Norwich Western Link

Environmental Statement

Chapter 12: Road Drainage and the Water Environment

Appendix 12.2: Flood Risk Assessment

Sub Appendix H: Ringland Lane Hydraulic Modelling Report

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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
1D model	A hydraulic model used for watercourses that calculates flow in the direction of the channel only. It does not calculate movement vertically or horizontally in the channel.
2D model	A hydraulic model used for watercourses and floodplains that calculates flow along a plane in two directions, often at 90 degrees to each other. It does not calculate movement in the vertical direction.
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
Digital Terrain Model	A surface produced from LIDAR data where surface features such as buildings and vegetation have been removed so that is represents ground level.
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.

Term	Definition
Flood Estimation Handbook	A manual consisting 5 volumes that sets out the techniques to be used within the UK to derive flood flows, which are used to support Flood Risk Assessments.
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 Modeller Pro	A hydraulic modelling software package
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
Fluvial Flood Risk	Flooding resulting from flows within a watercourse exceeding the capacity of that watercourse.
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.

Term	Definition
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.
LIDAR	Light Detection and Ranging, a method used to collect ground level data from an aircraft allowing large areas to be collected. The data in its unfiltered form will pick up vegetation and properties. A filtered form is generated to represent the ground surface and is used in assessments.
Manning's Roughness Value or Coefficient	A coefficient to represent different surface roughness and used in the Manning equation to understand the relationship between flow and water depth.
Model cell size	The resolution that LIDAR data is sampled at for use in the model. Smaller cell sizes increase the length of time it takes for a model to run.
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
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
Proposed Scheme	The proposed Norwich Western Link scheme.

Term	Definition
QMED	The median flow extracted from an AMAX series. This is considered to represent the 1 in 2 annual probability event flood.
ReFH	The Revitalised Flood Hydrograph rainfall runoff method. One of the Flood Estimation Handbook methods for determining peak flows and hydrographs.
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
River Gauge	A location within a watercourse where the flow and depth relationship is understood so that accurate data on river flows can be collected.
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.
TUFLOW	A hydraulic modelling software package

1 Introduction

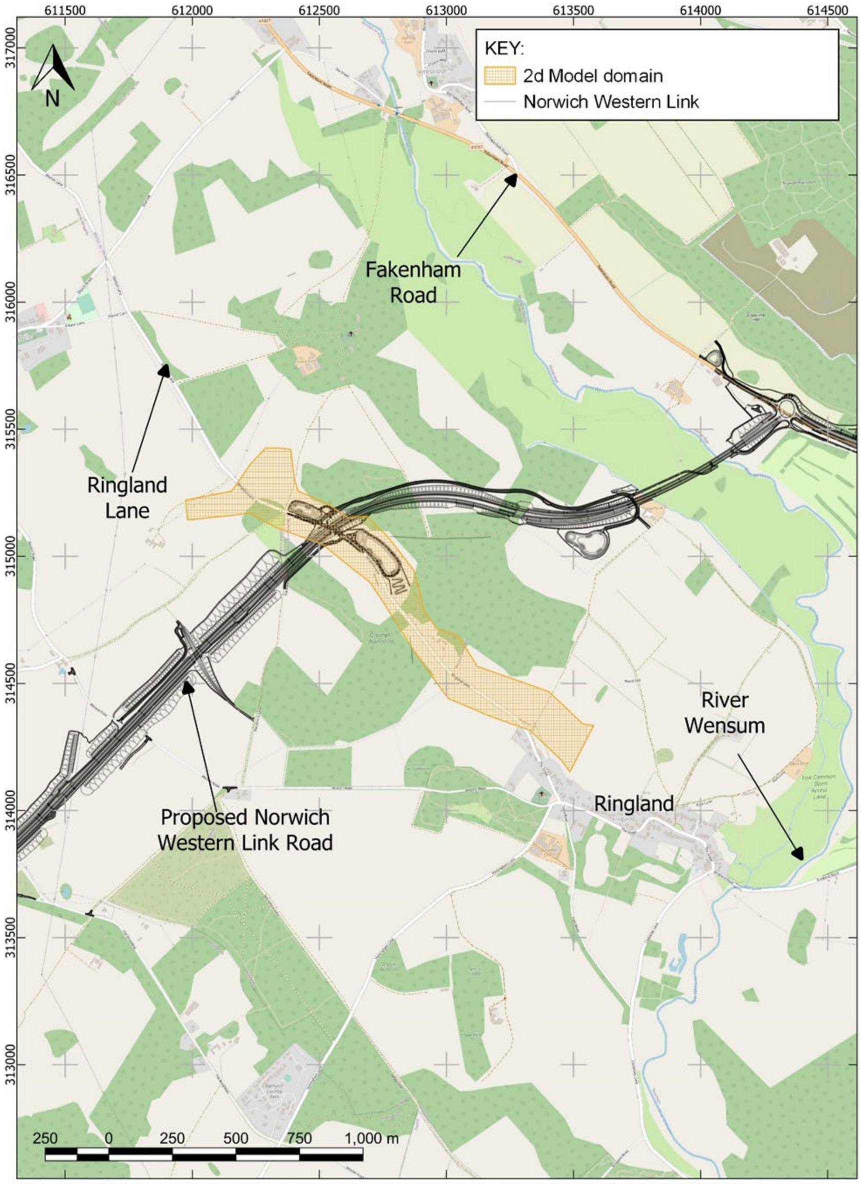
1.1 Project requirements

1.1.1 This modelling report forms an Appendix of the **Flood Risk Assessment** (Document Reference: 3.12.02) and should be read in conjunction with **Appendix 12.2i Ringland Lane Technical Modelling Log** (Document Reference: 3.12.02i) and **Appendix 12.2j Ringland Lane FEH Calculation Record** (Document Reference: 3.12.02j).

1.2 Site overview

1.2.1 The Proposed Scheme passes over a small road called Ringland Lane. There is an overland flow path parallel to the road which meets the River Wensum near Ringland. In order to assess the impacts of the Proposed Scheme on the existing flood risk of this overland flow path, and to investigate the suitability of the proposals to convey flood waters past the Proposed Scheme, a hydraulic model has been developed. The extent of the hydraulic model, shown in **Figure 1.1**, incorporates the existing overland flow path.

Figure 1-1 Site overview



1.3 Background data

Hydraulic modelling studies

1.3.1 There are no previous modelling studies of the Ringland Lane overland flow path.

Topographic data

WSP Cross Section Survey

1.3.2 There were no cross-section surveys as there is no defined watercourse.

Spot Level Survey

1.3.3 Spot level survey was completed by Survey Solutions in 2021. This survey covers the footprint of the Proposed Scheme.

LIDAR data

1.3.4 LIDAR data for the study was downloaded from the UK Government's website in 2022. The data was flown in November 2017 and downloaded as a composite 1m resolution grid.

