Norwich Western Link

Environmental Statement

Chapter 12: Road Drainage and the Water Environment

Appendix 12.2: Flood Risk Assessment

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Glossary of Abbreviations and Defined Terms

The definition of key terms used in this report are provided below. These definitions have been developed by reference to the definitions used in EU and UK legislation and guidance relevant to the water environment as well as professional judgement based on knowledge and experience of similar schemes in the context of the Proposed Scheme.

Term	Definition
AMAX	A data series showing the maximum flow recorded in any flood year
Attenuation Basin	Areas of storage that provide flow control through attenuation of stormwater runoff. They also facilitate some settling of particulate pollutants.
Bailey Bridge	The temporary bridge structure over the River Wensum connecting the temporary works platform on either bank
Bank	Side of a river channel or island which extends above the normal (e.g., mean) water level and is only completely submerged during periods of high river flow
Bar	In-channel, elevated sediment deposit exposed during periods of low flow, which may be a side bar (including a point or counterpoint bar, located respectively along the convex or concave bank of a meander bend) or a mid-channel bar
Berm	Natural or artificial, flat-topped, shelf along the margin of a river channel that is exposed above water level during low flows, but is submerged during high flows: natural berms are vegetated features composed of sediments deposited by the river to the baseflow level, which evolve into benches as further deposited sediment raises their surface gradually to higher elevations within the river channel

Term	Definition
Climate Change Allowance	An uplift applied to peak flow or rainfall estimates, which are based on data available today, to account for predicted increases in rainfall in the future.
Culvert	Arched, enclosed or piped structure constructed to carry water under roads, railways and buildings
Deposition	Laying down of part, or all, of the sediment load of a stream on the bed, banks or floodplain. Mostly occurs at the end of a high flow event. Forms various sediment features such as bars, berms and floodplain deposits.
Drainage Strategy	Demonstrates how surface water will be managed within a scheme so it does not increase flood risk elsewhere, how the scheme is compliant with the relevant legislation and manages risks to water quality.
Erosion	Removal of sediment or bedrock from the bed or banks of a channel by flowing water. Mostly occurs during high flows and flood events. Forms various river features such as scour holes and river cliffs.
Flood Map for Surface Water	A nationally available dataset showing areas that are susceptible to surface water (or pluvial i.e. from rainfall) flooding produced by the Environment Agency.
Flood Risk Assessment	As assessment that identifies and assesses the risk of flooding to and from a proposed development for all sources. It is a requirement under the national planning policy framework for all new developments that are in flood zone 2 or 3 and are more than 1 hectare.
Flood Zone	The classification of an area based on its risk of flooding from fluvial or tidal sources.
Floodplain	Valley floor adjacent to a river that is (or was historically) inundated periodically by flood waters and is formed of sediments deposited by the river

Term	Definition
Flow regime	Typical magnitude, frequency, timing, and duration of river flows that drive physical and some ecological processes and so, within the constraints of valley slope and confinement, influence the sizes and types of river channel that may be present
Fluvial Flood Risk	Flooding resulting from a flows within a watercourse exceeding the capacity of that watercourse.
Fluvial Geomorphology	The study of sediment sources, fluxes and storages within a river catchment over all timescales and the associated interaction with the channel's floodplain.
Groundwater	Water located beneath the ground surface.
Hydraulic Model	A software tool used to estimate water levels during a flood event based on topographical data of watercourse channels and the floodplain and flood event flows or rainfall data.
Hydrology	The study of the properties, distribution, and effects of water on the earth's surface, in the soil and underlying rocks.
Infiltration Basin	Vegetated depressions designed to store surface water runoff and infiltrate it gradually into the ground. They are dry except during periods of heavy rainfall.
Left Bank	Left bank is defined by the direction of flow of the watercourse, looking downstream in the direction of flow. For the purposes of this FRA both the River Wensum and Foxburrow Stream run in a south-easterly direction in the vicinity of the Proposed Scheme. The left bank is therefore on the north-east side of these watercourses.
Manning's Roughness Value or Coefficient	A coefficient to represent different surface roughnesses and used in the Manning equation to understand the relationship between flow and water depth.

Term	Definition
NMU (non-motorised users)	A specific group of road users including walkers, cyclists or horse riders.
Norwich Western Link Highway	The highway section of Proposed Scheme which encompasses 6 Kilometre (Km) of long dual-carriageway road connecting the A1067 Fakenham Road and the A47 and a dualled section of the A1067 to the existing A1270 roundabout
Outfall	A point of discharge into a watercourse.
Piles	Below ground vertical structures that are used to transfer loadings from structures at the surface to suitable load bearing ground.
Pre-Earthwork Ditch	An earth ditch that will run along the outer edge on the Norwich Western Link Highway to collect and convey surface water runoff
Principal Aquifer	Have the potential to provide significant quantities of drinking water, and water for business needs. They may also support rivers, lakes and wetlands.
Reach	Section of river along which boundary conditions are sufficiently uniform that the river maintains a near consistent internal set of process–form interactions
Right Bank	Right bank is defined by the direction of flow of the watercourse, looking downstream in the direction of flow. For the purposes of this FRA both the River Wensum and Foxburrow Stream run in a south-easterly direction in the vicinity of the Proposed Scheme. The right bank is therefore on the south-west side of these watercourses

Term	Definition
Riparian zone	Transitional, semi-terrestrial area of land adjoining a river channel (including the river bank) that is regularly inundated and influenced by fresh water and can influence the condition of the aquatic ecosystem (e.g. by shading and leaf litter input and through biogeochemical exchanges)
River Wensum Viaduct	(BR1). Drawing Structure Reference. Viaduct crossing the River Wensum Special Area of Conservation and floodplain (approximately 490m long). The ten-span bridge design includes piled piers within the floodplain.
Site of Special Scientific Interest	Protected areas under legislation that are of particular interest due to the rare species of fauna or flora, or geological features that it contains.
Source Protection Zone	Zones which are designated for public drinking water supplies and show the risk associated with activities that have the potential to impact water quality.
Special Area of Conservation	Protects one or more special habitats and / or species, terrestrial or marine, as listed in the Habitats Directive.
Superficial Deposits	The youngest geological deposits formed during the most recent period of geological time, the Quaternary, which extends back about 2.6 million years from the present.
Surface Water Drainage Strategy	Demonstrates how surface water will be managed within a scheme so it does not increase flood risk elsewhere, how the scheme is compliant with the relevant legislation and manages risks to water quality.
Swale	Shallow, broad and vegetated channels designed to store and / or convey surface water runoff and remove pollutants.
Temporary Works Platform	The term to refers to the temporary platform across the floodplain use to construct the viaduct. It will cross the River Wensum by means of a temporary bailey bridge.
Tidal Flood Risk	Flooding resulting from the sea.

Term	Definition
WC5	An ordinary watercourse situated to the south of the River Wensum. It runs parallel to the River Wensum and is situated within its floodplain and so is hydraulically connected during flood flows. It outfalls to the River Wensum at Ringland.
Weir	Artificial structure across a river for controlling flow and upstream surface level, or for measuring discharge

1 Introduction

1.1 Project Overview

1.1.1 Norfolk County Council, as Highway Authority (hereafter referred to as 'the Applicant'), is seeking to obtain planning permission for the proposed Norwich Western Link (NWL) Road (hereafter referred to as 'the Proposed Scheme') located to the north-west of Norwich. The Proposed Scheme is a highway scheme linking the A1270 Broadland Northway from its junction with the A1067 Fakenham Road to the A47 trunk road near Honingham.

1.1.2 This document is the Applicant's Flood Risk Assessment (FRA) of the Proposed Scheme and is appended to **Chapter 12: Road Drainage and the Water Environment** (Document Reference: 3.12.00) of the Environmental Statement (ES). It should be read in conjunction with the **Drainage Strategy Report** (Document Reference: 4.04.00) and the **Drainage Strategy Report, Appendix 4.15 Construction Surface Water Management Strategy** (Document Reference 4.04.15).

1.2 Requirement for A Flood Risk Assessment

1.2.1 The Proposed Scheme includes three watercourse crossings, one of which is a viaduct over the River Wensum (a main river) and WC5 (an ordinary watercourse within the River Wensum floodplain) and the other which is a culvert of the Foxburrow Stream (an ordinary watercourse). It also bisects two major existing overland flow routes in the vicinity of Ringland Lane and Weston Road amongst other minor surface water interactions.

1.2.2 All these elements have the potential to increase flood risk to adjacent land and therefore it is necessary to assess this risk. The Proposed Scheme is also greater than 1ha and some aspects of the Proposed Scheme are located in Flood Zones 2 and 3, therefore an FRA is required to support the planning application according to the National Planning Policy Framework (NPPF), 2021 (**Ref. 12.2.1**).

1.3 Structure of the Flood Risk Assessment

1.3.1 This FRA incorporates a series of Appendices providing supporting information, documentation and evidence for the findings presented in this report and these should be read in conjunction with the FRA. The following sets out these documents:

Sub Appendix A: Figures (Document Reference 3.12.02a)

1.3.2 The **FRA Figures** (Document Reference 3.12.02a) is split into four sections, scheme wide figures, River Wensum figures, Foxburrow Stream figures and Ringland Lane overland flow path figures. The figures presented for the River Wensum, Foxburrow Stream and Ringland Lane overland flow path provide the evidence base for the findings presented in this FRA.

Scheme wide figures

1.3.3 The scheme wide figures are numbered 3.12.02a-1 to 3.12.02a-7 and are those not associated with a specific watercourse or overland flow path. They provide the context of the Proposed Scheme. Figures 3.12.02a-1 **Water Environment Interfaces**, 3.12.02a-2 **Non-Motorised User Water Environment Interfaces** and 3.12.02a-3 **Overland Surface Water Catchments** in particular are important for understanding the scope of the Proposed Scheme and the references to key elements of the scheme and the water environment referred to in this FRA.

River Wensum figures

1.3.4 The River Wensum figures are numbered 3.12.02a-8 to 3.12.02a-143 and are those specifically associated with the River Wensum. Figure 3.12.02a-8 **River Wensum Flood Map for Planning Fluvial Flood Risk** and Figure 3.12.02a-9 **River Wensum Flood Map for Planning Reservoir Flood Risk** reflect nationally available data not prepared specifically for this FRA.

1.3.5 All the remaining maps are outputs from the hydraulic modelling work completed for this FRA. They include extent, depth, velocity and hazard maps for the Baseline (current situation), Temporary (with the temporary works in place) and Proposed Scheme (post development situation) scenarios.

Outputs are provided for the 1 in 2, 5, 30, 50, 100 and 1000 annual probability events. Climate change allowance maps are provided for baseline and proposed scenarios for the 1 in 30 annual probability event with a 44% climate change allowance increase and the 1 in 100 annual probability event with 11%, 20% and 44% climate change allowance increases.

1.3.6 Difference maps are also provided for the depth and velocity maps, these reflect the change in depth or velocity from the baseline, so a positive number means an increase from existing and a negative number a decrease from existing. Differences associated with the Temporary Works proposals are referred to as Temporary Works Difference maps and differences associated with the Proposed Scheme are referred to as Proposed Scheme Difference maps.

1.3.7 In addition, Reservoir Breach maps are provided for the 1 in 100 annual probability event with a 44% climate change allowance increase. These maps are provided for depth, velocity, hazard and the difference maps described above.

1.3.8 Finally Environmental Mitigation maps are provided which reflect the Prosed Scheme with the environmental mitigation in place. These are presented for the 1 in 100 and 1000 annual probability events and the 1 in 100 annual probability event with a 44% climate change allowance. Difference maps provided for these maps should be considered separate from all the other difference maps. These reflect the change in depth or velocity from the Proposed Scheme rather than the baseline. Again a positive number means an increase from Proposed Scheme and a negative number a decrease from the Proposed Scheme. These maps are referred to as the Environmental Mitigation Difference maps.

Foxburrow Stream figures

1.3.9 The Foxburrow Stream figures are numbered 3.12.02a-144 to 3.12.02a-160 and are those specifically associated with Foxburrow Stream. Figure 3.12.02a-144 **Foxburrow Stream Flood Map for Planning Fluvial Flood Risk** reflects nationally available data not prepared specifically for this FRA. All the remaining maps are outputs from the hydraulic modelling work completed for this FRA. They include extent and depth maps for the Baseline (current situation) and Proposed Scheme (post development) scenarios. Outputs are provided for the 1 in 30, 100 and 1000 annual probability events. Climate change allowance maps are provided for the 1 in 30 and 100 annual probability events with a 45% climate change allowance increase. Difference maps are also provided for the depth outputs.

Ringland Lane overland flow path figures

1.3.10 The Ringland Lane overland flow path figures are numbered 3.12.02a-161 to 3.12.02a-233 and are those specifically associated with the Ringland Lane overland flow path. All the maps presented are outputs from the hydraulic modelling work completed for this FRA. They include extent and depth maps for the Baseline (current situation) and Proposed Scheme (post development) scenarios. Outputs are provided for the 1 in 2, 5, 30, 75, 100 and 1000 annual probability events. Climate change allowance maps are provided for the 1 in 30 and 100 annual probability events with a 45% climate change allowance increase. Difference maps are also provided for the depth and velocity outputs.

Sub Appendix B: River Wensum Hydraulic Modelling Report (Document Reference 3.12.02b)

Sub Appendix C: River Wensum Technical Modelling Log (Document Reference 3.12.02c)

Sub Appendix D: River Wensum Hydrology Verification (Document Reference 3.12.02d)

1.3.11 Sub Appendices B, C and D relate to the River Wensum hydraulic modelling work completed to support the assessment. The **River Wensum Hydraulic Modelling Report** (Document Reference 3.12.02b) provides an overview of the modelling work presented. It is intended as an accessible summary of the work completed. It presents the approaches to the hydrology and the modelling for the baseline, temporary and post development situation. Whilst some results and sensitivity tests are presented here, this document does not report in detail on the impacts of the Proposed Scheme. This information is in this FRA and the FRA **Figures** (Document Reference 3.12.02a).

1.3.12 The **River Wensum Technical Modelling Log** (Document Reference 3.12.02c) provides more detail on the hydraulic model build. There are no outputs provided in this report. This is a technical document setting out in detail the modelling assumptions.

1.3.13 The **River Wensum Hydrology Verification** (Document Reference 3.12.02d) sets out how the hydrology of the River Wensum was reviewed against the latest available data to confirm its suitability for the assessment.

Sub Appendix E: Foxburrow Stream Hydraulic Modelling Report (Document Reference 3.12.02e)

Sub Appendix F: Foxburrow Stream Technical Modelling Log (Document Reference 3.12.02f)

Sub Appendix G: Foxburrow Stream FEH Calculation Record (Document Reference 3.12.02g)

1.3.14 The data presented in the Foxburrow Stream Hydraulic Modelling Report (Document Reference 3.12.02e) and the **Foxburrow Stream Technical Modelling Log** (Document Reference 3.12.02f) are consistent with the approach described for the River Wensum above. The **Foxburrow Stream FEH Calculation Record** (Document Reference 3.12.02g) is a complete hydrological assessment to derive design flows for the Foxburrow Stream. This is a technical assessment and sets out the different approaches used, the assumptions and the final preferred approach for the design flows.

Sub Appendix H: Ringland Lane Hydraulic Modelling Report (Document Reference 3.12.02h)

Sub Appendix I: Ringland Lane Technical Modelling Log (Document Reference 3.12.02i)

Sub Appendix J: Ringland Lane FEH Calculation Record (Document Reference 3.12.02j)

1.3.15 The data presented in the **Ringland Lane Hydraulic Modelling Report** (Document Reference 3.12.02h), the **Ringland Lane Technical Modelling Log** (Document Reference 3.12.02i) and **Ringland Lane FEH Calculation Record** (Document Reference 3.12.02j) are consistent with the approach described for the Foxburrow Stream.

Sub Appendix K: Design Drawings (Document Reference 3.12.02k)

1.3.16 The **Design Drawings** (Document Reference 3.12.02k) includes the Temporary and Proposed Scheme design for the key structures interacting with the water environment. Drawings are provided of the Proposed Scheme showing the Tud tributary culvert / Bat underpass culvert (CU2), the River Wensum Viaduct General Arrangement and the Maintenance access crossings MA1 across WC5. Drawings of the Temporary Works showing the temporary crossing of WC5, the Bailey Bridge and the General Arrangement of the Temporary Works Platform.

Sub Appendix L: Non-Motorised User and Side Road Provision General Arrangement Layout (Document Reference 3.12.02l)

1.3.17 The **Non-Motorised User and Side Road Provision General Arrangement Layout** (Document Reference 3.12.02l) provides full details and descriptions of the non-motorised user proposals. This is an extract from the **Sustainable Transport Strategy** (Document Reference 4.02.00) where further details on the proposals can be found. The locations are also presented in Figure 3.12.02a-2 **Non-Motorised User Water Environment Interfaces** where the various interactions with the water environment can be reviewed.

Sub Appendix M: Environmental Enhancements of the Proposed Scheme Overview (Document Reference 3.12.02m)

1.3.18 The **Environmental Enhancements of the Proposed Scheme Overview** (Document Reference 3.12.02m) presents the off site mitigation concept proposals. This is an extract from the **Essential Environmental Mitigation Plans** (Document Reference 2.11.00) where further details on the proposals can be found.

1.4 Site details

Overview

1.4.1 A detailed description of the Proposed Scheme is provided in **Chapter 3: Description of Scheme** (Document Reference 3.03.00) of the ES.

1.4.2 The Proposed Scheme consists of the construction, operation and maintenance of an approximately 6 Kilometre (Km) long dual-carriageway road connecting the A1067 Fakenham Road and the A47 with a dualled section of the A1067 to the existing A1270 roundabout (hereafter referred to as the NWL Highway). Along this alignment there are a variety of interactions with side roads and tracks to provide continued access arrangements.

1.4.3 As part of a separate planned scheme, National Highways proposes to realign and dual the A47 from the existing roundabout at Easton to join the existing dual carriageway section at North Tuddenham, noting that this incorporates

the length of the A47 to which the Proposed Scheme would join. Development consent was granted for this scheme on 12 August 2022. National Highways will construct the A47 junction at Honingham and the Proposed Scheme would connect to the north-eastern side of that junction.

1.4.4 The Proposed Scheme would include ancillary works including provision for Non-Motorised Users (NMUs), necessary amendments to the local road network, including the stopping up of some minor roads, and the provision of environmental mitigation measures.

Water Environment Interfaces

1.4.5 The Figure 3.12.02a-1 **Water Environment Interfaces** in **Sub Appendix A: Figures** (Document Reference 3.12.02a) presents the Water Environment Interfaces relevant to the Proposed Scheme. In summary the key interfaces with the Norwich Western Link Road running from east to west are:

- Pre-Earthwork Ditches (PEDs) (Scheme wide) would run adjacent to the main carriageway of the Proposed Scheme on the upstream and downstream faces over its entire length to collect and convey local surface water runoff to the nearest crossing point, watercourse or, at either end of the Proposed Scheme, the existing Northern Distributor Road or the A47 North Tuddenham to Easton Dually Scheme drainage systems.
- Surface water drainage basins (Scheme wide) would collect runoff from the Proposed Scheme. These are a variety of infiltration and attenuation basins.
- Below ground structures, (Scheme wide) in general consisting of piles at the viaduct and various bridges along the length of the Proposed Scheme would penetrate into the groundwater.
- Surface water runoff from a catchment to the north of the A1067 Fakenham Road / NWL roundabout (A1067 Chainage 75) would be

conveyed beneath the A1067 Fakenham Road by means of a culvert (C-03-A-1.000)

- The River Wensum and its floodplain (Chainage 100 to 550) would be crossed by means of a viaduct. An access track crossing the River Wensum floodplain would be conveyed across WC5 (Chainage 500) by means of a culvert (MA1). A Temporary Works Area would be situated within the River Wensum Floodplain, crossing both the River Wensum and WC5, and include a working platform to construct the viaduct.
- A surface water flow path adjacent to Ringland Lane (Chainage 1700) (hereafter referred to as the Ringland Lane overland flow path) would be collected by an attenuation feature and conveyed by the PED network around Surface Water Drainage Basin 3 and beneath the Proposed Scheme via three surface water culverts: two for maintenance access tracks (C-06-D-5.000 and C-06-D-7.000) and one for the main highway (C-06-D-9.000). Downstream of culvert C-06-D-9.000 the PED network would transport the flow path around Surface Water Drainage Basin 4 before discharging it on its existing alignment. A temporary works access corridor running to the west of Ringland Lane would cross the Ringland Lane flow path upstream of the Proposed Scheme. Further downstream as the surface water flow path passes through the town of Ringland it crosses Back Lane, which would be resurfaced to provide access for the works.
- A surface water flow path adjacent to Weston Road (Chainage 2900) (hereafter referred to as the Weston Road overland flow path) is collected by the PED network and conveyed to the Ringland Lane surface water crossing. The flow path cuts across the Temporary Works Area adjacent to Weston Road to the west of the Proposed Scheme.
- Foxburrow Stream (Chainage 4450) is conveyed beneath the Proposed Scheme through a combined surface water and bat

underpass culvert (the Tud tributary culvert / Bat underpass culvert (CU2)). Paddy's Lane conveys a surface water flow path (hereafter referred to as Paddy's Lane overland flow path) to Foxburrow Stream upstream of the Proposed Scheme. The Paddy's Lane overland flow path crosses the entrance to a Temporary Works Area adjacent to the Broadway.

- A tributary of Foxburrow Stream that collects in a natural pond adjacent to the NWL (Chainage 5150) before eventually joining Foxburrow Stream is conveyed beneath the Proposed Scheme via a three surface water culverts (C-16-C-2.000, C-16-C-3.000 and C-16-C-4.000). A surface water flow path joins this tributary just upstream of its confluence with Foxburrow Stream. This surface water flow path (Chainage 4660) is collected by the PED network and discharged to Foxburrow Stream upstream of the Proposed Scheme.

1.4.6 Further detail of these structures is provided in Section 1.5. Full details of the PED network (Section 7.5) and the surface water drainage basins (Section 7.7, 7.8 and Table 15) are provided in the **Drainage Strategy Report** (Document Reference: 4.04.00).

1.4.7 The locations of the Temporary Works Areas are shown in Figure 3.12.02a-1 **Water Environment Interfaces** in **Sub Appendix A: Figures** (Document Reference 3.12.02a) and discussion on the management of surface water at these locations is provided in Section 2 of the **Drainage Strategy Report, Appendix 4.15 Construction Surface Water Management Strategy** (Document Reference 4.04.15).

1.4.8 In addition to the Proposed Scheme there are ancillary NMU proposals. These are set out in detail in the **Sustainable Transport Strategy** (Document Reference 4.02.00) and an overview provided in **Sub Appendix L: Non-Motorised User and Side Road Provision General Arrangement Layout** (Document Reference 3.12.02l). Figure 3.12.02a-2, the **Non-Motorised User Water Environment Interface**, in **Sub Appendix A: Figures** (Document

Reference 3.12.02a) shows where these interface with the water environment. Water environment interfaces associated with these proposals running from east to west are as follows:

- Route 11 is a new shared pedestrian-cycleway to the north side of the A1067 Fakenham Road which crosses the surface water runoff conveyed by culvert (C-03-A-1.000). This route is part of the dualling works of the A1067.
- Route 7 is the existing Ringland Footpath which crosses the River Wensum and WC5. There are no changes to this structure and so it is considered as a receptor only.
- Route 10a crosses the River Wensum floodplain and WC5. This is a new public footpath along a proposed maintenance access track for the River Wensum viaduct.
- Route 10 crosses the River Wensum floodplain at its eastern end and Ringland Lane surface water flow path at its western end. This is a new public footpath along a proposed maintenance access for the NWL Highway.
- Route 6, Ringland Lane, crosses the Ringland Lane surface water flow path. There are no proposed changes to Ringland Lane but existing laybys are to be formalised.
- Route 4 crosses the Weston Road surface water flow path. This is the existing Weston Road / Church Hill Lane and is to be closed to all traffic except pedestrians, cyclists, horse riders and private access.
- Route 2 is the existing road The Broadway which is to be closed to all traffic except pedestrians, cyclists, horse riders and carriages and for access to adjacent private land. It connects to the Paddy's Lane overland flow path at its western end.

- Route 1b is a diversion of Honingham Restricted Byway 1 and crosses Foxburrow Stream and the Foxburrow Stream tributary surface water flow path sources. It crosses Foxburrow Stream and its tributary over the Tud tributary culvert / Bat underpass culvert (CU2) and culvert C-16-C-4.000 respectively.

- Route 12 is set away from the main carriageway of the Proposed Scheme and consists of the provision of an off-carriageway shared pedestrian-cycleway to the east of Marl Hill Road and a crossing over the A1067 Fakenham Road at its eastern end. A surface water flow path runs adjacent to Marl Hill Road (hereafter referred to as the Marl Hill Road overland flow path) for the length of Route 12 from south to north. At its northern end the Marl Hill surface water flow path and a second flow path from the north cross Marl Hill Road; these eventually join WC5. The A1067 Fakenham Road is also a surface water flow path at the junction with Marl Hill Road.

1.4.9 Essential environmental mitigation measures are also proposed as part of the Proposed Scheme. Full details of these are provided in the **Essential Environmental Mitigation Plans** (Document Reference 2.11.00) and plans providing an overview of the proposals are provided **Sub Appendix M: Environmental Enhancements of the Proposed Scheme Overview** (Document Reference 3.12.02m). Water environment interfaces associated with these proposals running from east to west are as follows:

- Woodland and scrub creation is proposed in the surface water runoff catchment to the north of the A1067 Fakenham Road / NWL roundabout (A1067 Chainage 75).

- Along the River Wensum corridor in a reach upstream of the NWL Highway, gravel bars with associated large wood structures and riffles are proposed alternating intervals. Approximately 120m of the channel is to be diverted into a historic meander. A riparian buffer zone with associated planting is proposed along the banks.

- Localised riparian buffer zones with associated planting are proposed at intervals along the banks of WC5 and its tributaries.
- Within the wider River Wensum floodplain grassland creation and enhancements are proposed.
- Woodland and scrub creation is proposed where the Ringland Lane overland flow path crosses Ringland Lane and the location of the attenuation feature here.
- To the north west of Paddy's Lane a corridor of woodland and scrub creation is proposed. The access to this corridor connects to the Paddy's Lane overland flow path at Paddy's Lane and the woodland and scrub creation crosses the same surface water flow path further upstream.
- The Foxburrow Stream channel is to be reprofiled and leaky dams incorporated both upstream and downstream of the Proposed Scheme. A riparian buffer zone with associated planting is also proposed along the banks of the modified reach. An existing culvert and a failed bridge downstream of the Proposed Scheme are to be removed.
- Between Rectory Road and Hockering Road a surface water flow path (hereafter referred to as the Hockering Road overland flow path) running in a north easterly direction is crossed by an area of proposed grassland creation and enhancements. The same flow path continues in the same direction parallel to Hockering Road and crosses an area of woodland and scrub creation west of the Weston Equestrian Centre.

