A12 Chelmsford to A120 widening scheme
TR010060

6.3 ENVIRONMENTAL STATEMENT
APPENDIX 14.5 FLOOD RISK ASSESSMENT

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A12 Chelmsford to A120 widening scheme

Development Consent Order 202[ ]

ENVIRONMENTAL STATEMENT
APPENDIX 14.5 FLOOD RISK ASSESSMENT

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0 Executive Summary

0.1.1 This Flood Risk Assessment (FRA) has been undertaken to provide flood risk information to inform the Environmental Statement for the A12 Chelmsford to A120 widening scheme (the proposed scheme). This FRA has been produced in accordance with the technical guidance to the National Planning Policy Framework (NPPF) (Ministry of Housing, Communities and Local Government, 2021a) and demonstrates compliance with the requirements of the National Networks National Policy Statement (NNNPS) (Department for Transport, 2014), specifically that the proposed scheme would:

- remain operational and safe for users in times of flood
- not increase flood risk elsewhere

0.1.2 This FRA also provides evidence to demonstrate how the proposed scheme is considered to pass the Sequential and Exception Tests.

0.1.3 Flood risk from all sources has been assessed, with consideration of existing risk, risk to the proposed scheme and the impact of the proposed scheme on flood risk elsewhere. Both the construction and operational phases of the proposed scheme have been considered within this FRA. The proposed scheme would cross seven Main Rivers. Hydraulic modelling has been undertaken to determine existing flood risk and to assess the impact of the operational phase of the proposed scheme. Where the potential impact on water levels is greater than negligible (for any event up to the 1% (1 in 100) Annual Exceedance Probability (AEP) event plus an allowance for climate change), potential mitigation measures are identified which aim to achieve a neutral impact upon flood risk.

0.1.4 The proposed scheme would also cross approximately 36 Ordinary Watercourses. Existing culverts that would need to be extended and new culverts that would be required have been assessed to confirm their impact upon flood risk. Where the possibility of an impact on existing levels of risk has been identified, hydraulic modelling has been undertaken to confirm if mitigation would be required.

0.1.5 The proposed drainage for the operation of the proposed scheme is designed to ensure no increase in flood risk in the 1% (1 in 100) AEP event plus a 20% allowance for climate change, as well as allowing the proposed scheme to remain operational in surface water flooding events. Excess flows in this event would be stored safely within the Order Limits, or where they do flow beyond site boundaries, would be at a reduced volume from the existing situation in the same event.

0.1.6 Sections of the proposed scheme are within areas that have potential for groundwater flooding at the ground surface. Mitigation measures have therefore been proposed to mitigate the risk to below ground elements of the proposed scheme.

0.1.7 Other sources of flooding are considered to present a low risk to, and would not be impacted by, the proposed scheme.

0.1.8 With the proposed mitigation measures in place, it is considered that the proposed scheme would comply with the requirements of the NNNPS.

1 Introduction

1.1 Purpose

1.1.1 National Highways has carried out a Flood Risk Assessment (FRA) in support of the Development Consent Order (DCO) application for the A12 Chelmsford to A120 widening scheme (hereafter referred to as the proposed scheme).

1.1.2 This FRA has been produced to provide flood risk information to inform the Environmental Statement [TR010060/APP/6.1].

1.1.3 This FRA has been produced in accordance with the technical guidance provided with the National Planning Policy Framework (NPPF) (Ministry of Housing, Communities and Local Government, 2021a) and demonstrates compliance with the requirements of the National Networks National Policy Statement (NNNPS) (Department for Transport, 2014) (requirements detailed in Table 1.1). An FRA is required for projects in Flood Zones 2 and 3; the proposed scheme would be constructed in areas of Flood Zones 1, 2 and 3.

1.1.4 The flood risk design criteria, the scope of this FRA and the information that will be required by the Secretary of State to reach a decision have been agreed through extensive consultation with the Environment Agency and the Lead Local Flood Authority (LLFA): Essex County Council (ECC) (Table 14.3 in Chapter 14, of the Environmental Statement [TR010060/APP/6.1] details pre-application consultation undertaken with key stakeholders).

Table 1.1 NNNPS flood risk requirements

Requirement applies to	Requirement
Proposed scheme would	• Remain operational and safe for users in times of flood • Not increase flood risk elsewhere
FRA should demonstrate	• An assessment of flood risk to and from the proposed scheme from all sources, demonstrating how the risks would be managed and, where relevant, mitigated • Appropriate consideration of the impacts of climate change on flood risk over a 100 year development lifetime using the latest UK Climate Projections available • Consideration of vulnerability of those using the infrastructure including arrangements for safe access and exit • Consideration of if there is a need to remain operational during a worst case flood event over the development’s lifetime • An assessment of residual risk • The evidence for application of the Sequential and Exception Tests

1.1.5 This FRA is supported by the following annexes:

- Annex A: Proposed scheme (operational elements)
- Annex B: Proposed scheme (operational and construction elements)
- Annex C: Topographic elevation
- Annex D: Baseline surface water flood risk
- Annex E: Baseline fluvial flood risk
- Annex F: Baseline groundwater flood risk
- Annex G: Baseline flood risk from reservoir failure (table)
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- Annex L: Hydraulic modelling reports
- Annex M: Details of watercourses crossed by proposed scheme
- Annex N: Culvert schedule
- Annex O: Proposed construction elements and baseline fluvial and surface water flood risk
- Annex P: Culvert screening assessment

1.1.6 Reference is also made to the Surface Water Drainage Strategy throughout this FRA (Appendix 14.6 of the Environmental Statement [TR010060/APP/6.3]).

1.2 Proposed scheme

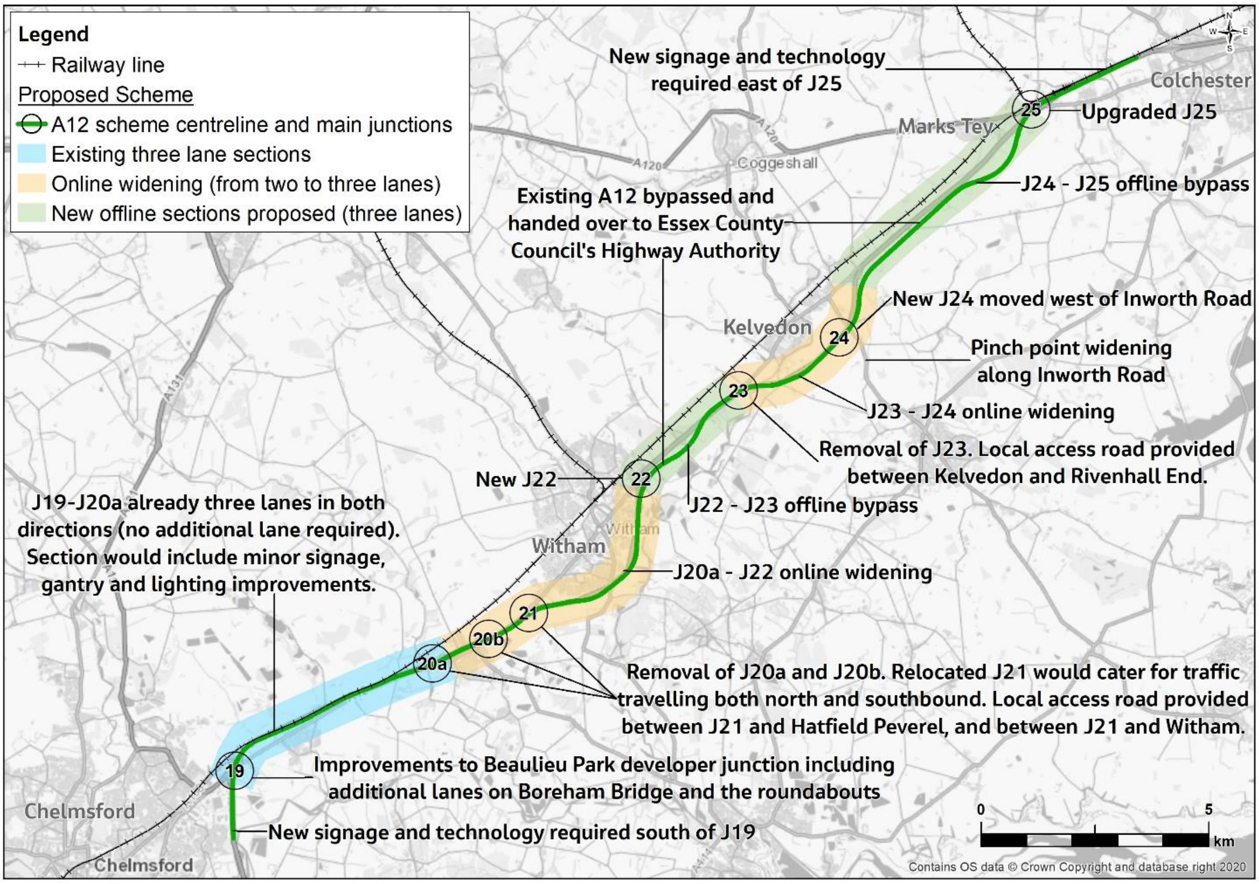
Context

1.2.1 The purpose of the proposed scheme is to address strategic traffic problems and congestion, and associated safety issues, along the strategic road network between junctions 19 (Boreham interchange) and 25 (Marks Tey interchange) (see Annex A of this FRA for an overview of the proposed scheme).

1.2.2 The existing A12 between junctions 19 and 25 is predominantly a dual two-lane carriageway, with a limited length of dual three-lane carriageway between junction 19 (Boreham interchange) and 20a (Hatfield Peverel South interchange). There are a number of direct accesses onto the carriageways, particularly between junctions 22 (Colemans interchange) and 23 (Kelvedon South interchange) and between junctions 24 (Kelvedon North interchange) and 25 (Marks Tey interchange).

1.2.3 The proposed scheme involves widening the existing A12 to three lanes throughout in each direction (Plate 1.1), where it is not already three lanes. This would mainly involve online widening of the carriageway, with offline bypasses created between junctions 22 and 23 (Rivenhall End Bypass) and between junctions 24 and 25 (Kelvedon to Marks Tey). This would be accompanied by junction improvements (junctions 19 and 25), construction of new junctions catering for traffic movements both north and southbound (junctions 21, 22 and 24), and removal of existing junctions (junctions 20a, 20b and 23).

Plate 1.1 Overview of proposed scheme highway design



1.2.4 A detailed description of the proposed scheme is available in Chapter 2 of the Environmental Statement [TR010060/APP/6.1]. The proposed scheme works are described in Schedule 1 of the draft DCO [TR010060/APP/3.1]. The General Arrangement Plans [TR010060/APP/2.9] illustrate the preliminary design of the proposed scheme and identify its key components and features. The Engineering Section Drawings [TR010060/APP/2.11] present further proposed scheme design information.

1.2.5 The proposed scheme highway boundary is shown in Annex A. Annex A and Annex B of this FRA show the proposed operational and construction elements of the proposed scheme.

1.2.6 The Surface Water Drainage Strategy (Appendix 14.6 of the Environmental Statement [TR010060/APP/6.3]) provides a list of surface water flood risk design principles and standards considered during the development of the proposed scheme to limit potential flood risk impact.

Limits of deviation

1.2.7 Limits of deviation have been incorporated within the Order Limits (see the General Arrangement Plans [TR010060/APP/2.9]) to allow minor modifications to be made to the proposed scheme during the detailed design and construction stages. Limits of deviation provide an envelope of development, as opposed to specific dimensions, and are used to allow design flexibility. Such flexibility is required, for example, to enable the Principal Contractor to alter their working procedures or make minor adjustments to the position of certain infrastructure in response, for example, to unforeseen ground conditions.

1.2.8 The limits of deviation have been defined using lateral limits of deviation for all permanent infrastructure elements of the proposed scheme, including utilities diversions, and vertical limits of deviation for all the road elements. The extents of the lateral limits of deviation are shown on the Permanent Works Plans [TR010060/APP/2.2.1] and Utility Diversion Works Plans [TR010060/APP/2.2.2].

1.2.9 The vertical limits of deviation are referenced against the vertical profile levels indicated on the Highway Engineering Section Drawings [TR010060/APP/2.11]. The vertical limit of deviation for the proposed scheme is +/- 1.0m.

1.2.10 Any modifications to the proposed scheme (afforded by the limits of deviation) with the potential to increase flood risk from that assessed in this FRA would require reassessment to confirm that the conclusions of this FRA were still valid. Any changes to the design within the limits of deviation, would only occur if they do not lead to any materially new or materially different environmental effects in comparison to those reported in the Environmental Statement, unless the change relates to resulting flood levels. In this instance, changes could be made in agreement with the Environment Agency that there would not be a material exceedance of the flood levels shown in this FRA, or that all affected landowners accept the predicted exceedance levels.

1.2.11 Therefore, this FRA has been undertaken based on the proposed scheme as shown in the General Arrangement Plans [TR010060/APP/2.9]. Only the groundwater assessment within this document has considered the potential impact of the limits of deviation, with consideration made of the vertical limits.

Site description

Location

1.2.12 The proposed scheme extends from south-east of Chelmsford to the south-west of Colchester and has a length of approximately 24km. The proposed scheme is within the area governed by ECC and passes through the administrative areas of Braintree and Maldon District Councils, Colchester Borough Council and Chelmsford City Council.

1.2.13 The proposed scheme is located adjacent to greenfield areas, including agricultural land, as well as several residential areas including Chelmer Village, Boreham, Hatfield Peverel, Witham, Rivenhall End, Kelvedon, Feering and Marks Tey.

1.2.14 The proposed scheme is located within the Essex Combined Management Catchment and more specifically crosses the Chelmer and Blackwater Operational Catchments. It also crosses numerous Main Rivers (and associated floodplains), Ordinary Watercourses and drains, as described in Annex M.

Topography

1.2.15 According to Environment Agency Light Detection and Ranging (LiDAR) (Environment Agency, 2020a), the topographical levels vary across the proposed scheme, ranging from approximately 19m Above Ordnance Datum (AOD) up to 46.0mAOD. The lowest topographical levels are usually recorded close to riverbed locations. Detailed topography is presented in Annex C.

Geology

1.2.16 A summary of the bedrock and superficial geology pertinent to the FRA is provided here to provide context to the groundwater and surface water interactions likely across the proposed scheme.

1.2.17 Based on the British Geological Survey (BGS) (2020) mapping, the underlying geology of the proposed scheme can be described predominantly as Thames Group (London Clay): Clay, Silt, Sand and Gravel. However, the geology of a small part of the proposed scheme at the north-east side of Witham is determined as Thanet Formation: Sand and at the south-west side of Kelvedon as Thanet Formation and Lambeth Group (undifferentiated): Clay, Silt and Sand. Superficial deposits vary across the length of the proposed scheme.

1.2.18 A detailed summary of the superficial and bedrock geology, as well as the aquifer designation, is presented in Chapter 10: Geology and soils, of the Environmental Statement [TR010060/APP/6.1].

Hydraulic context

1.2.19 Section 72(1) of the Land Drainage Act 1991 defines a watercourse as including all rivers and streams and all ditches, drains, cuts, culverts, dikes, sluices, sewers (other than public sewers within the meaning of the Water Industry Act 1991) and passages, through which water flows. The watercourses that would be crossed by the proposed scheme are classified into two categories:

- Ordinary Watercourses: The Land Drainage Act 1991 defines Ordinary Watercourses as watercourses that do not form part of a Main River.", while the ECC defines an Ordinary Watercourse as a '*small stream or ditch which drains away water*' (ECC, 2020). The LLFA (in this case ECC) or Internal Drainage Boards are responsible for regulating activities affecting an Ordinary Watercourse. Many of the Ordinary Watercourses near the proposed scheme do not have names that are commonly in use, so all Ordinary Watercourses have been numbered for ease of reference (see Annex E).

- Main Rivers: Defined under the section 113 of the Water Resources Act 1991 as a watercourse shown as such on the Statutory Main River Map (Environment Agency, 2020b). These rivers are generally larger than Ordinary Watercourses and have bigger floodplains and greater potential impact on the local area. Main Rivers are regulated by the Environment Agency under the Water Resources Act 1991. Construction work on or surrounding a Main River is controlled by Anglian Water Authority Land Drainage and Sea Defence Byelaws enforceable by the Environment Agency under the provisions of the Water Resources Act 1991.

1.2.20 Seven Main Rivers and approximately 36 Ordinary Watercourses would be crossed by the proposed scheme (including proposed utilities diversions). Descriptions of watercourses crossed can be found in Annex M.

1.3 Methodology

1.3.1 This FRA has been undertaken in accordance with Design Manual for Roads and Bridges (DMRB) LA 113 Road Drainage and the Water Environment (Revision 1) (Highways England, 2020a). DMRB LA 113 provides an assessment method for determining and managing the effects of the proposed scheme on the water environment.

1.3.2 This FRA has adopted a range of assessment techniques, ranging from hydraulic calculations to detailed one-dimensional (1D)/two-dimensional (2D) hydraulic modelling, to quantify the existing risk of flooding, the risk to the proposed scheme and the potential impact of the proposed scheme on flood risk. The methods chosen have been selected to ensure a proportionate level of assessment can be undertaken.

1.3.3 Where the FRA has identified potential flood risk impacts, a range of flood mitigation measures (either embedded in design or standalone) have been considered with the aim of achieving a neutral effect on overall flood risk to reduce the overall impact on flood risk during construction and for the estimated lifetime of the proposed scheme (100 years).

Sources of flood risk considered

1.3.4 The assessment of flood risk has considered all sources of flooding, including fluvial, surface water, groundwater, failure of water-retaining infrastructure, flooding from sewers and water mains, coastal and land drainage. Table 1.2 describes these sources of flooding and outlines the methodology used to assess flood risk from those sources for this FRA.

Table 1.2 Sources of flood risk considered and assessment methodology for this FRA

Flood source	Assessment methodology
Fluvial (Main Rivers and Ordinary Watercourses) Fluvial flooding occurs when watercourses are unable to cope with the volume of water draining from the surrounding land because of sustained or intense rainfall. The increase in water causes the watercourse to rise above its banks and/or retaining structures and flow across land (see Section 2: Fluvial flood risk – Main Rivers and Section 3: Fluvial flood risk – Ordinary Watercourses). The proposed scheme could interact with this source of flood risk through several mechanisms, including the following: • Impediment/loss of watercourse channel/watercourse floodplain • Watercourse alteration/diversion/constriction • Alterations to existing watercourse crossing structures • Alterations of surface water flow paths draining to watercourses • Discharge of construction flows (e.g. dewatering) to watercourses	Main Rivers Initial screening was undertaken to identify elements of the proposed scheme which could significantly impact (or be impacted by) flood risk from Main Rivers. Detailed hydraulic modelling has been undertaken for the seven Main Rivers identified to assess baseline flood risk and potential proposed scheme impacts.
	Ordinary Watercourses A review of topographic survey results and the Environment Agency Risk of Flooding from Surface Water (RoFSW) mapping (Environment Agency, 2020c) has been conducted to identify Ordinary Watercourses. However, the RoFSW mapping may not include all watercourses or ditches or structures on them. This FRA has therefore adopted a staged approach to the assessment of flood risk from Ordinary Watercourses to ensure an appropriate level of assessment is undertaken for each crossing location: • For existing crossings, the flow condition of the existing watercourse crossing structures was assessed (i.e. free-flow or surcharged). • The Revitalised Flood Hydrograph Method has been used to estimate the peak design flow for each watercourse, in accordance with the Flood Estimation Guidelines (Environment Agency, 2020f). • The flow condition of existing structures has been obtained primarily from drainage surveys. Other sources of information included the National Highways Drainage Data Management System (DDMS), available drainage construction drawings/as-built drainage records, and topographical survey information (see Appendix 14.6: Surface

Flood source	Assessment methodology
	Water Drainage Strategy, of the Environmental Statement [TR010060/APP/6.3], for more details). • The assessment was based on guidance in the Construction Industry Research and Information Association (CIRIA) Culvert, Screen and Outfall Manual (C786) (CIRIA, 2019). • Where the assessment suggested that the proposed scheme could have an adverse flood impact, or that there could be a risk of flooding to the proposed scheme, the hydraulic analysis of these watercourse crossings was considered in further detail using hydraulic modelling. (Hydraulic modelling has been carried out for five Ordinary Watercourses.) • A similar methodology was adopted to assess the impact of any new crossings introduced by the proposed scheme. The proposed scheme drainage has been designed to prevent significant changes in flow rates into an Ordinary Watercourse, but where potential increases have been identified, an assessment of the impact of this has been undertaken. This assessment has used existing RoFSW mapping to identify potential receptors and professional judgement to identify likely impacts.
Surface water Surface water (pluvial) flooding results from rainfall-generated overland flow before the runoff enters any watercourse, drainage system or sewer or when the infiltration capacity of the ground surface is exceeded during extreme rainfall events. Excessive surface water runoff can pose a flood hazard especially if flowing at high velocity. Localised depressions in the ground topography can result in the ponding of water, sometimes to a significant depth. The antecedent conditions and permeability of the soil type or geology can affect the volume of runoff. The capacity and condition of the	Review of the Environment Agency RoFSW mapping and results of hydraulic modelling as presented in the local Surface Water Management Plans (SWMPs) identified areas of high, medium and low surface water flood risk within the Order Limits. Potential overland flow pathways with potential for interaction with the proposed scheme were assessed using a Geographic Information System and topography data. A full assessment of existing and proposed drainage has also been undertaken, the methodology for which can be found in Appendix 14.6:

Flood source	Assessment methodology
drainage network can affect how much water remains on the surface. The topography of the land and location of urban features such as road networks also influence surface water flood risk (see Section 4: Surface water flood risk). The proposed scheme could interact with this source of flood risk through several mechanisms, including the following: • Impediment/alteration of surface water flow paths • Alterations to existing flow path crossing structures • Alteration of impermeable area and subsequent alteration of rate and volume of surface water runoff	Surface Water Drainage Strategy, of the Environmental Statement [TR010060/APP/6.3].
Groundwater Groundwater flooding occurs when groundwater levels rise above the ground surface. In some instances, groundwater can emerge at surface level following heavy or prolonged rainfall events and contribute to existing flooding from other sources. The risk can increase if construction works or long-term, large-scale developments, such as road schemes, intersect areas with shallow groundwater levels or create pathways for deeper confined artesian pressures, which can be released at ground level and cause widespread flooding. The presence of linear below ground structures, such as sheet pile walls, can also increase the risk of flooding (see Section 5: Groundwater flood risk). The proposed scheme could interact with groundwater through several mechanisms, including the following: • Impediment/alteration of groundwater flow paths • Altered rates of groundwater recharge	Ground investigation (GI) has been carried out in different geographical sections along the route of the proposed scheme. A review of groundwater levels reported through all phases of the GI has been undertaken as well as a review of the study area for potential indicators of shallow groundwater emergence (such as springs). This information was then used to determine if any of the design would increase or decrease groundwater flooding. Data from the GI have been compared with the BGS susceptibility to groundwater flooding data (BGS, 2021a). Local Strategic Flood Risk Assessments (SFRAs) were also consulted regarding the groundwater flood risk.

Flood source	Assessment methodology
Water-retaining infrastructure Flooding can occur due to the collapse and/or failure of man-made water-retaining features such hydropower-dams, water supply reservoirs, canals, flood defence structures, underground conduits, and water treatment tanks or pumping stations (see Section 6: Other sources of flood risk). Reservoir flooding can occur as a result of the failure of artificially created ponds/lakes and is detailed in the flood risk and coastal change planning practice guidance to be a residual risk (Ministry of Housing, Communities and Local Government, 2021b). The failure of a reservoir can result in a large volume of water escaping, potentially at high velocity, and flooding land within its flow path. This can lead to significant consequences in the surrounding area. Flooding due to the failure and/or collapse of flood defence infrastructure is considered to be a residual risk. The proposed scheme could interact with this source of flood risk through impediment/alteration of flow paths.	The assessment was based on Environment Agency mapping that determines areas at flood risk due to reservoir or areas benefitting from flood defence structures within the Order Limits. Local SFRAs were also consulted regarding the condition and nature of the water-retaining structures and these were used alongside local mapping to identify any smaller reservoirs near the proposed scheme that were not included on the Environment Agency mapping. Once potential water-retaining infrastructure was identified, professional judgement was used to identify any potential impact from the proposed scheme on the risk from this source.
Sewers and water mains infrastructure Sewer or water supply infrastructure flooding occurs when there is a failure, collapse and/or blockage of the network. The probability of sewer or water supply infrastructure flooding is dependent on the combined effect of several factors, such as infrastructure condition, existing maintenance regimes and other outside influences. However, failure could potentially result in a release of a large volume of water (see Section 6: Other sources of flood risk). The proposed scheme could interact with this source of flood risk through several mechanisms, including through damage to existing sewers or water supply infrastructure during construction.	Local SFRAs were consulted regarding the sewer and water main infrastructure flood risk. A review was undertaken of mapping showing the known locations of existing water supply and sewer infrastructure to determine the potential impact to and from the proposed scheme. This was assessed using professional judgement to identify if the proposed works would change existing levels of risk, or if there were a risk to the proposed scheme.

Flood source	Assessment methodology
Coastal/tidal Coastal/tidal flooding originates from the sea where water levels exceed the normal tidal range and flood onto the low-lying areas that define the coastline. Coastal/tidal flooding results in the inundation of low-lying areas and areas where sea defences have been breached or overtopped. It is generally caused by seasonal high tides and where stormy weather conditions result in strong wave action that increases water levels above the norm.	The proposed scheme does not cross areas considered to be at risk of coastal flooding and would not increase the risk of coastal flooding. Therefore, the FRA has not considered this source of flooding further.
Land drainage and artificial drainage Failure of land drainage infrastructure such as drains, channels and outflow pipes, which is most commonly the result of obstructions, poor maintenance and/or blockages. For the proposed scheme, a like-for-like replacement would be undertaken where this infrastructure is affected. Therefore, the risk of flooding is unlikely to change.	The assessment of flood risk from land and artificial drainage is undertaken in the following sections: • Ordinary Watercourses for drains that cross the proposed scheme and; • Surface Water for flow paths shown on the surface water flood maps Where drains do not cross the proposed scheme and do not show flows on surface water flood mapping, it is assumed that the drains are small, serve small catchments, and that any flooding from them would be dealt with by the proposed scheme drainage. Consequently, the FRA has not considered this source of flooding further.

Flood risk information sources

1.3.5 Flood risk has been assessed based on information from the following sources:

- Anglian River Basin Management Plan and Annexes (Environment Agency, 2018)
- Bedrock and superficial aquifer designations from the MAGIC map application (Department for Environment, Food and Rural Affairs (Defra), 2021)
- BGS Susceptibility to Groundwater Flooding mapping (BGS, 2021a)
- Detailed River Network Mapping (Ordnance Survey, 2019)
- Catchment Data Explorer (Environment Agency, 2020e)
- Flood Map for Planning (Environment Agency, 2021b)
- Historic Flood Map (Environment Agency, 2021c)
- Long Term Flood Risk Information Mapping (Environment Agency, 2020d)
- Risk of Flooding from Reservoirs (Environment Agency, 2021d)
- RoFSW Extent: 0.1, 1 and 2.2 percent annual chance (Environment Agency, 2020c) datasets
- Ground investigation data (2021)
- National Highways Drainage Data Management System (i.e. DDMS)
- OS Open Rivers dataset (Ordnance Survey, 2021a)
- Statutory Main River Map (Environment Agency, 2020b)
- OS MasterMap Topography Layer. Ordnance Survey mapping for identifying the locations of springs, sinks, sources, spreads, collects, issues, wells (Ordnance Survey, 2021b)
- Essex County Council Preliminary Flood Risk Assessment (Scott Wilson, 2011)
- Local SFRAs:
  - Braintree District Council Level 1 SFRA Update (AECOM, 2016a)
  - Mid-Essex SFRA, Appendix D Maldon Supplementary Report (Scott Wilson, 2008)
  - Chelmsford City Council Level 1 and Level 2 SFRA (JBA Consulting, 2018)

  - Colchester Borough Council Level 1 and Level 2 SFRA Update (AECOM, 2016b; 2017)
  - Mid-Essex SFRA (Scott Wilson, 2007)
- Local SWMPs:
  - Braintree and Witham SWMP and modelling outputs (AECOM, 2016c)
  - Chelmsford SWMP (Capita Symonds, 2014)
  - Colchester Town SWMP (Capita Symonds, 2013a)

Hydraulic modelling

1.3.6 Watercourses crossed by the proposed scheme are detailed in Annex M and can be seen in Annex E. Seven Main Rivers and 36 Ordinary Watercourses would be crossed by the proposed scheme (including proposed utilities diversions).

1.3.7 Detailed hydraulic modelling has been undertaken for watercourses that have the potential to significantly impact or be impacted by the proposed scheme with regards to flood risk. The modelling was carried out to confirm baseline fluvial flood risk, ensure the proposed scheme does not impede flood flows, inform the design process, assess potential proposed scheme impacts, and design appropriate mitigation for any such impacts. Early liaison has been undertaken with the Environment Agency to review baseline Main River hydraulic models completed.

1.3.8 Hydraulic modelling has been undertaken for the following watercourses:

- Seven Main Rivers (Boreham Brook, River Ter, River Brain, Rivenhall Brook, River Blackwater, Domsey Brook and Roman River)
- Five Ordinary Watercourses (7, 21, 21a, 23 and 26)

1.3.9 According to the Flood Map for Planning (Environment Agency, 2021b), the Order Limits would cross an area of River Chelmer floodplain. However, proposed scheme works within the River Chelmer floodplain are limited (e.g. changes to signage) and are not considered to have the potential to impact fluvial flood risk. The existing road is not shown to be at risk of flooding from the River Chelmer – according to Environment Agency LiDAR (Environment Agency, 2020a), the maximum level of Environment Agency Flood Zone 2 near the proposed scheme is approximately 19.6mAOD, and the lowest existing A12 road level in this area is approximately 20.2mAOD. Therefore, the River Chelmer has not been modelled.

1.3.10 For each modelled watercourse, the following rainfall events have been modelled:

- 5% (1 in 20) AEP event
- 1% (1 in 100) AEP event

- 1% (1 in 100) AEP event plus an allowance for climate change (see Section 1.6 for details of climate change uplift applied to different watercourses)

1.3.11 Once modelled, 1D and 2D model outputs were extracted. Various plates throughout the FRA illustrate the impacts on peak flood level difference caused by the proposed scheme, categorised as shown in Table 1.3.

Table 1.3 Fluvial flood risk impacts

Potential flood impact		Change in peak flood level
(red)	Major adverse	Increase in peak flood level >100mm
(orange)	Moderate adverse	Increase in peak flood level 50–100mm
(yellow)	Minor adverse	Increase in peak flood level 10–50mm
(green)	Negligible	Negligible change in peak flood level <+/-10mm
(light blue)	Minor beneficial	Decrease in peak flood level 10–50mm
(dark blue)	Moderate beneficial	Decrease in peak flood level 50–100mm
(purple)	Major beneficial	Decrease in peak flood level >100mm

1.3.12 The hydraulic models include survey information obtained for the proposed scheme, including watercourse cross-sections, and are more detailed and up to date than the version used to produce the current Environment Agency Flood Zones and RoFSW mapping. Therefore, the hydraulic models would be anticipated to give a more realistic indication of current and future flood risk than the Environment Agency mapping.

1.3.13 For further details of hydraulic modelling undertaken (including comparison of model outputs with historic flood records and Environment Agency (2021b) Flood Map for Planning), please refer to the modelling reports as detailed in Annex L.

Assessment assumptions and limitations

1.3.14 The Environment Agency (2020c) RoFSW mapping is considered to sufficiently represent the risk associated with Ordinary Watercourses away from proposed scheme crossings (for more details see Section 3). The RoFSW mapping does not take climate change into account. Therefore, the 0.1% (1 in 1000) AEP RoFSW mapping has been assessed as a proxy for the 1% (1 in 100) AEP event plus an allowance for climate change. The RoFSW mapping is generally found to be conservative (over-estimating flood risk) due to the absence of many culverts and drainage features from the models used. This assumption should result in a conservative assessment of flood risk to the proposed scheme. Similarly, use of this information would be anticipated to over-estimate potential impacts from the proposed scheme. Where mitigation is identified as being required, additional assessment would be undertaken to reduce the risk of over-design of this mitigation.

1.3.15 It is assumed in the assessment that all sustainable drainage systems (SuDS), drainage networks and other proposed mitigation would be fully maintained and managed as per standard guidance and practice for the predicted operational lifetime of the proposed scheme.

1.3.16 Where hydraulic modelling has been undertaken, there are uncertainties and limitations associated with the modelling (e.g. where topographical survey of ground elevation is not currently available, lower resolution LiDAR data has been used). Refer to the hydraulic modelling reports in Annex L for additional details of model assumptions and limitations.

1.3.17 It is assumed that borrow pits would be restored such that designed flood mitigation would function as described in this FRA (as per the borrow pit restoration principles, outlined in the Borrow Pits Report [TR010060/APP/7.8]).

1.3.18 The estimated depths of the proposed retaining walls have been assumed to be two-thirds of the maximum retained height.

1.3.19 The detailed drainage design for the proposed scheme is not known, and outline designs and assumptions have been used in this assessment. For the purpose of this assessment, it is assumed that all attenuation ponds would be constructed to a maximum of 2.5mbgl (below ground level), with depths varying between 1.2 to 2.5mbgl.

1.3.20 It is assumed that the attenuation ponds would be either lined or underlined directly by a low permeability layer such that it would prevent infiltration to deeper soil horizons.

1.3.21 It is assumed that where private means of access routes would cross areas of floodplain, existing ground levels would be maintained where practicable.

1.3.22 Freeboard requirements for mitigation measures would need to be confirmed at the detailed design stage and may change stated levels.

1.3.23 Three phases of exploratory GI were undertaken along the proposed scheme route and within the areas of the borrow pits, including groundwater level monitoring. Geological maps and/or historic BGS records were used to assess the geology further away from the proposed scheme.

1.3.24 Groundwater monitoring and strike data were used to provide a preliminary conservative assessment of depths to water, using the shallowest depth encountered. Due to the linear nature of the investigation, groundwater flow directions are largely based on topography and location of surface water bodies.

1.3.25 In some cases, groundwater level information is limited to groundwater strikes and seeps recorded in borehole logs provided by the BGS, as no GI boreholes are located nearby.

1.3.26 Groundwater monitoring data up to September 2021 (earliest start January 2020, but this varies by location) have been included in the assessment. Groundwater monitoring is ongoing at the majority of locations.

1.3.27 It should be noted that dewatering estimates referenced in Section 7: Construction phase are likely to be overestimates due to the conservative estimation methodology followed. These dewatering estimates are based on the following:

- Geological units derived from GI characteristics or BGS boreholes near the excavations where available, or BGS geological mapping.
- Generic hydraulic conductivity values from the scientific literature (Domenico and Schwartz, 1990) appropriate to the materials recorded in the boreholes or mapping at the cutting/widening/borrow pit location.
- A simple analytical calculation. Strata types are assumed to be continuous within the dewatering zone, whereas the geology often varies laterally across the proposed scheme. This is likely to lead to the dewatering estimates to be over-estimated, as the deposits away from the cutting would vary and the permeability would be expected to reduce and this heterogeneity was not factored into the calculations.

1.4 Historic flooding

1.4.1 The Environment Agency's Historic Flood Map (Environment Agency, 2021c) identifies the maximum extent of recorded flood outlines from rivers, sea, and groundwater springs. A review of this mapping has identified several areas of historic flooding within the study area, shown in Annex I. This mapping and the SFRAs have been reviewed for details of historic flood events which have occurred within the Order Limits. These have been summarised in Table 1.4.

Table 1.4 Details of historic flooding recorded as occurring near the Order Limits of the proposed scheme

Source of historic flooding information	Flood source	Description of historic flooding incidents
Environment Agency (2021c) Historic Flood mapping	Fluvial	At the western extent of the proposed scheme, the historic flood mapping indicates that there has been recorded flooding associated with the River Chelmer to the east of Chelmer Village.
	Fluvial	Historic flood mapping indicates that there has been recorded flooding associated with the River Brain in two areas within Witham upstream of the River Brain A12 crossing.
	Fluvial	Historic flood mapping indicates that there has been recorded flooding associated with the River Blackwater east of Witham.
	Fluvial	Historic flood mapping indicates that there has been recorded flooding associated with the River Blackwater south-west of Kelvedon and within Kelvedon.
Colchester Borough Council Level 1 SFRA Update (AECOM, 2016b)	Fluvial	There is no record of historic fluvial flooding within the Order Limits (recorded fluvial flood events recorded by ECC are shown in Appendix A, Figures 2A to 2J, of the SFRA).
	Surface water	There is no record of historic surface water flooding incidents within the Order Limits.
	Sewer	Mapping included in Appendix A, Figures 4A to 4D, of the local SFRA indicates a flood event of unknown sources west of the Prince of Wales roundabout (National Grid Reference (NGR) TL917238). The area is residential, and the flood event can be considered to have occurred due to the sewer overflowing.
Braintree District Council Level 1 SFRA Update (AECOM, 2016a)	Fluvial	1947: River Blackwater, Rivenhall Brook and the city of Witham 1970: River Brain south of Witham 2001: Kelvedon and Witham 2009: Kelvedon and Witham

Source of historic flooding information	Flood source	Description of historic flooding incidents
Chelmsford City Council Level 1 and Level 2 SFRA (JBA Consulting, 2018)	There are no historic records for the location of the proposed scheme.	
Mid-Essex SFRA, Appendix D Maldon Supplementary Report (Scott Wilson, 2008)	No historic flood mapping included in the SFRA.	
Colchester Borough Council Level 2 SFRA Update (AECOM, 2017)	There are no historic records for the location of the proposed scheme.	

1.5 Flood risk policy and guidance

National planning policy

European and national policy

1.5.1 Defra is responsible for all aspects of water policy in England. Some of the key current legislation and policies relating to the water environment are detailed in Table 1.5.

Table 1.5 Key national legislation and policy relating to the water environment

Legislation/policy	Relevance to the proposed scheme
Flood Risk Regulations 2009 (SI 2009/3042)	The Flood Risk Regulations establish a framework for assessing and managing flood risk, aimed at reducing the negative impact of flooding on human health, the environment, cultural heritage and economic activity. The regulations require the preparation of flood risk assessments, flood hazard maps, flood risk maps and flood management plans for river basin districts in England and Wales and certain cross-border river basin districts.
Flood and Water Management Act 2010	The Flood and Water Management Act 2010 defines the responsibilities of various flood risk management authorities. The Act gives the Environment Agency strategic overview for national flood risk management in England and gives unitary and county councils responsibility for local flood risk management.
Environment Act 1995	The Environment Act 1995 set the standard for environmental management and made provision for the establishment of the Environment Agency. The Environment Agency is a key consultee for water environment elements and flood risk management of the proposed scheme.
Water Resources Act 1991	The Water Resources Act 1991 regulates water resources, water quality, water pollution, flood defence, and provides for the general management of water resources, the standards expected for controlled waters, and prevention/mitigation through flood defence.
Land Drainage Act 1991	The Land Drainage Act 1991 outlines the responsibilities of various bodies that deal with local (land) drainage including local authorities, internal drainage boards and riparian owners. The Act requires that a watercourse be maintained by its owner in such a condition that the free flow of water is not impeded. The riparian owner must accept the natural flow from upstream but need not carry out work to cater for increased flows resulting from some types of works carried out upstream.
Environmental Protection Act 1990	The Environmental Protection Act 1990 defines the structure and authority of waste management and control of emissions into the environment within England, Wales and Scotland.
Reservoirs Act 1975	This legislation was enacted to protect against escapes of water from large reservoirs or from artificially created or enlarged lakes. It

Legislation/policy	Relevance to the proposed scheme
	essentially provides regulation for assessing the risk of escape of water and ensuring that reservoirs are regularly monitored, and their asset status (integrity) is regularly assessed. This is enforced by the Environment Agency in England.

National Networks National Policy Statement

1.5.2 The National Networks National Policy Statement (Department for Transport, 2014) is a requirement of the Planning Act 2008. It sets out the need for, and Government's policies to deliver, development of Nationally Significant Infrastructure Projects on the national road and rail networks in England. It provides planning guidance for promoters of Nationally Significant Infrastructure Projects on the road and rail networks, and the basis for the examination by the Examining Authority and decisions by the Secretary of State.

1.5.3 The NNNPS policies relevant to flood risk include paragraph 5.94, which states that, if an FRA is required, the applicant should:

- '*consider the risk of all forms of flooding arising from the project (including in adjacent parts of the United Kingdom), in addition to the risk of flooding to the project, and demonstrate how these risks would be managed and, where relevant, mitigated, so that the development remains safe throughout its lifetime;*
- *take the impacts of climate change into account, clearly stating the development lifetime over which the assessment has been made;*
- *consider the vulnerability of those using the infrastructure including arrangements for safe access and exit;*
- *include the assessment of the remaining (known as 'residual') risk after risk reduction measures have been taken into account and demonstrate that this is acceptable for the particular project;*
- *consider if there is a need to remain operational during a worst case flood event over the development's lifetime;*
- *provide the evidence for the Secretary of State to apply the Sequential Test and Exception Test, as appropriate.'*

1.5.4 Paragraph 5.109 of the NNNPS states that '*any project that is classified as 'essential infrastructure' and proposed to be located in Flood Zone 3a or b should be designed and constructed to remain operational and safe for users in times of flood; and any project in Zone 3b should result in no net loss of floodplain storage and not impede water flows*'.

1.5.5 As set out in Chapter 1: Introduction, of the Environmental Statement [TR010060/APP/6.1], the Overarching National Policy Statement for Energy (EN-1) and National Policy Statement for Gas Supply Infrastructure and Gas and Oil Pipelines (EN-4) (Department of Energy and Climate Change, 2011a; 2011b) apply in relation to the diversion of an existing high pressure gas main (the ‘gas main diversion’) owned and operated by Cadent Gas Limited (Cadent).

National Planning Policy Framework

1.5.6 The NPPF and associated planning practice guidance are the relevant guidance documents that local authorities use in reviewing proposals for development with respect to flood risk. If a site was to be developed, the NPPF sets out policies for planning authorities to:

- ensure flood risk is properly considered at all stages of the planning process
- prevent inappropriate development in areas at high risk of flooding
- direct development away from areas at highest risk
- ensure that new developments take climate change into account and do not increase flood risk elsewhere

1.5.7 The NPPF provides guidance on the assessment of flood risk and how it may be addressed or mitigated. The guidance includes advice for planning authorities to use a risk-based approach to avoid flood risk wherever possible and manage flood risk elsewhere in their planning decisions.

Sustainable drainage systems guidance

1.5.8 Department for Environment, Food and Rural Affairs published the Non-Statutory Technical Standards for Sustainable Drainage Systems (Defra, 2015), which includes the following guidance:

- ‘*The drainage system must be designed so that, unless an area is designated to hold and/or convey water as part of the design, flooding does not occur on any part of the site for a 1 in 30 year rainfall event.’*
- *‘The design of the site must ensure that, so far as is reasonably practicable, flows resulting from rainfall in excess of a 1 in 100 year rainfall event are managed in exceedance routes that minimise the risks to people and property.’*

1.5.9 It should be noted the proposed scheme drainage has been designed to DMRB standards. As such, testing of the 3.33% (1 in 30) AEP event has not been undertaken. Section 4.5 demonstrates the testing that has been undertaken.

Local flood risk policy and guidance

1.5.10 The proposed scheme is within an area governed by ECC, as the LLFA, and four local planning authorities: Braintree District Council, Colchester Borough Council, Maldon District Council and Chelmsford City Council.

Local Plans

1.5.11 The Local Plans are prepared by the local planning authorities and provide guidance for future growth and development within the local area, such as Core Strategies and Development Policies. The key flood risk management policies and objectives identified relevant to the proposed scheme are summarised in Table 1.6.

Table 1.6 Local planning policies and objectives

Local planning authority	Flood risk policy/objective	Key requirements
Braintree District Council (2017) Braintree Publication Draft Local Plan Section 2 (June 2017) (Emerging)	Policy LPP 78: Flooding Risk and Surface Water Drainage	• Proposals will be located to avoid the risk of flooding in a sequential manner. Development must be designed to be flood resilient and resistant and safe for its users for the lifetime of the development taking climate change and the vulnerability of the residents into account. Development will take climate change into account in accordance with the most up to date analysis of flood risk and will not increase flood risk elsewhere. • Retain at least an 8m wide undeveloped buffer strip alongside Main Rivers and explore opportunities for riverside restoration. Any proposed development within 8m of a Main River watercourse will require an environmental permit from the Environment Agency. • Retain at least a 3m buffer strip on at least one side of an Ordinary Watercourse. Any development that could impact the flow within and Ordinary Watercourse will require consent from ECC (as LLFA). • All new development within Flood Zones 2 and 3 must not result in a net loss of flood storage capacity. Where possible, opportunities should be sought to achieve an increase in the provision of floodplain storage. • Ensure there is no adverse impact on the operational functions of any existing flood defence infrastructure, and new development should not be positioned in areas which would be in an area of hazard should defences fail. Where the development sites will benefit from the construction of Flood Management Infrastructure such as Flood Alleviation Schemes, appropriate financial contributions will be sought.
Colchester Borough Council (2014)	SD1: Sustainable Development Locations ENV1: Environment	• New development in rural locations should adopt a sequential approach. • Proposed developments should promote sustainable solutions by minimising and/or providing mitigation to areas at risk of flooding.

Local planning authority	Flood risk policy/objective	Key requirements
Local Development Framework – Core Strategy		
Colchester Borough Council (2017) Colchester Borough Local Plan 2017 – 2033 Section Two – Publication Draft	Policy DM23: Flood Risk and Water Management	• Development will only be supported where it can be demonstrated that the proposal meets flood management requirements in the NPPF, the planning practice guidance and policy DM23.
Chelmsford City Council (2020) Chelmsford Local Plan: Our Planning Strategy 2013 to 2036	S1: Spatial Principles S9: Infrastructure Requirements	• Proposed development will be focused in areas where there is no or low risk of flooding. Where this is not possible, then the Sequential Test will be applied as outlined in the NPPF, followed if necessary, by the Exception Test. • New development should also ensure that it does not exacerbate or create flood risk elsewhere. • New development must be safe from all types of flooding and suitable strategic and site level measures will need to provide appropriate flood risk management.
	S2: Addressing Climate Change and Flood Risk	• Proposed development should be safe for the proposed lifespan of the development. It should identify mitigation measures for the current and future flood risk taking into account climate change. Proposed developments should not increase the flood risk elsewhere.
	DM18: Flooding/SuDS	• Planning permission can be granted if the proposed development can demonstrate it is safe from all types of flooding, either due to its location or due to implementation of appropriate mitigation measures during the construction and operation of the development. • All major proposed developments are required to include water management solutions such as SuDS.

Local planning authority	Flood risk policy/objective	Key requirements
		• Proposed developments should not increase the flood risk elsewhere.
Maldon District Council (2017) Maldon District Approved Local Development Plan 2014 – 2019	S1: Sustainable Development	• Proposed developments need to ensure that they do not increase the flood risk on site or elsewhere. • Proposals should follow the sequential approach and apply the Exception Test.
	D5: Flood Risk and Coastal Management	• Proposed developments need to ensure that they do not increase the flood risk on site or elsewhere. • Proposed developments should incorporate SuDS measures, where possible, as flood mitigation.

Essex County Council Preliminary Flood Risk Assessment

1.5.12 A Preliminary Flood Risk Assessment (PFRA) provides a high-level overview of the flood risk from local sources and more specifically surface water, groundwater and Ordinary Watercourses. As ECC is the LLFA for the proposed scheme area, the ECC PFRA (Scott Wilson, 2011) has been consulted. The document identifies areas with a high flood risk with potential consequences on the local population. The LLFA investigates the high flood risk areas by producing SFRAs and SWMPs. According to the ECC PFRA, the proposed scheme lies predominantly within an area of medium to low risk of surface water flooding. The PFRA indicates that there was no available information on future groundwater or Ordinary Watercourse flooding.

1.5.13 The ECC PFRA expands on the risk from the flood sources mentioned in paragraph 1.5.12 that could have '*significant harmful consequences for human health, economic activity and the environment*' in Essex, from future flooding. To identify the harmful consequences, the Environment Agency used Environment Agency (2020c) Risk of Flooding: Surface Water mapping and the National Receptors Dataset to determine areas that exceed a given flood risk threshold. The potential consequences of future flooding were mapped and presented in the ECC PFRA using the Environment Agency dataset. The mapping shows that the proposed scheme crosses two areas identified as having potential significant harmful consequences:

- NGR TL 80880 12829 (north-east end of junction 21) to TL 82884 15475 (south-west end of junction 22)
- NGR TL 85988 17722 (south of Kelvedon) to TL 86984 18315 (south-west end of junction 24)

Strategic Flood Risk Assessment

1.5.14 An SFRA is a document produced by local planning authorities that helps various parties consider flood risk in planning decisions. It provides an overall understanding of the flood risk within its scope area, considering all potential sources. The SFRAs of relevance to the proposed scheme is as follows:

- Braintree District Council Level 1 SFRA Update (AECOM, 2016a)
- Chelmsford City Council Level 1 and Level 2 SFRA (JBA Consulting, 2018)
- Colchester Borough Council Level 1 SFRA Update (AECOM, 2016b)
- Colchester Borough Council Level 2 SFRA Update (AECOM, 2017)
- Mid-Essex SFRA (Scott Wilson, 2007) and Appendix D Maldon Supplementary Report (Scott Wilson, 2008)

Surface Water Management Plans

1.5.15 An SWMP is produced by the LLFA and investigates the flood risk from local sources and determines a long-term plan of flood risk management. The flood sources commonly include surface water drains, groundwater and Ordinary Watercourses.

1.5.16 At the time of writing, SWMPs have been published for the following areas crossed by the proposed scheme:

- Braintree and Witham (AECOM, 2016c)
- Chelmsford (Capita Symonds, 2014)
- Colchester (Capita Symonds, 2013a)

1.6 Climate change

1.6.1 The Environment Agency's (2021a) published guidance on climate change allowances has been considered for this assessment. In May 2022, the Environment Agency updated this guidance, with new values for climate change allowances for rainfall intensity, to account for the United Kingdom Climate Projections 2018 (UKCP18). Given the timing of the revised guidance being published, it has not been possible to incorporate it into the relevant DCO application documents and also ensure the application is submitted in a timely fashion (given the time it would take to update the relevant documents). However, it is proposed that the guidance will be considered post-submission (and ideally pre-examination), by way of a sensitivity test that will report the implications of the new guidance on the assessments undertaken to date. The results of this will be submitted to the examination and will, as necessary to reflect any updates, be the basis on which the detailed design of the scheme is undertaken, should the DCO be granted.

1.6.2 This guidance details the climate change allowance required to assess the impacts of climate change on flooding for new developments, and is dependent on the location, design life and vulnerability classification of the development as detailed in Table 2 of the National Planning Practice Guidance (Ministry of Housing, Communities and Local Government, 2021b).

1.6.3 In line with Table 2 (Flood risk vulnerability classification) of the flood risk and coastal change planning practice guidance (Ministry of Housing, Communities and Local Government, 2021b), the proposed scheme is considered to be essential infrastructure.

Peak river flow

1.6.4 The Environment Agency (2021a) climate change guidance also recommends the peak river flow allowance to use when assessing impacts of climate change. This guidance is based on the UKCP18. The assessment is based on the location of the proposed scheme in relation to the identified river management catchment district and the proposed scheme's flood risk vulnerability classification. The proposed scheme is located within the Combined Essex Management Catchment.

1.6.5 The Environment Agency's (2021a) recommended climate change uplifts for peak river flow for the Essex Combined Management Catchment are presented in Table 1.7.

1.6.6 In accordance with Environment Agency (2021a) climate change guidance, as the proposed scheme involves elements located within Flood Zone 3b, the higher central climate change allowance should be applied. As the proposed scheme has a 100-year design life, a 38% climate change allowance should be applied for peak river flows (as presented in Table 1.7).

Table 1.7 Current climate change allowances for peak river flow, Combined Essex Management Catchment (Environment Agency, 2021a)

Management catchment	Allowance category	Total potential change anticipated for the '2020s' (2015 to 2039)	Total potential change anticipated for the '2050s' (2040 to 2069)	Total potential change anticipated for the '2080s' (2070 to 2115)
Combined Essex Management Catchment	Upper end	27%	37%	72%
	Higher central	13%	16%	38%
	Central	7%	8%	25%

1.6.7 The latest update to the climate change allowance guidance for peak river flow was published in July 2021, after much of the hydraulic modelling and assessment of the proposed scheme's impact on flood risk had already been completed (applying the 65% climate change allowance required by the previous version of the climate change guidance).

1.6.8 It was considered that it would not be necessary to rerun hydraulic modelling with the updated peak river flow climate change allowance (38%) for the River Ter and Roman River crossings. This decision was taken as the 65% climate change allowance modelling confirmed no flood mitigation requirements at these crossings, and updated levels were not required to size new crossing structures.

Maximum credible climate Change

1.6.9 In accordance with the NPS, consideration has been given to potential effects of greater climate change in the future on the operation of the proposed scheme. This assessment was originally undertaken in accordance with climate change guidance from the July 2020 version of the guidance. This identified no locations where upper end levels of climate change would have resulted in a risk of flooding to the carriageway due to the freeboard at watercourse crossings. Since this assessment was undertaken, the 2021 update to the guidance has been published. This increased the recommended credible maximum climate change allowance to be applied from 65% to 72%. As shown in Table 1.8, for each of the Main Rivers, there is considerable freeboard and generally small changes in flood depth owing to the additional allowance of 38% climate change. Given this and the evidence from past modelling of the 65% climate change allowance, the risk of flooding to the road in a 1% (1 in 100) AEP event plus 72% climate change is considered to be low.

Table 1.8 Freeboard to road in climate change event.

		1% (1 in 100) AEP		1% (1 in 100) AEP plus 38% climate change		
	Finished road level	Peak modelled with-scheme water level (mAOD)	Freeboard between peak modelled water level and finished road/surface level (m)	Peak modelled with-scheme water level (mAOD)	Freeboard between peak modelled water level and finished road/surface level (m)	Level change from 1% AEP to 1% AEP plus 38% climate change (m)
Boreham Brook	31.65	24.63	7.02	24.82	6.83	0.19
River Ter	23.69	18.31	5.38	18.99	4.7	0.68
River Brain	16.32	13.09	3.23	13.28	3.04	0.19
Rivenhall Brook	21.97	19.41	2.56	19.56	2.41	0.15
River Blackwater (mainline A12)	23.82	19.20	4.62	19.34	4.48	0.14
River Blackwater (footbridge)	20.78	19.20	1.58	19.34	1.44	0.14
Domsey Brook (western)	29.19	23.57	5.62	23.8	5.39	0.23
Domsey Brook (eastern)	38.27	32.80	5.47	32.89	5.38	0.09
Roman River	28.51	26.13	2.38	26.35	2.16	0.22

Peak rainfall intensity

1.6.10 The Environment Agency (2021a) climate change allowance guidance recommended the peak rainfall intensity allowance used to assess impacts of climate change based on United Kingdom Climate Projections 2009 (UKCP09).

1.6.11 Assuming a 100-year design life, this corresponds to a climate change allowance of 20% for rainfall intensity using the central allowance and 40% for rainfall intensity using the upper end allowance, as per Table 1.9.

1.6.12 For the Ordinary Watercourse modelling conducted as part of this FRA, a 40% climate change allowance has been applied, in accordance with the Environment Agency (2021a) climate change guidance.

1.6.13 The surface water drainage for the proposed scheme has been designed using a 20% climate change allowance and sensitivity test undertaken using a 40% climate change allowance.

1.6.14 The recent update to the guidance in May 2022, updates the recommended allowances to be used as per Table 1.10.

Table 1.9 Recommended climate change allowance for peak rainfall intensity in small and urban catchments (Environment Agency, 2021a)

Anglian river basin district	Total potential change anticipated for '2020s' (2015 to 2039)	Total potential change anticipated for '2050s' (2040 to 2069)	Total potential change anticipated for '2080s' (2070 to 2115)
Upper end	10%	20%	40%
Central	5%	10%	20%

Table 1.10 Recommended climate change allowance for peak rainfall intensity in small and urban catchments, 1% annual exceedance rainfall event (Environment Agency, 2022)

Combined Essex Management Catchment	Total potential change anticipated for '2050s' (2040 to 2069)	Total potential change anticipated for '2080s' (2070 to 2115)
Upper end	45%*	40%
Central	20%	25%

*The guidance states that the higher of the 2050's and 2080's allowances should be used in flood risk assessment if the 2050's allowance is higher and the development has a lifetime beyond 2061.

2 Fluvial flood risk – Main Rivers

2.1 Introduction

2.1.1 The proposed scheme has the potential to be at risk of fluvial flooding associated with Main Rivers.

2.1.2 The proposed scheme has the potential to increase fluvial flood risk as a result of the following without appropriate mitigation:

- Loss of floodplain storage (e.g. by displacing existing floodplain with widened highway embankments)
- Passing increased water downstream (e.g. by increasing the size of existing crossing structures)
- Restricting watercourse flow (e.g. by altering watercourse crossing structures or by any temporary in-channel works)

2.1.3 Hydraulic modelling has been used to assess the safety of the proposed scheme in relation to flood risk associated with Main Rivers and to assess how the proposed scheme could impact flood risk associated with Main Rivers.

2.2 Boreham Brook A12 crossing

Baseline flood risk

Watercourse description

2.2.1 A description of the Boreham Brook is included in Annex M. Boreham Brook is a tributary of the River Chelmer which is crossed by the existing A12 at NGR TL 74600 09900. The river flows in a south-westerly direction towards the A12 crossing, before continuing south-west under the Great Eastern Main Line (GEML) railway and the A12 via an 80.2m long culvert with a cross-section of 4m x 2m. Approximately 40m upstream of this culvert an Ordinary Watercourse (Ordinary Watercourse 3) flowing in a south-easterly direction converges with the Boreham Brook.

2.2.2 Downstream (south) of the A12/GEML railway culvert, the Boreham Brook flows in a south-easterly direction, passing beneath the B1137 via a culvert approximately 280m downstream of the A12/GEML railway culvert. Beyond the B1137 culvert, the watercourse continues in a south-easterly direction for approximately 2.2km before its confluence with the River Chelmer (approximately 2.5km downstream of the A12/GEML railway culvert). Immediately up- and downstream of the A12 crossing of the watercourse, Boreham Brook flows primarily through agricultural or other greenfield land.

Baseline modelled flooding

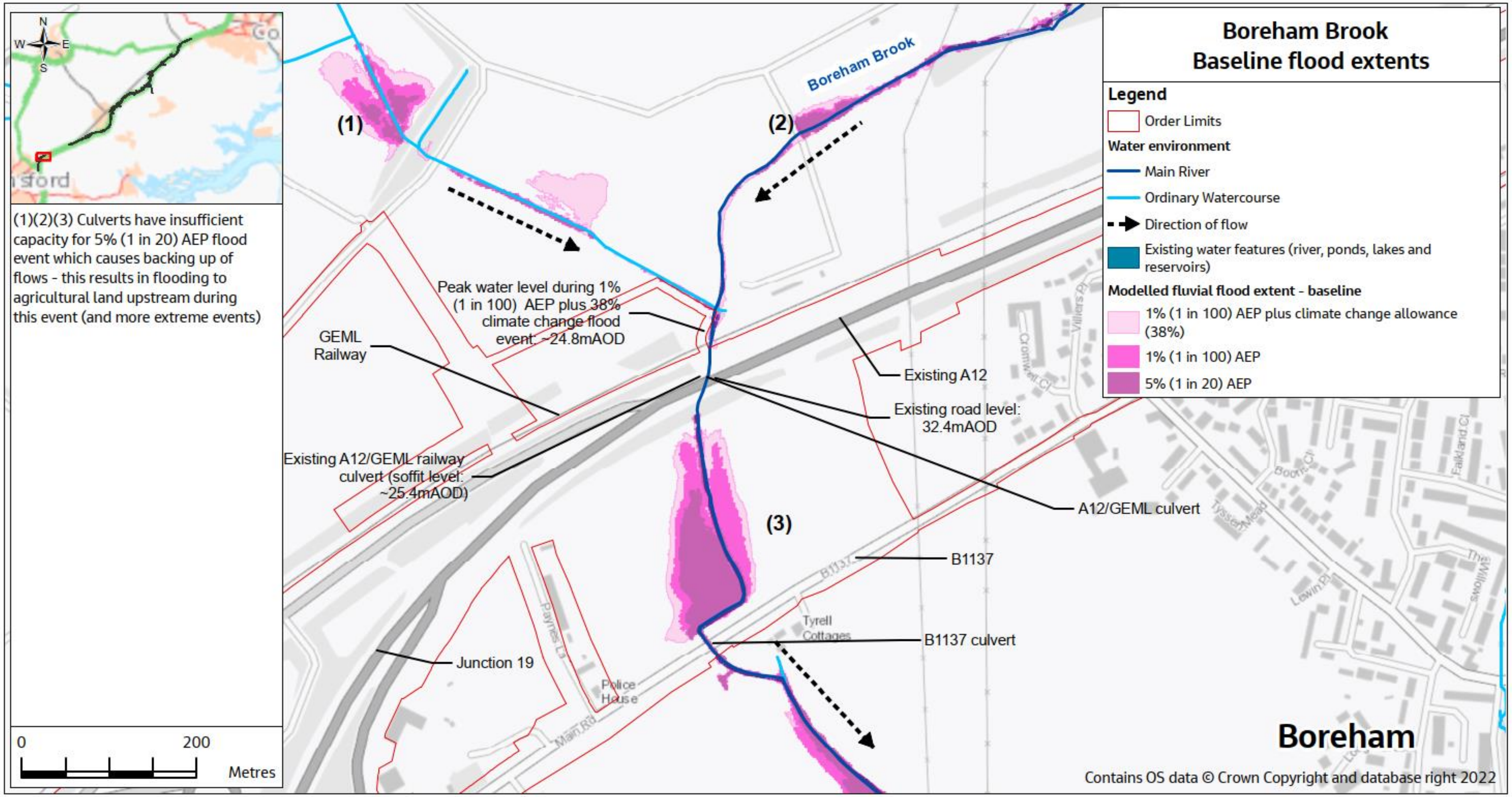
2.2.3 Modelled baseline flood extents (5% (1 in 20) AEP event, 1% (1 in 100) AEP event, and 1% (1 in 100) AEP event plus allowance for climate change) are included in Plate 2.1. For this watercourse, a 38% allowance for climate change has been applied to the 1% (1 in 100) AEP flood event (see Section 1.6 for further information on how climate change has been considered).

2.2.4 There is freeboard of greater than 0.6m between peak water level during the 1% (1 in 100) AEP event plus 38% allowance for climate change (24.82mAOD) and the soffit of the crossing structure (25.44mAOD). The road surface level in this location is 32.38mAOD. The existing A12 is not at risk of fluvial flooding for all flood events modelled.

2.2.5 For the 1% (1 in 100) AEP event plus 38% allowance for climate change, one property adjacent to the watercourse approximately 1km upstream of the A12 crossing is within the modelled flood extent and within 1km of the proposed scheme Order Limits. Other areas at risk of flooding appear to be agricultural or other greenfield land.

2.2.6 Modelling identified limited areas of agricultural land at risk of flooding upstream of the A12/GEML railway culvert for the 1% (1 in 100) AEP event plus 38% allowance for climate change, but immediately upstream of the A12/GEML railway culvert water remained in-bank for all events modelled. The modelling also indicated that there is agricultural land at risk of flooding downstream of the A12/GEML railway culvert between the A12 and the B1137 for all flood events modelled.

Plate 2.1 Boreham Brook modelled baseline fluvial flood extents



Proposed scheme design

2.2.7 At the existing A12 Boreham Brook crossing, the proposed scheme would involve slip road widening. This would require widening of the southbound highway embankment but would not involve altering or extending the existing A12/GEML railway culvert.

2.2.8 Although the Order Limits include the B1137 crossing of the Boreham Brook, and crossings of the Boreham Brook and Ordinary Watercourse 3 upstream of the A12 Boreham Brook crossing, no physical works to alter these existing crossings are proposed.