Gauge data

1.3.5 There are no flow gauges on the Ringland Lane overland flow path.

Historical data

1.3.6 There is no historical flooding data for the study.

1.4 Approach to the study

1.4.1 Assessment of the available Environment Agency flood mapping and LiDAR data indicates that the floodplain of the overland flow path is not constrained to a particular watercourse. In the event of a flood, the water spreads in the floodplain. The proposals to convey the overland flow path past the Proposed Scheme include Preliminary Earthwork Ditches (PEDs), which are small ditches to collect and convey natural runoff, and a series of culverts beneath the main routes.

1.4.2 A 1D-2D model schematisation has been deemed appropriate for the study, with the 1D elements in the model applied for the mitigation strategy only. That is the culvert structures as well as PEDs in the proposed scenario are modelled as 1D elements. TUFLOW-ESTRY software has been used for the model simulations.

1.4.3 The overland flow path discharges to the River Wensum approximately 0.9 km downstream of the model extent. Based on the LiDAR information, which shows the River Wensum floodplain at 8.5mAOD compared to the downstream end of the model domain at 14mAOD, water levels on the River Wensum would have no impact water levels in the area of interest.

2 Hydrological assessment

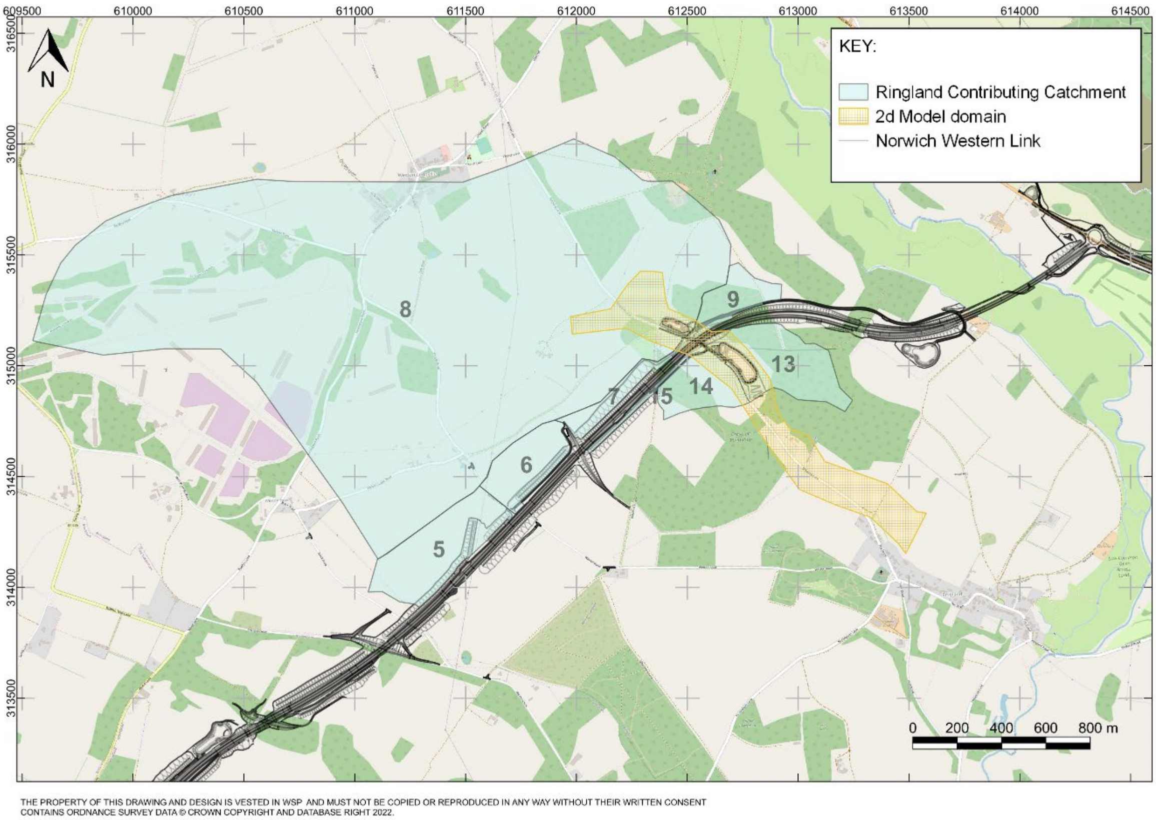
2.1 Overview

2.1.1 Full details of the hydrological assessment are provided in **Appendix 12.2j Ringland Lane FEH Calculation Record** (Document Reference: 3.12.02j).

2.2 Design hydrology

2.2.1 **Figure 2-1** shows the catchment for which design flows have been derived and **Table 2-1** the design flows for the catchment. The statistical approach was the preferred method to derive the design flows up to the 1 in 100 annual probability event. For events above the 1 in 100 annual probability event and for events with a climate change allowance applied, a risk based approach has been used to reflect the uncertainty associated with this permeable catchment.

Figure 2-1 Overview of contributing catchment



2.2.2 Catchments 7, 8 and 9 in **Figure 2.1** shows the contributing area in the existing situation. Catchments 5 and 6 are additional areas that sit within the Weston Road overland flow path catchment that contributes additional flow to the overland flowpath as a result of the Proposed Scheme.

2.2.3 The hydrology in the model includes for the catchment area upstream of the Proposed Scheme only on the basis that the catchment downstream is unchanged and so is consistent in the scenarios with and without the Proposed Scheme.

2.2.4 There are two inflow locations in the baseline scenario and three inflow locations in the proposed scenario models reflecting where runoff meets the overland flow path. Catchment 8 has been split into two, the majority is applied at the upstream of the model, the western most limit of the 2D domain. A second small inflow which reflect Catchment 8 to the east of Ringland Lane is applied at the northern limit of the 2D domain to understand how runoff from this direction interacts with the attenuation feature incorporated into the Proposed Scheme. The third inflow is applied adjacent to the Proposed Scheme from the south. This inflow reflects the existing catchment downstream of the attenuation feature as well as the diverted catchments so comprises Catchments 5, 6, 7 and 9. Catchments 7 and 9 are applied at the upstream limit of the baseline scenario model hence the reason there is one less inflow.