1.4.10 The Study Area for this FRA is determined by including the Proposed Scheme and all potential receptors (land and property) that could be at risk of increased flood risk as a result of the Proposed Scheme. The process of the FRA set out through this document will quantify that risk and so confirm receptors impacted by the scheme.

The River Wensum and Floodplain

1.4.11 The River Wensum is the only main river crossed by the Proposed Scheme. The River Wensum is a low gradient groundwater (chalk aquifer) dominated chalk stream. It is a designated 'Main River' under the jurisdiction of the Environment Agency. Its headwaters are located to the northwest of Norwich in the vicinity of the town of Fakenham. The catchment area as measured at the gauging station Costessey Mill (NRFA Station Number 34004) is 571km^2. Costessey Mill gauge is situated approximately 10km downstream of the Proposed Scheme and is the location of a large crump weir with other ancillary structures that controls upstream water levels.

1.4.12 The River Wensum holds European designation as a Special Area of Conservation (SAC) and UK designation as a Site of Special Scientific Interest (SSSI) and therefore is afforded the highest level of environmental protection.

1.4.13 The river is also under the Demonstration Test Catchment (DTC) (**Ref 12.2.2**) program which was launched in England to provide research to help inform both policy and practical approaches for reducing diffuse pollution and improving the ecological status of freshwater.

1.4.14 The floodplain of the River Wensum is well established and consists of agricultural fields with the occasional rural property located near but typically outside the floodplain. The river's floodplain does not form part of the SAC, although it is understood that the River Wensum is predominately groundwater fed. **Figure 1-1** below shows the reach of interest, by Ford Bridge.

Figure 1-1 River Wensum at the location of the Proposed Viaduct

1.4.15 The floodplain of the River Wensum in the locality of the Proposed Scheme is mostly comprised of managed grassland with areas of fen, wet grassland, woodland and wet woodland. The floodplain has historically been drained for agricultural purposes by series of Internal Drainage Board (IDB) 'main drains' managed by the Norfolk Rivers IDB. The largest of these drains is the Ordinary Watercourse WC5 that runs parallel to the river. The remainder bisect the floodplain before typically discharging into one of these larger watercourses.

1.4.16 There is a gas main that crosses the bed of the River Wensum approximately 450m downstream of the location of the Proposed Scheme viaduct crossing. The exact depth of the gas main has not been confirmed but headwall structures were visible during site walkovers suggesting the gas main may be relatively shallow.

Foxburrow Stream

1.4.17 Foxburrow Stream is a small ordinary watercourse that flows through woodland and marshland to the south of The Broadway, located between Weston Green (approx. NGR TG 09718 13979) and Honingham (approx.

NGR TG 10844 12404). The watercourse flows in a south-easterly direction and discharges to the River Tud, a main river, approximately 2km downstream of the Proposed Scheme.

1.4.18 At the point where the watercourse is crossed by the Proposed Scheme, it flows in a narrow and contained channel. **Figure 1-2** and **Figure 1-3** shows photographs typical of Foxburrow Stream at the point of the Proposed Scheme. Foxburrow Stream is under the jurisdiction of Norfolk County Council as the relevant Lead Local Flood Authority (LLFA).

Figure 1-2 Foxburrow Stream in the Vicinity of the Proposed Scheme

Figure 1-3 Foxburrow Stream in the Vicinity of the Proposed Scheme

Overland Flow Paths

1.4.19 The Environment Agency's Flood Map for Surface Water (FMfSW) shows overland flow paths crossing the NWL highway alignment along the major watercourse corridors discussed above and at Ringland Lane, Weston Road and two to the west of Foxburrow Stream, shown in Figure 3.12.02a-1, the **Water Environment Interfaces**, in **Sub Appendix A: Figures** (Document Reference 3.12.02a)

1.4.20 The Ringland Lane overland flow path drains a catchment of approximately 4.0km^2 (Catchment 8) to the west of the Proposed Scheme between Weston Green and Weston Longville. There is no defined channel conveying runoff from this catchment, but flows cross the alignment of the Proposed Scheme at approximate Chainage 1700 immediately to the north of Ringland Lane. Downstream of the Proposed Scheme the flow path continues in a south easterly direction adjacent to Ringland Lane. It passes the Keeper and the Dell (wedding venue), which is shown as at risk of flooding, and continues through the village of Ringland where the FMfSW suggests flows could impact a number of properties in this location before meeting the River Wensum a short distance upstream of Ringland Lane Bridge.

1.4.21 The Weston Road overland flow path (Catchments 5 and 6) is not as large (less than 0.1km^2 upstream of the Proposed Scheme) as the Ringland Lane flow path. It is crossed by the Proposed Scheme at approximate Chainage 2850. This flow path flows east where it meets the Ringland Lane overland flow path (discussed above) downstream of the Proposed Scheme.

1.4.22 The Foxburrow Stream Tributary overland flow path drains a small catchment (Catchments 1a and 1b) immediately adjacent to the NWL highway. It has a catchment area of 0.6km^2 in total of which 0.4km^2 is situated upstream of the Proposed Scheme. It crosses the Proposed Scheme via two parallel flow paths at Chainage 4645 and Chainage 5100 which join on the downstream face of the Proposed Scheme and discharge into Foxburrow Stream approximately 50m downstream of the Tud tributary culvert / Bat underpass culvert (CU2).

1.4.23 The FMfSW shows the largest overland flow paths but there are also smaller surface water catchments immediately adjacent to the Proposed Scheme which drain through the Proposed Scheme alignment. These are shown in Figure 3.12.02a-3, **Overland Surface Water Catchments**, in **Sub Appendix A: Figures** (Document Reference 3.12.02a). One such catchment is a tributary of the Weston Road overland flow path (Catchment 5) and two more are tributaries of Foxburrow Stream (Catchments 1a and 1b). Unless otherwise stated these are picked up by the PED network and conveyed to the nearest Proposed Scheme crossing.

1.4.24 The catchment to the north of the A1067 Fakenham Road / NWL roundabout (Catchment 11) does not show an overland flow path on the FMfSW. The FMfSW does show a natural pond approximately 1350m^2 in area located immediately north of the A1067. It is assumed that this pond collects much of the runoff from this catchment. The catchment is less than 0.2km^2 and falls towards the River Wensum. It is a mixture of woodland and arable farmland.

1.4.25 In addition to the above catchments, there are a number of surface water runoff catchments that interact with the NMU proposals and environmental enhancements. These are:

- The Paddy's Lane overland flow path which drains to Foxburrow Stream and interacts with the entrance to Temporary Works Area P04, the NMU Route 2 The Broadway and the environmental enhancements corridor connecting Paddy's Lane to Breck Road.
- The Marl Hill Road overland flow path and associated catchments which interacts with the NMU Route 12
- The Hockering Road overland flow path crosses areas of proposed grassland, woodland and scrub creation and enhancements.

1.4.26 The Paddy's Lane overland flow path has a catchment area of 1.9km^2 and constitutes the majority of the Foxburrow Stream catchment upstream of the Proposed Scheme. Its headwaters are in the vicinity of Ley's Lane, and it runs in a north-easterly direction to Weston Green Road before doubling back and running in a south-westerly direction along Paddy's Lane. The catchment is broadly arable with a number of commercial premises dotted throughout.

1.4.27 The Marl Hill Road overland flow path has a catchment area of 2km^2. Its headwaters are at Weston Longville and it flows in a north-easterly direction and along Mar Hill Road itself, **Figure 1-4**. The catchment is predominantly arable fields which drain towards Marl Hill Road, hence its function as a surface water flow path. At its northern end a small catchment, 0.2km^2 in size, drains across Marl Hill Road and joins the overland flow path approximately 350m south-east of Marl Hill Road. The flow path continues into the River Wensum floodplain and discharges to WC5.

Figure 1-4 Marl Hill Road looking north approximately 150m from Fakenham Road

1.4.28 The A1067 Fakenham Road surface water catchment at the end of Marl Hill Road is approximately 0.8km^2 and runs parallel but to the north of the Marl Hill Road overland flow path. The catchment is largely made up of the Royal Norwich golf course with the remainder arable land. The catchment joins the Marl Hill Road overland flow path in the River Wensum floodplain upstream of WC5.

1.4.29 The Hockering Road overland flow path catchment is 1.3km^2 to the Weston Equestrian Centre. The catchment is largely arable with its headwaters around Weston Green Road. The catchment drains in a north-easterly direction and apart from the proposed environmental enhancements has not further interaction with the Proposed Scheme.

Geology and Hydrogeology

1.4.30 The Proposed Scheme is underlain by White Chalk Subgroup (bedrock geology), designated a Principal Aquifer, deemed capable of supporting water supplies at a regional scale, meaning they usually provide a high level of water storage (Environment Agency, 2020). Principal Aquifers may support water supply and / or river baseflow on a strategic scale.

1.4.31 An overview of the superficial deposits along the Proposed Scheme is presented in Figure 3.12.02a-7 **Superficial Deposits**, in **Sub Appendix A: Figures** (Document Reference 3.12.02a). These are dominated by Sheringham Cliffs Formation to the north and these deposits are composed of sands and gravels. Alluvium and River Terrace Deposits are present along the areas closest to river channel. The Alluvium is composed of clay, silt, sand and gravel and the River Terrace Deposits are composed of sand and gravel. The south of the Proposed Scheme is dominated by the Lowestoft Formation and its composition varies between clay, sand and gravel. There are also sporadic superficial Head Deposits, which are variable in composition and are generally composed of poorly sorted clay, silt, sand and gravel.

1.4.32 The Lowestoft Formation, Alluvium and River Terrace Deposits are classified as Secondary A Aquifers by the Environment Agency. Secondary A Aquifers are defined as permeable strata capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of baseflow to rivers. The Head Deposits are classified as Secondary B Aquifers, and these are defined as having low permeability layers which may store and yield limited amounts of groundwater but may support local water supplies. The Sheringham Cliffs Formation is classified as both a Secondary A and Secondary Undifferentiated Aquifer by the Environment Agency. Secondary Undifferentiated Aquifers are assigned in cases where it has not been possible to attribute either category A or B to a rock type.

1.4.33 The groundwater aquifer beneath the Proposed Scheme is designated as Zone 3 of a Source Protection Zone (SPZ). Water resources in SPZs are usually used to support public water supplies and activities within SPZs are therefore controlled to protect the quality of the resource. Zone 3 is defined as the Total Catchment and activities within this area are not usually as tightly controlled as activities within the more sensitive Zone 1 (Inner Protection Zone) or Zone 2 (Outer Protection Zone), although control of potential impacts must still be considered and managed very carefully. Zone 1 of the SPZ is situated around the Taverham area.

1.4.34 Discrete manual dip groundwater level data have been recorded at a number of onsite monitoring boreholes within the proposed route alignment. Groundwater levels along the Proposed Scheme were recorded between 0.50mBGL (metres Below Ground Level) and 21.95mBGL (recorded on 15th October 2020), where shallow groundwater levels tend to coincide with valley locations. Further monitoring during 2020 and 2021 indicates an overall increase in groundwater levels between November 2020 and March 2021. Additional ground investigation has been undertaken between October 2022 and January 2023, where groundwater levels show a similar pattern to what was previously recorded. This is in line with expected seasonal variations.

1.5 Elements of the Proposed Scheme

1.5.1 An overview of the details of the key elements of the Proposed Scheme relevant to this FRA is provided in Figure 3.12.02a-1, **Water Environment Interfaces**, **Sub Appendix A: Figures** (Document Reference 3.12.02a). The elements of the design which are significant to assessing the impact to flood risk are detailed below.

Watercourse Crossings

1.5.2 The River Wensum is crossed by viaduct. The viaduct would be approximately 500m in length over 10 spans supported by 9 sets of 3 circular 2.7m diameter piers. Pier spans are typically 54m in length with the longest span, which crosses the River Wensum, being 60m in length. The piers are in excess of 8m from the bank full level of the River Wensum. The viaduct would span the full width of the River Wensum floodplain with both abutments situated outside the modelled flood extent for the 1 in 100 annual probability event with a 44% climate change allowance.

1.5.3 Piers within the River Wensum floodplain are set back from the local drains. The closest is 6m from the top of the bank of WC5.

1.5.4 Access tracks for the maintenance of the viaduct would extend across the River Wensum floodplain from the north-east and south-west to both banks of the River Wensum. These are to be set close to existing floodplain levels to prevent the introduction of a barrier to flood flow conveyance. A culvert (MA1) would carry the southern maintenance track across WC5. This culvert would be 12m in length a consist twin box culverts 1.5m high and 3.3m wide with approximately 300mm sediment in the base.

1.5.5 Foxburrow Stream would be conveyed beneath the Proposed Scheme by a box culvert (the Tud tributary culvert / Bat underpass culvert (CU2)) 4m by 4m and 50m in length. A small proportion of the Foxburrow Stream tributary overland flow path (less than 0.1km^2) is diverted into Foxburrow Stream upstream of the culvert increasing flows in Foxburrow Stream above existing for approximately 150m. The structure is located at a sharp meander in

Foxburrow Stream; the meander would be removed and the structure would tie into the existing channel at its upstream and downstream location resulting in a small reduction in the length of the watercourse. The structure is sized for bats, which far exceeds size requirements for flood risk, i.e. the size of the structure required to convey flood flows with an appropriate freeboard allowance.

Pre-Earthwork Ditches Network

1.5.6 Overland flow paths are intercepted by the Pre-Earthwork Ditches (PEDs) network described in detail in Section 7.5 within the **Drainage Strategy Report** (Document Reference: 4.04.00). These are open earth channels which collect and manage natural runoff at the base of the earthwork embankments. The channels are of varying sizes but are generally designed so the base width and channel depth match and the side slopes are 1:1.

1.5.7 The catchment in the vicinity of the Proposed Scheme generally falls from north-west to south-east with the exception of the catchments to the east of the River Wensum which fall from north-east to south-west. The PED network mimics this and collects runoff from the upstream face of the Proposed Scheme and conveys it to five locations that pass beneath the NWL highway to discharge downstream. These locations are at WC5 in the River Wensum floodplain, Ringland Lane, Foxburrow Stream, the Foxburrow Stream tributary and north-west of the A1067 Fakenham Road / NWL roundabout. At either end of the Proposed Scheme, the PED network outfalls into the existing Northern Distributor Road or the A47 North Tuddenham to Easton Dually Scheme drainage systems.

1.5.8 Figure 3.12.02a-3, the **Overland Surface Water Catchments**, in **Sub Appendix A: Figures** (Document Reference 3.12.02a), shows the PED drainage catchments; the catchments are numbered to be consistent with those presented in Section 6 of the **Drainage Strategy Report** (Document Reference: 4.04.00). Catchments downstream of the Proposed Scheme are typically small as the topography falls aways in that direction. The following

list presents the catchments which discharge upstream of the Proposed Scheme and the location to which they are conveyed:

- Catchments 12 and 24 drain to WC5;
- Catchments 5, 6, 7, 8 and 9 discharge to Ringland Lane overland flow path. Broadly, catchments 7, 8 and 9 sit within the existing Ringland Lane catchment upstream of the Proposed Scheme. Catchments 5 and 6 are diverted by the PED network from an adjacent catchment;
- Catchments 1b, 2, 3, and 4 discharge to Foxburrow Stream. Catchments 2 is the existing Foxburrow Stream catchment upstream of the Proposed Scheme. Catchments 1b, 3 and 4 are diverted by the PED network from adjacent catchments;
- Catchment 1a is the Foxburrow Stream tributary catchment;
- Catchment 11 is the A1067 Fakenham Road catchment which discharges into WC7.

1.5.9 Full details of the PED drainage paths and design are provided in Section 7.5 and Volume 3 of the **Drainage Strategy Report** (Document Reference: 4.04.00). The exception to this is the Ringland Lane overland flow path which incorporates an attenuation feature which is not set out in the **Drainage Strategy Report** (Document Reference: 4.04.00). The requirements for this feature are set out below.

1.5.10 The PED network at Ringland Lane collects the runoff from the Ringland Lane and Weston Road overland flow paths. The Weston Road overland flow path is diverted by the PED network and so would increase runoff at the location of the Ringland Lane crossing and for a short distance downstream above existing, which would increase flood risk to the Keeper and the Dell (wedding venue). A control structure, in addition to the attenuating effects of the PED network past the NWL in this location, reduces flows from the Ringland Lane overland flow path to compensate for the diversion of the Weston Road

overland flow path. Further details of the Proposed Scheme in this location are provided in Section 5.6.

Management of Surface Water Runoff from the Proposed Scheme

1.5.11 The section covers surface water runoff from impermeable surfaces across the Proposed Scheme. These surfaces are associated with the NWL Highway, the NMU routes and the temporary works areas. Full details of the surface water drainage system are provided in Section 7 and Volume 3 of the **Drainage Strategy Report** (Document Reference: 4.04.00).

1.5.12 For the NWL Highway a surface water drainage system would collect runoff. This system has been split into 8 drainage sub-catchments serving the Proposed Scheme which would collect and convey highway runoff to attenuation basins for treatment and discharge, the location of the drainage basins is shown in Figure 3.12.02a-1, **Water Environment Interfaces** in **Sub Appendix A: Figures** (Document Reference 3.12.02a). The geology suggests that infiltration is likely viable in many places due to the presence of sands, gravel and chalk. Specific infiltration testing has been undertaken in the various locations where surface water drainage basins are proposed and site specific decisions made based on the outcome of these tests.

1.5.13 A summary of each of the catchments and the proposed management of runoff is provided in **Table 1-1**.

Table 1-1 Summary of Proposed Highway Drainage

Catchment	Location	Management
NWL Catchment 1	A1067 roundabout, eastern arm to A1270 roundabout and southern arm to Wensum viaduct	Discharge via NWL Basin 1 attenuation basin with integrated sediment forebay at a rate of 43 l/ as into existing Northern Distributor Road infiltration basin (NDR Basin 1A) located north-east of the A1067 and Northern Distributor Road junction. The discharge rate is agreed with the LLFA and reflects the available capacity of NDR Bain 1A.
NWL Catchment 2	Wensum viaduct to the Ringland Lane overland flow path	Discharge to NWL Basin 2 shallow infiltration basin with integrated sediment forebay. Basin depth of 2m or less located on the southern side of the Proposed Scheme to the south of the River Wensum floodplain.
NWL Catchment 3	Ringland Lane overland flow path to Breck Road	Discharge to NWL Basin 3 shallow infiltration basin with integrated sediment forebay. Basin depth of 2m or less on the eastern side of the Proposed Scheme north of Ringland Lane
NWL Catchment 4	Ringland Lane to Chainage 2500	Discharge to NWL Basin 4 shallow infiltration basin with integrated sediment forebay. Basin depth of 2m or less on western side of the Proposed Scheme north of Ringland Lane.
NWL Catchment 5	Breck Road to Chainage 5135	Discharge via NWL Basin 5 attenuation basin with integrated sediment forebay into the Foxburrow Stream restricted to 19 l/s.

Catchment	Location	Management
NWL Catchment 6	Chainage 5135 to intersection with National Highways Scheme	Discharge via NWL Basin 6 attenuation basin with integrated sediment forebay into the A47 North Tuddenham to Easton Dualling DCO Scheme drainage system.
A1067 Catchment 1	Western arm of the A1067 roundabout	Discharge to A1067 Basin 1 shallow infiltration basin with integrated sediment forebay. Basin depth of 2m or less on to north of the A1067.
A1067 Catchment 2	A1270 roundabout	Discharges to existing NDR Basin 2 attenuation basin.

1.5.14 The management of the runoff from the various NMU routes is summarised below:

- Runoff from the following routes would be collected by the highway drainage system as follows: Routes 1b between The Broadway and Foxburrow Stream would be discharged to Drainage Basin 5; Route 9 west of the Proposed Scheme would be discharged to Drainage Basin 4; and Route 11 would be discharged to Drainage Basins 1 and A1067 1. Discharge from the listed Drainage Basin would be as detailed in **Table 1-1**.
- Runoff from Route 5 for its diversion of Blackbreck Lane to Ringland Lane is collected by the PED network and discharged to the Ringland Lane overland flow path. Berms along the length of the PED would provide attenuation and to encourage infiltration.
- Runoff from Route 1b between Foxburrow Stream and the Foxburrow Stream Tributary overland flow path, Route 2 and Route 3 between Breck Road and Weston Longville Road, Route 9 east of the Proposed Scheme, Route 10, Route 10a, Route 10b and Route 12 is discharged

over the edge of the route to the ground or a watercourse. The proposed management in these instances would be to collect runoff in ditches with berms situated to provide attenuation and to encourage infiltration.

- Route 2 west of Route 3, Route 3 on Breck Road, Route 4, Route 5 along Blackbreck Lane, Route 6, Route 7 and Route 8 are unchanged from the existing surface arrangements and as such no additional management of runoff is proposed.

1.5.15 Temporary works areas have been classified as either main compounds, satellite working areas or haul roads. The approach to the management of surface water runoff to these sites is dependent on the type of the temporary works site. The main compounds are limited to three areas to the west of the Proposed Scheme adjacent to the Broadway, Ringland Lane and the viaduct north abutment. An overview of the locations of the temporary works areas is provided in Figure 3.12.02a-1, **Water Environment Interfaces** in the FRA **Sub Appendix A: Figures** (Document Reference 3.12.02a). Full details of the management of runoff from the temporary works compounds is provided in Section 4 of the **Drainage Strategy Report, Appendix 4.15 Construction Surface Water Management Strategy** (Document Reference 4.04.15).

1.5.16 The PED network would play an important role in the management of surface water runoff from temporary works areas and would be embedded at the start of the construction phase. Additional drainage ditches would be constructed around the perimeter of the main and satellite compounds to collect overland flow that flows towards the compounds and convey it to the PEDs and so prevent runoff onto the compounds. Within the compounds themselves runoff would be directed via ditches and sediment barriers towards the lowest part of the compounds where a settlement pond would be installed to provide attenuation as well as silt and pollution management before discharge to the nearest PED.

1.5.17 Drainage ditches would be constructed to run parallel to haul routes or access roads or around the perimeter of parking areas. Cut off ditches or small earth bunds would be constructed bisecting the working areas to spread the discharge points of runoff into the drainage ditches and minimise flow rates. The ditches would incorporate berms to slow flows and would convey water to local settlement ponds.

Below Ground Structures

1.5.18 **Table 1-2** below presents the below ground structures identified on the scheme which may be impacted by or have an impact on groundwater flows.

Table 1-2 Summary of locations of below ground structures

Structure name	Description of below ground structure	Chainage
Piles for Wensum Viaduct	Piles consisting of 9 rows with 3 piles in each row. Diameter of 2.1m and below ground length in the region of 40m.	100 to 500
Sheet piles walls for the Temporary Works Platform	Sections of deep sheet pile walls extending to in the region of 15m below ground level in the River Wensum floodplain. These would be removed following construction.	100 to 500
Temporary works bailey bridge	In situ piles, dimensions to be confirmed in detailed design	140

Structure name	Description of below ground structure	Chainage
Piles for the Wensum Viaduct Northern Abutments	Piles consisting 2 rows of 5 piles with a diameter 1.8m. Below ground length for front row in the region of 40m, below ground length for bank row in the region of 30m.	40
Piles for the Wensum Viaduct Southern Abutments	Piles consisting 2 rows of 5 piles with a diameter 1.8m. Below ground length for front row in the region of 35m, below ground length for bank row in the region of 30m.	540
GB5 Nursery Woodland Green Bridge	Piles 1.2m diameter with below ground length up to 25m	990
Ancient woodland retaining wall	Piles 1.35m diameter with below ground length up to 18.5m	1200
BR2 Ringland Lane Bridge	Earth walls for bridge, no piles proposed	1750
GB4 Additional Green Bridge	Piles 1.2m diameter with below ground length up to 27m	2480
GB1 Broadway Green Bridge	Piles 1.2m diameter with below ground length up to 38m	3735

Structure name	Description of below ground structure	Chainage
GB2 Foxburrow Green Bridge	In situ piles, dimensions to be confirmed in detailed design	4370
Tud tributary culvert / Bat underpass culvert (CU2)	Underpass with some below ground foundations, no piles proposed.	4470

Environmental enhancements

1.5.19 Full details of the proposed environmental enhancement are set out in the **Offsite Mitigation Plans** (Document Reference 2.11.00) and plans providing an overview of the proposals are provided in **Sub Appendix M: Environmental Enhancements of the Proposed Scheme Overview** (Document Reference 3.12.02m). Typically these involve woodland, grassland or riparian planting and creation. These works would not be expected to result in an increase in runoff. The planting of these areas is expected to require minimal soils disturbance and sediment and pollution runoff risks are therefore considered to be low. As such these sites are not incorporated into the **Drainage Strategy Report** (Document Reference: 4.04.00).

1.5.20 The interaction of these sites with the various watercourses and flow paths is set out in Section 1.4.

1.6 Assessment Methodology

1.6.1 In brief the methodology used for this FRA comprises:

- Review of available relevant flood risk information to identify existing risks from all sources;
- Use all available data to determine where productive aquifers are present with shallow groundwater levels through review of previous land use and information available from Ground Investigation, the Environment Agency and the British Geological Survey (BGS);

- Review of the Proposed Scheme's proposals in terms of flood risk vulnerability and flood zone compatibility, in accordance with the methodology defined in the NPPF;
- Update of the existing 1D-2D River Wensum model to support a detailed assessment of flood risk to the Proposed Scheme and to other land;
- Development of a 1D model of Foxburrow Stream to support a detailed assessment of flood risk to the Proposed Scheme and third parties;
- Liaise with the drainage design team to ensure the management of overland flows are incorporated into the design of the proposed drainage strategy, and consider the flood risk implications of the proposed drainage strategy both to and from the Proposed Scheme;
- Consultation with the Environment Agency, Natural England, Norfolk County Council and the Norfolk Rivers IDB to confirm potential flood risk to the Proposed Scheme and agree principles for the mitigation of potential flood risk to the Proposed Scheme and other land arising from the Proposed Scheme; and
- Development of mitigation measures, as necessary, to reduce flood risk to the Proposed Scheme and third-party land to an acceptable level as informed by the hydraulic models.