Flood risk to the proposed scheme

2.2.9 With-scheme modelling has been used to assess the flood risk from Boreham Brook to the proposed scheme. Table 2.1 details the anticipated finished proposed scheme road level and the peak modelled water level during the 1% (1 in 100) AEP event plus 38% allowance for climate change.

2.2.10 Table 2.1 also demonstrates that the finished road level of the proposed scheme would be safe from fluvial flooding at this location, with freeboard to the finished road level in excess of 6m.

Table 2.1 Proposed scheme road levels and peak modelled with-scheme water level during 1% (1 in 100) AEP event plus 38% allowance for climate change

Peak modelled with-scheme 1% (1 in 100) AEP event plus 38% allowance for climate change water level (mAOD)	Lowest proposed finished road/surface level (mAOD)	Freeboard between peak modelled water level and finished road/surface level (m)
24.82	31.65	6.83

Flood risk from the proposed scheme

Unmitigated impact of proposed scheme on flood risk

2.2.11 With-scheme modelling has been used to assess how the proposed scheme could impact flood risk in this location. As shown in Plate 2.2, Plate 2.3 and Plate 2.4, the proposed scheme would result in no change to flood extent or levels elsewhere for all modelled flood events. The proposed scheme would not require alteration of the existing Boreham Brook culvert, and the embankment widening required for the proposed scheme would not displace any flooding for all events modelled.

Flood mitigation

2.2.12 During all modelled events, the proposed scheme causes no change to flood risk elsewhere, and there is significant freeboard (greater than 6m) between peak flood levels and finished proposed scheme road levels. Therefore, it is considered no flood mitigation is required at this location.

Plate 2.2 Boreham Brook crossing – modelled change in flood extent as a result of the proposed scheme (1% (1 in 100) AEP event plus 38% allowance for climate change)

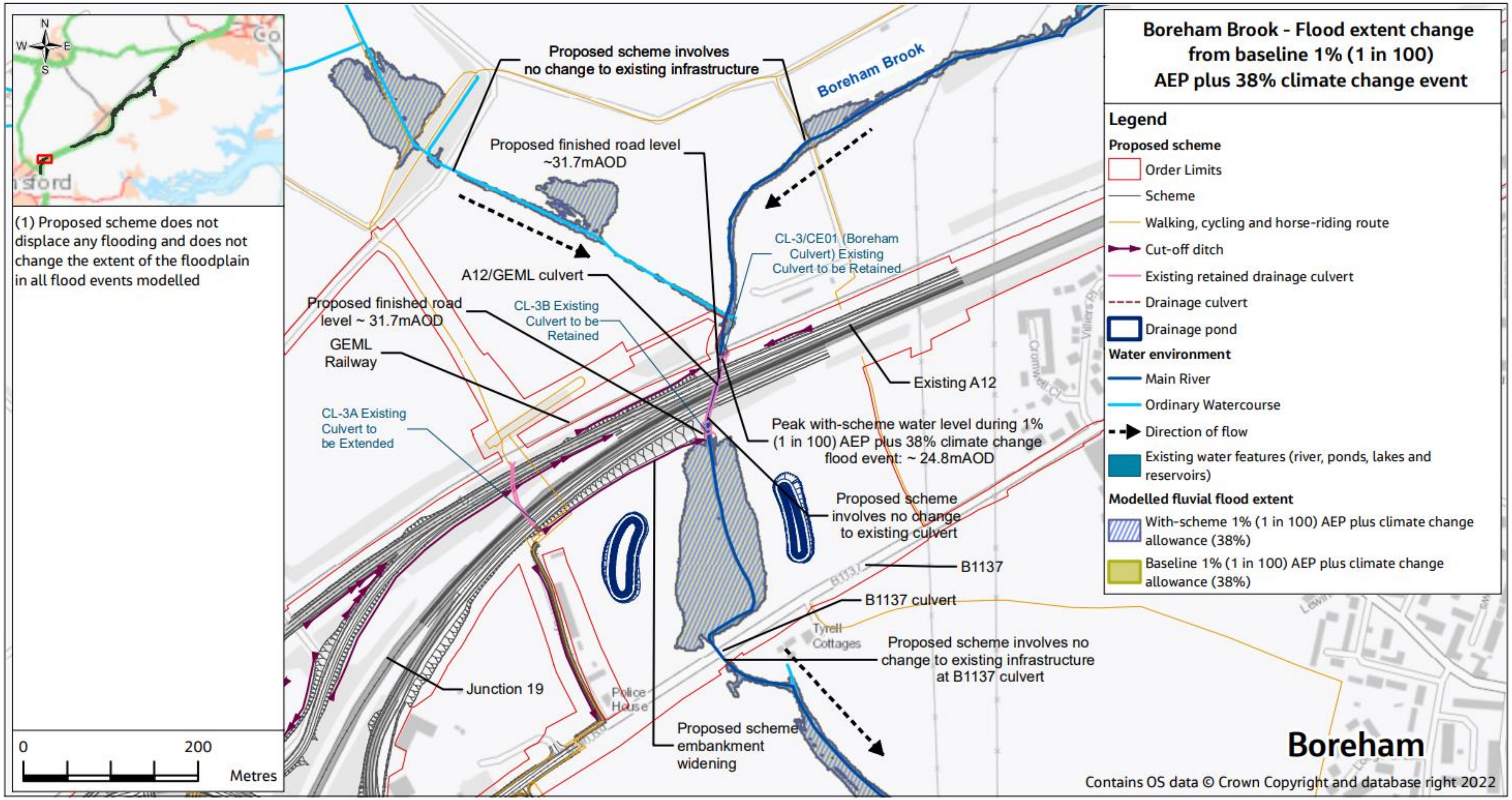


Plate 2.3 Boreham Brook crossing – modelled change in flood levels as a result of the proposed scheme (5% (1 in 20) AEP event)

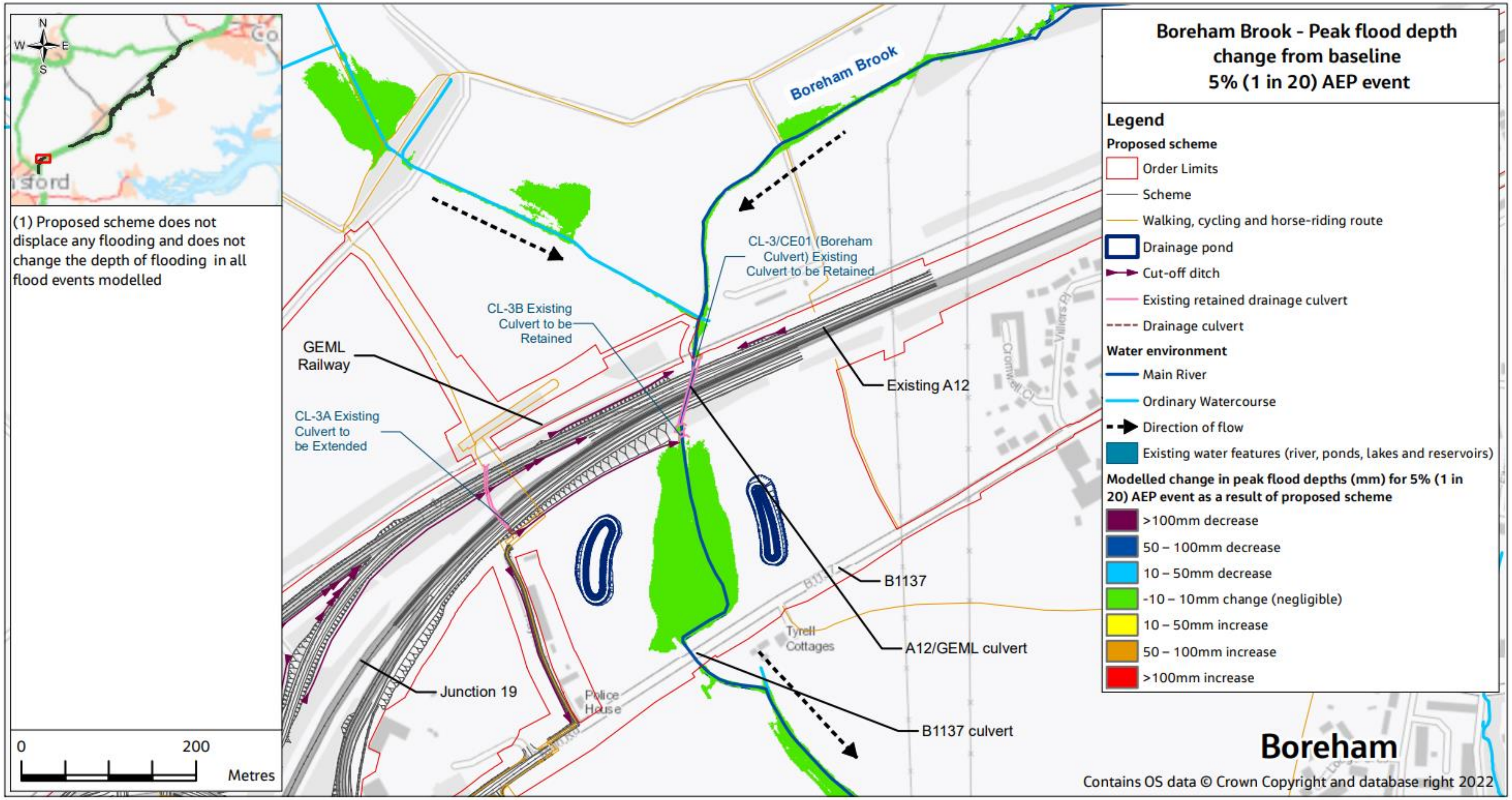
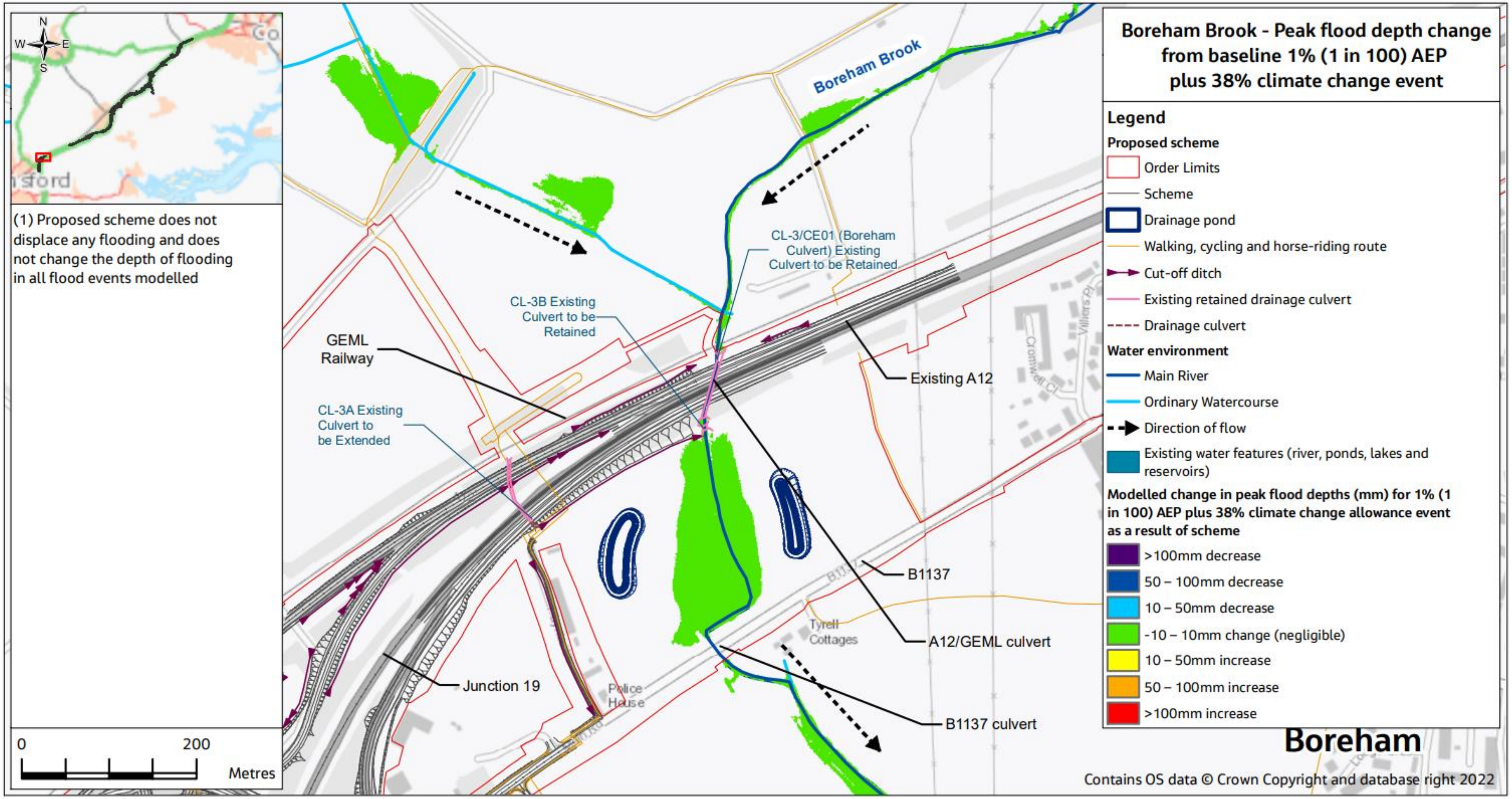


Plate 2.4 Boreham Brook crossing – modelled change in flood levels as a result of the proposed scheme (1% (1 in 100) AEP event plus 38% allowance for climate change)



2.3 River Ter A12 crossing

Baseline flood risk

Watercourse description

2.3.1 A description of River Ter is included in Annex M. The River Ter is a tributary of the River Chelmer which is crossed by the existing A12 at NGR TL 57830 21150. The river flows in a south-easterly direction towards the A12 and beneath the GEML railway via a bridge structure approximately 300m upstream of the A12 crossing.

2.3.2 To the north of the A12 there is a 450m long flood relief channel which runs parallel to the River Ter to the east of the Main River. This flood relief channel is culverted beneath the GEML railway and re-joins the river immediately upstream of the A12. Approximately 30m upstream of the A12 River Ter crossing, an Ordinary Watercourse joins the flood relief channel from the north-east.

2.3.3 The existing A12 crosses the River Ter on a bridge approximately 420m west of Hatfield Peverel. The B1137 crosses the river on a bridge approximately 20m downstream of the A12 bridge crossing. The river flows north to south into the River Chelmer approximately 3.8km downstream of the A12 crossing. Approximately 140m downstream of the A12 River Ter crossing, two Ordinary Watercourses join the Main River from the north-west.

Baseline modelled flooding

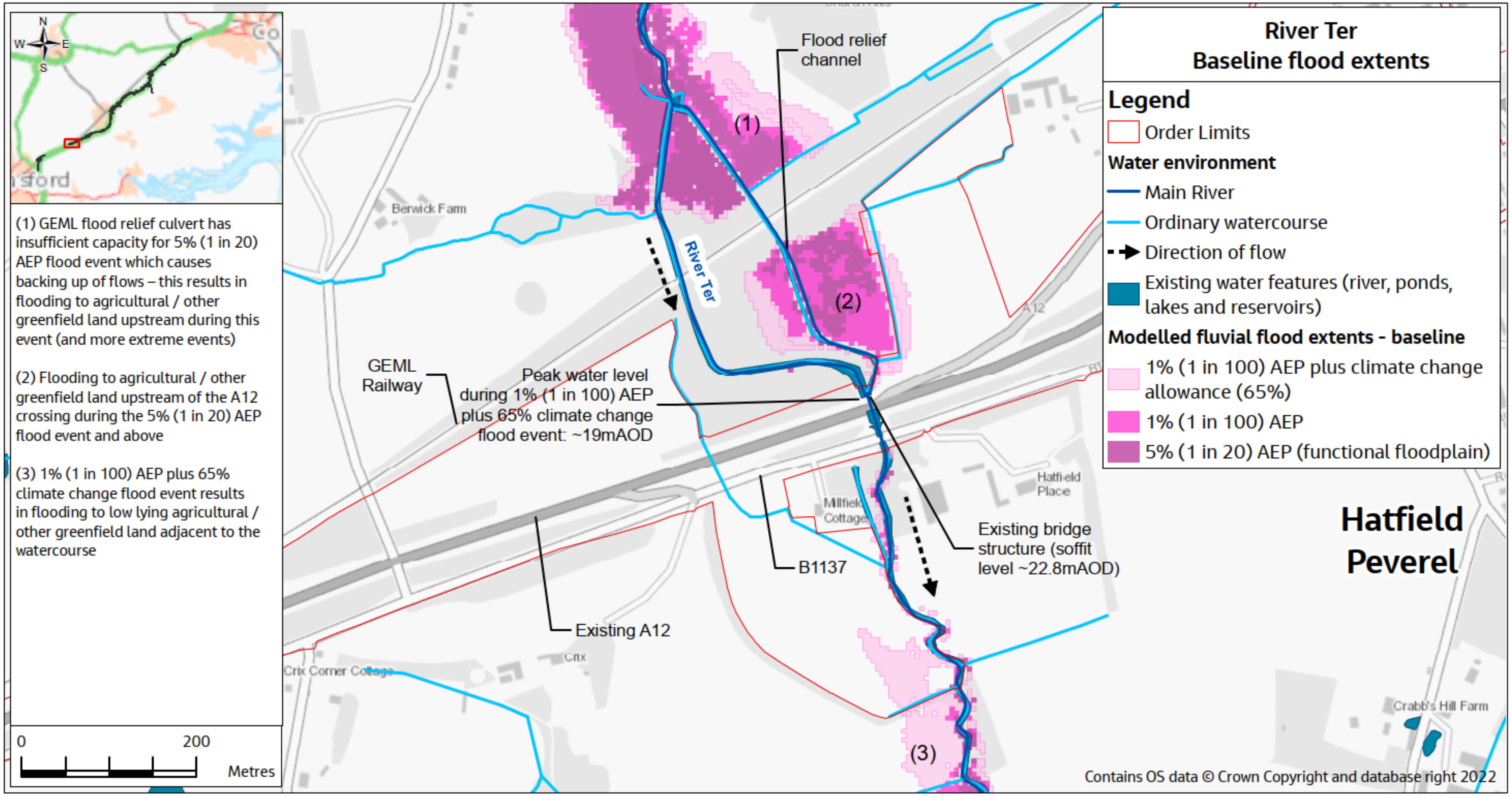
2.3.4 Modelled baseline flood extents (5% (1 in 20) AEP event, 1% (1 in 100) AEP event, 1% AEP event plus allowance for climate change) are included in Plate 2.5. For this watercourse, a 65% climate change allowance has been applied to the 1% (1 in 100) AEP flood event (see Section 1.6 for further information on how climate change has been considered).

2.3.5 The existing A12 is not at risk of fluvial flooding for all flood events modelled, with freeboard of greater than 3.5m between peak water level (18.99mAOD) and the soffit of the crossing structure (22.79mAOD) during the 1% (1 in 100) AEP event plus 65% allowance for climate change.

2.3.6 Modelling identified areas of agricultural or other greenfield land either side of the flood relief channel immediately upstream of the A12 River Ter crossing at risk of flooding for the 5% (1 in 20) AEP event and above. The modelling also identified agricultural or other greenfield land adjacent to both the Main River and the flood relief channel upstream of the GEML railway crossing at risk of flooding for the 5% (1 in 20) AEP event and above.

2.3.7 Downstream of the A12 River Ter crossing, modelling identified small areas of agricultural or other greenfield land immediately adjacent to the watercourse at risk of flooding for the 1% (1 in 100) AEP event plus 65% allowance for climate change. Approximately 240m downstream of the A12 crossing, the modelled 1% (1 in 100) AEP event plus 65% allowance for climate change flood extent widens on the west side of the watercourse. A local road (Crabbs Hill) approximately 1.3km downstream of the A12 crossing is shown to be at risk of flooding in a 1% (1 in 100) AEP event plus 65% allowance for climate change. No properties are located within the modelled flood extent within the study area.

Plate 2.5 River Ter modelled baseline fluvial flood extents



Proposed scheme design

2.3.8 At the existing A12 River Ter crossing, the proposed scheme would involve upgrading the highway to three lanes per carriageway. This widening would be achieved with no change to the existing bridge structure or highway embankment.

Flood risk to the proposed scheme

2.3.9 As there is no impact on the crossing structure or other features within the floodplain, with-scheme modelling has not been undertaken for the River Ter. Baseline modelling has therefore been used to assess the flood risk from the River Ter to the proposed scheme. Table 2.2 details the anticipated finished proposed scheme road level and peak modelled water level during the 1% (1 in 100) AEP event plus 65% allowance for climate change.

2.3.10 Table 2.2 also demonstrates that the finished road level of the proposed scheme would be safe from fluvial flooding at this location, with freeboard to the finished road level in excess of 4m.

Table 2.2 Proposed scheme road levels and peak modelled with-scheme water level during 1% (1 in 100) AEP event plus 65% allowance for climate change

Peak modelled baseline 1% (1 in 100) AEP event plus 65% allowance for climate change water level (mAOD)	Lowest proposed finished road/surface level (mAOD)	Freeboard between peak modelled water level and finished road/surface level (m)
18.99	23.69	4.70

Flood risk from the proposed scheme

Unmitigated impact of proposed scheme on flood risk

2.3.11 As the proposed scheme would involve no changes to the existing bridge structure or highway embankment in this location, it would have no impact on flood levels.

Flood mitigation

2.3.12 As the proposed scheme does not alter flood risk elsewhere and there is significant freeboard between peak flood levels and proposed finished road levels (greater than 4m in the 1% (1 in 100) AEP event plus 65% allowance for climate change), no mitigation is required at this location.

2.4 River Brain A12 crossing

Baseline flood risk

Watercourse description

2.4.1 A description of the River Brain is included in Annex M. The River Brain is a tributary of the River Chelmer which is crossed by the existing A12 at NGR TL 82830 13730. The river flows north-west to south-east underneath the existing A12 through a bridge prior to its confluence with the River Blackwater approximately 400m downstream. An existing sill structure associated with the A12 River Brain bridge sits above the natural watercourse bed level and reduces the natural capacity of the watercourse channel at this location.

2.4.2 Upstream of the A12 crossing, the watercourse flows through Witham relatively close to residential and commercial properties and is crossed by a number of local roads. Downstream of the A12 crossing, the watercourse flows through agricultural and other greenfield land before its confluence with the River Blackwater.

Baseline modelled flooding

2.4.3 Modelled baseline flood extents (5% (1 in 20) AEP event, 1% (1 in 100) AEP event, 1% (1 in 100) AEP event plus allowance for climate change) are included in Plate 2.6. For this watercourse, a 38% climate change allowance has been applied to the 1% (1 in 100) AEP event (see Section 1.6 for further information on how climate change has been considered).

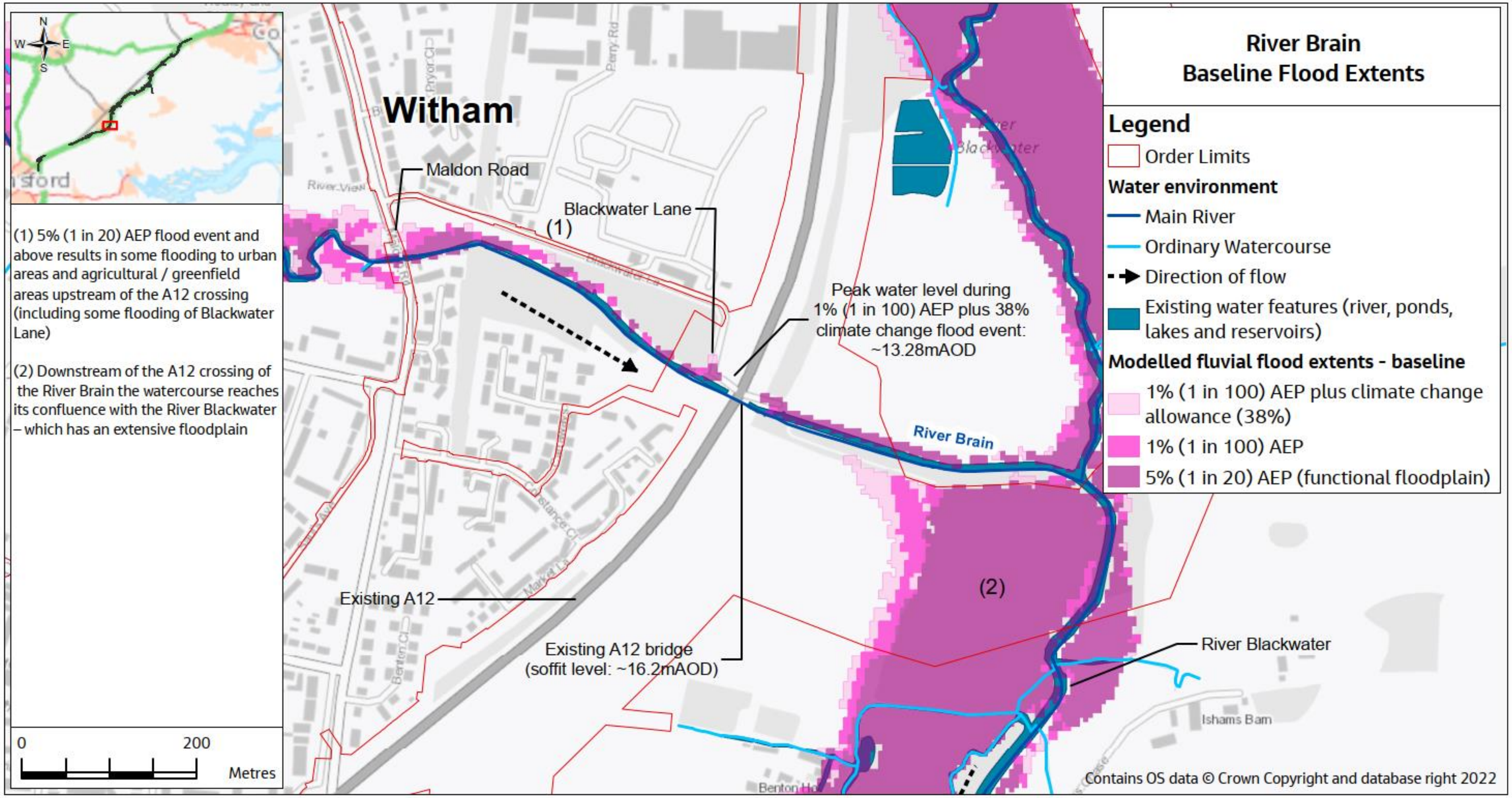
2.4.4 During the 1% (1 in 100) AEP event plus 38% allowance for climate change there is freeboard of greater than 2.5m between peak water level (13.28mAOD) and the soffit of the crossing structure (16.17mAOD). The existing A12 is not at risk of fluvial flooding for all flood events modelled.

2.4.5 Modelling identified areas of urban land at risk of flooding upstream of the A12 River Brain bridge adjacent to the watercourse for all flood events modelled. Modelling also indicates that there is agricultural and other greenfield land at risk of flooding downstream of the crossing for all flood events modelled.

2.4.6 Approximately 35 properties are situated within the 1% (1 in 100) AEP event plus 38% allowance for climate change River Brain floodplain. All flooded properties are located a considerable distance from the proposed scheme. The nearest properties within the 1% (1 in 100) AEP event plus allowance for climate change flood extent are approximately 0.4km upstream of the A12 crossing of the watercourse.

2.4.7 Blackwater Lane (immediately upstream of the A12 crossing), Maldon Road (approximately 420m upstream of the A12 crossing), Bridge Street (approximately 1.3km upstream of the A12 crossing), Guithavon Road (approximately 1.8km upstream of the A12 crossing), other local roads, and agricultural or other greenfield land are also within the modelled flood extent for the 1% (1 in 100) AEP plus 65% climate change event.

Plate 2.6 River Brain modelled baseline fluvial flood extents



Proposed scheme design

2.4.8 At the existing A12 River Brain crossing, the proposed scheme would involve upgrading the highway to three lanes per carriageway. This would require widening of the highway embankment on both sides by up to 14m and would require an extension of the existing bridge (by 4.9m and 6.9m to the west and east respectively) under the highway.

Flood risk to the proposed scheme

2.4.9 With-scheme modelling has been used to assess the flood risk from the River Brain to the proposed scheme. Table 2.3 details the anticipated finished proposed scheme road level and peak modelled water level during the 1% (1 in 100) AEP event plus 38% allowance for climate change.

2.4.10 Table 2.3 also demonstrates that the finished road levels of the proposed scheme would be safe from fluvial flooding at this location, with freeboard to the finished road level in excess of 3m.

Table 2.3 Proposed scheme road levels and peak modelled with-scheme water level during 1% (1 in 100) AEP event plus 38% allowance for climate change

Peak modelled with-scheme 1% (1 in 100) AEP event plus 38% allowance for climate change water level (mAOD)	Lowest proposed finished road/surface level (mAOD)	Freeboard between peak modelled water level and finished road/surface level (m)
13.28	16.32	3.04

Flood risk from the proposed scheme

Unmitigated impact of proposed scheme on flood risk

2.4.11 With-scheme modelling has been used to assess how the proposed scheme could impact flood risk in this location. The modelled change in flood extent caused by the proposed scheme for the 1% (1 in 100) AEP event plus 38% allowance for climate change is shown in Plate 2.7. Modelled changes in flood level caused by the proposed scheme are shown in Plate 2.8 (5% (1 in 20) AEP event) and Plate 2.9 (1% (1 in 100) AEP event plus 38% allowance for climate change).

2.4.12 The embankment widening displaces out-of-channel flood flows to the surrounding floodplain (see Table 2.4 for details). Modelling shows that the impacts of this displacement on flood risk elsewhere are negligible, resulting in water level changes of below 10mm for all modelled flood events. The proposed scheme causes zero change in peak water levels from baseline for locations further than 10m from the bridge (including zero change to water levels at properties greater than 0.4km upstream of the crossing).

Table 2.4 Out-of-channel flood volumes displaced by the proposed scheme

Modelled flood event	Volume of out-of-channel flooding displaced by proposed scheme
5% (1 in 20) AEP	$15m^3$
1% (1 in 100) AEP	$25m^3$
1% (1 in 100) AEP plus 38% allowance for climate change	$40m^3$

Flood mitigation

2.4.13 Even during the most extreme event modelled for this crossing (1% (1 in 100) AEP event plus 38% allowance for climate change), the proposed scheme causes negligible changes to flood risk elsewhere, and there is significant freeboard (greater than 3m) between peak flood levels and finished proposed scheme road levels. Therefore, no flood mitigation is proposed at this location.

Plate 2.7 River Brain crossing – modelled change in flood extent as a result of the proposed scheme (1% (1 in 100) AEP event plus 38% allowance for climate change)

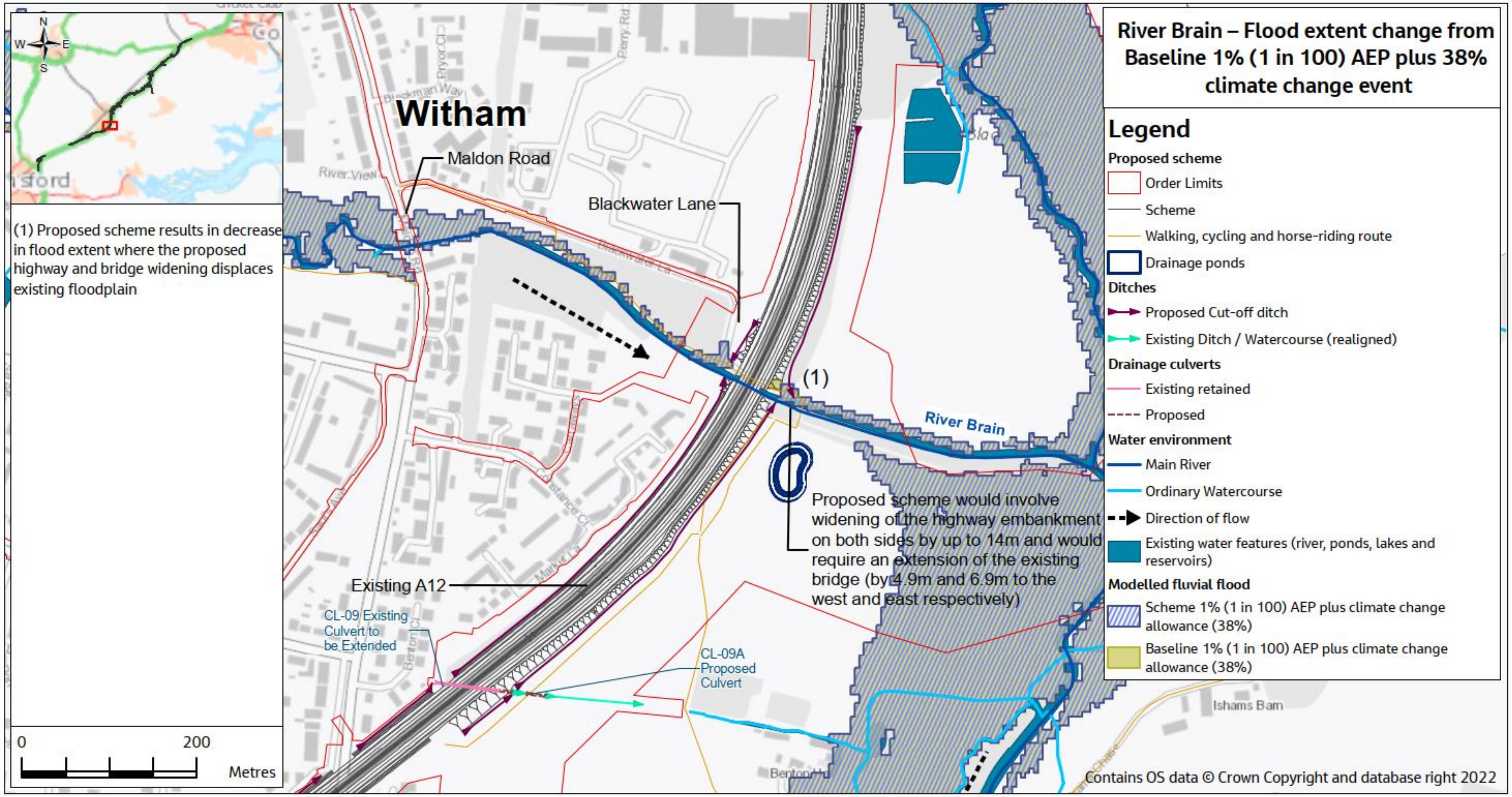


Plate 2.8 River Brain crossing – modelled change in flood levels as a result of the proposed scheme (5% (1 in 20) AEP event)

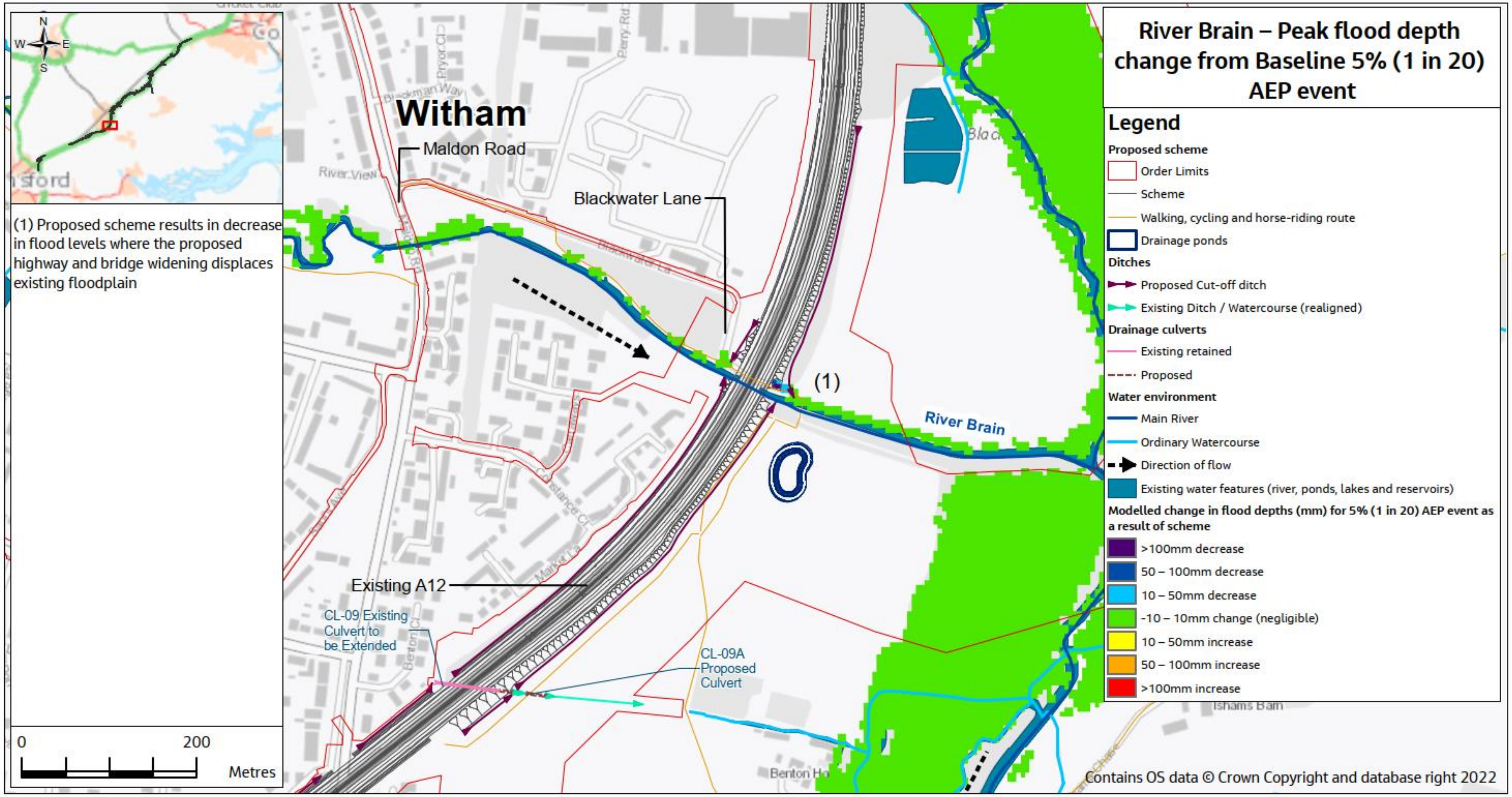
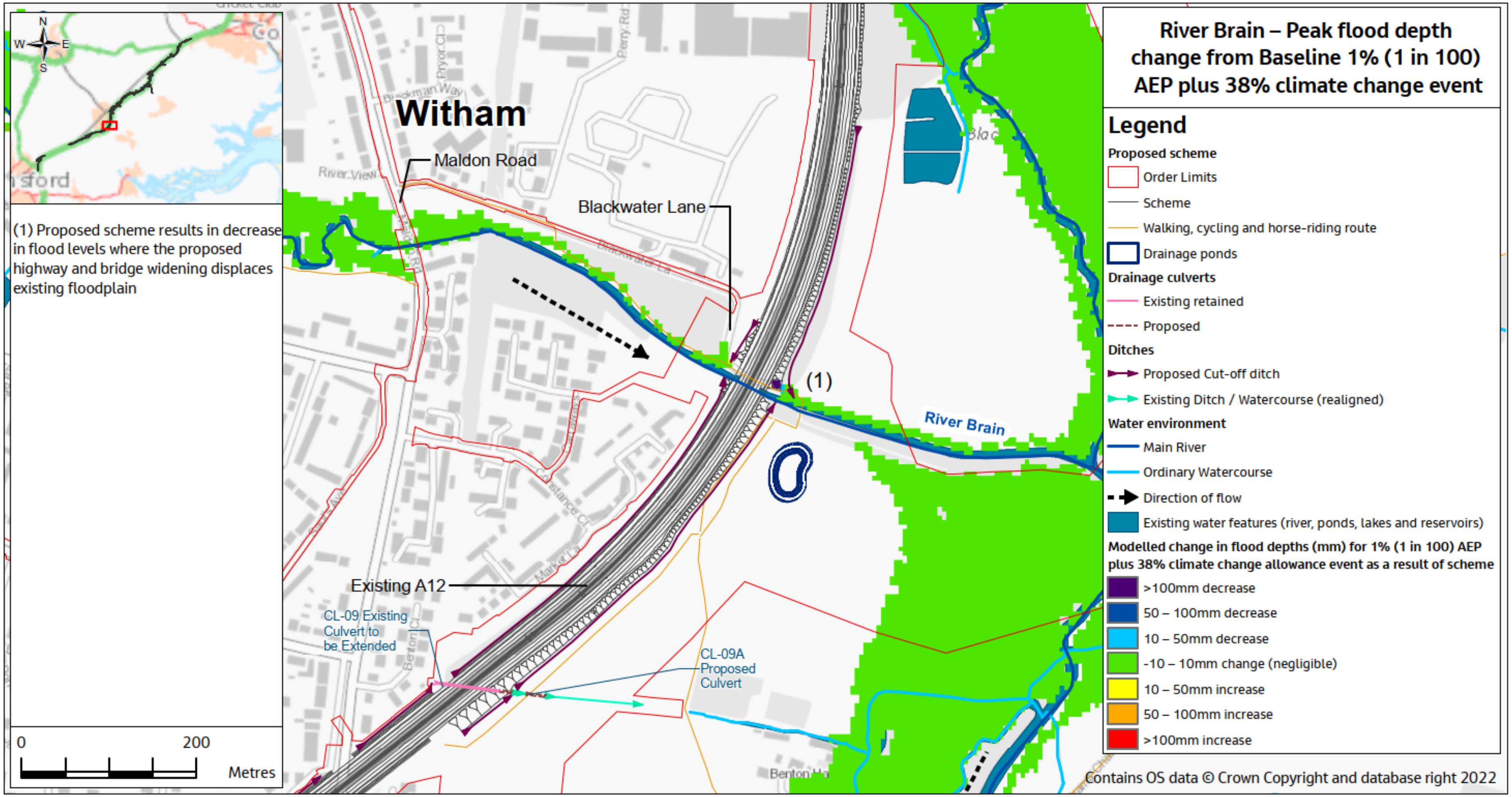


Plate 2.9 River Brain crossing – modelled change in flood levels as a result of the proposed scheme (1% (1 in 100) AEP event plus 38% allowance for climate change)



2.5 Rivenhall Brook A12 crossing

Baseline flood risk

Watercourse description

2.5.1 A description of the Rivenhall Brook is included in Annex M. Rivenhall Brook is a tributary of the River Blackwater which is crossed by the existing A12 at NGR TL 84250 16796. The channel has its source at a network of drainage channels approximately 300m north-east of Tye Green, and approximately 7.5km north-west of the proposed scheme. Rivenhall Brook generally flows south-east through arable and pastoral agricultural land towards the River Blackwater approximately 850m south-east of the A12 crossing.

2.5.2 Approximately 500m upstream of the A12 crossing, the river flows underneath the GEML railway via a culvert. At the existing A12 crossing, the watercourse flows beneath the road through a 28m long rectangular crossing structure with a cross-section of 4.2m x 0.9m. Immediately up- and downstream of the A12 crossing of the watercourse, Rivenhall Brook flows primarily through agricultural or other greenfield land.

Baseline modelled flooding

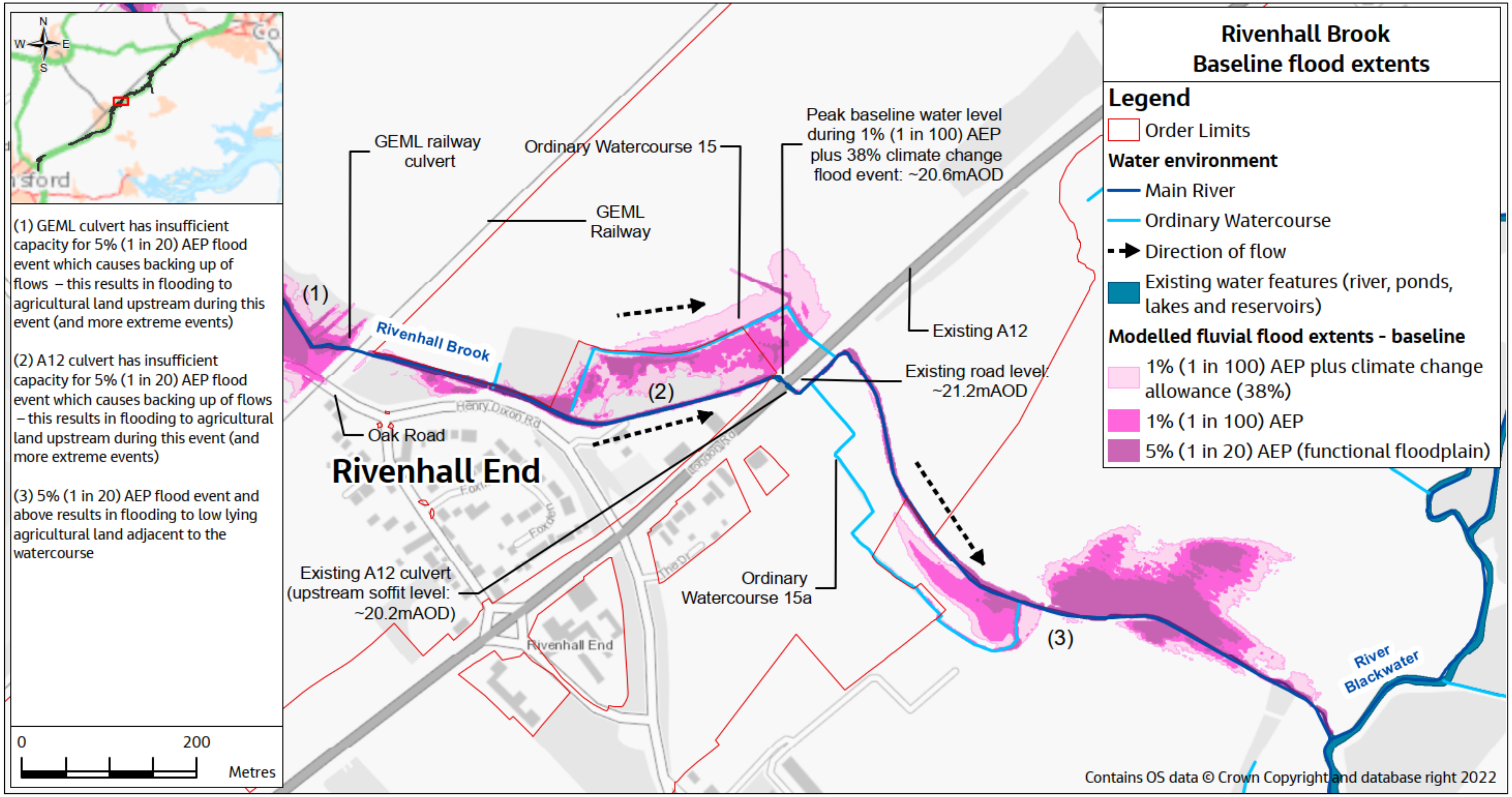
2.5.3 Modelled baseline flood extents (5% (1 in 20) AEP event, 1% (1 in 100) AEP event, 1% (1 in 100) AEP event plus allowance for climate change) are included in Plate 2.10. For this watercourse, a 38% climate change allowance has been applied to the 1% (1 in 100) AEP flood event (see Section 1.6 for further information on how climate change has been considered).

2.5.4 In this location the existing A12 culvert soffit level (20.20mAOD) is lower than the peak water level during the 1% (1 in 100) AEP event plus 38% allowance for climate change (20.62mAOD). However, in this event there is greater than 0.5m freeboard between the peak modelled water level and the existing road surface level (21.16mAOD), and therefore the existing A12 is not at risk of fluvial flooding for all flood events modelled.

2.5.5 Modelling indicates that agricultural areas are at risk of flooding alongside Rivenhall Brook upstream of the Granary Farm access road, where in-channel flows get locally constricted for all events modelled. The modelling also indicates that, around Rivenhall End village and the existing A12, Rivenhall Brook maximum flood levels are predicted to remain largely in-bank for the 5% (1 in 20) AEP event, but that some flooding would be expected for the 1% (1 in 100) AEP event. The 1% (1 in 100) AEP event plus 38% allowance for climate change exhibits flooding to agricultural land adjacent to the watercourse for almost all the modelled reach, apart from the area immediately downstream of the A12 due to the hydraulic restriction at the existing A12 crossing.

2.5.6 For the 1% (1 in 100) AEP event plus 38% allowance for climate change, no properties are located within the modelled flood extent within the study area. Modelling identified agricultural areas at risk of flooding upstream of the existing A12 Rivenhall Brook crossing and upstream of the GEML railway (including flooding to Oak Road) for the 1% (1 in 100) AEP event plus 38% allowance for climate change, in both instances due to limited crossing structure capacity.

Plate 2.10 Rivenhall Brook modelled baseline fluvial flood extents



Proposed scheme design

2.5.7 The proposed scheme would involve a new offline crossing of the Rivenhall Brook adjacent to the current A12. It is proposed that the Rivenhall Brook would be realigned, and that the new A12 crossing of the river would be through a 46m long culvert structure with a cross-section of 4.5m x 3.6m, located approximately 90m south-east of the existing A12 culvert crossing of the river.

2.5.8 The stretch of realigned watercourse located between the existing A12 and the proposed new offline section of A12 would be shorter, at 238m in length, than it currently is (315m). The realigned channel bed slope would also be increased from the baseline in order to tie into the existing bed levels up- and downstream of the proposed scheme.

2.5.9 A 22m long raised bund would be placed along the right bank of the watercourse immediately downstream of the new Rivenhall Brook A12 culvert, to ensure the watercourse realignment would not result in any increased flooding to the western floodplain of the watercourse. To contain the 1% (1 in 100) AEP event plus 38% allowance for climate change, the required height of the bund would be 0.62m (without freeboard inclusion). The bund would tie-in with the culvert wingwall structure at the upstream extent and the existing raised right-hand side bank top of Rivenhall Brook on the downstream extent.

Flood risk to the proposed scheme

2.5.10 With-scheme modelling has been used to assess the flood risk from Rivenhall Brook to the proposed scheme. Table 2.5 details the anticipated finished proposed scheme road level and peak modelled water level during the 1% (1 in 100) AEP event plus 38% allowance for climate change.

2.5.11 Table 2.5 demonstrates that the finished road levels of the proposed scheme would be safe from fluvial flooding at this location, with freeboard to the finished road level in excess of 2m.

Table 2.5 Proposed scheme road levels and peak modelled with-scheme water level during 1% (1 in 100) AEP event plus 38% allowance for climate change

Peak modelled with-scheme 1% (1 in 100) AEP event plus 38% allowance for climate change water level (mAOD)	Lowest proposed finished road/surface level (mAOD)	Freeboard between peak modelled water level and finished road/surface level (m)
19.56	21.97	2.41

2.5.12 North of the A12 crossing of the Rivenhall Brook the proposed scheme requires a Walking, cycling and horse riding (WCH) route to be permanently relocated such that it would cross an area of Rivenhall Brook floodplain (see Annex B). Therefore, the relocated WCH route would be at risk of flooding. A public safety risk assessment would be completed for the WCH route, and appropriate mitigation (such as signage) would be provided to advise potential users of the risk.

Flood risk from the proposed scheme

Impact of proposed scheme on flood risk

2.5.13 With-scheme modelling has been used to assess how the proposed scheme could impact flood risk in this location. The modelled change in flood extent caused by the proposed scheme for the 1% (1 in 100) AEP event plus 38% allowance for climate change is shown in Plate 2.11. Modelled changes in flood level caused by the proposed scheme are shown in Plate 2.12 (5% (1 in 20) AEP event) and Plate 2.13 (1% (1 in 100) AEP event plus 38% allowance for climate change). Table 2.6 details the difference in in-channel water levels between the baseline and with-scheme scenarios.

Table 2.6 Rivenhall Brook in-channel water levels during baseline and with-scheme scenarios during the 1% (1 in 100) AEP event plus 38% allowance for climate change

Location	Baseline water level (mAOD)	With-scheme (including flood mitigation bund) water level (mAOD)	Difference between baseline and with-scheme water level (m)
Upstream of GEML railway culvert	22.95	22.95	+0.00
Downstream of railway culvert	22.07	22.07	+0.00
Upstream of existing A12 culvert	20.61	20.47	-0.14
Downstream of existing A12 culvert	20.28	19.92	-0.36
445m downstream of proposed new A12 carriageway culvert	17.41	17.41	+0.00

2.5.14 The proposed scheme results in reduced peak water levels upstream of the new crossing (Table 2.6). This occurs due to the increased slope of the realigned channel improving the conveyance of flows compared to the baseline scenario, while the new A12 culvert would not restrict flow conveyed downstream of the proposed scheme. Depth-difference mapping shows that the proposed scheme results in a decrease in flood depths observed immediately upstream of the existing A12 culvert for all modelled events. The proposed scheme results in more than 100mm lower flood depths during the 1% (1 in 100) AEP event plus 38% allowance for climate change (shown in Plate 2.13).

2.5.15 During all modelled events, flow is contained within the realigned channel in between the existing and the new A12 crossing of the watercourse.

2.5.16 Downstream (south) of the new A12 culvert, flow is contained within the channel due to the raised bund on the right bank. Due to the flow being contained in-channel, the water level in the channel downstream of the new culvert is increased compared to the baseline scenario. However, this results in a negligible (below 10mm) impact to out-of-bank flood levels downstream during all modelled events.

2.5.17 Depth-difference mapping shows that the proposed scheme results in an increase in flood depths to a small area of land directly adjacent to the realigned watercourse channel immediately downstream of the proposed A12 crossing (greater than 100mm increase in flood depths) in between the existing and the proposed watercourse channel.

2.5.18 The proposed realignment of Rivenhall Brook would result in Ordinary Watercourse 15a being disconnected from its source. This has been included in the modelling, and no adverse flood impacts have been identified as a result.

Flood mitigation

2.5.19 As previously mentioned, a raised bund (22m long, 0.62m tall without freeboard inclusion) would be placed along the right bank of the watercourse immediately downstream of the new Rivenhall Brook A12 culvert, to ensure the watercourse realignment would not result in any increased flooding to the western floodplain of the watercourse.

2.5.20 With this bund in place, for all flood events modelled for this crossing, the proposed scheme would cause an increase in flood risk to a small area of land adjacent to the realigned watercourse channel directly downstream of the proposed new A12 culvert. The area for which the proposed scheme causes increased flood risk is situated immediately downstream of the proposed new A12 culvert. It is not anticipated that any flood mitigation would be required in this location, as the land area of increased flood risk would be acquired by National Highways for the purpose of the proposed scheme and would remain as unused land (i.e. this land does not and would not contain any receptors which could be harmed by the increase in peak flood depth).

2.5.21 Other than the increase in flooding to a small area immediately downstream of the proposed new culvert crossing, the proposed scheme causes negligible and beneficial change to flood risk elsewhere. There is also significant freeboard (greater than 2m) between peak flood levels and finished proposed scheme road levels. Therefore, no further flood mitigation is proposed at this location.

Plate 2.11 Rivenhall Brook crossing – modelled change in flood extent as a result of the proposed scheme (1% (1 in 100) AEP event plus 38% allowance for climate change)

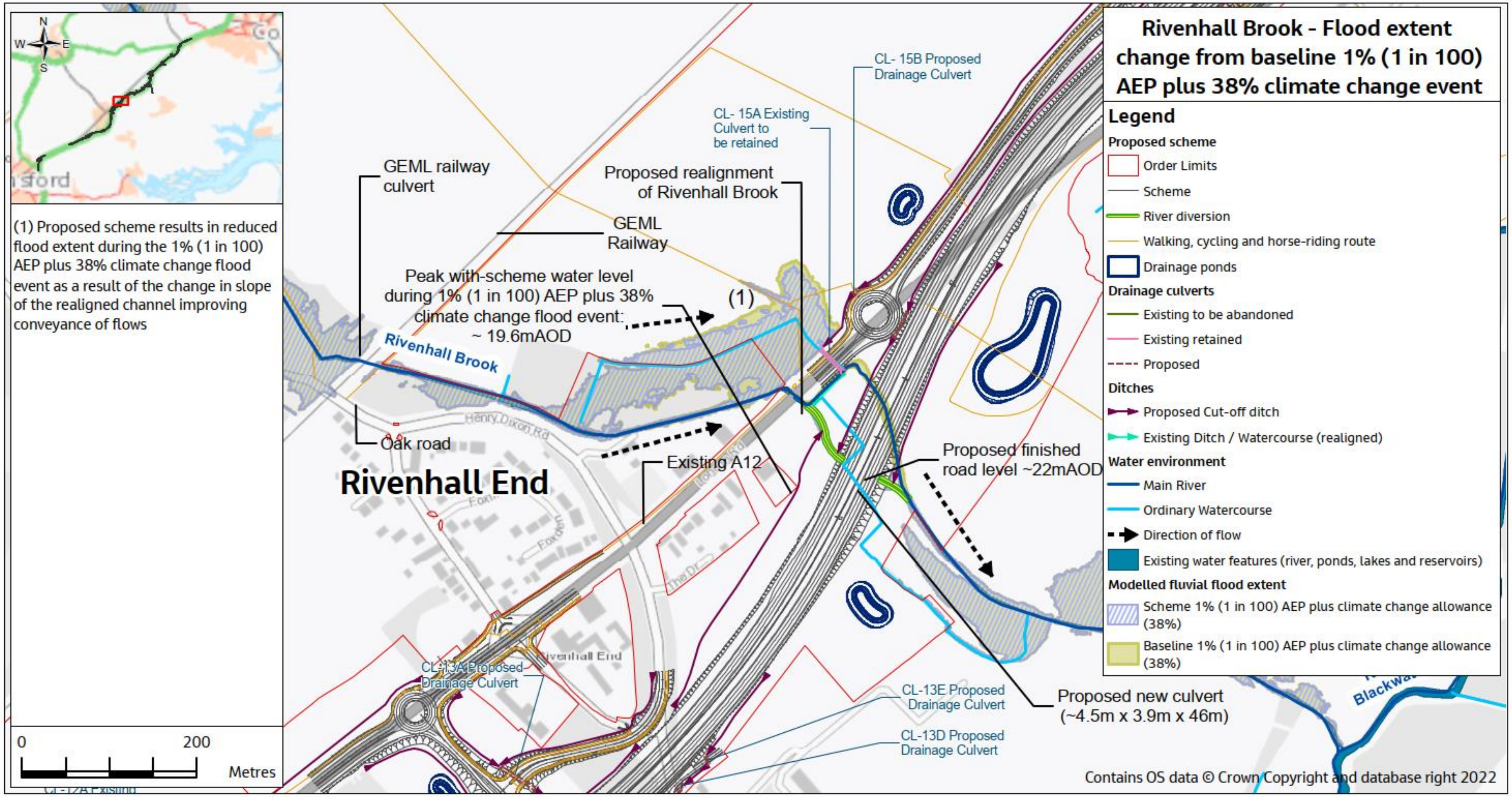


Plate 2.12 Rivenhall Brook crossing – modelled change in flood levels as a result of the proposed scheme (5% (1 in 20) AEP event)

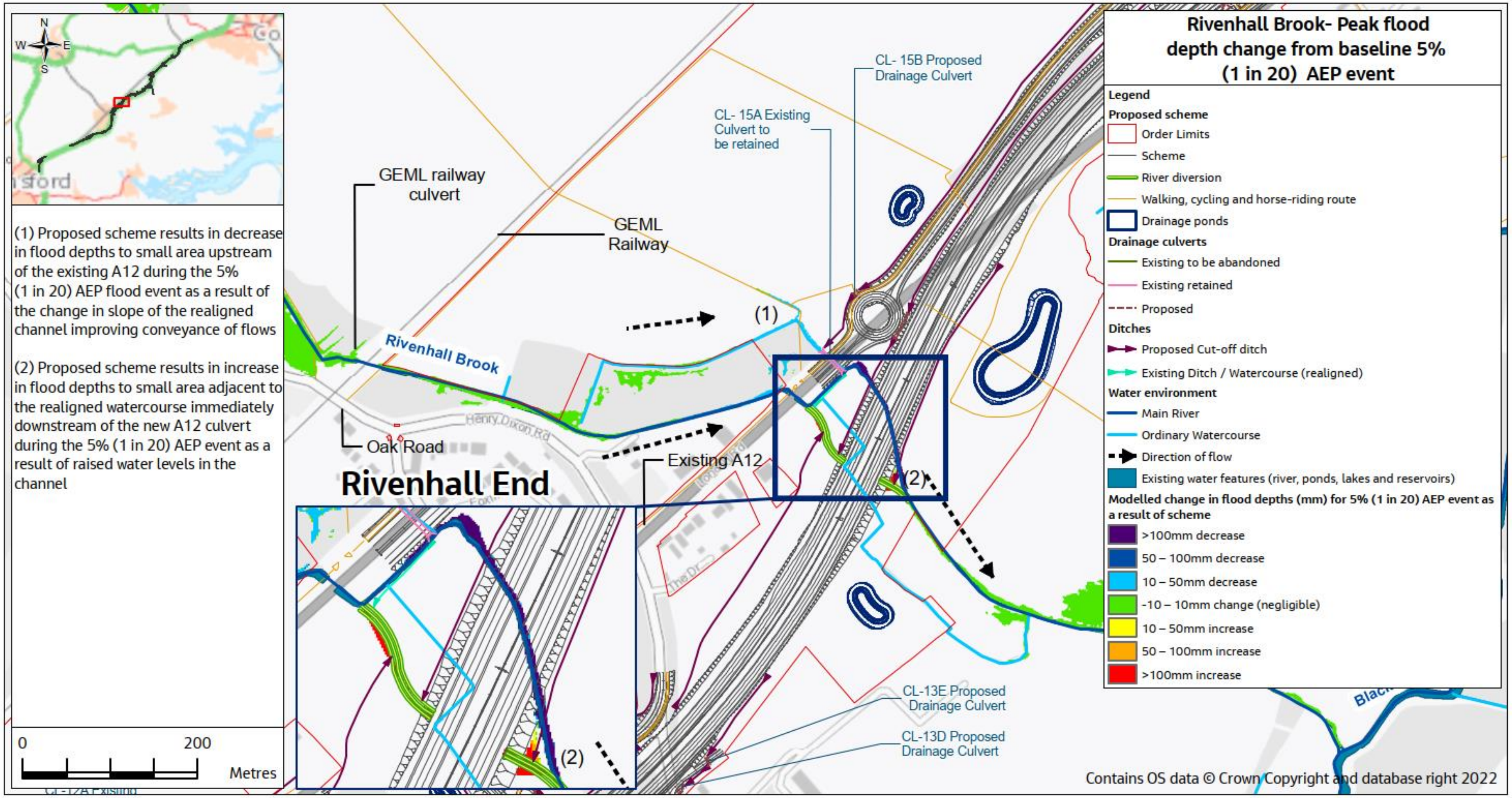
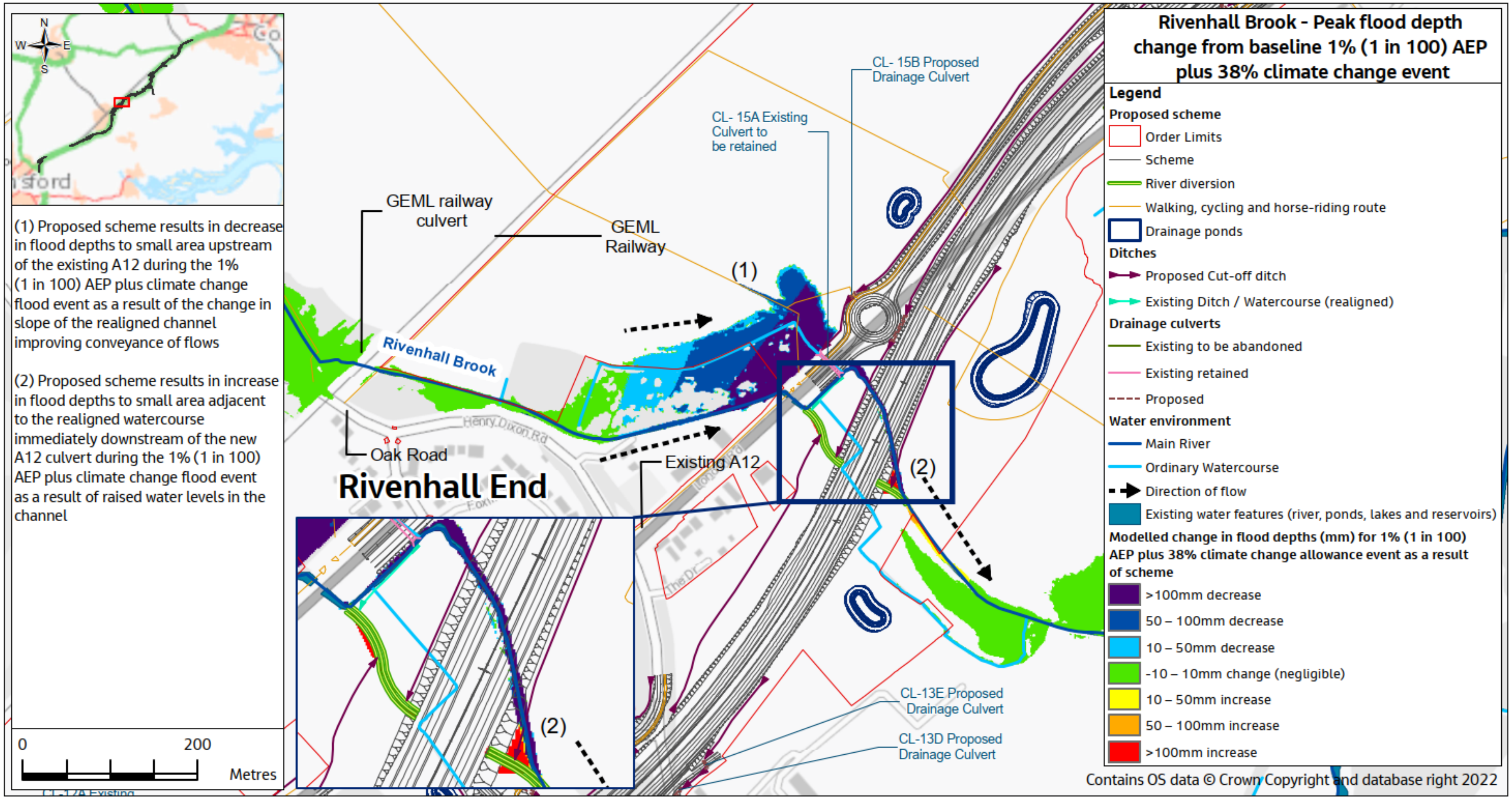


Plate 2.13 Rivenhall Brook crossing – modelled change in flood levels as a result of the proposed scheme (1% (1 in 100) AEP event plus 38% allowance for climate change)



2.6 River Blackwater A12 crossing

Baseline flood risk

Watercourse description

2.6.1 A description of the River Blackwater is included in Annex M. The River Blackwater is a tributary of the River Chelmer and originates at Braintree (where the watercourse is referred to as the River Pant). The watercourse flows south-west underneath the existing A12 via a 29m wide bridge (Ashman's Bridge, soffit level 23.93mAOD) at NGR TL 85569 17696, and then beneath a WCH route footbridge approximately 25m downstream at NGR TL 85559 17653 before continuing flowing south-west until its confluence with the River Chelmer approximately 12km downstream of the A12 crossing.