Table 2.1 Design flows for each catchment

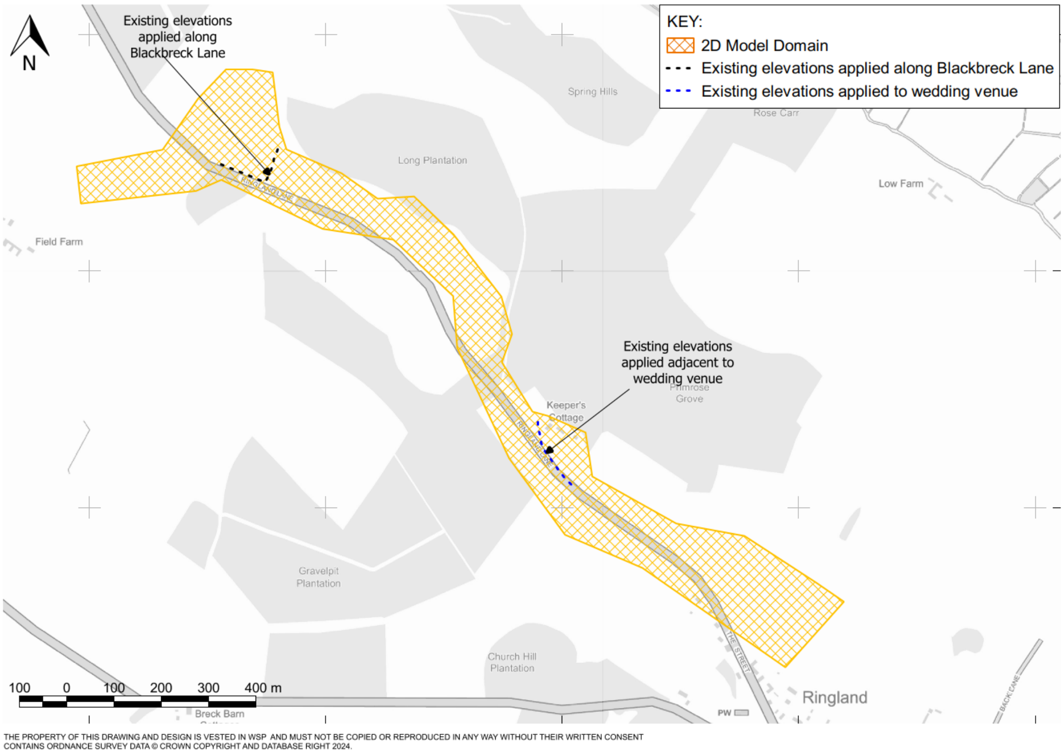
Return Period (in years)	Original from FEH Calculation (m^3/s)	Baseline Upstream of NWL Highway (m^3/s)	Proposed Upstream of NWL Highway (m^3/s)
2	0.21	0.19	0.20
5	0.21	0.19	0.20
10	0.3	0.27	0.29
20	0.36	0.32	0.34
30	0.44	0.39	0.42
50	0.5	0.45	0.48
75	0.57	0.51	0.54
100	1.24	1.11	1.18
200	1.50	1.34	1.43
1000	2.33	2.08	2.22
100+45%	1.80	1.61	1.71

3 Hydraulic modelling

3.1 Overview

3.1.1 A 1D-2D model of the Ringland Lane overland flow path has been constructed. The extent of the modelled area and the model nodes are shown in **Figure 3.1**.

Figure 3-1 Overview of model extent and details



3.1.2 The baseline model is simply a routing model of flows over the existing topography, defined by the topographic survey and LiDAR data. The exceptions to this are two locations where the crest elevations from the LiDAR data have been extracted and stamped into the model to make sure they are picked up, these are shown in **Figure 3.1**. Full details of the hydraulic model construction and associated parameters are provided in **Appendix 12.2i Ringland Lane Technical Modelling Log** (Document Reference: 3.12.02i).

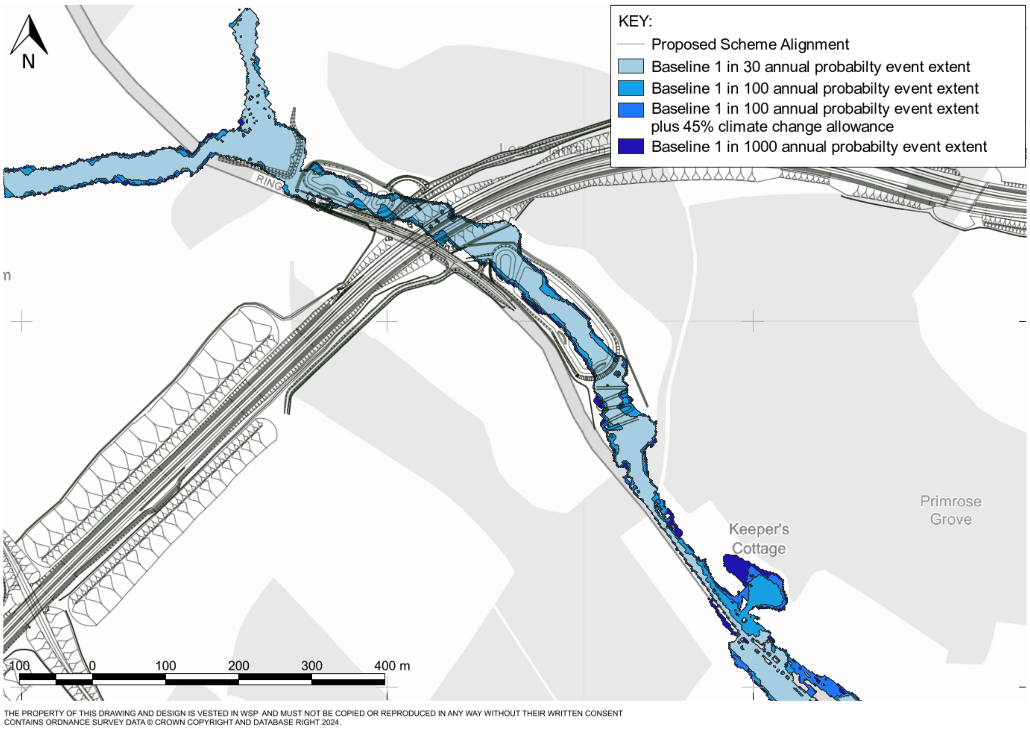
3.2 Model calibration

3.2.1 There is no calibration data available for the study.

3.3 Baseline Flood Risk and Extents

3.3.1 Baseline flood levels, representative of the existing condition, have been derived for the 1 in 2, 1 in 5, 1 in 30, 1 in 50, 1 in 75, 1 in 100, 1 in 1000 and 100 plus 45% climate change annual probability events. The baseline flood extents for the 1 in 30, 1 in 100, 1 in 1000 and 100 plus 45% climate change annual probability events are presented in **Figure 3-2**.

Figure 3-2 Baseline flood extent at the Ringland Lane location for the 1 in 30, 1 in 100, 1 in 1000 and 1 in 100 plus 45% annual probability events