1.7 Data Sources

1.7.1 The data sources used for this assessment are as follows:

- Environment Agency's online maps for flood risk (accessed August 2022) (**Ref 12.2.3**), (**Ref 12.2.4**);
- British Geological Survey (BGS) Geology of Britain viewer (**Ref 12.2.5**);
- DEFRA MAGIC Map portal (**Ref 12.2.6**);
- Flood Estimation Handbook Web Service (**Ref 12.2.7**);

- Ordnance Survey (OS) mapping;
- Google maps, Aerial Imagery (**Ref 12.2.8**);
- Greater Norwich Local Plan (GNLP), (July 2021) (**Ref 12.2.9**);
- LLFA Statutory Consultee for Planning Guidance Document (July 2022) (**Ref 12.2.10**);
- Norfolk Local Flood Risk Management Strategy (July 2015) (**Ref 12.2.11**);
- Greater Norwich Area Level 1 Strategic Flood Risk Assessment (2017) (**Ref 12.2.12**),
- Norfolk County Council Preliminary Flood Risk Assessment (**Ref 12.2.13**);
- River Wensum Restoration Strategy and associated 1D 2D hydraulic model (**Ref 12.2.14**);
- Data reviews and assessments undertaken for the Proposed Scheme by WSP:
    - **Sub Appendix B: River Wensum Hydraulic Modelling Report** (Document Reference 3.12.02b)
    - **Sub Appendix E: Foxburrow Stream Hydraulic Modelling Report** (Document Reference 3.12.02e)
    - **Sub Appendix H: Ringland Lane Hydraulic Modelling Report** (Document Reference 3.12.02h)
    - **Solar Exposure Analysis** (Document Reference 3.10.37)
    - **Drainage Strategy Report** (Document Reference: 4.04.00)
    - **Drainage Strategy Report, Appendix 4.15 Construction Surface Water Management Strategy** (Document Reference 4.04.15).

- Preliminary GIR NCCT41793-04-B-12-03 dated November 2020 provided in the Drainage Strategy Report (Document Reference: 4.04.00)
- Factual Ground Investigation Reports (GIR) and respective Appendices provided in the Drainage Strategy Report (Document Reference: 4.04.00):
    - NCCT41793-HAG-VGT-FSC-RP-GI-0001 dated February 2022,
    - NCCT41793-HAG-VGT-FSC-RP-GI-0002 dated October 2022
    - NCCT41793-HAG-VGT-FSC-RP-GI-0003 dated November 2022

2 Legislative Framework and Guidance

2.1 European Policy

2.1.1 The coordination of policies for the water environment is managed by the UK Government. Many flood risk and water quality requirements are set at European level, which are then transposed into UK law. While the United Kingdom is no longer a member of the European Union, European provisions remain in force until repealed, in accordance with the terms of the European Union (Withdrawal) Act 2018, the Retained EU Law (Revocation and Reform) Act 2023 and related provisions. The Environment Agency has a strategic overview regarding the management of all of sources of flooding and an operational responsibility for managing the risk of flooding from main rivers, reservoirs, estuaries and tidal sources. Lead Local Flood Authorities (LLFAs), in this case, Norfolk County Council are responsible for managing the risk of flooding from local sources, including surface water, groundwater and ordinary watercourses.

2.1.2 The applicable legislative framework is summarised below.

Floods Directive (2007/60/EC)

2.1.3 The key objective of the *Floods Directive* (**Ref 12.2.15**) is to coordinate the assessment and management of flood risks within Member States. Specifically, it requires Member States to assess if all watercourses and coastlines are at risk of flooding, map the flood extent, flood assets and humans at risk in these areas, and take adequate and coordinated measures to reduce this risk.

2.2 National Policy and legislation

Land Drainage Act 1991

2.2.1 Local Authorities and Internal Drainage Boards have additional functions associated with the management of flood risk under the *Land Drainage Act 1991* (**Ref 12.2.16**) Land Drainage Authorities, regulate permanent or temporary works within ordinary watercourses under their jurisdiction in order to ensure that local flood risk is not increased.

2.2.2 Section 23 of the *Land Drainage Act 1991* specifies that the following works would require formal consent from the appropriate authority:

- Construction, raising or alteration of any mill dam, weir or other like obstructions to the flow of a watercourse.
- Construction of a new culvert.
- Any alterations to an existing culvert that would affect the flow of water within a watercourse.

2.2.3 The *Land Drainage Act 1991* also sets out the maintenance responsibilities riparian owners have in order to reduce local flood risks. Riparian owners, who are landowners with a watercourse either running through their land or adjacent to it, have the responsibility to ensure that the free flow of water is not impeded by any obstruction or build-up of material within the watercourse.

Flood Risk Regulations (2009)

2.2.4 The Flood Risk Regulations (2009) (**Ref 12.2.17**) transpose the EU Floods Directive (2007/60/EC) into UK Law as of December 2009 and set out duties for the Environment Agency (EA) and Lead Local Flood Authorities (LLFAs) to prepare a range of reports and mapping outputs.

2.2.5 This includes the production of a preliminary flood risk assessment, which is a high-level screening to determine whether there is a local flood risk within the County based on past and future flood risk data.

Flood and Water Management Act 2010

2.2.6 The *Flood and Water Management Act 2010* (**Ref 12.2.18**) extended the role of the LLFA set out in the Flood Risk Regulations (**Ref 12.2.17**) to take responsibility for leading the co-ordination of local flood risk management in their areas. In accordance with the Act the Environment Agency is responsible for the management of risks associated with main rivers, the sea and reservoirs. LLFAs are responsible for the management of risks associated with local sources of flooding such as ordinary watercourses, surface water and groundwater.

2.2.7 The Act is also guiding the role of the LLFA in the review and approval of surface water management systems. The LLFA is required to review and comment on significant development in regard to Sustainable Drainage Systems (SuDS).

2.2.8 Schedule 3 of the *Flood and Water Management Act* introduced a requirement for SuDS to be designed to national standards and approved by a SuDS Approval Body (SAB) prior to construction works beginning. In England Schedule 3 was not immediately implemented however Non-Statutory Technical Standards for SuDS, discussed below, were published in 2015. A review of the implementation of Schedule 3 was completed in January 2023 which recommended its commencement. It recommended the SAB be the unitary authority or county council and the regulations not apply to

permitted development or single buildings under 100m^2. The review was accepted in January 2023 with a view to implementation in 2024.

Environmental Permitting (England and Wales) Regulations 2016

2.2.9 The *Environmental Permitting (England and Wales) Regulations 2016* (**Ref 12.2.19**) replaced the *Water Resources Act 1991* (**Ref 12.2.20**) as the key legislation for regulating the discharge of potentially polluting substances into the water environment. Under the *Environmental Permitting Regulations,* it is an offence to cause or knowingly permit a water discharge activity, including the discharge of polluting materials to freshwater, coastal waters, relevant territorial waters or groundwater, unless complying with an exemption or an environmental permit. An environmental permit is obtained from the Environment Agency.

2.2.10 With regards to flood risk activities, certain works in, under or near a main river require an environmental permit from the Environment Agency. This is obtained as a Flood Risk Activities Permit (FRAP).

National Planning Policy Framework 2023

2.2.11 The NPPF, first published in 2012 and regularly updated, (**Ref 12.2.21**) sets out the Government's planning policies for England, providing a framework within which local councils can produce their own plans that better reflect the specific needs of their communities. In regard to planning and flood risk, NPPF states that "Inappropriate development in areas at risk of flooding should be avoided by directing development away from areas at highest risk (whether existing or future). Where development is necessary in such areas, the development should be made safe for its lifetime without increasing flood risk elsewhere".

2.2.12 NPPF Paragraph 173 of Chapter 14, Meeting the challenge of climate change, flooding and coastal change, sets out standards to be met should an application be located in an area of flood risk. The application should demonstrate, through a site specific FRA, that:

(a) within the site, the most vulnerable development is located in areas of lowest flood risk, unless there are overriding reasons to prefer a different location;

(b) the development is appropriately flood resistant and resilient such that, in the event of a flood, it could be quickly brought back into use without significant refurbishment;

(c) it incorporates sustainable drainage systems, unless there is clear evidence that this would be inappropriate;

(d) any residual risk can be safely managed; and

(e) safe access and escape routes are included where appropriate, as part of an agreed emergency plan.

2.2.13 These standards should be considered in parallel with the sequential and exception test, set out in detail in the Planning Policy Guidance (PPG) for Flood Risk and Coastal Change (**Ref 12.2.22**).

2.2.14 Planning Policy Guidance (PPG) for Flood Risk and Coastal Change has been published online alongside the NPPF since 2014 to set out how certain policies, including those relating to flood risk, should be implemented. Significant updates to the PPG for Flood Risk and Coastal Change were made in August 2022 and have been considered in this FRA (discussed below).

2.2.15 PPG for Climate Change (**Ref 12.2.23**) sets out the reasons for new developments to make an allowance for climate change impacts. The climate change allowances and based on UK Climate Projections for peak river flows (July 2021) and peak rainfall intensities (May 2022). The PPG advises how to identify suitable mitigation and adaptation measures in the planning process to address the impacts of climate change.

PPG for Flood Risk and Coastal Change

2.2.16 The PPG for Flood Risk and Coastal Change identifies how new developments must take flood risks into account and steer development to those areas at lowest risk.

2.2.17 The PPG describes the Sequential Test that ensures that a sequential, risk-based approach is followed to steer new development to areas with the lowest risk of flooding, taking all sources of flood risk and climate change into account and ignoring the presence of flood management infrastructure. Only where development cannot be located in low and medium risk areas should high risk areas be considered. For individual planning applications subject to the Sequential Test, PPG states that the area to apply the Sequential Test will be defined by local circumstances relating to the type of development proposed.

2.2.18 Following the application of the Sequential Test and if it is demonstrated that the proposed development cannot be located outside of the Environment Agency's defined Flood Zones (discussed below) the Exception Test is applied to assess the flood risk vulnerability and development's incompatibility with the identified Flood Zone.

The PPG identifies Flood Zones in relation to annual flood probability. The zones refer to the probability of river (fluvial) and sea (tidal) flooding, whilst ignoring the presence of defences. **Table 2-1** summarises the relationship between Flood Zone category and the identified flood risk.

Table 2-1 Flood Zone Categorisations

Flood Risk Area	Identification	Annual probability of fluvial flooding	Annual probability of tidal flooding
Zone 1	Low probability	< 1 in 1000 (0.1%)	< 1 in 1000 (0.1%)

Flood Risk Area	Identification	Annual probability of fluvial flooding	Annual probability of tidal flooding
Zone 2	Medium probability	1 in 100 (1%) – 1 in 1000 (0.1%)	1 in 200 (0.5%) – 1 in 1000 (0.1%)
Zone 3a	High probability	> 1 in 100 (1%)	> 1 in 200 (0.5%)
Zone 3b	Functional Floodplain	> 1 in 30 (3.3%)	> 1 in 30 (3.3%)

Note that the identification of the functional floodplain should take account of local circumstances. It will normally comprise land at risk of flooding in the 1 in 30 annual probability event. The functional floodplain also includes land that is designed to flood (such as a flood attenuation scheme) even if it would only flood in more extreme events (such as 1 in 1000 annual probability of flooding)

2.2.19 To apply the Exception Test, the PPG identifies five classifications of flood risk vulnerability and provides recommendations on the incompatibility of each vulnerability classification with the Flood Zones, as shown in **Table 2-2**. Full details of the Flood Zones and flood risk vulnerability classifications can be found in the PPG for Flood Risk and Coastal Change.

Table 2-2 Flood risk vulnerability and associated acceptability of development in Flood Zone

EA Flood Zone	Essential Infrastructure	Water Compatible	Highly Vulnerable	More Vulnerable	Less Vulnerable
Zone 1	Exception test not required	Exception test not required	Exception test not required	Exception test not required	Exception test not required

EA Flood Zone	Essential Infrastructure	Water Compatible	Highly Vulnerable	More Vulnerable	Less Vulnerable
Zone 2	Exception test not required	Exception test not required	Exception test required	Exception test not required	Exception test not required
Zone 3a	Exception test required	Exception test not required	Development should not be permitted	Exception test required	Exception test not required
Zone 3b	Exception test required	Exception test not required	Development should not be permitted	Development should not be permitted	Development should not be permitted

2.2.20 The PPG clarifies that:

- For Essential Infrastructure in Flood Zone 3a, development should be designed and constructed to remain operational and safe in times of flood; and
- For Essential Infrastructure and Water Compatible development in Flood Zone 3b, development should be designed and constructed to:
    - Remain operational and safe for users in times of flood;
    - Result in no net loss of floodplain storage; and
    - Not impede water flows and not increase flood risk elsewhere.

2.2.21 For the Exception Test to be passed, it should also be demonstrated that:

- The development would provide wider sustainability benefits to the community that outweigh the flood risk; and
- The development would be safe for its lifetime taking account of the vulnerability of its users, without increasing flood risk elsewhere, and, where possible, would reduce flood risk overall.

2.2.22 For the assessment of flood risk, the PPG requires the following sources of flooding, relevant to this study, to be considered:

- Fluvial flood risk from nearby watercourses;
- Surface water flooding from within the application boundary and adjacent land;
- Groundwater flooding; and
- Flood risk from other artificial sources such as canals and impounded reservoirs.

2.2.23 The PPG clarifies the definition of the 'design flood' to be a flood event of a given annual flood probability, which is generally taken as:

- River flooding likely to occur with a 1 in 100 (1%) annual probability; or
- Tidal flooding with a 1 in 200 (0.5%) annual probability; or
- Surface water flooding likely to occur with a 1 in 100 (1%) annual probability,

2.2.24 The PPG sets out the requirement to consider Sustainable Drainage Systems (SuDS) within all new development where appropriate. It states that developments should aim to discharge surface run off as high up the following hierarchy of drainage options as reasonably practicable:

1. Into the ground (infiltration);
2. To a surface water body;
3. To a surface water sewer, highway drain, or another drainage system;
4. To a combined sewer.

2.2.25 Within Norfolk there is a change to this hierarchy where collection for reuse is inserted as the first stage with the remaining stages following in the order presented above. This is discussed further in Section 2.3 with the LLFA's Statutory Consultee for Planning Guidance document.

2.2.26 Information regarding expected minimum standards is provided within the Non-Statutory Technical Standards for Sustainable Drainage Systems (SuDS) published by DEFRA in March 2015 (discussed below).

PPG for Climate Change

2.2.27 Scientific consensus is that the global climate is changing as a result of human activity. While there remain uncertainties as to how a changing climate will affect areas already vulnerable to flooding, it is expected to increase risk significantly over time. For the UK, projections of future climate change indicate that more frequent short-duration high-intensity rainfall events and more frequent periods of long-duration rainfall could be expected.

2.2.28 Updated climate change recommendations for peak river flows were published by the Environment Agency in July 2021. The impacts of climate change are expected to increase over time and the Environment Agency guidance provides a range of estimates for increases in peak river flow, peak rainfall intensity and sea level rise over the next 100 years. This is reflected by larger allowances recommended for developments with a longer design life.

2.2.29 The precise extent of the impacts of climate change is unknown. This is reflected in the Environment Agency's guidance which provides 'Central', 'Higher Central' and 'Upper End' estimates that are based on the 50th, 70th and 90th percentile predictions for climate change.

2.2.30 The increases in peak fluvial flows are also expected to vary depending on geographical location. To account for this the Environment Agency guidance divides England into eleven river basin districts. The Proposed Scheme that is the focus of this FRA is located within the Broadland Rivers Management Catchment. **Table 2-3** shows the recommended increase in peak river flows to be assessed within this FRA to allow for the impacts of climate change in this district.

Table 2-3 Recommended climate change peak river flow allowances for the Broadland Rivers Management Catchment

Peak river flow allowance category	Total potential change anticipated 2020s (%)	Total potential change anticipated 2050s (%)	Total potential change anticipated 2080s (%)
Upper End	27	27	44
Higher Central	14	10	20
Central	8	3	11

2.2.31 The selection of peak river flow allowances depends on the vulnerability of the proposed development. For Essential Infrastructure, it is advised that the Higher Central allowance is used to inform the assessment of flood risk. It is also advised that the Central Allowance is used in most cases to calculate floodplain storage compensation, unless the affected area contains Essential Infrastructure in which case the Higher Central allowance should be used.

2.2.32 The 2080s epoch is considered most applicable for this FRA to reflect the likely design life of the Proposed Scheme. Whilst PPG indicates the Higher Central allowance is used to inform the assessment, it also recommends the Upper End allowance is considered as a credible maximum scenario to understand the sensitivity of the scheme to uncertainty. Given the nature of this scheme, the Upper End allowance has been applied, with a 44% increase in modelled peak river flow, to be confident the Proposed Scheme is not sensitive to a credible maximum scenario. This is greater than is required under the PPG and will provide more robust assessment and mitigation of flood risk.

2.2.33 **Table 2-4** summarises the Environment Agency's guidance for increases to peak rainfall intensity for the Broadland Rivers Management Catchment for the 1% annual exceedance probability event. This information is typically applied to the assessment of surface water runoff but can also be applied to

small watercourses that have a catchment of less than c.5km^2 which respond much more quickly to intense rainfall events.

Table 2-4 Peak rainfall intensity allowance for the Broadland Rivers Management Catchment

Annual exceedance probability	Peak rainfall intensity allowance category	Total potential change anticipated 2050s (%)	Total potential change anticipated 2070s (%)
1 in 30	Upper End	40	40
1 in 30	Central	20	20
1 in 100	Upper End	45	40
1 in 100	Central	20	20

2.2.34 For development with a design life beyond 2100, the Upper End allowances for the 2070s epoch should be applied within the assessment for both the 1 in 30 and 1 in 100 annual probability events in accordance with the NPPF. The exception to this is where the allowances for the 2050s epoch are higher than the 2070s epoch, in these instances the higher of the two allowances should be used. That is the case in the Broadlands Rivers Management Catchment.

National Flood and Coastal Erosion Risk Management Strategy for England 2021

2.2.35 The Flood and Water Management Act 2010 places a statutory duty on the Environment Agency to develop a National Flood and Coastal Erosion Risk Management Strategy for England. This strategy describes what needs to be done by all risk management authorities (RMAs) involved in flood and coastal erosion risk management for the benefit of people and places. The strategy provides a framework for guiding the operational activities and decision making of practitioners.

2.2.36 The strategy, supported by its Action Plan, sets out how it will complement the NPPF and PPG to achieve climate-resilient places and development. The Environment Agency, as a statutory advisor, infrastructure provider and regulator with a strategic overview provides a key role in advising those

involved with development to avoid inappropriate development in flood zones and to enable climate resilient development.

Non-Statutory Technical Standards for Sustainable Drainage Systems 2015

2.2.37 The Non-Statutory Technical Standards for SuDS (**Ref 12.2.24**), published by DEFRA in March 2015, set out the core technical standards for SuDS proposed within England. These standards should be used in accordance with the NPPF and PPG. The standards include guidance on controlling flood risk within a development boundary and elsewhere, peak flow and runoff volume control, and the structural integrity of SuDS.

2.2.38 Consultations in preparation for the implementation of Schedule 3 to the *Flood and Water Management Act* indicate these Non-Statutory Technical Standards for SuDS will be replaced by new standards.to be implemented by the SABs.

LA 113 Road Drainage and the Water Environment

2.2.39 The Design Manual for Roads and Bridges (DMRB) (LA 113) sets out the requirements for the assessment and management of the impacts that road projects can have on the water environment, including those related to flood risk.

2.2.40 Of key importance is that LA 113 states that road projects must be compliant with relevant national policy and meet the requirements of the relevant overseeing organisations (in this case the Environment Agency and Norfolk County Council).

2.2.41 It states that, if required, an FRA shall be carried out in accordance with the NPPF and associated PPG on Flood Risk and Coastal Change.

2.2.42 It also states that all projects on motorways and all-purpose trunk roads shall be designed to:

- Remain operational and safe for users in times of flood;
- Result in no net loss of floodplain storage;
- Not impede water flows; and

- Not increase flood risk elsewhere.

2.2.43 To support the assessment of significance of impacts on the water environment LA 113 provides guidance on classifying the importance on water environment attributes and the magnitude of the impact on an attribute. These should be read in conjunction with the significance matrix provided in LA 104 Environmental Assessment and Monitoring and duplicated in **Table 2-5**.

Table 2-5 LA 104 Environmental Assessment significance matrix

Environmental value (sensitivity)	**No change**	**Negligible Impact**	**Minor Impact**	**Moderate Impact**	**Major Impact**
Very high	Neutral	Slight	Moderate or large	Large or very large	Very large
High	Neutral	Slight	Slight or moderate	Moderate or large	Large or very large
Medium	Neutral	Neutral or slight	Slight	Moderate	Moderate or large
Low	Neutral	Neutral or slight	Neutral or slight	Slight	Slight or moderate
Negligible	Neutral	Neutral	Neutral or slight	Neutral or slight	Slight

2.2.44 With respect to flood risk LA 113 classifies the environmental value (sensitivity) of water environment attributes using the NPPF vulnerability classifications as follows:

- Very high – Essential infrastructure or highly vulnerable development
- High – More vulnerable development
- Medium – Less vulnerable development
- Low – Water compatible development

2.2.45 With respect to increases in flood risk LA 113 classifies the magnitude of adverse impact as follows:

- Major adverse – Increase in peak flood level (>100mm)
- Moderate adverse – Increase in peak flood level (>50mm)
- Minor adverse – Increase in peak flood level (>10mm)
- Negligible – Increase in peak flood level (<10mm)

2.2.46 The assessment of flood risk must apply the latest climate change allowances published by the Environment Agency for the river basin district in which the scheme is located.

2.2.47 Environmental permits / licences (or registered exemptions) must be obtained prior to carrying out any activity that has the potential to affect flood risk, in accordance with the relevant legislative requirements.

2.3 Local Policy

Emerging Greater Norwich Local Plan

2.3.1 Broadland District Council, Norwich City Council and South Norfolk Council have, together with Norfolk County Council, prepared the Greater Norwich Local Plan (GNLP). The GNLP was submitted to the Secretary of State for examination in public on 30 July 2021 and is currently being examined.

2.3.2 The GNLP will provide the strategy to meet the government requirements for growth in the Greater Norwich area to 2038. It identifies the locations for future housing and employment growth and the associated infrastructure needs. The development of the strategy recognises the requirements set out in the NPPF and as such is consistent with promoting development that provides for blue green infrastructure (natural and semi-natural areas designed to deliver a wide range of ecosystem services) and considers the risk of flooding.

2.3.3 Policy 4 of the GNLP sets out the need for strategic infrastructure and is supported by the Greater Norwich Plan Local Infrastructure Needs Report (GNLPIR) (**Ref 12.2.25**) for its evidence base.

Lead Local Flood Authority Statutory Consultee for Planning Guidance Document

2.3.4 As a statutory consultee on plans for major development Norfolk County Council has set out its requirements in the LLFA Statutory Consultee for Planning Guidance Document (October 2022). This document includes standing advice for ordinary watercourse consenting and reiterates Policy OW4 in the Norfolk Local Flood Risk Management Strategy (LFRMS).

2.3.5 The document also sets out in detail the requirements for Sustainable Drainage Systems (SuDS) design. In a slight change from the NPPF drainage hierarchy, reflecting water supply pressures in the east of England, the guidance prioritises the efficient use of water and promotes collection for reuse as the primary option in the SuDS hierarchy.

2.3.6 For the design of watercourse crossings this guidance directs designers to the Construction Industry Research and Information Association (CIRIA) Culvert Design and Operation Guide (**Ref 12.2.26**).

Norfolk Local Flood Risk Management Strategy (2015)

2.3.7 The Local Flood Risk Management Strategy (LFRMS) establishes the roles and responsibilities for managing flood risk within Norfolk and a framework of policies that will ensure that riparian owners, businesses, developers and authorities apply a consistent and strategic approach to flood management. It includes details of how flood risk management operations will be funded and resulting activities monitored.

2.3.8 The LFRMS sets out the management context for all watercourses within Norfolk. For the purposes of this FRA the Proposed Scheme sits within the River Wensum catchment, which is a tributary of the River Yare and as such sits within the Broadland Rivers (River Yare) WFD Management Catchment Area. The Wensum catchment itself straddles the boundaries of Broadland,

Breckland and North Norfolk District Councils; the Proposed Scheme sits wholly within Broadlands District Council Boundary. Both the River Wensum and Foxburrow Stream are covered by the Norfolk Rivers IDB, noting that the River Wensum is a main river and as such falls under the remit of the Environment Agency. The floodplains of both the River Wensum and River Tud are important for ameliorating the effect of flooding within Norwich.

2.3.9 The LFRMS identifies seven core objectives as follows:

- Determine and communicate flood risk – undertake projects to support this understanding;
- Partnership working – work and coordinate with other RMAs;
- Partnership programmes and projects – coordinate with RMAs to optimise resources;
- Riparian responsibilities – encourage the management of privately owned watercourses;
- Flood risk and development – support planning policies and drive consistency in development;
- Water Framework Directive – support the requirements of the WFD; and
- Support Water and Sewerage Infrastructure - work with utilities companies to support flood risk reduction.

2.3.10 These objectives are supported by a suite of policies. These policies were revised and updated in 2021 as part of a Local Flood Risk Management Strategy Policy Review in response to significant flooding post 2015 and to provide consistency with the National Flood and Coastal Erosion Risk Management Strategy for England (July 2020). Policies of note and relevant to this FRA are:

- Policy OW4 Culverting which sets out the preference to avoid culverting of ordinary watercourses and the conditions to be met where culverting is proposed.

Greater Norwich Area Level 1 Strategic Flood Risk Assessment (2017)

2.3.11 The Greater Norwich Area Level 1 Strategic Flood Risk Assessment (SFRA, 2017) states that its aim is to inform the preparation of future Local Plans, through shared objectives and strategic priorities.

2.3.12 A consortium of Norfolk Local Planning Authorities (LPAs) comprising Broadland District Council, Great Yarmouth Borough Council, the Borough Council of King's Lynn and West Norfolk, North Norfolk District Council, Norwich City Council, South Norfolk Council and the Broads Authority, commissioned the Level 1 SFRAs to inform strategic planning decisions, the preparation of Local Plans and to inform development management decisions.

2.3.13 The Greater Norwich SFRA summarises flood risk from all sources and defines the Functional Floodplain, as well as provides information regarding historic flooding events in the region. It presents a sequential approach to site allocation, which includes, as a first stage, the Sequential Test and Exception Test as outlined by the NPPF. The SFRA states that any new development proposal must also be in line with policies set out in Local Plans, until the Greater Norwich Local Plan is adopted.

Greater Norwich Area Level 2 Strategic Flood Risk Assessment (2021)

2.3.14 The Greater Norwich Area Level 2 Strategic Flood Risk Assessment (SFRA, 2021) builds on the Level 1 SFRA and investigates flood risk at 26 sites in and around Norwich in increased detail.

2.3.15 The River Wensum catchment was identified in the Cumulative Impact Assessment as at high risk from development in the future, albeit within Norwich.

Norfolk County Council Preliminary Flood Risk Assessment Report (2011)

2.3.16 In 2011 Norfolk County Council prepared a Preliminary Flood Risk Assessment (PFRA) to meet the council's duties, as LLFA, to manage local flood risk and deliver the requirements of the Flood Risk Regulations.