2.6.2 The Rivenhall Brook and the River Brain join the River Blackwater at 1.8km and 5.8km downstream of the A12 Blackwater crossing, respectively. Approximately 1.7km upstream of the A12 Blackwater crossing, the Domsey Brook joins the Blackwater from the north-east.

Baseline modelled flooding

2.6.3 Modelled baseline flood extents (5% (1 in 20) AEP event, 1% (1 in 100) AEP event, 1% AEP event plus allowance for climate change) are included in Plate 2.14. For this watercourse, a 38% climate change allowance has been applied to the 1% (1 in 100) AEP flood event (see Section 1.6 for further information on how climate change has been considered).

2.6.4 At the existing A12 crossing (Ashman's Bridge), there is freeboard of greater than 4m between peak water level (19.34mAOD) and the soffit of the crossing structure (23.93mAOD) during the 1% (1 in 100) AEP event plus 38% allowance for climate change. Therefore, the existing A12 is not at risk of fluvial flooding for all flood events modelled.

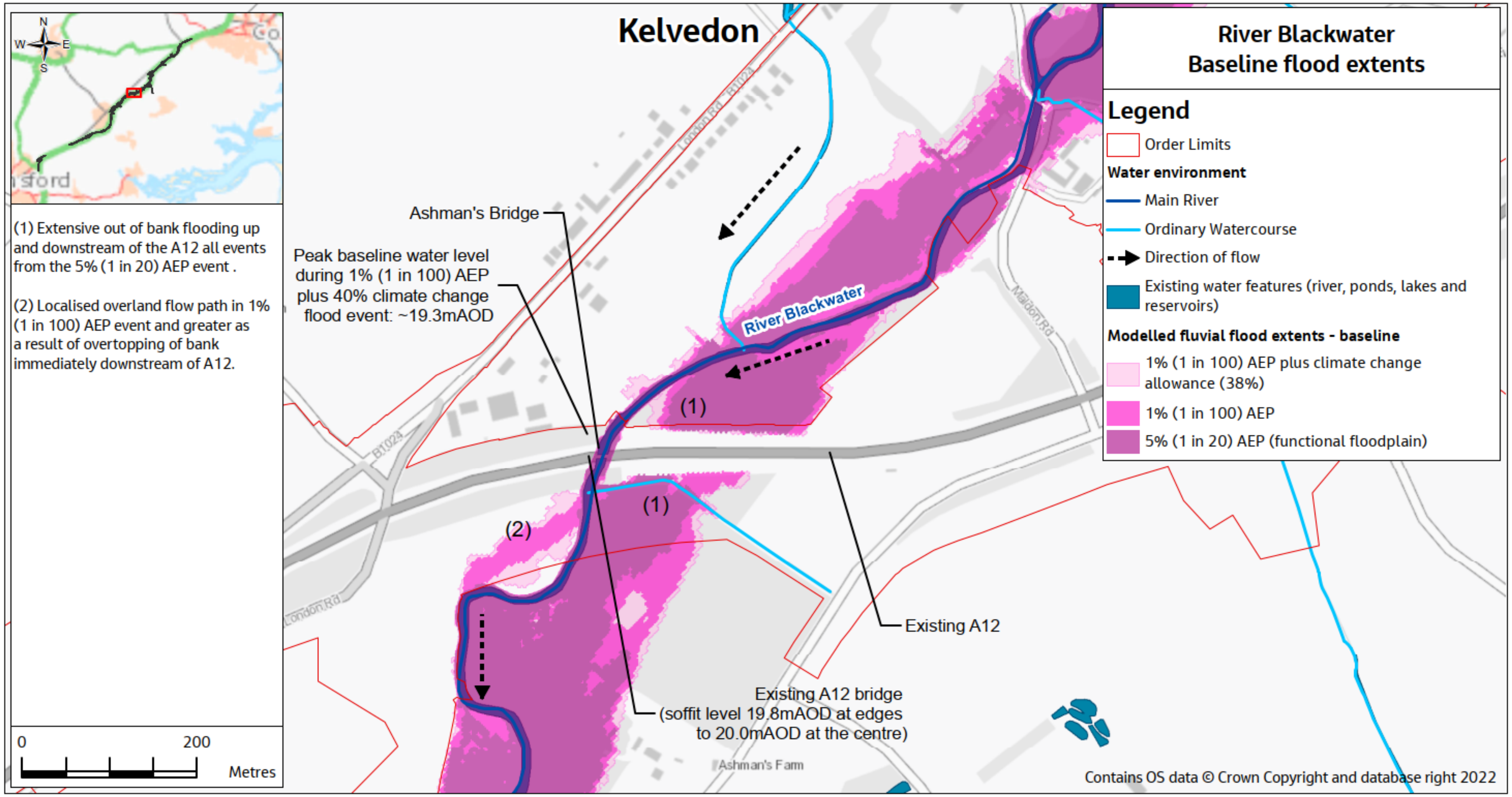
2.6.5 At the existing WCH route footbridge, there is freeboard of greater than 0.4m between peak water level (19.34mAOD) and the soffit of the crossing structure (19.80mAOD at the edges to 20.01mAOD at the centre) during the 1% (1 in 100) AEP event plus 38% allowance for climate change. Therefore, the existing footbridge is not at risk of fluvial flooding for all flood events modelled.

2.6.6 Modelled flood extents appear to indicate that the existing crossing does not have a significant effect on constricting flows. Supporting this theory, modelled head loss across the structure from the upstream to the downstream side is negligible (under 10mm) in all modelled events.

2.6.7 Modelling identified that significant flooding is predicted to occur downstream of Ashman's Bridge for all modelled flood events. Immediately upstream and downstream of the existing A12 crossing, the River Blackwater remains in-bank for the 5% (1 in 20) AEP event, while it floods out-of-bank for the higher magnitude events modelled. The WCH route downstream of the crossing would be flooded in these events.

2.6.8 For the 1% (1 in 100) AEP event plus 38% allowance for climate change, there are approximately 23 properties within the modelled flood extent within 1km of the proposed scheme Order Limits. The nearest flooded property is approximately 620m upstream from the existing A12 River Blackwater crossing. Most of the flooded properties within the model domain are approximately 2.2km to 2.4km upstream of the existing A12 River Blackwater crossing.

Plate 2.14 River Blackwater modelled baseline fluvial flood extents

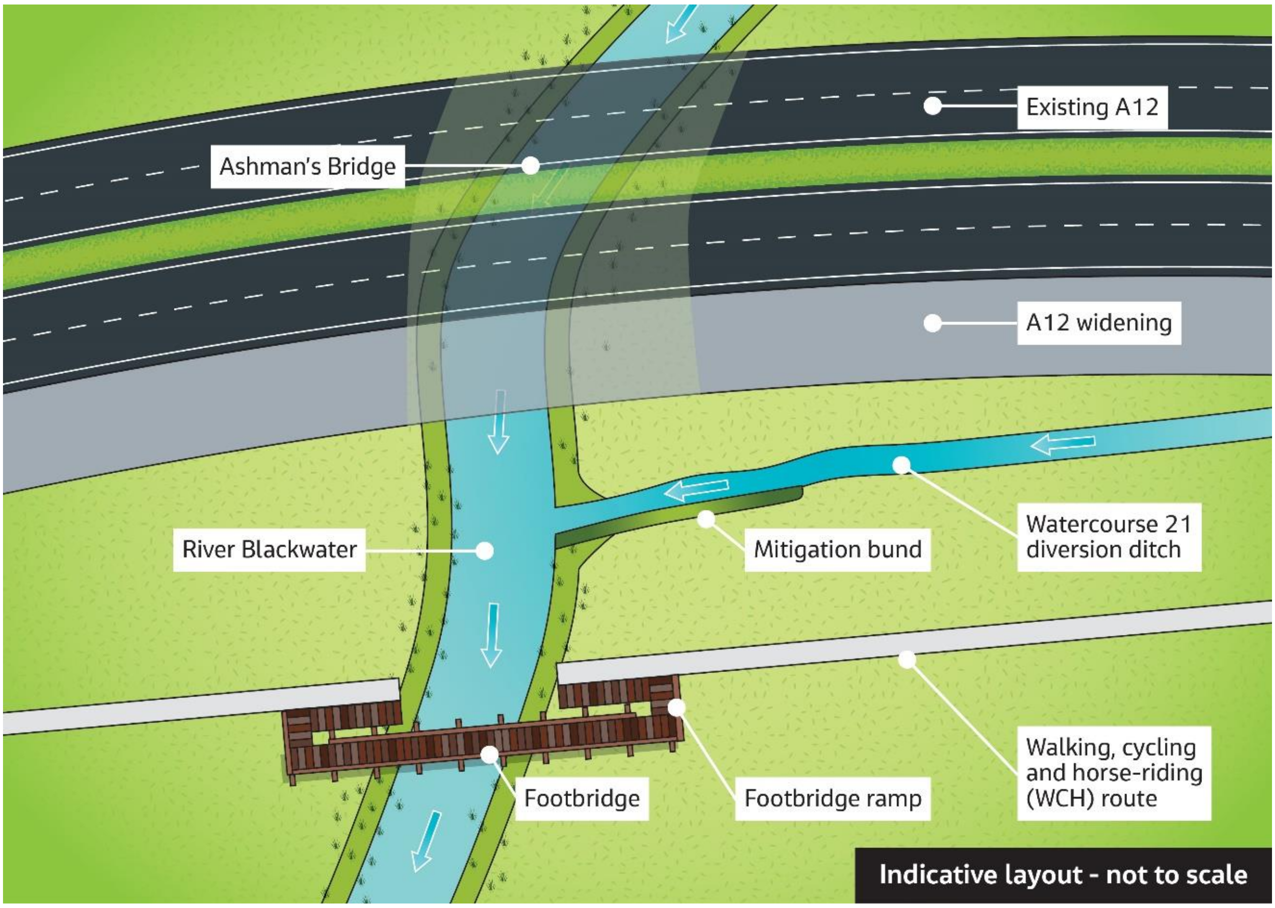


Proposed scheme design

2.6.9 At the existing A12 River Blackwater crossing, the modelled proposed scheme comprises three separate proposed scheme elements (shown in Plate 2.15):

- Widened existing A12 (including Ashman's Bridge): It is proposed to widen the existing bridge (Ashman's Bridge) and highway embankment 10.1m to the south in order to upgrade the mainline highway to three lanes per carriageway.
- Relocated WCH route (including footbridge): The relocation of a WCH route and associated footbridge 75m to the south is required as the proposed scheme A12 widening works clash with an existing WCH route. The proposed relocated WCH route would be 3m wide and the footbridge over the River Blackwater would include accessibility ramps at either side with a 1:20 gradient. The proposed footbridge soffit level (19.94mAOD) was dictated by the modelled maximum water level at this location. The finished top of footbridge deck level would be 20.78mAOD.
- Watercourse 21 diversion ditch: The flood mitigation proposed for Ordinary Watercourse 21 includes a pipe/ditch combination designed to convey flows from Ordinary Watercourse 21 to the River Blackwater along the southern side of the A12 (refer to Section 3.2: Ordinary Watercourse 21 for more information regarding these mitigation works).

Plate 2.15 Modelled proposed scheme elements (indicative)



Flood risk to the proposed scheme

2.6.10 With-scheme modelling has been used to assess the flood risk from the River Blackwater to the proposed scheme. Table 2.7 details the anticipated finished proposed scheme road level and peak modelled water level during the 1% (1 in 100) AEP event plus 38% allowance for climate change.

2.6.11 Table 2.7 demonstrates that the finished road levels of the proposed scheme and realigned public footbridge would be safe from fluvial flooding at this location, with freeboard to the finished road level in excess of 4m and freeboard to finished footbridge level in excess of 1m.

Table 2.7 Proposed scheme road levels and peak modelled with-scheme water level during 1% (1 in 100) AEP event plus 38% allowance for climate change

Proposed scheme element	Peak modelled with-scheme 1% (1 in 100) AEP event plus 38% allowance for climate change (mAOD)	Lowest proposed finished road/surface level (mAOD)	Freeboard between peak modelled water level and finished road/surface level (m)
Mainline A12	19.34	23.82	4.48
Realigned footbridge		20.78	1.44

2.6.12 As can be seen in Plate 2.16, around the area of the existing A12 crossing of the River Blackwater, the river floodplain extends across a wide area of land directly adjacent to the watercourse on both sides. The position and levels of the existing WCH route in this area mean that the WCH route is susceptible to flooding in the existing situation. The proposed scheme requires the relocation of this existing WCH route.

2.6.13 It was considered impracticable to place the relocated WCH route outside of the floodplain area, due to the requirement for the WCH route to cross the River Blackwater and the impracticalities of further widening the existing A12 bridge to allow space for a diverted WCH route. It was also considered impracticable to raise the WCH route such that it would not be at risk of flooding as this would act as a barrier across the floodplain and cause considerable altered flood risk elsewhere.

2.6.14 Therefore, the relocated WCH route either side of the footbridge would be at risk of flooding, and the footbridge itself could become an isolated dry island during flood events. A public safety risk assessment would be undertaken for the WCH route and public footbridge, and suitable mitigation measures (such as signage) would be provided to advise potential users of the risk, which also exists with the existing bridge.

2.6.15 East of Witham (around NGR TL 82955 14415), a Private Means of Access route is proposed to be located within the River Blackwater floodplain to the east of Witham, tracking along the eastern edge of the A12 carriageway (see Annex B). Therefore, the Private Means of Access route would be at risk of flooding. Modelling suggests that areas of this Private Means of Access route could experience flood depths of up to 650mm during a 1% (1 in 100) AEP event plus 38% allowance for climate change. This route would be provided to enable access for multiple external organisations and could also be open to the general public. Therefore a public safety risk assessment would be undertaken for the route, and suitable mitigation measures (such as signage) would be provided if required to advise potential users of the risk.

Flood risk from the proposed scheme

Unmitigated impact of proposed scheme on flood risk

2.6.16 With-scheme modelling has been used to assess how the proposed scheme could impact flood risk in this location. The modelled change in flood extent caused by the proposed scheme for the 1% (1 in 100) AEP event plus 38% allowance for climate change is shown in Plate 2.16. Modelled changes in flood level caused by the proposed scheme are shown in Plate 2.17 (5% (1 in 20) AEP flood event) and Plate 2.18 (1% (1 in 100) AEP event plus 38% allowance for climate change).

2.6.17 The mainline section of the proposed scheme displaces out-of-channel flood flows in all modelled events (see Table 2.8 for precise volumes displaced).

Table 2.8 Out-of-channel flood flows displaced by proposed mainline A12 and footbridge ramps

Flood event	Out-of-channel flood flows displaced (m^3)	
	A12 widening	WCH route bridge ramps
5% (1 in 20) AEP event	135.73	27.67
1% (1 in 100) AEP event	224.58	45.30
1% (1 in 100) AEP event plus 38% allowance for climate change	331.13	53.57

2.6.18 The proposed footbridge ramps within the floodplain result in a minor increase in flood levels immediately upstream of the bridge (maximum increase of 130mm during the 1% (1 in 100) AEP event plus 38% allowance for climate change). The Ordinary Watercourse 21 flood mitigation ditch works also cause an increase in maximum flood levels within the excavated ditch where this is filled up by flood water.

2.6.19 Other than these areas, the proposed scheme impact on flood risk elsewhere is beneficial or negligible (below 10mm change in flood level) for all modelled events.

Flood mitigation

2.6.20 There is significant freeboard (greater than 1m) between peak flood levels and the finished road levels of the proposed scheme and public footbridge levels.

2.6.21 The proposed scheme results in increased flood levels around the Ordinary Watercourse 21 flood mitigation ditch located within the Blackwater floodplain, and increased flood levels immediately upstream of the proposed footbridge ramps. However, these areas would be retained by National Highways and would not contain any receptors sensitive to flood water. Otherwise, the proposed scheme causes beneficial or negligible change to flood risk elsewhere.

2.6.22 No flood mitigation has therefore been proposed at this location.

Plate 2.16 River Blackwater crossing – modelled change in flood extent as a result of the proposed scheme (1% (1 in 100) AEP event plus 38% allowance for climate change)

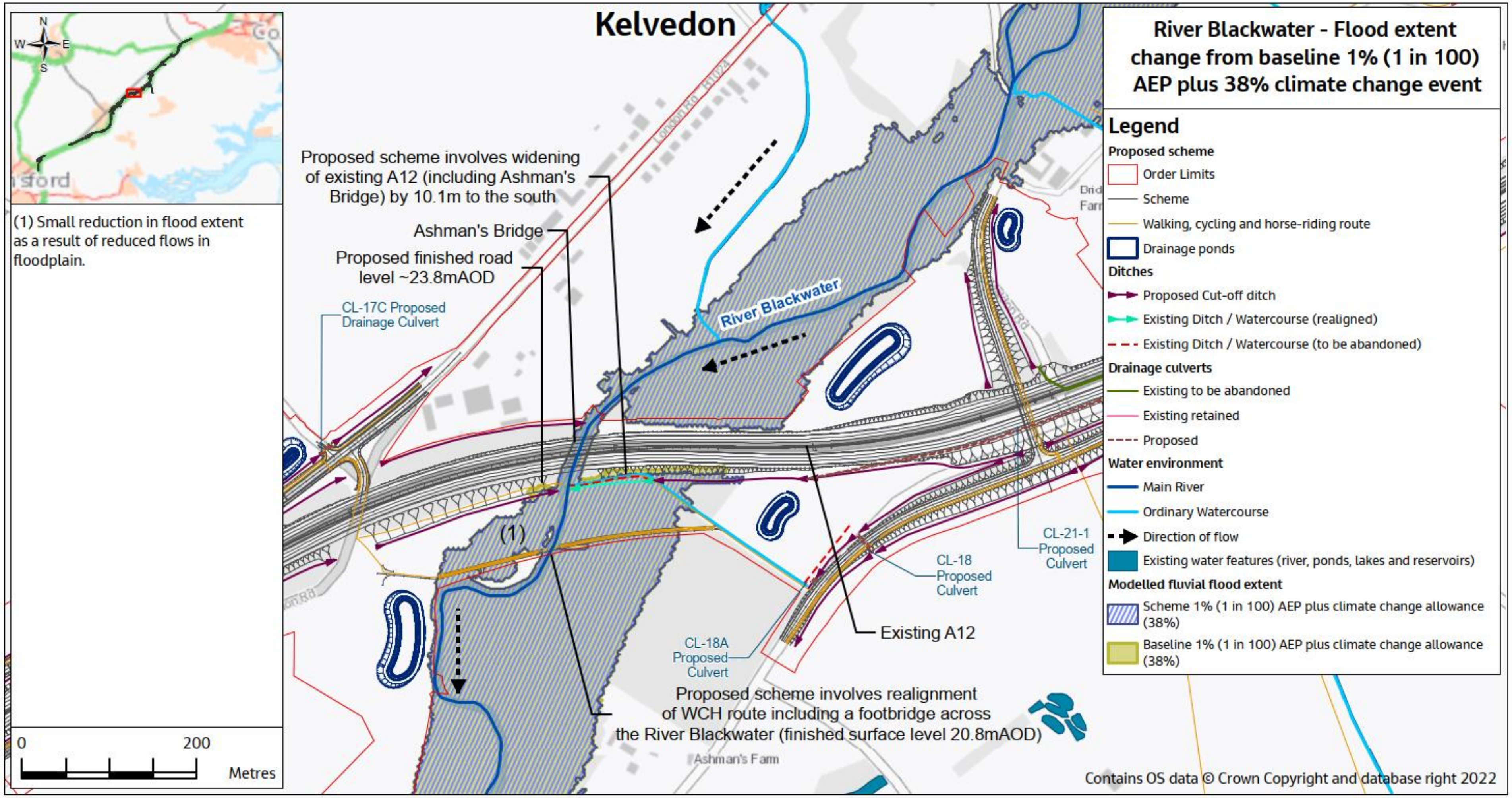


Plate 2.17 River Blackwater crossing – modelled change in flood levels as a result of the proposed scheme (5% (1 in 20) AEP event)

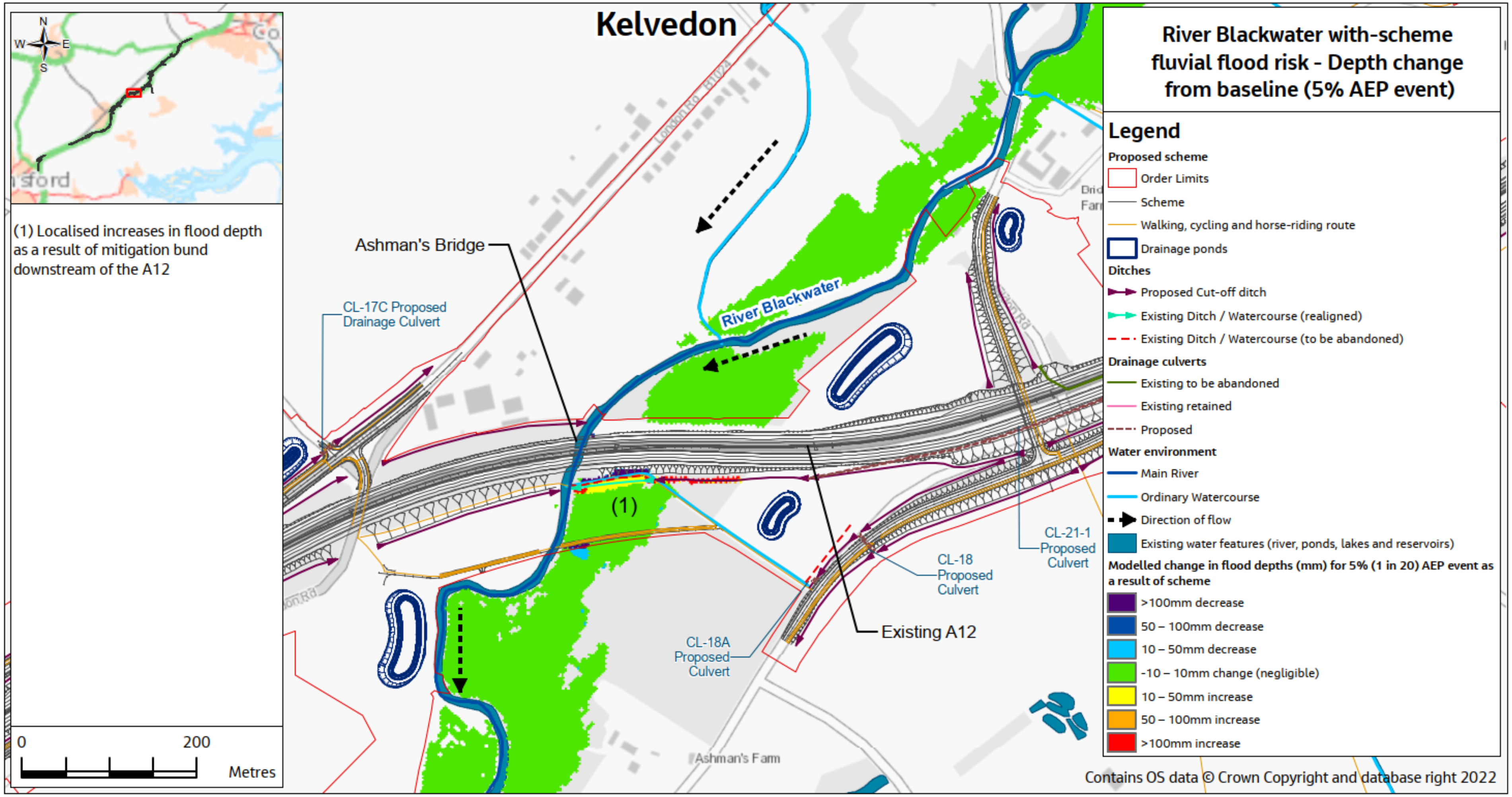
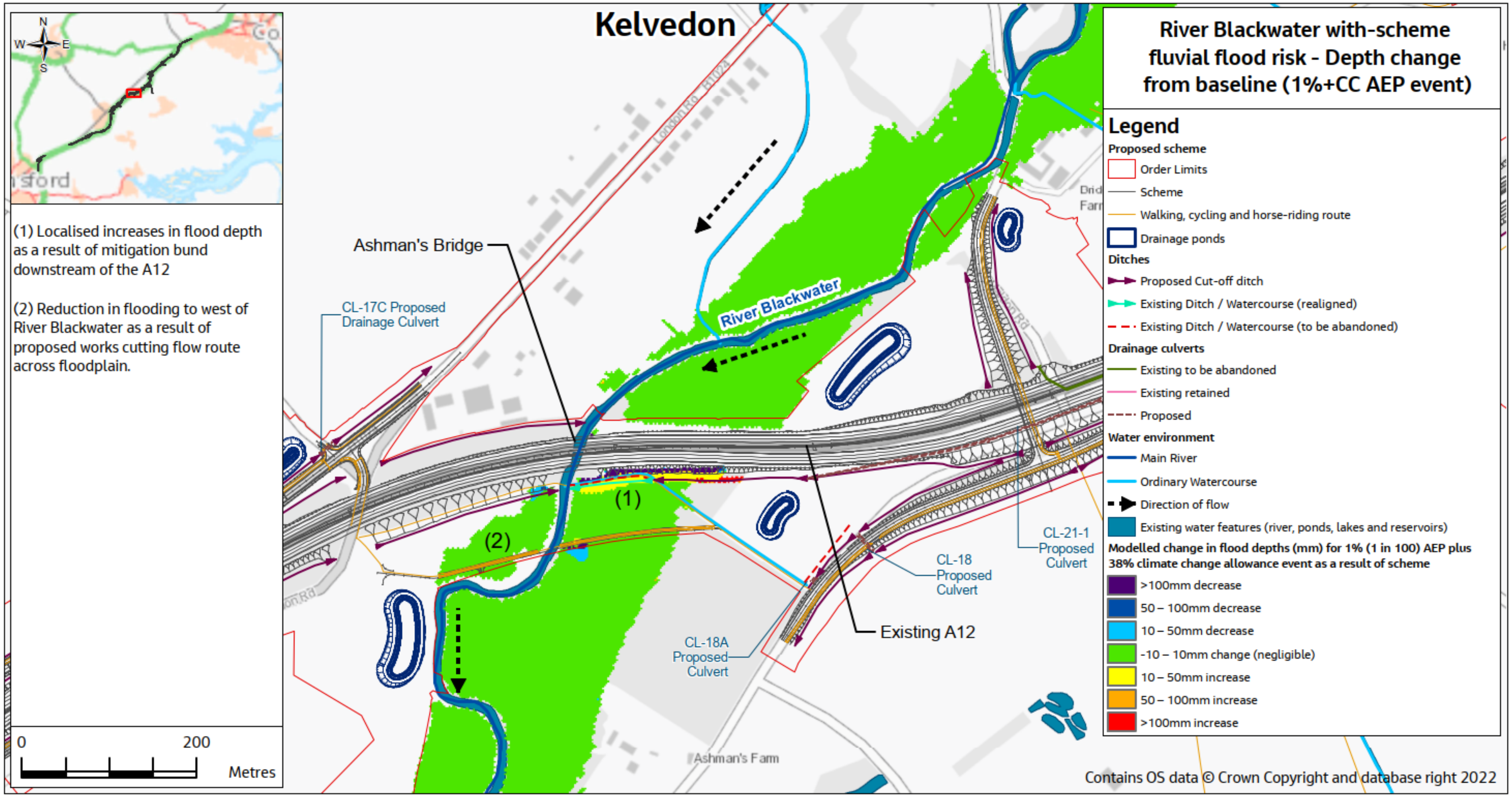


Plate 2.18 River Blackwater crossing – modelled change in flood levels as a result of the proposed scheme (1% (1 in 100) AEP event plus 38% allowance for climate change)



2.7 Domsey Brook A12 crossing (western)

Baseline flood risk

Watercourse description

2.7.1 A description of the Domsey Brook is included in Annex M. Domsey Brook originates north of the existing A12 around Marks Tey and is crossed by the existing A12 twice. The upstream crossing is to the south-west of Marks Tey via two circular culverts (both 1m diameter x 45m long). Approximately 6.2km downstream of the upstream crossing, the A12 crosses Domsey Book for a second time, via a 38.1m long crossing structure (plus 12.8m headwall at each end) with a cross-section of 7m x 5.5m. Approximately 1.7km downstream of this second A12 crossing, the watercourse joins with the River Blackwater. This section focuses on the downstream (western) A12 crossing of the Domsey Brook (NGR TL 87681 19076).

2.7.2 Immediately up- and downstream of the western A12 crossing of the watercourse, Domsey Brook flows primarily through agricultural or other greenfield land.

Baseline modelled flooding

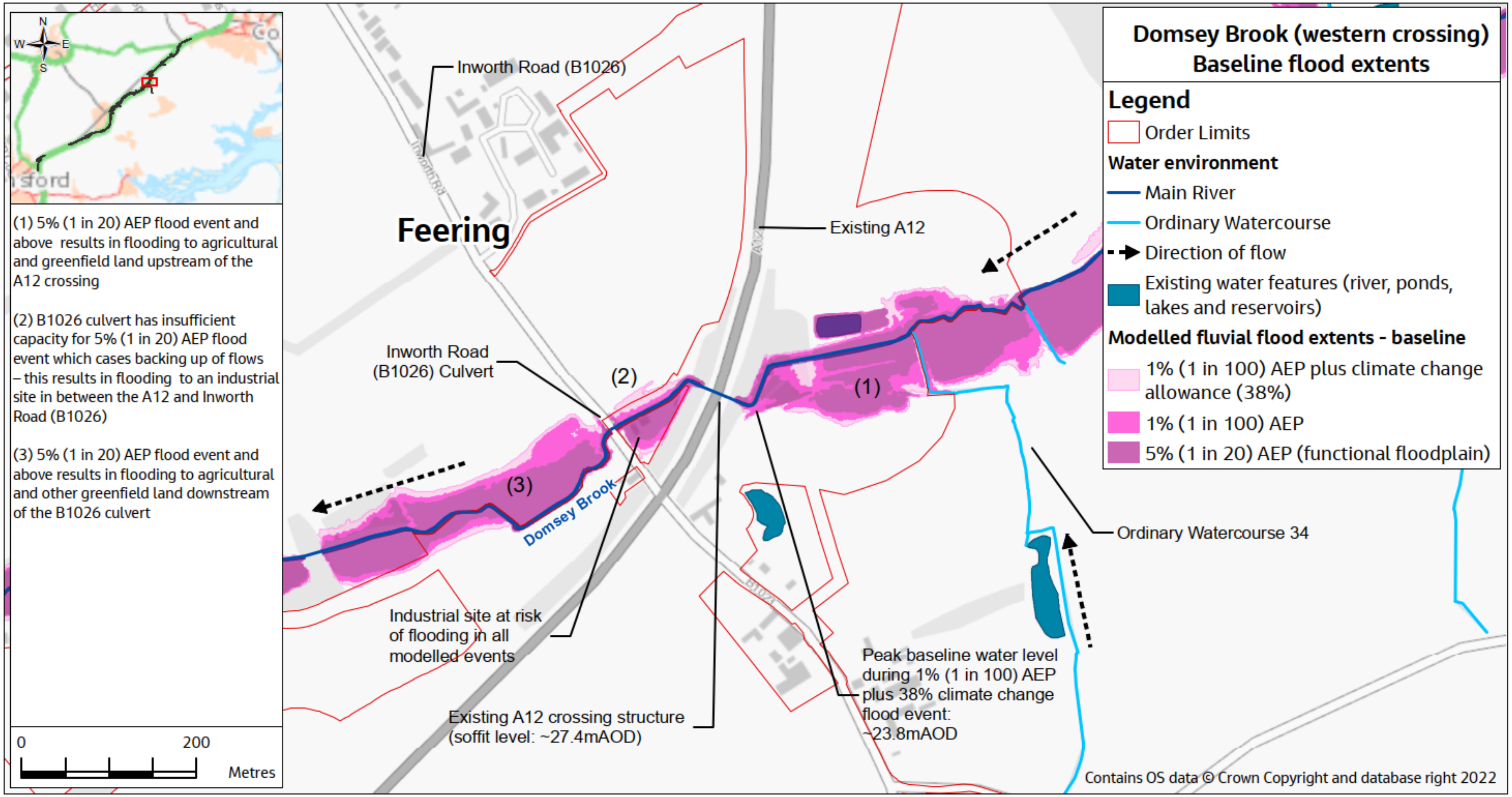
2.7.3 Modelled baseline flood extents (5% (1 in 20) AEP event, 1% (1 in 100) AEP event, 1% AEP event plus allowance for climate change) are included in Plate 2.19 For this watercourse, a 38% climate change allowance has been applied to the 1% (1 in 100) AEP flood event (see Section 1.6 for further information on how climate change has been considered).

2.7.4 The existing A12 is not at risk of flooding in this location, with freeboard of greater than 3.5m from peak water level (23.76mAOD) to the soffit of the crossing structure (27.38mAOD) during the most extreme event modelled (1% (1 in 100) AEP event plus 38% allowance for climate change).

2.7.5 Modelling indicates that the Domsey Brook exhibits flooding for all modelled AEP events in this area. Modelled head loss across the structure from the upstream to the downstream side is greater than 200mm in the 1% (1 in 100) AEP event plus 38% allowance for climate change, suggesting the crossing does constrict flows.

2.7.6 For the 1% (1 in 100) AEP event plus 38% allowance for climate change, one small industrial site on the B1023, just downstream of the A12 crossing, is inundated for all flood events modelled. No residential properties are located within the modelled flood extent within the study area. Other areas at risk of flooding appear to be agricultural or other greenfield land.

Plate 2.19 Domsey Brook (western) crossing modelled baseline fluvial flood extents



Proposed scheme design

2.7.7 At the existing A12 western crossing of the Domsey Brook, the proposed scheme would involve widening and realigning the existing crossing. This would require lengthening the existing arch structure which the Domsey Brook flows through under the existing A12 (approximate dimensions 7m x 5.5m x 38.1m) by approximately 36.4m. A short section of the watercourse immediately upstream of the crossing would be displaced by the proposed scheme and would therefore be realigned.

Flood risk to the proposed scheme

2.7.8 With-scheme modelling has been used to assess the flood risk from the Domsey Brook to the proposed scheme. Table 2.9 details the anticipated finished proposed scheme road level and peak modelled water level during the 1% (1 in 100) AEP event plus 38% allowance for climate change.

2.7.9 Table 2.9 demonstrates that the finished road levels of the proposed scheme would be safe from fluvial flooding at this location, with freeboard to the finished road level in excess of 5m.

Table 2.9 Proposed scheme road levels and peak modelled with-scheme water level during 1% (1 in 100) AEP event plus 38% allowance for climate change

Peak modelled with-scheme 1% (1 in 100) AEP event plus 38% allowance for climate change water level (mAOD)	Lowest proposed finished road/surface level (mAOD)	Freeboard between peak modelled water level and finished road/surface level (m)
23.80	29.19	5.39

Flood risk from the proposed scheme

Unmitigated impact of proposed scheme on flood risk

2.7.10 With-scheme modelling has been used to assess how the proposed scheme could impact flood risk in this location. The modelled change in flood extent caused by the proposed scheme for the 1% (1 in 100) AEP event plus 38% allowance for climate change is shown in Plate 2.20. Modelled changes in flood level caused by the proposed scheme are shown in Plate 2.21 (5% (1 in 20) AEP flood event) and Plate 2.22 (1% (1 in 100) AEP event plus 38% allowance for climate change).

2.7.11 The proposed scheme causes negligible changes to the in-channel maximum flows at the western A12 Domsey Brook crossing (see Table 2.10). Modelling shows that for all modelled flood events the proposed scheme results in a decrease in flood levels upstream of the A12 crossing (due to the channel realignment having improved the hydraulic performance of the channel) and has a negligible impact (below 10mm change in flood levels) on flood risk elsewhere.

Table 2.10 Domsey Brook in-channel peak flows during baseline and with-scheme scenarios during the 1% (1 in 100) AEP event plus 38% allowance for climate change

Location	Baseline peak flow (m^3/s)	With-scheme peak flow (m^3/s)	Difference between baseline and with-scheme peak flow (m^3/s)
62m upstream of western A12 crossing	13.27	13.28	0.01
Immediately upstream of western A12 crossing	13.27	13.27	0.00
Immediately downstream of western A12 crossing	13.27	13.27	0.00
540m downstream of western A12 crossing	13.47	13.49	0.02

Flood mitigation

2.7.12 For all modelled flood events, the proposed scheme results in negligible or beneficial impacts on flood risk. During the most extreme event modelled for this crossing (1% (1 in 100) AEP event plus 38% allowance for climate change), there is significant freeboard (greater than 5m) between peak flood levels and finished proposed scheme road levels. No flood mitigation is therefore proposed at this location.

Plate 2.20 Domsey Brook (western) crossing – modelled change in flood extent as a result of the proposed scheme (1% (1 in 100) AEP event plus 38% allowance for climate change)

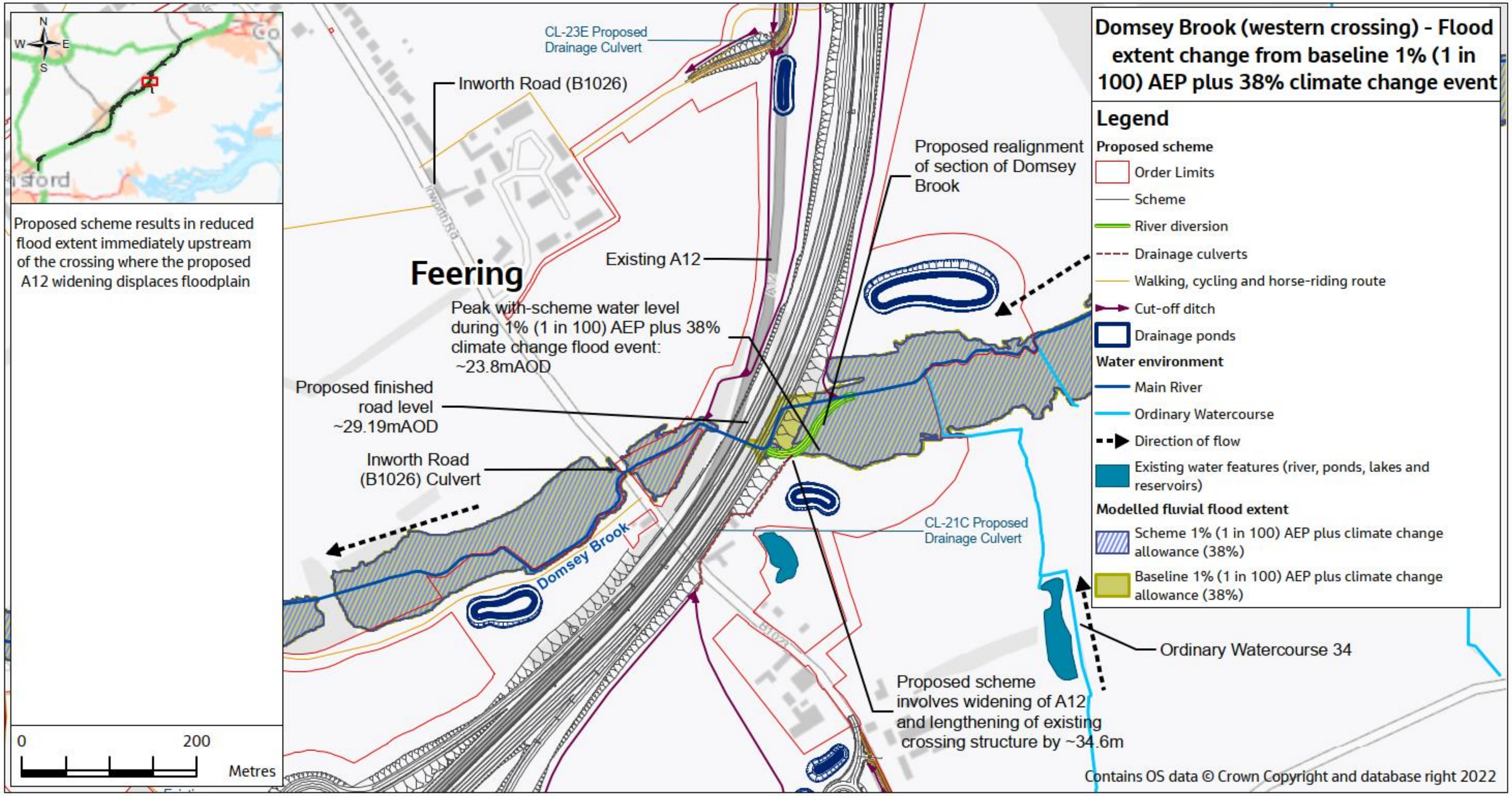


Plate 2.21 Domsey Brook (western) crossing – modelled change in flood levels as a result of the proposed scheme (5% (1 in 20) AEP event)

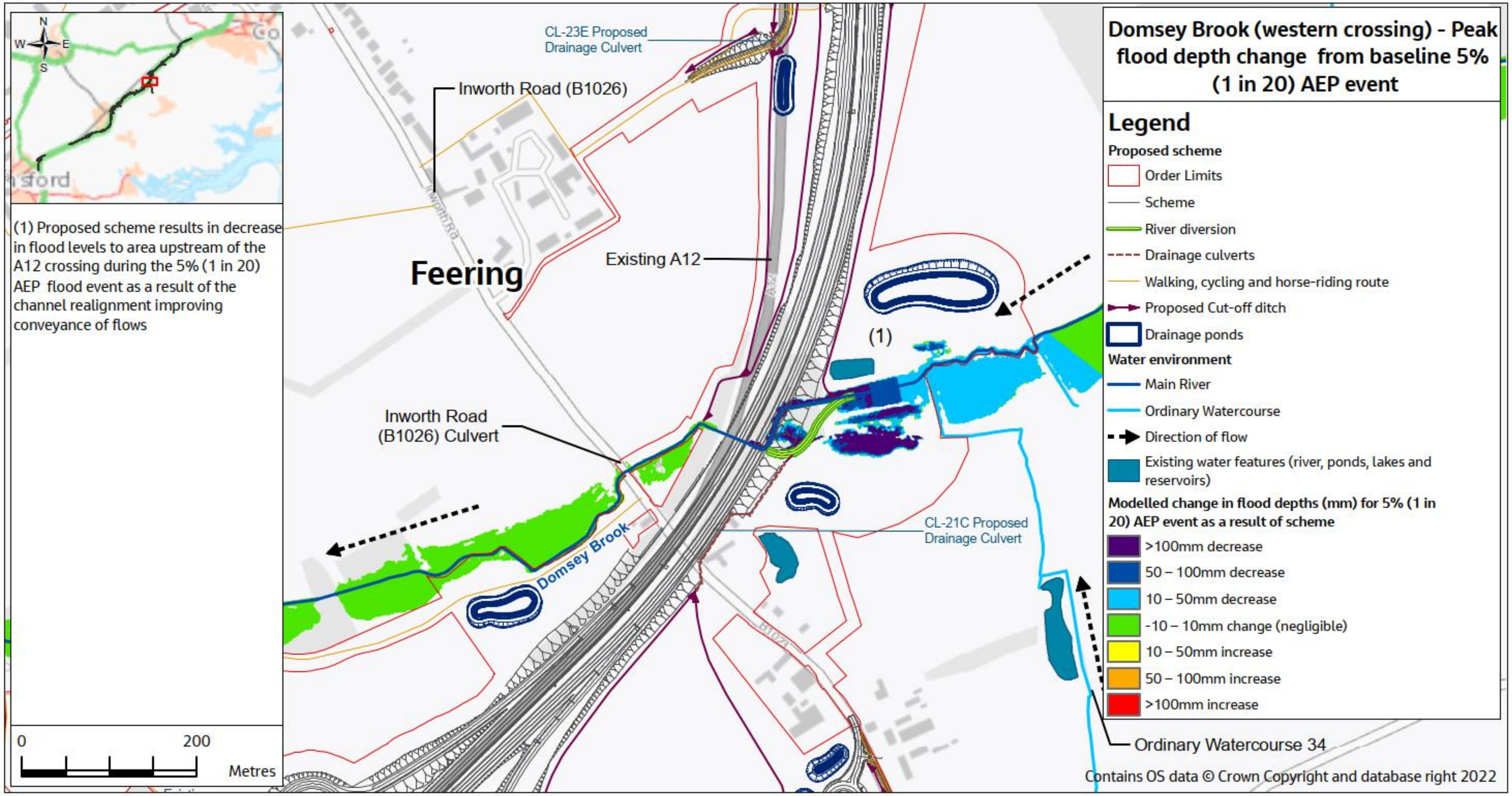
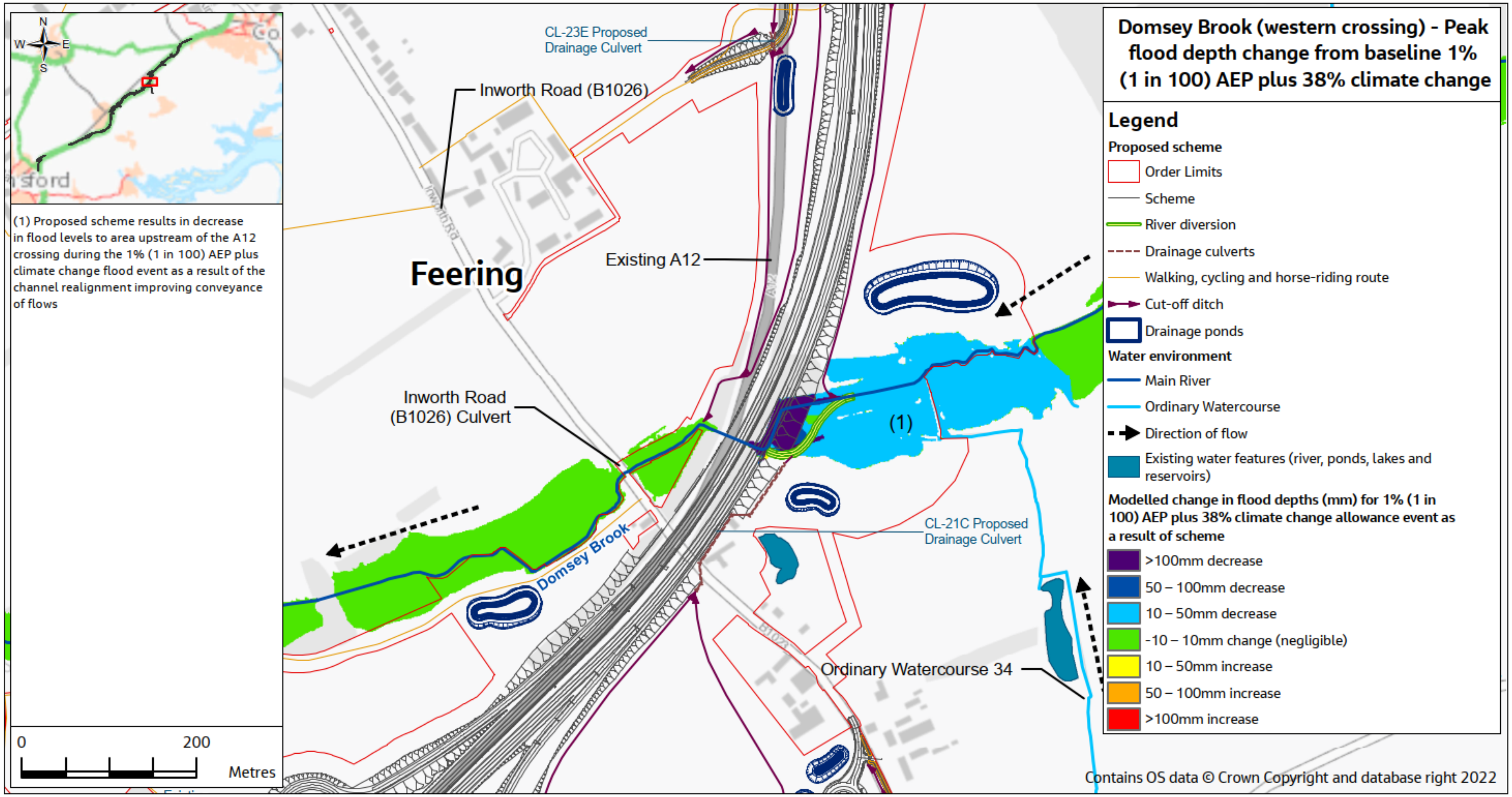


Plate 2.22 Domsey Brook (western) crossing – modelled change in flood levels as a result of the proposed scheme (1% (1 in 100) AEP event plus 38% allowance for climate change)



2.8 Domsey Brook A12 crossing (eastern)

Baseline flood risk

Watercourse description

2.8.1 A description of the Domsey Brook is included in Annex M. Domsey Brook originates north of the existing A12 around Marks Tey and is crossed by the existing A12 twice. The upstream crossing is to the south-west of Marks Tey via two circular culverts (both 1m diameter x 45m long). Approximately 6.2km downstream of the upstream crossing, the A12 crosses Domsey Book for a second time, via a 38.1m long crossing structure (plus 12.8m headwall at each end) with a cross-section of 7m x 5.5m. Approximately 1.7km downstream of this second A12 crossing, the watercourse joins with the River Blackwater. This section focuses on the upstream (eastern) A12 crossing of the Domsey Brook (NGR TL 87681 19076).

2.8.2 Immediately up- and downstream of the eastern A12 crossing of the watercourse, Domsey Brook flows primarily through agricultural or other greenfield land.

Baseline modelled flooding

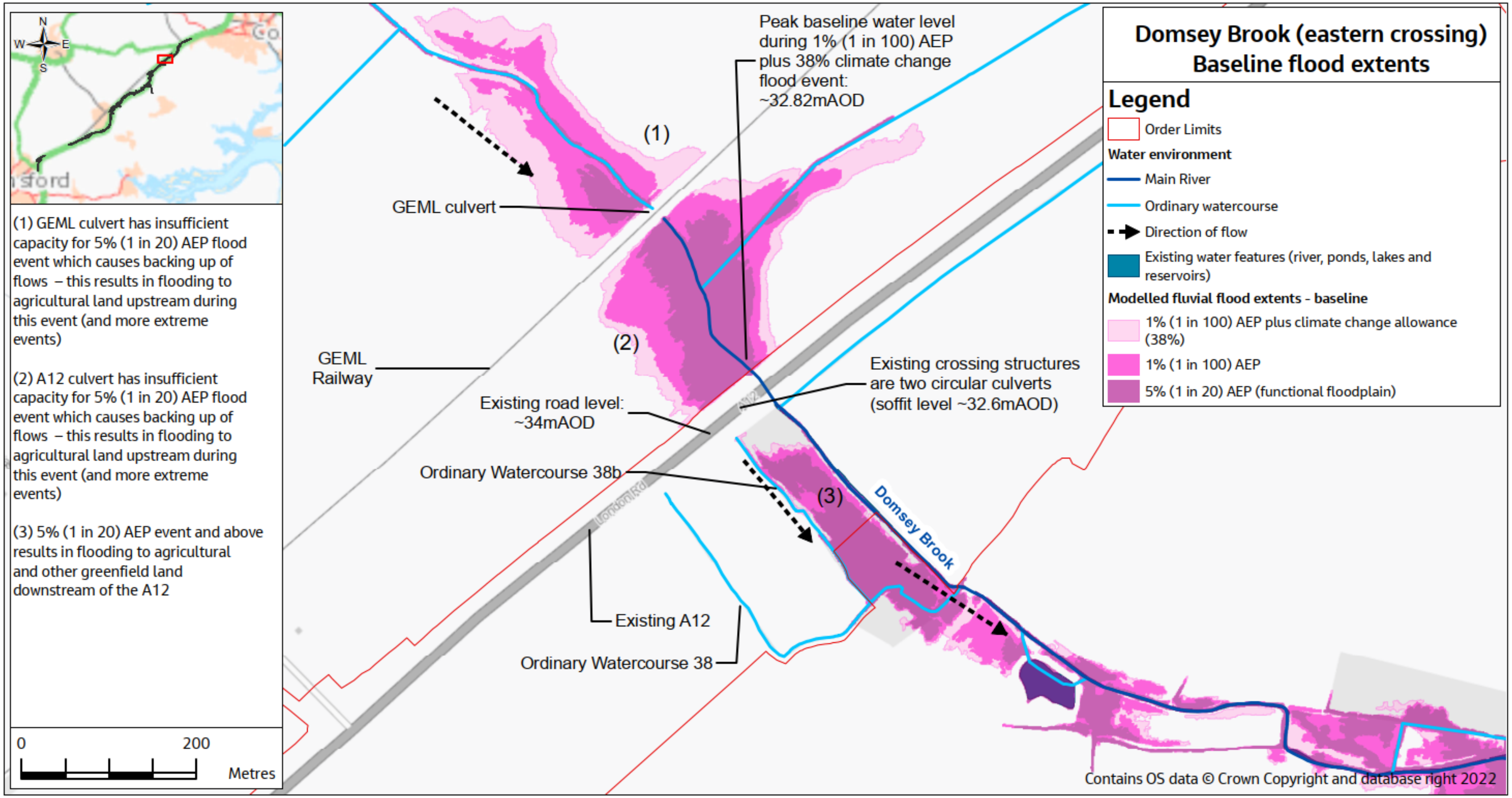
2.8.3 Modelled baseline flood extents (5% (1 in 20) AEP event, 1% (1 in 100) AEP event and 1% AEP event plus allowance for climate change) are included in Plate 2.23. For this watercourse, a 38% climate change allowance has been applied to the 1% (1 in 100) AEP flood event (see Section 1.6 for further information on how climate change has been considered).

2.8.4 During the most extreme event modelled (1% (1 in 100) AEP event plus 38% allowance for climate change), the peak water level (32.82mAOD) is higher than the soffit level of the crossing structures (32.57mAOD). Despite this, the existing A12 is not at risk of flooding, with freeboard of greater than 1m between peak water level and road surface level (34mAOD).

2.8.5 Modelling indicates that significant flooding occurs to agricultural land upstream of the existing A12 where flows are constricted by the existing A12 crossing for all events modelled, as indicated by the more expansive floodplain on the upstream side of the A12 in Plate 2.23. Between the existing A12 crossing and Easthorpe Road (approximately 1.5km downstream), some flooding to agricultural land and greenfield areas occurs for the 5% (1 in 20) AEP event and 1% (1 in 100) AEP events, while it floods more significantly for the 1% (1 in 100) AEP event plus 38% allowance for climate change.

2.8.6 Modelling indicates that there is flooding to agricultural land upstream of the A12 crossing (in between the A12 and the GEML railway), and to agricultural land and to Easthorpe Road downstream of the A12 crossing. No properties are located within the modelled flood extent within the study area.

Plate 2.23 Domsey Brook (eastern) crossing modelled baseline fluvial flood extents



Proposed scheme design

2.8.7 The proposed scheme would require a slight realignment of the Domsey Brook (approximately 5m to the north-east) and installation of a new offline crossing via a 60m long culvert with a cross-section of 2.7m x 2.7m.

Flood risk to the proposed scheme

2.8.8 With-scheme modelling has been used to assess the flood risk from the Domsey Brook to the proposed scheme. Table 2.11 details the anticipated finished proposed scheme road level and peak modelled water level during the 1% (1 in 100) AEP event plus 38% allowance for climate change.

2.8.9 Table 2.11 demonstrates that the finished road levels of the proposed scheme would be safe from fluvial flooding at this location, with freeboard to the finished road level in excess of 5m for the 1% (1 in 100) AEP event plus 38% allowance for climate change.

Table 2.11 Proposed scheme road levels and peak modelled with-scheme water level during 1% (1 in 100) AEP event plus 38% allowance for climate change

Peak modelled with-scheme 1% (1 in 100) AEP event plus 38% allowance for climate change water level (mAOD)	Lowest proposed finished road/surface level (mAOD)	Freeboard between peak modelled water level and finished road/surface level (m)
32.89	38.27	5.38

Flood risk from the proposed scheme

Unmitigated impact of proposed scheme on flood risk

2.8.10 With-scheme modelling has been used to assess how the proposed scheme could impact flood risk in this location. The modelled change in flood extent caused by the proposed scheme for the 1% (1 in 100) AEP event plus 38% allowance for climate change is shown in Plate 2.24. Modelled changes in flood level caused by the proposed scheme are shown in Plate 2.25 (5% (1 in 20) AEP event) and Plate 2.26 (1% (1 in 100) AEP event plus 38% allowance for climate change).

2.8.11 The proposed scheme causes in-channel maximum water levels immediately upstream of the new eastern crossing to increase (maximum increase of 70mm during the 1% (1 in 100) AEP event plus 38% allowance for climate change). This increase is restricted to the 33m length of channel in between the existing A12 and the new A12 crossing. Water levels remain in-bank for this section of channel.

2.8.12 The proposed scheme would cause a decrease in flood levels where it would displace existing floodplain (see Table 2.12 for details), and to the north-west of the proposed scheme as the proposed highway separates this area from the floodplain to the south-east. Other than these changes, the proposed scheme causes negligible change (less than 10mm) to out-of-bank flood levels for all modelled flood events.

Table 2.12 Out-of-channel flood volumes displaced by the proposed scheme

Modelled flood event	Volume of out-of-channel flooding displaced by proposed scheme
5% (1 in 20) AEP	$122m^3$
1% (1 in 100) AEP	$385m^3$
1% (1 in 100) AEP plus 38% allowance for climate change	$602m^3$

Flood mitigation

2.8.13 During all modelled flood events, the proposed scheme causes a decrease in flood levels where the proposed scheme displaces or severs connectivity of floodplain and causes a negligible change to flood risk elsewhere. Any increases in water level as a result of this displacement are contained within the river channel. There is significant freeboard (greater than 5m) between peak flood levels and finished proposed scheme road levels. No flood mitigation is therefore proposed at this location.