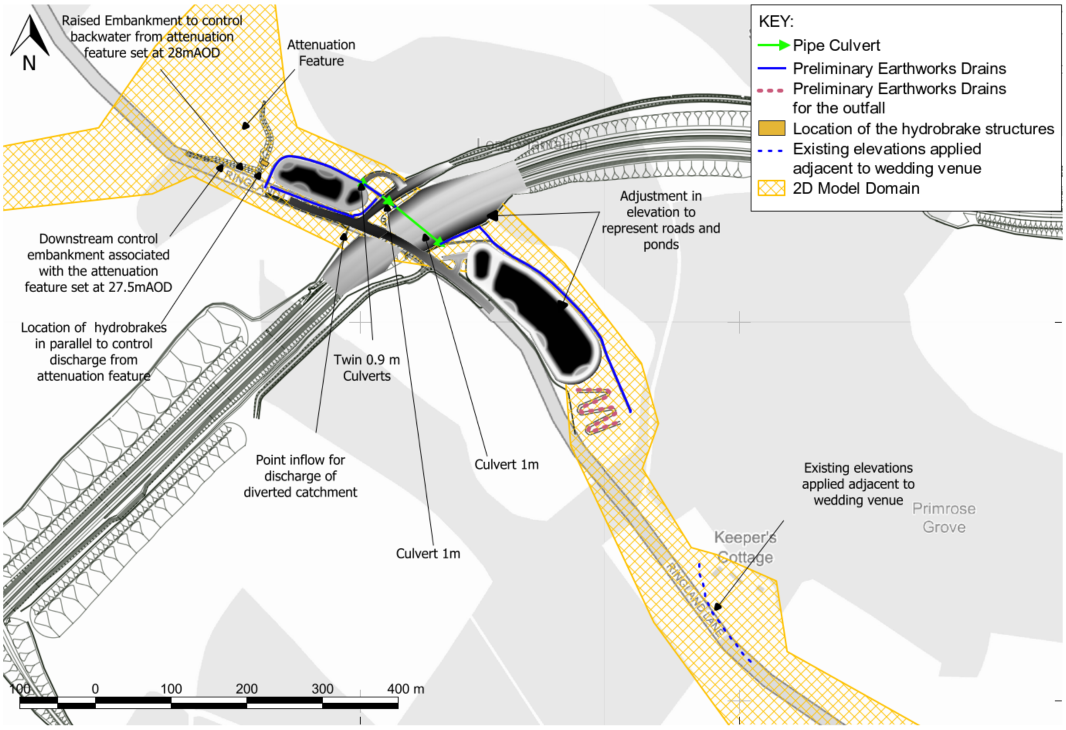
3.4 Scheme proposals

3.4.1 A summary of important details of the Proposed Scheme in the vicinity of the Ringland Lane overland flow path is provided in **Figure 3.3**. The Scheme in this area consists of the following elements:

- The NWL itself which includes a bridge to pass over Ringland Lane and earth embankments in the existing Ringland Lane overland flow path. The road level is between 32.0mAOD to 33.0mAOD.

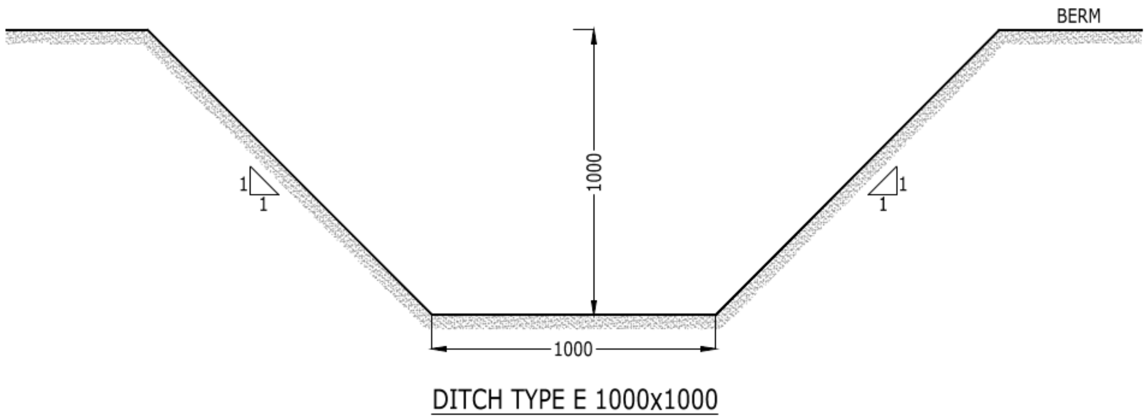
- Two surface water infiltration ponds located upstream (Basin 3) and downstream (Basin 4) of Norwich Western Link Road (NWL).
- An access track on an embankment to provide maintenance access to Basin 3 and which crosses the Ringland Lane overland flow path in two locations.
- The PED network that collects surface water runoff from the surrounding catchments and conveys this runoff around the infiltration ponds and beneath the Proposed Scheme to discharge the runoff along the existing overland flow path to the east of Basin 4
- Three culvert structures beneath the various embankments connect the PED networks upstream and downstream of the Proposed Scheme as follows:
    - Basin 3 maintenance access track culvert upstream - 2 x 0.9m diameter culverts – 6.27m long
    - Basin 3 maintenance access track culvert downstream - 1 x 0.9m diameter culvert – 12.9m long
    - NWL Road culvert - 1 x 0.9m diameter culvert – 77.8m long
- Flood risk mitigation measures which include:
    - An attenuation feature upstream of Basin 3 to offset the downstream impacts associated with the diversion of the additional flows from the Weston Road overland flow path into the Ringland Lane catchment.
    - Three parallel hydrobrakes to control discharge from the attenuation feature and a high level hydrobrake structure to allow overspill from the attenuation feature
    - A spreader ditch downstream of Basin 4 to slow flows as they are released back onto the alignment of the overland flow path (note that this has not been modelled for model stability)

Figure 3-3 Post development model details



3.4.2 A typical cross-section on a Preliminary Earthworks Drain (PED) is shown in **Figure 3.4** noting that the cross sections throughout the PED vary in base width and height.

Figure 3-4 Typical preliminary earthworks ditch (PED) cross-section



3.5 Proposed flood risk and extents

3.5.1 Post-development flood levels, representative of the condition once the NWL road has been developed, have been derived for the 1 in 2, 1 in 5, 1 in 30, 1 in 50, 1 in 75, 1 in 100, 1 in 1000 and 100 plus 45% climate change annual probability events. Results for the 1 in 30, 1 in 100, 1 in 1000 and 100 plus 45% climate change annual probability events are shown in **Figure 3.5**.

3.5.2 The impacts of the Proposed Scheme compared to the existing baseline are discussed in the **Flood Risk Assessment** (Document Reference: 3.12.02). A comparison of the baseline and proposed flood extents for the 1 in 30, 1 in 100, 1 in 1000 and 100 plus 45% climate change annual probability events are presented in **Figure 3.6** to **Figure 3.9**.