2.3.17 The document is a high-level screening as to whether there is a local flood risk from surface water, groundwater, ordinary watercourses and canals within the LLFA boundary based on past (historic) and future (potential) flood risk data.

2.3.18 The PFRA has been based on the Environment Agency's Final PFRA Guidance (**Ref 12.2.27**) and Defra's Guidance on selecting Flood Risk Areas (**Ref 12.2.28**). This approach identified indicative Flood Risk Areas across the country where the flood risk thresholds set-up by the DEFRA guidance reached over 30,000 people based on Flood Map for Surface Water (FMfSW) and the National Receptor Dataset (NRD). No indicative Flood Risk Areas have been identified in Norfolk, however, it must be noted that there is a high risk of flooding from local sources across the county, particularly from surface water and in combination with other sources of flooding such as main rivers and the sea.

River Wensum Restoration Strategy

2.3.19 The River Wensum Restoration Strategy (RWRS) is a long-term strategy aimed at facilitating positive change in the river corridor. It is anticipated that the strategy will deliver physical improvements and greater activity to the River Wensum and will, in combination with other proposals and initiatives, help change perceptions of the river and the city as a visitor destination, and act as an economic driver to attract significant external investment into the river corridor.

2.3.20 The aim of the RWRS is not for the River Wensum to achieve its former 'natural' condition, but to restore hydrological functioning so that it can sustain wildlife and fisheries characteristic of its chalk stream river type. The rationale for this is set out in draft guidelines for restoration of river SSSIs, prepared

jointly by Natural England and the Environment Agency. Work is currently ongoing and is set to be completed by 2027.

2.3.21 The RWRS includes improvements upstream near Attlebridge, with the works referred to as the Attlebridge Scheme, and downstream at Costessey. The details of the latter restoration works have been provided for the purposes of this study in the form an updated hydraulic model incorporating the proposals. Further details are provided in **Sub Appendix B: River Wensum Hydraulic Modelling Report** (Document Reference 3.12.02b).

2.3.22 Further proposals currently under consideration aim to reduce the impact of the impoundment of water at the mill structure at Taverham Mill. The main hydraulic control within the mill complex is the weir structure on the main Wensum channel. Therefore, any works at Taverham Mill are likely to address this structure specifically. The work is at an early stage, but it appears a bypass channel approach is the preferred improvement strategy. Further discussion on these proposals is provided in **Sub Appendix B: River Wensum Hydraulic Modelling Report** (Document Reference 3.12.02b).

2.4 Local Partnerships

Norfolk Strategic Flood Alliance

2.4.1 The Norfolk Strategic Flood Alliance (NSFA) was formed in February 2021 following the significant flooding in December 2020 and the recognition that flood response between Risk Management Authorities (RMAs) could be better coordinated.

2.4.2 The NSFA proposes a tiered approach to coordination, these tiers reflect the levels of communication to be undertaken between RMAs. These tiers are at strategic (between the NSFA and Water Resources East), tactical (between the NSFA, local authority and associated primary stakeholders) and operational levels (between the NSFA and parish and town councils).

2.4.3 An accompanying action plan identifies 28 locations where further work is ongoing to address known flood risk problems.

2.5 Consultation

2.5.1 Statutory consultees have been involved through the FRA process. Early consultations were undertaken through the Outline Business Case process, and these are duplicated in **Table 2-6**. A summary of consultation undertaken since the submission of the OBC and to inform this FRA is presented in **Table 2-7**.

2.5.2 Responses to the consultation received as part of the EIA scoping phase are presented in Section 12.3 of **Chapter 12: Road Drainage and the Water Environment** (Document Reference: 3.12.00) of the Environmental Statement.

2.5.3 In addition to the tables below, extensive consultation has been undertaken with the LLFA as part of the development of the **Drainage Strategy Report** (Document Reference: 4.04.00). Full details are presented in Section 12 of the same report and are not reproduced here.

2.5.4 Finally full details of consultation to support the assessments associated with **Chapter 12: Road Drainage and the Water Environment** (Document Reference: 3.12.00) of the Environmental Statement are provided in the **Road Drainage and the Water Environment Consultation** (Document Reference: 3.12.06).

Table 2-6 Summary of Consultation in OBC Stage

Body / Organisation	Date of Consultation	Key Outcomes of Discussions
Joint Environment Agency / Natural England meeting with Norfolk County Council	18 October 2018	Initial discussions on flood risk, design levels and requirements for climate change, water quality, biodiversity & WFD.
Joint Environment Agency / Natural England meeting with Norfolk County Council	08 March 2019	Discussion regarding flood risk, design levels and requirements for climate change; potential construction mitigation for effects of the bridge structure to rivers and floodplains; and opportunities for surface water design, SuDS, infiltration as possible drainage strategy.
Joint Environment Agency / Natural England meeting with Norfolk County Council	13 June 2019	Discussion of proposed scope to inform Outline Business Case and understanding of the Flood Risk Appraisal.
Environment Agency	09 August 2019	The Applicant shares scope of works for the Water Environment EAR Chapter and Flood Risk Appraisal to support the Outline Business Case.
Joint Environment Agency / Natural England meeting with Norfolk County Council	13 August 2019	Discussion of flood risk scope. Surface water surveys.
Environment Agency	16 August 2019	Meeting to discuss the preliminary ground investigation observation borehole placement rationale with the Environment Agency. Meeting ended in agreement of proposed borehole placement strategy and proposed monitoring scheduling.
Environment Agency	28 August 2019	The Environment Agency agree on proposed Flood Risk Appraisal methodology for assessing of flood risks arising from the proposed development but note that a more detailed assessment will be necessary to determine the flood risk impacts in enough detail for the planning application stage.
Environment Agency	04 November 2019	The Applicant shares the proposed methodology for updating the Environment Agency approved CH2M 2016 1D model of the Upper Wensum to inform the Flood Risk Appraisal and Flood Risk Assessment.
Joint Environment Agency / Natural England meeting with Norfolk County Council	05 November 2019	Discussion on surface water: modelling and Flood Risk Appraisal. Agree on data request to the EA to inform drainage design team on minimum requirements.

Body / Organisation	Date of Consultation	Key Outcomes of Discussions
Environment Agency	21 November 2019	Response from Environment Agency to confirm understanding that updated 1D hydraulic model will be developed to support the Outline Business Case. After which the hydraulic model will be further developed into a 1D-2D linked hydraulic model to support the Flood Risk Assessment for the submission of the planning application. Comments provided on methodology.
Environment Agency / Natural England	14 January 2020	The Applicant shares viaduct substructure plans with Natural England and the Environment Agency.
Joint Environment Agency / Natural England meeting with Norfolk County Council	21 January 2020	Discussion on requirements of WFD Screening Assessment.
Environment Agency	24 January 2020	The Applicant issues revised methodology for flood risk modelling following receipt of EA comments on 21 November 2019.
Norfolk County Council (as Lead Local Flood Authority)	29 January 2020	Meeting to discuss proposed drainage strategy and design for watercourse crossings and water quality treatment measures.
Environment Agency	03 February 2020	Data request with an accompanying study area of interest to Environment Agency. The data is to inform the drainage design team and the Road Drainage and Water Environment chapter of the Environmental Statement.
Environment Agency	10 February 2020	Environment Agency's response on constructability and implications for flood risk, water quality and WFD. Environment Agency also confirms floodplain compensation is to be provided during construction phase of the Scheme.
Natural England	21 February 2020	Natural England comment on constructability of the Scheme, particularly the protection of the River Wensum, its flora, fauna and supporting processes (ground and surface hydrology). Natural England also state discharges to surface waters with potential to enter the river should be of sufficient quality not to have an adverse effect on the River Wensum, with appropriate pre-treatment as required.
Environment Agency	10 March 2020	Environment Agency Data request received.

Table 2-7 Summary of consultations regarding the flood risk assessment

Consultee	Type of consultation and date	Opinion
Environment Agency	Various through 2021 / 2022. Confirmation of suitability received 17 June 2022	*River Wensum Hydraulic Model* Consultation undertaken on the development of the baseline hydraulic modelling work. Feedback has been received on the suitability of the hydrology and the need to adequately consider the River Wensum restoration strategy. The baseline hydraulic modelling methodology, hydrology and model have been issued and been through a number of iterations with the Environment Agency to address comments. The Environment Agency have confirmed these methods set out in the submitted reports and the model are acceptable for the baseline.
Environment Agency	Various through 2021 Agreement reached 07 May 2021	*River Wensum Restoration Study* Consultation to confirm the scope of work for adequately accounting for the restoration strategy within the River Wensum model. The work builds on the latest restoration strategy model and this incorporates the updates around Costessey. The remaining reaches of relevance identified were Reach 4, 5, 6 and 7. Reaches 7 was identified to have limited potential to go forward and Reach 5 and 6 were expected to have minimal impact on water levels. It was agreed that the proposals at Reach 4 to lower the Taverham Mill weir level should be included in the assessment.

Consultee	Type of consultation and date	Opinion
Environment Agency / Natural England	Various through 2021 / 2023	*River Wensum Temporary Works* Continuing engagement on the temporary works proposals and likely impacts through a series of meetings and correspondence. Full details of the temporary works proposals are provided in Section 4.2 of this FRA, but they will include a Temporary Works Platform across the Wensum floodplain which will funnel flows along the River Wensum increasing velocities along this reach and increasing the risk of scour during a flood event. Mitigation is included within the temporary works proposals through the incorporation of flood relief culverts beneath the working platform but this will not be able to prevent increasing water levels upstream or remove the risk of scour. Options for erosion protection works were considered and presented to the EA and NE at a meeting on the 16th December 2021. The broad consensus at the meeting was that the impact of erosion protection works on the River Wensum SAC would likely exceed the potential impact of scour from a flood event. This is discussed further with the **Water Framework Directive Assessment** (Document Reference 3.12.03). In their response to the presentation on 20th January 2022 NE agreed in principle that the Wensum should not be a static river. NE requested further evidence within the HRA that scour impacts would not exacerbate existing in channel hydromorphological issues on this reach. The EA responded similarly to the presentation on the 20th January 2022 that there is benefit to encouraging flow diversity through this reach and that in channel erosion protection works should be avoided. However, requests were made to make the bailey bridge that spans the River Wensum connecting the temporary works platform on either bank as large as possible and to include more culverts beneath the temporary works platform where possible to mitigate scour. These discussions are relevant from a flood risk perspective only on the basis that the temporary works proposals are likely to remain broadly consistent with the approach presented. Further correspondence was received from the Environment Agency on the 18th July 2023 highlighting the need for the FRA to demonstrate that adequate compensatory storage for the temporary works to offset the impacts. A follow up meeting relating to this was held on 13th December 2023. This is further discussed in Section 4.2.

3 Existing Flood Risk

3.1 Introduction

3.1.1 This chapter reviews the existing flood risk in the vicinity of the Proposed Scheme. This is informed by a desk-based study of freely available flood risk information, hydraulic modelling of affected watercourses, and information gained from site visits that also informs some of the flood risk conclusions.

3.2 Tidal flood risk

3.2.1 Tidal flood risk to the Proposed Scheme would be via the River Wensum corridor. The normal tidal limit for the River Wensum is located at New Mills in the centre of Norwich. The Wensum Model Report (2017) (**Ref 12.2.29**) indicates that tidal flood events are typically attenuated by storage in the broads and that within Norwich itself flood risk is fluvially dominated. Further to the above, bed levels in the River Wensum in the vicinity of the scheme are approximately 8m AOD. The 1 in 200 annual probability event peak water level at Reedham (the closest coastal design sea level estimation point), downstream of Norwich is 1.79m AOD to the 97.5% confidence level. The total sea level rise allowances for the Anglian Region to 2125 is 1.6m and the H++ allowance to 2100 is 1.9m. Using the H++ allowance for sea level rise, the 1 in 200 annual probability event peak water level at Reedham is 3.69m AOD.

3.2.2 On the basis of the above there is no evidence that the Proposed Scheme is located within an area that is affected by tidal flood risk. As such, this source of flooding is not considered further in the assessment.

3.3 Fluvial Flood Risk

3.3.1 The site of the Proposed Scheme is identified to be at risk from fluvial sources associated with the River Wensum and Foxburrow Stream. These sources of flooding are discussed in detail below.

3.3.2 The assessment considers mapping presented in the Environment Agency's Flood Map for Planning that defines the fluvial Flood Zones. Mapping from these national data sources can be found in Figures 3.12.02a-8 **River Wensum Flood Map for Planning Fluvial Flood Risk** and 3.12.02a-144 **Foxburrow Stream Flood Map for Planning Fluvial Flood Risk** in **Sub Appendix A: Figures** (Document Reference 3.12.02a). The presentation of fluvial flood risk is provided separately for the two watercourses crossed by the Proposed Scheme.

3.3.3 To fully assess the baseline condition and flood risk impacts associated with the Proposed Scheme, hydraulic modelling of the pertinent sections of the affected watercourses has been completed, through two flood modelling studies: one for the River Wensum and another for Foxburrow Stream. Full details of the modelling work completed are provided in **Sub Appendix B: River Wensum Hydraulic Modelling Report** (Document Reference 3.12.02b) and **Sub Appendix E: Foxburrow Stream Hydraulic Modelling Report** (Document Reference 3.12.02e).

River Wensum

3.3.4 The Environment Agency's Flood Map for Planning shows that the River Wensum has a wide floodplain throughout the Study Area, where land currently lies in Flood Zones 2 and 3. Flood Zone 3 is classed as having a High Probability of flooding and is assessed as land having a 1 in 100 or greater annual probability of river flooding. Flood Zone 2 is classed as having a Medium Probability of flooding and is assessed as land having between a 1 in 100 and 1 in 1,000 annual probability of river flooding.

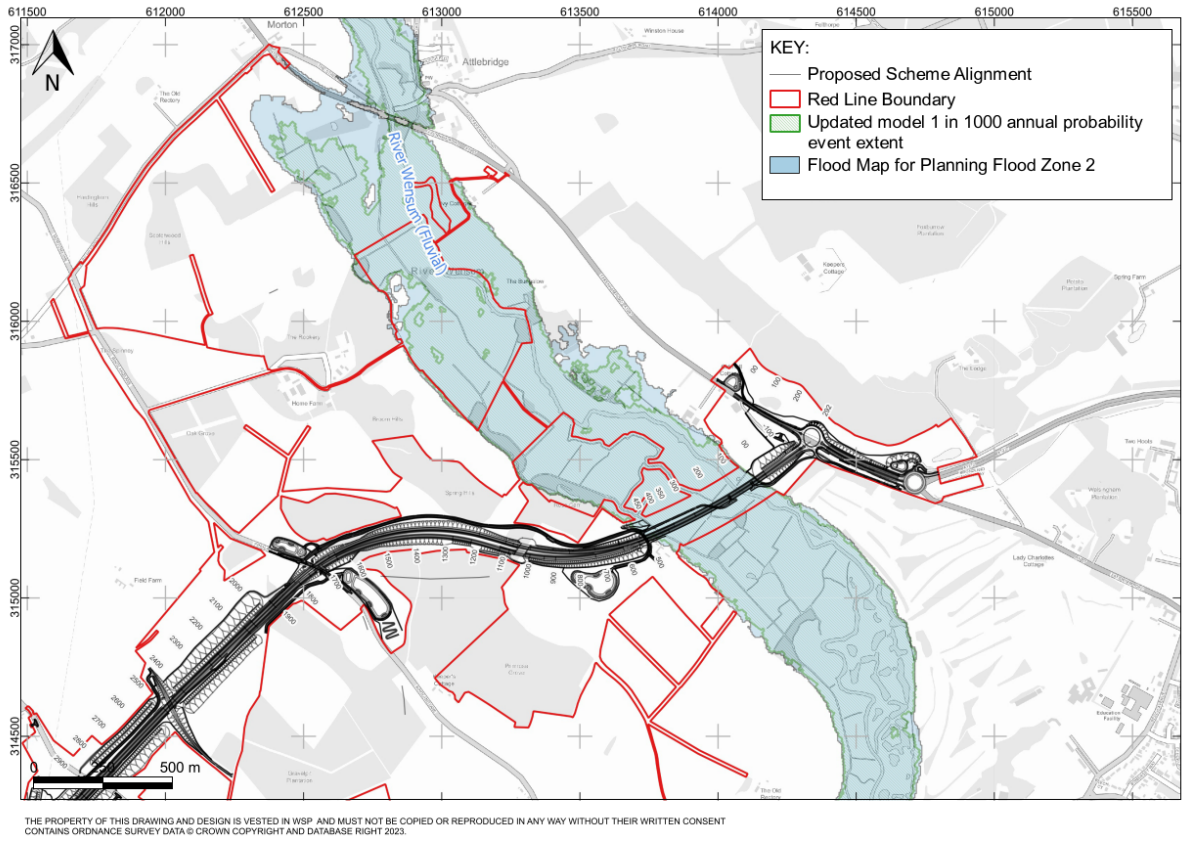
3.3.5 The floodplain of the River Wensum at the location of the Proposed Scheme is largely confined to the surrounding rural floodplain and open green space. The right bank of the floodplain is significantly wider, approximately 300m, and contains a network of drainage ditches. The left bank is constrained by high ground and the floodplain here is closer to 50m wide in comparison.

3.3.6 A review of the Chronology of British Hydrological Events (2020) indicates that the largest flood on the Wensum occurred in 1912. More recently, a flood investigation report by Norfolk County Council from 2014 indicates that two rainfall events occurred on the 27th of May and the 20th of July 2014, resulting in the flooding of 80 properties within the Norwich urban area. Along the reach of interest, no flooding incidents have been reported.

3.3.7 The latest hydraulic model and associated hydrology for the River Wensum has been provided for the purposes of this study. It is a linked 1D 2D model that extends from the Trout Stream tributary upstream of Attlebridge to Drayton. It has been updated to improve representation in the local area. Full details of the modelling work undertaken are provided in **Sub Appendix B: River Wensum Hydraulic Modelling Report** (Document Reference 3.12.02b).

3.3.8 Flood extents have been generated for the 1 in 2, 5, 30, 30+44%, 50, 100, 1000, 100+11%, 100+20% and 100+44% annual probability events presented in Figure 3.12.02a-10 to Figure 3.12.02a-43 in **Sub Appendix A: Figures** (Document Reference 3.12.02a). These extents include the floodplain as grid surface in the model, allowing for detailed representation of floodplain capacity and flow direction, compared to the existing Flood Zones, which represent the floodplain as extended cross sections only, and so represent an improved baseline compared to the national datasets. The new extents also take account of the latest climate change guidance. The baseline flood extents and depth, velocity and hazard grids for the River Wensum for a range of return periods are shown in Figures 3.12.02a-10 to 3.12.02a-43 in **Sub Appendix A: Figures** (Document Reference 3.12.02a). **Figure 3.1** provides a comparison between the Flood Zone 2 and the updated model extents at the location of the viaduct for the 1 in 1000 annual probability event. The 1 in 100 +44% annual probability event is very similar in magnitude to the 1 in 1000 annual probability event albeit slightly larger. These two extents are therefore very similar in size.

Figure 3-1 River Wensum comparison of updated model extent with the Flood Zone 2 for the 1 in 1000 annual probability event



3.3.9 The modelled extents are slightly reduced compared to the Flood Zones, most likely a result of more detailed representation of the floodplain which includes full representation of the ground model using the latest available LIDAR data.

3.3.10 The baseline mapping confirms the River Wensum floodplain extent is not overly sensitive to flows. The functional floodplain (1 in 30 annual probability event) extent is smaller in locations but broadly consistent with the modelled extents shown in the 1 in 1000 and 1 in 100+44% annual probability events. There is also negligible difference in extents between the 1 in 100 and 1 in 100+44% annual probability events.

3.3.11 The groundwater influence on the River Wensum means water levels are elevated for a long time. The gradient is shallow as well, as such during flood events the floodplain fills to capacity and flows at the location of the Proposed Scheme viaduct are controlled by the downstream channel capacity and

Ringland Lane. Typical velocities are low, less than 0.5m/s, even in the 1 in 100 plus 44% annual probability event.

3.3.12 Potential flood risk receptors in the River Wensum floodplain have been identified following a review of the 1 in 100 +44% annual probability event. Potential receptors are discussed below.

3.3.13 Upstream of the Proposed Scheme viaduct the following receptors are noted:

- The floodplain downstream of Fakenham Road is grazing farmland (which is classified as a less vulnerable receptor) except for a local access road linking Fakenham Road at the Wensum Bridge to St Margaret's Church. This is not the primary access route for the church and as such has also been classified as a less vulnerable receptor.
- On the left bank 300m upstream of the Proposed Scheme viaduct, Old Hall Farm house is close to but not within the floodplain, this is classified as a more vulnerable receptor.
- On the left bank 400m downstream of Fakenham Road Bridge there is a residential property close to but not within the floodplain, this is classified as a more vulnerable receptor.
- Upstream of Fakenham Road Bridge on the left bank there are a number of commercial properties and on the right bank two residential properties within the flood extent, the commercial properties are classified as less vulnerable receptors and the residential properties as more vulnerable receptors.
- On the left bank 300m upstream of Fakenham Road Bridge, Ashtree Farm properties are within the flood extent, these are classified as more vulnerable receptors.

3.3.14 Downstream of the Proposed Scheme viaduct the following receptors are noted:

- The floodplain to Ringland Lane Bridge is predominantly grazing farmland, a less vulnerable receptor.
- A gas main runs across the River Wensum and can be seen in the bed approximately 450m downstream of the viaduct, this is classified as essential infrastructure.
- Wensum Valley Hotel golf course is within the floodplain on the left bank and classified as a less vulnerable receptor.
- On the right bank 600m upstream of Ringland Lane Bridge, Glebe Farm, classified as a more vulnerable receptor is within the floodplain.
- On the right bank in Ringland there are a number of residential properties, classified as more vulnerable receptors, upstream of Ringland Lane in the floodplain.
- Downstream of Ringland Lane the floodplain has no properties of note until Taverham.

Foxburrow Stream

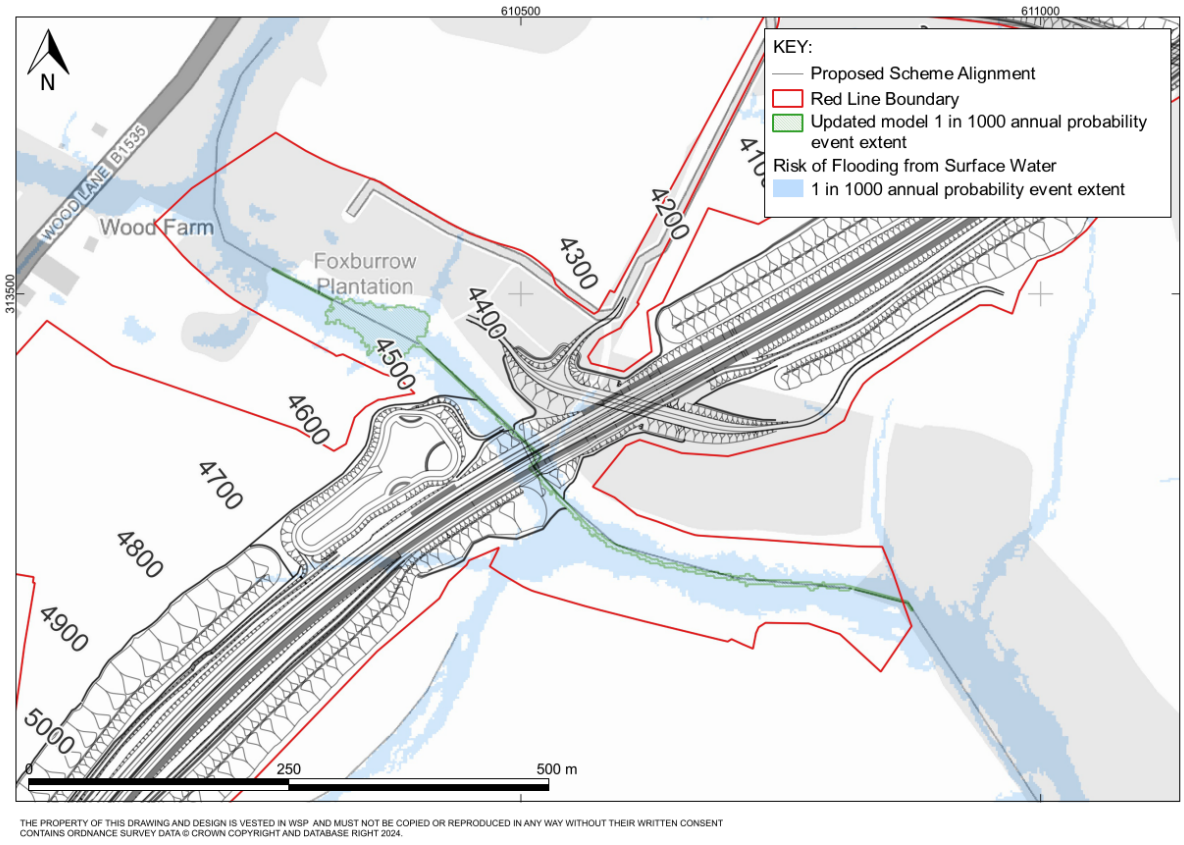
3.3.15 The Environment Agency's Flood Map for Planning identifies Flood Zone 2 and 3 immediately downstream of the Proposed Scheme crossing of Foxburrow Stream. Flood Zone 2 and 3 are closely aligned in this location and constrained to the existing channel; this largely remains the case to the watercourse's confluence with the River Tud. The Flood Map for Planning does not extend upstream of the Proposed Scheme location, presumably because the upstream catchment is below the threshold typically used for the Flood map for Planning (c. 3-5km^2). It is likely that flood waters would remain in channel as per the downstream extents, however this has been assessed via hydraulic modelling (discussed below).

3.3.16 There was no existing hydraulic model of Foxburrow Stream and a new model and associated hydrology for the watercourse have been developed for the purposes of this study. This model has been used to generate baseline flood levels reflecting the existing conditions in the vicinity of the Proposed Scheme.

The model is a 1D model with extended cross sections in the floodplain. It models Foxburrow Stream for a distance of 600m in total continuing approximately 350m downstream of the Proposed Scheme. Full details of the modelling work undertaken are provided in **Sub Appendix E: Foxburrow Stream Hydraulic Modelling Report** (Document Reference 3.12.02e).