Plate 2.24 Domsey Brook (eastern) crossing – modelled change in flood extent as a result of the proposed scheme (1% (1 in 100) AEP event plus 38% allowance for climate change)

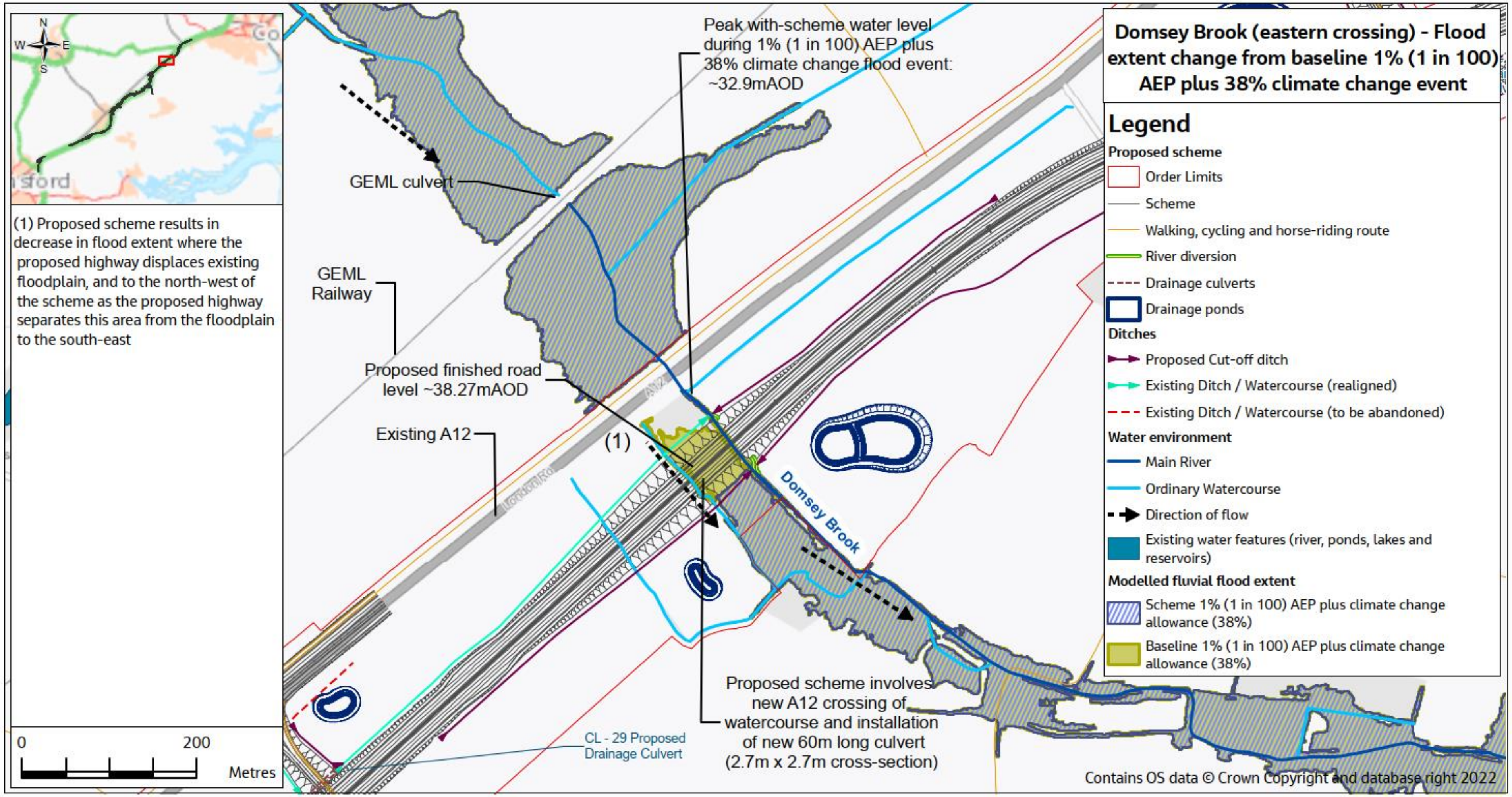


Plate 2.25 Domsey Brook (eastern) crossing – modelled change in flood levels as a result of the proposed scheme (5% (1 in 20) AEP event)

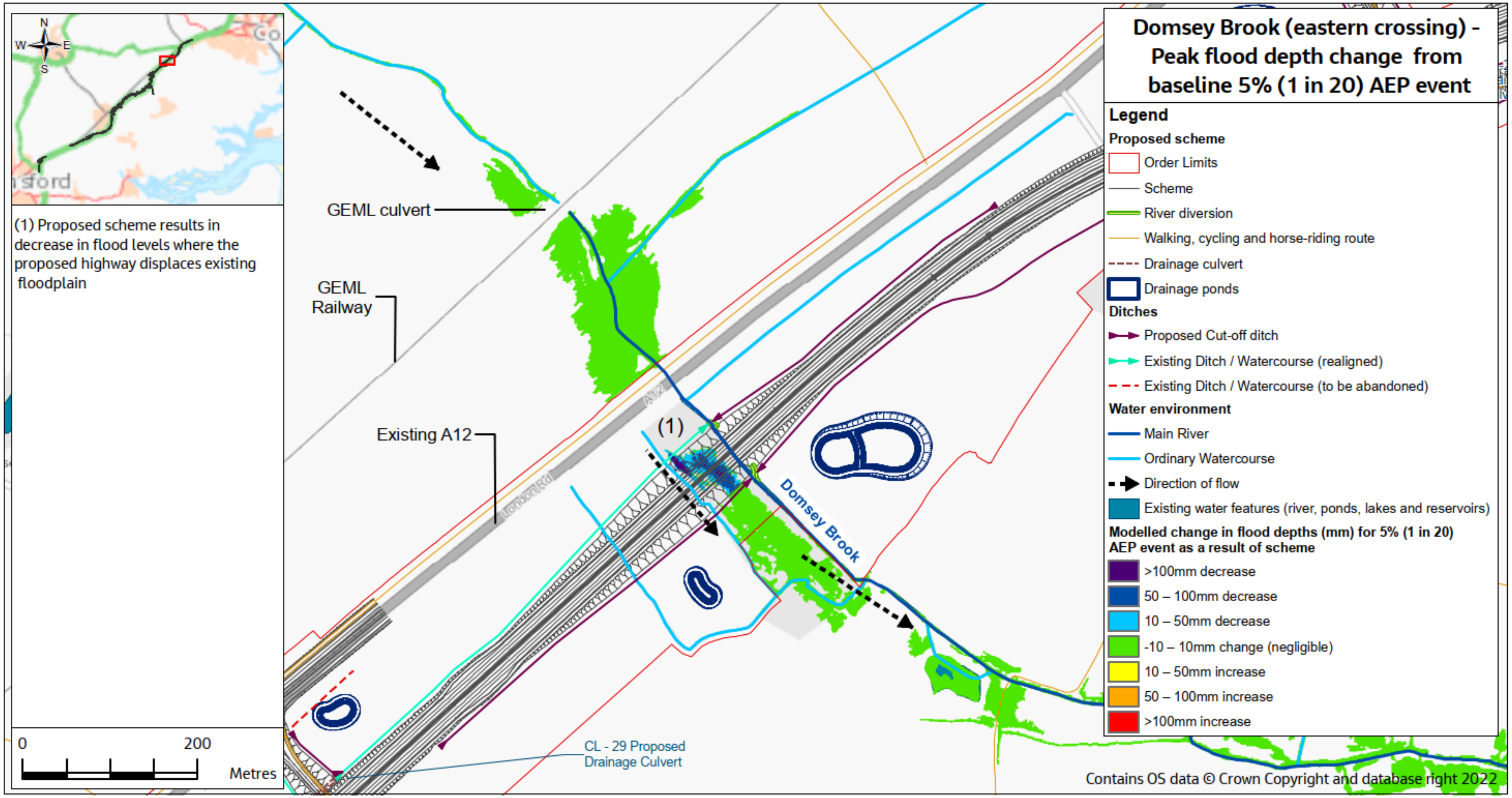
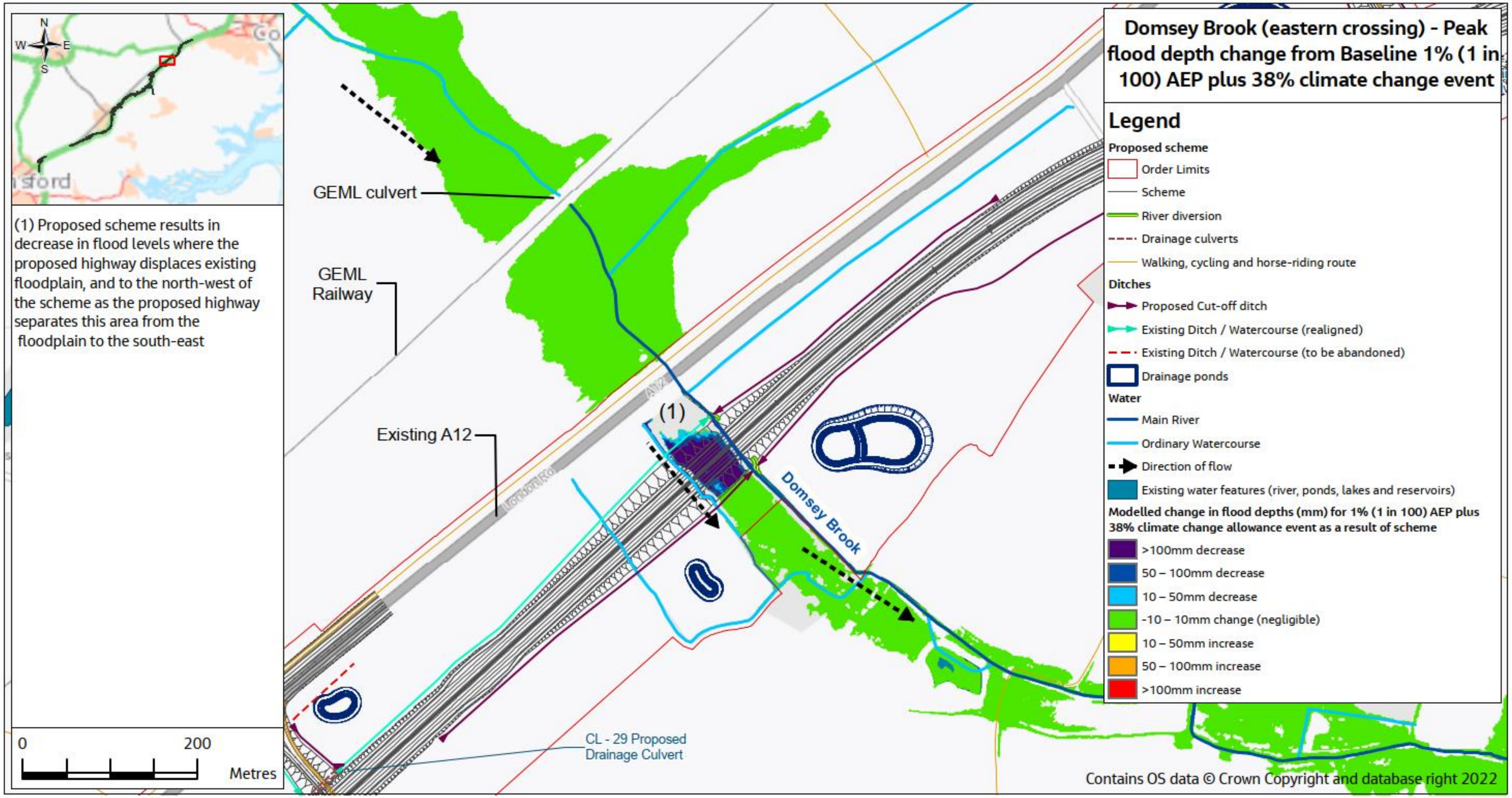


Plate 2.26 Domsey Brook (eastern) crossing – modelled change in flood levels as a result of the proposed scheme (1% (1 in 100) AEP event plus 38% allowance for climate change)



2.9 Roman River A12 crossing

Baseline flood risk

Watercourse description

2.9.1 A description of the Roman River is included in Annex M. Roman River originates north of the A12, in Willow Wood. From there, the watercourse passes through woodland and agricultural land before being crossed by the GEML railway via a bridge and running beneath the A12 via a 40m long culvert with a cross-section of 4.8m x 2.1m in a southernly direction (NGR TL 92740 24391). Downstream of this, the channel flows north-east alongside the A12 and then south-east through woodland, agricultural land, and an urban area before it joins with the River Colne (approximately 15km downstream of the A12 crossing).

Baseline modelled flooding

2.9.2 Modelled baseline flood extents (5% (1 in 20) AEP event, 1% (1 in 100) AEP event, 1% AEP event plus allowance for climate change) are included in Plate 2.27. For this watercourse, a 65% climate change allowance has been applied to the 1% (1 in 100) AEP flood event (see Section 1.6 for further information on how climate change has been considered).

2.9.3 At this location, the existing A12 is not at risk of fluvial flooding for the most extreme event modelled (1% (1 in 100) AEP event plus 65% allowance for climate change), with freeboard of greater than 1m between peak water level (26.35mAOD) and the soffit of the crossing structure (27.38mAOD).

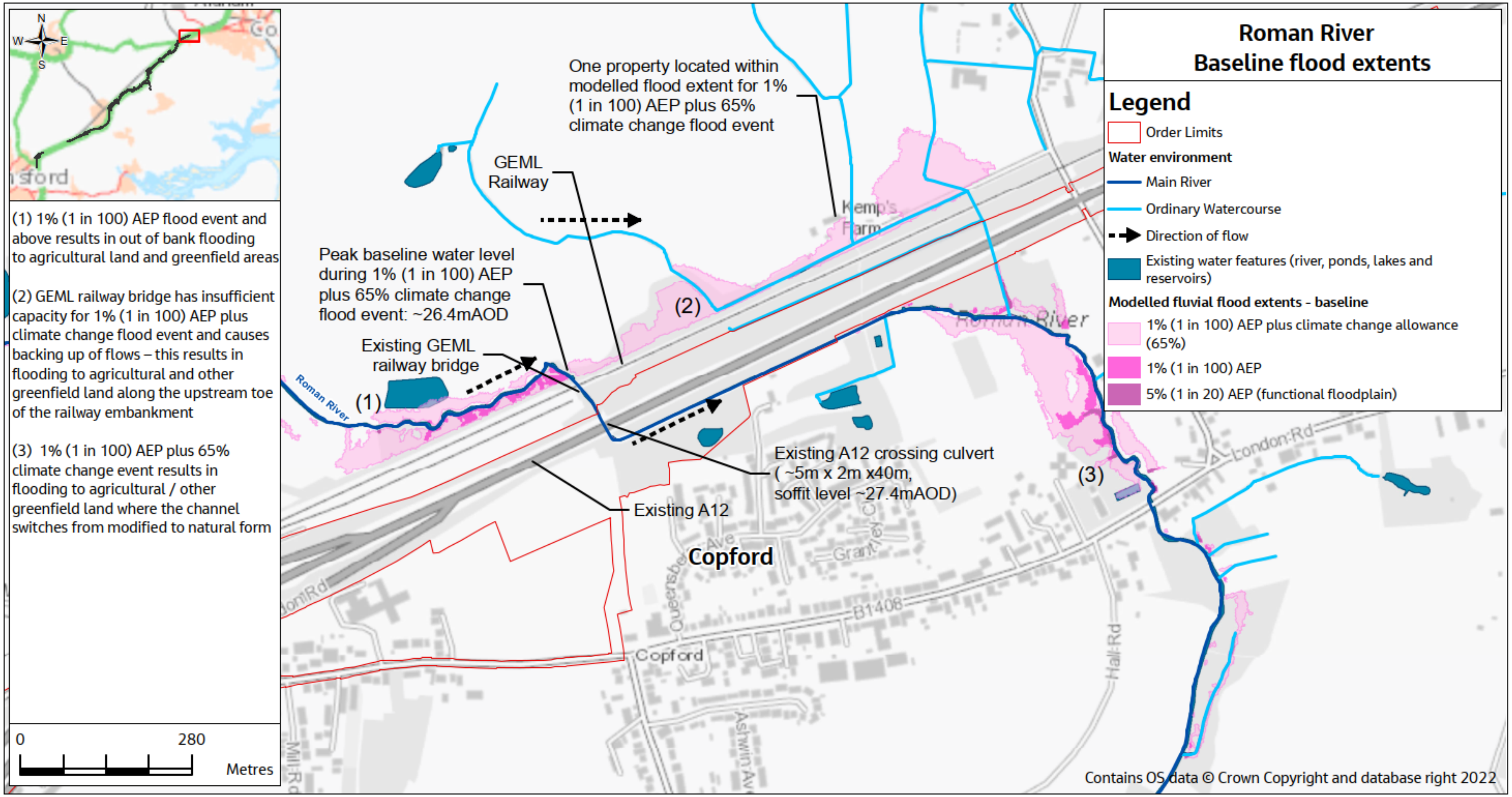
2.9.4 Modelling identified that for the 5% (1 in 20) AEP flood event, no flooding is predicted within the model reach. During the 1% (1 in 100) AEP flood event, minor flooding to agricultural land and greenfield areas is predicted directly upstream of both the existing A12 and London Road.

2.9.5 For the 1% (1 in 100) AEP event plus 65% allowance for climate change, due to the limited capacity of the GEML railway bridge (approximately 60m upstream of the existing A12 crossing), flows back up and flood north-east and south-west along the upstream toe of the railway embankment, as far as the drainage culvert located 700m north-east of the Roman River crossing.

2.9.6 The watercourse immediately downstream from the existing A12 crossing is not modelled to flood as the river channel and the A12 bridge both have sufficient capacity for all modelled events. For the 1% (1 in 100) AEP event plus 65% allowance for climate change, flooding of agricultural land and greenfield areas occurs from approximately 600m upstream of the B1408 (London Road) where the channel switches from modified to natural form.

2.9.7 For the 1% (1 in 100) AEP event plus 65% allowance for climate change, there is flooding to agricultural land upstream of the GEML railway to the north of the existing A12, as well as to agricultural land downstream of the existing A12 crossing. One property is located within the modelled flood extent within the study area approximately 500m north-east of the railway crossing culvert.

Plate 2.27 Roman River modelled baseline fluvial flood extents



Proposed scheme design

2.9.8 At the existing A12 Roman River crossing, the proposed scheme would involve widening the southbound highway embankment by 14m and extending the existing watercourse culvert (retaining existing cross-sectional dimensions of width 4.8m x height 2.1m) by approximately 12m (plus 4.5m headwall).

2.9.9 The widening of the highway and embankment would also necessitate the realignment of a section of the Roman River south-east of the A12. The realigned channel would be designed to match the channel capacity of the existing channel, which has sufficient capacity for all flood events tested.

Flood risk to the proposed scheme

2.9.10 With-scheme modelling has been used to assess the flood risk from the Roman River to the proposed scheme. Table 2.13 details the anticipated finished proposed scheme road level and peak modelled water level during the 1% (1 in 100) AEP event plus 65% allowance for climate change.

2.9.11 Table 2.13 demonstrates that the finished road levels of the proposed scheme would be safe from fluvial flooding at this location, with freeboard to the finished road level in excess of 2m during the 1% (1 in 100) AEP event plus 65% allowance for climate change flood event.

Table 2.13 Proposed scheme road levels and peak modelled with-scheme water level during 1% (1 in 100) AEP event plus 65% allowance for climate change

Peak modelled with-scheme 1% (1 in 100) AEP event plus 65% allowance for climate change water level (mAOD)	Lowest proposed finished road/surface level (mAOD)	Freeboard between peak modelled water level and finished road/surface level (m)
26.35	28.51	2.16

Flood risk from the proposed scheme

Unmitigated impact of proposed scheme on flood risk

2.9.12 With-scheme modelling has been used to assess how the proposed scheme could impact flood risk in this location. The modelled change in flood extent caused by the proposed scheme for the 1% (1 in 100) AEP event plus 65% allowance for climate change is shown in Plate 2.28. Modelled changes in flood level caused by the proposed scheme are shown in Plate 2.29 (5% (1 in 20) AEP event) and Plate 2.30 (1% (1 in 100) AEP event plus 65% allowance for climate change).

2.9.13 Modelling shows that the impacts of the proposed scheme at this location on flood risk elsewhere are negligible across the whole area, resulting in water level changes of less than 10mm for all modelled flood events.

Flood mitigation

2.9.14 During the most extreme event modelled for this crossing (1% (1 in 100) AEP event plus 65% allowance for climate change), the proposed scheme causes negligible changes to flood risk elsewhere, and there is significant freeboard (greater than 2m) between peak flood levels and finished proposed scheme road levels. No flood mitigation is therefore proposed at this location.

Plate 2.28 Roman River crossing – modelled change in flood extent as a result of the proposed scheme (1% (1 in 100) AEP event plus 65% allowance for climate change)

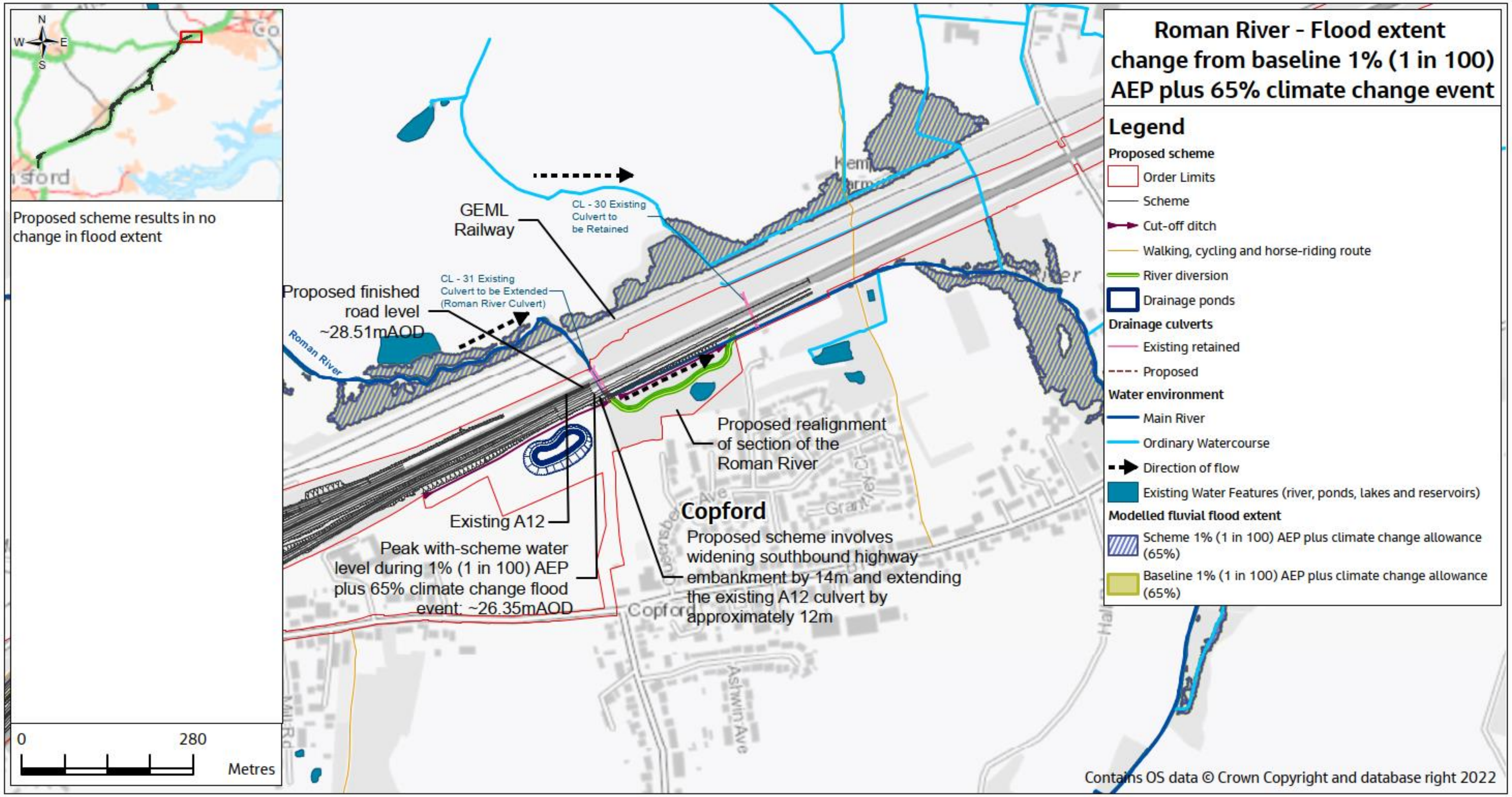


Plate 2.29 Roman River crossing – modelled change in flood levels as a result of the proposed scheme (5% (1 in 20) AEP event)

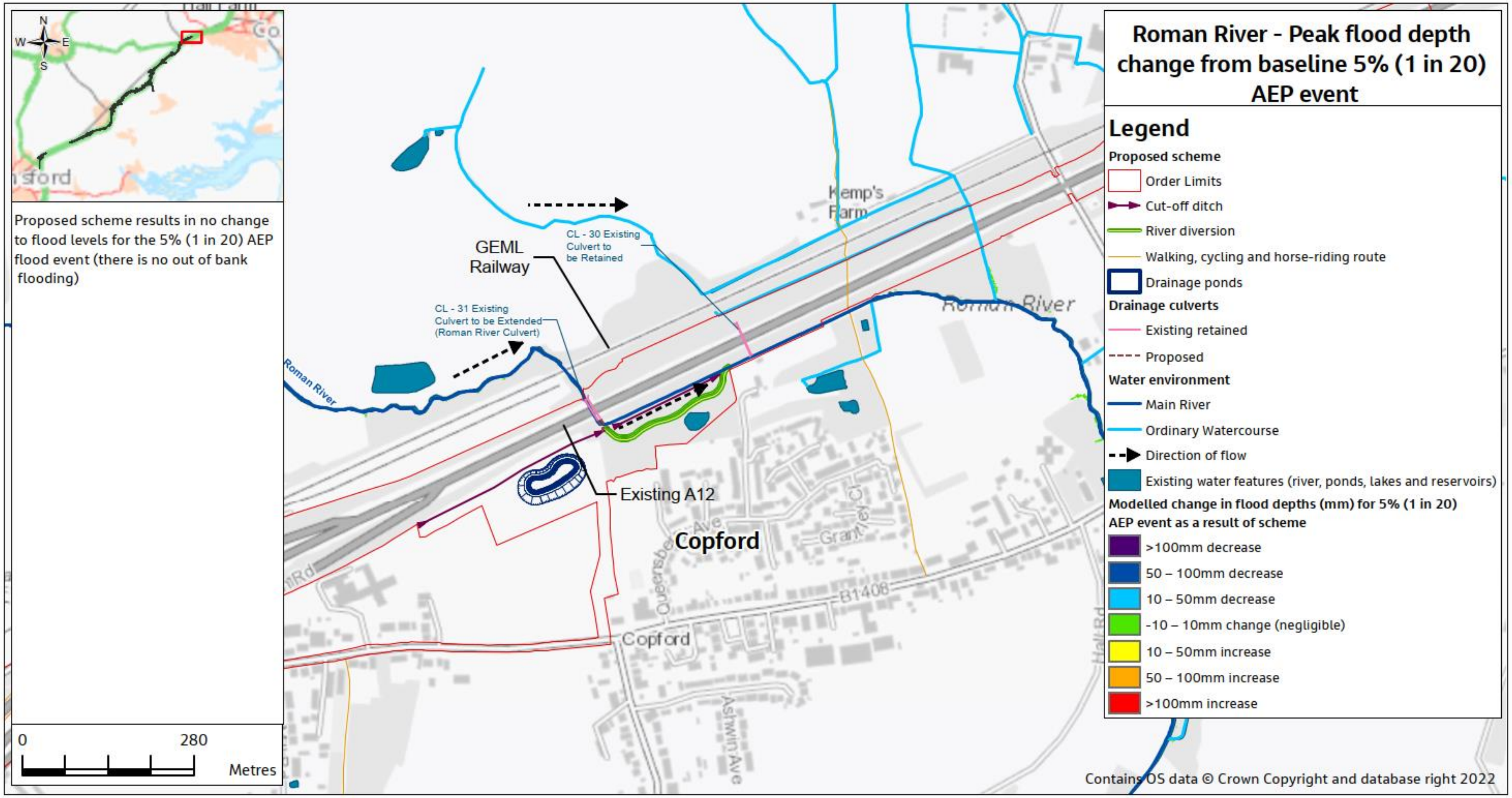
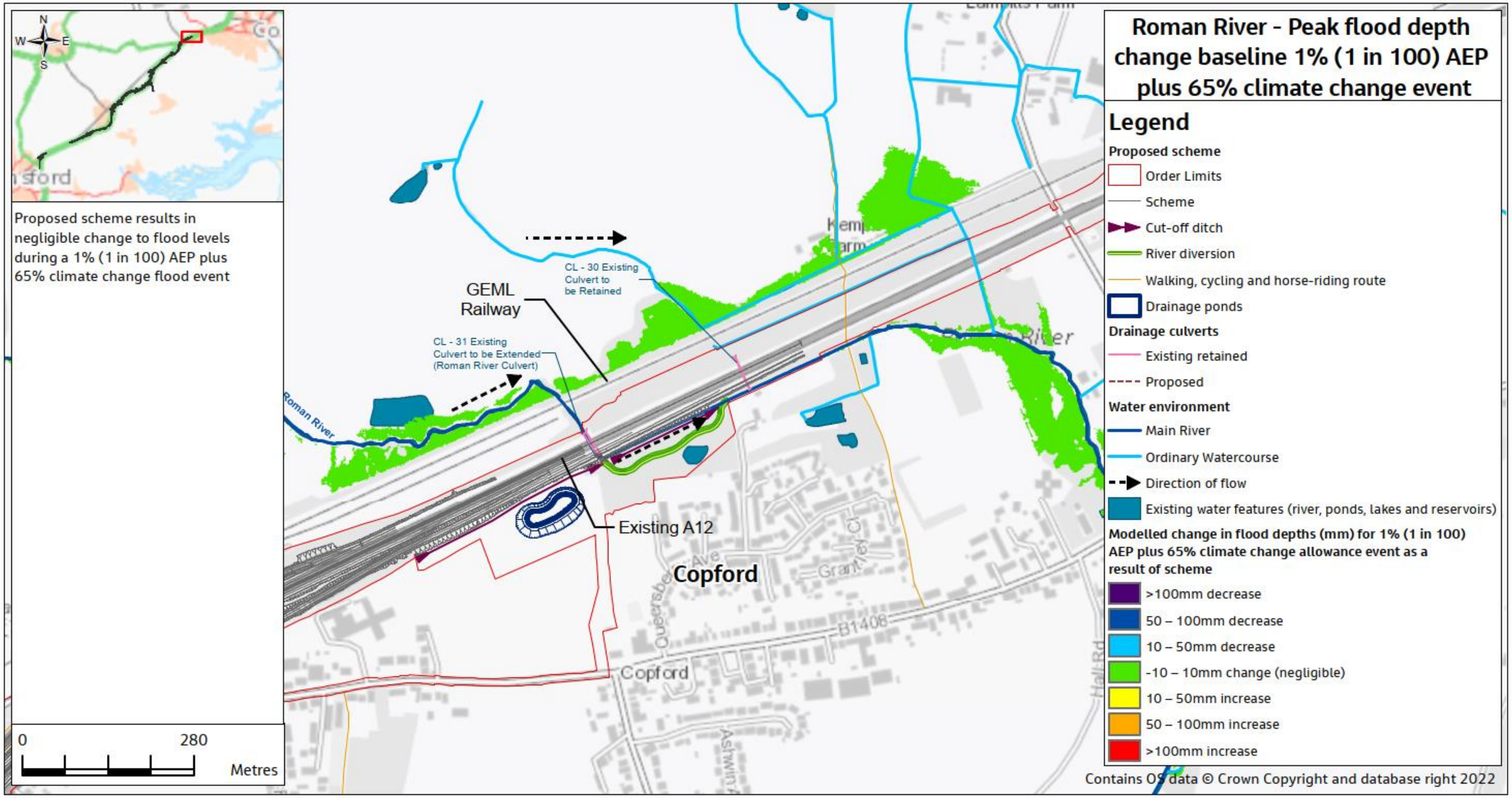


Plate 2.30 Roman River crossing – modelled change in flood levels as a result of the proposed scheme (1% (1 in 100) AEP event plus 65% allowance for climate change)



2.10 Summary

2.10.1 Table 2.14 summarises the Main River related flood risk to and from the proposed scheme for the areas for which hydraulic modelling has been undertaken.

2.11 Residual risks

2.11.1 While the proposed scheme has been designed to ensure that it would not increase flood risk elsewhere and is not at risk of flooding during the design flood event, a residual risk remains that it could flood from a more extreme event or as a result of blockages to watercourse crossings. However, given the high level of freeboard to proposed road levels demonstrated in Table 2.14, the likelihood of an exceedance event or blockage causing flooding to the proposed scheme is considered extremely small and therefore is not considered further in this assessment.

Table 2.14 Summary of fluvial flood risk associated with modelled Main Rivers to and from the proposed scheme during most extreme flood event modelled

Location	Most extreme event modelled	Proposed scheme impact on watercourse/ floodplain	Freeboard between peak modelled with-scheme water level and finished A12 road level	Primary impact of proposed scheme on flood risk	Flood mitigation proposed
Boreham Brook A12 crossing	1% (1 in 100) AEP event plus 38% allowance for climate change	Widening of the southbound highway embankment	>6m	No impact	None
River Ter A12 crossing	1% (1 in 100) AEP event plus 65% allowance for climate change	None (no change to existing bridge structure or highway embankment within floodplain area)	>4m	No impact	None
River Brain A12 crossing	1% (1 in 100) AEP event plus 38% allowance for climate change	Widening of highway embankment on both sides into floodplain area and extension of existing bridge	>3m	Negligible (<10mm change in surrounding flood levels)	None
Rivenhall Brook A12 crossing	1% (1 in 100) AEP event plus 38% allowance for climate change	New offline crossing and watercourse realignment	>2m	Increase in out-of-bank flood levels to small area immediately downstream of new culvert adjacent to channel	Flood mitigation bund along right bank of watercourse immediately downstream of new A12 culvert. No other mitigation proposed – remaining increase is within land to be acquired for the

Location	Most extreme event modelled	Proposed scheme impact on watercourse/ floodplain	Freeboard between peak modelled with-scheme water level and finished A12 road level	Primary impact of proposed scheme on flood risk	Flood mitigation proposed
					proposed scheme, with no sensitive receptors
River Blackwater A12 crossing (and WCH route bridge crossing)	1% (1 in 100) AEP event plus 38% allowance for climate change	Widening of existing bridge structure and highway embankment to the south. Relocation of WCH route and footbridge. Introduction of Ordinary Watercourse flood mitigation ditch.	>4m (to finished A12 road level) (>1m to finished realigned footbridge level)	Increase in flood levels within proposed excavated Ordinary Watercourse 21 flood mitigation channel. Increase in flood levels immediately upstream of footbridge ramp located within floodplain.	No mitigation proposed for increase in flood levels – increase is within land to be acquired for the proposed scheme, with no sensitive receptors A public safety risk assessment would be completed for the WCH route crossing of the River Blackwater and appropriate mitigation (such as signage) identified would be included within the proposed scheme.
Domsey Brook (western) A12 crossing	1% (1 in 100) AEP event plus 38% allowance for climate change	Widening of highway embankment, lengthening of existing crossing structure, and watercourse realignment	>5m	Decrease in flood levels upstream of the A12 crossing	None

Location	Most extreme event modelled	Proposed scheme impact on watercourse/ floodplain	Freeboard between peak modelled with-scheme water level and finished A12 road level	Primary impact of proposed scheme on flood risk	Flood mitigation proposed
Domsey Brook (eastern) A12 crossing	1% (1 in 100) AEP event plus 38% allowance for climate change	New offline crossing and watercourse realignment	>5m	Decrease in flood levels in between existing and new A12 crossing	None
Roman River A12 crossing	1% (1 in 100) AEP event plus 65% allowance for climate change	Widening of highway embankment, lengthening of existing culvert, and watercourse realignment	>2m	Negligible (<10mm change in surrounding flood levels)	None

3 Fluvial flood risk – Ordinary Watercourses

3.1 Introduction

3.1.1 The proposed highway scheme would cross approximately 36 Ordinary Watercourses (including utilities diversions) (see Annex M). Ordinary Watercourses are typically smaller unnamed streams, confined to narrow, often deep channels with relatively small catchment areas (under 5km^2). Ordinary Watercourses which have the potential to impact or be impacted by the proposed scheme have been numbered for ease of reference (see Annex M).

3.1.2 In the majority of locations, the Environment Agency (2020c) RoFSW mapping is considered to give sufficient representation of the risk associated with Ordinary Watercourses (see Annex D) as well as surface water flood risk (see Section 4 for more details). The mapping does not take climate change into account, so the 0.1% (1 in 1,000) AEP RoFSW mapping has been assessed as a proxy for the 1% (1 in 100) AEP plus climate change flood event.

3.1.3 The RoFSW mapping may not include all Ordinary Watercourses or ditches or include all structures on them. Therefore, a staged approach has been taken to the assessment of flood risk from such watercourses to ensure an appropriate level of assessment has been undertaken for each crossing location or other areas of potential interaction with the proposed scheme:

- The Revitalised Flood Hydrograph Method has been used to estimate the peak design flow for each watercourse. Using these estimated peak design flows, a preliminary assessment has been undertaken to assess the flow condition of existing watercourse crossing structures and proposed scheme watercourse crossing structures. The preliminary assessment included initial culvert sizing based on the guidance provided in CIRIA (2019) C786 (using Figure A7.1 – initial assessment of circular culverts).

- Where this preliminary assessment has suggested either that the proposed scheme could have an adverse flood impact, that there would be flood risk to the finished A12 scheme, or where crossing arrangements meant the CIRIA C786 methodology was unsuitable, a hydraulic analysis of these watercourse crossings has been undertaken to assess these in further detail.

3.1.4 For five Ordinary Watercourses (7, 21, 21a, 23 and 26) (see Annex M), the preliminary assessment identified that hydraulic modelling was required to assess the potential impact of the proposed scheme on flood risk associated with these watercourses. This hydraulic modelling has been completed and details included in the following sections.

3.1.5 There are several areas at medium (between 1% (1 in 100) AEP event and 3.3% (1 in 30) AEP event) and high (greater than 3.3% (1 in 30) AEP event) surface water flood risk associated with Ordinary Watercourses that do not cross the proposed scheme but do pass close to it predominantly at the south-west end of the proposed scheme. These surface water flow paths run along or through the Order Limits, flowing from the natural catchment towards the proposed scheme. However, these flow paths are not shown as causing flood risk to it and the proposed scheme elements would not alter the flows on these flow paths, so no further assessment of these areas has been undertaken.

3.2 Modelled Ordinary Watercourses

Ordinary Watercourse 7

Baseline flood risk

3.2.1 A description of Ordinary Watercourse 7 is included in Annex M and the watercourse is shown in Plate 3.1. Ordinary Watercourse 7 is situated immediately north-east of Hatfield Peverel. The watercourse flows south-east as it passes through arable land present both up- and downstream of the A12 culvert before meeting the River Blackwater.

3.2.2 The watercourse has two drainage paths originating approximately 300m upstream (north) of the A12 flowing south-east. The two tributaries converge immediately upstream of the A12, where a 52.5m long circular culvert (diameter 375mm) conveys the flow under the carriageway (NGR TL 579865). Downstream of the culvert, Ordinary Watercourse 7 continues to flow south-east for approximately 3km before draining into the River Blackwater.

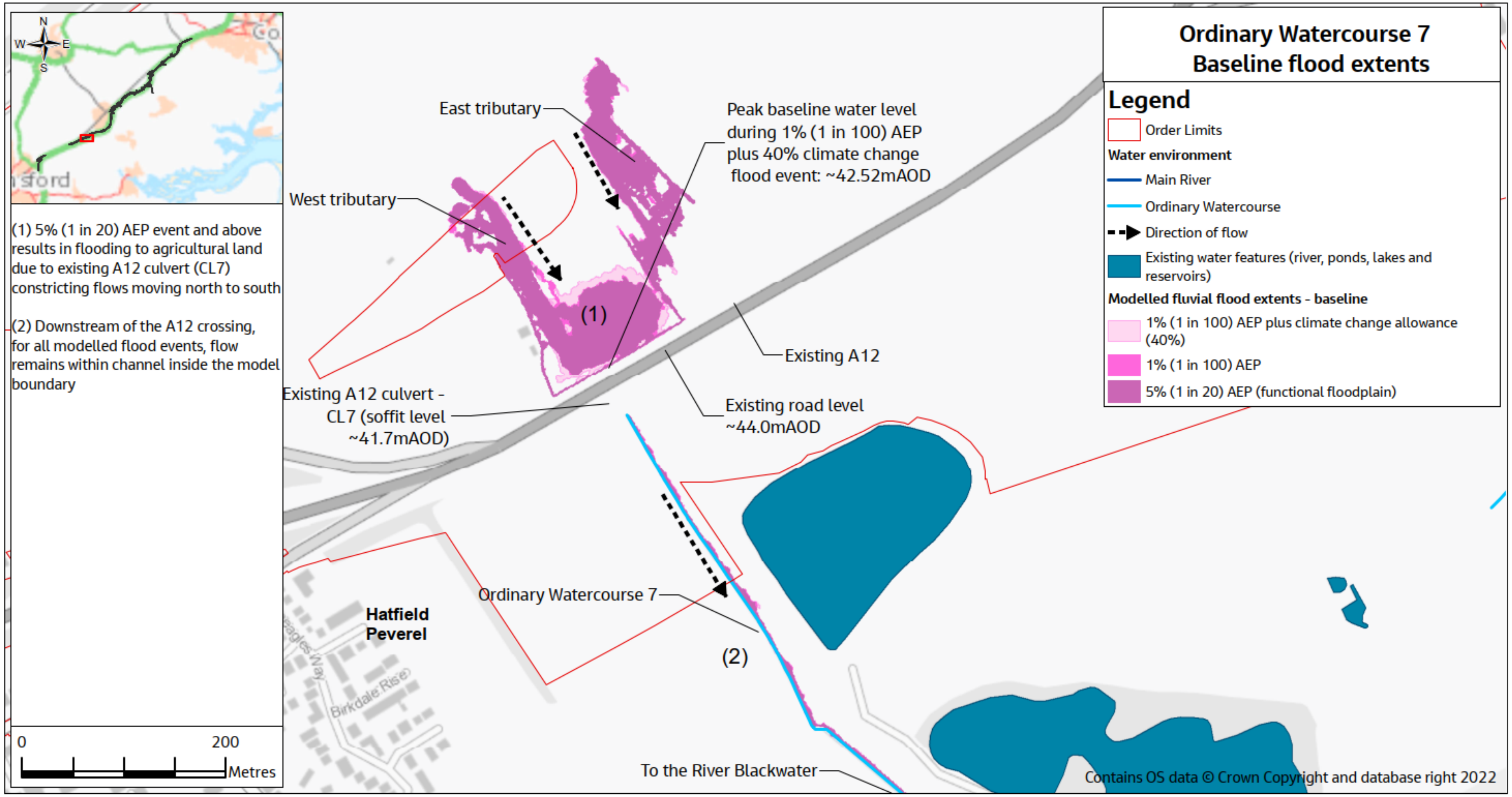
Baseline modelled flooding

3.2.3 Modelled baseline flood extents (5% (1 in 20) AEP event, 1% (1 in 100) AEP event, 1% AEP event plus 40% allowance for climate change) are included in Plate 3.1 (see Section 1.6 for further information on how climate change has been considered).

3.2.4 The upstream soffit level of the existing A12 crossing structure (41.69mAOD) is lower than the peak water level during the 1% (1 in 100) AEP event plus 40% allowance for climate change (42.52mAOD). Since the road level of the existing A12 in this location is 44.00mAOD, the existing A12 is not at risk of flooding during the most extreme event modelled (1% (1 in 100) AEP event plus 40% allowance for climate change).

3.2.5 During all modelled events, areas of agricultural land upstream of the existing A12 culvert are at risk of flooding due to this culvert constricting flows moving north to south. Downstream of the A12 crossing, for all modelled events flow remains in-channel inside the model boundary. No residential properties are located within the modelled flood extent within the study area.

Plate 3.1 Ordinary Watercourse 7 modelled baseline fluvial flood extents



Proposed scheme design

3.2.6 The proposed scheme (shown in Plate 3.2) would include a new junction 21 between Hatfield Peverel and Witham. These works would include slip roads on both the north and south sides of the junction and widening of the existing highway embankment. The proposed works also involve a toe-drain situated along the upstream (northern) side of the proposed road.

3.2.7 The proposed works would involve a new culvert (CL-07C) under the northern slip road and the extension of the existing culvert (CL-07) under the highway by 30m to the north to accommodate highway embankment widening (see Table 3.1 for proposed culvert works details). The proposed scheme involves redirecting an existing farm ditch to the north of the A12 (the eastern tributary of the watercourse) in between the two proposed drainage ponds and towards the inlet of CL-07C. The redundant section of this farm ditch would then be infilled.

3.2.8 The proposed scheme also includes the addition of two drainage ponds to the north of the Ordinary Watercourse 7 A12 crossing (base level: 41.8mAOD, top of pond level: 43.32mAOD).

Table 3.1 Proposed Ordinary Watercourse 7 culvert works

Culvert	Details of works
Extended CL-07 (80m long, 375mm circular culvert)	Extending existing culvert (55m long) 25m to the north (on the upstream side)
New proposed CL-07C (21m long, 450mm diameter circular culvert)	Addition of 450mm diameter 21m long circular culvert associated with proposed junction slip road north of the A12

Flood risk to the proposed scheme

3.2.9 With-scheme modelling has been used to assess the flood risk from Ordinary Watercourse 7 to the proposed scheme. Table 3.2 details the anticipated finished proposed scheme road levels and peak modelled water level during the 1% (1 in 100) AEP event plus 40% allowance for climate change.

3.2.10 Table 3.2 demonstrates that the finished road levels of the proposed scheme at this location (and the drainage ponds to the north) would be safe from flooding, with freeboard to the finished road level of 0.22m (on the northern slip road) and freeboard to the top level of the drainage ponds of approximately 0.4m. At this stage it has not been possible to increase this freeboard due to local topography, but the risk of flooding to the road is still considered low, with further areas of upstream floodplain available for floodwaters prior to overtopping of the road taking place. Freeboard to the A12 mainline would be 0.3m.

Table 3.2 Proposed scheme levels and peak modelled with-scheme water level during 1% (1 in 100) AEP event plus 40% allowance for climate change

Proposed scheme element	Peak modelled with-scheme 1% (1 in 100) AEP event plus 40% allowance for climate change water level (mAOD) adjacent to proposed scheme	Lowest proposed finished road/surface level (mAOD)	Freeboard between peak modelled water level and finished road/surface level (m)
Drainage ponds to the north of the A12	42.94	43.32[1]	0.38
A12 northern slip road	42.94	43.16	0.22
A12 mainline	42.60	42.90	0.30

[1]*Top of drainage pond level*

Flood risk from the proposed scheme

3.2.11 With-scheme modelling has been used to assess how the proposed scheme could impact flood risk in this location. The modelled change in flood extent caused by the proposed scheme for the 1% (1 in 100) AEP event plus 40% allowance for climate change flood event is shown in Plate 3.2. Modelled changes in flood level caused by the proposed scheme are shown in Plate 3.3 (5% (1 in 20) AEP event) and Plate 3.4 (1% (1 in 100) AEP event plus 40% allowance for climate change).

3.2.12 The proposed scheme (roads, culverts and drainage ponds) would displace baseline flooding and restricts flows. When modelled, this results in minimal change to the flood extent to the north of the road but does result in increased upstream flood depths in this area. When modelled, the proposed scheme causes an increase in flood levels upstream of the proposed scheme northern slip road (maximum increase of 415mm during the 1% (1 in 100) AEP event plus 40% allowance for climate change). The area for which the proposed scheme would cause an increase in flood risk would be retained by National Highways. The proposed scheme does not result in increased flood risk downstream of the A12 crossing (flows remain in-channel for all events modelled).

3.2.13 For all modelled flood events, the proposed scheme results in minimal changes to pass forward flow (especially in relation to the receiving watercourse which is the River Blackwater) (see Table 3.3). The proposed culverts would convey flow downstream without any adverse impacts to water levels in the channel in the 1% (1 in 100) AEP event and 1% (1 in 100) AEP event plus 40% allowance for climate change, but there are some increases in water level in the downstream channel during the 5% (1 in 20) AEP event. The proposed scheme does not result in increased flood risk downstream of the A12 crossing (flows remain in-channel for all events modelled).

Table 3.3 Change in pass-forward flows caused by the proposed scheme

Event	Ordinary Watercourse 7 downstream boundary peak flow (m^3/s)			Peak flow rate at River Blackwater (calculated at A12 crossing) (m^3/s)
	Baseline	With-scheme	Difference between baseline and with-scheme	
5% (1 in 20) AEP	0.261	0.272	+0.011	24.894
1% (1 in 100) AEP	0.379	0.360	-0.019	34.455
1% (1 in 100) AEP plus 40% allowance for climate change	0.481	0.437	-0.044	47.610

Flood mitigation

3.2.14 In the most extreme event modelled (1% (1 in 100) AEP event plus 40% allowance for climate change), the proposed scheme A12 carriageway and associated slip roads (and drainage ponds) remain unaffected by flooding. The northern slip road has a freeboard of 0.22m to finished proposed scheme road level. The mainline A12 road has a freeboard of 0.30m to finished proposed scheme road level.

3.2.15 In all modelled events, the proposed scheme causes increased depths of flooding upstream of the A12 (maximum increase of 415mm during the 1% (1 in 100) AEP event plus 40% allowance for climate change). However, the area for which the proposed scheme would cause an increase in flood risk would be retained by National Highways and would remain as unused land (i.e. this land does not and would not contain any receptors which could be harmed by flood water).

3.2.16 The proposed scheme results in a minor increase in pass-forward flow in the 5% (1 in 20) AEP event. However, flows remain in-bank, and this increase is considered to pose no significant change in flood risk associated with the receiving watercourse (the River Blackwater) due to the size of change related to the size of receiving watercourse and the likelihood that peak flows would not coincide given the size of each watercourse catchment. Therefore, no mitigation is proposed at this location.

Plate 3.2 Ordinary Watercourse 7 crossing – modelled change in flood extent as a result of the proposed scheme (1% (1 in 100) AEP event plus 40% allowance for climate change)

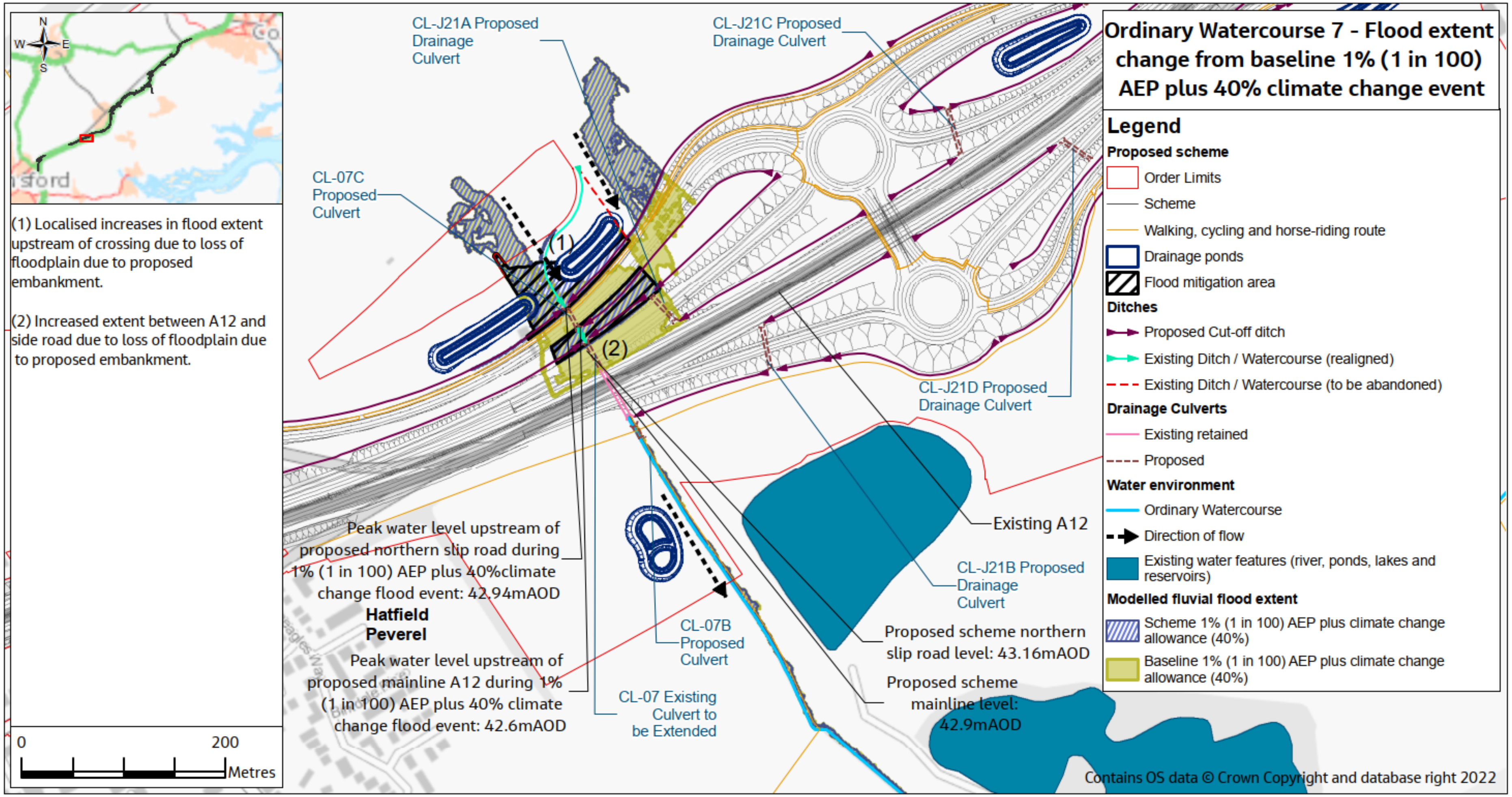


Plate 3.3 Ordinary Watercourse 7 crossing – modelled change in flood levels as a result of the proposed scheme (5% (1 in 20) AEP event)

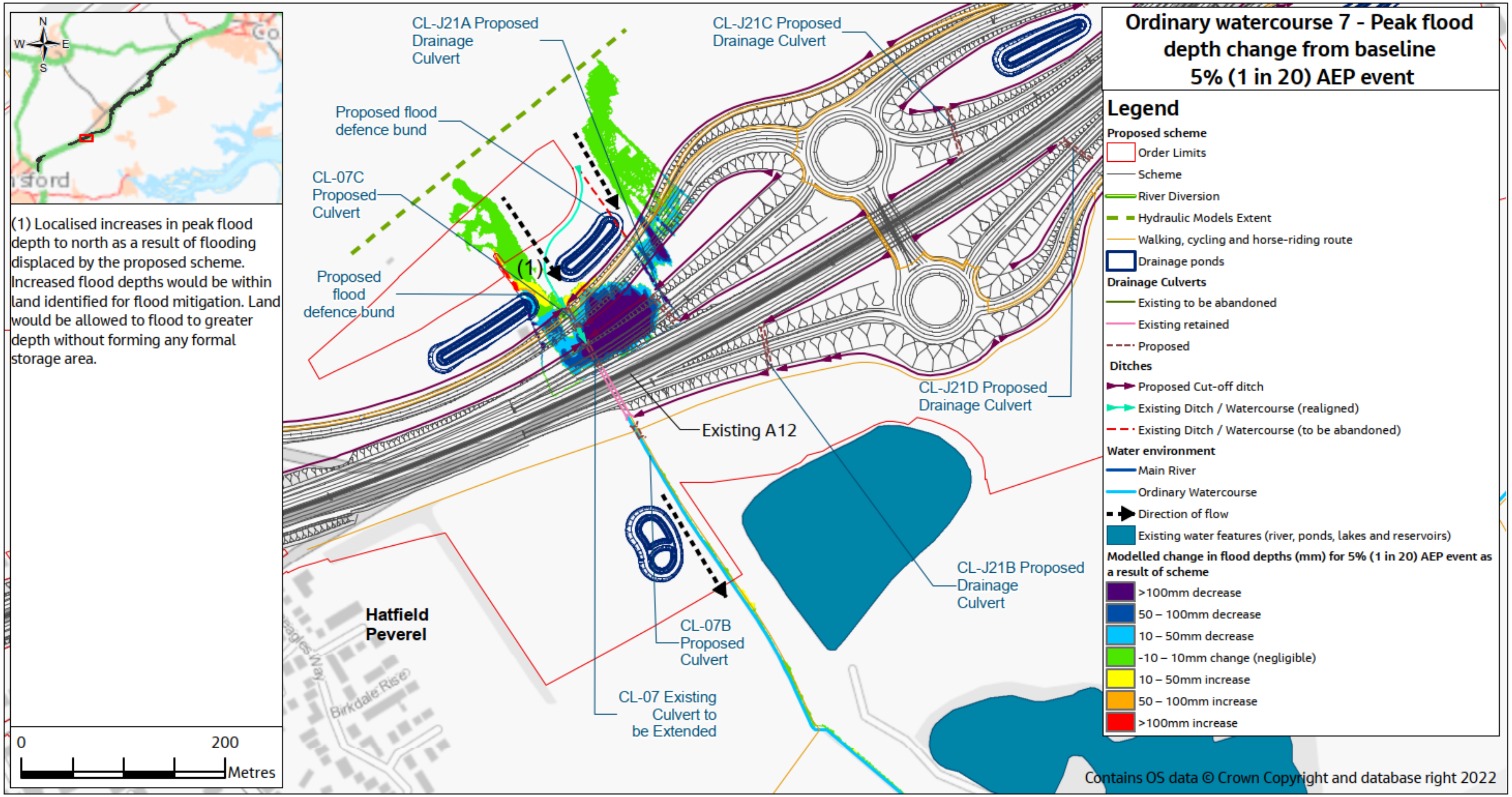
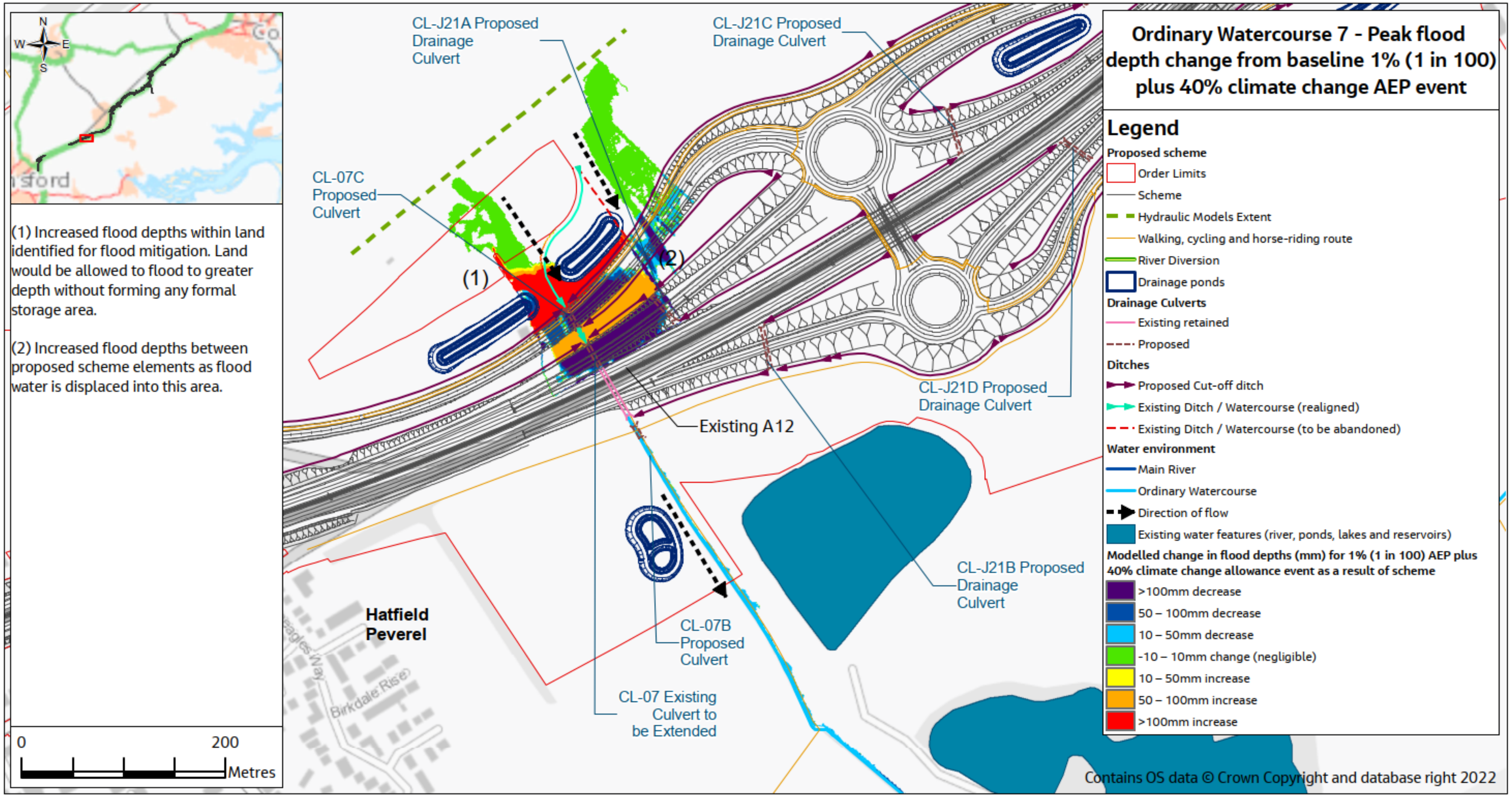


Plate 3.4 Ordinary Watercourse 7 crossing – modelled change in flood levels as a result of the proposed scheme (1% (1 in 100) AEP event plus 40% allowance for climate change)



Ordinary Watercourse 21

Baseline flood risk

3.2.17 A description of Ordinary Watercourse 21 is included in Annex M and the watercourse is shown in Plate 3.5. Ordinary Watercourse 21 is an ephemeral drainage channel, which only becomes a flowing watercourse during periods of heavy rain. The watercourse originates at Perry Wood, south of Kelvedon and immediately to the west of Inworth Road. From its source, the channel flows typically north-west towards the A12 and the River Blackwater, passing through pastoral and arable agricultural land.

3.2.18 The watercourse has three drainage tributaries (referred to as the western, middle and eastern tributaries) originating approximately 1km to 3km upstream (south-east) of the A12 and flowing in a north-westerly direction. Upstream of the A12, the two smallest tributaries (middle and eastern) are conveyed westwards along the toe of the A12 embankment via a 450mm culvert before discharging into a large (10m^3) chamber (NGR TL 86303 07826) at the confluence of the tributaries.

3.2.19 The western tributary discharges into the same chamber via a 900mm culvert (CL-21.6). Downstream of the chamber, flows are conveyed north via a circular culvert (CL-21.7 – 450mm diameter, 50m long) before discharging downstream (north of the A12) into the open channel reach of Ordinary Watercourse 21. From here, the watercourse runs north-west for approximately 375m before flowing into the River Blackwater.

3.2.20 At the chamber, an additional 600mm diameter bypass culvert (CL-21.3) conveys flows exceeding the capacity of CL-21.7 into the main highway drainage, which runs westwards until discharging into the River Blackwater upstream of Ashman's Bridge.

Baseline modelled flooding

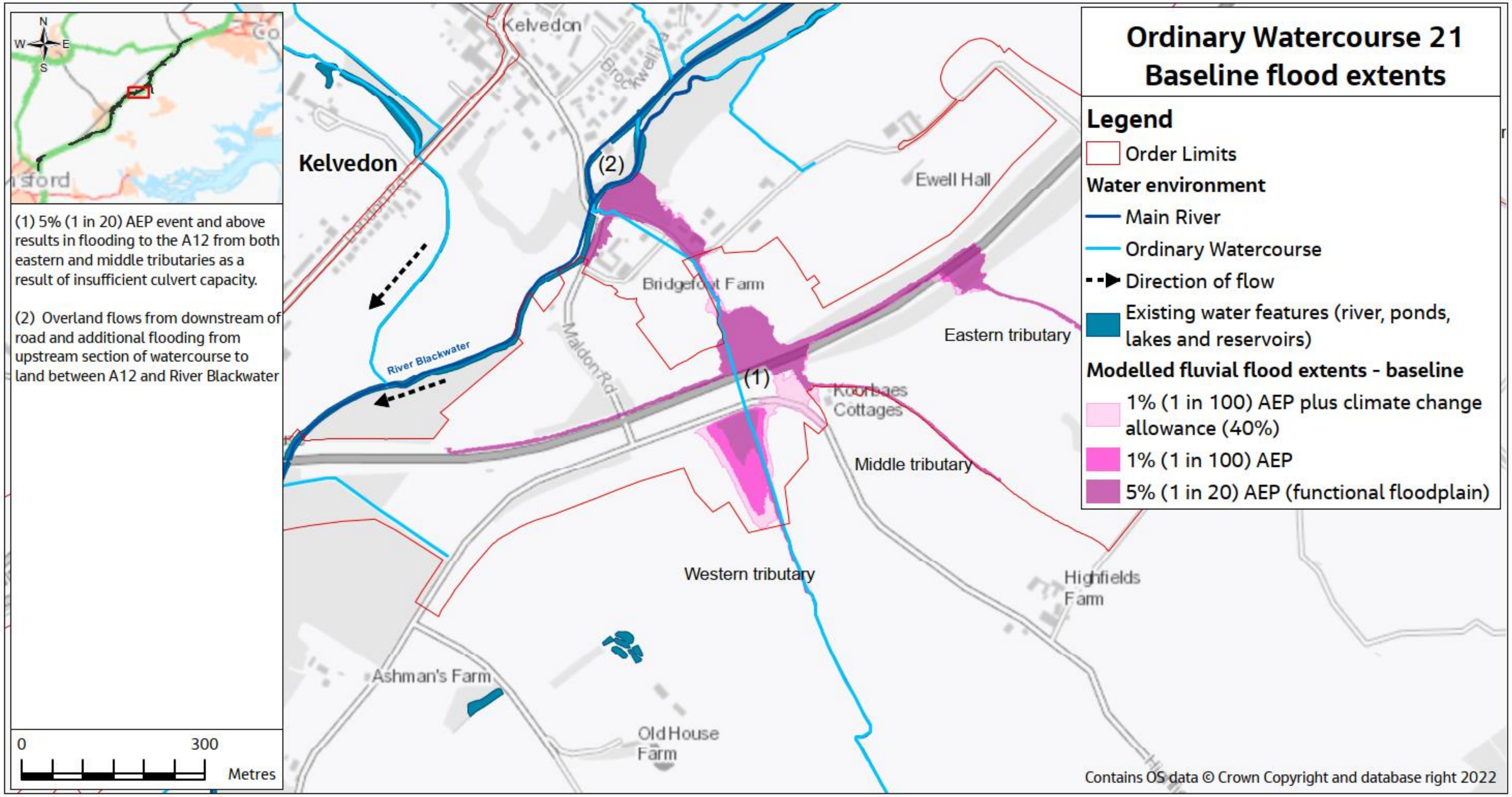
3.2.21 Modelled baseline flood extents (5% (1 in 20) AEP event, 1% (1 in 100) AEP event, 1% AEP event plus 40% allowance for climate change) are included in Plate 3.5 (see Section 1.6 for further information on how climate change has been considered).

3.2.22 Modelling identifies that the middle and eastern tributaries cause flooding to the existing A12 carriageway in all modelled flood events. The flooding of the carriageway results in a flow path on the northern verge of the A12 which flows west towards the River Blackwater.