Figure 3-5 Proposed flood extents at the Ringland Lane location for the 1 in 30, 1 in 100, 1 in 1000 and 100 plus 45% climate change annual probability events

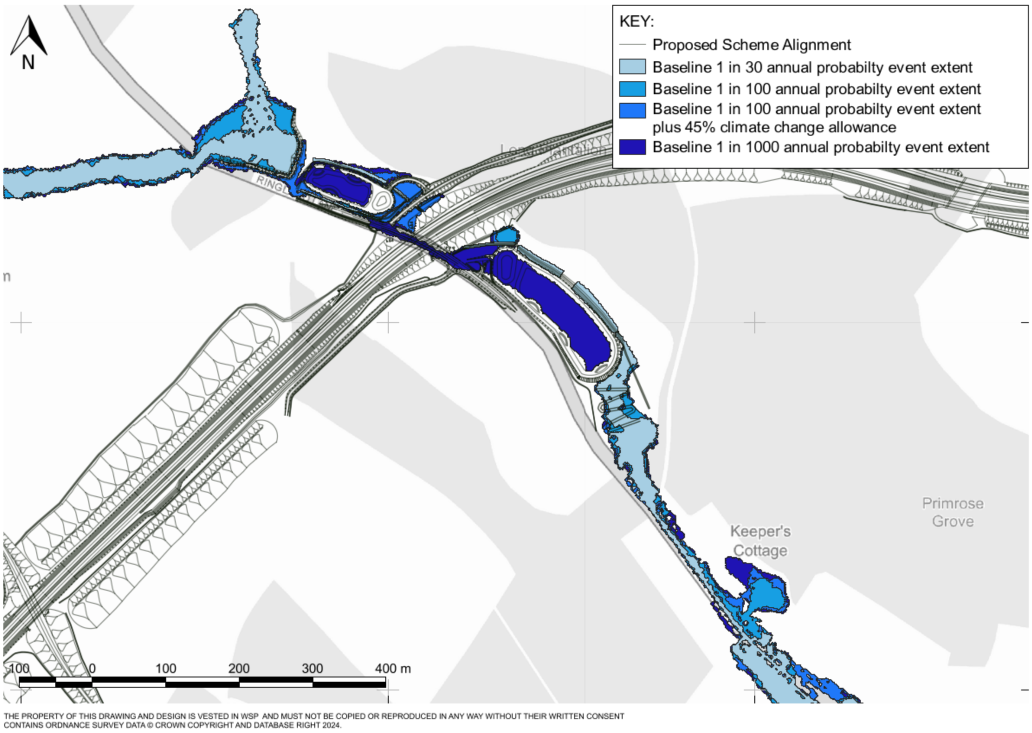


Figure 3-6 Flood extent comparison for 1 in 30 annual probability event

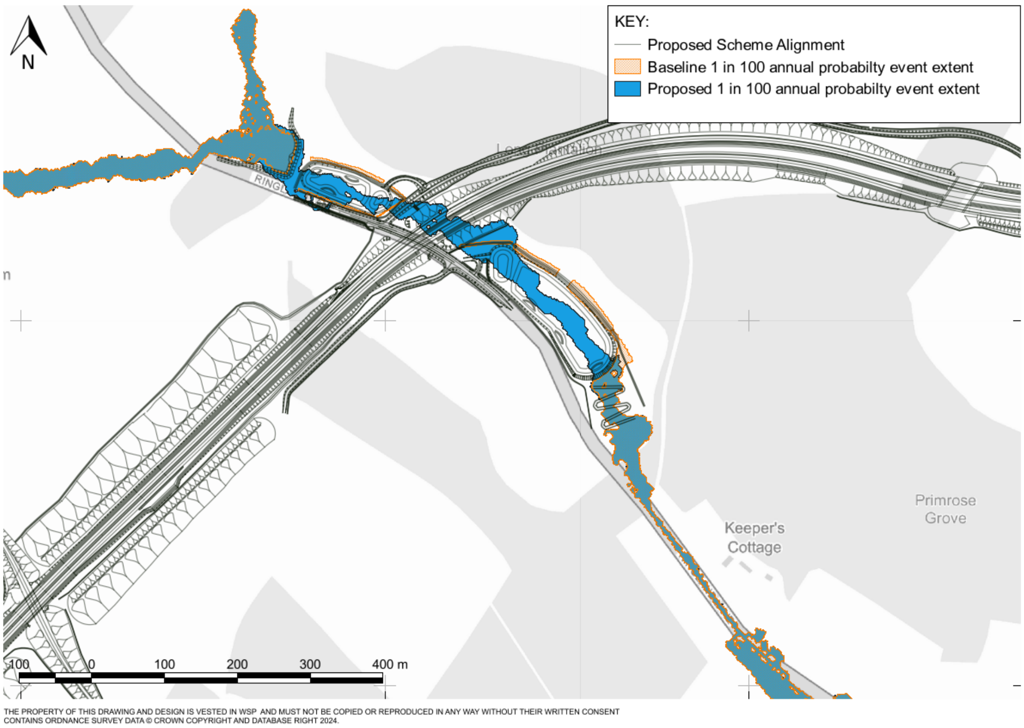


Figure 3-7 Flood extent comparison for 1 in 100 annual probability event

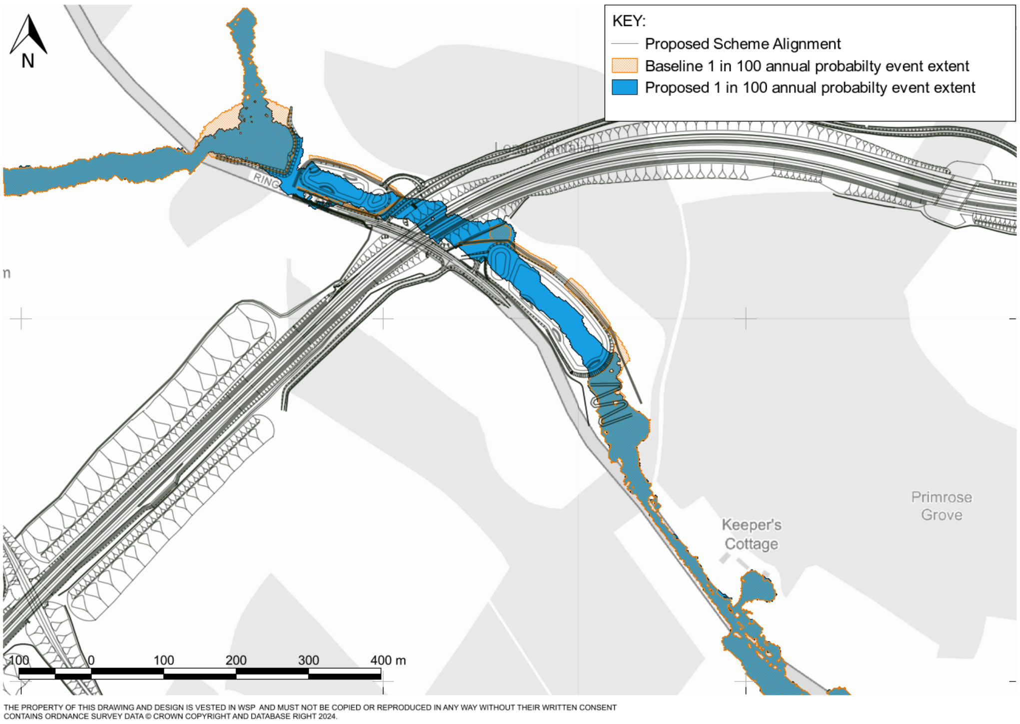


Figure 3-8 Flood extent comparison for 1 in 1000 annual probability event