3.3.17 Flood extents have been generated for the 1 in 30, 30+45%, 100, 1000 and 100+45% (based on rainfall intensity requirements) annual probability events. A 45% climate change allowance for the 1 in 30 annual probability event is higher than the requirement set out in the PPG for climate change but has been used for consistency. These extents are based on topographic survey, allowing for the full channel capacity and local structures to be accounted for, compared to the existing Flood Zones and Flood Map for Surface Water which are based on aerial LIDAR only, and don't include local structures, as so represent an improved baseline compared to the national datasets. The new extents also take account of the latest climate change guidance. The baseline flood extents and depths for the Foxburrow Stream for a range of return periods are shown in Figures 3.12.02a-145 to 3.12.02a-150 in **Sub Appendix A: Figures** (Document Reference 3.12.02a). **Figure 3.2** provides a comparison between the Flood Map for Surface Water and the updated model extents at the location of the Proposed Scheme. The Flood Map for Surface Water has been compared in this instance as the Flood Zones do not extent upstream beyond the Proposed Scheme.

Figure 3-2 Foxburrow Stream comparison of updated model extent with the FMfSW for the 1 in 1000 annual probability event



3.3.18 Flows are predicted to remain in channel as the watercourse crosses the Proposed Scheme, up to the 1 in 1000 annual probability event.

3.3.19 Potential flood risk receptors in the Foxburrow Stream floodplain have been identified following a review of the available data. The floodplain of Foxburrow Stream is grazing farmland and woodland down to the confluence with the River Tud with the exception of an access track which crosses the watercourse 1km downstream of the Proposed Scheme. All these are classified as less vulnerable receptors.

3.4 Surface Water Flood Risk

3.4.1 Surface water flooding happens when rainwater does not drain away through the normal drainage systems or soak into the ground but lies on or flows over the ground instead. In rural locations such as the site of the Proposed

Scheme, it typically occurs when the underlying soils are saturated, with overland flows following topography and flowing downhill.

3.4.2 Surface water flooding has been assessed by review of the Environment Agency's Flood Risk from Surface Water maps. Review of these maps indicates that there are pockets of high, medium and low flood risk from surface water along the Proposed Scheme. Noteworthy areas of surface water flood risk are discussed below (**Table 3-1**) at chainages from the east end of the Proposed Scheme to the west.

3.4.3 For reference, High risk means that each year this area has a chance of flooding of greater than 1 in 30. Medium risk means that each year this area has a chance of flooding of between 1 in 100 and 1 in 30. Low risk means that each year this area has a chance of flooding of between 1 in 1000 and 1 in 100.

3.4.4 Mapping of surface water flood risk is shown in Figures 3.12.02a-4 to 3.12.02a-6 in **Sub Appendix A: Figures** (Document Reference 3.12.02a).

Table 3-1 Locations of Surface Water Flood Risk in vicinity of the Proposed Scheme

Chainage or reference	Flood Risk Annual Probability	Description
A1270 / Fakenham Road Roundabout	Medium to Low Risk	Surface water ponding area of medium risk on the southern Fakenham Road arm. Low risk of surface water flooding on the roundabout.

Chainage or reference	Flood Risk Annual Probability	Description
1700	Medium to High Risk	Major surface water flow path, referred to as Ringland Lane overland flow path in Section 1.3, draining a catchment to the west and passing across the scheme alignment to the east of Ringland Lane. High risk pockets in a topographic low spot on the southern side of the Proposed Scheme.
2850	Low to Medium Risk	Minor surface water flow path, referred to as Weston Road overland flow path in Section 1.4 draining a catchment to the west and passing across the scheme alignment to the east of Weston Road.
4470	Medium to High Risk	Foxburrow Stream channel (assessed as fluvial flood risk). In addition, there is a minor low risk of surface water flooding flow path connecting to the channel from the north where Foxburrow Stream crosses the Proposed Scheme alignment.
4645	Low risk	Low risk of surface water flooding from minor surface water flow path that joins Foxburrow Stream tributary to the east of the Proposed Scheme.
5100	Low risk	A tributary of Foxburrow Stream providing a low risk of surface water flooding. It runs eastwards to join Foxburrow Stream to the east of the Proposed Scheme.

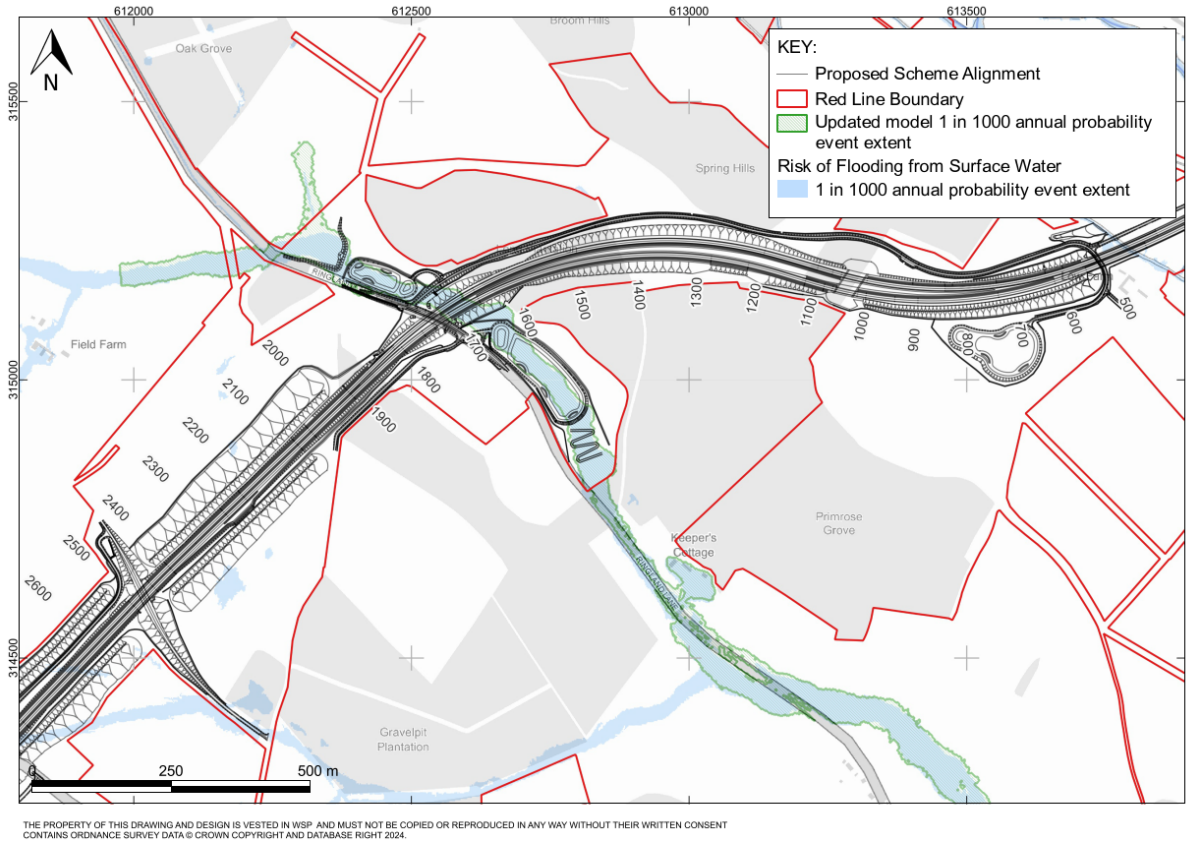
Chainage or reference	Flood Risk Annual Probability	Description
5135	High risk	Topographical low point of the Foxburrow Stream tributary on the western side of the Proposed Scheme. The low point shows a high risk of flooding. The alignment of the Proposed Scheme crosses downstream of the low point and in this location the surface water flow path is shown as low risk.
Paddy's Lane	High Risk	High risk flow path along Paddy's Lane referred to as Paddy's Lane overland flow path in Section 1.4 that eventually discharges into Foxburrow Stream. In its upstream reaches it passes through Green Farm potentially affecting properties in this location.
Marl Hill Road	Low to High Risk	Flow path that runs along Marl Hill Road from the south-west and referred to as Marl Hill overland flow path in Section 1.4. Additional flow paths of low to medium risk drain from the north-west and cross Marl Hill Road at its northern end. These all eventually join WC5.
Fakenham Road nr Marl Hill	Low Risk	Low risk flow path on Fakenham Road that eventually joins WC5.

Chainage or reference	Flood Risk Annual Probability	Description
Hockering Road	Low to High Risk	Flow path that runs parallel to Hockering Road from the south-west and referred to as Hockering overland flow path in Section 1.4. It drains away from the NWL highway crossing Morton Lane and potentially flooding commercial properties in this area.

3.4.5 The Ringland Lane overland flow path (Chainage 1700) has been modelled explicitly using the latest available LIDAR data. Flood extents have been generated for the 1 in 2, 30, 30+45%, 100, 1000 and 100+45% (based on rainfall intensity requirements) annual probability events amongst others presented in **Sub Appendix A: Figures** (Document Reference 3.12.02a). A 45% climate change allowance for the 1 in 30 annual probability event is higher than the requirement set out in the PPG for climate change but has been used for consistency.

3.4.6 **Figure 3.3** provides a comparison between the 1 in 1000 annual probability event from the Flood Map for Surface Water and the updated model extents at the location of the Proposed Scheme. Full details of the modelling work undertaken are provided in **Sub Appendix H: Ringland Lane Hydraulic Modelling Report** (Document Reference 3.12.02h).

Figure 3-3 Ringland Lane overland flow path comparison of updated model extent with the FMfSW for the 1 in 1000 annual probability event



3.4.7 Potential flood risk receptors in the Ringland Lane overland flow path floodplain have been identified following a review of the available data. The floodplain of Ringland Lane is generally arable or grazing farmland or woodland, which are classified as less vulnerable receptors. It also crosses Ringland Lane upstream of the Proposed Scheme and runs along it downstream of the Proposed Scheme. Downstream of the Proposed Scheme the Keeper and the Dell (wedding venue) is within the floodplain, classified as a more vulnerable receptor. Because of this property, Ringland Lane is also classified as a more vulnerable receptor downstream of the Proposed Scheme, elsewhere it is classified as less vulnerable. Finally, the flow path passes through Ringland itself impacting both residential and commercial properties, classified as more and less vulnerable receptors respectively.

3.5 Groundwater Flood Risk

3.5.1 Groundwater flooding occurs when the groundwater levels rise to within close proximity of ground level, either causing flood risk to underground structures or emerging and flowing across the ground's surface. Groundwater flooding is generally a result of extended periods of heavy rainfall associated with porous underlying geology, such as chalk, limestone and gravels.

3.5.2 As discussed in Section 1.4 within the vicinity of the River Wensum, geology comprises predominantly Chalk bedrock overlain with permeable sands and gravel. This provides an efficient hydraulic link between the Principal Aquifer (Chalk) and the River Wensum and drainage channels in the floodplain of the river.

3.5.3 Mapping presented in the Greater Norwich SFRA includes the Environment Agency's Areas Susceptible to Groundwater Flooding dataset and indicates that the vast majority of the Proposed Scheme is located within an area considered to be at very low risk of groundwater flooding.

3.5.4 Discrete manual dip groundwater level data have been recorded at a number of onsite monitoring boreholes within the Proposed Scheme between 2020 and 2023, particularly during the winter. Groundwater levels during 2022 were recorded to be between 0.86mbgl – 20.15mbgl across the Proposed Scheme, where shallow groundwater levels tend to coincide with valley locations. Groundwater levels recorded during November 2020, March 2021 and January 2023 indicated groundwater at surface level within the River Wensum floodplain. There are also shallow groundwater levels present at the location of the proposed the Tud tributary culvert / Bat underpass culvert (CU2) on Foxburrow Stream, where there is a stream valley present. Groundwater levels at surface were often recorded at borehole BHR35, where this is situated adjacent to the Foxburrow Stream towards the southern end of the Proposed Scheme.

3.5.5 The Ground Investigation (GI) groundwater monitoring data, presented in the various reports referenced in Section 1.7, supports the Environment Agency's

Areas Susceptible to Groundwater Flooding dataset and confirms that only those areas of lower topography in close proximity to the River Wensum and the Foxburrow Stream are considered to have a higher risk of groundwater flooding. The presence of the widespread manmade drainage channels in the River Wensum floodplain also reflects the historical human response to the presence of shallow groundwater in this area.

3.5.6 It can also be concluded from the GI monitoring data that it is highly likely that the groundwater aquifer beneath the Proposed Scheme provides an important baseflow to the River Wensum. This is because measured groundwater levels in the River Wensum valley indicated a highly efficient hydraulic connection between surface water, shallow groundwater and the groundwater in the Chalk. This has been confirmed by numerical groundwater flow modelling, which has been undertaken as part of the EIA and is presented in the **River Wensum Crossing – Groundwater Modelling Report** (Document Reference 3.12.05). This baseflow may also be important for supporting its SAC and SSSI designations.

3.5.7 High groundwater levels have also been observed at Drainage Basins 3 and 4 near Ringland Lane and Drainage Basin 6 near the proposed A47 junction at Honingham. However, these instances are attributable to localised perched water levels within low permeability strata rather than being representative of the groundwater conditions across the wider area.

3.5.8 In conclusion groundwater flood risk only exists in the low lying areas of the scheme, most notably associated with the River Wensum floodplain but also at Foxburrow Stream.

3.6 Risk of Flooding from Sewers

3.6.1 The alignment of the Proposed Scheme is generally across a rural landscape with little in the way of existing infrastructure along which drainage infrastructure would be present.

3.6.2 There are no surface water sewers located along the Proposed Scheme alignment. There is a watermain running along the southern side of Fakenham Road from the A1270 / Fakenham Road Roundabout to the start of the Proposed Scheme (Chainage 0000). There is a watermain and an abandoned watermain running along the northern site of Weston Road (Chainage 2875).

3.6.3 The Greater Norwich SFRA records historic cases of flooding from sewers through Anglian Water's DG5 register. This record only includes locations where properties were impacted by flooding and is provided at a postcode level only. The Proposed Scheme crosses postcode areas NR8 and NR9. The SFRA records 8 properties in the Taverham, Drayton area at the eastern end of the Proposed Scheme and 4 properties in the Lyng, Lenwade, Easton and Honingham area at the western end of the Proposed Scheme. The ends of the Proposed Scheme are not situated within the populated areas of the postcode areas above and there is nothing within the SFRA to suggest the flood risk to the properties listed would interact with the Proposed Scheme.

3.6.4 Based on the information above, the Proposed Scheme is therefore considered to be at negligible risk of flooding from sewers.

3.7 Flood Risk from Artificial Sources

3.7.1 Sources of artificial flooding include reservoirs, canals, lakes and pumped systems.

3.7.2 Review of Ordnance Survey mapping indicates there are no canals or artificial lakes in the vicinity of the Proposed Scheme that are likely to pose flood risk to the Proposed Scheme.

3.7.3 The Environment Agency's Flood Risk from Reservoirs mapping indicates that the Proposed Scheme may be at risk of flooding in the event of reservoir failure from Haveringland Lake on the Trout Stream tributary of the River Wensum upstream of Attlebridge. The flood waters in the event of reservoir failure are indicated to follow the alignment of the River Wensum, with the

mapped flood extents being broadly similar to the mapped Flood Zone 2 and Flood Zone 3 fluvial flood extents. Mapping of reservoir flood risk is shown in Figure 3.12.02a-9 in **Sub Appendix A: Figures** (Document Reference 3.12.02a).

3.7.4 Risk of flooding from reservoirs has a very low likelihood of occurring in any given year. Reservoirs are inspected regularly by a suitably qualified reservoir inspecting engineer to ensure that risk of failure is minimised.

3.7.5 The Proposed Scheme is therefore considered to be at low risk of flooding from artificial sources. The risk of reservoir flooding has been identified; as this follows the alignment of the River Wensum and has similar extents to the identified fluvial flood risk, risks associated with this floodplain will be assessed during the fluvial flood risk assessment. Consideration will however be given to risks associated with rapid inundation that may occur following reservoir failure.

3.8 Summary of Existing Flood Risk

3.8.1 The analysis presented above identifies that that the Proposed Scheme is at greatest risk of flooding from fluvial sources associated with the River Wensum. A summary of all identified sources of flood risk is presented in **Table 3-2**.

Table 3-2 Summary of existing flood risk

Source of flooding	Risk	Commentary
Tidal	No risk	Proposed Scheme not located within an area at tidal flood risk
Fluvial – River Wensum	High risk	Proposed Scheme crosses the functional floodplain of the River Wensum

Source of flooding	Risk	Commentary
Fluvial – Foxburrow Stream	Medium risk	Proposed Scheme crosses the alignment of the Tud Tributary, although flooding largely remains in channel
Surface water	Low to high risk	Proposed Scheme crosses one significant overland flow path, Ringland Lane overland flow path, and other minor flow paths, the largest of these being the Weston Road overland flow path. Pockets of surface water ponding identified in close proximity to Proposed Scheme.
Groundwater	Low risk	Majority of Proposed Scheme at very low risk of groundwater flooding. Areas of lower topography in close proximity to River Wensum and Foxburrow Stream may be at higher risk of groundwater flooding.
Sewers	Negligible risk	Proposed Scheme located in rural areas and not in close proximity to recorded sewer flooding.
Artificial sources - reservoirs	Low risk	Proposed Scheme crosses predicted route of floodwater that would follow the alignment of the River Wensum. Reservoir flooding unlikely to occur.
Artificial sources – other	No risk	No known risk from other artificial sources.

4 Assessment of Flood Risk during Construction

4.1 Introduction

4.1.1 This section of the FRA provides an assessment of potential flood risk to the Proposed Scheme and to people, property and land elsewhere as a result of the Proposed Scheme during the construction phase of the project.

4.1.2 The assessment considers the sources of flood risk identified in Section 3.8, namely: the risks associated with works in the floodplain of the River Wensum; the crossing of Foxburrow Stream; the crossing of overland flow paths; excavation in areas of potentially shallow groundwater; and the potential for flooding from reservoirs. It does not address the management of runoff from the Proposed Scheme or Temporary Works areas which is summarised in Section 1.5 but addressed in detail in Section 7 of the **Drainage Strategy Report** (Document Reference: 4.04.00) and Section 4 of the **Drainage Strategy Report, Appendix 4.15 Construction Surface Water Management Strategy** (Document Reference 4.04.15). These documents confirm that appropriate measures would be put in place to manage runoff from these surfaces during the construction period. The exception to this is the environment mitigation proposals; the detail of which have not yet been developed. For these mitigation areas have been assessed on a reasonable worst case basis and recommendations are made to inform their detailed design.

4.1.3 Elements of the scheme not listed above are not considered to be at risk of flooding during the construction phase of the works.

4.1.4 The importance of the impacts has been presented in two ways:

- A significance classification is presented in line with the approach outlined in LA 113 and detailed in Section 2.2 and to provide consistency with discussions presented in the ES. This has used the ‘design flood’ as defined by NPPF PPG to assess the potential impact

magnitude, although qualitative consideration has also been given to residual events that may be larger than the design flood.

- A comparative hazard classification is presented to allow more context to be considered where appropriate in areas where there is existing flood risk.

4.2 River Wensum

4.2.1 The construction of the viaduct would require temporary works within the active floodplain of the River Wensum. The design of the temporary works proposals are presented in **Sub Appendix K: Design Drawings** (Document Reference 3.12.02k). In brief the temporary works design consists of the following:

- A raised working platform extending across the full width of the River Wensum floodplain constructed to 10.8m AOD, which is sufficiently high to avoid overtopping in all flood events. The platform width ranges between approximately 60m at its narrowest to 100m at its widest.
- A box culvert approximately 108m in length with internal dimensions 3m wide and 1m high to provide continued connectivity for WC5.
- Flood relief culverts within the River Wensum floodplain beneath the Temporary Works Platform to reduce the risk of flooding upstream. The design incorporates 12 flood relief culverts with an internal diameter of 900mm. Gradients vary reflecting the floodplain levels. Culverts are typically between 80m and 90m in length reflecting the width of the working platform.
- A bailey bridge to provide connectivity between the Temporary Works Platform on either side of the River Wensum. The soffit of the structure is set to approximately 11.1m AOD, which is above the peak water level in all events.

4.2.2 The design of the temporary works reflects the nature of flooding in the River Wensum floodplain, that is prolonged periods of elevated water levels. The Temporary Works Platform is to facilitate construction works that would extend beyond 6 months. The flood relief culverts provide embedded mitigation and reduce the impact of the Temporary Works Platform but cannot completely mitigate the impact.

4.2.3 PPG Paragraph 49 of the NPPF requires level for level floodplain compensation be provided where flood storage is lost. Whilst the volume taken up by the Temporary Works Platform could be interpreted as a loss of floodplain storage, in fact the nature of the structure (a hydraulic control in the floodplain) means that it cannot be treated as a function of floodplain storage. PPG paragraph 49 recognises the different impact posed by the constriction of flood flow routes and requires only that the FRA demonstrates the safe management of these flow routes. Finally, it states that where it is not possible to fully mitigate the impacts of development, as is the case here, the FRA should detail the extent and nature of the increase in risk and assess its significance.

4.2.4 To highlight the hydraulic difference between a loss of floodplain storage and a constriction of flood flow routes the Temporary Works model has been run with an excavation down to 9m AOD of 40,000m^2 (equivalent to the footprint of the temporary works platform) on the right bank of the River Wensum floodplain upstream of the Temporary Works Platform. This resulted in a reduction in water levels of less than 1mm. Similarly, a review of the volume in the 1 in 1000 annual probability event above 50.2m^3/s, the flow rate the Temporary Works Platform's various bypass structures can convey at the existing 1 in 1000 annual probability water level. This confirmed the volume would be in excess of 15.4Mm^3 or would require a compensation area in the region of 4.5km^2. These figures are presented only to justify the approach within this FRA, which is to detail the extent and nature of the increase in risk associated with the Temporary Works Platform and to assess its significance.

4.2.5 The proposed temporary works has been assessed in the hydraulic model of the River Wensum to understand potential flood risk implications. The changes in depths and velocities resulting from the temporary works compared to the baseline are shown in Figures 3.12.02a-62 to 3.12.02a-73 in **Sub Appendix A: Figures** (Document Reference 3.12.02a). Increases in water levels are summarised in **Table 4-1**. The assessment of the temporary works scenarios has been completed on the 1 in 2, 100 and 1000 annual probability events. The latter event is considered a conservative assessment given the short duration (3 years) for which the temporary works will be in place and is presented for the purposes of residual risks only.

4.2.6 The proposed environmental enhancements within the floodplain of the River Wensum generally consist of planting in the floodplain and are expected to be undertaken in the dry. The construction of the gravel bars and riffles in the River Wensum generally involve the placing of material in the channel with some allowance for the River Wensum itself to naturally determine the final placement. The new meander would be constructed offline with the diversion of flows allowed once complete. Groundwater ingress is expected into the new meander channel and overpumping would be required to minimise water levels in the working area. Access matting would also be required across the floodplain for any plant required.

Flood risk to the Proposed Scheme

4.2.7 The modelling indicates that the various bypass structures beneath the Temporary Works Platform, both culverts and bailey bridge, can be sized to convey all flows up to the 1 in 1000 annual probability event without the crest of the Temporary Works Platform level being reached. Modelled peak water levels in the 1 in 1000 annual probability event are 10.4m AOD.

4.2.8 The environmental enhancements in the River Wensum floodplain are situated upstream of the NWL highway. Changes to water levels resulting from these environmental enhancements would be localised and would slow flows, as such there would be no increase in flood risk at the location of the viaduct.

4.2.9 In all cases the enhancements are considered water compatible, and works would be undertaken from the bank to minimise flood risk to people and plant. The works in this instance are in the floodplain of the River Wensum and systems would be put in place for removal of people and plant in the event of a flood.

4.2.10 The management of flood risk to people and plant associated specifically with the construction works are discussed in associated with the CEMP in Section 4.7.

Flood risk to third parties

Impact to flood depths

4.2.11 The Temporary Works Platform would result in increases in water levels during flood flow conditions upstream of the Proposed Scheme. The embedded mitigation has reduced these impacts. The impacts are quantified in the Figure 3.12.02a-62 to 3.12.02a-67 **River Wensum Temporary Works Depth Difference** maps and Figure 3.12.02a-68 to 3.12.02a-73 **River Wensum Temporary Works Velocity Difference** maps in **Sub Appendix A: Figures** (Document Reference 3.12.02a) and summarised below.

4.2.12 The greatest increases in flood depths would occur immediately adjacent to the upstream face of the Temporary Works Platform. Increases in flood depths would decrease towards the bailey bridge as this is the largest capacity structure. Similarly, the predicted increases in water levels taper off in the upstream direction away from the Temporary Works Platform. The maximum increase in water levels in the 1 in 2 annual probability event are approximately 0.1m and the greatest increase associated with the 1 in 1000 annual probability event is approximately 0.45m.

Table 4-1 Summary of water level increases associated with the temporary works

Return Period (annual probability)	Water level increase at the working platform (m)	Maximum water level on upstream face of the working platform (m AOD)
1 in 2	0.13	9.57
1 in 100	0.42	10.24
1 in 1000	0.46	10.45

Note that Increases in water levels extend to the upstream limit of the model. In this location increases are approximately 20mm for the 1000 annual probability event.

4.2.13 The receptors impacted by these increases in water levels in the 1 in 100 annual probability flood event are the NMU Route 7, grazing farmland and the local secondary access road to St Margaret's Church. The depths on NMU Route 7 increase by 0.4m to depths of approximately 1m from 0.6m in the 1 in 100 annual probability flood event. The depths at the access road increase by 40mm to a depth of approximately 0.33m from 0.28m in the 1 in 100 annual probability flood event.

4.2.14 In the 1000 annual probability flood event, water levels in the vicinity of the property at Old Hall Farm increase by 450mm with an associated increase in extent of approximately 13m. This increase in extent means water levels reach the boundary of a property on Old Hall Farm. Further review of the water levels for a range of events in this location suggests the residual risk of external flooding to this property is around the 1 in 200 annual probability event. The residual risk of internal flooding to this property is considered to be in excess of the 1 in 1000 annual probability event based on the property's threshold levels. Given the duration (3 years) of the temporary works the risk is low and considered acceptable.

4.2.15 There is a small increase in water levels observed downstream of the working platform in the 1 in 100 annual probability flood event. This is observed within the existing floodplain as far as 800m downstream of the Ringland Lane crossing and affects the gas main, Wensum Valley Hotel golf course and

grazing farmland. Increases in depths at the golf course are approximately 2mm. This is attributed to the change in flow dynamics caused by funnelling a large proportion of the flows through the bailey bridge. This flow dynamic is not in place for the 1 in 1000 annual probability flood event and there is a reduction in downstream water levels in this event.

4.2.16 There are no flood risk implications associated with the construction of the environmental enhancements. The potential flood risk implications associated with the completed works are discussed in Section 5.2.

Impact to flood velocity

4.2.17 Velocities in the wider floodplain are generally slowed by the presence of the Temporary Works Platform. This is true of the south-western side of the floodplain both upstream and downstream of the Temporary Works Platform.