3.2.23 In all modelled events, significant ponding (associated with the western tributary) occurs upstream of the A12 crossing, where flows are locally constricted by Highfields Lane for all modelled flood events. In the 1% (1 in 100) AEP event plus 40% climate change allowance, this flooding overtops Highfields Lane and flows converge with the middle tributary, where these flows then overtop the A12 carriageway.

3.2.24 Downstream (north) of the Ordinary Watercourse 21 A12 crossing, modelling shows that there is out-of-channel flooding of agricultural land for all modelled events. At Ewell Hall Chase, two residential properties near the confluence of Ordinary Watercourse 21 and the River Blackwater are shown to be at risk of flooding (up to 100mm depth during the 1% (1 in 100) AEP event plus 40% allowance for climate change).

Plate 3.5 Watercourse 21 modelled baseline fluvial flood extents



Proposed scheme design

3.2.25 The proposed scheme (shown in Plate 3.7) would involve widening of the existing A12 (approximately 2.1m to the north and approximately 11.2m to the south) to accommodate three lanes per carriageway. Highfields Lane/Braxted Road to the south of the A12 would be realigned, and the middle and eastern tributaries of Ordinary Watercourse 21 would be disconnected from the existing drainage network and directed into a new trapezoidal open channel running along the toe of the southern A12 embankment. This new channel would outfall into a new drainage chamber located further south (upstream) via a 450mm circular culvert.

3.2.26 The existing chamber at the confluence of the tributaries and the existing A12 crossing culverts (CL-21.6 and CL-21.7) would remain unchanged.

With-scheme modelling (pre-mitigation)

3.2.27 With-scheme modelling has been used to assess the flood risk from Ordinary Watercourse 21. Plates showing with-scheme without-mitigation modelled flooding can be found in the modelling report – Annex L.

3.2.28 When modelled, during all modelled events the proposed A12 carriageway remained at risk of flooding, and the proposed scheme resulted in an increased flood risk to residential properties at risk of flooding in the baseline scenario (maximum increase of 45mm in the 1% (1 in 100) AEP event plus 40% allowance for climate change). Therefore, mitigation is required at this location. For more detail of the with-scheme (pre-mitigation) flooding mechanisms, please refer to the modelling report (Annex L).

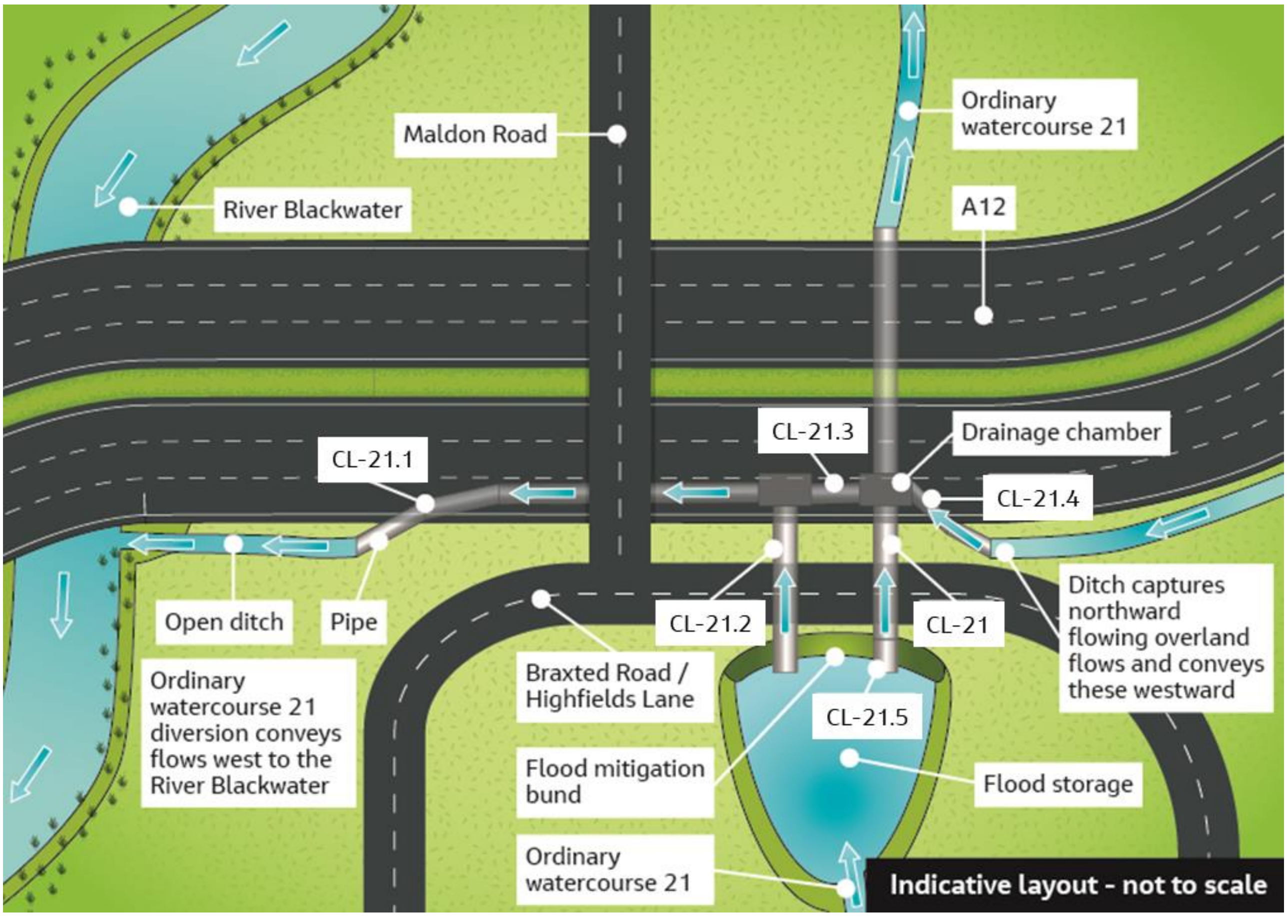
Proposed mitigation

3.2.29 The following mitigation measures have been included to both prevent the proposed A12 from flooding and to prevent adverse impacts to residential properties downstream (see Plate 3.6 for indicative illustration of proposed mitigation works):

- A bund (crest elevation 26.5mAOD) has been added across the western tributary channel and floodplain, upstream (south) of the proposed A12 crossing, creating a flood storage area (storing approximately 8380m3 of water in a 1% (1 in 100) AEP plus climate change event) and preventing flows from the western tributary ponding against the A12 embankment, Highfields Lane, or overtopping the proposed scheme.
- Proposed new connection culvert for the eastern open channel into the new chamber (CL-21.4) has been increased to a 1m diameter culvert.
- New CL-21.5 (approximately 20m long, diameter 450mm) through the flood mitigation bund has been added to convey water from the flood storage area to the existing CL-21.6 so the storage area can drain to the new chamber. The existing CL-21.7 (900mm diameter upstream of A12, 450mm downstream of A12) conveys water from the chamber to the open channel reach of Ordinary Watercourse 21 downstream of the A12.

- New CL-21.1 (approximately 70m long, diameter 800mm) has been added to provide additional drainage of the flood storage area into a flood mitigation culvert and channel that flows into the River Blackwater on the south side of the A12 (see Plate 3.6).
- A new 1m diameter circular culvert (CL-21.3) would convey water from the new chamber into the flood mitigation culvert (CL-21.1) and channel. Immediately downstream (west) of this connection, the system consists of a 1.5m diameter circular pipe of 500m length (CL-21.1), that conveys flows west alongside the southern edge of the A12 highway (where there is insufficient space for an open ditch). This pipe outfalls into a new open channel ditch of approximately 200m length running westwards through River Blackwater floodplain and discharging into the River Blackwater immediately downstream (south) of Ashman's Bridge.

Plate 3.6 Proposed Ordinary Watercourse 21 flood mitigation works (indicative)



3.2.30 Table 3.4 details the maximum volume of water the proposed flood storage area is predicted to contain, and the total length of time the flood storage area would contain water during each of the events modelled.

Table 3.4 Modelled maximum water volume and total length of time water stored in proposed flood storage area

Flood event	Maximum volume of water stored in flood storage area	Total length of time water stored in flood storage area
5% (1 in 20) AEP	1,990m^3	15hrs
1% (1 in 100) AEP	3,730m^3	16.5hrs
1% (1 in 100) AEP plus 40% climate change	8,380m^3	21hrs

With-scheme modelling (including mitigation)

3.2.31 The mitigation described in the section above has been included in the with-scheme modelling. The modelled change in flood extent caused by the proposed scheme (including mitigation) for the 1% (1 in 100) AEP event plus 40% allowance for climate change is shown in Plate 3.7. Modelled changes in flood level caused by the proposed scheme (including mitigation) are shown in Plate 3.8 (5% (1 in 20) AEP event) and Plate 3.9 (1% (1 in 100) AEP event plus 40% allowance for climate change).

Flood risk to the proposed scheme

3.2.32 Inclusion of the proposed mitigation measures described above results in the proposed scheme A12 carriageway and the realigned Braxted Road/Highfields Lane no longer being at risk of flooding (for all flood events modelled).

3.2.33 With-scheme modelling has been used to assess the flood risk from Ordinary Watercourse 21 to the proposed scheme. The finished road levels of the proposed scheme would be safe from fluvial flooding at this location, with the storage area upstream including 300mm freeboard to prevent overtopping and overland flow towards the road.

Flood risk from the proposed scheme

3.2.34 As shown in Plate 3.8, the proposed scheme (including mitigation measures) appears to result in increased flood levels adjacent to the open drain at the western end of the flood mitigation channel. This drain and accompanying floodplain are represented within the Middle Blackwater model and are seen to be inundated (with flows from the River Blackwater) in all modelled events.

3.2.35 In both the baseline and the with-scheme scenario, the total volume of Ordinary Watercourse 21 flows entering the River Blackwater would remain broadly the same (some small losses from flood flows overland in the baseline scenario not withstanding). The proposed scheme would result in a change to the timing of these flows entering the River Blackwater, with the proposed mitigation measures providing a faster route for flows than existing overland flow routes.

3.2.36 The flows associated with the Ordinary Watercourse 21 diversion works in this location are comparatively minor, with peak discharge from the channel of 3.51m^3/s during the 1% (1 in 100) AEP event plus 40% allowance for climate change. The River Blackwater is a large catchment of approximately 220km^2

with peak flows of 47.61m^3/s (1% (1 in 100) AEP event plus 38% allowance for climate change). Given the relative catchment sizes (220km^2 to 3.33km^2), the catchments would be expected to react very differently in storm events, with a far quicker response on Ordinary Watercourse 21 than on the River Blackwater (approximately 11 hours on Ordinary Watercourse 21 and 37 hours on the River Blackwater). As such, peak discharge from the diverted channel would be anticipated to occur well before peak flows on the River Blackwater from the same event.

3.2.37 Given that only the timing (not the total volume) of Ordinary Watercourse 21 flows entering the River Blackwater would be altered by the proposed scheme, and that Ordinary Watercourse 21 flows are comparatively minor compared to the receiving watercourse (River Blackwater), it is considered that the proposed Ordinary Watercourse 21 diversion works would not alter the flood risk associated with the River Blackwater.

3.2.38 Downstream of the Ordinary Watercourse 21 A12 crossing, within the River Blackwater floodplain the proposed scheme (including mitigation measures) results in a reduction in flood levels by up to 50mm (during the 1% (1 in 100) AEP event plus 40% allowance for climate change), and one residential property that was at risk of flooding in the baseline scenario is no longer at risk of flooding during any of the events modelled.

3.2.39 The proposed scheme (including mitigation measures) results in reduced flood extents when compared to the baseline scenario (for all events modelled).

Plate 3.7 Ordinary Watercourse 21 crossing – modelled change in flood extent as a result of the proposed scheme (including mitigation works) (1% (1 in 100) AEP event plus 40% allowance for climate change)

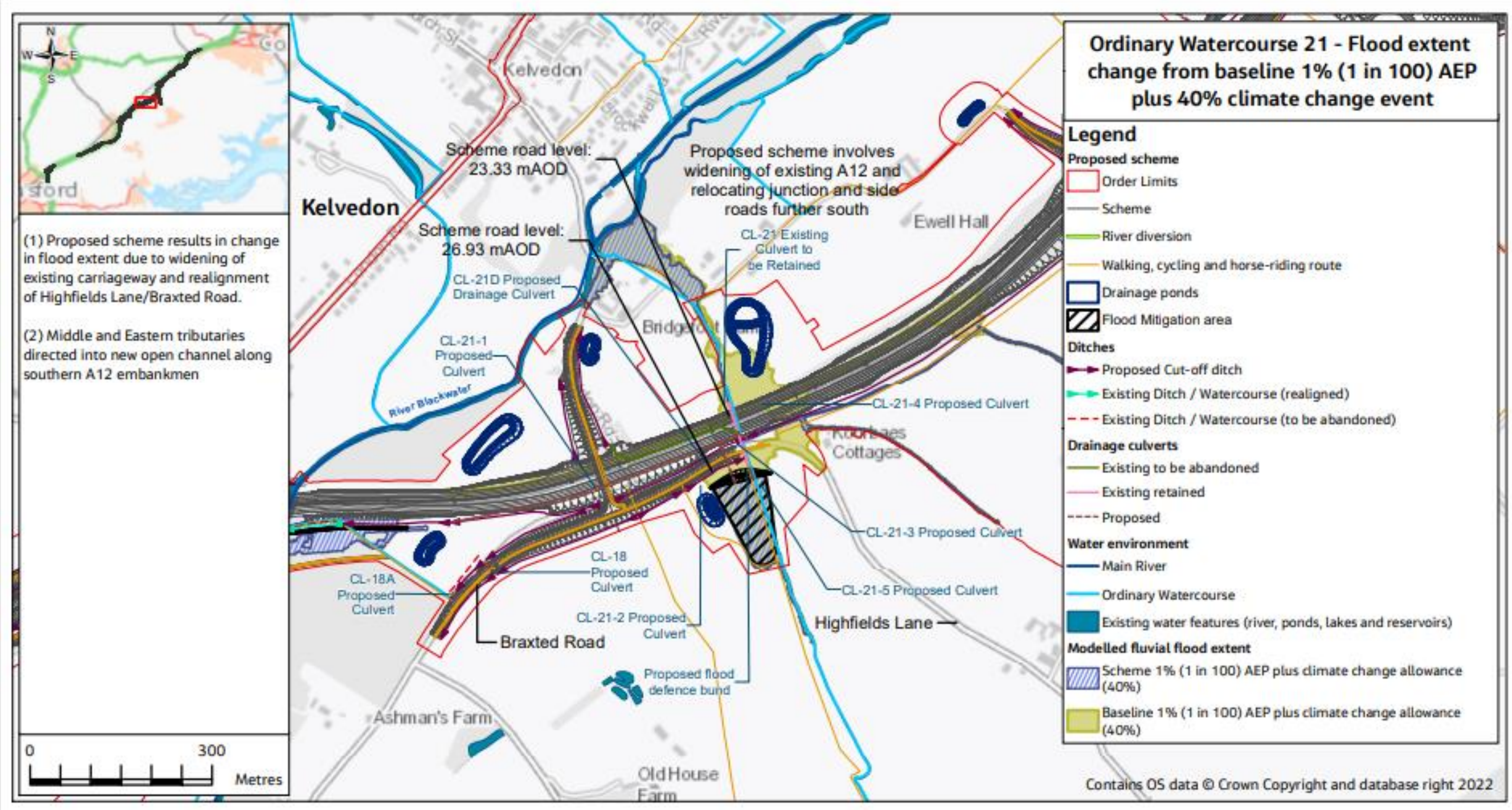


Plate 3.8 Ordinary Watercourse 21 crossing – modelled change in flood levels as a result of the proposed scheme (including mitigation works) (5% (1 in 20) AEP event)

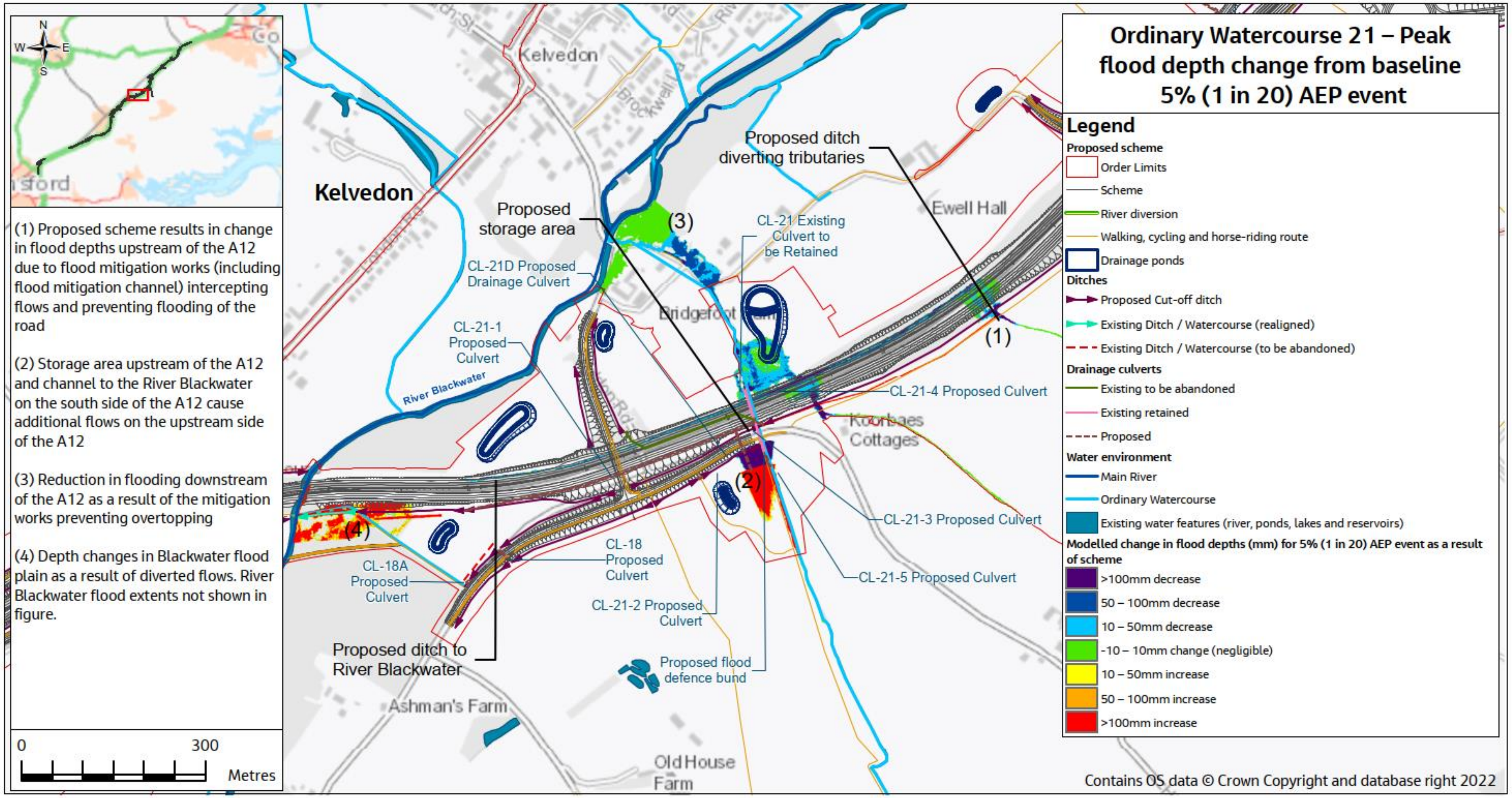
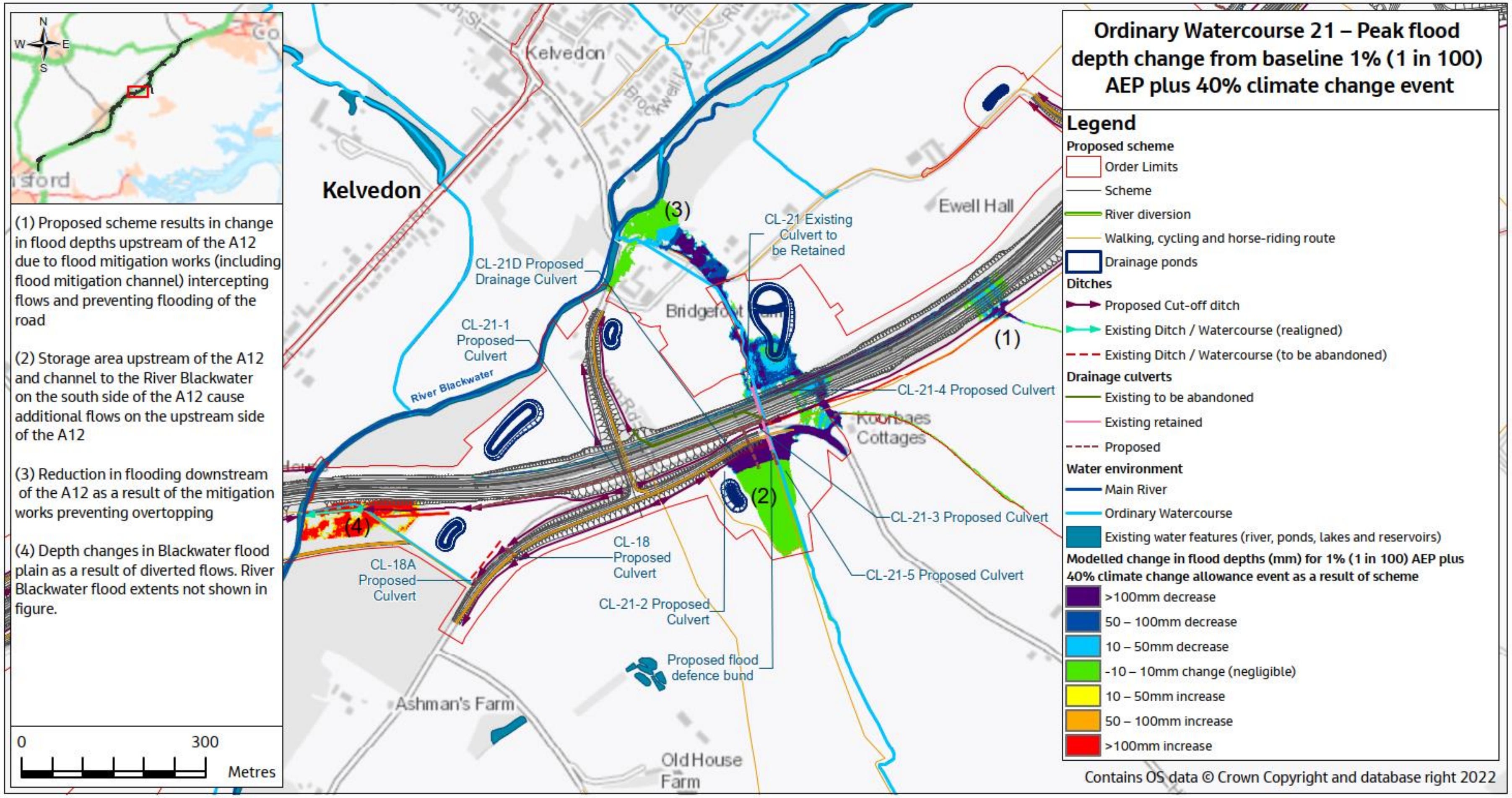


Plate 3.9 Ordinary Watercourse 21 crossing – modelled change in flood levels as a result of the proposed scheme (including mitigation works) (1% (1 in 100) AEP event plus 40% allowance for climate change)



Ordinary Watercourse 21a

Baseline flood risk

3.2.40 A description of Ordinary Watercourse 21a is included in Annex M and the watercourse is shown in Plate 3.10. Ordinary Watercourse 21a has its source south-east of the A12 and Kelvedon. The watercourse is formed by two distinct tributaries originating approximately 500m upstream (south) of the A12, flowing north-west. The two tributaries converge immediately upstream (south) of the existing A12, where a 900mm diameter, 65m length culvert (CL-21A) (TL 87121 18444) conveys the flow under the carriageway. Downstream of the A12 crossing, the channel continues its course north-west before flowing into the River Blackwater approximately 400m downstream of the A12 crossing.

Baseline modelled flooding

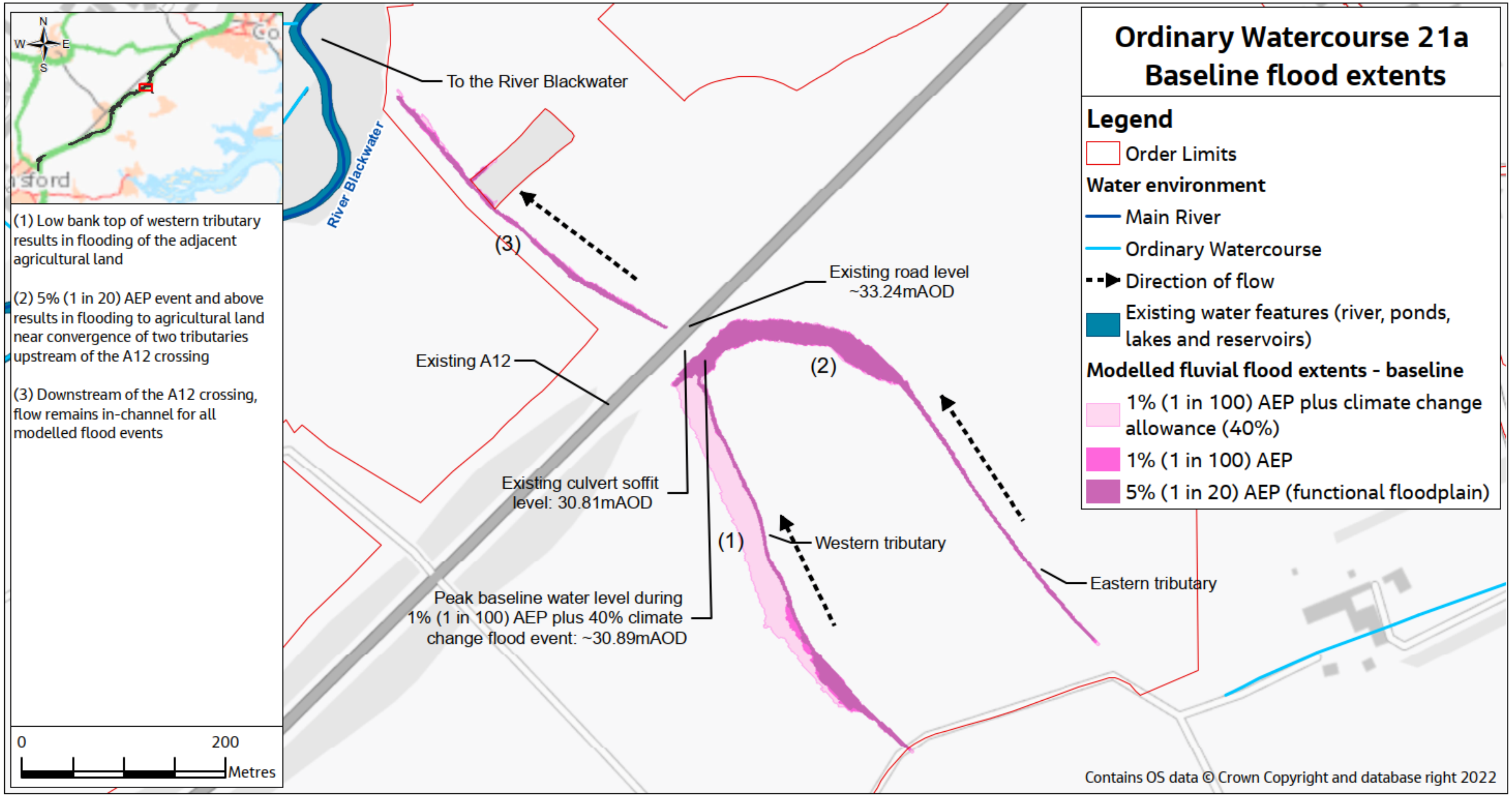
3.2.41 Modelled baseline flood extents (5% (1 in 20) AEP event, 1% (1 in 100) AEP event, 1% AEP event plus 40% allowance for climate change) are included in Plate 3.10 (see Section 1.6 for further information on how climate change has been considered).

3.2.42 Upstream of the existing A12, the eastern Ordinary Watercourse 21a tributary remains largely in-channel for all modelled events where the watercourse is clearly defined in the topography of the landscape. Also on the upstream side of the A12 crossing, the western Ordinary Watercourse 21a tributary floods out of back along its entire length within the model extent during the 1% (1 in 100) AEP event and 1% (1 in 100) AEP event plus 40% allowance for climate change as a result of the low western bank top.

3.2.43 Upstream of the A12 crossing, where the two Ordinary Watercourse 21a tributaries converge, flood water pools near the CL-21A inlet to depths of almost 375mm during a 1% (1 in 100) AEP event plus 40% allowance for climate change. Downstream of the A12 crossing, flow remains in-channel for all modelled events.

3.2.44 During the most extreme event modelled (1% (1 in 100) AEP event plus 40% allowance for climate change flood event), the peak water level (30.89mAOD) is higher than the soffit level of the culvert (30.81mAOD). Despite this, the existing A12 is not at risk of flooding, with freeboard of greater than 2m between peak water level and road surface level (33.24mAOD).

Plate 3.10 Watercourse 21a modelled baseline fluvial flood extents



Proposed scheme design

3.2.45 The proposed scheme at the Ordinary Watercourse 21a crossing (shown in Plate 3.11) would involve widening of the existing A12 carriageway and addition of a new junction and associated slip roads on the north and south sides of the widened A12. The proposed scheme would involve replacing the existing Ordinary Watercourse 21a culvert (CL-21A) with three connected culverts (CL-21B, CL-21C and CL-21D) to convey flow from upstream to downstream of the proposed scheme (see Table 3.5 for details).

3.2.46 For 68m upstream of the proposed CL-21B inlet, and for 74m downstream of the proposed CL-21D outlet, the watercourse channel would be regraded to 8m width.

Table 3.5 Proposed new watercourse 21a culverts

Culvert	Details	Purpose
CL-21B	Diameter: 1.2m Length: 31.5m	To convey Ordinary Watercourse 21a under proposed southern slip road. Inlet lies approximately 60m upstream of the proposed scheme.
CL-21C	Diameter: 1.2m Length: 210m	To convey Ordinary Watercourse 21a under proposed widened A12 carriageway (inlet connects to the CL-21B outlet).
CL-21D	Diameter: 1.2m Length: 60m	To convey Ordinary Watercourse 21a under proposed north slip road (inlet connects to CL-21C outlet). Discharges water into Ordinary Watercourse 21a open channel approximately 70m downstream of the proposed scheme.

With-scheme modelling (pre-mitigation)

3.2.47 With-scheme modelling has been used to assess the flood risk from Ordinary Watercourse 21a to and from the proposed scheme. Plates showing with-scheme without-mitigation modelled flooding can be found in the modelling report – Annex L.

3.2.48 The proposed scheme is flooded in all modelled flood events from the eastern Ordinary Watercourse 21a tributary flooding directly onto the proposed southern slip road, which lies 3.5m lower than the bed of the eastern tributary at the location where it floods the proposed scheme. Therefore, flood mitigation is required at this location. For more detail of the with-scheme (pre-mitigation) flooding mechanisms, please refer to the modelling report (Annex L).

Proposed mitigation

3.2.49 The following mitigation measures have been included to ensure that the proposed scheme is safe from flooding:

- An excavated channel, upstream of the proposed southern slip road, to capture and divert northern-flowing flows from the eastern tributary towards the inlet of proposed culvert CL-21B (maximum width: 10m, maximum excavated depth: 2m).

- A weir (1.5m high), located in the diverted eastern tributary immediately upstream of the confluence with the western tributary to attenuate flows.
- A small drain on the left floodplain of the western tributary to divert flood water back into the channel immediately upstream of the CL-21B inlet. A 500mm high bund would prevent water ponding against the new A12 embankment.

With-scheme modelling (including mitigation)

3.2.50 The mitigation described in the section above has been included in the with-scheme modelling. The modelled change in flood extent caused by the proposed scheme (including mitigation) for the 1% (1 in 100) AEP event plus 40% allowance for climate change is shown in Plate 3.11. Modelled changes in flood levels caused by the proposed scheme (including mitigation) are shown in Plate 3.12 (5% (1 in 20) AEP event) and Plate 3.13 (1% (1 in 100) AEP event plus 40% allowance for climate change).

Flood risk to the proposed scheme

3.2.51 The proposed mitigation is effective in preventing flooding to the proposed scheme in all modelled flood events.

3.2.52 Water remains in-channel along the entire reach of the eastern Ordinary Watercourse 21a tributary. The excavated channel diverting the eastern tributary is effective in attenuating flows from the eastern tributary before discharging into the western tributary. Water remains in-channel along the entire reach during all flood events modelled.

3.2.53 The new drain and bund on the left (western) floodplain of the western tributary capture all floodwater and redirect it back into the main channel, resulting in no ponding against the proposed A12 embankment during all flood events modelled.

Flood risk from the proposed scheme

3.2.54 As shown in Plate 3.11, Plate 3.12 and Plate 3.13, the proposed scheme (including mitigation measures) results in an increase in flood risk to the excavated flood mitigation channel and just upstream of the proposed headwall.

3.2.55 For all modelled events, the proposed scheme (including mitigation works) results in a reduction in maximum water levels in the downstream channel.

3.2.56 The proposed scheme has a negligible impact on flood risk elsewhere for all flood events modelled.

Plate 3.11 Ordinary Watercourse 21a crossing – modelled change in flood extent as a result of the proposed scheme (including mitigation works) (1% (1 in 100) AEP event plus 40% allowance for climate change)

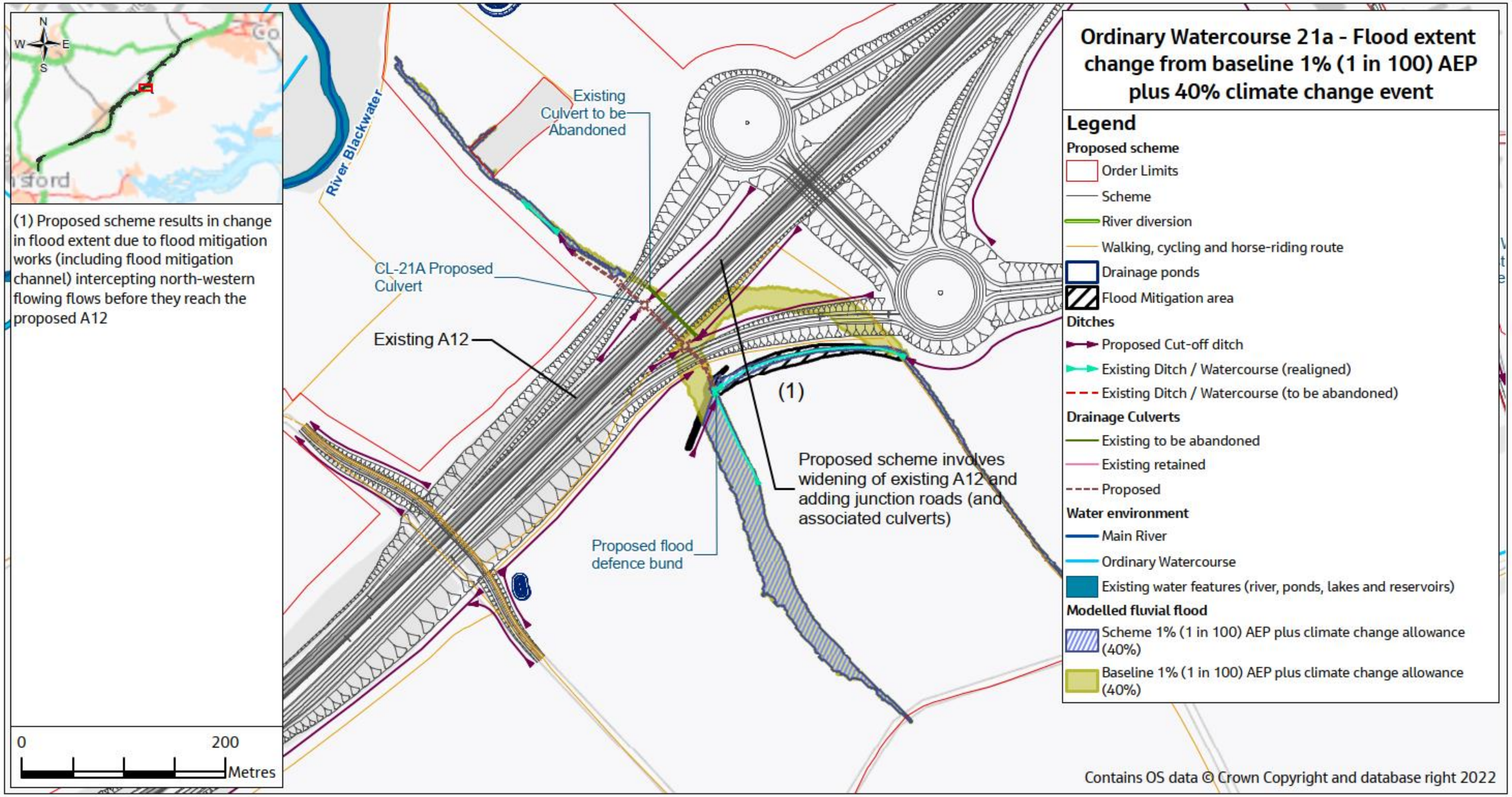


Plate 3.12 Ordinary Watercourse 21a crossing – modelled change in flood levels as a result of the proposed scheme (including mitigation works) (5% (1 in 20) AEP event)

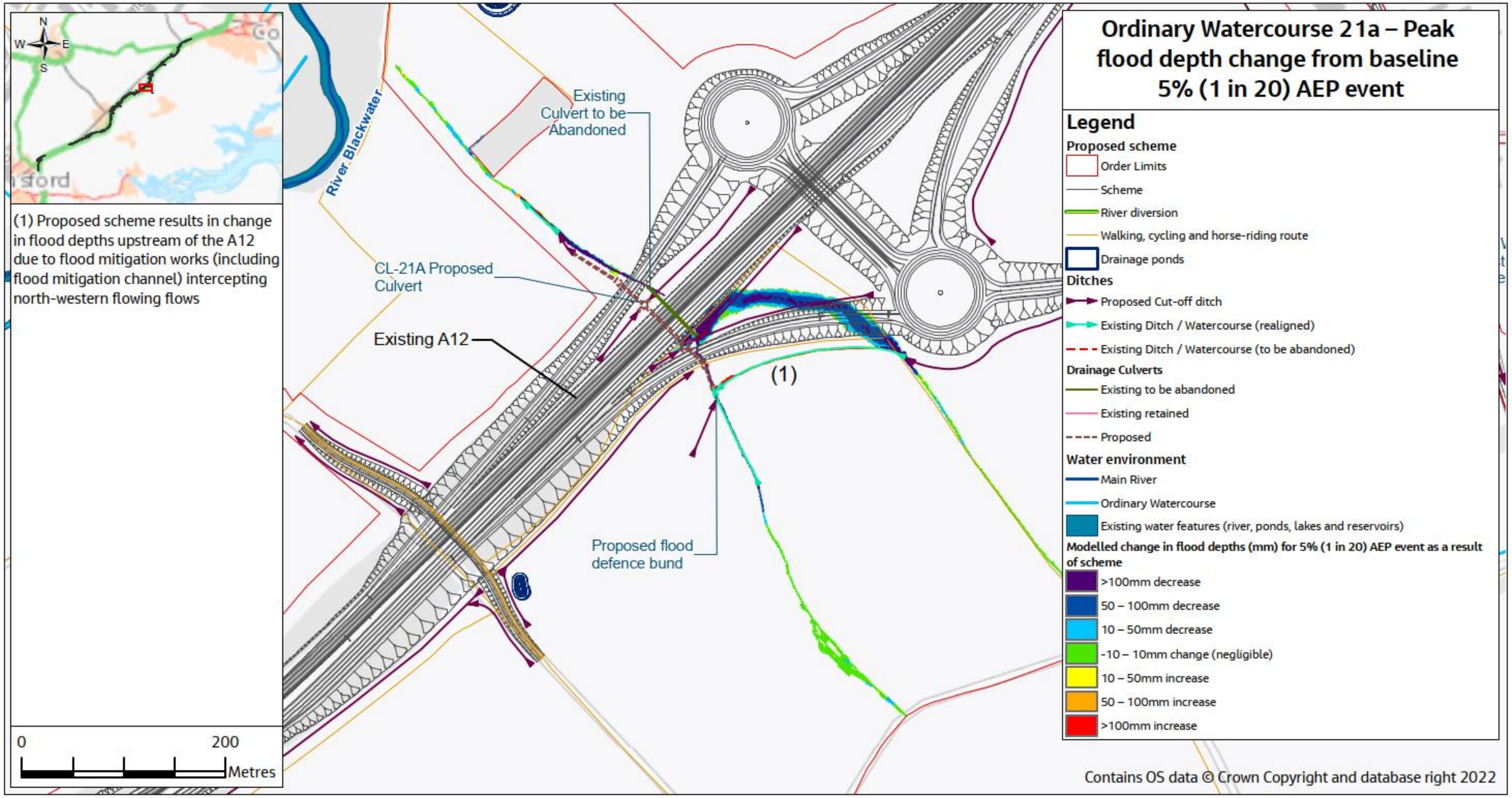
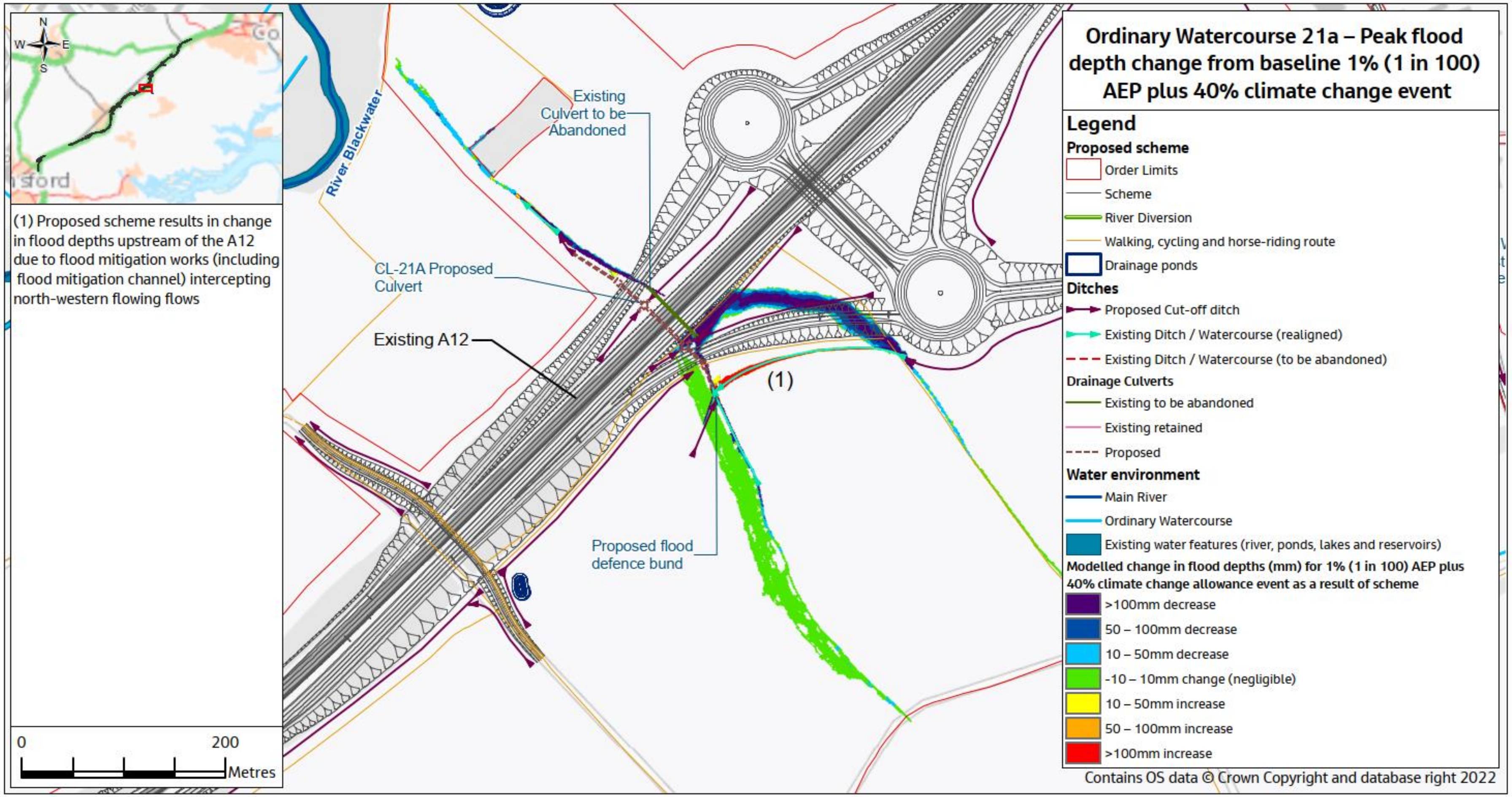


Plate 3.13 Ordinary Watercourse 21a crossing – modelled change in flood levels as a result of the proposed scheme (including mitigation works) (1% (1 in 100) AEP event plus 40% allowance for climate change)



Ordinary Watercourse 23

Baseline flood risk

3.2.57 A description of Ordinary Watercourse 23 is included in Annex M and the watercourse is shown in Plate 3.14. The watercourse features north and west upstream branches that converge around Prested Hall. The watercourse passes beneath the existing A12 in a south-easterly direction at two locations before it joins with the Domsey Brook approximately 1.1km downstream of the current A12 crossing. The north tributary was not modelled explicitly as it is a smaller tributary. Instead, it was included as a point inflow into the MWC23 east tributary in the model located downstream of the A12 crossing.

3.2.58 1.2.2 Historically the west tributary has been diverted into the A12 highway carrier drain, via a culvert network. There are numerous changes of pipe size and direction, so an explicit labelling system was utilised in the baseline model. On the north side of the A12 CL-24K conveys flow from the “West Ditch” (which is a toe drain of London Road) to a confluence with the “North Ditch” and CL-24J. CL-24J then carries the combined flow into CL-24D. Culvert CL-24D crosses under New Lane and flows into two pipe sections in series which are designated CL-24Ba and CL-24Bb, this pipeline outfalls into CL-24C near its upstream end.

3.2.59 CL-24C conveys flows the combined flows from the north of the existing A12 into the existing A12 main carrier drain. The continuation of A12 drainage follows the alignment of the A12 for approximately 500m beyond the model extent before discharging into Domsey Brook.

3.2.60 The remaining downstream stretch of the MWC23 west tributary therefore drains just the area to the south of the existing A12, it converges with MWC23 east tributary at Prested Hall before discharging into Domsey Brook. CL-23H is an access road culvert that conveys flow north to south under properties near Prested Hall.

Baseline modelled flooding

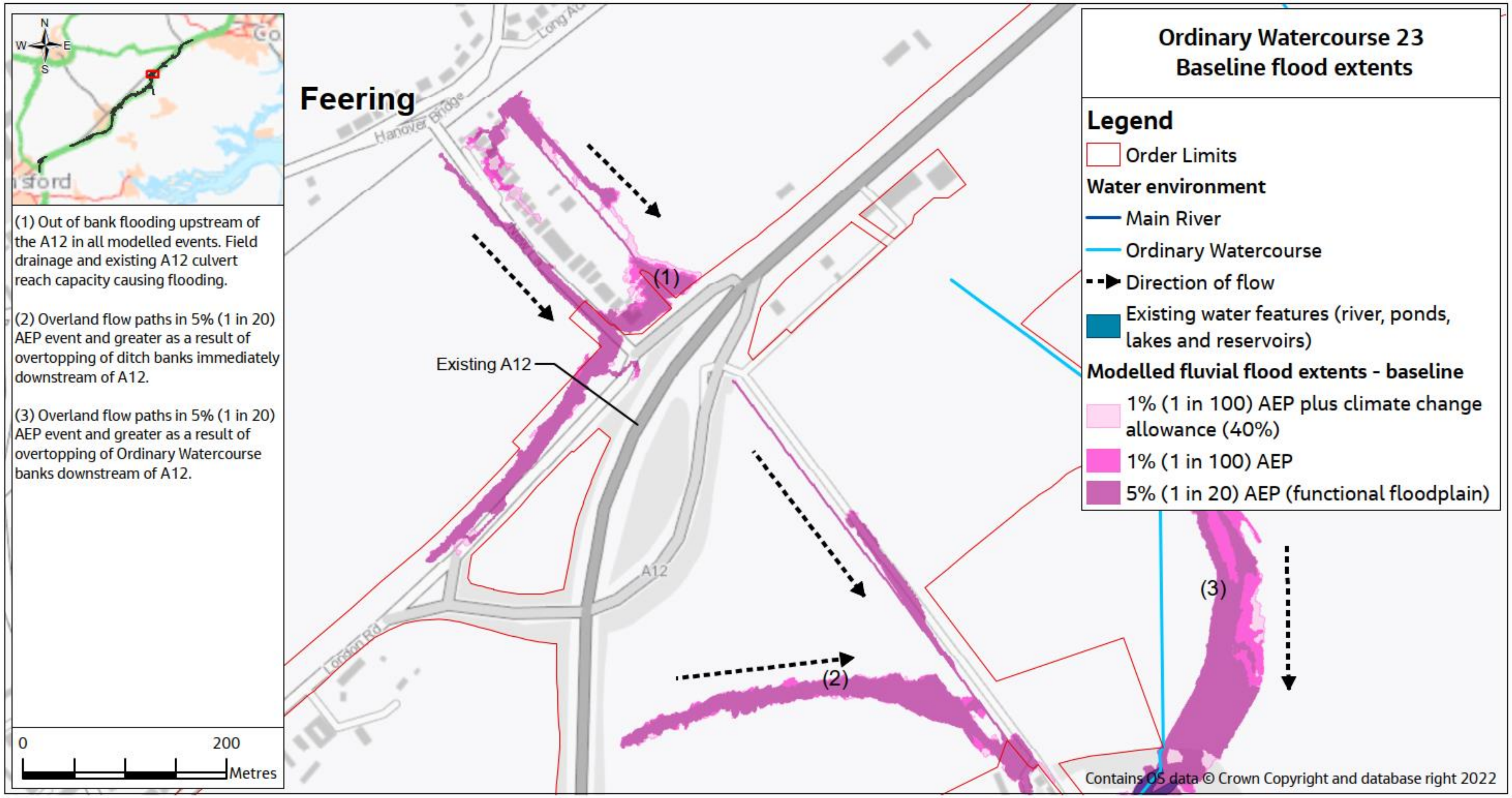
3.2.61 Modelled baseline flood extents (5% (1 in 20) AEP event, 1% (1 in 100) AEP event, 1% AEP event plus allowance for climate change) are included in Plate 3.14. For this watercourse, a 40% climate change allowance has been applied to the 1% (1 in 100) AEP flood event (see Section 1.6 for further information on how climate change has been considered).

3.2.62 The area upstream of the A12 is flooded for all modelled events and shows impounding behind the A12. There are 12 residential properties on New Lane that are affected.

3.2.63 Downstream of the A12 crossing, there is some flooding (including to the Prested Hall complex) from the watercourse channels for all modelled events.

3.2.64 At the existing A12 crossing, the culvert soffit level (31.93mAOD) is lower than the peak water level during the 1% (1 in 100) AEP event plus 40% allowance for climate change (32.73mAOD). However, in this event there is greater than 2m freeboard between the peak modelled water level and the existing road surface level (35.25mAOD), so the existing A12 is not at risk of fluvial flooding for all flood events modelled.

Plate 3.14 Ordinary Watercourse 23 modelled baseline fluvial flood extents



Proposed scheme design

3.2.65 The proposed scheme would involve a new offline crossing of Ordinary Watercourse 23 by the proposed realigned mainline A12. The proposed scheme in this location would also include slip roads on both its north-west and south-east sides, as well as a new junction. Changes would include the addition of culverts under the new mainline, slip roads and junction, and the realignment of the watercourse channel.

With-scheme modelling (pre-mitigation)

3.2.66 With-scheme modelling has been used to assess the flood risk from Ordinary Watercourse 23. Plates showing with-scheme without-mitigation modelled flooding can be found in the modelling report – Annex L.

3.2.67 When modelled, the proposed scheme results in increased flood risk on the west side of Prested Hall for the 1% (1 in 100) AEP event and the 1% (1 in 100) AEP event plus 40% allowance for climate change.

3.2.68 Therefore, mitigation is required at this location. For more detail of the with-scheme (pre-mitigation) flooding mechanisms, please refer to the modelling report (Annex L).

Proposed mitigation

3.2.69 The following mitigation measures have been proposed to prevent adverse impacts to flood risk external to the proposed scheme:

- The 150mm diameter culvert, CL-23K, west of New Lane is replaced with a ditch system, to contain flows and protect the new A12 access road, involving minor works to the north and west ditches.
- An excavated flood storage area upstream of the proposed new A12, with a culvert outlet to discharge the stored water into the A12 culvert
- A flood bund is proposed alongside London Road.

3.2.70 Table 3.6 details the maximum volumes of water the proposed flood storage areas are modelled to contain, and the total length of time they are modelled to contain water.

Table 3.6 Modelled maximum water volume and total length of time water stored in southern proposed flood storage area

Flood event	Maximum volume of water stored in flood storage area	Total length of time water stored in flood storage area
5% (1 in 20) AEP	538 m^3	Approx. 24hrs*
1% (1 in 100) AEP	822 m^3	Approx. 30hrs*
1% (1 in 100) AEP plus 40% climate change	1612 m^3	Approx. 35hrs*

* Approximation extrapolated from longest model run completed (24hrs)

With-scheme modelling (including mitigation)

3.2.71 The mitigation described in the section above has been included in the with-scheme modelling. The modelled change in flood extent caused by the proposed scheme (including mitigation) for the 1% (1 in 100) AEP event plus 40% allowance for climate change is shown in Plate 3.15. Modelled changes in flood depth caused by the proposed scheme (including mitigation) are shown in Plate 3.16 (5% (1 in 20) AEP event) and Plate 3.17 (1% (1 in 100) AEP event plus 40% allowance for climate change).

Flood risk to the proposed scheme

3.2.72 When modelled, the proposed scheme (including mitigation) resulted in the proposed scheme carriageways being free from flood risk for all modelled events.

Flood risk from the proposed scheme

3.2.73 The proposed scheme results in increased flood levels immediately upstream of where the watercourse first meets the proposed mainline A12, causing a greater than 500mm increase in all events modelled. The area for which the proposed scheme causes increased flood risk would be acquired by National Highways for the purpose of the proposed scheme and would remain as unused land (i.e. this land does not and would not contain any receptors which could be harmed by the increase in peak flood depth). Therefore, it is not anticipated that any further flood mitigation would be required to mitigate this small area of increased flood risk.

3.2.74 Other than this small area of increased flood risk, the proposed scheme causes negligible (<10mm change in depth) and beneficial change to flood risk elsewhere for all modelled flood events.

Plate 3.15 Ordinary Watercourse 23 crossing – modelled change in flood extent as a result of the proposed scheme (including mitigation works) (1% (1 in 100) AEP event plus 40% allowance for climate change)

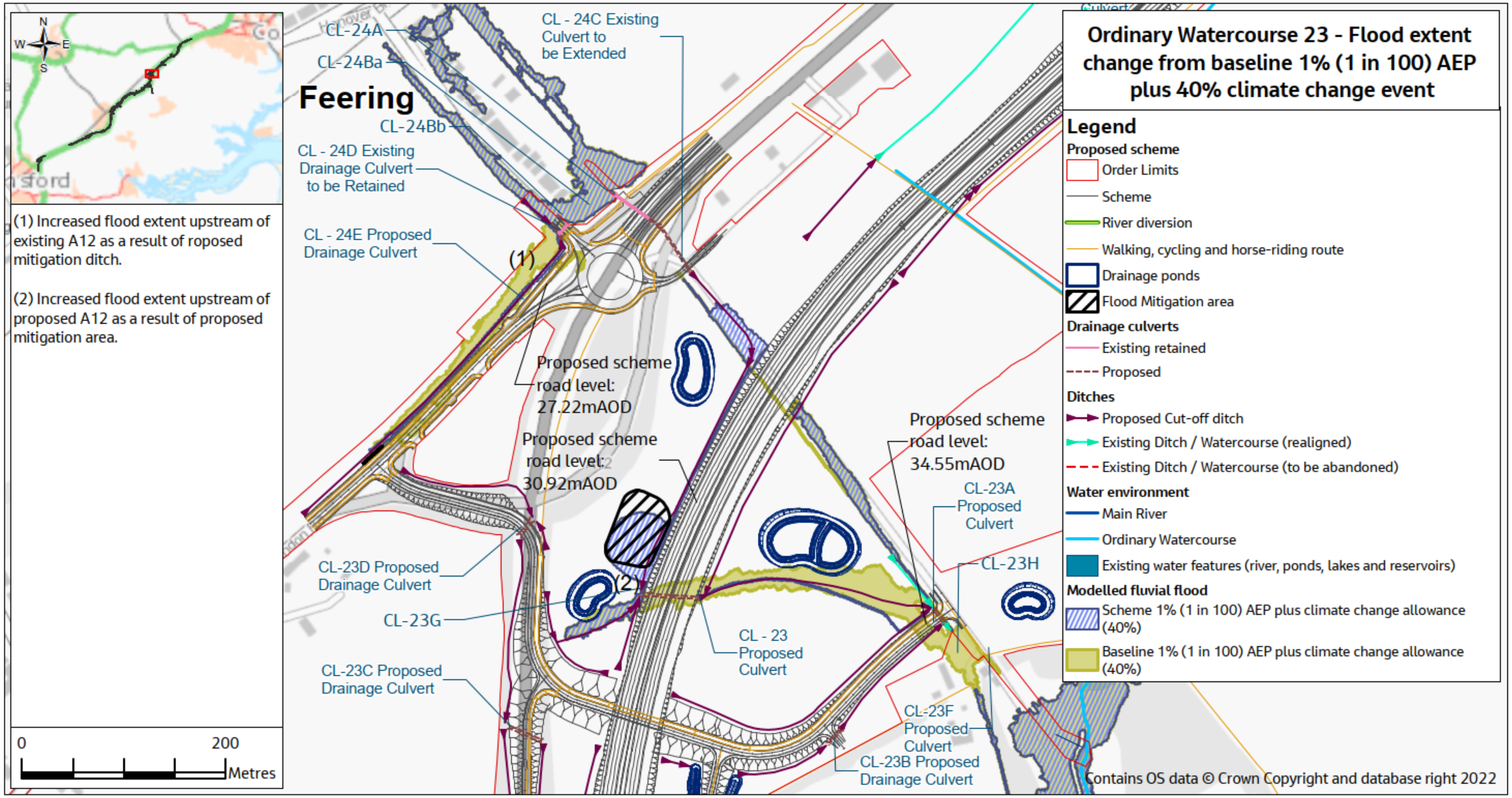


Plate 3.16 Ordinary Watercourse 23 crossing – modelled change in flood depths as a result of the proposed scheme (including mitigation works) (5% (1 in 20) AEP event)

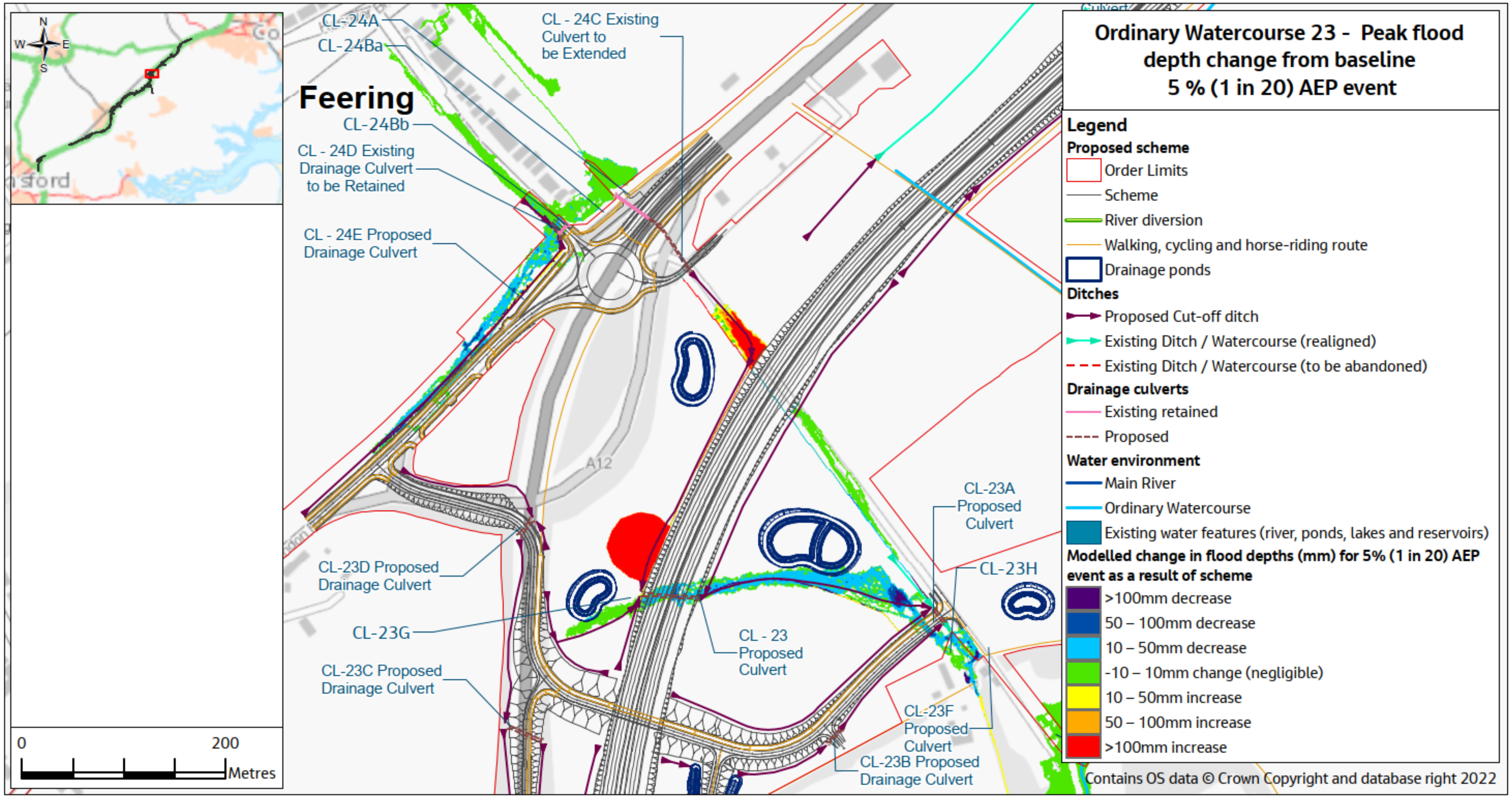
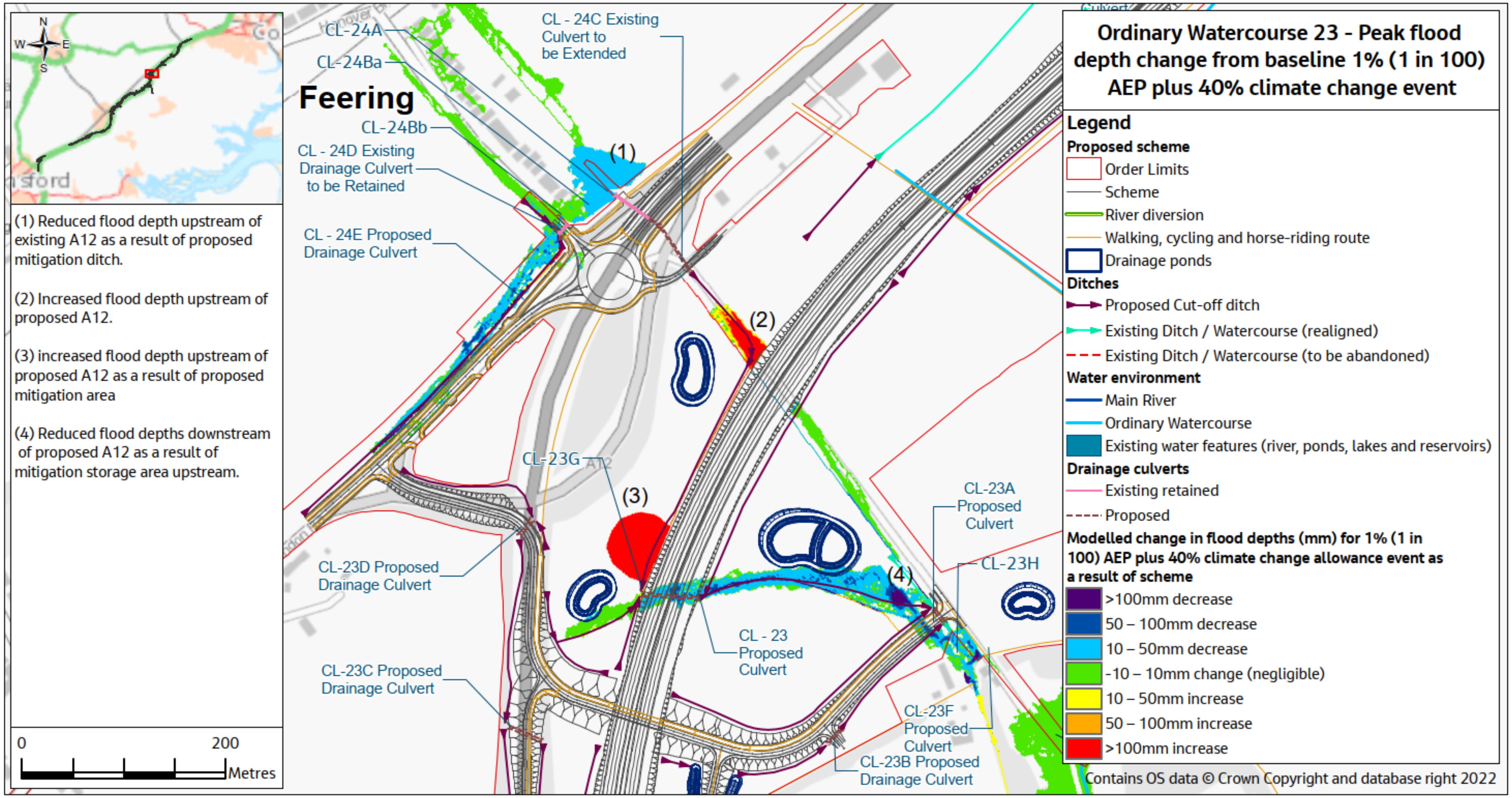


Plate 3.17 Ordinary Watercourse 23 crossing – modelled change in flood depths as a result of the proposed scheme (including mitigation works) (1% (1 in 100) AEP event plus 40% allowance for climate change)



Ordinary Watercourse 26

Baseline flood risk

3.2.75 A description of Ordinary Watercourse 26 is included in Annex M (shown in Plate 3.18). Ordinary Watercourse 26 is a field drain which originates south-east of the A12 (adjacent to Hall Chase) and flows north-west towards the A12. The watercourse is composed of two upstream reaches, referred to as eastern tributary and western tributary, originating approximately 600m upstream (south) of the A12 and flowing in a north-westerly direction.