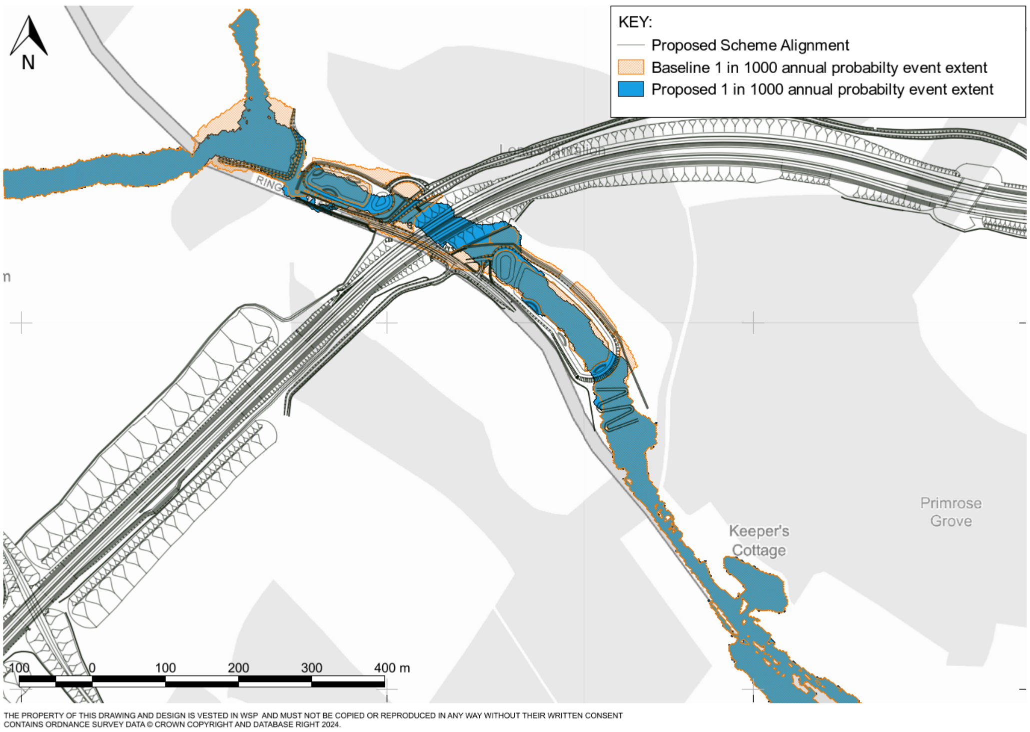
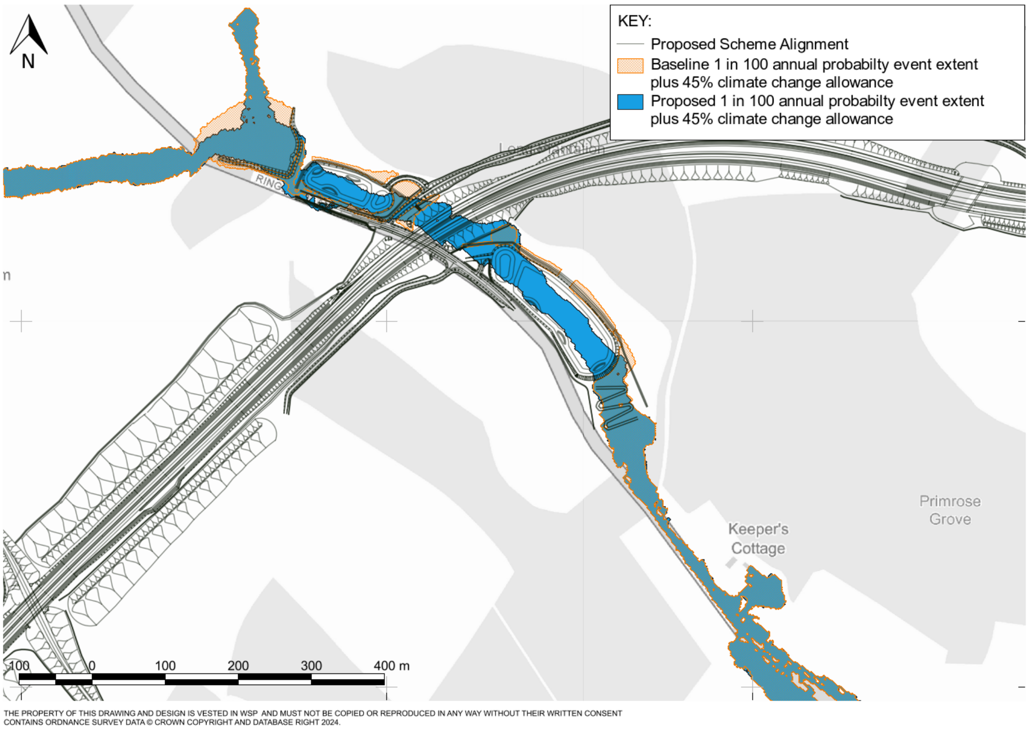


Figure 3-9 Flood extent comparison for 1 in 100 + 45% climate change event

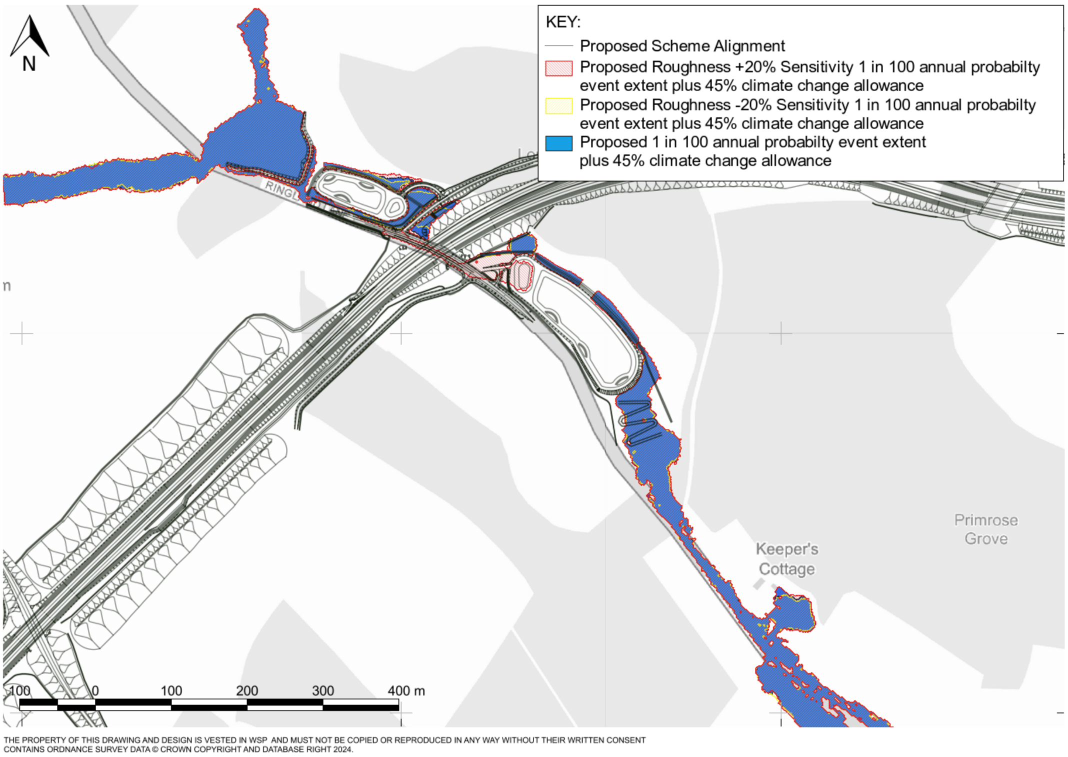


3.6 Sensitivity analysis

3.6.1 Sensitivity analysis was carried out to test the sensitivity to Manning's roughness, flow change, downstream boundary levels and culvert blockage for the proposed development for the 1 in 100 annual probability plus 45% climate change event.