4.2.18 Increases in velocities are observed on the upstream face of the Temporary Works Platform focussed about the Wensum channel as flows are funnelled through the bailey bridge. These velocities peak at an increase of 1m/s on the right bank upstream of the works. Increases of similar magnitude are observed in the River Wensum channel downstream. These dissipate approximately 400m downstream of the bailey bridge in the 1 in 100 annual probability event.

4.2.19 There is a residual risk associated with the exposure of the gas main located downstream of the viaduct location. In the 1 in 1000 annual probability event velocities are increased in this location by approximately 0.15m/s with a peak velocity of 0.76m/s compared to an existing velocity of 0.62m/s. Both velocities are considered to be erosional given the likely sediments in this location and as such the increase does not represent a change in dynamic but rather a moderate increase in risk. The final approach to the management of this residual risk will be determined through discussions between NCC and National Grid.

Conclusions

4.2.20 The temporary works associated with the construction of the viaduct would be constructed to a level to reduce flood risk to the platform itself but are predicted to result in increases in water levels in the vicinity of the Proposed Scheme. Embedded mitigation in the form of flood relief culverts has reduced this impact but cannot remove it entirely. **Table 4-2** summarises the impacts In the 1 in 100 annual probability event.

Table 4-2 Summary of significance of temporary works impacts on the River Wensum in the 1 in 100 annual probability event

Receptor	Vulnerability classification	Water level impact	Significance
Gas main	Essential infrastructure	<+2mm	Slight
Grazing land including NMU Route 7	Less vulnerable	Up to +420mm	Moderate or large significance
Golf course	Less vulnerable	+2mm	Neutral or slight
St Margaret's Church access track	Less vulnerable	+40mm	Slight

4.2.21 Further to **Table 4-2** water levels are predicted to reach the corner of a property at Old Hall Mill Farm, which is classified as more vulnerable receptor, from the 1 in 200 annual probability event. The property is not expected to flood internally in the 1 in 1000 annual probability event given its threshold levels. The Temporary Works Platform is expected to stay in place for 3 years. Given the duration of the temporary works, the residual risk of a flood event is low and considered to be acceptable.

4.2.22 In the 1 in 1000 annual probability event velocities and predicted to increase downstream as far as the gas main by approximately 0.15m/s. This increase is not considered to pose increased erosional risk when compared to baseline

velocities predicted during the same magnitude event. The management of this residual risk will be determined in discussions with National Grid.

4.2.23 Works to complete the environmental enhancements can be managed in such a way so that there is no increase in flood risk to the Proposed Scheme or third parties.

4.3 Reservoir Flood Risk

4.3.1 Flood risk from reservoirs has been modelled using the Wensum hydraulic model. Details of the methodology used are presented in Section 5.4 and the results presented in Figures 3.12.02a-21, 3.12.02a-32 and 3.12.02a-43 for the baseline condition and 3.12.02a-84, 3.12.02a-95 and 3.12.02a-106 for the Proposed Scheme in **Sub Appendix A: Figures** (Document Reference 3.12.02a). This work concluded that the volumes within the hydrograph modelled are insufficient to recreate the flood levels observed in design flood events. Similarly, flow velocities are consistent with the velocities in the design flood events assessed.

4.3.2 The likelihood of a reservoir breach is considered to be less than the 1 in 100 annual probability event. As such the risk of flooding to third parties from a reservoir breach would be less than assessed in Section 4.2 for fluvial flood risk.

4.3.3 In conclusion there is no additional flood risk during construction to the Proposed Scheme or third parties from reservoir flooding than presented for the fluvial flood risk for the River Wensum.

4.4 Foxburrow Stream

4.4.1 The alignment of the Tud tributary culvert / Bat underpass culvert (CU2) at Foxburrow Stream connects to the existing alignment of the watercourse upstream and downstream of the Proposed Scheme. To construct this culvert in the dry would therefore either require the diversion of the existing stream flows during construction or offline construction with the eventual diversion of the watercourse onto a new alignment.

4.4.2 As part of the environmental mitigation works, Foxburrow Stream is also being reprofiled for a distance of up to 590m and two existing structures are to be removed (a culvert and failed bridge). Flows are typically low on Foxburrow Stream and it is expected the reprofiling works can be undertaken on the bank and in the dry with no expected change to normal or flood flows. The works to remove the culvert and the failed bridge are situated within the channel and as such would require temporary diversion of flows. The culvert is located immediately downstream of the Tud tributary culvert / Bat underpass culvert (CU2) and as such it will be incorporated into those works. Options to divert the watercourse for the failed bridge could include coffer dams in the existing channel to control flows with the construction of a parallel temporary channel, or overpumping to convey the flows downstream.

Flood risk to the Proposed Scheme

4.4.3 The watercourse itself is small and flows are typically low. The 1 in 100 annual probability event flows are 0.8m^3/s and the 1 in 1000 annual probability event flows are 1.9m^3/s and as such it is considered that proposals can be developed for a diversion that can convey these flows in a controlled manner past the site at the same rate as existing. In this way flood risk to the Proposed Scheme would be constrained to the footprint of the watercourse diversion.

4.4.4 Similarly, construction offline would retain flood risk to the footprint of the existing watercourse.

Flood risk to third parties

4.4.5 As above, it is considered that proposals can be developed for a diversion that can convey these flows in a controlled manner past the site at the same rate as existing. There would be no change in upstream water levels where existing flow rates past the site are achieved.

4.4.6 There is a slight reduction in length associated with the Proposed Scheme by virtue of the removal of a small meander and it is assumed the diversion of the watercourse would similarly have a reduced length. The removal of the

two existing structures would also have a minor impact on the flow regime of the watercourse. The assessment of changes in downstream flows associated with the Proposed Scheme presented in Section 5.3 confirms these changes are insufficient to change downstream flows and so would have no impact of third parties. The findings presented in Section 5.3 are applicable for the temporary works proposals.

Conclusion

4.4.7 In conclusion either works can be undertaken offline or the small magnitude of the flows within the Foxburrow Stream means a construction method which conveys flows downstream to be connected with the existing watercourse at the existing rate can be developed. In such a scenario flood risk past the Proposed Scheme would be contained and there would be no change to the existing flow dynamics meaning no change to flood risk upstream and downstream of the site. The resulting impact significant in accordance with LA 113 would be neutral.

4.5 Management of Overland Flows

4.5.1 Sections 1.4, 1.5 and 3.4 set out the various overland flow routes that are crossed by the Proposed Scheme. Section 1.5 sets out how the PED network will collect and convey flows past the Proposed Scheme at WC5 in the River Wensum floodplain, Ringland Lane, Foxburrow Stream, Foxburrow Stream tributary, to the north of the A1067 Fakenham Road / NWL roundabout and at either end of the Proposed Scheme.

4.5.2 The flood risk impacts associated with WC5 are appropriately covered in the impacts for the River Wensum in Section 4.2. Similarly, the impacts for Foxburrow Stream are discussed in Section 4.4. These overland flow routes will therefore not be discussed further in this section. Remaining overland flow routes are discussed below.

Flood Risk to the Proposed Scheme

4.5.3 The PED network, as set out in Section 7.5 and Volume 3 of the **Drainage Strategy Report** (Document Reference: 4.04.00) is critical for the management of overland flows to prevent inundation onto the site and would be installed at the start of the construction phase. Large sections of the PED network are situated offline from the overland flow routes identified by the Environment Agency's FMfSW and the expectation is that these can be constructed in the dry. Similarly overland flow routes are ephemeral and so the connection of the PED network into these routes can be timed for when flows are low or negligible.

4.5.4 As such the direction of overland flow path drainage routes during construction would be consistent with the Proposed Scheme post development. There would be exceptions to this where the presence of the Temporary Works Areas would require local diversions, these are set out in Section 2 of the **Drainage Strategy Report, Appendix 4.15 Construction Surface Water Management Strategy** (Document Reference 4.04.15).

4.5.5 The PED network at either end of the Proposed Scheme outfalls into the existing Northern Distributor Road or the A47 North Tuddenham to Easton Dual Scheme drainage systems. The consent for these systems sits outside this FRA and so no further works beyond the construction of the PED network are discussed.

4.5.6 It should be possible to construct the Foxburrow Stream tributary and A1067 Fakenham Road culverts in the dry. However, if construction is proposed during periods of heavy rainfall the diversion of the overland flows or offline construction maybe required. Options to divert the flow paths could include coffer dams to control flows with the construction of a parallel temporary channel, or overpumping to convey the flows downstream. Peak flows from these catchments in the 1 in 100 annual probability plus 45% climate change event (based on rainfall intensity requirements) are 0.16m3/s for the Foxburrow Stream tributary catchment and 0.07m3/s for the A1067 Fakenham Road catchment. It is considered that proposals can be developed for a

diversion that can convey these flows in a controlled manner past the site at the same rate as existing. In this way flood risk to the Proposed Scheme would be constrained to the footprint of the existing flow path or the diversion, further details are provided in the **Drainage Strategy Report, Appendix 4.15 Construction Surface Water Management Strategy** (Document Reference 4.04.15).

4.5.7 The Ringland Lane overland flow path is largest of the overland flow paths. The existing overland flow path is wide and shallow, ranging from between 30m and 45m in width at the Proposed Scheme alignment in the 1 in 30 and 1 in 1000 annual probability events respectively. Again, as this is not a watercourse there would be opportunities to construct the PED network in the dry. However, given the complexity of the scheme in this location it is possible the construction period would be long enough for there to be a risk of heavy rainfall occurring.

4.5.8 The Ringland Lane overland flow path itself is shallow with depths of around 0.15m in the 1 in 1000 annual probability event. The width of the floodplain means there is sufficient space available for local dams to channel flows past the Proposed Scheme using only a proportion of the floodplain with a commensurate increase in flood depths whilst works are undertaken to install the PED network. The proposed PED network is of sufficient capacity to convey the 1 in 100 annual probability plus 45% climate change event (based on rainfall intensity requirements) past the site and so once this is installed all flows would be managed appropriately during the remainder of the construction period.

4.5.9 Paddy's Lane overland flow path runs past the entrances to the Temporary Works Area main compound, NMU Route 2 and the access to the environmental enhancement corridor connecting to Breck Road. Marl Hill Road overland flow path runs along the alignment of NMU Route 12. Both these flow routes sit lower than the ground levels on either side of the highway and do not flood outside of the highway up to the 1 in 100 annual probability event in the Environment Agency's FMfSW. These surface water

flow paths are also ephemeral and as such the creation of access routes from Paddy's Lane and the new shared pedestrian-cycleway are expected to be undertaken in the dry.

4.5.10 The Hockering Road overland flow path crosses two areas where environmental enhancements are proposed. The works themselves consist of grassland creation in the upstream area and woodland and scrub creation in the downstream area and are considered water compatible. It would be possible to complete the works in the dry however the management of flood risk to people and plant situated within the flow path should be consistent with the recommendations set out in the CEMP in Section 4.7.

Flood risk to third parties

4.5.11 The attenuation feature associated with the Ringland Lane overland flow path would be installed at the same time as the PED network. This feature would mitigate the potential increase in flows associated with the diversion of upstream catchments towards Ringland Lane. With this feature in place downstream flows would be reduced in the 1 in 100 annual probability event and greater, which reflects the onset of flooding to the Keeper and the Dell (wedding venue). For smaller events there would be an increase in flows and depths along Ringland Lane. The effect of this structure and the PED network are presented in Section 5.6. The findings confirm there would be a reduction in flood risk to the Keeper and the Dell (wedding venue).

4.5.12 For the overland flow paths at Paddy's Lane, Marl Hill Road and Hockering Lane the construction of the Proposed Scheme would not change the direction or negatively impact the magnitude of the overland flow. There is therefore no change to the existing flood risk resulting from the construction of the Proposed Scheme.

Conclusion

4.5.13 The PED network is the primary infrastructure to manage flood risk during the construction phase. This, in conjunction with the Ringland Lane attenuation feature, would be installed at the start of the construction phase. Following the

construction of the PED network and the associated assets that convey overland flows past the Proposed Scheme (the culverts at WC5 in the River Wensum floodplain, Ringland Lane, Foxburrow Stream, Foxburrow Stream tributary and to the north of the A1067 Fakenham Road / NWL roundabout), the conclusions presented in Section 5.6 that there is no risk to the Proposed Scheme from overland flows will hold.

4.5.14 For the construction of these assets themselves the ephemeral nature of the overland flow paths means that works would in the main be completed in the dry. Where flow diversions are required, the assessment concludes flows are sufficiently small to be managed with diversions or overpumping. Where works are completed within the footprint of a potential overland flow path the recommendations for working in areas of flood risk as set out in the CEMP in Section 4.7 should be applied.

4.6 Groundwater

4.6.1 Full details of the below ground structures are set out in Section 1.5. Of these only the works in the River Wensum floodplain, Foxburrow Stream and the Surface Water Drainage Basins are expected to interact with the groundwater levels. The remaining structures are not either sufficiently deep or of sufficient size to influence groundwater flows and levels and as such would not influence groundwater flood risk.

Flood risk to the Proposed Scheme

4.6.2 The Proposed Scheme excavations and cuttings, as required for the works in particular in the River Wensum floodplain, Foxburrow Stream and the Surface Water Drainage Basins, may extend below maximum groundwater levels. Construction works in these locations may require temporary dewatering to manage the risk of localised groundwater flooding of the construction area. Construction dewatering would be managed through the controls and measures within the OCEMP.

4.6.3 Significant below ground structures (sheet pile walls) would be temporarily implemented during construction of the River Wensum Temporary Works

Platform. These would form barriers to groundwater flow and are expected to cause a rise in ground water levels. Embedded mitigation in the form of groundwater drainage systems is incorporated into the temporary works design to mitigate the risk of local groundwater flooding.

Flood risk to the third parties

4.6.4 The impacts on groundwater flooding of the River Wensum viaduct foundations during construction are equivalent to the impacts presented in Section 5.5 following construction. Groundwater modelling has been undertaken to assess changes to groundwater flow and levels. This is presented in the **River Wensum Crossing – Groundwater Modelling Report** (Document Reference 3.12.05). The results confirm that the viaduct foundations do not significantly alter the groundwater/surface water hydraulic link and consequently do not represent an additional flood risk.

4.6.5 The embedded mitigation to manage risks of groundwater flooding associated with the Temporary Works Platform (in the form of groundwater drainage) would prevent impacts to third parties.

4.6.6 For the below ground works near the Foxburrow Stream and the drainage basins the impacts to third parties would be consistent with the risks presented in Section 5.5 for post construction.

Conclusion

4.6.7 The impact of the construction works associated with the Proposed Scheme have been assessed using detailed groundwater modelling. The construction and operational impacts are considered to be equivalent in terms of risk and the permeability of the geology means there is low risk of below ground structures creating barriers to flow. In accordance with the methodology promoted in LA 113 the impact significance will be neutral.

4.7 Other Construction Impacts

Flood Risk to the Proposed Scheme and third parties

4.7.1 In order to construct the Proposed Scheme, some works would be located within the floodplain of the River Wensum, Foxburrow Stream, the Ringland Lane overland flow path or other localised surface water flow paths. Without putting in place appropriate management practises this could pose risk to the construction workers and to receptors elsewhere. For example, washing away of unsecured machinery and equipment which in turn could cause damage to infrastructure downstream. Similarly, temporary blockage to flood flow conveyance routes, such as the PED network, or loss of flood storage volume can also pose increased flood risk to both the Proposed Scheme and receptors outside of the working area.

4.7.2 Appropriate management practises would therefore reduce the risk of flooding to both the Proposed Scheme and third parties. The PED network, and its installation at the start of the construction phase, is one management measure, allowing conveyance routes to be established across the route.

4.7.3 In addition, the following measures are proposed to be adopted during the construction phase as part of the CEMP in order to reduce adverse flood risk to construction workers, the Proposed Scheme and third parties during the construction phase.

- Adoption and implementation of a Flood Action Plan;
- Contractor to sign up for flood warnings and check online warnings regularly;
- Avoid working in the floodplain or watercourse during high flow events, intense rainfall events or when a flood warning is issued;
- Site compound(s) and welfare facilities located outside of the 1 in 1000 annual probability floodplain and in the path of identified overland flow routes;

- Do not store unnecessary materials and mobile machinery within the 1 in 1000 annual probability floodplain or in the path of identified overland flow routes; and,
- If flood warning issued, move all machinery and equipment out of the 1 in 1000 annual probability floodplain. If this cannot be completed in a safe time, secure equipment to prevent it being washed away.

4.7.4 It is recognised that the River Wensum working platform would be situated within the floodplain footprint and the removal of all plant and materials would not be viable in response to an event. In this instance the height of the platform should be sufficient to remove it from flood risk in the 1 in 1000 annual probability event.

Conclusion

4.7.5 Poor working practices have the potential to increase flood risk to the Proposed Scheme and third parties. It is not possible to remove the risk of increased flood risk entirely, but the CEMP should set out reasonable expectations to reduce these risks as far as practicable.

5 Post-Development Flood Risk

5.1 Introduction

5.1.1 This section of the FRA provides an assessment of potential flood risk to the Proposed Scheme and to people, property and land elsewhere as a result of the Proposed Scheme during the operational phase of the project.

5.1.2 The assessment considers the sources of flood risk identified in Section 3.8, which in turn relates back to the water environment interfaces set out in Section 1.4, namely: the proposed crossings of the River Wensum and Foxburrow Stream; the crossing of overland flow paths; excavation in areas of potentially shallow groundwater; and the potential for flooding from reservoirs. Consideration has also been given to risks associated with scheme-generated and natural catchment surface water runoff. Outside of these locations and

associated flood risk sources, the remainder of the Proposed Scheme is not considered to have an identifiable source of flood risk and has not been assessed further.

5.1.3 As for the impacts during construction, the importance of the impacts has been presented in two ways:

- A significance classification is presented in line with the approach outlined in LA 113 and detailed in Section 2.2 and to provide consistency with discussions presented in the ES. This has used the 'design flood' as defined by NPPF PPG to assess the potential impact magnitude, although qualitative consideration has also been given to residual events that may be larger than the design flood.
- A comparative hazard classification is presented to allow more context to be considered where appropriate in areas where there is existing flood risk.

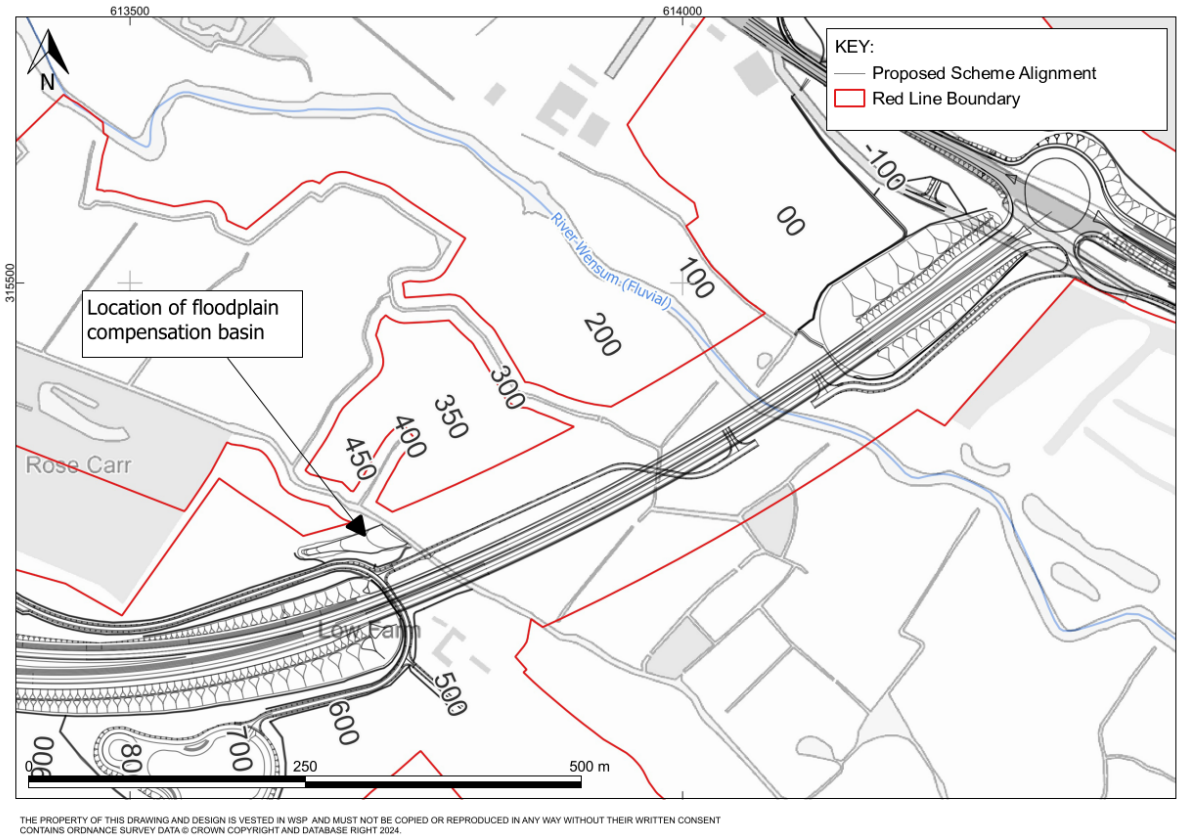
5.2 River Wensum Floodplain

5.2.1 The Proposed Scheme incorporates embedded flood risk mitigation in the form of a viaduct over the River Wensum floodplain. It also includes a maintenance access track (half of which would be NMU Routes 10 and 10a) across the floodplain, a culvert crossing of WC5 and environmental enhancements in the River Wensum floodplain upstream of the viaduct location. The details of the viaduct are presented in Section 1.5. Drawings of the Proposed Scheme are provided in **Sub Appendix K: Design Drawings** (Document Reference 3.12.02k) and further details of the design can be found in in **Chapter 3: Description of the Scheme** (Document Reference 3.03.00) of the ES. An overview of the environmental enhancements is provided in **Sub Appendix M: Environmental Enhancements of the Proposed Scheme Overview** (Document Reference 3.12.02m).

5.2.2 The loss of floodplain storage associated with the elements of the Proposed Scheme that are located in the floodplain, namely the maintenance tracks and

viaduct piers, is minimal given the low vertical profile of the maintenance tracks and small footprint of the piers. A location where level for level compensation would be provided has been identified on the right bank of the floodplain upstream of the viaduct and is shown in **Figure 5-1**.

Figure 5-1 Location of floodplain compensation basin



5.2.3 The level for level floodplain compensation requirement calculations are summarised in **Table 5-1**. These show the material volumes, rather than the floodplain volumes, within the footprint of the maintenance tracks and pier footprints in each of the level for level envelopes presented. Therefore, increases in volumes are reductions in floodplain capacity. The results of the analysis confirm that the proposed floodplain compensation is sufficient to offset the volume lost with the Proposed Scheme.

Table 5-1 Floodplain compensation requirement calculations

Level Envelope (m AOD)	Existing Material Volume (m^3)	Design Material Volume (m^3)	Compensation Requirement (m^3)	Compensation Provided (m^3)	Increase in Floodplain Capacity (m^3)
Below 9.0	12277	12551	274	279	5
9.0 to 9.2	3852	3974	122	418	296
9.2 to 9.4	7737	7924	187	609	422
9.4 to 9.6	4794	4868	74	686	612
9.6 to 9.8	1974	1990	16	702	686
9.8 to 10	738	746	8	709	701

5.2.4 It is important to note that a conservative approach has been adopted to the modelling to support the FRA. The floodplain compensation has not been incorporated and the impacts presented in this report do not include the mitigation provided by the floodplain compensation. .

5.2.5 Environmental mitigation proposals have not been developed in detail at this stage but include grassland creation in the River Wensum floodplain, riparian planting along the banks of the River Wensum and floodplain drains and the creation of gravel bars and riffles and reinstatement of an old meander in the River Wensum itself.

Flood risk to the Proposed Scheme

5.2.6 The soffit level of the proposed viaduct as it crosses the River Wensum drops from east to west. The soffit level of the structure at the western end of the viaduct (i.e. at its lower level) is in excess of 16.1m AOD. This is 6m above the modelled height of the 1 in 100 annual probability event with a 44% climate change allowance, shown in **Table 5-2**, and, as such, the Proposed Scheme in the vicinity of the River Wensum is not at risk of flooding. The impact significance in accordance with LA 113 is assessed to be neutral.

Table 5-2 Peak water levels (m AOD) for a range of return periods in the channel at the viaduct post development

2yr	30yr	30yr + 44%	100yr	100yr + 44%	1000yr
9.46	9.74	9.90	9.82	10.03	9.98

5.2.7 The proposed maintenance tracks, which include part of NMU Routes 10 and Route 10a, would be located in the floodplain of the River Wensum and will be designed to be inundated during flooding events. It is recommended flood risk to the maintenance tracks would be documented in the Health and Safety file for the Proposed Scheme. Public signage for the new NMU routes warning of the flood risk whilst not a requirement should be considered as good practice. The maintenance tracks and NMU Routes 10 and 10a are considered to be water compatible. The predicted depth of flooding would indicate a major adverse impact significance, however this risk has been considered in the proposed design and operation of the Proposed Scheme.

5.2.8 The proposed environmental enhancements are located in the floodplain of the River Wensum and would be inundated during flood events. These enhancements are considered to be water compatible and no further assessment of flood risk impacts is required.

Flood risk to third parties

Impact to flood depths

5.2.9 Potential impacts to flood depths (and subsequently flood extents) have been assessed in the hydraulic model of the River Wensum. The changes in depths resulting from the Proposed Scheme are shown in in Figures 3.12.02a-107 to 3.12.02a-117 in **Sub Appendix A: Figures** (Document Reference 3.12.02a). Increases in water levels are summarised in **Table 5-3**.

5.2.10 The piers across the floodplain have very little impact on water levels. The greatest increases are predicted at the outer edges of the right bank floodplain where the proposed maintenance track drops down to the floodplain level. There is a minor embankment in this location causing the localised changes.

5.2.11 A review of the receptors that could be impacted by these increases in water levels confirms that, in all events up to the 1 in 100 annual probability flood event plus 44% climate change allowance, only grazing farmland is affected. There is no increased risk to property or infrastructure. The predicted increase in water levels to the grazing land shown in **Table 5-3** extend for approximately 20m upstream of the viaduct on the outer edge of the floodplain and are of slight significance. Beyond this localised area the increases are considered to be of neutral significance.

5.2.12 From a flood risk perspective given the small increases in water levels as presented in **Table 5-3**, changes in the flood extents are marginal and the land affected by this increase is already located within the floodplain. There is also no significant attenuation resulting from the piers of the viaduct and as such it can be concluded no significant change to the duration of flooding resulting from the proposals. Based on the above it can be concluded that flood risk to the grazing farmland upstream of the scheme is unchanged.