3.2.76 The eastern and western tributaries converge immediately upstream of the A12, where a 450mm culvert (CL-26i) conveys part of the flow northerly under the A12 highway (TL 591200 223300). A 250m long toe drain diverts the rest of the flow north-east towards Hall Chase, where a 300mm culvert (CL-26ii) located west of Hall Chase access road conveys flows south under the A12 in a second location. A small (150mm) culvert (CL-26iii) connects the toe drain to a small area of depression east of Hall Chase.

3.2.77 Flows conveyed northwards under the A12 by CL-26i and CL-26ii flow in a northerly direction, converging upstream of the GEML railway where a culvert conveys flows north-east under the railway. Approximately 1.4km downstream of the A12 crossing, Ordinary Watercourse 26 reaches its confluence with the Roman River.

Baseline modelled flooding

3.2.78 Modelled baseline flood extents (5% (1 in 20) AEP event, 1% (1 in 100) AEP event, 1% AEP event plus 40% allowance for climate change) are included in Plate 3.18 (see Section 1.6 for further information on how climate change has been considered).

3.2.79 The upstream soffit level of the existing A12 crossing structure (CL-26i, 450mm diameter) (40.22mAOD) is lower than the peak water level during the 1% (1 in 100) AEP event plus 40% allowance for climate change (40.60mAOD). However, the road level of the existing A12 in this location is 41.31mAOD, so there is 0.71m freeboard between the peak water level during the 1% (1 in 100) AEP event plus 40% allowance for climate change and the road level. Therefore, the existing A12 is not at risk of flooding during the most extreme flood event modelled.

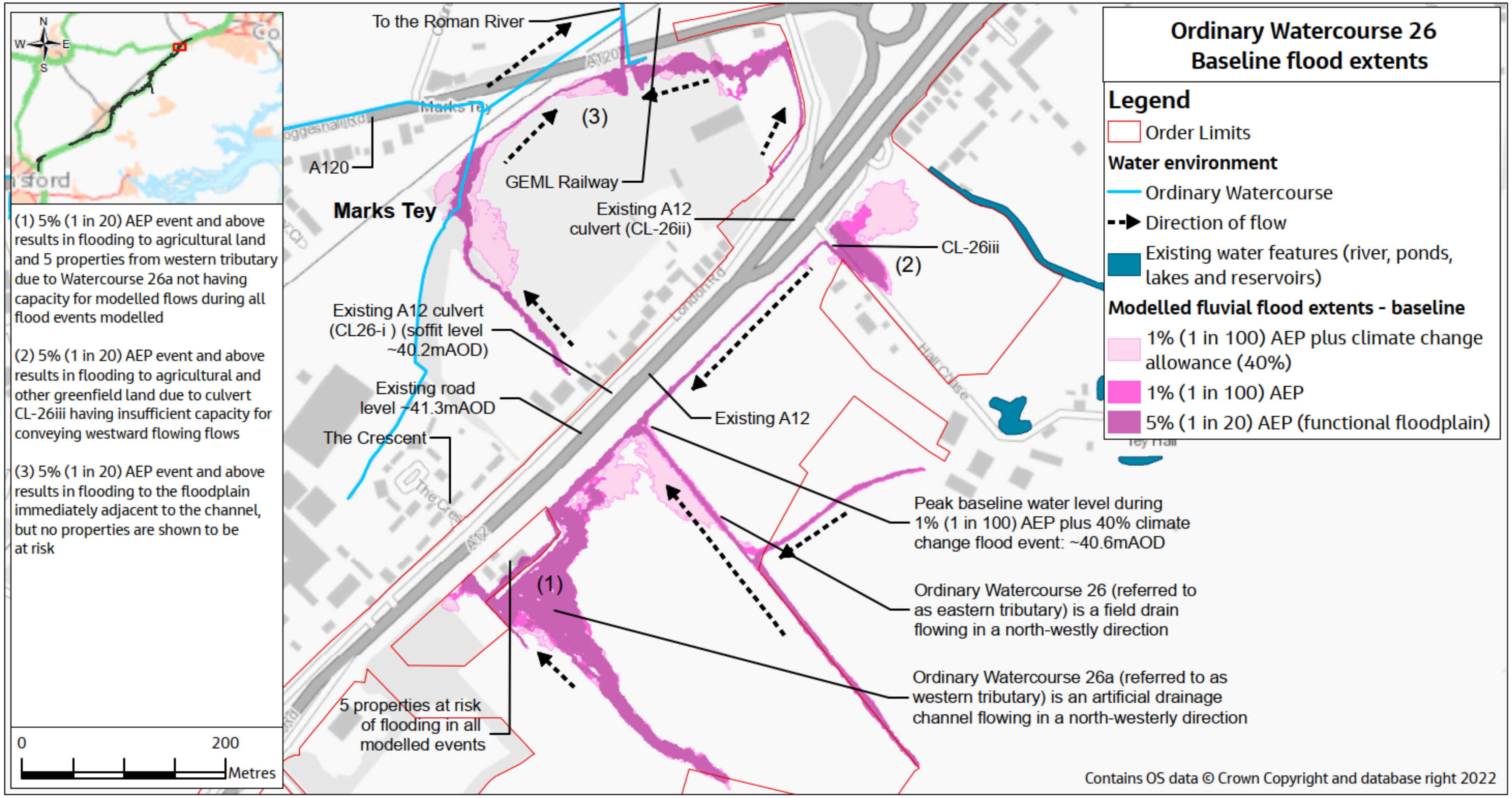
3.2.80 Upstream of the A12 crossing, the western tributary is unable to contain flows for all modelled events and results in flooding to five residential properties on the south-eastern side of the A12, opposite the entrance to The Crescent. These properties are predicted to flood to depths of up to 230mm during a 1% (1 in 100) AEP event plus 40% climate change allowance.

3.2.81 Where the western and eastern drains converge upstream of the A12 crossing, agricultural or other greenfield land is flooded for all modelled events. Flows not conveyed south-west under the A12 by CL-26i flow north-east along a toe drain towards CL-26ii (300mm diameter). Only a small portion of these flows are conveyed north-west under the A12 by CL-26ii. Most of these flows overtop Hall Chase and pond in the field north-east of Hall Chase (Hall Chase and the field to the north-east flood during all modelled events).

3.2.82 Downstream of the existing A12, for all modelled flood events there is some flooding to the floodplains, but no properties are shown to be at risk of flooding. Downstream of the GEML railway, flows remain in-channel for all modelled flood events.

3.2.83 The road level of the existing A12 in this location (44.00mAOD) is higher than the peak water level during the 1% (1 in 100) AEP event plus 40% allowance for climate change (40.98mAOD). Therefore, the existing A12 is not at risk of flooding during the most extreme event modelled.

Plate 3.18 Watercourse 26 modelled baseline fluvial flood extents



Proposed scheme design

3.2.84 The proposed scheme would involve a new offline crossing of Ordinary Watercourse 26 and would include three new circular culverts to convey flow through the proposed scheme mainline and the roundabout (CL-26A, CL-26B, CL-26C – see Table 3.7 for details). Existing culvert CL-26i would be retained unmodified.

3.2.85 The proposed scheme would cut across the flow path of the eastern tributary. A new circular concrete culvert (CL-26A, 450mm diameter, length 82m) would convey the eastern tributary flow under the proposed mainline and discharge into a newly excavated 2m-wide ditch which would direct water towards another new circular culvert (CL-26B, 450mm diameter, 16m length) that would outfall into a ditch within the central island of a new roundabout. The eastern tributary upstream of the new mainline would be regraded to produce a smooth gradient between the open and culverted sections.

3.2.86 The proposed scheme western roundabout arm would cut across the western tributary. As part of the proposed scheme, the tributary would be redirected via a 2m-wide open channel running along the southern toe of the roundabout arm embankment as it approaches the roundabout. The new channel would outfall via a 450mm diameter, 16m long circular culvert (CL-26C) into a new drainage ditch within the central island of the proposed roundabout.

3.2.87 Flows from the western and eastern tributaries would combine in the middle of the proposed roundabout, where a newly excavated ditch would direct flows to the existing CL-26i which would convey the flows north-west under the existing A12.

3.2.88 The proposed scheme drainage design includes two highway drainage attenuation ponds immediately west of the new junction 25 roundabout. These ponds are located within the floodplain of the western tributary, and as such, flood protection bunds have been included in the design of the ponds.

Table 3.7 Proposed new Ordinary Watercourse 26 culverts

Culvert	Details	Purpose
CL-26A	Diameter: 450mm Length: 82m	To convey eastern tributary under new A12
CL-26B	Diameter: 450mm Length: 16m	To convey eastern tributary north-west into the middle of the new junction 25 roundabout from upstream of the roundabout (downstream of CL-26A)
CL-26C	Diameter: 450mm Length: 16m	To convey western tributary north-east into the middle of the new junction 25 roundabout

With-scheme modelling (pre-mitigation)

3.2.89 With-scheme modelling has been used to assess the flood risk from Ordinary Watercourse 26 to and from the proposed scheme. Plates showing with-scheme without-mitigation modelled flooding can be found in the modelling report – Annex L.

3.2.90 When modelled, the proposed new slip roads and junction 25 roundabout are at risk of flooding during the 1% (1 in 100) AEP event plus 40% allowance for climate change (junction 25 roundabout experiences flood depths of 50–70mm). The addition of the proposed culverts would result in more water being directed into the existing culvert CL-26i, which would cause a notable increase in peak flow to the downstream channel (including resulting in a 25mm increase in maximum water levels within the toe drain alongside the railway line during a 1% (1 in 100) AEP plus 40% climate change allowance event). Therefore, flood mitigation is required at this location. For more detail of the with-scheme (pre-mitigation) flooding mechanisms please refer to the modelling report (Annex L).

Proposed mitigation

3.2.91 The following mitigation measures have been proposed:

- An excavated floodplain compensation area located approximately 30m upstream of the proposed culvert CL-26A (area: 2,200m2, base level: 40.2mAOD, maximum depth of excavation: 2.5m) with a 300mm diameter outlet pipe
- Excavated channels to divert flow into the excavated flood storage area from both the east and west tributaries

With-scheme modelling (including mitigation)

3.2.92 The proposed mitigation has been included in the with-scheme modelling. The modelled change in flood extent caused by the proposed scheme (including mitigation) for the 1% (1 in 100) AEP event plus 40% allowance for climate change is shown in Plate 3.19. Modelled changes in flood level caused by the proposed scheme (including mitigation) are shown in Plate 3.20 (5% (1 in 20) AEP event) and Plate 3.21 (1% (1 in 100) AEP event plus 40% allowance for climate change).

3.2.93 Table 3.8 details the maximum volume of water the proposed floodplain compensation area is modelled to contain, and the total length of time the flood storage area is modelled to contain water during each of the events modelled.

Table 3.8 Modelled maximum water volume and total length of time water stored in proposed flood storage area

Flood event	Maximum volume of water stored in flood storage area (m^3)	Total estimated length of time water stored in flood storage area
5% (1 in 20) AEP	538	35hrs*
1% (1 in 100) AEP	822	43hrs*
1% (1 in 100) AEP plus 40% allowance for climate change	1,612	50hrs*

Approximation extrapolated from longest modelled run (24hrs)

Flood risk to the proposed scheme

3.2.94 The flood storage area holds back flood flows and lowers the peak flow through culvert CL-26i (in comparison to the baseline and the with-scheme without mitigation scenarios). Inclusion of the proposed mitigation measures results in the proposed scheme carriageway no longer being at risk of flooding (for all flood events modelled).

3.2.95 With-scheme modelling has been used to assess the flood risk from Ordinary Watercourse 26 to the proposed scheme. Table 3.9 details the anticipated finished proposed scheme road levels and peak modelled water level during the 1% (1 in 100) AEP event plus 40% allowance for climate change.

3.2.96 Despite a proportion of the east drain flows being conveyed into the storage area by the proposed mitigation, a considerable amount of ponding against the proposed scheme would still occur (to depths of up to 200mm at the inlet of CL-26A in a 1% (1 in 100) AEP event plus 40% allowance for climate change). However, Table 3.9 demonstrates that the finished road levels of the proposed scheme would be safe from fluvial flooding at this location, with freeboard to the finished road level in excess of 2m for the 1% (1 in 100) AEP event plus 40% allowance for climate change.

Table 3.9 Proposed scheme road levels and peak modelled with-scheme water level during 1% (1 in 100) AEP event plus 40% allowance for climate change

Proposed scheme element	Peak modelled with-scheme 1% (1 in 100) AEP event plus 40% allowance for climate change water level (mAOD)	Lowest proposed finished road/surface level (mAOD)	Freeboard between peak modelled water level and finished road/surface level (m)
Upstream of southern road embankment	40.72	43.27	2.55
Within roundabout	40.55	40.70	0.15

Flood risk from the proposed scheme

3.2.97 Despite a proportion of the east drain flows being conveyed into the proposed floodplain compensation area, some of the east drain flows would continue flowing along their original alignment towards the proposed A12. In the 1% (1 in 100) AEP event plus 40% allowance for climate change, this would result in ponding (to depths of up to 200mm) against the proposed-A12 embankment at the inlet of CL-26A. The increased flood depths would be constrained to within the watercourse channel.

3.2.98 Aside from this area (and the proposed flood storage area and mitigation channels), the proposed scheme (including mitigation measures) results in a negligible or beneficial impact on flood risk elsewhere for all flood events modelled.

3.2.99 For all modelled events, the proposed scheme (including mitigation measures) eliminates Ordinary Watercourse 26 associated flooding near Hall Chase, because flows associated with both Ordinary Watercourse 26 tributaries upstream of the new A12 would be captured and directed to the flood storage area before being conveyed northwards through the proposed scheme by the new culverts and ditches (i.e. no flows would flow east and pond near Hall Chase).

3.2.100 As a result of the flood storage area capturing flows and lowering peak forward flow through culvert CL-26i in comparison to the baseline scenario, areas downstream of culvert CL-26i experience reduced flood depths in all modelled events. In addition, the properties immediately upstream of the existing A12 which experience flooding in the baseline scenario (opposite the entrance to The Crescent) experience shallower flooding (up to 10–50mm lower in all modelled events) as a result of the proposed scheme (including mitigation measures).

Plate 3.19 Ordinary Watercourse 26 crossing – modelled change in flood extent as a result of the proposed scheme (1% (1 in 100) AEP event plus 40% allowances for climate change)

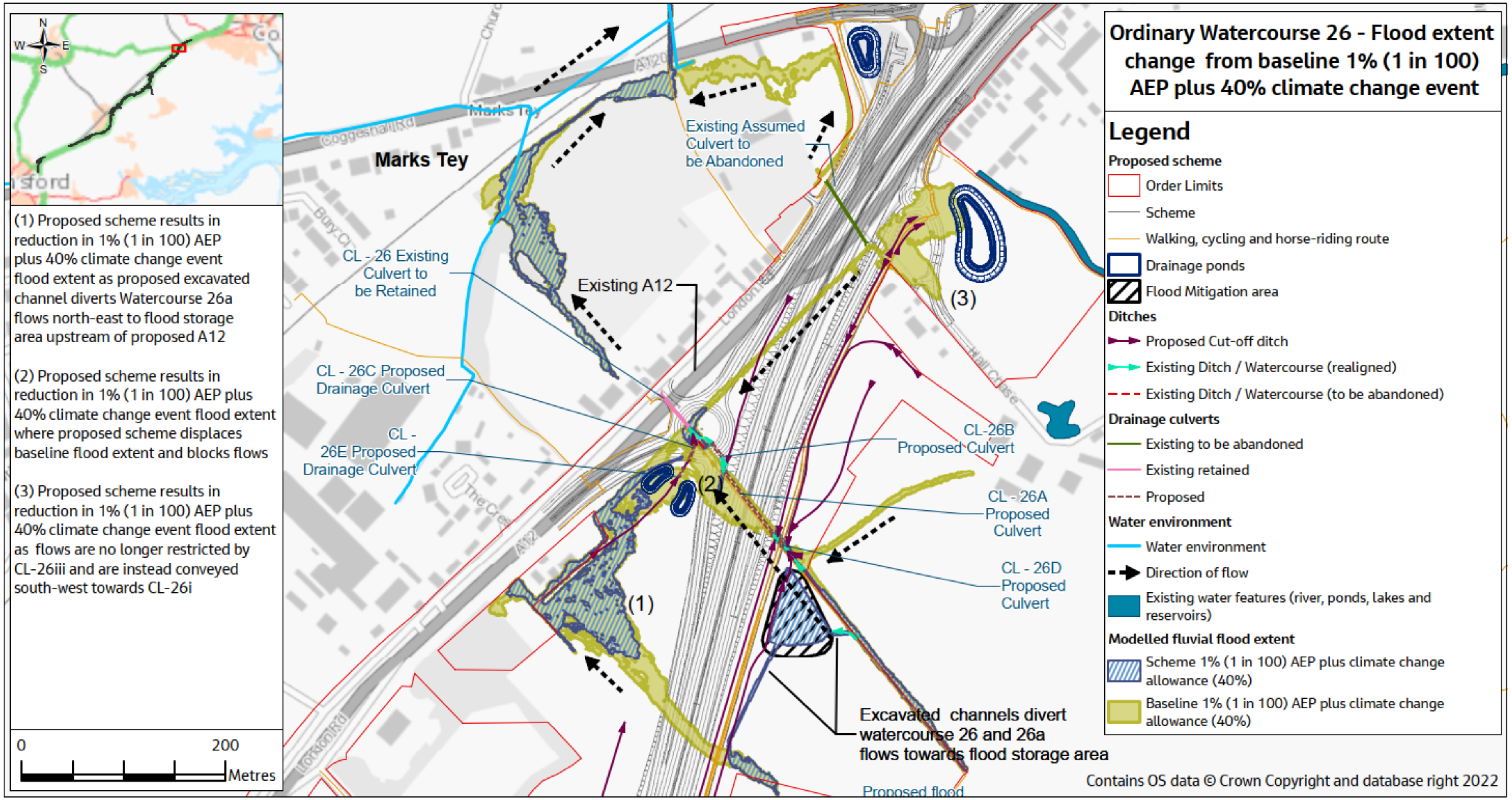


Plate 3.20 Ordinary Watercourse 26 crossing – modelled change in flood levels as a result of the proposed scheme (5% (1 in 20) AEP event)

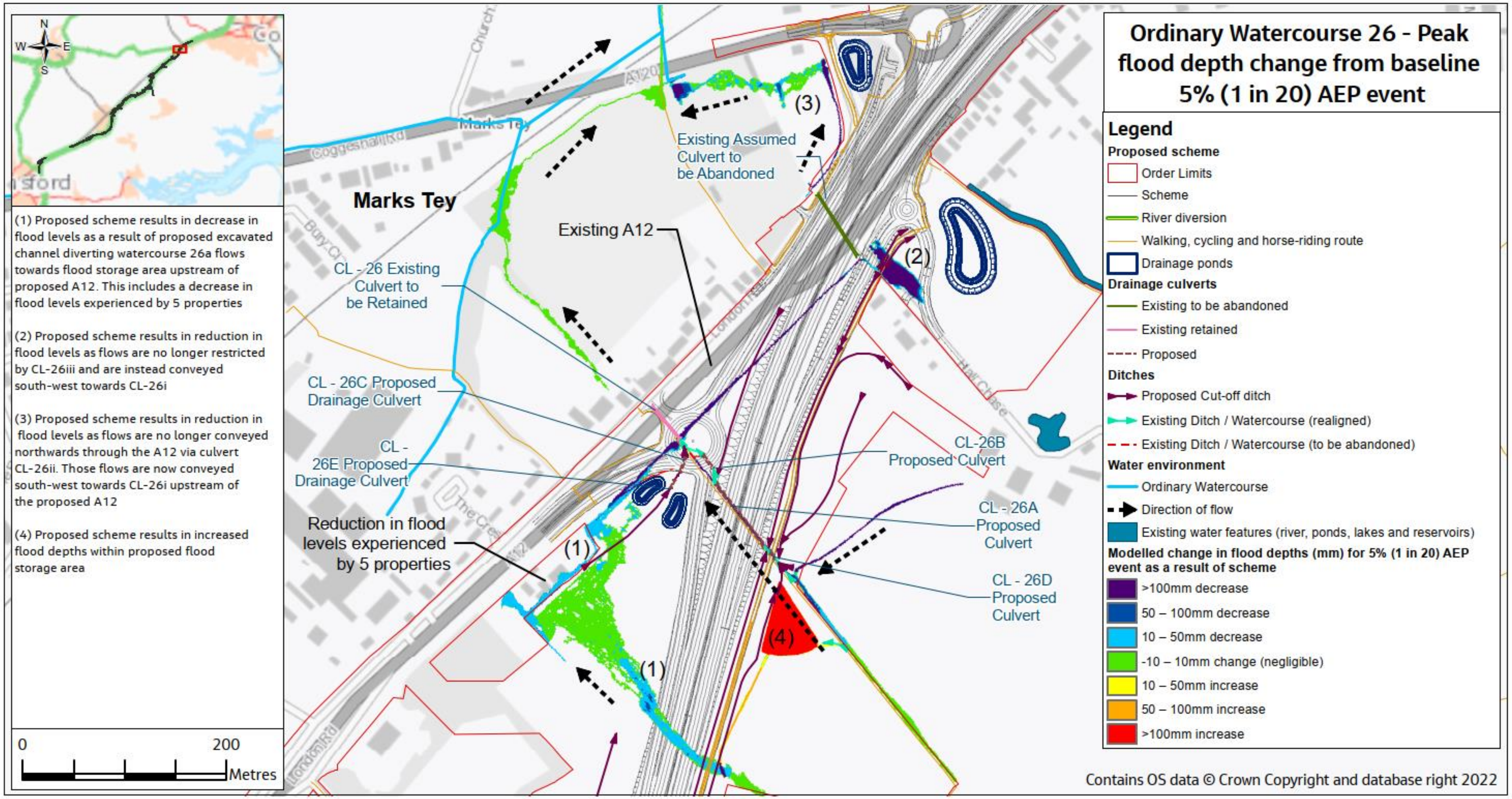
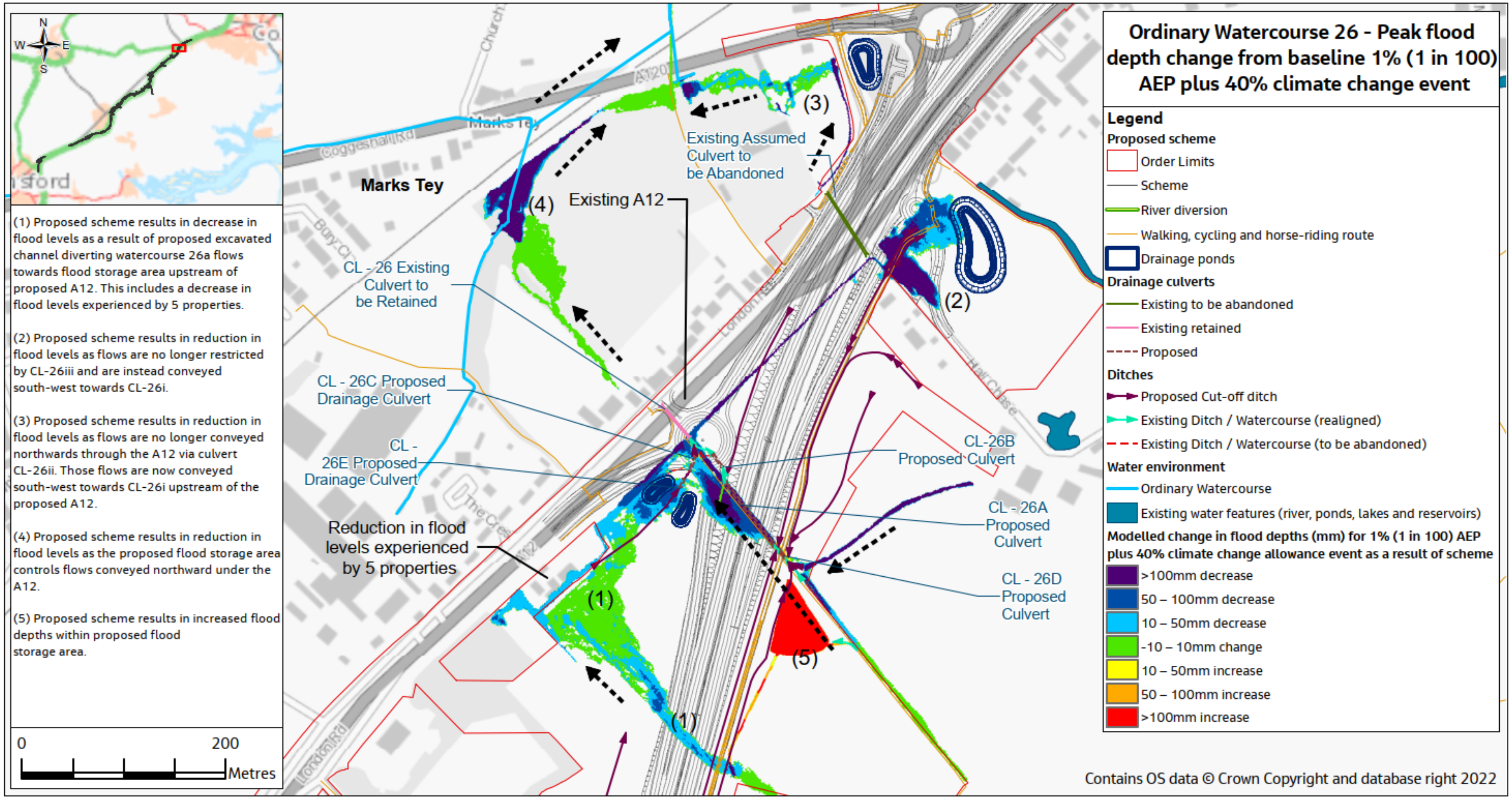


Plate 3.21 Ordinary Watercourse 26 crossing – modelled change in flood levels as a result of the proposed scheme (1% (1 in 100) AEP event plus 40% allowance for climate change)



3.3 Inworth Road

Proposed scheme design

3.3.1 The proposed scheme works to Inworth Road are illustrated in Annex A. To accommodate the predicted traffic flow and improve the safety of road users along Inworth Road, carriageway widening between the proposed junction 24 roundabout and the Perrywood Garden Centre has been proposed. The proposed carriageway widening ranges from 0.25m to approximately 1.5m. The main purpose of the widening would be to improve the substandard width of the existing carriageway and also to remove the pinch-points along the curvatures of the road to facilitate the smooth flow of traffic and reduce the risk of collisions between heavy goods vehicles.

3.3.2 The proposed works to Inworth Road described above were not included or assessed in the Preliminary Environmental Information Report (Highways England, 2021), as these elements of the proposed scheme were still in development.

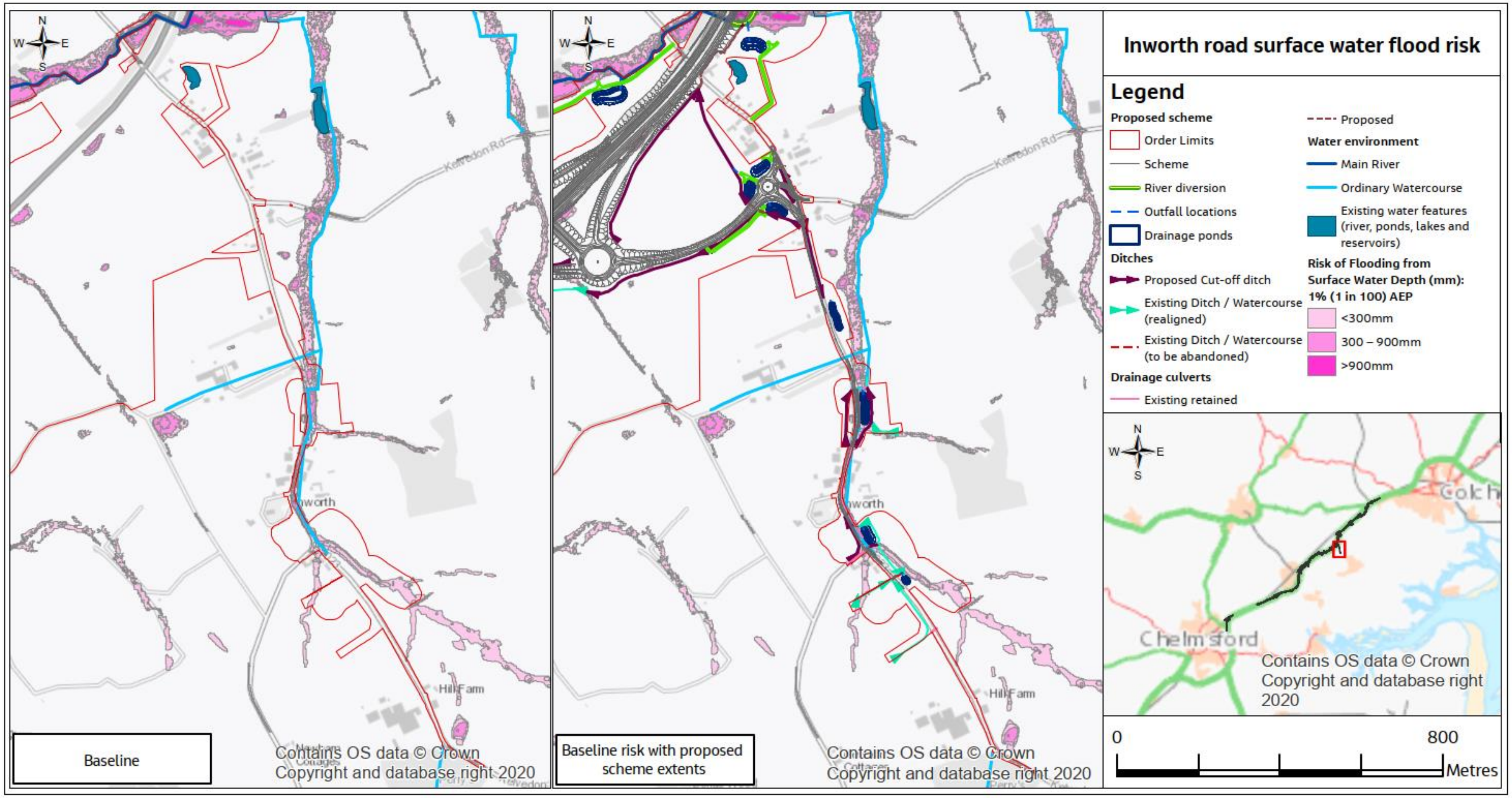
Baseline flood risk

3.3.3 Several Ordinary Watercourses (Ordinary Watercourses 34, 34a, 34b, 34c and 21) are closely aligned with, or crossed by, Inworth Road. The Environment Agency (2020c) RoFSW mapping has been consulted in the assessment of baseline flood risk associated with Ordinary Watercourses (as well as surface water flood risk).

3.3.4 The Environment Agency RoFSW mapping (Environment Agency, 2020c, shown on Annex D and Plate 3.22) shows Inworth Road to be at risk of flooding. The mapping shows several flow paths converging on Inworth Road, running northwards along the road, before diverging from the road approximately 130m north of The Red Dog restaurant and flowing north-east through farmland (crossing Kelvedon Road) and discharging into Domsey Brook approximately 370m upstream of the existing western A12 Domsey Brook crossing.

3.3.5 The RoFSW mapping indicates that the road could be at risk of flooding from Ordinary Watercourses in the range of 300–900mm depth in a 1% (1 in 100) AEP event (Plate 3.22). Residents of Inworth Road have also provided photographs showing the road experiencing flooding.

Plate 3.22 Environment Agency RoFSW mapping: Surface water flood risk water depth in a low risk scenario (1% (1 in 100) AEP event)



Flood risk to the proposed scheme

3.3.6 The proposed scheme works to Inworth Road are described in paragraph 3.3.1. Given that the proposed scheme at Inworth Road would consist primarily of online widening of the road, the high risk of flooding from Ordinary Watercourses to the existing road could equally apply to the finished proposed scheme.

Flood risk from the proposed scheme

3.3.7 The proposed scheme at Inworth Road consists primarily of online widening of the road. Unmitigated, widening would result in increased runoff of surface water from the road, which could result in a small increase in existing flood risk to local receptors, including properties and Inworth Road itself.

3.3.8 It is anticipated that the proposed scheme surface water drainage design would mitigate any increased flood risk caused by the increase in surface water runoff as a result of road widening.

Mitigation

3.3.9 For the purpose of this FRA, a precautionary approach has been taken and it has been assumed that the proposed drainage would only mitigate the impact of the additional paved areas as a result of the proposed scheme widening (i.e. there would be no capacity in the network for any additional flood flows). Flood storage areas have therefore been designed following this approach, using a hydrological assessment to calculate surface water flows towards the road from external catchments.

3.3.10 The proposed mitigation areas would reduce the existing flood risk to the road and protect the road from surface water flood events up to a 1% (1 in 100) AEP event plus climate change allowance.

3.4 Other unmodelled Ordinary Watercourse crossings

3.4.1 The proposed scheme would include modifications to existing watercourse crossings where the main alignment embankments would be widened. The proposed scheme would also include new watercourse crossings where localised offline realignment is required and where new access roads and access tracks are proposed.

3.4.2 The design process for Ordinary Watercourse crossings is complex, taking account of a range of design criteria and constraints to develop the most appropriate crossing for each watercourse.

3.4.3 During the design process, the decision-making hierarchy adopted was to retain the existing culvert or to extend the culvert on a ‘like-for-like’ basis to accommodate the proposed scheme wherever possible. Where this could not be achieved, a replacement culvert would be provided.

3.4.4 Where practicable, proposed new culverts and culvert extensions would be designed following the design principles and standards outlined in paragraph 3.6.3 – these are intended to reduce the risk of flooding as a result of any culvert works.

3.4.5 Flood risk to the proposed scheme from Ordinary Watercourse crossings has been assessed as part of the preliminary culvert assessment. Where existing or proposed culverts have hydraulic capacity to pass the 1% (1 in 100) AEP event plus 40% allowance for climate change, the flood risk at the crossing is considered low.

3.4.6 The risk to the proposed scheme from flooding associated with new crossings of Ordinary Watercourses is considered to be low given the integration of design principles and standards outlined in paragraph 3.6.3 into proposed scheme design.

3.4.7 Where the preliminary culvert assessment indicated the potential for insufficient hydraulic capacity within culverts, or where existing mapping indicated additional flood risk from the watercourse unrelated to crossing capacity, further assessment has been undertaken. Where levels of risk could not be established using hydraulic calculations, hydraulic modelling has been undertaken. At culverts where initial assessment indicated culverts have adequate capacity, no modelling has been undertaken, and the existing risk has been assessed as being low.

3.5 Potential impacts from the proposed scheme

Unmodelled Ordinary Watercourses

3.5.1 There is potential for the proposed scheme to have an adverse impact on flood risk associated with Ordinary Watercourses. For example, changing of culvert geometry or building within the floodplain could increase water levels upstream or downstream of the proposed scheme, reduce floodplain storage volume or pass additional flood flow downstream, increasing the risk of flooding.

3.5.2 However, it is considered that the proposed scheme would have a negligible impact on flooding associated with Ordinary Watercourses at new watercourse crossings due to the integration of design principles and standards outlined in paragraph 3.6.3 into the design for any new culvert. None of the culvert works proposed at unmodelled crossings would involve increasing existing hydraulic capacity, and therefore there should be no increase in flood risk downstream because of the proposed scheme.

3.5.3 Extension of existing culverts has been assessed, with none considered to result in a significant increase in flood risk upstream (see Annex N) as a result of the increased head loss along the culvert. Displacement of flood water from areas immediately upstream has also been considered. Where these occur, any potential impacts results from the proposed scheme are likely to be within land acquired by compulsory acquisition and flow into the described proposed scheme drainage.

3.6 Mitigation

3.6.1 This section provides details of the proposed flood risk management measures to ensure that the proposed scheme is not at risk from fluvial flooding and does not result in increased flood risk elsewhere.

Culvert design

3.6.2 Culverts on Ordinary Watercourses generally have small catchments (under 5km^2) and therefore would be designed to convey flows up to a 1% (1 in 100) AEP event including a 40% climate change allowance as rainfall intensity allowances are more appropriate for use in small catchments.

3.6.3 The proposed culverts have been designed in accordance with the requirements of DMRB CD 529 (National Highways, 2021) and the CIRIA (2019) guidance C786. The design assumptions incorporated to size the culverts include freeboard requirements to reduce risk of blockage or under sizing of structures and include the following:

- The proposed culverts have been designed to convey the 1% (1 in 100) AEP event plus a 40% allowance for climate change.
- The Revitalised Flood Hydrograph Method has been used to estimate the resulting discharge rates (flood hydrology peak flows) for each affected watercourse.
- A freeboard and sediment allowance has been provided in accordance with CIRIA C786.

- For circular culvert lengths >12m, the proposed culvert is to be a minimum of 1.2m in diameter. For culverts >1.5m in diameter, a box culvert has been considered.
- For box culvert lengths >12m, the proposed culvert is to be a minimum 1.2m both in span and height to facilitate access for maintenance.
- Where the existing culvert hydraulic capacity has been found to be adequate, the existing culvert extension would retain the existing pipe culvert alignment, geometry and gradient. It is assumed that no mitigation would be required.
- Where the existing culvert hydraulic capacity has been found to be inadequate, providing a larger diameter culvert would increase the flood risk downstream and would be constrained by existing road levels. Therefore, it is assumed that the culvert extension would also retain existing pipe culvert geometry and gradient.

Existing culverts

3.6.4 Extensions of existing culverts have generally maintained the existing culvert capacity (culvert extension would retain existing pipe culvert geometry and pipe gradient). Modifications are required for 10 existing culverts to reduce risk to the proposed scheme.

3.6.5 A summary of the existing culverts is presented in Annex N.

3.6.6 To assess the potential impacts on flooding, an assessment of required sizing for each culvert crossing was undertaken for the design flood event. This preliminary sizing was undertaken using the discharge capacity graphs for circular culverts from CIRIA (2019) C786. Where culverts were found to have potential to cause an adverse flood impact (due to not passing the design flood event) or where there could be flood risk to the proposed scheme, further hydraulic analysis has been undertaken in greater detail using hydraulic modelling or HY-8 Culvert Analysis software (U.S. Department of Transportation, Federal Highway Administration, 2021).

3.6.7 As shown in Table 3.10, five existing culverts were found to have insufficient capacity. Thirteen culverts have sufficient hydraulic capacity, but their diameter is smaller than the required diameter based on current design principles, including freeboard to culvert soffit and embedment depth.

3.6.8 Five existing culverts included in Table 3.10 where existing culvert hydraulic capacity was found to be insufficient have been assessed through detailed hydraulic modelling. For the thirteen culverts where the culverts are identified as being able to freely convey the design flow, there would be no increase in existing flood risk to and from the proposed scheme. Freeboard and embedment provide an allowance for floating debris and minor blockage risk. The potential blockage risk has been assessed in accordance with CIRIA C786 and is presented in Annex P.

3.6.9 Existing culvert CL-28 would be further investigated, and checks would be performed taking into account the flow diverted from the River Ter.

Table 3.10 Existing culverts with insufficient freeboard and sediment allowance based on current design standards

Culverts	Freeboard to road (available cover above culvert) (m)	Comments
CL-01A.1	No vertical alignment information available for pond access tracks.	Existing culvert hydraulic capacity was found to be sufficient. However, the estimated required pipe culvert diameter including freeboard and embedment is greater than the diameter of the existing culvert.
CL-01	1.17	
CL-01.1	-	
CL-02	1.21	
CL-10	0.83	
CL-11A	3.24	
CL-12A	1.60	
CL-12A.1	2.10	
CL-30	2.69	
CL-IWR-4	-	Existing culvert hydraulic capacity assumed to be sufficient. However, the estimated required pipe culvert diameter including freeboard and embedment is likely to be greater than the diameter of the existing culvert.
CL-IWR-7	-	
CL-IWR-8	-	
CL-07	2.70	Existing culvert hydraulic capacity was found to be insufficient and the estimated required pipe culvert diameter including freeboard and embedment is greater than the diameter of the existing culvert. Confirmation required on assumed pipe diameter of existing culvert. A hydraulic analysis of these existing culverts has been undertaken using hydraulic modelling and appropriate mitigation measures have been proposed.
CL-21	2.02	
CL-24C	0.98	
CL-24D	-	
CL-26	-0.6	
CL-28	3.26	Existing hydraulic capacity found to be sufficient. Further checking is required taking into account the flow diverted from the River Ter, but the significant freeboard to the proposed road means no flood risk to the proposed scheme is anticipated.

3.6.10 Overall, the following has been concluded:

- Ten existing culverts would be extended on a like-for-like basis (i.e. with same dimensions and gradient). The preliminary assessment undertaken at this stage indicates that these proposed culvert extensions would have a negligible impact on flood risk as the existing culverts have sufficient capacity to pass the design event.

- Four culverts; CL-17, CL-21 (western part), CL-21A and CL-32, would be abandoned as the watercourses would be diverted and drained through proposed new culverts designed to current design principles.
- The rest of the existing culverts would be retained without alteration. In these locations, no change in flood risk would be anticipated. None of these culverts have been identified as causing a risk of flooding to the proposed scheme.

Proposed culverts

3.6.11 A summary of new proposed culverts is presented in Annex N. The proposed culverts would achieve the following:

- Draining of open catchments
- Draining proposed ditches
- Maintaining existing drainage ditches
- Convey flows from diverted watercourses

3.6.12 Design has been undertaken using appropriate assumptions where the existing drainage surveys were incomplete. The proposed culverts have been designed following the criteria presented in paragraph 3.6.3. In addition to the Ordinary Watercourses, there are a number of smaller culverts, or piped ditches, where service access routes or tracks cross the ditches. There would also be a requirement for the drainage of natural catchment areas at proposed junctions using pipe crossings/culverts. The proposed culvert sizes at these locations are assumed to be a minimum of 450mm in diameter in accordance with DMRB CD 529 (National Highways, 2021).

3.6.13 Design of the culverts to the design standards specified would ensure the proposed culverts would not increase the flood risk within the proposed scheme or elsewhere.

3.6.14 Where additional permanent watercourse crossings are identified as being required, they will be designed to pass the 1% (1 in 100) AEP plus 40% allowance for climate change to ensure no significant effect on flood risk.

Blockage risk

3.6.15 An initial assessment of the blockage risk for watercourse crossings has been undertaken in accordance with CIRIA (2019) C786 and is presented in Annex P. Where further assessment identifies the need for a trash or security screen to reduce risks, these would be included at the detailed design stage.

3.7 Residual risks

3.7.1 The residual flood risks from Ordinary Watercourses include the following:

- Blockages of culverts that reduce capacity to convey flows. The blockage risk has been assessed, and appropriate mitigation in the form of trash screens may be provided depending on the risk level to reduce residual risk. However, flooding may still occur.

- Blockage of flow control pipes at flood mitigation areas. In the event of blockage, this could result in additional flooding upstream of storage areas.
- Severe flood events which exceed the design capacity of the culverts.

3.8 Conclusion

3.8.1 Culvert design would ensure that the hydraulic capacity of new watercourse crossings is sufficient to convey flows up to the design event so that the proposed road is safe from flooding and that flood risk would not be increased elsewhere. Where potential impacts have been identified as a result of the proposed scheme, appropriate mitigation measures have been proposed. With this mitigation in place, fluvial flood risk from Ordinary Watercourses is considered to be low and there is negligible change in flood risk elsewhere as a result of the proposed scheme.

4 Surface water flood risk

4.1 Introduction

4.1.1 The construction of the widened road and proposed carriageway would result in an increase in impermeable area and consequently could increase the surface water runoff for any given rainfall event. Without mitigation, this would result in an increase in peak discharge rates, potentially increasing flood risk.

4.1.2 The proposed scheme includes proposed new culverts, extension of existing culverts, diversions of Ordinary Watercourses, modifications to existing drainage catchments and modifications to existing flows discharging into Main Rivers. All of these aspects of the proposed scheme are included within the Surface Water Drainage Strategy (Appendix 14.6 of the Environmental Statement[TR010060/APP/6.3]).

4.1.3 This section sets out the risk of surface water flooding and demonstrates how the proposed surface water drainage strategy contributes to ensuring that the proposed scheme is safe from flooding and does not increase flood risk elsewhere.

4.2 Baseline flood risk

4.2.1 The Environment Agency RoFSW mapping (Environment Agency, 2020c) details that the proposed scheme is predominantly within an area at medium risk (between 1% (1 in 100) and 3.3% (1 in 30) AEP) to low risk (between 0.1% (1 in 1,000) and 1% (1 in 100) AEP) of surface water flooding. However, there are areas designated as high risk (greater than 3.3% (1 in 30) AEP) of surface water flooding (see Annex D).

4.2.2 The mapping identifies that there is generally a high flood risk at the locations where the proposed scheme crosses a watercourse. The flood risk associated with Ordinary Watercourses has been assessed in detail in Section 3 and is not considered further here.

4.2.3 Away from Ordinary Watercourses or Main River locations, several overland flow routes and isolated areas of ponding were identified on or crossing the main A12 carriageway. The flood risk can be described predominantly as medium to low, with flood depths varying from below 300mm up to over 900mm depending on the location.

4.2.4 The most significant areas of surface water flood risk related to external flows are at the locations presented in Table 4.1. Areas of high and medium surface water flood risk have been identified across the main carriageway, haul routes and compound areas. Areas where flood water is predicted to pond in local low points without the influence of significant external flow paths have not been included. Where these areas of localised ponding are predicted to be on areas of the proposed scheme, they would be addressed by the proposed scheme drainage without causing significant impact elsewhere. Similarly, areas of flooding where the source of flooding appears to be within the highway boundary would also be dealt with as part of the proposed scheme drainage and so are not included within Table 4.1.

Table 4.1 Areas at risk of surface water flooding due to external flows

Location (NGR)	Description
TL 74077 07662 (close to chainage 9200 at the south end of the proposed scheme)	A high to medium surface water flood risk flow path has been identified running from north to south. The main flow path follows the route of an existing drainage ditch, with additional inflows from the residential area on the outskirts of Chelmsford to the west. The surface water flow path runs along the Order Limits to beyond the southernmost extent and then crosses the A12 carriageway in a culvert outside of Order Limits. The average flood depth is between 300mm and 600mm and the flood velocity mainly over 0.25m/s.
TL 74008 09210 (A130 roundabout connecting A130 main carriageway with Drovers Way and Winsford Way)	A high to medium surface water flood risk flow path has been identified running from north-west to south-east, with further component from the north-east. The flow path is likely to represent flooding against the road embankment or from existing drainage ditches, including from Ordinary Watercourse 2. The flow path then flows over the existing roundabout, before flowing north-east along the A130 or south along Winsford Way. The flood depth is described as between 300mm and 600mm while the flood velocity is predicted to be predominantly less than 0.25m/s.
TL 75988 10544 (A12 main carriageway at the height of Boreham Industrial Estate)	A high to medium surface water flood risk in this location appears to potentially be caused by flows from an Ordinary Watercourse combining with road and local runoff in a low topographical point on the carriageway. Based on Environment Agency (2020c) RoFSW mapping, the flood depth is described as between 300mm and 600mm and the flood velocity is predicted to be predominantly less than 0.25m/s. An historic flood event of medium severity has been recorded on National Highways Drainage Data Management System (i.e. DDMS) at this location. The description of the event detailed standing water on the A12 main carriageway resulting in flooding of the central reserve.
TL 80372 12523 (approximately 1,000m south-west of the north-east end of junction 21)	Review of the Environment Agency RoFSW mapping identified the presence of a high to medium surface water flood risk flow pathway. The flow path runs from south-west to north-east and then flows from north-west to south-east. The flood depth is predominantly shown to be below 300mm and the flood velocity over 0.25m/s.
TL 81969 13053	Two high to medium surface water flood risk flow paths are shown on the mapping at this location. The flow path that runs from west to east carries flows from Gershwin Boulevard Road. The flow path that runs from north-west to south-east is associated with overland flows generated within the residential area of Witham. Based on Environment Agency RoFSW mapping, the flood depth is between 300mm and 600mm and the flood velocity is predicted to be predominantly less than 0.25m/s. Flows combine with surface water flow paths on the existing A12.
TL 88182 20593	A high to medium surface water flood risk flow path has been identified running from north-west to south-east resulting in a surface water flood risk area on the A12 carriageway. The flood risk is associated with overland flows that lead to a low topographical point on the carriageway.

Location (NGR)	Description
	The flood depth is determined to be mainly between 300mm and 600mm, and the flood velocity is below 0.25m/s.
TL 90386 22441 (on A12 main carriageway approximately 380m north-east from the junction between A12 main carriageway and Easthorpe Road)	A high to medium surface water flood risk flow path is identified running from north-east to south-west, crossing the A12 carriageway. The flow path is associated with an existing ditch and overland flows from the area adjacent to the proposed scheme. Based on Environment Agency RoFSW mapping, the flood depth is predominantly below 300mm and the flood velocity over 0.25m/s.

4.2.5 Hydraulic modelling was undertaken as part of the local SWMPs. The models included both pluvial and Ordinary Watercourse components of surface water flooding and were tested for the following return periods:

- 5% (1 in 20) AEP
- 3.33% (1 in 30) AEP (Braintree and Witham SWMP only)
- 1.3% (1 in 75) AEP
- 1% (1 in 100) AEP
- 1% (1 in 100) AEP plus 20% allowance for climate change
- 0.5% (1 in 200) AEP

4.2.6 The models’ outputs include the following:

- Flood depth
- Flood velocity
- Flood hazard

4.2.7 Flood hazard is expressed as a function of the flood depth, flood flow velocity and a debris allowance dependent on the flood depth. The hazard rating was determined based on Flood Risks to People Phase 2, FD2321/TR1 (Defra and Environment Agency, 2006). The categories derived are presented in Table 4.2.

Table 4.2 Flood hazard rating based on Table 3.2 of FD2321/TR1 (Defra and Environment Agency, 2006)

Flood hazard rating (HR)		Description
HR < 0.75	Low	Caution – Flood Zone with shallow flowing water or deep standing water
0.75 ≥ HR ≤ 1.25	Moderate	Dangerous for some (i.e. children) – Danger: flood zone with deep or fast flowing water
1.25 > HR ≤ 2.0	Significant	Dangerous for most people – Danger: flood zone with deep fast flowing water
HR > 2.0	Extreme	Dangerous for all – Extreme danger: flood zone with deep fast flowing water

4.2.8 A summary of the surface water flood risk based on the local SWMPs is presented in Table 4.3.

Table 4.3 Summary of surface water flood risk within the Order Limits based on the local SWMPs

Local planning authority	Description
Braintree District Council	• The Order Limits cross the south-east end of Critical Drainage Area (CDA) W6. CDAs are areas designated as having critical drainage problems and where surface water from developments would generally be expected to be managed to a higher standard to contribute to a reduced risk of flooding. • Based on the modelling results for the 1% (1 in 100) AEP event plus 20% allowance for climate change, the proposed scheme is at surface water flood risk with predicted flood depth higher than 0.5m in places. The risk is associated with overland flows along the main carriageway as well as that from watercourses such as the River Brain. • The areas at surface water flood risk are predominantly consistent with the Environment Agency (2020c) RoFSW mapping.
Colchester Borough Council	• The proposed scheme is not located within an identified CDA. • The maximum flood depth varies predominantly between 0.1m and 0.5m, and the hazard varies between moderate and significant. • The maximum flood depth is described as 1.0m to 1.5m and the hazard rating is determined to be extreme. The flood risk is associated with the presence of a tributary of the Roman River at approximately NGR TL 93268 24606 and overland flow routes across the proposed scheme. • The areas at surface water flood risk are predominantly consistent with the Environment Agency (2020c) RoFSW mapping.
Chelmsford City Council	• The proposed scheme is not located within a CDA. • The maximum flood depth is predominantly between 0.25m and 0.5m and the hazard rating is described as moderate to significant. • The maximum flood depth is determined to be over 1.5m at the location where the proposed scheme crosses Boreham Brook and the hazard rating is described as extreme. However, the flood risk is associated with Boreham Brook, so this flooding has been considered within the fluvial flood risk section (Section 2 of this FRA). • The areas at surface water flood risk are predominantly consistent with the Environment Agency (2020c) RoFSW mapping.

4.2.9 A more detailed review was undertaken of the Braintree and Witham surface water modelling results for the 1% (1 in 100) AEP event plus 20% allowance for climate change as the proposed scheme crosses the south-east end of CDA W6. The mapping is shown in Annex D and determines that the predicted flood depth for most of the proposed scheme included within the CDA is over 50mm.

4.2.10 A review of National Highway's DDMS was undertaken to identify existing flood hotspots (see Annex I). Three flood hotspots were identified along the proposed scheme. A spot check of flood events suggests that these flood hotspots were due to blocked gullies or blocked gratings associated with V-shaped channels. It is worth noting however that many flood events were recorded without a description, so the cause of these flood events is unknown.

4.3 Flood risk to the proposed scheme

4.3.1 Surface water flood risk to the proposed scheme would be managed by the proposed surface water drainage. The surface water flood risk outlined in Section 4.2 has been taken into account in the development of the Surface Water Drainage Strategy (Appendix 14.6 of the Environmental Statement [TR010060/APP/6.3]). The drainage has been designed to ensure that the road remains operational in all flood events up to a 1% (1 in 100) AEP event plus a 40% allowance for climate change.

4.4 Potential impacts from the proposed scheme

4.4.1 The proposed scheme has the potential to impact existing surface water flood risk in the following ways:

- Constructing new features over existing overland flow paths, including culverts, which could impede the movement of water causing local changes to catchment drainage patterns and consequently flood risk.
- Altering surface water runoff rates from areas impacted by the proposed scheme, with potential for compaction of ground, altering of existing gradients and changes in vegetation levels. These could increase or decrease surface water runoff rates locally, but the impact on any receiving watercourse is anticipated to be low and would be expected to be negligible in the context of flows from a significant storm event.
- Causing an increase in impermeable area both temporarily during the construction phase and permanently at the operational phase. Unmitigated, this would lead to increased runoff rates, which could result in an increased surface water flood risk downstream.

4.5 Proposed surface water drainage

Design approach

4.5.1 The drainage for the proposed scheme has been developed in accordance with the proposed criteria outlined in Table 4.4. Further details, including other design criteria used, can be found in the Surface Water Drainage Strategy (Appendix 14.6 of the Environmental Statement [TR010060/APP/6.3]).

Table 4.4 Surface water drainage design criteria for the proposed scheme

Drainage design	Proposed criteria
Allowable discharge rates	Minimum practicable allowable discharge rate used to inform the proposed highway drainage design is 5l/s based on a minimum flow control diameter of 100mm for both hydrobrakes and orifice plates to reduce the risk of blockage.
Piped network	• Surface water carrier drains and filter drains within the proposed highway drainage systems are designed to accommodate a 100% (1 in 1) AEP event within the drainage pipes without surcharge. • A design check is carried out to ensure that a 20% (1 in 5) AEP event would not cause chamber surcharge levels to exceed the level of the chamber covers. • The proposed highway drainage system as a whole must be assessed for the consequences of exceedance flows associated with the 1% (1 in 100) AEP event plus climate change allowance (designed for 20%, sensitivity tested for 40%). Any flooding associated with the aforementioned design event is to be contained within the proposed highway boundary at depths and velocities that would not represent a safety risk for road users.
Attenuation storage	• Attenuation storage devices required throughout the proposed scheme are optimised for design storm events up to and including the 1% (1 in 100) AEP event plus 20% climate change allowance (and various storm durations from 15 minutes up to and including 24 hours) • Attenuation ponds would have a minimum freeboard of 0.3m

Proposed catchments and allowable discharge rates

4.5.2 Drainage Layout Plans, which include the existing, proposed and additional highway catchment areas, are presented in Annex A of the Surface Water Drainage Strategy (Appendix 14.6 of the Environmental Statement [TR010060/APP/6.3]).

4.5.3 The proposed surface water drainage for the proposed scheme would result in a reduction in discharge rates at the majority of proposed outfall locations as a result of the attenuation storage being provided. This is likely to have a negligible impact on flood risk elsewhere. However, in some locations, use of a minimum practicable discharge rate (of 5l/s) would result in a slight increase in discharge rates in comparison to the existing discharge or existing greenfield runoff rates. These locations are summarised in Table 4.5 and in the majority of cases are identified as having negligible impact on flood risk. However, in several locations on Ordinary Watercourse 23, it was identified that the increase was immediately upstream of Prested Hall, where anecdotal reports suggest there has been historic flooding from the watercourse. The minimum practicable discharge rate has been selected to reduce blockage risk and maintenance requirements and is based on standard industry practice. However, it is possible to reduce this rate. On Ordinary Watercourse 23 any increase in flows could impact a receptor that has experienced flooding in the past, while any blockage would be likely to cause flooding to open fields. Therefore the increased blockage risk and additional maintenance required are considered appropriate in this instance and discharge rates have therefore been reduced to 2.5l/s at some outfalls to match the existing cumulative discharge rate to the watercourse.

4.5.4 It should be noted that there are other outfalls (S1-OU19C, S1-OU19C1, S1-OU23C, S2-OU9, S2-OU15C1, S2-OU15D, S2-OU15H, S2-OU24A, S3-OU29, S3-OU20, S3-OU15B and S3-OU15C) which have greenfield runoff rate estimates less than 5l/s but where 5l/s is used as the practicable outfall discharge rate. These outfalls have been excluded from this assessment given that they discharge to existing outfall locations with higher existing case allowable discharge rates.

Table 4.5 Areas where minimum practicable discharge rate is higher than estimated greenfield runoff rates

Catchment	Greenfield runoff rates (l/s)	Min. practicable discharge rate (l/s)	Watercourse outfall	Flood risk implication
S1-OU7A	N/A	5	Outfall to Ordinary Watercourse 2	No receptors between the outfall to the Ordinary Watercourse and eventual discharge to the River Chelmer. Existing discharge is assumed to also be to a tributary eventually reaching the Chelmer. As such, there is anticipated to be negligible change in flood risk on the River Chelmer, and there are no sensitive receptors on Ordinary Watercourse 2 that would be impacted in the unlikely event of the 5l/s discharge resulting in additional flooding.
S1-OU24B	1.9	5	Outfall to Ordinary Watercourse 32	Ordinary Watercourse 32 flows east towards its confluence with the River Blackwater east of Maldon Road. Surface water flood mapping (Environment Agency, 2020c) indicates that in a 3.33% (1 in 30) AEP event, there is overland flow that flows parallel to the watercourse. This overland flow path is shown to flow between properties to the west of Maldon Road, before flowing over the road and ponding to the east before discharging into the River Blackwater. Two properties are shown to be in the flood extents in a 3.33% (1 in 30) AEP event, approximately 1.5km east of the proposed drainage outfall. A discharge rate of 5l/s compared to 1.91l/s is considered unlikely to make a significant difference to flood risk on the watercourse. Flows are likely to be small in comparison to flows within the watercourse, and any impact would be anticipated to be negligible and contained within fields to the north of the watercourse where flooding is predicted to occur prior to the watercourse reaching Maldon Road.

Catchment	Greenfield runoff rates (l/s)	Min. practicable discharge rate (l/s)	Watercourse outfall	Flood risk implication
S3-OU13	0.9	5	Existing field ditch/watercourse Assumed ultimate outfall to River Blackwater	The outfall is into a drain, part of Ordinary Watercourse 35. The surface water flood mapping indicates no existing flood risk on the watercourse prior to its confluence with the River Blackwater. The River Blackwater is significantly larger than Ordinary Watercourse 35, and as such, any minor change in flows would not be anticipated to impact flood risk on this watercourse.
S3-OU14	0.3	5	Proposed ditch, ultimate outfall to watercourse at CL-21A	Proposed ditch would be designed to take the flows from the outfall. This then flows towards Ordinary Watercourse 21a. As demonstrated in Section 3.2, this watercourse has mitigation provided to prevent an increase in flood risk.
S3-OU20	0.4	5	Proposed ditch, ultimate discharge to Domsey Brook	Proposed ditch into which the outfalls discharge would be designed to account for the flows without increasing flood risk. The ultimate outfall is to the Domsey Brook. At the S3-OU19 outfall into Domsey Brook, the proposed scheme would reduce discharge rates by at least 9l/s in all modelled events. Therefore, the proposed scheme would result in a localised reduction in flows into Domsey Brook.
S3-OU26B	0.9	5	Ordinary Watercourse 38	The discharge to the Ordinary Watercourse is immediately upstream of the Domsey Brook, with no sensitive receptors between the outfall and the confluence with the Main River. Given the small flows in comparison to the flows on the Domsey Brook, this would be anticipated to have a negligible impact on flood risk.
S3-OU27	1.2	5	Proposed ditch at north of culvert CL-29B, ultimate discharge to Ordinary Watercourse 39	Downstream of the S3-OU27 and S3-OU28 outfalls, surface water flood mapping (Environment Agency, 2020c) indicates that the existing Ordinary Watercourse 39 does not cause flooding in the 1% (1 in 100) AEP event prior to its confluence with the Domsey Brook. Given the small flows in comparison to the flows on the Domsey Brook, this would be anticipated to have a negligible impact on flood risk.