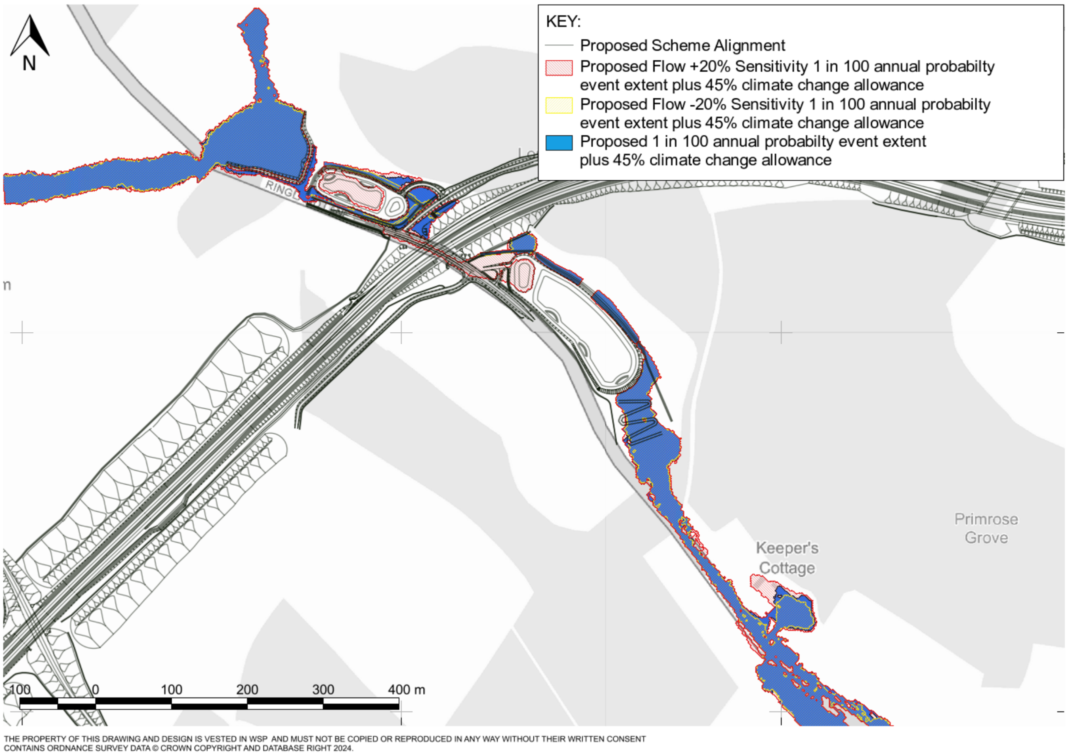
3.6.2 **Figure 3-10** presents the changes in flood extents associated with roughness. The roughness sensitivity tests increased and decreased Manning's n values by 20% in the floodplain, the PED network and the culverts beneath the Proposed Scheme. The results are generally consistent with the baseline for the two sensitivity test results. There is an increase in extent in the roughness plus 20% test where flows overtop the PED network, run along Ringland Lane and discharge into the northern side of Drainage Basin 4.

Figure 3-10 Proposed flood extent sensitivity to manning's roughness for the 1 in 100 plus 45% climate change annual probability event



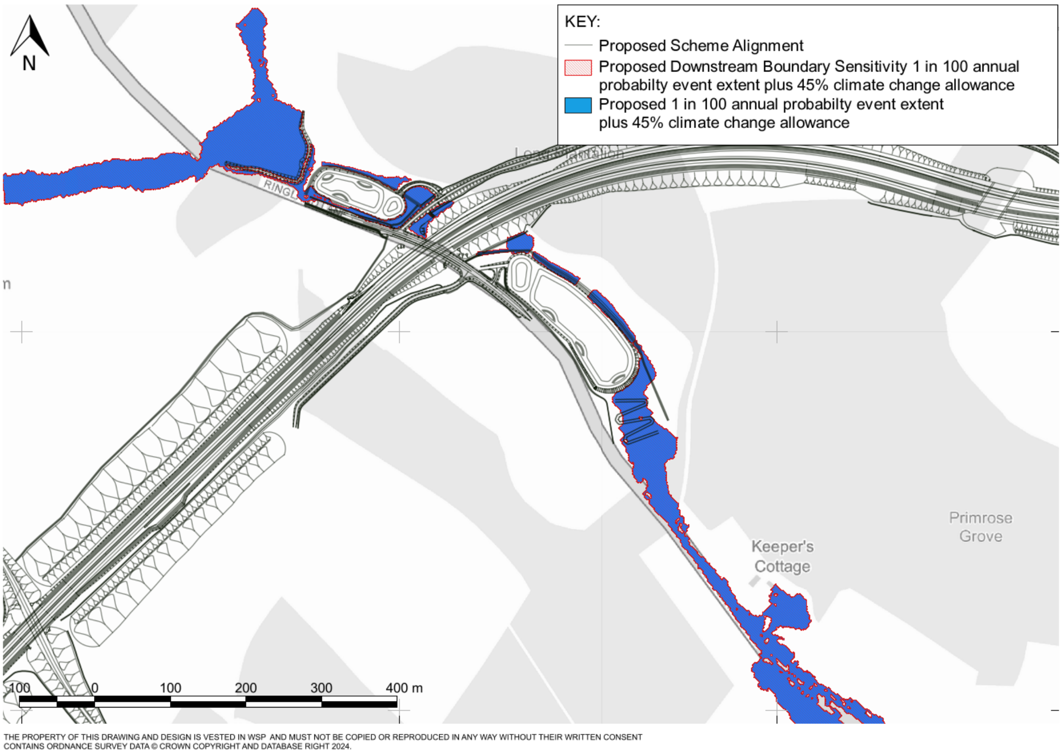
3.6.3 **Figure 3-11** presents the changes in flood extents associated with the change in flows. Flows have been increased and decrease by 20% from the 1 in 100 annual probability plus 45% climate change event. The results again show some sensitivity in the flood extent in Drainage Basin 4 as well as Drainage Basin 3 with an increase in flows. Flood risk at the Keeper and the Dell (wedding venue) also increases but this would be expected with an increase in flow.