5.2.13 There is no change to flood risk downstream of the Proposed Scheme.

Table 5-3 Summary of water level increases associated with the Proposed Scheme

Return Period (annual probability)	Water level increase at the viaduct (m)
1 in 2	0.004
1 in 100	0.011
1 in 1000	0.011
1 in 100+44%CC	0.012

5.2.14 The environmental mitigation proposals have not been developed in detail at this stage, however to understand the potential impacts associated with these proposals a sensitivity test has been completed and is presented in detail in **Sub Appendix B: River Wensum Hydraulic Modelling Report** (Document Reference 3.12.02b) and the results are presented in Figures 3.12.02a-129 to 3.12.02a-143 in **Sub Appendix A: Figures** (Document Reference 3.12.02a).

The interventions would equate to a localised increase in roughness on the banks of the River Wensum (reflecting riparian planting), an increase in watercourse length and hence reduction in channel gradient (reflecting the added tortuosity of the meander) and an increase in roughness in the floodplain. The main downstream hydraulic control would remain the floodplain itself.

5.2.15 The nearest receptors outside of grazing land and St Margaret's Church access track are the properties upstream of Fakenham Road. The sensitivity tests indicate increases are constrained to the area between the environmental enhancements and the A1067 Fakenham Road. In the 1 in 100 plus 45% annual probability event the assessment indicates an increases in flood depths of 50mm to St Margaret's Church access track and a maximum of 60mm to the grazing land just downstream of the location of the proposed meander. In accordance with the methodology promoted in LA 113 there would be an impact significance of moderate to the St Margaret's Church access track and grazing land.

5.2.16 St Margaret's Church access track and the grazing land are within the functional floodplain and are already predicted to flood to 400mm depth in the most sensitive areas in the 1 in 100 plus 45% annual probability event. Given the existing flood risk, changes to the overall flood hazard at these sites is minimal and the flood risk is considered to be unchanged.

Impact to flood velocity

5.2.17 The introduction of the viaduct piers in the floodplain of the River Wensum has the potential to impact flood flow velocities by throttling the flow through a narrower area. Changes in flow velocities have the potential to result in scour and so have a long term impact on changes in flood risk to infrastructure if not properly considered.

5.2.18 The impact of the Proposed Scheme on velocity has been assessed by extracting the peak velocity that occurs at all points across the floodplain events up to the 1 in 100 annual probability plus 44% climate change event.

5.2.19 Figures 3.12.02a-118 to 3.12.02a-128 in **Sub Appendix A: Figures** (Document Reference 3.12.02a) shows how velocities change as a result of the Proposed Scheme. Changes in peak velocities in the floodplain are localised around the Proposed Scheme with the greatest changes immediately adjacent to the viaduct. The small magnitude of the changes in velocities within the River Wensum and floodplain following the construction of the Proposed Scheme mean the resulting velocities are consistent with the existing situation. On this basis there is considered to be no increase in flood risk associated with local or downstream scour.

5.2.20 The proposed environmental enhancements would increase the hydraulic roughness in the River Wensum and floodplain. As such there is a general reduction in velocities with localised minor increases of less than 0.1m/s where flow paths are changing.

Impacts associated with changes to vegetation

5.2.21 **Chapter 10: Biodiversity Appendix 10.37: Solar Exposure Analysis** (Document Reference 3.10.37), which discusses the impacts of shading by the River Wensum viaduct, has been prepared to assess the impacts of the proposed viaduct on vegetation growth within the River Wensum floodplain. The findings of the report indicate that a change in the plant mix would occur as a result of the Proposed Scheme, but that there are sufficient shade tolerant plants in the area to compensate for the loss of those plants that are more sensitive to shade. The overall impact would therefore be no overall loss of vegetation growth and the continued presence of floodplain roughness equivalent to existing.

5.2.22 For the purposes of this FRA, a sensitivity assessment has been completed to confirm the impacts of a reduction in the density of the existing vegetation cover in the floodplain. Natural England had raised concerns that a reduction in floodplain roughness would increase flows past the site and so impact flooding downstream. The findings of this assessment indicated local lowering of water levels associated with the reduced roughness, but no impact on downstream flows, as these are controlled by structures and the floodplain

beyond the viaduct. This reflects the shallow gradient of the watercourse and the fact that the downstream channel capacity drives water levels. Full details of this sensitivity test are provided in **Sub Appendix B: River Wensum Hydraulic Modelling Report** (Document Reference 3.12.02b).

5.2.23 The potential change to vegetation cover in the River Wensum floodplain caused by shade from the viaduct is considered to have negligible impact to flood risk to the Proposed Scheme or elsewhere.

Conclusions

5.2.24 The proposed viaduct over the River Wensum manages flood risk to both the Proposed Scheme and to third parties in the near vicinity. **Table 5-4** summarises the impacts In the 1 in 100 annual probability flood event plus 44% climate change allowance associated with the NWL highway works. **Table 5-5** summarises the impacts In the 1 in 100 annual probability flood event plus 44% climate change allowance associated with the environmental enhancement works.

Table 5-4 Summary of impact significance of post development works associated with the River Wensum in the 1 in 100 pls 44% annual probability event

Receptor	Vulnerability classification	Water level impact	Significance
Grazing land adjacent to southern viaduct abutment	Less vulnerable	+12mm	Slight
NMU Routes 10 and 10a	Water compatible	+1200mm (full depth assessed for new assets)	Slight

Receptor	Vulnerability classification	Water level impact	Significance
Grazing land between the viaduct and environmental enhancements including NMU Route 7	Less vulnerable	<+10mm	Neutral

Table 5-5 Summary of impact significance of environmental enhancement works associated with the River Wensum in the 1 in 100 plus 44% annual probability event

Receptor	Vulnerability classification	Water level impact	Significance
St Margaret's Church access track	Less vulnerable	+50mm from existing 400mm depth	Moderate
Grazing land upstream of the environmental enhancements and downstream of the A1067 Fakenham Road	Less vulnerable	+60mm from existing 650mm depth	Moderate

5.2.25 Depths adjacent to the southern abutment in the region of the greatest increases in water levels are approximately 0.5m. There is little to no change to the flood extent in this area and as such the flood hazard for the area remains unchanged.

5.3 Foxburrow Stream

5.3.1 Foxburrow Stream requires a culvert structure beneath the embankment of the Proposed Scheme, which carries both the NWL highway and NMU Route 1b across Foxburrow Steam in this location, to allow passage of flows from upstream to downstream.

5.3.2 The Foxburrow Stream culvert has been designed to accommodate bats; as such the proposed culvert is a significant size and this requirement has greater dominance over the size of the culvert than other competing design requirements. The proposed structure is a rectangular culvert 4m wide, 4.5m high and 50m long. The culvert would have a 500mm deep natural bed in its invert.

5.3.3 The proposed culvert has been modelled using the 1D hydraulic model as described in **Sub Appendix E: Foxburrow Stream Hydraulic Modelling Report** (Document Reference 3.12.02e). The results are presented in Table 3-1 to Table 3-4 in **Sub Appendix E: Foxburrow Stream Hydraulic Modelling Report** (Document Reference 3.12.02e) and Figures 3.12.02a-146 to 3.12.02a-160 in **Sub Appendix A: Figures** (Document Reference 3.12.02a). The results for the 1 in 1000 annual probability event are presented below as these are larger than the 1 in 100 plus 45% annual probability event for Foxburrow Stream.

5.3.4 The PED network would divert flows from adjoining catchments (0.16km^2 in total) through the Foxburrow Stream culvert as discussed in Section 1.5. This would result in an increase in flows along the watercourse for a distance of about 500m, inclusive of the culvert.

Flood risk to the Proposed Scheme

5.3.5 The analysis presented in Table 3-1 to Table 3-4 in **Sub Appendix E: Foxburrow Stream Hydraulic Modelling Report** (Document Reference 3.12.02e) has demonstrated that the culvert has sufficient capacity to accommodate all modelled flood events. The soffit of the culvert is 39.2m AOD resulting in freeboard through the structure in the 1 in 1000 annual probability event in excess of 2.5m. There is no residual risk of surcharging with larger events and overtopping of the Proposed Scheme is not predicted to occur.

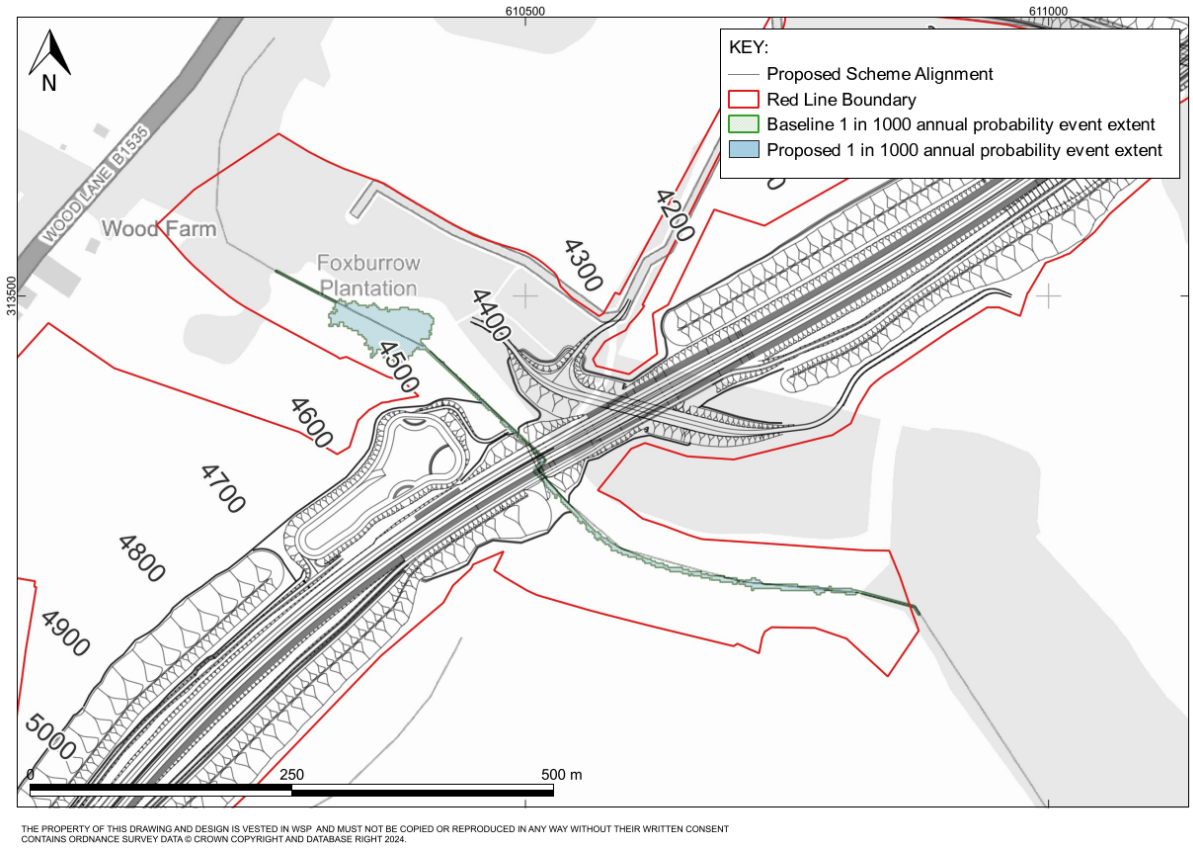
Flood risk to third parties

5.3.6 Catchments 1b, 3 and 4 as shown in Figure 3.12.02a-3 the **Overland Surface Water Catchments**, in **Sub Appendix A: Figures** (Document Reference 3.12.02a) form part of the larger topographical catchment of Foxburrow Stream. They currently join the watercourse at a location a short distance downstream of the Proposed Scheme. The diversion of flows from these catchments by the PED network increases the drainage path length of these catchments. It is therefore reasonable to conclude that these proposals would result in a reduction in peak downstream flows beyond the current confluence of Catchments 1b, 3 and 4 with Foxburrow Stream. Between the Proposed Scheme and the most downstream confluence there would be an increase in flows, this increase in flows would occur over a distance of approximately 500m and result in a maximum increase in water levels of 20mm.

5.3.7 The baseline modelling of Foxburrow Stream demonstrated that the existing channel has sufficient capacity for the 1 in 100 annual probability plus 45% climate change event, with all flow remaining within bank through the reach where the Proposed Scheme is located. As discussed above, the proposed culvert would maintain the capacity of the channel and no surcharging of the culvert is predicted. No loss of floodplain storage would occur and no compensatory floodplain storage is therefore proposed. **Figure 5-2** shows the change in flood extent resulting from the Proposed Scheme.

5.3.8 The extents presented **Figure 5-2** confirm that the increase in water levels from the flow diversions is constrained to the channel and as such there is no change in flood extent or associated flood risk. In accordance with the methodology promoted in LA 113 the impact significance would be slight

Figure 5-2 Comparison of 1 in 1000 annual probability extents for Baseline and Proposed for Foxburrow Stream



Conclusions

5.3.9 The analysis presented above demonstrates that the proposed crossing of Foxburrow Stream would have no adverse effect on flood risk upstream of the Proposed Scheme. There would be an increase in flows for approximately 500m downstream of the Proposed Scheme where the surface water runoff is diverted. These increases remain in bank and there is no increased risk to the Proposed Scheme or to land, property and infrastructure elsewhere. In accordance with the methodology promoted in LA 113 the impact significance would be neutral.

5.4 Reservoir Flood Risk

5.4.1 Flood risk from a breach of the Haveringland Lake embankment has been assessed to understand the potential changes in velocities past the viaduct piers and hence the requirements for scour protection.

5.4.2 The assessment has used the 1 in 100 plus 44% annual probability event peak flow and applying this to the River Wensum model as a 2 hour event to replicate a 'flash flow' scenario with significant volumes of water passing through the floodplain in a significantly reduced duration. The lake has a footprint of approximately 56,000m^2 and the volume in the modelled hydrograph equates to an average depth of 14m based on the footprint of the lake. The depth of the reservoir is unknown but this assumed depth based on the hydrograph volume is considered to be an appropriately conservative assumption.

5.4.3 Modelled results are presented Figures 3.12.02a-21, 3.12.02a-32 and 3.12.02a-43 for the baseline condition and 3.12.02a-84, 3.12.02a-95 and 3.12.02a-106 for the Proposed Scheme in **Sub Appendix A: Figures** (Document Reference 3.12.02a).

Flood risk to the Proposed Scheme

5.4.4 The volumes within the hydrograph modelled are insufficient to recreate the flood levels observed in design flood events. Similarly, the resulting peak velocities at the location of the viaduct do not exceed 0.5m/s. These are broadly consistent with the velocities in the design flood events assessed.

5.4.5 On the basis of the modelling it can be stated that the risk of scour to the viaduct piers from a reservoir breach is consistent with the occurrence of a fluvial flood event. The likelihood of a breach is expected to be less than the probability associated with the 1 in 100 plus 44% annual probability event. As such the risk of scour is concluded to be less than the risk presented by existing fluvial flood events.

Flood risk to the third parties

5.4.6 As stated above water levels from a reservoir breach would be less than predicted to occur in the 1 in 100 plus 44% annual probability event and the likelihood of a breach is considered to be less than the same event. The additional risk of flooding to third parties resulting from the Proposed Scheme

in the event of a reservoir breach is therefore considered to be less than assessed in Section 5.2 for fluvial flood risk from the River Wensum.

Conclusion

The risk of flooding from a reservoir flood breach is considered to be less than the 1 in 100 plus 44% annual probability event. The conclusions presented in Section 5.2 are considered appropriate to summarise the risk of flooding from a reservoir breach.

5.5 Groundwater Flood Risk

Flood Risk to the Proposed Scheme

5.5.1 The NWL highway is typically at or above local ground levels and as such is not susceptible to groundwater flooding. Where proposed road cuttings extend below maximum groundwater tables, permanent groundwater drainage will be developed through the detailed design stage so that the groundwater discharges are captured and groundwater levels in the vicinity of the Proposed Scheme are kept sufficiently below the proposed highway. Furthermore, current ground investigation data do not indicate risks of high groundwater inflows as areas of elevated groundwater outside of the main watercourse channels are attributed to perched water tables and as such seepage is volume constrained. Details of the ground investigations are presented in **Appendix 12.5: River Wensum Crossing – Groundwater Modelling Report** (Document Reference: 3.12.05)

5.5.2 The soakaway basins (which excludes basins 1, 5 and 6) are located outside areas of shallow groundwater tables, therefore the operation of these basins is not expected to be compromised by the presence of elevated groundwater levels. Details of groundwater levels in relation to each of the soakaway basins are presented in Table 15 of the **Drainage Strategy Report** (Document Reference: 4.04.00). Basins 5 and 6 are located in areas of high groundwater; these have embedded mitigation (drainage measures) and as a result would not be susceptible to groundwater inundation, full details are

provided in Section 5.2.7 Groundwater mitigation measures in the **Drainage Strategy Report** (Document Reference: 4.04.00).

Flood risk to third parties

5.5.3 To assess the potential impact of the River Wensum viaduct foundations on groundwater, modelling has been undertaken to assess groundwater level and flow changes. This is presented in the **River Wensum Crossing – Groundwater Modelling Report** (Document Reference 3.12.05). The results confirm that the viaduct foundations do not act as a groundwater flow barrier and consequently do not alter groundwater flows and levels.

5.5.4 Across the wider scheme the potential for below ground structures, discussed in Section 1.5, to act as groundwater flow barriers is considered a very low risk due to the ability for groundwater to flow around these structures.

5.5.5 Discharges from the soakaway basins (which excludes basins 1, 5 and 6) have the potential to contribute inflows to the ground from a larger catchment than existing. These could contribute to rising groundwater levels downstream of these basins. Comprehensive ground investigations have been undertaken in the proposed soakaway basin areas which showed relatively low infiltration rates, presented in Table 15 of the **Drainage Strategy Report** (Document Reference: 4.04.00).

5.5.6 There is a residual risk that these infiltration rates are not representative of the whole basin and localised productive pathways in the geology result in higher than expected discharges to groundwater and consequently an increase in groundwater flooding risk downstream. These risks would be managed on site during construction when the full geology of the drainage basin footprints get exposed. Mitigation would require additional low permeability base layer to be incorporated into the basin design.

Conclusions

5.5.7 The impact of the River Wensum viaduct foundations has been assessed using detailed groundwater modelling. This has confirmed groundwater levels following construction would be comparable to existing.

5.5.8 Other below ground structures are not expected to impede groundwater flow sufficiently to create additional flood risk. In accordance with the methodology promoted in LA 113 the impact significance would be neutral.

5.5.9 Residual risks associated with localised variations in geology in the vicinity of the soakaway basins would be managed on site during construction.

5.6 Overland Flows and surface water flood risk

5.6.1 Section 1.5 discusses the Management of Surface Water Runoff from the Proposed Scheme. Full details of the surface water drainage system are provided in Section 7 and Volume 3 of the **Drainage Strategy Report** (Document Reference: 4.04.00). The information presented in the **Drainage Strategy Report** (Document Reference: 4.04.00) confirms that the SuDS design proposed has sufficient capacity to prevent increases in flood risk resulting from runoff from the Proposed Scheme Mainline Highway itself.

5.6.2 Sections 1.4, 1.5 and 3.4 set out the various overland flow routes that are crossed by the Proposed Scheme. The approach to the management of overland flow and surface water flood risk is described in Section 1.5 and presented in detail in Section 7.5 and Volume 3 of the **Drainage Strategy Report** (Document Reference: 4.04.00). The PED network collects the overland flows and conveys it to local crossing points or infiltration features. The crossing points are at WC5 in the River Wensum floodplain, Ringland Lane, Foxburrow Stream, Foxburrow Stream tributary, to the north-west of the A1067 Fakenham Road / NWL roundabout and at either end of the Proposed Scheme.

5.6.3 Figure 3.12.02a-3, the Overland Surface Water Catchments, in **Sub Appendix A: Figures** (Document Reference 3.12.02a), shows the PED drainage catchments; the catchments are numbered to be consistent with those presented in Section 6 and Volume 3 of the **Drainage Strategy Report** (Document Reference: 4.04.00). The following list presents the catchments which discharge upstream of the Proposed Scheme and the location to which they are conveyed:

- Catchments 12 and 24 drain to WC5;
- Catchments 5, 6, 7, 8 and 9 discharge to Ringland Lane overland flow path. Broadly, catchments 7, 8 and 9 sit within the existing Ringland Lane catchment upstream of the Proposed Scheme. Catchments 5 and 6 are diverted by the PED network from an adjacent catchment;
- Catchments 1b, 2, 3, and 4 discharge to Foxburrow Stream. Catchments 2 is the existing Foxburrow Stream catchment upstream of the Proposed Scheme. Catchments 1b, 3 and 4 are diverted by the PED network from adjacent catchments;
- Catchment 1a is the Foxburrow Stream tributary catchment;
- Catchment 11 is the A1067 Fakenham Road catchment which discharges into WC7.

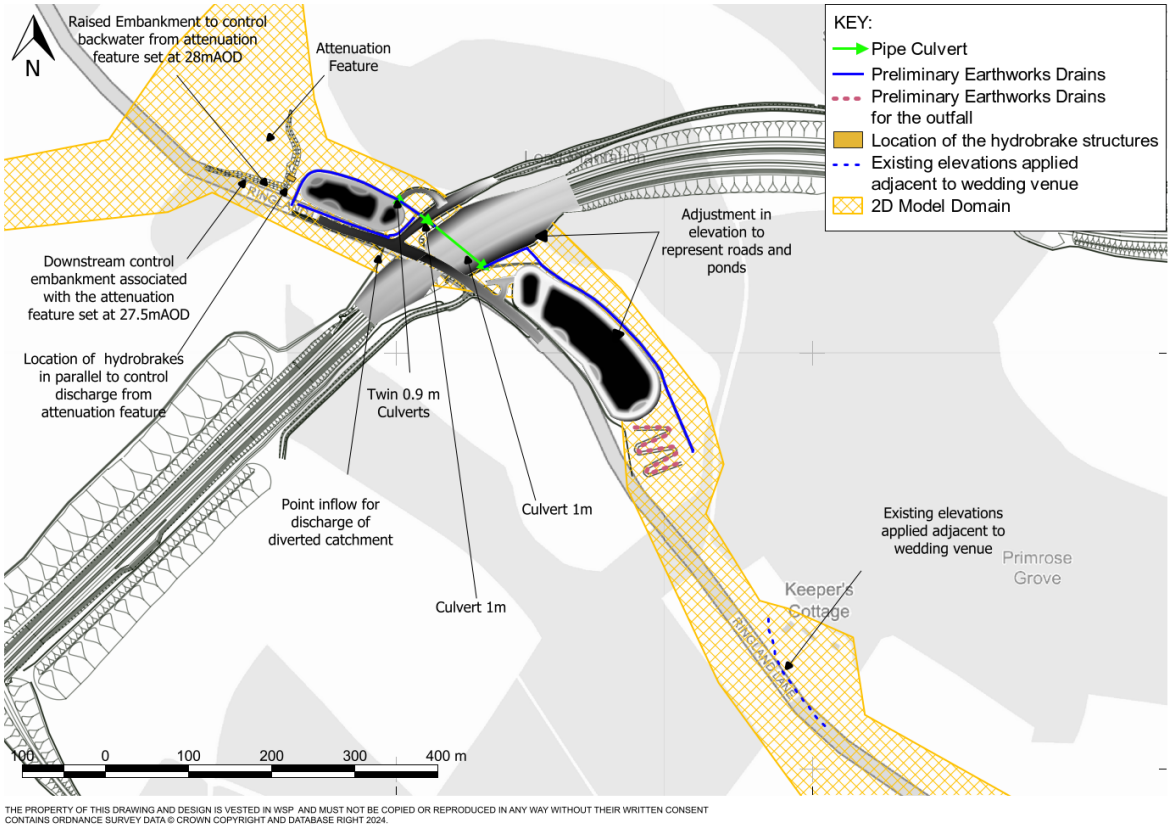
Flood risk to the Proposed Scheme

Ringland Lane overland flow path

5.6.4 A standalone hydraulic model has been developed for the Ringland Lane overland flow path and full details are presented in **Sub Appendix H: Ringland Lane Hydraulic Modelling Report** (Document Reference 3.12.02h) and an overview is given in **Figure 5-3**. This model incorporates the following:

- Additional flow contribution in the Post Development scenario from catchments 5 and 6
- Attenuation feature upstream of the Proposed Scheme
- PED network to convey flows around Drainage Basins 3 and 4
- 3 culverts to convey flows beneath the maintenance tracks, one of which is NMU Route 10, and the Proposed Scheme

Figure 5-3 Overview of Ringland Lane attenuation feature



5.6.5 Results from the modelling are presented in Figures 3.12.02a-161 to 3.12.02a-233 in **Sub Appendix A: Figures** (Document Reference 3.12.02a).

5.6.6 The PED network and culverts are of a sufficient size to convey the 1 in 100 plus 45% annual probability event (based on rainfall intensity requirements) past the Proposed Scheme with no impact on the maintenance tracks, NMU Routes 10, the surface water drainage basins or the highway itself. NMU Route 6 currently floods where Ringland Lane overland flow path crosses Ringland Lane, there would be an increase in flood depths in the 1 in 100 plus 45% annual probability event (based on rainfall intensity requirements) in this location of 130mm. In accordance with the methodology promoted in LA 113 the impact significance would be moderate.

5.6.7 There is a residual risk of flooding to the upstream surface water drainage basin (Basin 3) in the 1 in 1000 annual probability event. Similarly, sensitivity tests presented in **Sub Appendix H: Ringland Lane Hydraulic Modelling**

Report (Document Reference 3.12.02h) confirm a similar residual risk of flooding in the event of a breach to the attenuation feature retaining embankment. The Water levels remain approximately 9m below the crest of the highway in these events.

Remaining overland flow paths

5.6.8 Flood risk to the Proposed Scheme for the WC5 crossing and for Foxburrow Stream are assessed in Section 5.2 and 5.3 respectively.

5.6.9 Details of the design of the culverts for the Foxburrow Stream tributary and A1067 Fakenham Road overland flow paths are presented in Section 9 Highway Crossings of the **Drainage Strategy Report** (Document Reference: 4.04.00). The design for these two culverts is sufficient to convey the 1 in 100yr plus 45% climate change event (based on rainfall intensity requirements) past the site with an allowance for with an allowance of 10% loss of capacity for sedimentation.

5.6.10 Paddy's Lane overland flow path runs past the entrances to NMU Route 2 and the access point to the environmental enhancement corridor connecting to Breck Road and (in its upstream reaches) an area of woodland and scrub creation. Marl Hill Road overland flow path runs along the alignment of NMU Route 12. Hockering Road overland flow path crosses two environmental enhancement areas adjacent to Hockering Road. NMU Route 2 (the existing Broadway Highway), the access to the environmental enhancement corridor connecting Paddy's Lane to Breck (which consists of a paved farm track), the area of woodland creation and NMU Route 12 are all water compatible. As such there is no risk to the Proposed Scheme from inundation of these elements.