Catchment	Greenfield runoff rates (l/s)	Min. practicable discharge rate (l/s)	Watercourse outfall	Flood risk implication
S3-OU28	0.4	5	Outfall discharging to existing ditch and then into Ordinary Watercourse 39	
S3-OU27A	0.4	5	Outfall discharging to existing ditch, Ordinary Watercourse 40	Downstream of the outfalls, surface water flood mapping (Environment Agency, 2020c) indicates that the existing Ordinary Watercourse 40 does not cause flooding in the 1% (1 in 100) AEP event prior to its confluence with the Domsey Brook. Given the small flows in comparison to the flows on the Domsey Brook, this would be anticipated to have a negligible impact on flood risk.
S3-OU31	0.9	5	Proposed ditch, ultimate discharge to Domsey Brook	The outfalls discharge into ditches upstream of Ordinary Watercourse 41. The surface water flood mapping (Environment Agency, 2020c) indicates some overland flow from this watercourse in the 3.33% (1 in 30) AEP event. This flow is over greenfield land, and given the small magnitude of flow from the outfall, flood risk would not be anticipated to change significantly.
S3-OU32	1.1	5	Existing drainage ditch, ultimate outfall to Ordinary Watercourse 41	

Assessment of exceedance flows

4.5.5 There is a requirement to manage exceedance flows from the piped networks up to the 1% (1 in 100) AEP storm event with an allowance for climate change. As per Environment Agency climate change guidance (Environment Agency, 2021a), the rate of runoff from the site and any onsite flooding has been assessed using the upper end climate change allowance.

4.5.6 Exceedance flows have been assessed via the FloodFlow module in MicroDrainage for the critical 1% (1 in 100) AEP event with both a 20% and 40% allowance for climate change. A summary is included in the Surface Water Drainage Strategy (Appendix 14.6 of the Environmental Statement [TR010060/APP/6.3]).

4.5.7 Each catchment has been assessed and categorised as one of the following:

- Catchment with no surface water flooding for all events up to the 1% (1 in 100) AEP plus climate change allowance of 40%: Catchments in this category have not been assessed further as there is no flooding predicted.
- Catchment with surface water flooding contained within the proposed highway boundary
- Catchment with surface water flooding including to beyond the proposed highway boundary: These catchments have been assessed to ensure there is no increase in flood risk as a result of the proposed scheme. This includes assessment of total volumes of flood water leaving the highway boundary in comparison to the existing situation.

4.5.8 The latter two categories have been assessed further below.

4.5.9 Catchments with surface water flooding contained within the proposed highway boundary have been identified using the Exceedance Flow Analysis Maps included within Annex B of the Surface Water Drainage Strategy (Appendix 14.6 of the Environmental Statement [TR010060/APP/6.3]). Where flooding is shown to occur, an assessment has been made to see if the flooding would cause the proposed scheme to become unsafe or prevent access/operation of the proposed scheme.

4.5.10 It has been assumed that slow-moving or stationary flood water with depths of under 150mm in a 1% (1 in 100) AEP plus climate change event would not cause the road to be closed or prevent operation of the road. Vehicles would be expected to be able to pass safely through this depth of water, and prevailing conditions would mean drivers should be anticipating water on the carriageway. A more detailed assessment has been undertaken of any areas where there is predicted to be greater than 150mm of flood depth on the road surface (see Table 4.6.

4.5.11 Any standard maintenance activities would be suspended in short periods of extreme weather such as the storms that would cause the flooding represented in the Exceedance Flow Analysis Maps. Therefore, flooding against the road embankment, within highway drainage infrastructure or in other proposed scheme areas not carrying live traffic has been assessed as being highly unlikely to represent a risk to any users or to prevent operation of the proposed scheme. Surface water flood risk to proposed access tracks has also been identified. Where access tracks intercept flow paths outside of areas of proposed drainage, it is assumed that these access tracks will be constructed at grade, to avoid increasing flood risk. The majority of access tracks where such a risk has been identified are for the purposes of maintenance access to elements of the proposed scheme, particularly drainage ponds and ecological mitigation areas. Where such access routes are subject to flooding, risk assessments would be completed and appropriate mitigation would be identified as part of the operation of the proposed scheme to ensure safety of users of the access tracks.

4.5.12 Other access routes with similar risk of flooding that would not be mitigated by scheme drainage are generally access to agricultural land. These new accesses would generally only be subject to infrequent shallow flooding, that would be unlikely to prevent usage, particularly for the types of farm vehicles that would be anticipated to use the routes. As such, flooding in these areas has not been assessed further.

Table 4.6 Areas where there is surface water flood risk to the carriageway

Catchment	Exceedance event where significant flooding begins	Drawing shown on	Receptors impacted	Flood risk implication
S1-OU1	1% (1 in 100) AEP plus 20% allowance for climate change	HE551497-JAC-LDC-S1-DR-D-0831 and 0861	A138 Chelmer Road	Flooding is significantly reduced from existing and only at depths over 100mm close to the edge of the carriageway. Road would remain passable with no flooding towards the centre of the road.
S1-OU7	1% (1 in 100) AEP plus 20% allowance for climate change	HE551497-JAC-LDC-S1-DR-D-0831 and 0861	Link road between A130 roundabouts	Flooding is same as existing and on an area of the road network that is not impacted by the proposed scheme. Flood depths are generally below 150mm on the road surface, although depths of over 300mm are predicted in the verge in the 1% (1 in 100) AEP plus 40% climate change event, and the road is therefore likely to remain passable.
S2-OU24	1% (1 in 100) AEP plus 40% allowance for climate change	HE551497-JAC-LDC-S2-DR-D-0871	Proposed roundabout on the Existing A12	Flood depths generally below 150mm, with shallower flooding around outside of roundabout in particular that should remain passable. Isolated areas of deeper flooding in centre of roundabout.
S3-OU8A+7	1% (1 in 100) AEP plus 40% allowance for climate change	HE551497-JAC-LDC-S3-DR-D-0875	Junction underpass, link road to Inworth Road	Small patches of flooding with potential to cross one side of the road in each location. Flood depth is generally less than 150mm and the water would be anticipated to be stationary and should be passable. A deeper patch of water with a depth

Catchment	Exceedance event where significant flooding begins	Drawing shown on	Receptors impacted	Flood risk implication
				greater than 300mm would be contained within the verge.
S3-OU17	1% (1 in 100) AEP plus 20% allowance for climate change	HE551497-JAC-LDC-S3-DR-D-0851 and 0881	Station Road	Reduction in flooding compared to existing situation (69m^3 reduced to 64m^3). Flooding is predominantly under 100mm deep, with maximum close to 150mm at side of road, so the road would be anticipated to remain passable.
S3-OU17	1% (1 in 100) AEP plus 20% allowance for climate change	HE551497-JAC-LDC-S3-DR-D-0851 and 0881	A12	Some flooding on the verge and inside lane on the carriageway is predicted in the 1% (1 in 100) AEP plus climate change event. This flooding would generally be under 100mm deep, and the outside lane would remain unflooded (an improvement from the existing situation), so the road could remain operational.

4.5.13 Where catchments have been identified with drainage exceedance causing surface water flooding including to beyond the proposed scheme permanent acquisition of land boundary, they have been assessed further in Table 4.7.

Table 4.7 Areas where surface water exceedance flows leave the proposed scheme permanent acquisition of land boundary

Catchment	Exceedance event significant exceedance flows begin	Drawing shown on	Receptors impacted	Flood risk implication
S1-OU1	1% (1 in 100) AEP plus 20% allowance for climate change	HE551497-JAC-LDC-S1-DR-D-0831 and 0861	Side road (approach to A130 roundabout) and car park.	The volume of runoff has been reduced from the existing in both the 1% (1 in 100) AEP plus 20% and plus 40% climate change events. Therefore, the proposed scheme would reduce flood risk in this area.
S1-OU17	1% (1 in 100) AEP plus 20% allowance for climate change	HE551497-JAC-LDC-S1-DR-D-0834 and 0864	Greenfield land	The volume of runoff has been reduced in both the 1% (1 in 100) AEP plus 20% and plus 40% climate change events. Therefore, the proposed scheme would reduce flood risk in this area.
S2-OU8	1% (1 in 100) AEP plus 20% allowance for climate change	HE551497-JAC-LDC-S2-DR-D-0837 and 0867	Ordinary Watercourse 9a	The volume of runoff into the watercourse has been reduced from 10.3m^3 to 4.1m^3 in the 1% (1 in 100) AEP plus 20% climate change event and from 40.9m^3 to 6.0m^3 in the plus 40% climate change event.
S3-OU17	1% (1 in 100) AEP plus 20% allowance for climate change	HE551497-JAC-LDC-S3-DR-D-0851 and 0881	Car park and shrubland north of Station Road.	The volume of flood water leaving the highway boundary would be reduced by the proposed scheme from 13.9m^3 to 11.5m^3 in the 1% (1 in 100) AEP plus 40% climate change event.
S3-OU17	1% (1 in 100) AEP plus 20% allowance for climate change	HE551497-JAC-LDC-S3-DR-D-0851 and 0881	The Rookeries	The volume of flood water leaving the highway boundary would be reduced by the proposed scheme from 38.5m^3 to 27.0m^3 in the 1% (1 in 100) AEP plus 40% climate change event. Modelling indicates this could reduce flood risk to property, and remaining flooding would be contained predominantly on the road.
S3-OU18	1% (1 in 100) AEP plus 20% allowance for climate change	HE551497-JAC-LDC-S3-DR-D-0852 and 0882	Roman River	The volume of runoff into the watercourse has been reduced from 56m^3 to 38.5m^3 in the 1% (1 in 100) AEP plus 20% climate change event and from 84.0m^3 to 68.0m^3 in the plus 40% climate change event.

5 Groundwater flood risk

5.1 Introduction

5.1.1 Groundwater flooding occurs where water levels beneath the ground rise above the ground surface. In some instances, groundwater can emerge at surface level, following heavy rainfall events, and contribute to existing flooding from other sources. There is also a greater risk if construction works, or long-term, large-scale developments, such as road schemes, intersect areas with shallow groundwater levels or create pathways for deeper confined artesian pressures. These can then be released at ground level and cause widespread flooding.

5.1.2 To develop a conceptual understanding of groundwater flooding associated with the proposed scheme, groundwater level data from the three phases of GI along the proposed scheme corridor have been collated and reviewed.

5.2 Baseline risk

5.2.1 Details on the groundwater and aquifer characteristics within the study area can be found in the hydrogeology baseline (Appendix 14.4 of the Environmental Statement [TR010060/APP/6.3]). The following information from the baseline has been refined to focus on potential groundwater flooding risks.

Desk study review: local SFRAs and BGS groundwater flooding susceptibility

5.2.2 The local SFRAs were viewed to assess the groundwater flood risk within the Order Limits. The groundwater mapping within these SFRAs is based on the BGS (2021a) Areas Susceptible to Groundwater Flooding mapping. The mapping shows the susceptibility rating displayed on a 1km grid where geological and hydrogeological conditions indicate groundwater might emerge.

5.2.3 A summary of the susceptibility to groundwater flooding as defined by the local SFRAs is presented in Table 5.1. The percentages shown in Table 5.1 indicate the proportion of each 1km square that is susceptible to groundwater emergence. They do not show the likelihood of groundwater flooding occurring.

Table 5.1 Summary of groundwater flood risk as defined in the local SFRAs

Planning authority	Summary of SFRA description of groundwater flood risk
Chelmsford City Council Level 1 and Level 2 SFRA (JBA Consulting, 2018)	The proposed scheme falls predominantly within 1km grid squares assigned as having ≥75% of the area susceptible to groundwater emergence, which is up to NGR TL 57414 20931 (A12 junction 19). The remainder of the Order Limits located within the Chelmsford SFRA study area lies within grid squares assigned as having from ≥50% to <75% of the area susceptible to groundwater emergence.
Braintree District Council Level 1 SFRA Update (AECOM, 2016a)	The proportions for each 1km square that are susceptible to groundwater emergence for the part of the proposed scheme located within the Braintree SFRA study area show high variance. The Order Limits fall within areas assigned as having ≥75% of the area susceptible to groundwater emergence south-east of Witham, while elsewhere the susceptibility to groundwater emergence can be described overall as being from ≥25% to <50%.
Mid-Essex SFRA, Appendix D Maldon Supplementary Report (Scott Wilson, 2008)	The proposed scheme in the area covered by this SFRA is stated to not be susceptible to groundwater flooding due to the existing underlying bedrock geology, dominated by low permeability London Clay.
Colchester Borough Council Level 1 SFRA Update (AECOM, 2016b)	The proposed scheme lies within areas at very low risk of groundwater flooding up to Marks Tey. The Order Limits from Marks Tey to their northern extent fall predominantly within 1km grid squares assigned as having <25% and from ≥25% to <50% of each grid square being susceptible to groundwater emergence.

5.2.4 The BGS susceptibility to groundwater flooding mapping data was also obtained (BGS, 2021a) to further determine the groundwater flood risk to and from the proposed scheme. The BGS groundwater flood susceptibility classifications are detailed in Table 5.2 with the zones shown in Annex F.

Table 5.2 BGS classification of groundwater flood susceptibility areas

Classification	Groundwater flooding susceptibility	Description
A	Low	Limited potential for groundwater flooding to occur
B	Moderate	Potential for groundwater flooding of property situated below ground level
C	High	Potential for groundwater flooding to occur at the surface
Elsewhere (onshore)	None	Not considered to be prone to groundwater flooding

5.2.5 The BGS data shows that, across the central area of the proposed scheme (Witham to Kelvedon), the susceptibility to groundwater flooding is very high to moderate, as is the very south and very north (BGS, 2021a). In general, the northern area between Feering and Marks Tey has no susceptibility to groundwater flooding. There are some small areas in the south between Boreham and Hatfield Peverel and between Hatfield Peverel and the south of Witham where there is no susceptibility to groundwater flooding. However, around Hatfield Peverel the BGS mapping shows a moderate to high risk.

5.2.6 In general, across the proposed scheme, the flooding susceptibility seems to correlate with the nature of the mapped superficial deposits in that area. More permeable units such as Alluvium, River Terrace Deposits and Glaciofluvial Deposits have a higher risk, while low permeability units such as Head Deposits and the Lowestoft Formation are usually not associated with groundwater flooding.

Ground investigation

5.2.7 Three phases of GI took place in different geographical sections along the route of the proposed scheme as follows:

- Phase 1 – From the southern extent of the proposed scheme to the River Brain and all borrow pit locations
- Phase 2 – In the centre of the proposed scheme from the River Brain to the River Blackwater
- Phase 3 – From the River Blackwater to the northern extent of the proposed scheme

5.2.8 Where recorded in the GI, groundwater strikes and seepages were generally within 4m of the ground surface as shown in Table 5.3. In most instances, the rise in groundwater level was less than 1m, with a maximum rise of 8.45m recorded around chainage 35260 at the boundary between the glaciofluvial deposits and the overlying Lowestoft Formation. This indicates that there can be a degree of confinement where the Lowestoft Formation is present, but generally across the proposed scheme unconfined conditions are present at shallow depths.

5.2.9 A high-level review of historic BGS logs (BGS, 2021b) confirms that groundwater levels are encountered in the superficial deposits at varying depths, and frequently the borehole logs show groundwater is not encountered during drilling. These historic logs confirm that, in certain areas, groundwater can be encountered at relatively shallow depth, within 1m or 2m of the ground surface.

Table 5.3 Depth of water strikes in all GI locations

Water strike depth (mbgl)	No. of holes/trial pits
0 to 2	57
2 to 3	31

Water strike depth (mbgl)	No. of holes/trial pits
3 to 4	35
4 to 8	44
Deeper than 8	20

5.2.10 As part of the GI, the majority of groundwater level monitoring was undertaken in superficial deposits, with two boreholes having installations partly within the London Clay and one fully in this layer (see bedrock groundwater section below). The length and period of the data record varies between boreholes as they were installed during three different phases of GI. The monitoring results are discussed in the superficial groundwater section below.

Superficial groundwater

5.2.11 The mapped superficial deposits (Defra, 2021) are classified mainly as Secondary A (Alluvium, River Terrace Deposits, Glaciofluvial Deposits and Kesgrave Catchment Group) and Secondary undifferentiated (Head Deposits and Lowestoft Formation) aquifers with pockets of Secondary B aquifer (Brickearth) between junctions 19 (Boreham interchange) and 20b (Hatfield Peverel South interchange). Small pockets of unproductive strata are also shown near Rivenhall End. At the time of writing, Phases 1 and 2 of the GI have groundwater data for a whole year from August 2020 to September 2021. Phase 3 monitoring is still ongoing, with monitoring data limited between May 2021 to October 2021.

5.2.12 As part of the GI, groundwater monitoring took place with manual dip measurements at monthly intervals and by installing groundwater level data loggers in 97 boreholes across the proposed scheme. Along with this, for boreholes completed as groundwater monitoring points, manual measurements of groundwater levels have been undertaken on an approximately monthly basis. In total, 259 monitoring points are located across the proposed scheme with a mixture of data loggers and manual dip readings.

5.2.13 As shown in Table 5.4, the groundwater monitoring indicates that measured groundwater levels are typically within 6m of the ground surface, with the majority found within 2m of the surface, indicating generally shallow groundwater conditions throughout the proposed scheme. There is no clear pattern to the distribution of the depth to groundwater levels across the proposed scheme, which is a result of heterogeneity of the superficial materials and the discontinuous nature of some of the water bearing layers.

Table 5.4 Minimum depth to groundwater recorded in groundwater monitoring points

Shallowest groundwater level recorded (mbgl)	No. of boreholes
≤0	8
0 to 1	78
1 to 2	47
2 to 4	58
4 to 6	29
>6	30
Dry	9

5.2.14 The GI monitoring identified eight locations where maximum groundwater piezometric levels were recorded above ground level. Further details on these eight locations are provided in Table 5.5.

Table 5.5 Locations where groundwater monitoring recorded levels above surface level

Borehole reference	Location (Easting, Northing)	Approximate chainage	Maximum recorded groundwater level (mbgl)	Comments
BH+RC2203	582981, 214772	22220	-0.61	Reading from 16/01/2021. Levels shown to be above ground level in October 2020, December 2020 to mid-March 2021. Occasional values above ground level in June 2021 (4th and 18th).
BH2007	578344, 210826	15300	-0.18	Reading from 30/01/2021. Levels shown to be above ground level in January and February 2021.
BH+RC2273	585596, 217656	26380	-0.09	Reading from 16/01/2021. Levels shown to be above ground level in December 2020 and January 2021.
BH2005	578449, 211065	15500	-0.08	Reading from 30/01/2021. Levels shown to be above

Borehole reference	Location (Easting, Northing)	Approximate chainage	Maximum recorded groundwater level (mbgl)	Comments
				surface level in mid to late January 2021.
BH2041	581854, 212597	19460	-0.07	Reading from 30/01/2021. Levels shown to be above ground level in mid-January to early February 2021.
WS3425	589343, 221468	34960	-0.01	Reading from 9/07/2021. This level was recorded on the 9th and 12th of July.
WS1434	581465, 212933	19100	0	Reading from 02/10/2020. This level was recorded on the 2nd and 3rd of October 2020.
WS1510	580362, 212384	17800	0	Reading from the 16/12/2020, 19/01/2021 and 11/02/2021.

5.2.15 Half of these locations are associated with Alluvium and River Terrace Deposits, which have a very high BGS flooding susceptibility. The other four have been found in the Lowestoft Formation and Head Deposits. The shallow groundwater levels in the Lowestoft and Head Deposits could relate to more permeable layers within these formations which likely have a limited extent. Therefore, once they have been fully saturated, the only way for the groundwater to move is upwards towards the surface. These locations are spread across the proposed scheme and not associated with any particular areas. This emphasises the potential presence of discrete horizons within the more sandy and granular layers of the superficial deposits and variable groundwater conditions.

5.2.16 The high groundwater levels recorded on 16 and 30 January 2021 in several of the boreholes correlate with high rainfall events which occurred in the area on 14, 20 and 28 January 2021 (Chelmsford Weather Station, 2021). The lag time between the rainfall event and the groundwater reaching the surface is due to the time taken for the aquifer to recharge after these events; this demonstrates the aquifer's responsiveness to large rainfall events.

5.2.17 Seasonal variations in groundwater levels are best determined using data available from the dataloggers. In the 97 locations which had data loggers installed, groundwater fluctuation in the majority of locations is less than 2m (Table 5.6).

Table 5.6 Variation in groundwater levels in GI groundwater monitoring points

Variation in groundwater levels (m)	No. of boreholes
<0.5*	20
0.5 to 1	27
1 to 2	28
2 to 3	12
>3	10

**Includes boreholes which were recorded dry on all occasions*

Bedrock groundwater

5.2.18 The London Clay bedrock formation which underlies most of the proposed scheme is classified as unproductive strata, so it is very unlikely to contain any groundwater, meaning that there is no risk of artesian pressures from the bedrock.

5.2.19 From the GI, groundwater strikes were encountered during drilling in the London Clay in four boreholes (Table 5.7). In all locations there has been a slight rise in the groundwater level, indicating some small levels of confinement. However, no artesian conditions were identified in the London Clay.

5.2.20 In four of the GI locations, groundwater monitoring has taken place where the installation is either partially or fully within the London Clay (only fully within the London Clay in BH2051). The largest variation was identified in BH2051 (Table 5.7), where groundwater levels fluctuate by approximately 3.44m.

Table 5.7 Groundwater strikes in bedrock

Borehole ID	Chainage	Water strike (mbgl)	Groundwater level after 20 mins (mbgl)	Monitoring groundwater level range (mbgl)
WS1522	15750	4	3.95	0.74–2.9
WS1402	10925	2.15	2.11	2.01–2.03
BH+RC3219	15655	5.65	2.5	NA
BH2051	20630	4.5	4.2	0.25–3.69

5.2.21 The Lambeth Group and Thanet Formation present beneath the London Clay Formation are classified as Secondary A aquifers. One small area of Thanet Formation and Lambeth Group (undifferentiated) is mapped as sub-cropping to the west of Kelvedon at chainage 26500. One small area of the Thanet Formation is mapped as sub-cropping in the east of Witham at chainage 22950. Further details of bedrock geology are provided in Chapter 10: Geology and soils, of the Environmental Statement [TR010060/APP/6.1].

5.2.22 The presence of the London Clay Formation is important from a flooding perspective as it prevents infiltration to the deeper geological horizons, therefore confining and/or isolating bedrock groundwater from the overlying superficial deposits. This can therefore cause the groundwater above the London Clay Formation to rise, increasing the risk of groundwater reaching the surface.

5.3 Flood risk to the proposed scheme

5.3.1 By assessing recorded groundwater levels along the proposed scheme corridor, a screening assessment was carried out to identify those areas at greatest risk of groundwater flooding, potential proposed scheme impacts and to identify where potential mitigation may be required. This included a detailed review of all parts of the proposed scheme that would involve excavations below existing ground level, including cuttings, borrow pits and the proposed flood storage areas. Appendix 14.4: Groundwater Assessment, of the Environmental Statement [TR010060/APP/6.3] presents a dewatering assessment, and the outcome is used to identify any new potential groundwater flooding issues of relevance generated by the earthworks.

5.3.2 As the proposed scheme is located at, or below, ground level (cuttings and junctions) in several locations, there is a risk that groundwater flooding could affect the proposed scheme during both its construction and operational phases, if not managed. Excavations for new road cuttings and borrow pits can be particularly susceptible to groundwater flooding.

5.3.3 Appendix 14.4 of the Environmental Statement [TR010060/APP/6.3] provides the results of a separate road cutting/widening screening exercise, which has identified 31 cuttings/widenings that are likely to intercept groundwater during the construction phase. In these instances, appropriate drainage strategies would need to be implemented to mitigate for flooding within the excavation as identified in the construction phase (Section 7, Table 7.1).

5.3.4 There are three cuttings/widenings (W4, W5 and C8) where groundwater has been monitored at times to be above ground level, indicating shallow groundwater conditions where groundwater flooding could occur. Artesian conditions are found in the superficial deposits in eight locations across the proposed scheme in different formations as described in the baseline (see Table 5.5 above), so conditions are expected to be very localised. Details of these occasional artesian conditions correlating with proposed cuttings/widenings are listed in Table 5.8.

5.3.5 Of the other artesian locations, three lie outside of the Order Limits and so are not expected to impact the proposed infrastructure. One is located 44m from an embankment as part of junction 21 and another is located at an embankment adjacent to the proposed scheme at the River Blackwater crossing (see Table 5.9). In these two areas, the proposed scheme has the potential to therefore sit in areas of localised pre-existing artesian conditions. However, given that the proposed scheme is on embankment in these areas, the proposed scheme is not expected to be impacted.

Table 5.8 Cuttings where groundwater has been recorded at or above surface

Cutting/widening ID	Chainage	Maximum excavation depth (m)	Monitoring groundwater level range (mbgl)	Chainage where groundwater is above surface level
W4	18050-19190	8.1	0 to 5.85	19100
W5	21650-22580	6.02	-0.61 to 2.68	22220
C8	33790-35090	6.41	-0.01 to 1.22	34960

5.3.6 Borrow pits F, I and J are likely to intercept groundwater (see Section 3 of Appendix 14.4 of the Environmental Statement [TR010060/APP/6.3]). In these instances, appropriate drainage strategies would need to be implemented to mitigate for flooding within the excavation as identified in the construction phase (Section 7 of this FRA).

5.3.7 Groundwater intercepted during construction would be discharged most likely to nearby watercourses, and this could increase the risk of fluvial flooding. These potential risks are discussed in Section 7.3 of this FRA.

5.4 Potential impacts from the proposed scheme

5.4.1 Embankments within the proposed scheme may result in localised ground compaction which, in areas of shallow groundwater, could restrict groundwater flow and cause localised groundwater flooding arising next to the embankment, especially on the upgradient side. Table 5.9 below details the locations where groundwater is less than 1mbgl near the proposed embankments.

Table 5.9 Locations of shallow groundwater near embankments

Location/ chainage	Borehole ID	Distance from embankment (m)	Monitoring groundwater level range (mbgl)
Junction 21	WS1523	0	0.54 to 3.9
	WS1510	42	0 to 5.42
19050 (eastbound)	WS1513	15	0.77 to 2.7
20130	WS1514	8	0.85 to 4.52
20810-20950	WS1526	37	0.17 to 2.23
	BH2049	10	0.17 to 3.49
24665	BH+RC2264	0	0.67 to 1.64
25250	BH2664	0	0.15 to 0.79
25740	WS2462	0	0.8 to 3.18
26400	BH+RC2273	3.7	-0.9 to 1.31
31630	BH2075	0	0.64 to 2.38
32050	BH3013	0	0.6 to 1.45
35380–35470	BH3034	0	0.59 to 4.7
	BH3035	40	0.35 to 0.58
36350 (side road)	BH3038	0	0.95 to 4.04

5.4.2 Groundwater flooding can also occur where linear below ground structures, such as sheet piling, are proposed, which could act as a barrier to groundwater flow and increase the risk of groundwater flooding upgradient of the structure. On the down-hydraulic gradient side, the structure could cause a lowering of groundwater levels which would reduce the risk of groundwater flooding in this localised area. Table 5.10 details the locations of wall sections expected to require sheet piling for the proposed scheme and the potential for groundwater impediment at these locations. The estimated depth to toe has been calculated assuming a total depth of 4.5 times the maximum retained height of the wall. At this current stage, the estimated depths to toe are indicative due to the design not yet being finalised – these are likely to be refined at a later date, during detailed design. Any design mitigation that is required as a result of shallow groundwater at these locations is discussed in Section 5.5, and any construction mitigation is in Section 7.

Table 5.10 Summary of retaining walls throughout the proposed scheme

Wall ID	Chainage	Highways direction	Length	Maximum retained height (m)	Estimated depth to toe (mbgl)	Groundwater levels along wall (mbgl)	Position of retaining wall in relation to groundwater flow direction**	Likeliness of retaining wall causing groundwater impediment
RW1-1	10950-11050	Junction 19 (southbound off-slip)	99	5***	22.5	2.59–4.72	Diagonal	Given the position of the wall in relation to groundwater flow direction and the estimated depth to toe, there is likely to be some groundwater impediment along the wall on the upgradient side given that groundwater is recorded at shallower depths than the proposed wall.
RW1-7 to RW1-9	16030-16087	Southbound	56	5	22.5	1.22–9.9	Parallel	Given the position parallel to groundwater flow direction and the length of the wall, groundwater impediment is unlikely to be an overall issue. However, localised impact cannot be ruled out, especially where it correlates with an area of shallow groundwater being present.
RW1-10 to RW1-12	16100-16418	Northbound	318	5	22.5	1.79–4.86	Diagonal	Given the position of the wall in relation to groundwater flow directions and the estimated toe depth, localised impacts to groundwater cannot be ruled out, especially where it correlates with areas of shallow groundwater.
RW1-13 to RW1-15	16442-16700	Northbound	259	4	18	2.08–8.08	Parallel	Given the position parallel to groundwater flow, groundwater impediment is unlikely to be an overall issue. However, localised impact cannot be ruled out, especially where it correlates with areas of shallow groundwater.

Wall ID	Chainage	Highways direction	Length	Maximum retained height (m)	Estimated depth to toe (mbgl)	Groundwater levels along wall (mbgl)	Position of retaining wall in relation to groundwater flow direction**	Likeliness of retaining wall causing groundwater impediment
RW1-9	16447-16700	Southbound	251	5***	22.5	3.19–3.76	Diagonal	Given the position of the wall in relation to groundwater flow direction and the uncertainty of groundwater levels in the east of the area, shallow groundwater and the potential for groundwater impediment along the length of the wall cannot be ruled out.
RW1-16 to RW1-18	16700-17015	Southbound	314	4	18	3.04–5.6	Parallel	Given the position of the wall parallel to groundwater flow direction, groundwater impediment is unlikely to be an overall issue. However, localised impact cannot be ruled out, especially where it correlates with areas of shallow groundwater.
RW1-19	18517-18700	Northbound	183	3.6	16.2	3.04–5.85	Parallel	Given the position of the wall parallel to groundwater flow direction, groundwater impediment is unlikely to be an overall issue. However, localised impact cannot be ruled out, especially where it correlates with areas of shallow groundwater.
2.3	20535-20650	Northbound	115	3.68	16.56	0.45–8.17	Parallel	Given the position of the wall parallel to groundwater flow direction, groundwater impediment is unlikely to be an overall issue. However, localised impact cannot be ruled out, especially where it correlates with areas of shallow groundwater.
2.6	21400-21497	Northbound	97	0.58	2.61	2.38–4.6	Ground level flat in this area	Given the flat topography of the area and groundwater levels recorded near the base

Wall ID	Chainage	Highways direction	Length	Maximum retained height (m)	Estimated depth to toe (mbgl)	Groundwater levels along wall (mbgl)	Position of retaining wall in relation to groundwater flow direction**	Likeliness of retaining wall causing groundwater impediment
								of the proposed structure, groundwater impediments cannot be ruled out.
2.7	21503-21555	Northbound	52	0.94	4.23	2.38–3.76*	Ground level flat in this area	Given the flat topography of the area and the retaining wall section being of limited length, groundwater impediment is unlikely to be an overall issue. However, localised impact cannot be ruled out, especially where it correlates with an area of shallow groundwater being present.
2.9	20510-20615	Southbound	105	4.4	19.8	0.45–8.17	Diagonal	Given the position of the wall in relation to groundwater flow direction and localised shallow groundwater conditions in places, there is likely to be groundwater impediment along the wall on the upgradient side. Given the estimated depth to toe, groundwater emergence at the surface cannot be ruled out where levels are already relatively shallow.
2.12	23490-23510	On-slip	20	4.4***	19.8	6.35	Diagonal	Given the very short length of the retaining wall, no groundwater impediment is predicted. Groundwater would simply flow around the structure if intercepted.
2.13	23815-23835	On-slip	20	4.4***	19.8	Unknown	Perpendicular	
3.5	38085-38170	Southbound	85	1.02	4.59	9.87	Perpendicular	Given that groundwater levels are recorded at a greater depth than the base of the retaining wall, groundwater impediments are unlikely.

Wall ID	Chainage	Highways direction	Length	Maximum retained height (m)	Estimated depth to toe (mbgl)	Groundwater levels along wall (mbgl)	Position of retaining wall in relation to groundwater flow direction**	Likeliness of retaining wall causing groundwater impediment
3.7	38600-38760	Southbound	160	1.98	8.91	0.65–1.6*	Perpendicular	The retaining wall is likely to cause groundwater impediment on the upgradient side due to the wall expected to be perpendicular to the groundwater flow path. Given the uncertainty of groundwater levels in the area, shallow groundwater cannot be ruled out, and the potential rise of groundwater to the surface along the length of the wall is possible.
3.1	39580-39760	Southbound	180	1.89	8.5	0.6–4.08	Diagonal	Given the position of the wall in relation to groundwater flow direction and shallow groundwater recorded along the wall boundary in places, groundwater impediment cannot be ruled out.
3.11	38524-38568	Side road – northbound	44	1.43	6.44	6.41–6.55*	Perpendicular	Given that groundwater levels are recorded only at the very base of the proposed retaining wall, and the retaining wall section being of limited length, groundwater impediments are unlikely.

** No GI adjacent to the wall. Readings from boreholes over 100m away.*

*** Assuming topography is representative of shallow groundwater flow direction.*

**** Retaining walls where the maximum retained height has not been provided and therefore estimated depth to toe cannot be calculated. Assumed worst case scenario and used deepest piling depth for each section.*

5.4.3 Flood storage areas are located throughout the proposed scheme. The flood storage areas have been designed to be used during extreme flooding events, which means that water would generally be expected to be stored for less than two weeks per year. These areas are designed to be unlined, so when filled during a flood event they could lead to a recharge event in the aquifer. However, given the very limited periods when these storage areas are expected to be active, the recharge to groundwater is expected to be negligible over the course of the year and would not be expected to result in any localised groundwater flooding issues.

5.4.4 Table 5.11 details the hydrogeological conditions where these flood storage areas are proposed.

Table 5.11 Flood storage areas and the likeliness of intercepting groundwater

Flood Storage Area	Proposed mitigation	Approximate Chainage	Maximum proposed excavation depths (m)	Geology and estimate thickness (m)	Groundwater level range (mbgl)	Likeliness to intercept groundwater
Ordinary Watercourse 21 (south of Kelvedon)	Open ditch	26900	2.5	Alluvium and River Terrace Deposits (buried channel). Superficial deposits can be up to 15.37m thick. However, in BH3001, bedrock is present at 1.9mbgl.	1.14–14.8	Potential groundwater interception could occur in the ditch. Flowing water in ditch would limit the proportion of infiltration. If groundwater interception occurs, this could reduce the capacity of the flood storage in the event of a flood. However given that this feature is a ditch with flowing water, the function of the ditch is not expected to be impacted.
Ordinary Watercourse 21a (west of Inworth Road)	Channel	31100	1–2.5	TP1850 shows River Terrace Deposits to a depth of 4m north of the channel. Lowestoft Formation to approximately 3.2mbgl in BH2064.	1.35–3.4	Possible groundwater interception at the larger mitigation channel. However, the channel would contain running water, hence limiting infiltration.
Ordinary Watercourse 23 (east of Feering)	Open ditch and storage area	33000	Ditch: 2 Storage area: 1-2.5	Northern area: Head to 0.7mbgl, underlain by River Terrace Deposits Southern area: Lowestoft Formation	No groundwater monitoring for northern area. For southern area, strikes as shallow as	Given the depth of the excavation in the north there is potential to intercept the River Terrace Deposits. Groundwater levels in this area are unknown. However, given the permeable nature of the River Terrace

Flood Storage Area	Proposed mitigation	Approximate Chainage	Maximum proposed excavation depths (m)	Geology and estimate thickness (m)	Groundwater level range (mbgl)	Likeliness to intercept groundwater
					0.35mbgl. Monitoring indicates levels between 4.15–4.32mbgl.	Deposits, recharge to the underlying aquifer could occur. This is expected to be very intermittent and short lived. Given the permeable nature of the River Terrace Deposits, if groundwater interception occurs, the capacity of the flood storage could be reduced during a flooding event as rising groundwater would contribute to the storage area along with surface water. However, generally groundwater would be anticipated to respond to rainfall more slowly than the small catchment for surface water, making the likelihood of significant loss of storage volume low. For the southern area, the low permeability of the Lowestoft Formation would limit infiltration, so no changes to groundwater levels in this area are predicted.
Ordinary Watercourse	Storage area	37600	2.5	Lowestoft Formation, over 10m thick	Strikes at 1.2 and 4.6mbgl	There is potential for groundwater to be intercepted. However, groundwater is only

Flood Storage Area	Proposed mitigation	Approximate Chainage	Maximum proposed excavation depths (m)	Geology and estimate thickness (m)	Groundwater level range (mbgl)	Likeliness to intercept groundwater
26 (east of Marks Tey)						likely to be contained within more gravelly horizons and would hold limited volumes. The low permeability of the Lowestoft Formation would limit infiltration.
Inworth Road Ordinary Watercourse	Multiple storage areas	31800 (side road – Inworth Road)	1	Mainly located in London Clay with some small pockets for glaciofluvial in the west and north, which are not extensive	No groundwater levels recorded	Given the impermeable nature of the London Clay, no infiltration to groundwater is likely to occur. Where glaciofluvial deposits are present, there is likely to be limited/no groundwater given the localisation of the deposits.

5.4.5 The cuttings required for the borrow pits would only be temporary. Following completion of the borrow pit excavations, groundwater would be allowed to enter the pits and water levels equilibrate with the groundwater levels in the adjacent aquifer. As such, this would not be a concern and they would not be expected to significantly disturb groundwater levels locally nor exacerbate groundwater flood risk elsewhere.

5.4.6 The proposed construction depths for the proposed scheme are not expected to perforate or significantly reduce the thickness of the underlying and unproductive London Clay horizon. Where the London Clay was intercepted during the GI, no artesian conditions were identified, so no deep bedrock artesian conditions are expected to be released as a result of the proposed scheme.

5.4.7 There is no proposed soakaway discharge to the ground as part of this proposed scheme.

5.5 Mitigation measures

5.5.1 It is considered that a number of mitigation measures can be incorporated into the design development and prevent long-term groundwater flooding issues from arising. These are provided in Table 5.12 and follow the overarching principle that all aspects of the design, in particular the detailed drainage strategy, would be developed in cognisance of groundwater conditions. With these in place, both the risk of groundwater flooding affecting the proposed scheme and the risk of the proposed scheme affecting regional groundwater levels and flow paths would be low.

5.5.2 This detailed design would be developed based on a robust site characterisation. Additional GI would therefore be required in places to refine the understanding of localised groundwater conditions. This would particularly be the case in areas highlighted in Table 5.10 and Table 5.11 where uncertainty currently exists on groundwater levels.

5.5.3 The mitigation measures associated with groundwater construction risks can be found in Section 7.

Table 5.12 Groundwater mitigation measures to be embedded into design

Groundwater mitigation measures	Description
Long-term drainage of cuttings	To protect flood sensitive receptors (including the new road) from groundwater flooding during the operational phase, groundwater seepage would be collected by the proposed road drainage system.
Long-term drainage for infrastructure at grade	To protect infrastructure at grade from groundwater flooding during the operational phase, drainage systems would be installed where shallow, pre-existing groundwater conditions exist. These would collect excess groundwater to prevent groundwater reaching the surface.
Long-term drainage for embankments and retaining walls	To prevent flooding at the surface around embankment and retaining wall areas where pre-existing groundwater conditions are known to be shallow, drainage systems would be installed up-gradient of the embankment to limit the build-up of water.
Foundation design to permit groundwater flow	All foundations or below ground structures expected to intercept high groundwater levels and which could form a barrier to groundwater flow would be designed to allow existing groundwater flow paths to function. This would prevent an increase in groundwater flood risk and would protect flood sensitive receptors elsewhere. This would be achieved during the detailed design stage, and using complementary GI results.
Embankment design to permit groundwater flow	Ground compaction as a result of any embankments would be expected to restrict groundwater flow in the areas that coincide with shallow groundwater levels. In these instances, embankments would be designed to allow existing groundwater flow paths to function. This would prevent an increase in groundwater flood risk to flood sensitive receptors elsewhere.
Flood storage areas	Flood storage areas would be designed taking groundwater levels into account. This means that, as part of the detailed design phase, where groundwater is expected to be shallower than the bottom of the flood mitigation area, the design is adjusted to account for groundwater. However, it is likely that groundwater flows would drain from the storage areas at a faster rate than inflow from groundwater, so impact is anticipated to be minimal.

5.5.4 It is considered that embedded mitigation proposed as part of the proposed scheme would be sufficient to manage any groundwater flooding issues identified above and ensure the proposed scheme is safe for users, without increasing flood risk elsewhere.

5.6 Residual risks

5.6.1 With the implementation of the proposed mitigation measures (during both the construction (See Section 7) and operational phases) and taking groundwater conditions into account through the design process, no residual groundwater flood risk would be expected.

5.7 Conclusion

5.7.1 After implementation of mitigation measures, which include embedding groundwater conditions into the detailed design development and ensuring adequate drainage strategies are place, the proposed scheme is considered to be generally at a low risk of groundwater flooding.

5.7.2 Similarly, after implementation of mitigation measures during both the construction (See Section 7) and operational phases, the risks of the proposed scheme increasing groundwater flood risk on the wider environment are considered to be low.

6 Other sources of flood risk

6.1 Canals

6.1.1 There are numerous navigation channels that join the River Chelmer throughout Chelmsford. The Chelmer and Blackwater Navigation is the canalisation of the Rivers Chelmer and Blackwater in Essex. The Navigation connects Chelmsford with the tidal estuary of the River Blackwater but is considered within the fluvial flood risk sub-section (Section 2 of the FRA). No other canals and artificial water bodies have been identified that have potential to impact the proposed scheme. Consequently, there is no risk of flooding from canals that is not considered elsewhere within this FRA.

6.2 Flood defence infrastructure

6.2.1 The Environment Agency’s (2021b) Flood Map for Planning indicates that the proposed scheme is located approximately 300m to the east of areas benefitting from flood defences in Chelmer Village (see Annex E). According to the Chelmsford Level 1 and Level 2 SFRA (JBA Consulting, 2018), the flood defence structure is part of the Chelmer Village and is a flood wall offering protection against fluvial flood risk. The document details that the defences would overtop in the 1% (1 in 100) AEP event, resulting in flooding to properties at Eglington Drive (350m west of the Order Limits) and Harrington Mead (280m west of the Order Limits).

6.2.2 However, the proposed scheme is not located within areas benefitting from flood defences. Therefore, the flood risk due to failure of flood defence infrastructure to the proposed scheme is considered to be very low, and the proposed scheme would have no impact upon this source of flood risk.

6.3 Reservoirs

6.3.1 The Risk of Flooding from Reservoirs (Environment Agency 2021d) mapping provides an indication of the extent of flooding that would result from the failure of a large, raised reservoir, as defined under the Reservoirs Act 1975. A reservoir failure could potentially result in a large volume of water suddenly being released at extremely high velocities. This could result in catastrophic consequences, including risk to life.

6.3.2 There are several areas where the Order Limits and the proposed scheme cross areas shown as being at risk of reservoir flooding. Therefore, the proposed scheme is potentially at risk from this source of flooding and could potentially alter flow paths in the event of a flood (see Annex G and Annex H for details).

6.3.3 All large reservoirs are regularly inspected, and maintenance is supervised by reservoir panel engineers. In addition, no records of reservoir flooding have been included in the local SFRAs, PFRAs and Local Flood Risk Management Strategies. The likelihood of reservoir failure is therefore considered to be very low.

6.3.4 The proposed scheme is not anticipated to have any impact upon this source of flood risk.

6.4 Water supply and sewer infrastructure

6.4.1 Annex K displays existing water supply and sewer infrastructure near the proposed scheme. The proposed scheme crosses water supply and sewer infrastructure assets in multiple locations. The density of this infrastructure is higher in urban areas, including the following:

- North-east of Chelmsford
- Hatfield Peverel
- Whitham
- Rivenhall End
- North-east of Kelvedon
- South-east of Marks Tey

6.4.2 The local SFRAs provide information regarding flood risk from sewers. These state that the data available is not sufficient to determine the magnitude of sewer flood risk, but that it is expected to be low.

6.4.3 Based on correspondence with Anglian Water, it has been determined that no flood events due to water supply infrastructure failure have been recorded within the Order Limits.

6.4.4 It is not considered realistic to attach a probability of collapse and/or failure to water supply and sewer infrastructure within the Order Limits, as it would be dependent on the combined effect of several factors such as their condition, existing maintenance regimes and other outside influences. However, it is considered a low risk, particularly as any flooding from this source that reached the proposed scheme would be anticipated to flow into the proposed scheme's drainage.

6.4.5 The proposed scheme would not increase flows into existing sewer infrastructure or increase the risk of existing infrastructure failure (refer to Appendix 14.6: Surface Water Drainage Strategy, of the Environmental Statement [TR010060/APP/6.3], for more details).

6.4.6 The flood risk to the proposed scheme from water supply and sewer infrastructure is considered to be low, and it is not anticipated that the proposed scheme would increase flood risk from water supply and sewer infrastructure.

7 Construction phase

7.1.1 The construction phase is scheduled to commence in 2024. The proposed scheme would take approximately four years to construct, with an assumed opening year of 2027. A detailed description of proposed construction works is included in Section 2.6 of Chapter 2: The proposed scheme, of the Environmental Statement [TR010060/APP/6.1]. Further detail is available in the Construction Phase Plans, which is available in Volume 2 of the DCO application [TR010060/APP/2.15].

7.1.2 The construction methodology could change prior to the works being undertaken, particularly for elements of construction that are dependent on the supply chain, or for elements that are dependent on the detailed design. The assessment of flood risk during construction presented is therefore based on a reasonable worst-case scenario. Any alterations would need to ensure there are no materially new or different effects to those set out in the Environmental Statement.

7.1.3 The construction phase could create short-term impacts on existing flood risk. Appropriate mitigation would be embedded within the temporary works design to mitigate any increase in flood risk during this phase. In particular, the following construction elements have the potential to influence flood risk:

- Compounds and laydown areas
- Soil storage areas
- Haul roads and temporary roads
- Borrow pits
- Temporary drainage
- Dewatering activities
- Temporary watercourse crossings

7.2 Environmental Management Plan (EMP)

7.2.1 All construction works would be undertaken with appropriate environmental controls in place, in line with an Environmental Management Plan (EMP). In accordance with DMRB LA 120 (Highways England, 2020b), a first iteration of the EMP is included in the DCO application [TR010060/APP/6.5] to support the Environmental Statement. This first iteration EMP outlines the essential mitigation developed as part of the Environmental Impact Assessment. A second iteration of the EMP would be developed and implemented by the Principal Contractor prior to the start of construction works, based on the first iteration of the EMP [TR010060/APP/6.5].

7.2.2 The EMP includes a range of measures, which accord with legal compliance and good practice guidance, that would be undertaken during construction to mitigate temporary effects associated with flood risk. Development and implementation of the EMP would be undertaken before and during construction. The EMP is a live document which would be updated as additional information or alterations arise.

7.2.3 Table 7.1 outlines temporary construction activities which could impact flood risk, and proposed measures to mitigate such impacts.

Table 7.1 Potential flood risk impacts associated with construction activities and proposed mitigation measures

Construction activity	Potential impact	Proposed mitigation measures
Construction works (including stockpiled materials) in fluvial, overland and groundwater flow paths, fluvial floodplain, or any in-channel works	Could lead to flow being impeded or a loss of floodplain volume and a potential increase in flood risk.	Activities within areas at risk of flooding would be managed (i.e. kept to a minimum and timed for periods of lowest risk of flooding) with temporary land take required for construction located outside the floodplain as far as reasonably practicable, or allowances made for floodplain control measures and contingency actions (included in EMP). Where haul roads and temporary roads would cross areas of floodplain, existing ground levels would be maintained where practicable (included in EMP). Where necessary, implementation of temporary mitigation measures would prevent an increase in flood risk as a result of flood waters displaced during temporary construction works (for example due to raised storage areas, haul roads and cabins) (included in EMP). Construction work would be phased such that any required flood mitigation areas would be constructed prior to any encroachment into the floodplain caused by the proposed scheme to ensure no overall adverse impact (included in EMP). Where practicable, site layout would ensure material stockpiles and storage areas are located more than 10m from adjacent watercourses, ponds, boreholes, site drainage, and not within Flood Zone 3 and overland flow paths. Where this cannot be achieved, stockpiles would be limited such that they can be moved upon receipt of any flood warning/adverse weather conditions or on site additional mitigation measures (such as bunds) would be implemented to provide an adequate barrier between the potential source of contaminated runoff and the receptor. Therefore, soil storage areas and material stockpiles would result in negligible increase in flood risk (included in EMP).
Alterations to culverts and other structures conveying water could also result in a temporary loss of capacity or require watercourses to be temporarily diverted.		
Sediment, construction materials and equipment stored in the floodplain or on flow paths could be washed downstream.	Could lead to blockage of watercourse channels, land drains and sewers and increase the risk of flooding.	

Construction activity	Potential impact	Proposed mitigation measures
Construction works could cause an increase in the rate and volume of surface water runoff from an increase in impermeable areas or by reducing permeability by compacting soils.	This could lead to an increase in flood risk.	A Water Management Plan would be produced which would map the drainage pathways and identify mitigation measures. The Water Management Plan would be dependent on a temporary works design. However, proposed drainage should be constructed prior to works where practicable to ensure no increase to surface water flood risk. Temporary site drainage would be planned to manage the risks associated with heavy rainfall or flood events appropriate to the risk during construction such as the topography, catchment size and duration of the works. Where temporary drainage is required, it would be sized to provide an appropriate standard of flood protection, with a 10% (1 in 10) AEP event standard. This would be identified within the Water Management Plan prior to commencement of applicable works in that catchment, for example earthworks. Pre-earthworks drainage would be sized appropriately to intercept and accommodate all shallow groundwater flows entering the works area to protect flood-sensitive receptors. Outfalls from temporary site drainage would be to local surface water bodies and would maintain existing catchment boundaries wherever feasible. Temporary site drainage would look to use the permanent ponds as the temporary construction drainage, with additional ditch connections to watercourses. In some locations, new temporary ponds may need to be constructed. Land for new temporary ponds would be returned to its original use after construction. Key considerations when producing the plan are how water would drain from the site during construction and how it can be attenuated. The Water Management Plan would be available onsite and kept up to date (included in EMP).
Construction works could alter groundwater flow paths and levels.	This could lead to an increase in flood risk.	
Construction drainage discharge to watercourses or to ground could increase the rate and volume of runoff and increase the risk of blockages in watercourses that could lead to flow being impeded, and a potential increase in flood risk.	This could lead to an increase in flood risk.	

Construction activity	Potential impact	Proposed mitigation measures
Dewatering activities associated with proposed scheme areas in cutting and with borrow pits could increase fluvial, overland and groundwater flow paths	This could potentially increase flood risk	Management of the risk from groundwater flooding (during excavation) through appropriate working practices and with adequate plans and equipment in place for dewatering to ensure safe dry working environments. Management of the water removed from cuttings and borrow pits due to dewatering before discharge (included in EMP). If not disapplied, and where required, environmental permits for any temporary water discharges or dewatering of cuttings and borrow pits would be obtained from the Environment Agency prior to undertaking any dewatering activities (included in EMP). In significant flood events, dewatering activities would be paused to prevent additional flows that could increase flooding.
Excavations could potentially damage existing sewers or water supply infrastructure	Could lead to flooding	Plans of existing services (including existing sewer and water supply infrastructure) would be used to identify services close to any required construction works. Where necessary, existing services would be highlighted as a risk on design drawings to ensure awareness of these services and reduce the risk of service strike during construction.
Construction activities required within floodplain area present a risk to construction personnel and machinery	Flood risk to construction personnel/machinery	The Environment Agency's Flood Warning Service would be adopted by the Principal Contractor during construction and a suitable flood risk action plan developed to ensure effective and safe evacuation of personnel (and plant, if safe to do so) from areas at risk on receipt of a flood warning (included in EMP).
Public right of way routes required to be temporarily realigned through areas at risk of flooding could present a risk to users of these footpaths during flood events	Flood risk to users of public right of way routes	Public safety risk assessments would be completed, and appropriate mitigation (such as signage) would be identified and included.

7.3 Construction elements

Haul roads

7.3.1 To reduce the amount of construction traffic using the existing road network and provide access to construction areas, temporary haul roads would be needed. Proposed haul roads which interact with the 1% (1 in 100) AEP fluvial floodplain or with areas at high risk of surface water flooding are illustrated on Annex O. For these locations, a high-level assessment was undertaken to determine whether more detailed assessment using hydraulic modelling should be undertaken. This assessment included consideration of the potential extent of interaction of the haul route with the flood risk source, and the proximity and sensitivity of nearby receptors.

7.3.2 For the majority of locations where proposed haul roads interact with the 1% (1 in 100) AEP fluvial floodplain or with areas at high risk of surface water flooding, the volume of floodplain that would be lost is minimal and any impacts would be anticipated to be immediately upstream of the area of loss and therefore within Order Limits. For these areas it was not considered necessary to undertake hydraulic modelling assessment, as following application of proposed mitigation measures outlined in Table 7.1, it is anticipated that these proposed haul roads would result in a negligible change in flood risk elsewhere.

7.3.3 For two proposed haul road locations, it was considered appropriate to undertake hydraulic modelling to assess the potential fluvial flood risk impacts:

- Haul road running along the eastern edge of the proposed scheme east of Witham (situated within River Blackwater floodplain)
- Haul road and piling rig south of Ashman’s Bridge (within River Blackwater channel and floodplain)

7.3.4 To assess these locations in detail, hydraulic modelling has been undertaken. To assess the construction of proposed scheme elements, it is considered appropriate to test only up to the 1% (1 in 100) AEP flood event, as opposed to including a climate change uplift, given the limited timescales these would be in place.

Haul road east of Witham (within River Blackwater floodplain)

Baseline modelled flooding

7.3.5 East of Witham (around NGR TL 82955 14415), the River Blackwater is aligned parallel to the existing A12, flowing in a southerly direction. Modelled baseline flood extents (5% (1 in 20) AEP event and 1% (1 in 100) AEP events) are included in Plate 7.1.

Construction works design

7.3.6 A construction haul road of 10m width is proposed to be located within the River Blackwater floodplain to the east of Witham, tracking along the eastern edge of the A12 carriageway. This haul route would be raised above existing ground levels in places. It is currently thought that this haul route would need to be in place for less than 18 months.

Impact of proposed scheme on flood risk

7.3.7 With-scheme modelling has been used to assess how the haul road could impact flood risk in this location. The modelled change in flood extent caused by the proposed scheme for the 1% (1 in 100) AEP event is shown in Plate 7.2. Modelled changes in flood level caused by the proposed scheme are shown in Plate 7.3 (5% (1 in 20) AEP flood event) and Plate 7.4 (1% (1 in 100) AEP event).

7.3.8 When modelled (conservatively, with permanent proposed scheme and construction elements in place that would maximise impact on the floodplain), the haul road displaces approximately 810m^3 of water to the surrounding floodplain during the 1% (1 in 100) AEP flood event.

7.3.9 Modelling shows that, in general, the impacts of this proposed haul road on flood risk elsewhere are negligible across the whole area, resulting in water level changes of below 10mm for both flood events modelled.

7.3.10 In one small area (approximately 300m^2), within the west floodplain of the River Blackwater just downstream of Little Braxted Lane, the general increase of less than 10mm causes a small increase in the flood extent, causing the floodplain to extend into lower ground adjacent to the baseline flood extent. Within this small area, modelling shows a water level increase of up to 370mm (during the 1% (1 in 100) AEP flood event). An interrogation of the ground levels in this location reveals that this area of increased flood levels occurs within an area of depressed ground (likely a pond or ditch). As this small area is within woodland/wetland containing no receptors considered to be vulnerable to increased flood levels, no temporary flood mitigation has been proposed for this location.

Plate 7.1 River Blackwater floodplain east of Witham modelled baseline fluvial flood extents

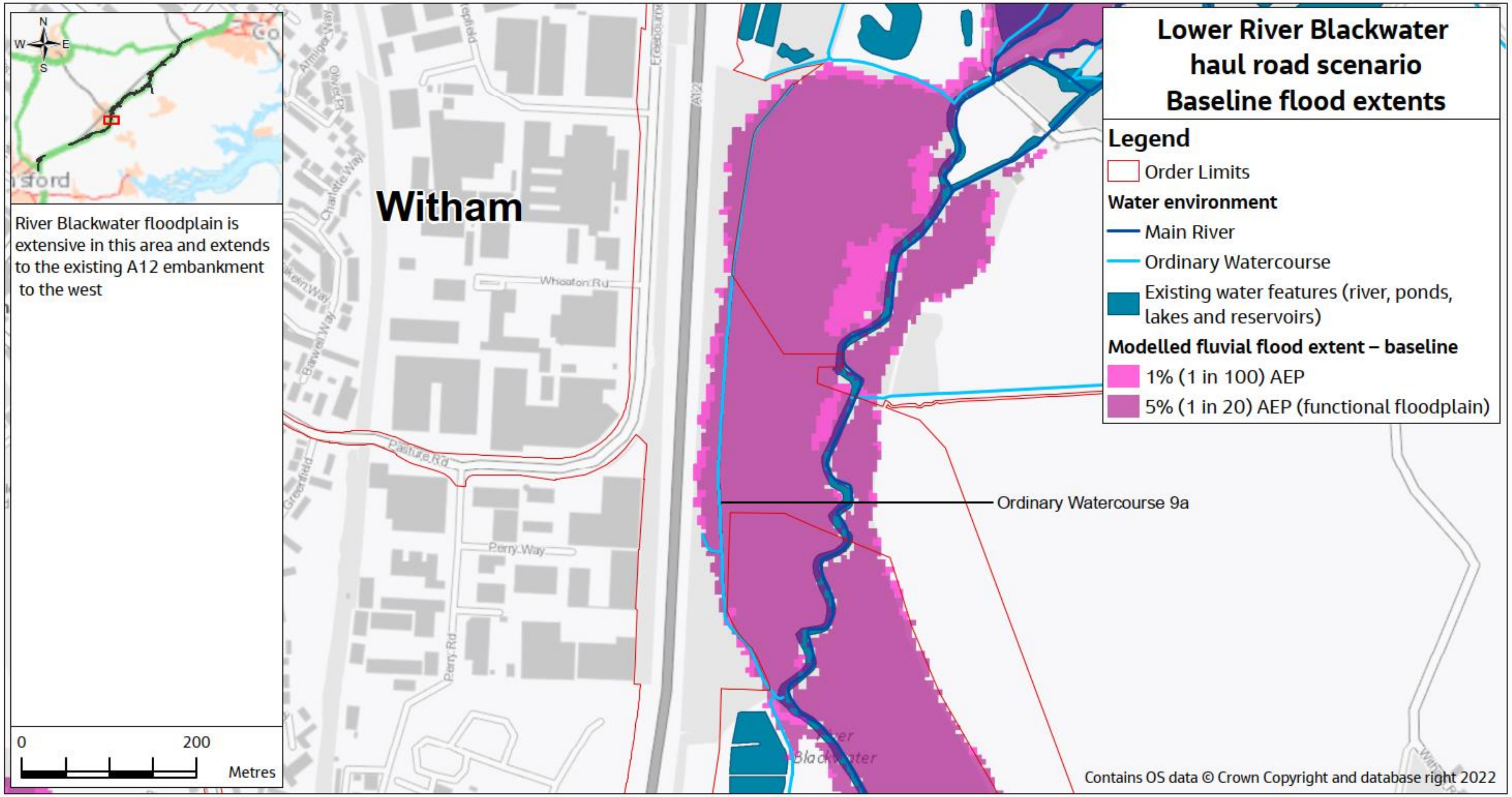


Plate 7.2 River Blackwater floodplain east of Witham – modelled change in flood extent as a result of the proposed haul road (1% (1 in 100) AEP event)

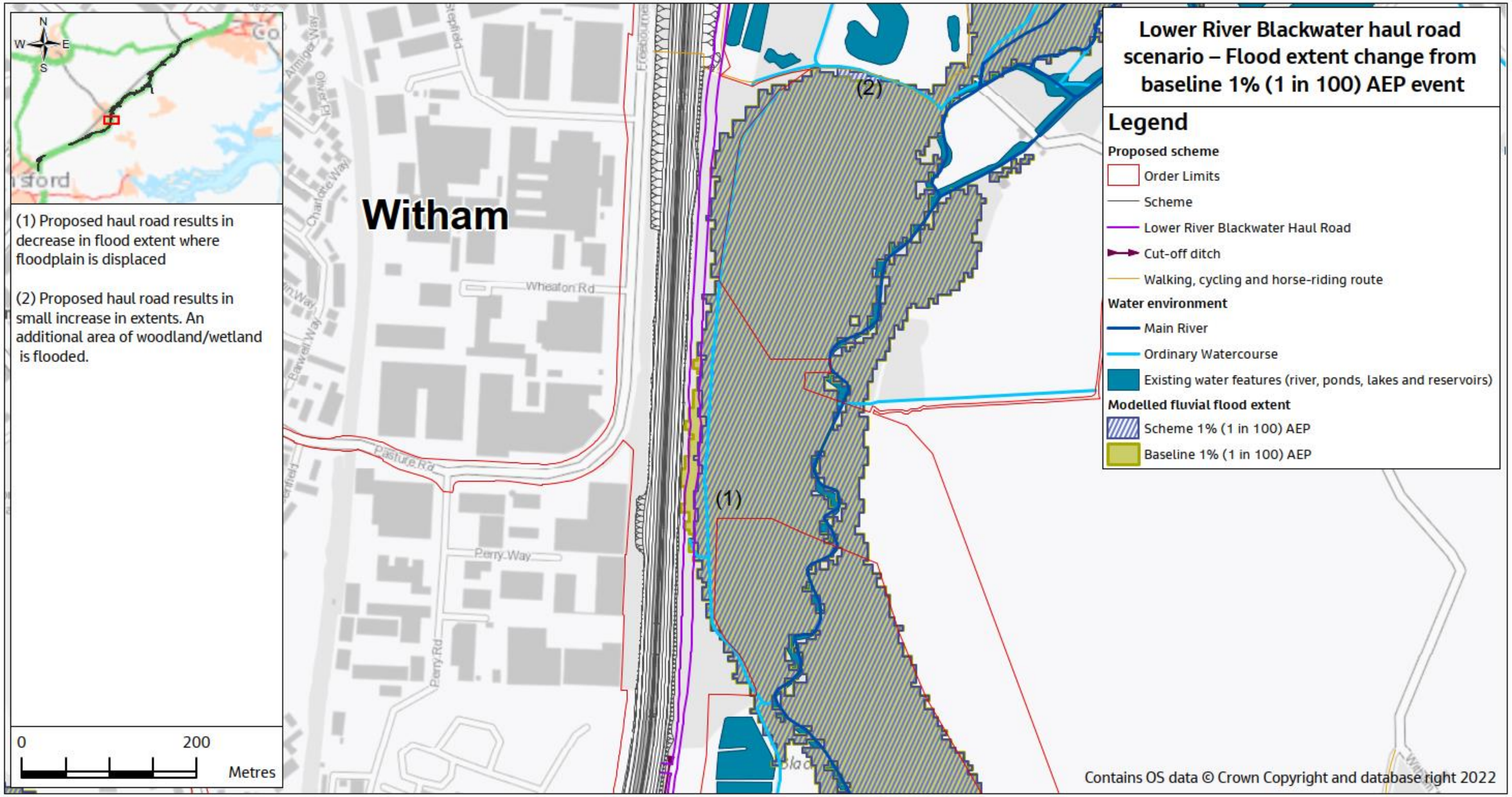


Plate 7.3 River Blackwater floodplain east of Witham – modelled change in flood levels as a result of the proposed haul road (5% (1 in 20) AEP event)

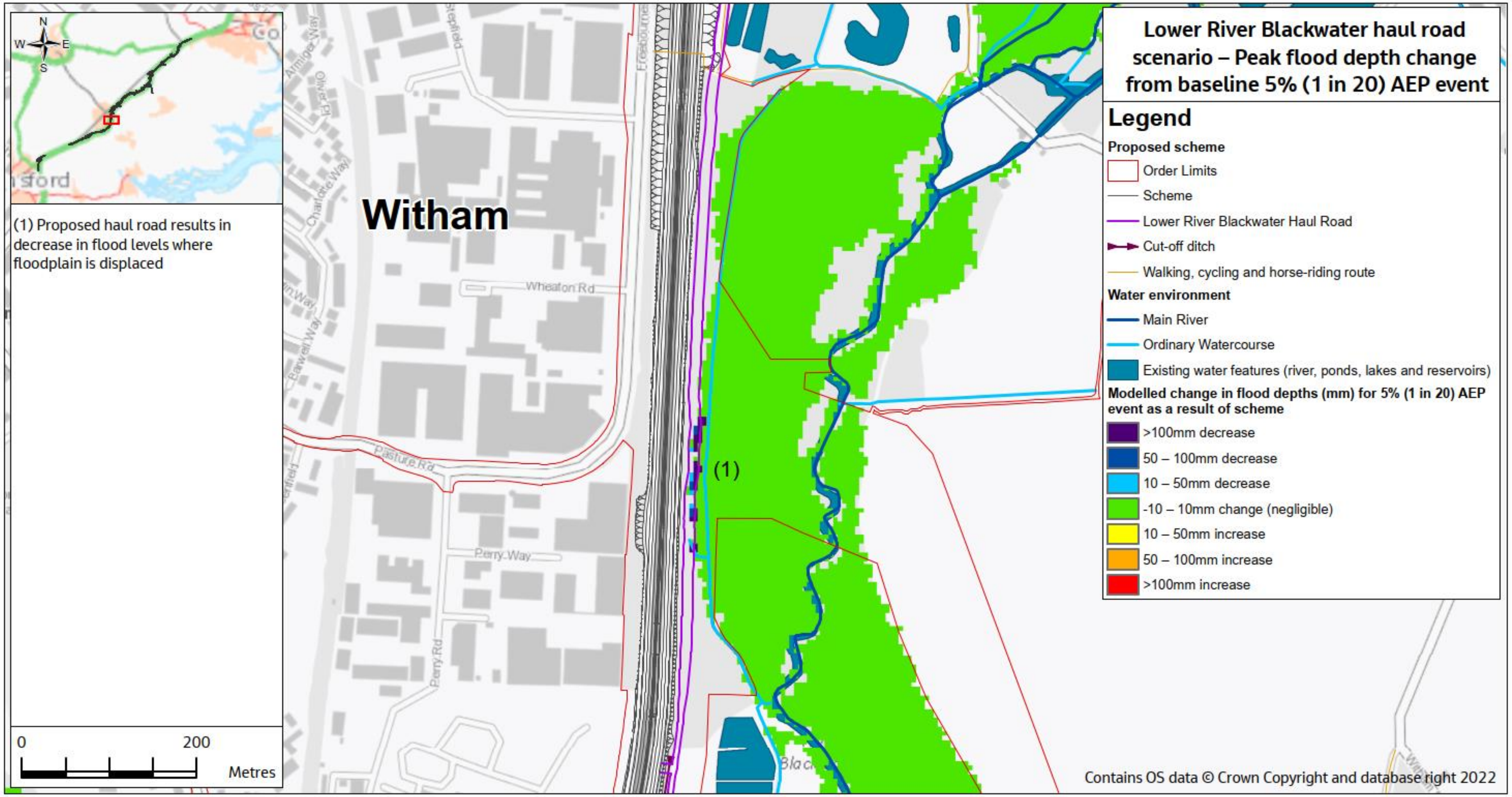
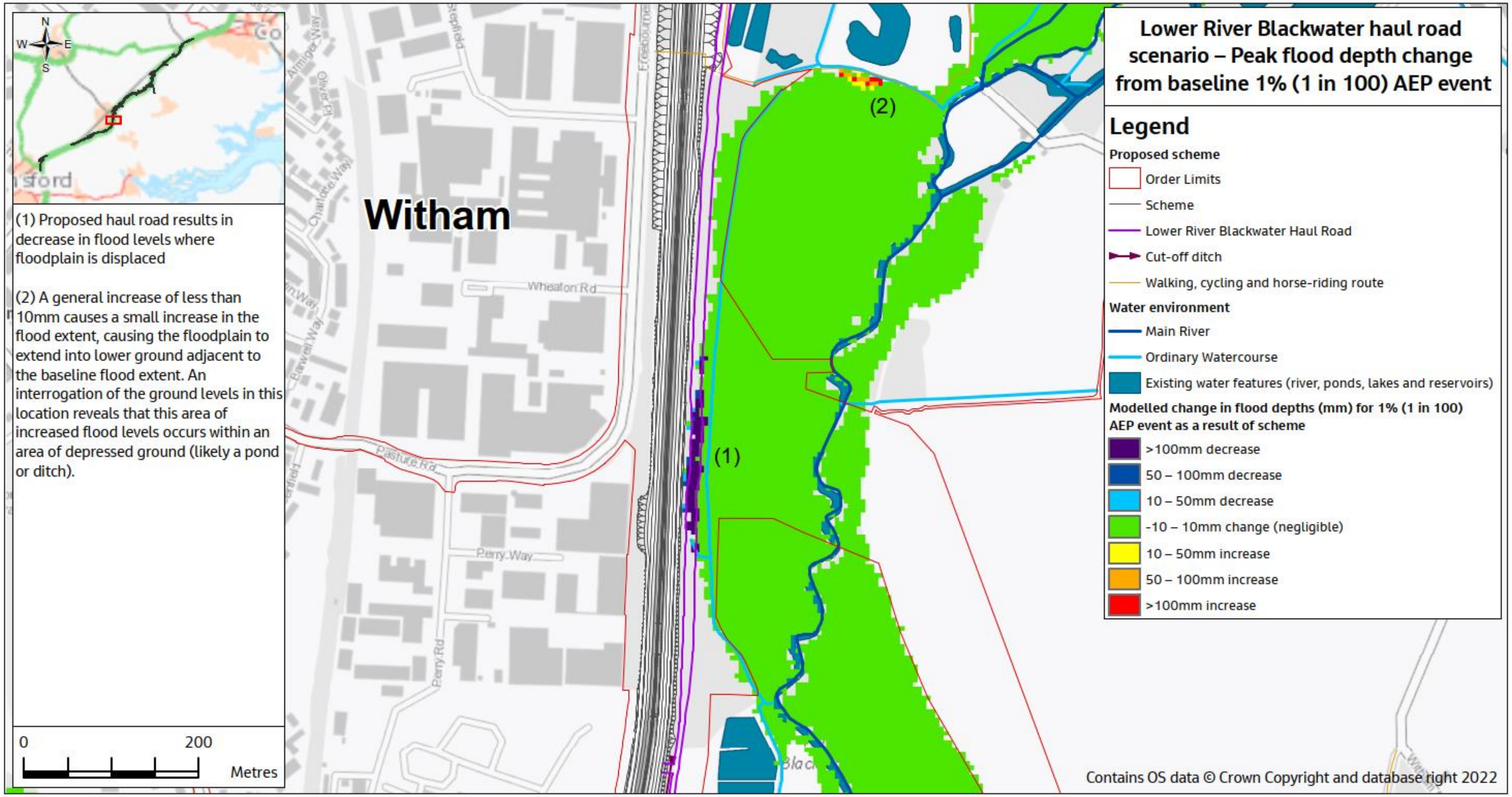


Plate 7.4 River Blackwater floodplain east of Witham – modelled change in flood levels as a result of the proposed haul road (1% (1 in 100) AEP event)



Haul road and piling rig south of Ashman's Bridge (within River Blackwater floodplain and channel)

Baseline flood risk

7.3.11 Baseline flood risk associated with the River Blackwater at the A12 crossing (Ashman's Bridge) is described in Section 2.6. Modelled baseline flood extents (5% (1 in 20) AEP, 1% (1 in 100) AEP) are included in Plate 7.5.