Figure 3-11 Proposed flood extent sensitivity to flow for 1 in 100 plus 45% climate change annual probability event



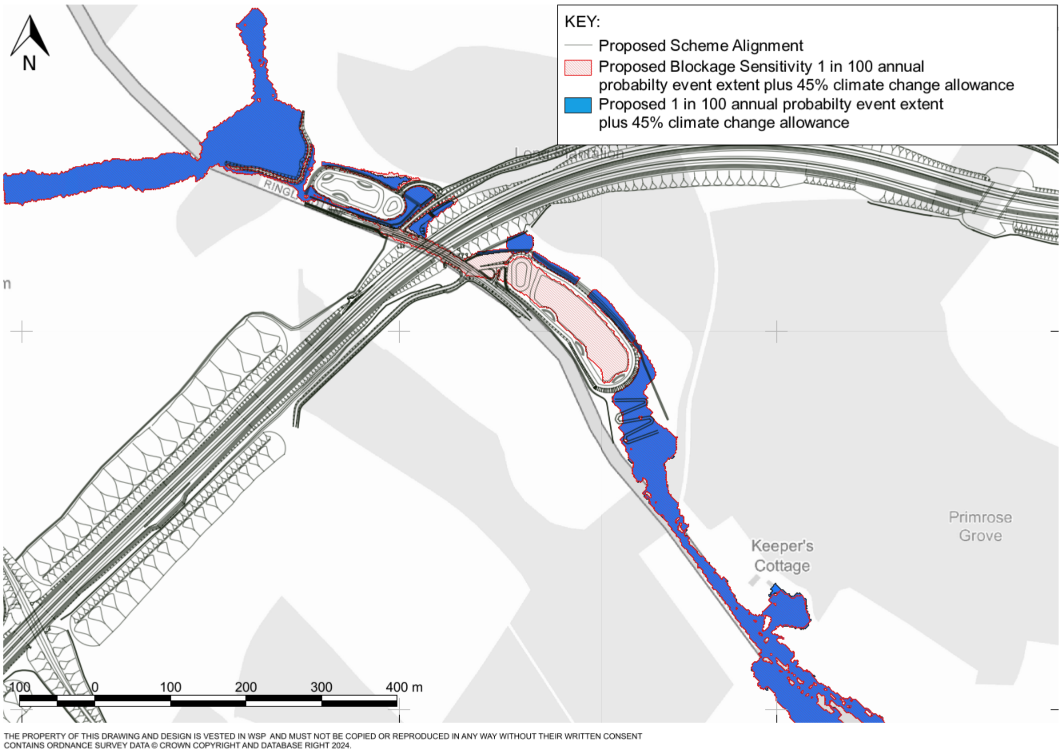
3.6.4 **Figure 3-12** presents the changes in flood extents associated with an increase in downstream boundary levels. The downstream boundary has been changed from a normal depth boundary to a fixed level of 15mAOD, an increase of 1.2m above the peak water level in this location. The results show no change in the area of interest indicating the model results are not sensitive to the downstream boundary.

Figure 3-12 Proposed flood extent sensitivity to downstream boundary levels for 1 in 100 plus 45% climate change annual probability event



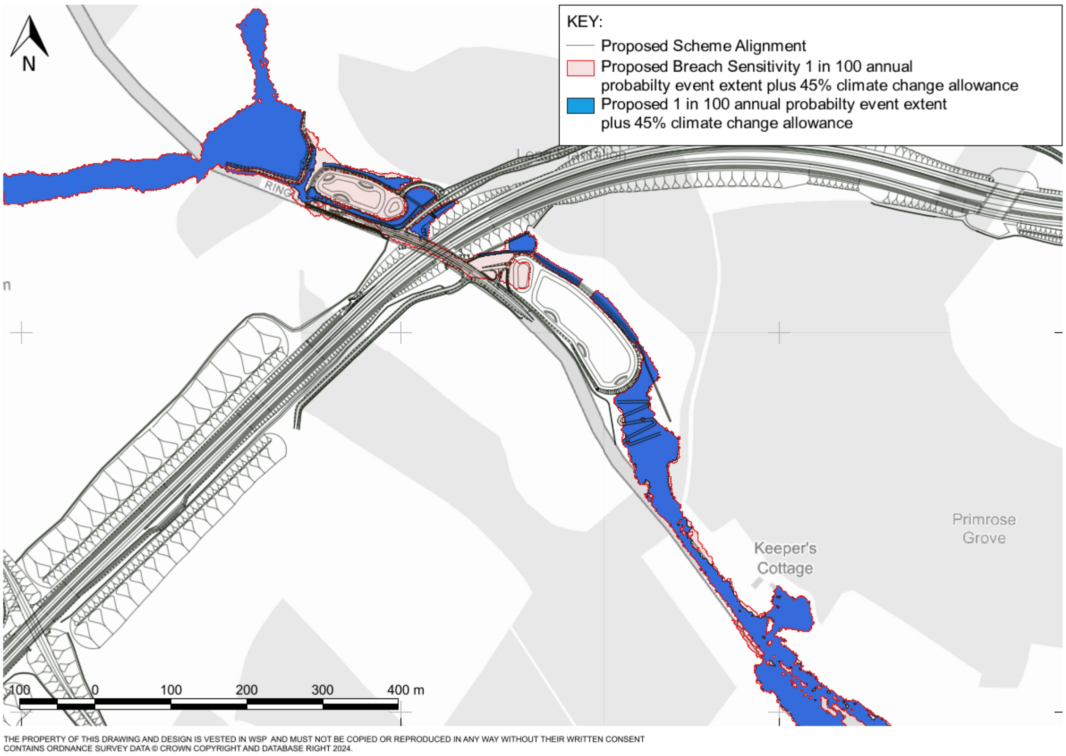
3.6.5 **Figure 3-13** presents the changes in flood extents associated with a blockage of the culvert beneath the Proposed Scheme. The culvert beneath the main road alignment has been blocked by 50%. The results show a blockage of this structure would result in flows backing up onto Ringland Lane and dropping into Drainage Basin 4.

Figure 3-13 Proposed flood extent sensitivity to blockage for 1 in 100 plus 45% climate change annual probability event



3.6.6 **Figure 3-14** presents the changes in flood extents associated with a breach of the attenuation feature embankment. A breach of the embankment 20m in width is assumed to occur when water levels in the attenuation feature are at their highest. This occurs at 12 hours. The breach reduces levels to ground level within 1 hour. The results show a breach would result in flows backing up onto Ringland Lane and dropping into Drainage Basin 4. There is no impact shown to the Keeper and the Dell (wedding venue).

Figure 3-14 Proposed flood extent sensitivity to breach for 1 in 100 plus 45% climate change annual probability event



3.6.7 The findings of the sensitivity assessment suggest there may be localised changes in flooding but these changes would likely be constrained to the Proposed Scheme footprint with no sensitivity observed to third parties.