powered machinery and/or delivery of tree trunks/branches for restoration/recreation of leaky barriers. Across the catchment it is recommended to undertake: • Landowner and stakeholder engagement.
Across the catchment soil improvements	Soil improvements will increase infiltration capability of the soil and footpath improvements would reduce poaching along the currently suggested public footpath and would encourage users to stick to a more direct route across the field. These conditions were evident across the majority of the upper catchment areas visited by the survey team. Wherever possible, fields or parts of fields from which there is a high risk of enhanced runoff flooding property and roads, and causing sediment pollution of watercourses, should not be used for growing vegetables. Land should be roughly cultivated

Opportunity	Next steps
	immediately after harvest to remove wheel ruts. Temporary ditches and single plough furrows can be created to divert runoff from headlands to soakaway areas. High risk gateways should be blocked where these are at the bottom of slopes and new field gates opened in less risky sites. More permanent hedge banks and silt traps can be constructed to attenuate runoff. Land should be subsoiled where deeply compacted by wheelings whenever the soil becomes suitably dry in summer. Grassed strips and woodland can be planted in valley bottoms, but soil structural damage should be removed first and these areas should not be used as access routes across the farm. Slurry spreading should be carried out when the soil is dry. Across the catchment it is recommended to undertake: • Landowner and stakeholder engagement

A Appendix A - ENV6006464R-JBAU-XX-01-AS-HM-0014-S3-P01-SladeBrook_2D-NFM-HydraulicModelling

B Appendix B - ENV6006464R-JBAU-XX-01-AS-EN-0010-S3-P01-SladeBrook_NFMWalkoverAssessment

C Appendix C - ENV6006464R-JBAU-XX-01-AS-HE-0006-S3-P01-Slade_Brook_Heritage_Baseline_Scoping

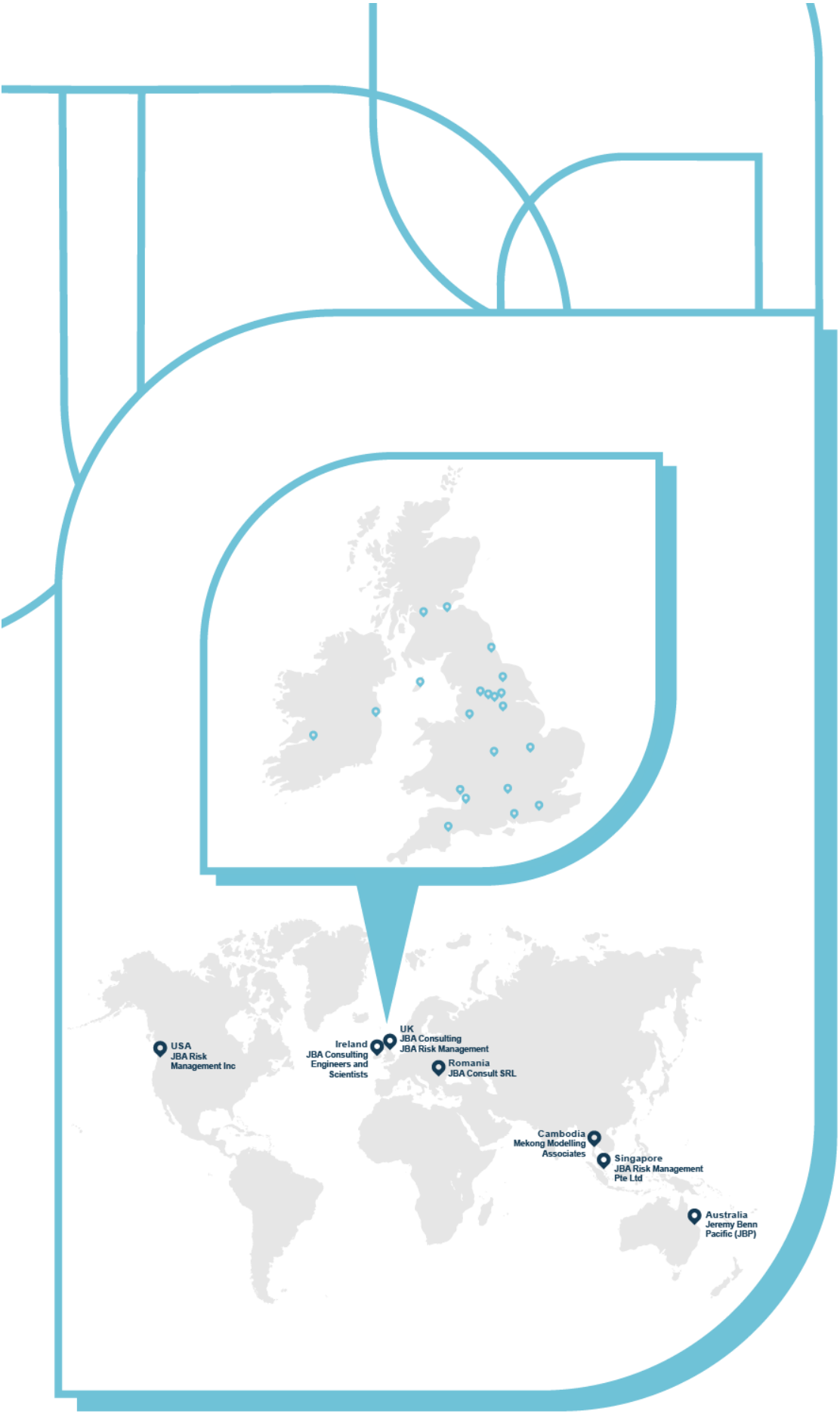
C.1 ENV6006464R-JBAU-XX-01-FI-HE-0015-S3-P01-Heritage_NFMPotential-Assessment_Overview

C.2 ENV6006464R-JBAU-XX-01-FI-HE-0016-S3-P01-Heritage_NFMPotential-Assessment_Figure2

C.3 ENV6006464R-JBAU-XX-01-FI-HE-0017-S3-P01-Heritage_NFMPotential-Assessment_Figure3

C.4 ENV6006464R-JBAU-XX-01-FI-HE-0018-S3-P01-Heritage_NFMPotential-Assessment_Figure4

D Appendix D - ENV6006464R-JBAU-XX-01-DS-C-0030-S2-P01-NFMShortList_DesignAccess_0324



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