Flood risk to third parties

Ringland Lane overland flow path

5.6.11 Catchments 5 and 6 form part of the Weston Road overland flow path and join the Ringland Lane overland flow path at a location approximately 800m downstream of the Proposed Scheme. Between the Proposed Scheme and

the Ringland Lane / Weston Road overland flow path confluence sits the Keeper and the Dell (wedding venue) property, classified as a more vulnerable receptor. The property is currently at risk of flooding, with the onset in flooding around the 1 in 100 annual probability event. Diverting greater flows past this property would increase flood risk. The situation of the property means it is sensitive to flood volumes rather than peak flows.

5.6.12 The embedded mitigation in the form of the attenuation feature upstream of Drainage Basin 3 manages the risk of flooding to this property. Full details of the embedded mitigation are provided in **Sub Appendix H: Ringland Lane Hydraulic Modelling Report** (Document Reference 3.12.02h) and an overview is included in **Figure 5-2**.

5.6.13 This feature incorporates a series of hydrobrakes that allow smaller events to continue downstream unhindered but, in conjunction with the series of culvert structures downstream, reduces peak flows in the larger events. It also reduces the spill volumes into the Keeper and the Dell (wedding venue) such that predicted flood depths are reduced for all events. **Table 5-6** presents the peak water levels in the Keeper and the Dell property.

Table 5-6 Comparison of peak water levels (m AOD) in the Keeper and the Dell (wedding venue)

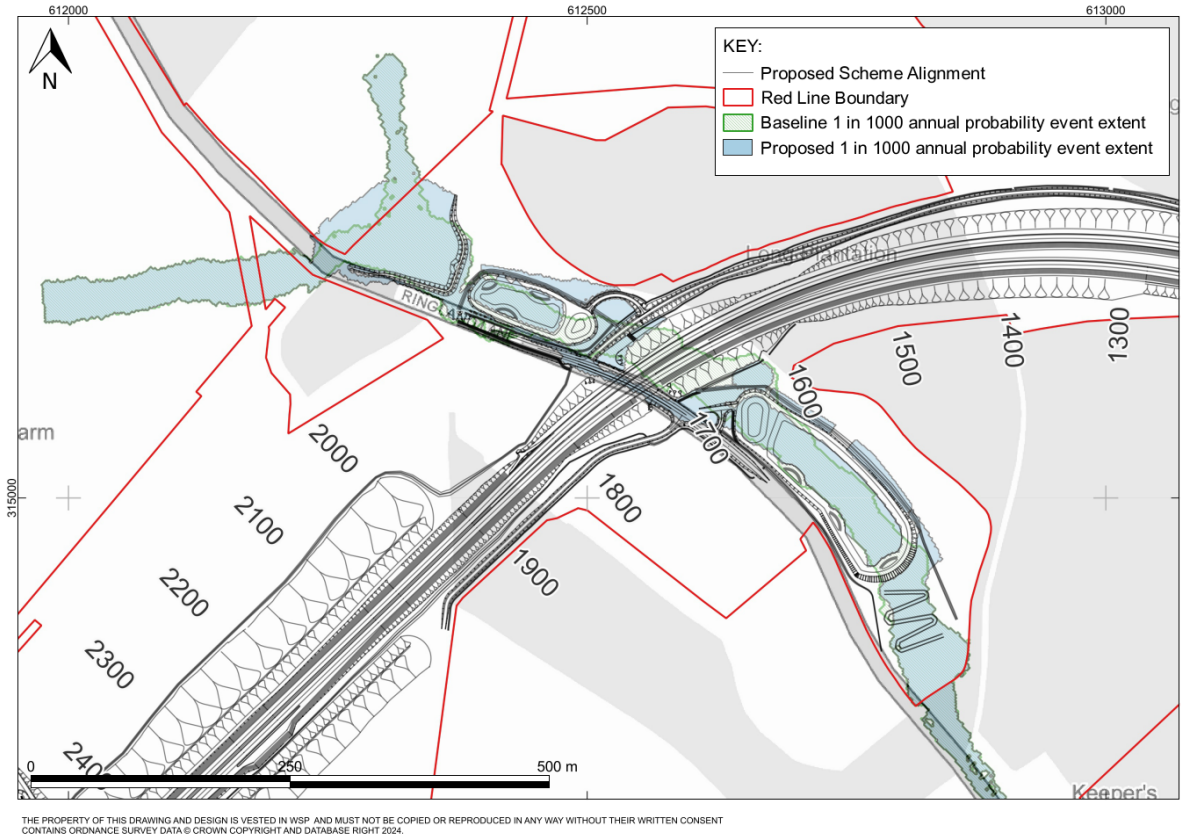
Scenario	30yr event	50yr event	75yr event	100yr event	100yr plus 45% event	1000yr event
Baseline	Not applicable	11.19	11.27	12.33	14.57	16.14
Proposed	Not applicable	11.19	11.23	12.16	14.52	15.94

5.6.14 There are localised reductions to water levels along Ringland Lane in the vicinity of the Keeper and the Dell (wedding venue) results from the attenuation feature. These reductions are modelled to occur from the 1 in 30 to the 1 in 1000 annual probability event and are limited to less than 10mm

because Ringland Lane itself is a conveyance route rather than a storage area. Ringland Lane is classified as a less vulnerable receptor and in accordance with the methodology promoted in LA 113 the impact significance would be Neutral.

5.6.15 There are increases in water levels at the upstream limit of the attenuation feature which extend onto agricultural land outside of the red line boundary and Ringland Lane within the red line boundary, as shown in **Figure 5-4**. The increases to both receptors occur in the 1 in 100 annual probability event and above.

Figure 5-4 Comparison of 1 in 1000 annual probability extents for Baseline and Proposed for Ringland Lane overland flow path



5.6.16 The affected area of agricultural land is approximately 3000m^2. The maximum increase is of the order of 1000mm in the 1 in 100 plus 45% annual probability event with depths dropping quickly away from the red line boundary. The increases are limited to the 1 in 100 annual probability event and above and

so it is not envisaged that there would be a material change to the viability of the agricultural land for its current use or the safety of users of this land given the existing inundation in the local vicinity.

5.6.17 The agricultural land is classified as a less vulnerable receptor and in accordance with the methodology promoted in LA 113 the impact significance would be Moderate. The LA 113 methodology looks at depth alone. In this location peak depths are associated with the functioning of the attenuation feature and so velocities are low (less than 0.1 m/s) meaning the flood hazard remains low. The location is also on agricultural land and surrounded to the north east and south west by active floodplain. Finally, as stated above, the inundation occurs in low frequency events only. On the basis of the above, the flood risk, reflecting the probability and consequences of flooding, is considered to remain negligible in this location.

5.6.18 Ringland Lane is affected for a distance of approximately 20m in an area already susceptible to flooding to a depth of 100mm and the maximum increase is of the order of 130mm in the 1 in 100 plus 45% annual probability event.

5.6.19 Ringland Lane is classified as a less vulnerable receptor and in accordance with the methodology promoted in LA 113, considering depth alone, the impact significance would be Moderate. Flood depths in the highway are already 100mm and would remain less than 300mm in the 1 in 100 plus 45% annual probability event. The resulting flood hazard rating could continue to be classed as low. On this basis flood risk is considered to remain unchanged in this location of Ringland Lane.

Remaining overland flow paths

5.6.20 Flood risk to the Proposed Scheme for the WC5 crossing and for Foxburrow Stream are assessed in Section 5.2 and 5.3 respectively. Details of the design of the culverts for the Foxburrow Stream tributary (culverts C-16-C-2.000, C-16-C-3.000 and C-16-C-4.000) and A1067 Fakenham Road (culvert C-03-A-1.000) overland flow paths are presented in Section 9 Highways Crossings of

the **Drainage Strategy Report** (Document Reference: 4.04.00). The design is sufficient to convey the 1 in 100 plus 45% climate change annual probability event (based on rainfall intensity requirements) past the site with an allowance of 10% loss of capacity for sedimentation.

5.6.21 Paddy's Lane overland flow path runs past the entrances to NMU Route 2 and the access to the environmental enhancement corridor connecting to Breck Road. In its upstream reaches it crosses an area of proposed woodland and scrub creation. There is no change to the surface or NMU Route 2 in this location. Similarly, the access to the environmental enhancement corridor at Paddy's Lane is expected to remain unchanged. As such there would be no change to the existing flow route along Paddy's Lane itself. Upstream, the planting of woodland and scrub would encourage infiltration and attenuate runoff and so would not result in an increase in downstream flows. In accordance with the methodology promoted in LA 113 the impact significance would be neutral.

5.6.22 Marl Hill Road overland flow path runs along the alignment of NMU Route 12. The proposed works in this location consist of a new pedestrian-cycleway set back from the main carriageway. Management of runoff from the pedestrian-cycleway is expected to be through attenuation and infiltration in grass swales, resulting in no net increase in flows along Marl Hill Road. The flow path itself is constrained to the highway itself and as such the Proposed Scheme would not interfere with the existing route. In accordance with the methodology promoted in LA 113 the impact significance would be neutral.

5.6.23 NMU Route 12 crosses the A1067 Fakenham Road at its downstream limit. In this location some minor works are proposed, consisting of marginal widening of the highway (approximately 85m^2 in area) and creation of a central bollard to support crossing in this location. The proposed works would not change the existing flow route and would have a negligible impact on runoff. In accordance with the methodology promoted in LA 113 the impact significance would be neutral.

5.6.24 The Hockering Road overland flow path crosses two areas where environmental enhancements are proposed. The works themselves consist of grassland creation in the upstream area and woodland and scrub creation in the downstream area. These works would encourage infiltration and attenuate runoff and so would not result in an increase in downstream flows. In accordance with the methodology promoted in LA 113 the impact significance would be neutral.

Conclusion

5.6.25 **Table 5-7** summarises the impacts of the Proposed Scheme on the overland flow routes in the 1 in 100 plus 45% annual probability event unless stated.

Table 5-7 Summary of impact significance of post development works associated with overland flow paths in the 1 in 100 plus 45% annual probability event

Receptor	Vulnerability classification	Maximum water level impact	Significance
Ringland Lane adjacent to the Ringland Lane attenuation feature	Less vulnerable	+130mm from existing 100mm depth	Moderate (Note 1)
Agricultural land upstream of the Ringland Lane attenuation feature	Less vulnerable	+1000mm	Moderate (Note 1)
The Keeper and the Dell (wedding venue)	More vulnerable	-50mm	Moderate (beneficial)
Ringland Lane adjacent to the Keeper and the Dell (wedding venue)	Less vulnerable	<-10mm	Neutral
Green Farm	Less vulnerable	0mm	Neutral
Morton Lane and associated commercial properties	Less vulnerable	0mm	Neutral

Note 1: Significance classification is based on maximum flood depths as consistent with LA 113. In these locations there is considered to be negligible change to flood risk.

5.6.26 The embedded mitigation for Ringland Lane manages risk to the Keeper and the Dell (wedding venue). Elsewhere, the proposals associated with the NMU routes and the environmental enhancements would have a neutral impact.

5.6.27 There is a moderate impact to the agricultural land and Ringland Lane upstream of the attenuation feature. Localised increases in flooding are limited to the 1 in 100, 1 in 1000 and 1 in 100 plus 45% annual probability events so no change to the consequences of flooding is expected and therefore no change to the existing viability of the land or highway or safety of users is envisaged. Flood depths in the highway would remain less than 300mm in the 1 in 100 plus 45% annual probability event and so would maintain a low hazard rating. In both cases the change in flood risk from existing is considered to be negligible.

6 Demonstration of Compliance with the NPPF in relation to Flood Risk

6.1 Meeting the challenge of climate change, flooding and coastal change

6.1.1 The requirements of the NPPF in relation to flood risk are set out in Section 2.2. The Proposed Scheme includes areas at risk of flooding and as such Paragraph 173 of the NPPF requires this FRA demonstrate, in parallel with the Sequential and Exception tests, that:

(a) within the site, the most vulnerable development is located in areas of lowest flood risk, unless there are overriding reasons to prefer a different location;

(b) the development is appropriately flood resistant and resilient such that, in the event of a flood, it could be quickly brought back into use without significant refurbishment;

(c) it incorporates sustainable drainage systems, unless there is clear evidence that this would be inappropriate;

(d) any residual risk can be safely managed; and

(e) safe access and escape routes are included where appropriate, as part of an agreed emergency plan.

6.1.2 Compliance with the above points is demonstrated and referenced through the discussions on the Sequential Test in Section 6.2 and the Exception Test in Section 6.3.

6.2 Sequential Test

6.2.1 The requirements for the Sequential Test are set out in Section 2.2. Full details of the alternative alignment routes considered and the justifications for selection the preferred route are set out in **Chapter 4: Reasonable Alternatives Considered** (Document Reference 3.04.00). Flood risk was considered in the route selection process and assessment of scheme options. That said, for a major infrastructure scheme such as this, flood risk only forms one element of the route alignment decision-making process and there are other drivers that must be considered in balance with flood risk.

6.2.2 The following points are noted with respect to the context of NPPF Paragraph 173 and the Sequential Test for the selected route alignment of the Proposed Scheme:

- There were no route alternatives identified that could avoid works to cross the River Wensum.
- The preferred route avoids crossing the River Tud, which was not the case for all route options.

6.2.3 With respect to NPPF Paragraph 173 (a), the Proposed Scheme mainline highway is considered to be a consistent vulnerability along its length. It has been located in areas of low flood risk as far as practicable but the nature of the scheme means that avoidance of flood risk is not possible. The Proposed Scheme is therefore considered compliant with NPPF Paragraph 173 (a).

6.2.4 The preferred route crosses the River Wensum, Foxburrow Stream and two overland surface flow paths as set out in Section 1.4. In accordance with NPPF, an assessment of the Exception Test is required.

6.3 Exception Test

6.3.1 The requirements for the Exception Test are set out in Section 2.2.

6.3.2 The Proposed Scheme is considered to be Essential Infrastructure on the basis of its strategic importance to travel in the Greater Norwich Area. In accordance with the PPG for Flood Risk and Coastal Change (**Ref 12.2.22**), the Exception Test should be satisfied for the development to be considered acceptable in Flood Zones 3a or 3b.

6.3.3 In summary, for the Exception Test to be passed, it should also be demonstrated that:

- The development would provide wider sustainability benefits to the community that outweigh the flood risk; and
- The development would be safe for its lifetime taking account of the vulnerability of its users, without increasing flood risk elsewhere, and, where possible, would reduce flood risk overall.

Strategic importance

6.3.4 To meet Part 1 of the Exception Test it must be demonstrated that the Proposed Scheme provides wider sustainability benefits to the community that outweigh flood risk. These benefits are set out in full in the **Planning Statement** (Document Reference 1.01.00). The Proposed Scheme provides a strategic travel corridor for the Greater Norwich Area. The Broadland Northway connects the A47 to the east of Norwich to Fakenham Road and the Proposed Scheme will complete the route by connecting Fakenham Road to the A47 to the west of Norwich. At present, in the absence of a major highway route, the minor roads between Fakenham Road and the A47 are subject to traffic congestion, rat-running and delays to journeys.

6.3.5 The **Planning Statement** (Document Reference 1.01.00) sets out the benefits of the Proposed Scheme. It states that the Proposed Scheme will:

- Reduce congestion and provide greater certainty over journey times for motorists;

- Enhance the local transport network for pedestrians, cyclists and horse riders, by incorporating a range of NMU provisions alongside the highway link design;
- Improve the resilience of the highway network in the area to the west of Norwich;
- Reduce forecast traffic on the existing local road network allowing for a range of wider 'Complementary Sustainable Transport Measures' which could include measures for improved walking, cycling and public transport which would help to promote active travel, consistent with improving quality of life.

Flood risk assessment

6.3.6 To satisfy Part 2 of the Exception Test a Flood Risk Assessment is required to demonstrate the Proposed Scheme remains operational and safe for users in times of flood, results in no net loss of floodplain storage and does not impede water flows or increase flood risk elsewhere. Section 2.2 provides full details of the requirements for the FRA.

6.3.7 Section 3.8 summarises the existing flood risk sources across the site and so identifies those sources of flood risk that require further consideration within the FRA. The Proposed Scheme is not within an area of tidal flood risk and is not within proximity of known sewer flooding sources. The implications of the Proposed Scheme should be considered for:

- fluvial flooding from the River Wensum and Foxburrow Stream
- surface water flooding from overland flow paths
- groundwater flooding
- reservoir flooding from Haveringland Lake in the event of a breach

Flood risk to the Proposed Scheme

6.3.8 Flood risk impacts during operation are discussed in Section 5.

6.3.9 Flood risk to the Proposed Scheme from fluvial flood risk sources has been assessed through hydraulic models of the River Wensum and Foxburrow Stream. Fluvial flood risk from the River Wensum is discussed in Section 5.2 and it is confirmed there is 6m freeboard between the underside of the viaduct and the 1 in 100 plus 44% annual probability event peak water level. The new NMU routes 10 and 10a are predicted to flood but these are considered to be water compatible and the impact would be slight. Fluvial flood risk from Foxburrow Stream is discussed in Section 5.3 and it is confirmed there is 2.5m freeboard between the soffit level of the culvert and the 1 in 1000 annual probability event peak water level. The Proposed Scheme would therefore remain operational at times of fluvial flooding.

6.3.10 Flood risk to the Proposed Scheme from surface water flooding is discussed in Section 5.6. Flood risk from the Ringland Lane overland flow path has been assessed through a hydraulic model. Flood risk from the smaller overland flow routes in the vicinity of the A1067 Fakenham Road and at the Foxburrow Stream Tributary are considered in the design of the PED network and associated structures in Section 7.5 and Section 9 of the **Drainage Strategy Report** (Document Reference: 4.04.00) respectively. The Proposed Scheme conveying the Ringland Lane overland flow path and the culverts crossing the Proposed Scheme at the A1067 Fakenham Road and at the Foxburrow Stream Tributary have been confirmed to be of sufficient capacity to convey the 1 in 100 plus 45% annual probability event peak flows past the site with no impacts on the Proposed Scheme.

6.3.11 The assessment of surface water flood risk to ancillary works associated with the NMU provision and environmental enhancements has considered the type of intervention proposed. In all cases the new proposals are water compatible or, where there are existing assets, there is no change in flood risk from the current situation.

6.3.12 Groundwater flood risk to the Proposed Scheme would be managed through permanent groundwater drainage developed through the detailed design

stage to ensure that the groundwater table remains sufficiently below the proposed highway.

6.3.13 Flood risk to the Proposed Scheme from reservoir flooding has been assessed using the hydraulic model of the River Wensum and applying a short duration event with a peak flow equivalent to the 1 in 100 plus 44% annual probability event. This has confirmed no increase in flood risk compared to the design flood events from the fluvial flood risk assessment. The scour risk to the viaduct piers from a breach at Haveringland Lake is unchanged from typical flood events.

6.3.14 The evidence presented above demonstrates that the Proposed Scheme will remain operational and safe for users in times of flood and so meets that criteria for the Exception Test. The same evidence is directly applicable to, and confirms compliance with NPPF Paragraph 173 (b) and (e). It is evident that the Proposed Scheme, in being operational at times of flood, would not require refurbishment to be bought back into use following a flood and would provide safe access and escape routes without the need for an emergency plan.

6.3.15 The residual risks to the Proposed Scheme from each flood source are discussed within each specific section. Residual risks were only identified at Ringland Lane overland flow path where either flood events in excess of the design event or the occurrence of a breach in the attenuation feature could result in inundation of Drainage Basin 3. In both these instances the Proposed Scheme would remain operational confirming compliance with NPPF Paragraph 173 (d) with respect to residual risks to the Proposed Scheme.

Flood risk to third parties during construction

6.3.16 Flood risk impacts during construction are discussed in Section 4.

6.3.17 The construction of the viaduct in the River Wensum floodplain would require a Temporary Works Platform across the floodplain with flood relief culverts incorporated to mitigate the impacts. The effects of this structure on upstream

water levels are large immediately adjacent to the structure but the only identified impacted receptors in the 1 in 100 annual probability event are grazing land, where the maximum increases are 0.42m at the upstream face of the platform, NMU Route 7, where depths increase by 400mm to a depth of approximately 1m from 0.6m, and a secondary access track to St Margaret's Church where depths increase by 40mm to a depth of approximately 0.33m from 0.28m.

6.3.18 There is a residual risk of external flooding to a property at Old Hall Mill Farm in the 1 in 200 annual probability event. The residual risk of internal flooding to this property is considered to be in excess of the 1 in 1000 annual probability event based on the property's threshold levels. Given the duration the temporary works would be in place is limited to 3 years this residual risk is considered acceptable.

6.3.19 The temporary works platform funnels flows along the River Wensum channel and an increase in velocity is predicted. This increase extends as far as the gas main receptor 450m downstream of the temporary works. Peak velocities in the 1 in 1000 annual probability event are 0.76m/s. This velocity is marginally higher than baseline conditions but not considered to pose increased risk of erosion. As such there is a residual risk to the gas main and the acceptability and management of this risk will need to be determined in discussions with National Grid. There are some minor increases in flood levels downstream associated with the funnelling of flows as well. The only receptor impacted by these is the golf course. Increases are predicted to be 2mm and so the impact is assessed as neutral or slight.

6.3.20 Review of flood risk associated with overland flows and Foxburrow Stream indicates that appropriate methods can be put in place by the contractor to appropriately manage conveyance of flows during construction of the Proposed Scheme to manage flood risks.

6.3.21 Flood risk impact during construction to third parties from groundwater are considered to be consistent with those for the operational phase of the Proposed Scheme and are discussed below.

Post development flood risk to third parties

6.3.22 Fluvial flood risk impacts associated with the River Wensum during operation are discussed in Section 5.2. The Proposed Scheme incorporates mitigation for potential impacts on water levels and flows on the River Wensum through the viaduct. The assessment confirms increases in water levels associated with the viaduct up to the 1 in 100 annual probability flood event plus 44% climate change allowance are constrained to grazing farmland. There is no increased risk to property or infrastructure. The maximum increase in flood depth is predicted to be 12mm at the viaduct with no notable change to flood extent. There is also no attenuation resulting from the piers of the viaduct and as such it can be concluded no change to the duration of flooding of farmland from the proposals. As the farmland is already located within the floodplain of the River Wensum, the increase on flood risk is considered negligible. There is no change to flood risk downstream of the Proposed Scheme.

6.3.23 Environmental enhancements in the River Wensum floodplain would increase water levels. An assessment of the impacts shows these are constrained to the area between the location of the environmental enhancements and the A1067 Fakenham Road. There is a moderate impact to the St Margaret's Church access track and grazing land upstream of the enhancements. These areas are within the functional floodplain and are already susceptible to flooding, as such there are only marginal changes to the flood hazard at these sites and the flood risk impact is considered to be unchanged.

6.3.24 Fluvial flood risk impacts associated with Foxburrow Stream during operation are discussed in Section 5.3. The proposed culvert would maintain the capacity of the channel and no surcharging of the culvert is predicted. The assessment has included proposed changes to the natural catchment of this watercourse upstream of the Proposed Scheme and there is a 20mm increase in water levels in the channel only downstream of the Proposed

Scheme for a distance of 500m resulting from the diversion of flows at the upstream face of the culvert. Beyond 500m downstream of the Proposed Scheme there would be a reduction in flows as the diversion increases the drainage path length and so attenuates flows.

6.3.25 Flood risk to the Proposed Scheme from reservoir flooding is discussion in Section 5.4. The assessment confirmed flood risks remained consistent with fluvial flood risk and concluded there is no change to flood risk resulting from a reservoir breach.

6.3.26 Groundwater flood risk to the Proposed Scheme is discussed in Section 5.5. The Proposed Scheme belowground structures are not of sufficient size to influence groundwater flows or levels given the ability for groundwater to flow around these structures as the geology is very permeable.

6.3.27 The Management of Surface Water Runoff from the Proposed Scheme is discussed in Section 1.5 and set out in full in the **Drainage Strategy Report** (Document Reference: 4.04.00). This information confirms that a SuDS design is in place, in accordance with NPPF Paragraph 173 (c), and this is has been design with sufficient capacity to prevent increases in flood risk resulting from runoff from the Proposed Scheme Mainline Highway itself.

6.3.28 Surface water flood is discussed in Section 5.6. For the Ringland Lane overland flow path the Proposed Scheme would include changes to the natural catchment and increase runoff towards Ringland Lane. Embedded mitigation in the form of attenuation would reduce flows to below existing runoff in events above the 1 in 50 annual probability event. There would be a moderate beneficial impact on the Keeper and the Dell (wedding venue). Upstream of the attenuation feature there would be a moderate impact to Ringland Lane and agricultural land in the 1 in 100 annual probability event and above. Consideration of the location, hazard and onset of flooding concludes the change in flood risk is negligible. The frequency of the impact in this location means there would be no material change to the viability of the land or highway or the safety of its users. This finding is applicable to NPPF

Paragraph 173 (d) and confirms this residual risk to third parties can be safely managed.

6.3.29 For the ancillary works associated the NMU strategy there would be a neutral impact as there is either no change to the existing situation, or runoff is envisaged to be managed through attenuation and infiltration in grass swales. The environmental enhancements would increase infiltration and attenuate flows and so would not increase flood risk.

Summary

6.3.30 The assessment concludes that, with the inclusion of mitigation, the Proposed Scheme is not at significant risk of flooding from all sources of flooding and would remain operational in times of flood during the 1 in 100 annual probability event plus appropriate climate change allowance and the 1 in 1000 annual probability event. The Proposed Scheme therefore satisfies the first half of Part 2 of the Exception Test and is compliant with NPPF Paragraph 173 (b) and (e).

6.3.31 In considering whether the Proposed Scheme satisfied the second half of Part 2 of the Exception Test it is necessary to consider the definition of flood risk. The NPPF defines flood risk as the product of the likelihood or chance of a flood occurring (flood frequency) and the consequence or impact of the flooding (flood consequence) such as potential damages, danger and disruption. The findings of this assessment confirm that for the great majority of the Proposed Scheme, the embedded mitigation and SuDS design mean there is no change in flood risk elsewhere from the existing situation. In some areas there is a slight change in flood depth compared to the baseline, these increases are very localised and typically within areas already affected by flooding. It is therefore considered there is no change to the potential damage, danger or disruption from a flood event as a result of the Proposed Scheme.

6.3.32 Some minor flood risk impacts are predicted during construction, but these are temporary in nature and can be appropriately managed during the

construction phase so as to not pose increased risk to potentially vulnerable receptors.

6.3.33 On the basis of change to flood risk as defined in the NPPF it is concluded that the Proposed Scheme satisfies the second half of Part 2 of the Exception Test and is compliant with NPPF Paragraph 173 (c) and (d).

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