Construction works design

7.3.12 A construction haul road of 10m width and a piling rig is proposed to the south of the A12 carriageway (and Ashman's Bridge) to enable the proposed works to Ashman's Bridge. These works would interact with the River Blackwater watercourse channel and with the 5% (1 in 20) AEP fluvial floodplain (functional floodplain). It has therefore been considered appropriate to assess the potential flood risk impacts of these proposed works (see Annex L for details of how the proposed construction works have been represented in the hydraulic model). It is currently thought that these construction works would last for less than 18 months.

Impact of proposed scheme on flood risk

7.3.13 With-scheme modelling (including both the permanent proposed scheme and the haul road to represent the worst-case scenario) has been used to assess how the construction elements could impact flood risk in this location. The modelled change in flood extent caused by the proposed scheme for the 1% (1 in 100) AEP event is shown in Plate 7.6. Modelled changes in flood level caused by the proposed scheme are shown in Plate 7.7 (5% (1 in 20) AEP flood event) and Plate 7.8 (1% (1 in 100) AEP event).

7.3.14 When modelled (conservatively, with permanent proposed scheme and construction elements in place that would maximise impact on the floodplain), the inclusion of the construction elements in the model results in an increase in water levels between the haul road and the A12 by up to 35mm (during the 1% (1 in 100) AEP event) as the haul road partially blocks southward flows. It is not anticipated that any temporary flood mitigation would be required in this location as the land area of increased flood risk would be acquired by National Highways for the purpose of the proposed scheme and would not contain any receptors which could be harmed by the increase in peak flood depth.

7.3.15 A beneficial impact on flood risk is seen immediately downstream of the haul roads (on both sides of the watercourse).

7.3.16 Aside from the areas mentioned, the proposed scheme (permanent works plus construction elements) result in a negligible impact (less than 10mm change in flood levels) on flood risk elsewhere. Subsequently, it is considered that no temporary flood mitigation would be required in this location.

Plate 7.5 River Blackwater floodplain at Ashman's Bridge – modelled baseline fluvial flood extents

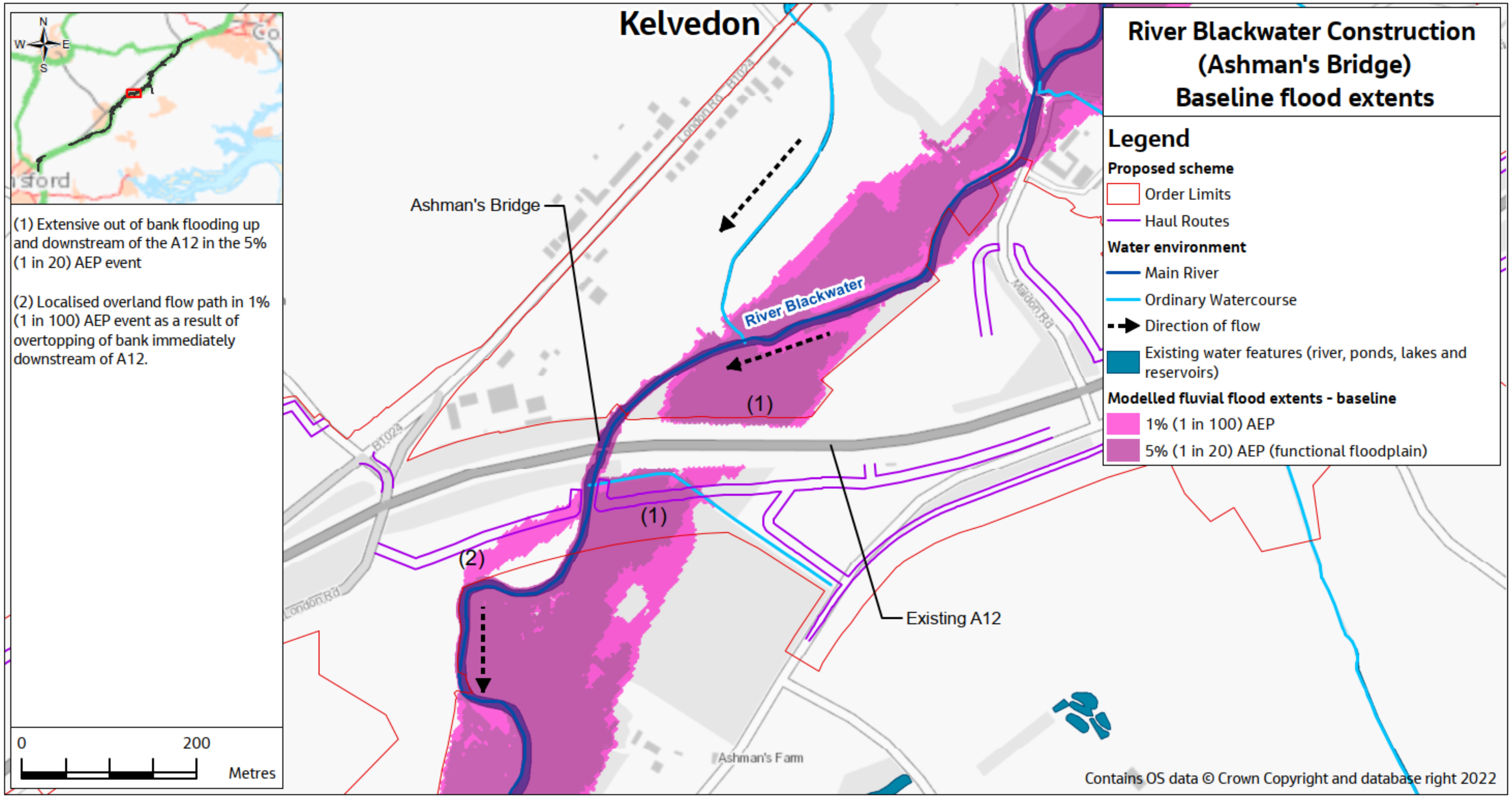


Plate 7.6 River Blackwater floodplain at Ashman's Bridge – modelled change in flood extent as a result of the proposed haul road and piling rig (1% (1 in 100) AEP event)

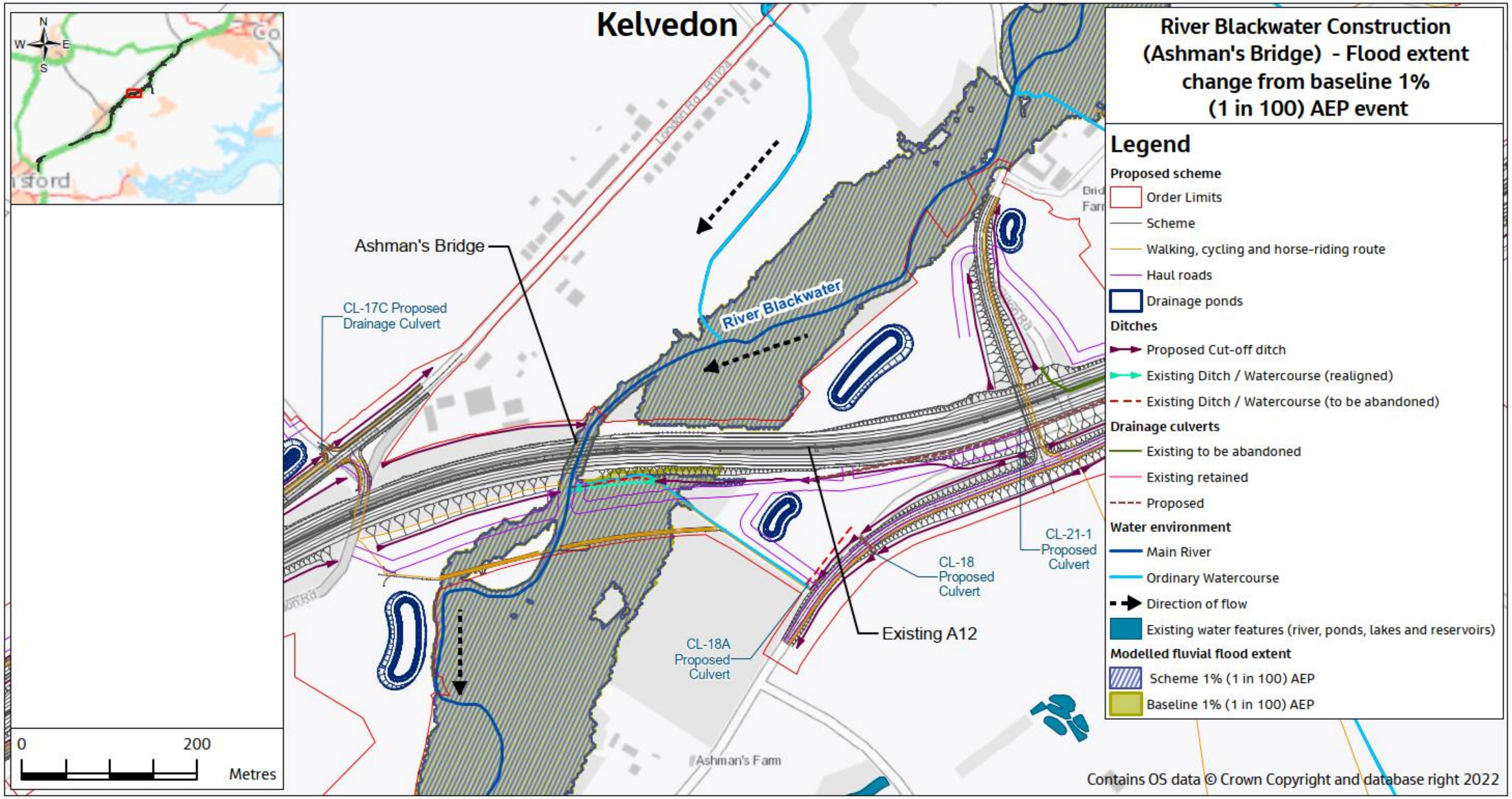


Plate 7.7 River Blackwater floodplain at Ashman's Bridge – modelled change in flood levels as a result of the proposed haul road and piling rig (5% (1 in 20) AEP event)

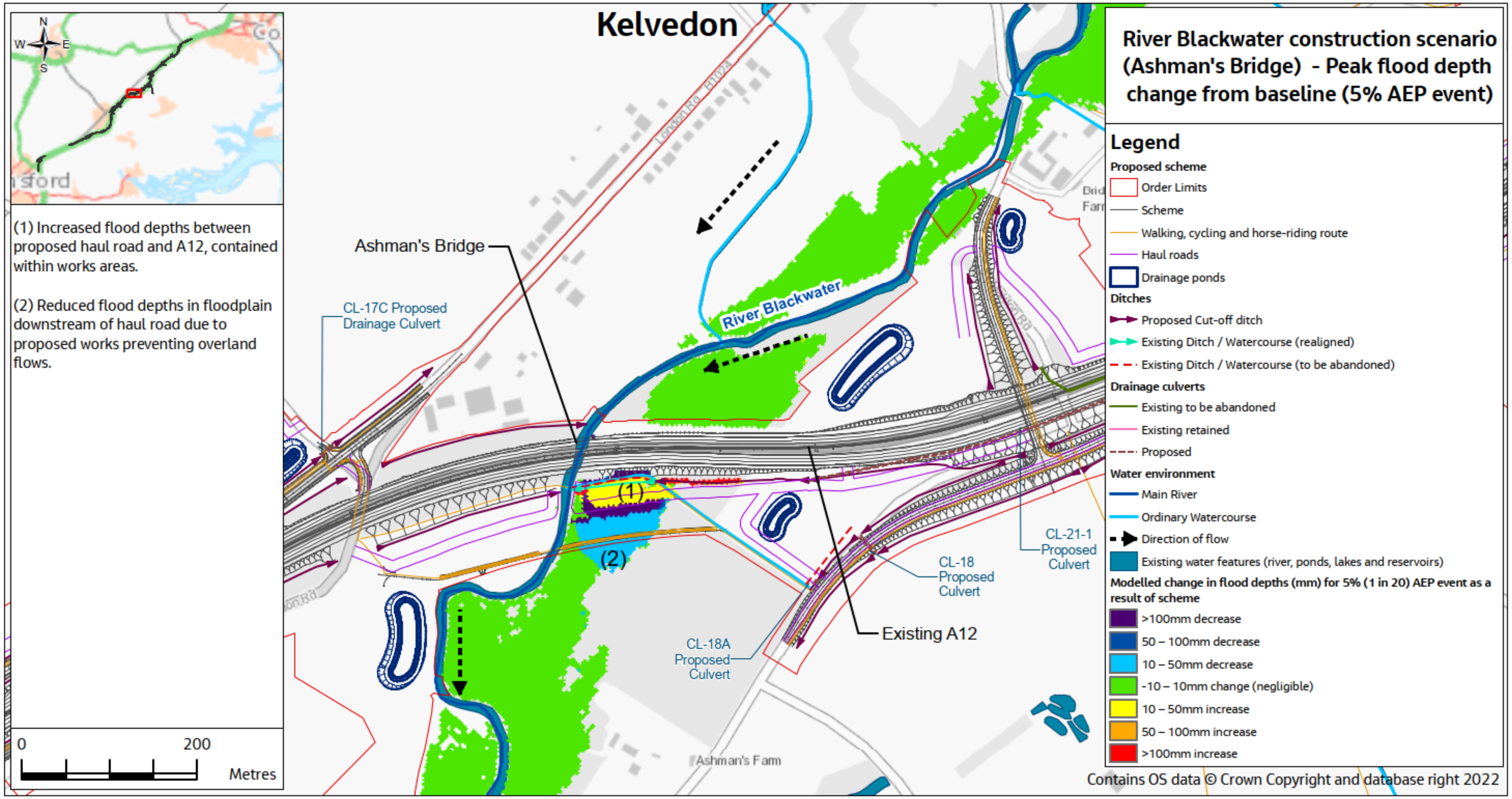
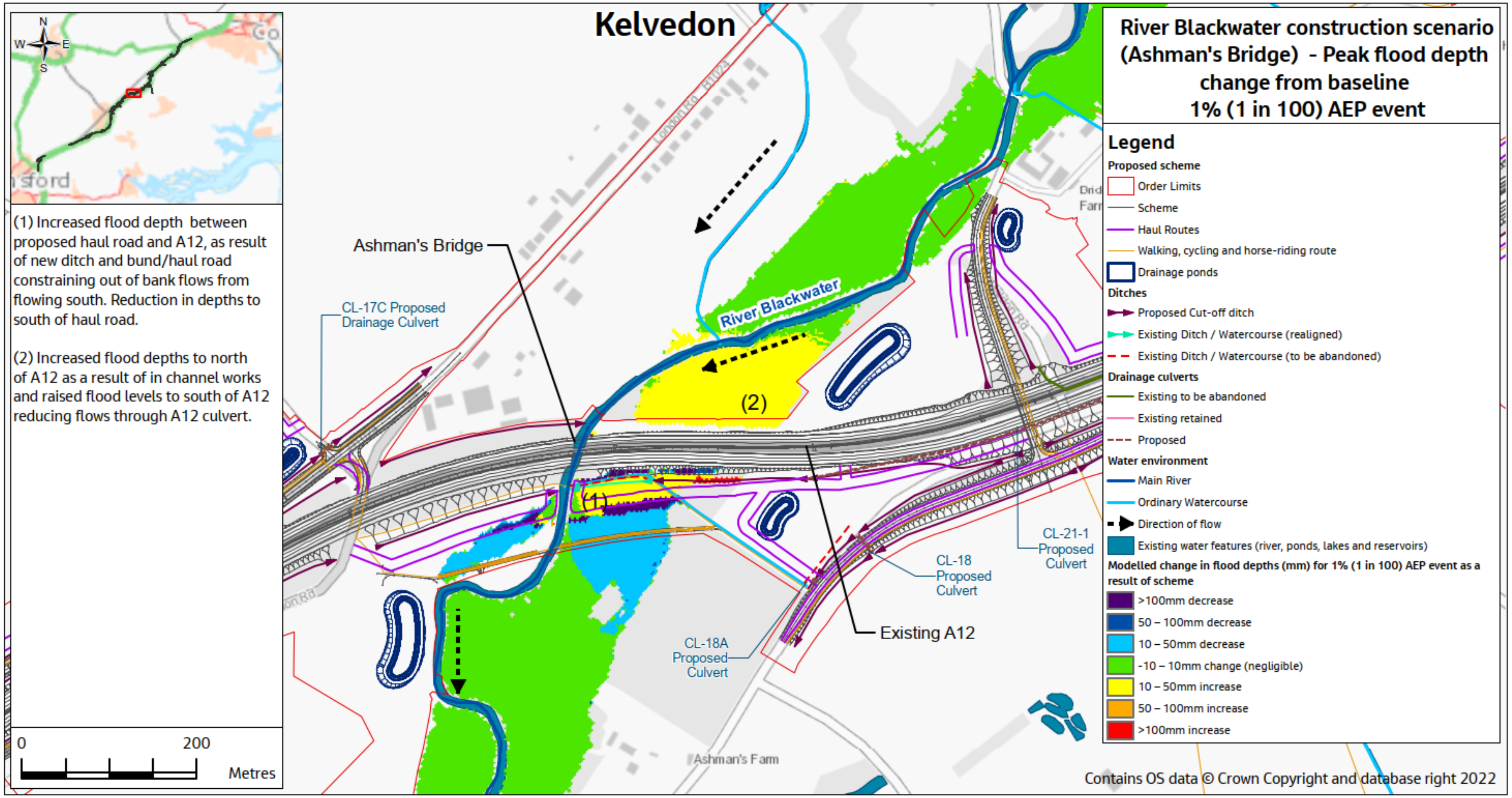


Plate 7.8 River Blackwater floodplain at Ashman's Bridge – modelled change in flood levels as a result of the proposed haul road and piling rig (1% (1 in 100) AEP event)



Borrow pits

7.3.17 Once suitable materials have been extracted from the four proposed borrow pits for the proposed scheme, they would be restored.

7.3.18 The Environmental Masterplan, Figure 2.1 of the Environmental Statement [TR010060/APP/6.2], shows the indicative borrow pit restoration proposals. A Borrow Pits Report has been included within Volume 7 of the DCO application [TR010060/APP/7.8] and provides more detail on the borrow pit restoration proposals. Borrow pits would be restored such that designed flood mitigation would function as described in this FRA.

7.3.19 Annex O displays interactions between proposed borrow pits and the 1% (1 in 100) AEP fluvial floodplain and areas at high risk of surface water flooding.

7.3.20 Ditches would be excavated at the top of the borrow pits to intercept water prior to it entering site. This would allow surface runoff to be channelled past the works and would prevent ingress into the borrow pit areas. Individual flood risk associated with each borrow pit is considered in the following paragraphs.

Borrow pits E and F

7.3.21 Borrow pit E (located between the existing junction 20b and junction 21, between the A12 and the GEML) does not cross any significant surface water flow paths. Although the Ordinary Watercourse 7 floodplain upstream of the A12 is crossed by the borrow pit, temporary ditches around the perimeter of the borrow pit would capture and convey flows around the borrow pit.

7.3.22 The southern edge of borrow pit F (located to the east of junction 21 on the south side of the A12, just below Witham) extends into a surface water flow path. Temporary ditches around the perimeter of the borrow pit would capture and convey these flows safely around the borrow pit.

7.3.23 It is therefore considered that borrow pit E and borrow pit F would have negligible impacts on flood risk elsewhere (assessed for up to the 1% (1 in 100) AEP event).

Borrow pit I

7.3.24 Borrow pit I (located to the east of Rivenhall End and to the west of junction 23 (Kelvedon South interchange), between the A12 and the GEML) is located partially within an area of fluvial floodplain associated with Rivenhall Brook. During a flood event, the borrow pit could flood and result in risk of flooding to people and plant within the borrow pit. If the borrow pit were to flood, then dewatering of the flooded borrow pit would be required following the flood event.

7.3.25 It is considered that borrow pit I would have negligible impacts on flood risk elsewhere (assessed for up to the 1% (1 in 100) AEP event) as it does not cross any surface water flow paths and would not displace any fluvial floodplain associated with Rivenhall Brook.

Borrow pit J

7.3.26 Proposed borrow pit J would be located along the southbound side of the A12 with Inworth Road located immediately to the east and Highfields Lane to the west.

7.3.27 The western area of borrow pit J would cross two north-western flowing tributaries of Ordinary Watercourse 21, and the eastern area of borrow pit J would cross two north-western flowing tributaries of Ordinary Watercourse 21a (see Section 3.2 for details of proposed flood mitigation works at Ordinary Watercourses 21 and 21a). It is anticipated that these tributaries would be temporarily realigned around the perimeter of the borrow pit during borrow pit operation. Temporary realignment would be suitably sized to safely convey flows. Borrow pits would be restored such that designed flood mitigation would function as described in this FRA. Refer to indicative borrow pit restoration plans on the General Arrangement Plans [TR010060/APP/2.9] for details of how the borrow pits could be restored.

7.3.28 To prevent the temporary realignment of these tributaries from resulting in increased flood risk to the existing A12, the permanent mitigation works for Ordinary Watercourses 21 and 21a (see Section 3 for details) would be completed prior to the temporary realignment.

Dewatering

7.3.29 It is expected that dewatering would be required at several locations (including proposed scheme cutting areas and borrow pits). Based on current information regarding groundwater, any dewatering in the borrow pit excavation area would be undertaken and groundwater treated prior to discharge to local watercourses.

7.3.30 If not disapplied and where required, environmental permits for groundwater abstraction and water discharge would be sought from the Environment Agency before this work commenced.

7.3.31 A number of cuttings and one borrow pit are anticipated to intercept groundwater and require potentially significant groundwater dewatering to take place during the construction phase (detailed in Table 7.2). In each case it is proposed the intercepted water would be discharged to a nearby watercourse (exact locations to be confirmed).

7.3.32 Table 7.2 includes estimated dewatering flow rates and flow rates of potential receiving watercourses (nearby watercourses) during flood events. Further GI will be undertaken to further inform groundwater abstraction rates and discharge required. In most locations, the magnitude of dewatering flow rates is small in comparison to the flood event flow rate of the potential receiving watercourse. A review of these potential receiving watercourses reveals that there are no sensitive receptors located near to the existing floodplain. Therefore, it is considered that in these locations discharge of dewatering flows to these watercourses would result in a negligible increase in flood risk. However, in two locations the dewatering flow rate is not considered negligible in comparison to the receiving watercourse:

- Cutting W5
- Borrow pit J

7.3.33 For cutting W5, the estimated dewatering flow rate ($0.115m^3/s$) is considered significant in comparison to the potential receiving watercourse, Ordinary Watercourse 10 ($0.314m^3/s$ at the existing A12 culvert during a 1% (1 in 100) AEP event). However, downstream of the existing A12 crossing, Ordinary Watercourse 10 flows only through agricultural or other greenfield land and drains into the River Blackwater (the watercourse largely lies within River Blackwater floodplain). The estimated dewatering flow for cutting W5 ($0.115m^3/s$) is small in comparison to the River Blackwater flow rate ($34.457m^3/s$ calculated at the existing A12 bridge crossing during a 1% (1 in 100) AEP event). There are also no receptors considered to be vulnerable to flooding in this downstream reach of Ordinary Watercourse 10. Therefore, it is considered that if W5 dewatering flows were to be discharged into this watercourse downstream of the A12 Ordinary Watercourse 10 crossing, this would result in a negligible increase in flood risk.

7.3.34 For borrow pit J, the estimated dewatering flow rate ($0.357m^3/s$) is considered significant in comparison to the potential receiving watercourse, Ordinary Watercourse 21, immediately upstream of the existing A12 ($2.254m^3/s$ during a 5% (1 in 20) AEP event, $3.337m^3/s$ during a 1% (1 in 100) AEP event). In the baseline scenario, the existing A12 has been shown to be at risk of flooding from Ordinary Watercourse 21 (see Section 3.2: Modelled Ordinary Watercourses for more details). In this location, the permanent proposed scheme involves flood mitigation works to ensure the A12 is safe from flooding. These works include a storage area which would hold back a large proportion of Ordinary Watercourse 21 flows upstream of the A12 during a flood event, and a ditch/pipe system to intercept and capture flows upstream of the A12 and safely divert these to the River Blackwater. These mitigation works would be implemented prior to the construction works to the mainline A12. It is considered that, were borrow pit J dewatering flows to be discharged to Ordinary Watercourse 21, these flows should be safely managed by the proposed mitigation works that would be in place. The dewatering would therefore result in a negligible increase in flood risk associated with Ordinary Watercourse 21.

7.3.35 Where discharge to watercourses is proposed, discharge rates would be carefully controlled to achieve no environmentally significant change to flood risk associated with the receiving watercourses. If required, dewatering discharge could be temporarily paused during flood events to prevent any increased flood risk during the flood event.

Table 7.2 High-level estimate of potential groundwater dewatering flows and peak flow rates of potential receiving watercourses during flood events

Cutting ID	Dewatering flow rate (Q) (m^3/s)*	Potential nearby receiving watercourse	Location of potential receiving watercourse flow rate calculation	Flow rate of potential receiving watercourse (Q) (m^3/s)** [percentage of receiving watercourse flow that dewatering flow would be equivalent to]	
				5% (1 in 20) AEP event	1% (1 in 100) AEP event
W2	0.046	River Ter	Upstream and downstream of existing A12 bridge crossing	10.674 [0.4%]	13.642 [0.3%]
W5	0.115	Ordinary Watercourse 10	At the existing A12 culvert crossing	-	0.314 [36.6%]
W6	0.118	River Blackwater	Upstream and downstream of existing A12 bridge crossing	24.901 [0.5%]	34.457 [0.3%]
W7	0.025	Ordinary Watercourse 21	Upstream of the existing A12 (the three tributaries combined)	2.254 [1.1%]	3.337 [0.7%]
Borrow pit J	0.357			2.254 [15.8%]	3.337 [10.7%]
WJ4	0.013	Boreham Brook	Downstream of existing A12 culvert crossing	2.626 [0.5%]	3.663 [0.4%]
CJ11	0.027			2.626 [1.0%]	3.663 [0.7%]
WJ2	0.015	Roman River	Upstream and downstream of existing A12 culvert crossing	2.600 [0.6%]	3.593 [0.4%]

* *Dewatering flow rates likely to be overestimates due to estimation methodology (refer to Section 1.3 for further methodology detail)*

** *Baseline flow rates*

Construction methodology at watercourse crossings

7.3.36 Watercourse channels may have to be temporarily diverted or constricted to facilitate construction works to existing watercourse crossing structures. Methods such as temporary overpumping of watercourses or use of sheet piling (or other water-retaining structures) would be employed to manage flows in the channel. This could temporarily reduce the capacity of the channel and increase flood risk.

7.3.37 Where overpumping of watercourses would be used during construction (e.g. to enable works within watercourse channels), overpumping pipes would be sized appropriately for the likely watercourse flows based on a risk-based approach in consultation with the Environment Agency (for Main Rivers) or the LLFA (for Ordinary Watercourses).This would be included in the Water Management Plan.

7.3.38 Where water-retaining structures would be utilised during construction to restrict flows in watercourse channels (e.g. to enable works within watercourse channels), the structures would be designed so that they would be overtopped by the 5% (1 in 20) AEP event. Therefore, the retaining structures would have minimal impact on channel capacity during a more extreme flood event.

7.3.39 Where watercourse crossings would be required during construction, a 10% (1 in 10) AEP event standard is proposed to be used to size these crossing structures. The flood event appropriate for each watercourse would be agreed with the Environment Agency (for Main Rivers) or the LLFA (for Ordinary Watercourses) as part of the relevant Flood Risk Activity Permit or watercourse consent application with the Environment Agency or the LLFA respectively. This would ensure a low risk of the works causing an increase in flooding to receptors, particularly as the risk of an event occurring during the short construction timescales would be low.

8 Sequential and Exception Tests

8.1 The Sequential Test

8.1.1 The aim of the Sequential Test is to ensure the safety and sustainability of new developments and provide guidance for developers. The Sequential Test ensures that a sequential approach is applied, steering developments to areas with a low probability of flooding. The Flood Zones are defined by the Environment Agency's (2021b) Flood Map for Planning and in the local SFRAs. The aim is to steer new development to Flood Zone 1 (areas with a low probability of river or sea flooding).

8.1.2 If this is not possible, decision-making should consider the flood risk vulnerability of land uses. Therefore, the decision makers should consider reasonably available sites in Flood Zone 2 (areas with a medium probability of river or sea flooding), applying the Exception Test if required. Only where there are no reasonably available sites in Flood Zones 1 or 2 should the suitability of sites in Flood Zone 3 (areas with a high probability of river or sea flooding) be considered. However, it should consider the flood risk vulnerability of land uses and apply the Exception Test if required.

8.1.3 Paragraph 019 of flood risk and coastal change planning practice guidance (Ministry of Housing, Communities and Local Government, 2021b) details that, within the flood zones, other sources of flooding need to be considered. Therefore, a sequential approach should be applied to determine the location of the new development.

8.2 Application of the Sequential Test

8.2.1 The proposed scheme is mostly located within Flood Zone 1, but there are parts of it located within Flood Zones 2 and 3. Various routes have been considered, and minimising the impact on Flood Zones has been a key criterion in the selection of the preferred route for the proposed scheme. However, it has not been practicable to completely avoid the functional floodplain due to the location of the existing infrastructure (A12 main carriageway). As such, it is considered that the Sequential Test should be passed.

8.2.2 In terms of flood risk vulnerability, the proposed scheme is classified as 'essential infrastructure'. As such, the development is deemed appropriate in Flood Zones 1 and 2, but the Exception Test is required for Flood Zone 3.

8.3 The Exception Test

8.3.1 The appliance of the Exception Test depends on the location of the proposed scheme and its flood risk vulnerability classification as shown in Table 8.1. The Exception Test is used to demonstrate and ensure that flood risk to people and property would be managed properly, while allowing the proposed scheme to go ahead in situations where suitable sites at lower risk of flooding are not available.

8.3.2 As detailed in paragraph 164 of the NPPF (Ministry of Housing, Communities and Local Government, 2021a), there are two sections of the Exception Test that the applicant needs to demonstrate:

- The proposed scheme provides wider sustainability benefits to the community that outweigh the risk of flooding
- The proposed scheme would be safe for its lifetime, without increasing flood risk elsewhere, and, where possible, reduce flood risk overall.

Table 8.1 Summary of conditions required for the application of the Exception Test (Ministry of Housing, Communities and Local Government, 2021b)

<table>
<tr><th rowspan="2">Flood Zones</th><th colspan="5">Flood risk vulnerability classification</th></tr>
<tr><th>Essential infrastructure</th><th>Highly vulnerable</th><th>More vulnerable</th><th>Less vulnerable</th><th>Water-compatible development</th></tr>
<tr><td>Zone 1</td><td colspan="5">Development is appropriate</td></tr>
<tr><td>Zone 2</td><td>Development is appropriate</td><td>Exception Test required</td><td colspan="3">Development is appropriate</td></tr>
<tr><td>Zone 3a</td><td>Exception Test required</td><td>Development should not be permitted</td><td>Exception Test required</td><td colspan="2">Development is appropriate</td></tr>
<tr><td>Zone 3b</td><td>Exception Test required</td><td colspan="3">Development should not be permitted</td><td>Development is appropriate</td></tr>
</table>

8.4 Application of the Exception Test

8.4.1 The A12 is an important economic link in Essex and across the east of England. Previous studies indicate several problems between junction 19 and junction 25 of the A12. The key problems and issues from these studies are documented in the Options Assessment Report (Highways England, 2016).

8.4.2 Moreover, there are over 40,000 dwellings and 20,000 jobs planned within the region over the coming years (National Trip End Model (Department for Transport, 2017)). In addition, the investment in the Haven Ports is likely to increase heavy goods vehicles along the route. As such, an increase in overall traffic volume during peak periods is expected on the A12.

8.4.3 Strategic issues that the proposed scheme aims to resolve are as follows:

- Traffic flows and congestion
- Consistency in standard
- Resilience
- Safety
- WCH and public transport provision

8.4.4 Section 2.3 in Chapter 2 of the Environmental Statement [TR010060/APP/6.1] provides the proposed scheme specific objectives.

8.4.5 This FRA establishes that the proposed scheme would not exacerbate existing levels of flood risk on or offsite other than in areas where this would be deliberately achieved as part of the flood mitigation strategy. This FRA also demonstrates that the proposed scheme would be safe for users for its lifetime, which includes consideration of the predicted impacts of climate change.

8.4.6 Therefore, the requirements to pass the Exception Test have been met.

9 Conclusions

9.1.1 This FRA has assessed flood risk to and from the proposed scheme for all sources of flood risk.

9.1.2 It is considered that the proposed scheme meets the requirements of the Sequential and Exception Tests and the flood risk requirements of paragraph 5.94 of the NNNPS (Department for Transport, 2014).

9.1.3 Including proposed mitigation, the proposed scheme would be expected to remain safe and operational in flood events up to the 1% (1 in 100) plus climate change event.

9.1.4 The impacts on flood risk during the construction phase are anticipated to be neutral.

9.1.5 Including proposed mitigation, the permanent residual effects of the proposed scheme on flood risk would mainly be negligible, with no change to flood risk outside the proposed scheme Order Limits. In some areas, the proposed scheme would reduce flood risk, particularly to the A12, but also to some local properties and land. Where adverse impacts have been identified, these are to areas within the permanent land-take of the proposed scheme.

Acronyms

Abbreviation	Term
AOD	Above Ordnance Datum
AEP	Annual Exceedance Probability
BGS	British Geological Survey
CDA	Critical Drainage Area
CIRIA	Construction Industry Research and Information Association
DCO	Development Consent Order
Defra	Department for Environment, Food and Rural Affairs
DMRB	Design Manual for Roads and Bridges
ECC	Essex County Council
EMP	Environmental Management Plan
FRA	Flood Risk Assessment
GEML	Great Eastern Main Line
GI	Ground investigation
DDMS	National Highways Drainage Data Management System
LiDAR	Light Detection and Ranging
LLFA	Lead Local Flood Authority
mbgl	Metres below ground level
NGR	National Grid Reference
NNNPS	National Networks National Policy Statement
NPPF	National Planning Policy Framework
PFRA	Preliminary Flood Risk Assessment
RoFSW	Risk of Flooding from Surface Water
SFRA	Strategic Flood Risk Assessment
SWMP	Surface Water Management Plan
SuDS	Sustainable drainage system
UKCP09	United Kingdom Climate Projections 2009
UKCP18	United Kingdom Climate Projections 2018
WCH	Walking, cycling and horse riding

Glossary

Term	Definition
Artesian	Relating to the upward movement of water under hydrostatic pressure in rocks or unconsolidated material beneath the earth's surface
Critical Drainage Area (CDA)	A discrete geographic area (usually a hydrological catchment) where multiple and interlinked sources of flood risk (surface water, groundwater, sewer, Main River and/or tidal) cause flooding in one or more Local Flood Risk Zones during severe weather, thereby affecting people, property or local infrastructure
Dewatering	Removal of groundwater from construction areas or proposed scheme areas
DG5 Register	A water-company held register of properties which have experienced sewer flooding due to hydraulic overload, or properties which are 'at risk' of sewer flooding more frequently than once in 20 years
Flood defence	Infrastructure used to protect an area against floods, such as floodwalls and embankments
Floodplain	Generally the low lying land surrounding a watercourse that experiences occasional or periodic flooding.
Fluvial flooding	Flooding resulting from water levels exceeding the bank level of a Main River
Freeboard	Culvert, screen and outfall manual, (CIRIA C786) published by CIRIA in 2019, defines freeboard as: 'An allowance for uncertainty in design water level and any other physical processes that may affect the ability of an asset to withstand the design water level such as wave action or superelevation.'
Greenfield	Undeveloped parcel of land
Groundwater	Water that is stored or flowing beneath the earth's surface
Headwall	A small retaining wall built at the inlet or outlet of a drainage pipe or culvert pipe to prevent erosion at the point of discharge into watercourses.
Internal Drainage Board	A local public body that manages flood risk and land drainage within areas of special drainage. The area covered is determined by the local hydrology and not by political boundaries such as those of counties.
Lead Local Flood Authority (LLFA)	The local authority responsible for taking the lead on local flood risk management. The duties of LLFAs are set out in the Floods and Water Management Act 2010.
Light Detection and Ranging (LiDAR)	A method of generating three-dimensional elevation models using light in the form of a pulsed laser to measure ranges (variable distances) to the Earth.

Term	Definition
Local planning authority	The local authority or council that is empowered by law to exercise planning functions for a particular area. This is typically the local study area or study area council
Main River	A watercourse shown as such on the Statutory Main River Map (Environment Agency, 2020b), and for which the Environment Agency has responsibilities and powers
Ordinary Watercourse	All watercourses that are not designated as Main Rivers. Local authorities or, where they exist, Internal Drainage Boards have similar permissive powers as the Environment Agency in relation to flood defence work. However, the riparian owner is responsible for maintenance.
Orifice Plates	A device to control the flow rate inside a pipe, by restricting flows through the plate.
Pluvial flooding (also known as surface water flooding)	Flooding as a result of surface water runoff as a result of high intensity rainfall when water is ponding or flowing over the ground surface before it enters the underground drainage network or watercourse, or cannot enter it because the network is full to capacity, thus causing what is known as pluvial flooding. Also known as surface water flooding.
Return period	An estimate of the interval of time between events of a certain intensity or size. In this instance, it refers to flood events. It is a statistical measurement denoting the average recurrence interval over an extended period of time.
Secondary A aquifer	Permeable layers that can support local water supplies, and may form an important source of base flow to rivers
Secondary B aquifer	Mainly lower permeability layers that may store and yield limited amounts of groundwater through characteristics like thin cracks (fissures) and openings or eroded layers
Secondary (undifferentiated) aquifer	Aquifers where it is not possible to apply either a Secondary A or B definition because of the variable characteristics of the rock type. These have only a minor value.
Sewer flooding	Flooding caused by a blockage or overflowing in a sewer or urban drainage system.
Sustainable drainage systems (SuDS)	Methods of management practices and control structures that are designed to drain surface water in a more sustainable manner than some conventional techniques
Surface water runoff	Rainwater (including snow and other precipitation) which is on the surface of the ground (whether or not it is moving) and has not entered a watercourse, drainage system or public sewer.
Toe Drain	Drains installed at the toe of the embankment to collect and convey surface water from adjoining road.

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Annex A Proposed scheme (operational elements)

Annex B Proposed scheme (operational and construction elements)

Annex C Topographic elevation

Annex D Baseline surface water flood risk

Annex E Baseline fluvial flood risk

Annex F Baseline groundwater flood risk

Annex G Baseline flood risk from reservoir failure (table)

Table G.1 Description of areas shown to be at risk from reservoir failure

Proposed scheme location (NGR)	Description	Source reservoir
Approximately 500m south of junction 19 (TL 74093 07750 to TL 74070 08813)	The area is at risk from reservoir flooding, with the flood depth described as being over 2m on the east side of the proposed scheme and between 0.3m and 2m on the west side. The flood water speed is predominantly between 0.5m/s and 2m/s.	Hanningfield Reservoir
Approximately 1.5km south-west of junction 21 (TL 78121 11457)	The area is at risk from reservoir flooding, with the flood depth described as being between 0.3m and 2m. The flow path crosses the proposed scheme moving from north-west to south-east. The flood water speed is predominantly below 0.5m/s.	Lavender and Lodge (Leigh's Power) Reservoirs
Approximately 0.8km and 1.5km south-west of junction 22 (TL 82995 15117; TL 82785 13661)	The area is at risk from reservoir flooding, with the flood depth described as being between 0.3m and 2m. The flow path crosses the proposed scheme moving from north-west to south-east. The flood water speed is predominantly between 0.5m/s and 2m/s.	Powers Hall Reservoir
Approximately 2.5km north-east of junction 22 (TL 85454 17676)	The area is at risk from reservoir flooding, with the flood depth described as being between 0.3m and 2m. The flow path crosses the proposed scheme moving from north-east to south-west. The flood water speed is predominantly below 0.5m/s.	Feeringbury Farm Reservoir
Approximately 5km north-east of junction 22 (TL 87667 19046)	The area is at risk from reservoir flooding, with the flood depth described as being between 0.3m and 2m. The flow path crosses the proposed scheme moving from north-east to south-west. The flood water speed is predominantly below 0.5m/s.	Feeringbury Farm Reservoir

Annex H Baseline flood risk from reservoir failure (figure)

Annex I Historic flooding

Annex J Historic flooding from existing water supply and sewer infrastructure (table)

Table J.1 Description of historic flooding risk by local planning authority

Local planning authority	Summary of risk described in SWMP
Braintree District Council	Anglian Water provided past sewer flood records for the production of the Braintree District Council Level 1 SFRA (AECOM, 2016a). The flood events are displayed on a map within the SFRA grouped by postcode area. Review of the mapping determines that the proposed scheme lies within a postcode area with one recorded flood event. However, the area is extensive, and it is not possible to determine whether the sewer flooding event lies within the Order Limits.
Colchester Borough Council	According to the Colchester Town SWMP (Capita Symonds, 2013a), Anglian Water stated that the existing sewer network is operating close to or at capacity. Anglian Water's Strategic Direction Statement 2010-2035 (Anglian Water, 2007) stated that the company planned to have zero properties at sewer flood risk by 2020. It is not known if this has been achieved. DG5 register data was provided and mapped as part of the SWMP. Review of the mapping determined that no sewer flooding events have been recorded within the Order Limits. Drainage modelling was undertaken as part of the Colchester Town SWMP in order to assess the flood risk. The sewer network was mapped and included in the SWMP. The mapping indicates that the proposed scheme does not cross the combined sewer network. The modelling undertaken was inconclusive due to limited available data and its quality. The SWMP recommends that the risk of sewer flooding should be assessed based on historic data. However, the historic data does not account for future changes due to climate change or development.
Chelmsford City Council	Detailed plans of the Anglian Water sewer network were assessed as part of the Chelmsford SWMP (Capita Symonds, 2014). The information was overlaid on the pluvial modelling results to determine whether flooding was associated with the capacity of the sewer network. The results were inconclusive due to limited available data and its quality. No reports of historic sewer flooding were included.
Maldon District Council	The Maldon SWMP (Capita Symonds 2013b) states that the risk of sewer flooding was assessed based on information provided by Anglian Water. No sewer related flood events were recorded within the Order Limits. Nevertheless, the SWMP states that additional areas may be at risk of sewer flooding in the future due to effects of the climate change.

Annex K Existing water supply and sewer infrastructure

Annex L Hydraulic modelling reports

Annex M Details of watercourses crossed by the proposed scheme

Table M.1 Main Rivers and other watercourses which would be crossed by the proposed scheme (listed in order from west to east)

Watercourse	Description
Ordinary Watercourse 1b (tributary of the River Chelmer)	Ordinary Watercourse 1b has its source in Dukes Park industrial estate, north of Chelmer Village and west of the A12. From there it flows east, through the A12 culvert and towards the River Chelmer, while exhibiting a generally straight planform.
Ordinary Watercourse 1a	Ordinary Watercourse 1a has its source approximately 0.5km west of the proposed scheme, in Springfield Business Park, north of Chelmer Village and west of the A12. The channel flows east, where it is culverted beneath the industrial estate, and flows into a small reservoir beneath the A12 via a culvert and towards its confluence with Ordinary Watercourse 1. The channel is largely impounded upstream of the A12, while downstream it acts a field drain and boundary. With the exception of some channel widening, the watercourse is hydromorphologically inactive.
Ordinary Watercourse 1 (tributary of the River Chelmer)	Ordinary Watercourse 1 originates at Colchester Road, approximately 0.5km west of the proposed scheme, in Springfield Business Park. The channel flows eastwards through numerous road culverts in the business park, through the A12 culvert and towards the River Chelmer. The channel is generally a culverted drainage channel upstream of the A12 and acts as a field boundary and drain downstream. It is hydromorphologically inactive. Planform is largely straight.
Ordinary Watercourse 2 (tributary of the River Chelmer)	Ordinary Watercourse 2 originates north of Springfield Business Park approximately 0.5km west of the proposed scheme, exhibiting a straightened planform. The channel flows south-east passing through industrial land and several culverts including the A12 crossing. Downstream of the A12, the channel flows through arable agricultural land before joining Ordinary Watercourse 1. The channel is a straightened and over-vegetated drainage channel, lacking significant depositional features and erosion. Its function was to form a field boundary since 1874 and has been modified by the construction of Springfield Business Park and the A12, which took place from 1983.
Ordinary Watercourse 3 (tributary of the Boreham Brook)	Ordinary Watercourse 3 has its source at Bulls Lodge Quarry (NGR TL 73306 12362) from where it flows south towards Boreham Brook, north of the A12. The channel exhibits a straight planform and forms a drainage ditch and land boundary function.
Boreham Brook (Main River)	Boreham Brook is a tributary of the River Chelmer with its source to the north of the A12 at Brent Hall, approximately 3km north-east of the proposed scheme. The channel flows through agricultural land

Watercourse	Description
	with a predominantly sinuous planform. The watercourse is culverted under the A12, Roman Road and other local access roads prior to the confluence with the River Chelmer. Hydromorphological characteristics include low energy, homogeneous flow; absence of depositional features such as bars and riffles; and a homogeneous gently sinuous planform immediately downstream of the culvert, with channel readjustment.
Ordinary Watercourse 28 (tributary of the River Ter)	Ordinary Watercourse 28 has a predominately straight planform and originates north of the proposed scheme. From its source, the watercourse flows south past pastoral agricultural land, through the A12 culvert and through arable agricultural land before draining into the River Ter. Desk-based hydromorphological observations suggest the channel acts as a field boundary and drainage channel lacking in significant depositional features and erosion.
River Ter (Main River)	The River Ter is a tributary of the River Chelmer and has its source west of Braintree at Stebbing Green. With a sinuous planform, it flows through woodland, agricultural land and small urban areas. The watercourse is culverted under the A120, A131 and A12, as well as several local access roads prior to its confluence with the River Chelmer. Hydromorphological observations of the channel suggest the A12 caused it to be realigned. Upstream of the A12, the channel is a straight, heavily modified planform, with impounded flow compared with a more natural channel downstream. Structures include several culverts, spillways and weirs.
Ordinary Watercourse 7 (tributary of the River Blackwater)	Ordinary Watercourse 7 has its source north-east of the A12 and Hatfield Peverel and has a predominately straight planform. The watercourse flows south-east as it passes through arable agricultural land present both up- and downstream of the A12 culvert before meeting the River Blackwater. Hydromorphological observations (desk study) suggest the channel forms a land boundary and drainage channel exhibiting no depositional features or extents of erosion.
Ordinary Watercourse 32 (tributary of the River Blackwater)	Ordinary Watercourse 32 has its source south of the A12. It is largely straight and passes through arable agricultural areas before draining into the River Blackwater. The channel acts as a field boundary and drain, exhibiting no significant depositional features or erosion, appearing largely dry and overgrown by vegetation.
Ordinary Watercourse 9 (tributary of the River Blackwater)	Ordinary Watercourse 9 originates north-east of the A12 at Witham. From there, the channel typically flows east, flowing through residential areas prior to crossing the A12 and passing though arable agricultural land before draining into a series of spillway channels

Watercourse	Description
	linked to the River Blackwater. The channel is used as a drainage channel, lacking morphological variation.
Ordinary Watercourse 9a (tributary of the River Blackwater)	Ordinary Watercourse 9a has its source east of the A12 and Witham, and flows southwards to the River Blackwater. The channel acts as a drainage channel, exhibiting no significant depositional features or erosion. The channel was realigned from 1974, exhibiting no sign of change since then.
Ordinary Watercourse 9g (tributary of the River Blackwater)	Originating in Wickham Bishops, Ordinary Watercourse 9g flows north-west towards the River Blackwater. The channel appears to largely be a dry and vegetated drainage channel, where visible.
River Brain (Main River)	The River Brain originates north-west of Braintree near Great Bardfield, approximately 22km north-west of the proposed scheme. Upstream of Braintree, the watercourse is named Pods Brook. The river channel has a predominantly sinuous planform but has been straightened in places. Land use includes woodland, agricultural land and large urban areas including Braintree and Witham. The watercourse is culverted under the A12 prior to its confluence with the River Blackwater. Hydromorphological observations suggest the channel has a uniform and trapezoidal cross-section and had been realigned from 1937. Channel substrate predominately consists of gravels to fines, while flows are predominately homogeneous and unenergetic.
Ordinary Watercourse 10 (tributary of the River Blackwater)	Ordinary Watercourse 10 has its source in Western Industrial Estate, east of the A12, in Witham. From there the predominately straightened channel flows typically south-east, likely culverted beneath the industrial estate, out of the A12 culvert and towards the River Blackwater. Hydromorphological observations suggest the channel is a drainage channel lacking morphological features. Historic analysis suggests the channel has been predominately used as a field boundary.
Ordinary Watercourse 11 (tributary of the River Blackwater)	Ordinary Watercourse 11 has its source near to Forest Road in Witham, west of the A12, flowing south-east towards the River Blackwater, passing beneath an industrial estate and the A12, and past a quarry and pastoral agricultural land, while exhibiting a gently sinuous planform. Hydromorphological observations (desk study) suggest the channel acts as a field boundary and drainage channel. Where visible, the channel lacks depositional features, while field-based photographs show an over-vegetated channel.
Ordinary Watercourse 12 (tributary of the River Blackwater)	Ordinary Watercourse 12 has its source at Rivenhall Oaks golf course, north-east of the A12. From there the channel flows south-east towards Ordinary Watercourse 11, exhibiting a predominately gently sinuous planform as it passes through both pastoral and arable agricultural land and a quarry.

Watercourse	Description
	Hydromorphological observations suggest the channel acts as a land boundary and drainage channel with no depositional features or erosion, appearing largely dry.
Ordinary Watercourse 12a (tributary of the River Blackwater)	Ordinary Watercourse 12a has its source south of the A12, from where it flows south through agricultural fields, through two reservoirs and towards the River Blackwater. The channel has a straightened planform. Desk-based hydromorphological observations suggest the channel is a surface water pathway with no distinguishable channel.
Ordinary Watercourse 13 (tributary of the River Blackwater)	Ordinary Watercourse 13 has its source south of the A12, from where it flows south through agricultural fields, Colemans Reservoir and towards the River Blackwater. The channel has a straightened planform. Desk-based hydromorphological observations suggest the channel acted as field boundary and drain and lacked significant depositional features or erosion. The construction of Colemans Reservoir from 1990 has since formed part of the channels drainage system.
Ordinary Watercourse 13a	Ordinary Watercourse 13a is sourced immediately north of Colemans Reservoir and flows south-west towards Ordinary Watercourse 13. From its source, Ordinary Watercourse 13a exhibits a straight channel used for drainage. This artificial channel is obscured by vegetation.
Ordinary Watercourse 15a (tributary of Rivenhall Brook)	Ordinary Watercourse 15a has its source south of the A12, from where it typically flows south-east towards Rivenhall Brook. The channel passes arable agricultural land and a deciduous plantation, exhibiting a largely straight planform. Hydromorphological observations suggest the channel acts as a field boundary and drain and is mostly obscured by riparian vegetation. Field observations highlight that the channel is largely dry and heavily vegetated where active flows only occur during periods of heavy rainfall.
Rivenhall Brook (Main River)	Rivenhall Brook discharges into the River Blackwater to the east of Rivenhall End. The channel has its source at a network of drainage channels approximately 300m north-east of Tye Green, and approximately 7.5km north-west of the proposed scheme. Predominately exhibiting a straightened planform, Rivenhall Brook generally flows south-east through arable and pastoral agricultural land towards the River Blackwater approximately 900m south-east of Rivenhall End. Hydromorphological observations suggest the channel has a uniform and trapezoidal cross-section. Channel substrate predominately consists of gravels and fines while flows are predominately homogeneous and still. Banks are steep, consisting of sand and soil.

Watercourse	Description
Ordinary Watercourse 15 (tributary of Rivenhall Brook)	Ordinary Watercourse 15 has its source north of the A12 near to the east bank of Rivenhall Brook. The straightened channel flows through deciduous woodland as it flows south-east towards Rivenhall Brook. The channel acts as a field boundary and drainage channel for a plantation and displays a lack of significant depositional features and erosion.
Ordinary Watercourse 17 (tributary of the River Blackwater)	Ordinary Watercourse 17 originates north of the A12 and has a gently sinuous planform. The channel initially flows south-west through plantation woodland, towards the A12, before flowing south-east, passing beneath the A12 and towards the River Blackwater, as it flows by recreational and arable agricultural land. Hydromorphological observations suggest the channel is largely used as a field boundary and drainage channel.
River Blackwater (Main River)	The River Blackwater originates at Braintree. The upstream length of this watercourse is referred to as River Pant, where its source is located approximately 32km north-west of the proposed scheme in the Common. The channel has a predominantly sinuous planform and flows through agricultural land, woodland and several urban areas prior to its confluence with the River Chelmer. Hydromorphology observations suggest that the River Blackwater is significantly influenced by modifications including the A12 which led to channel realignment in 1983. Flow is largely homogeneous, with sediment ranging from fine sediment upstream of the A12 to gravels downstream. Erosion is limited to bank scour upstream of the confluence with the River Brain, while depositional features predominately consist of accumulations of fines along the channel margins. Structures include channel crossings such as bridge structures and culverts, and bank reinforcement, which have influenced uniformity in channel form and features.
Ordinary Watercourse 33 (tributary of the River Blackwater)	Ordinary Watercourse 33 originates at Church Hill upstream of the proposed scheme. It flows in a southerly direction. The channel exhibits a slight sinuosity to some of its planform, but its largely straight, acting as a land boundary and field drain. The nature of the bends suggest it is a passive channel with no evidence of significant natural processes and no depositional features.
Ordinary Watercourse 18 (tributary of the River Blackwater)	Ordinary Watercourse 18 originates along Highfields Lane, Kelvedon, south of the A12. The channel exhibits a straightened planform as it flows north-west towards the River Blackwater. This channel acts as a field boundary and field drain.
Ordinary Watercourse 21 (tributary of the River Blackwater)	Ordinary Watercourse 21 originates at Perry Wood, south of the A12 and immediately to the west of Inworth Road. From its source, the channel flows typically north-west towards the A12 and the River

Watercourse	Description
	Blackwater. The channel has a straightened planform as it passes both pastoral and arable agricultural land. This is a field drain.
Ordinary Watercourse 21a (tributary of the River Blackwater)	Ordinary Watercourse 21a has its source south-east of the A12, where it flows north-west through an A12 culvert and towards the River Blackwater, passing arable agricultural fields and exhibiting a straightened planform. Desk-based hydromorphological observations suggest the channel acts a field drain.
Domsey Brook (Main River)	Domsey Brook originates approximately 0.5km north of the A12 and the proposed scheme, at Marks Tey, passing through agricultural land and woodland before crossing the A12 upstream of its confluence with the River Blackwater at Kelvedon. The river channel has a predominantly sinuous planform. Hydromorphological observations suggest the channel exhibits a uniform, trapezoidal cross-section, which had been realigned for the A12 from 1969. The river is a low energy environment with homogeneous bed substrate dominated by silt. The channel lacked significant extents of depositional features and erosion with the exception of the presence of gravel deposits localised to Inworth Road bridge.
Ordinary Watercourse 34a	Ordinary Watercourse 34a originates 400m west of Inworth Road from where it flows east along a straightened and culverted channel before draining into Ordinary Watercourse 34. The watercourse exhibited no significant hydromorphological processes or depositional features.
Ordinary Watercourse 34b	Ordinary Watercourse 34b originates approximately 300m south-west of Inworth Road and flows as a surface water pathway towards Ordinary Watercourse 34. As it is a surface water pathway only active during flood events, no defined channel is observable.
Ordinary Watercourse 34c	Ordinary Watercourse 34c originates approximately 365m east of Perrywood Garden Centre and flows north-west as a surface water path towards Ordinary Watercourse 34. The watercourse is a surface water path, which is only active during flood events, and lacks a defined channel.
Ordinary Watercourse 34 (tributary of Domsey Brook)	Ordinary Watercourse 34 originates by Inworth upstream of the proposed scheme. It flows in a northerly direction and exhibits a straightened planform, mainly devoid of any hydromorphological deposits or processes.
Ordinary Watercourse 23 (potential tributary of Domsey Brook)	Ordinary Watercourse 23 has its source north of the A12 and London Road, from where it flows south towards London Road, bordered by residential properties. The channel is a straightened drainage ditch exhibiting a homogeneous channel. The channel appears dry, while historic maps do not depict its presence.
Ordinary Watercourse 37b (tributary of Domsey Brook)	Ordinary Watercourse 37b has its source south of the A12, from where it flows south towards Ordinary Watercourse 37, passing

Watercourse	Description
	arable agricultural and managed recreational land, while exhibiting a largely straightened planform. The channel acted as a field boundary and drain, and lacked significant depositional features and erosion, appearing overgrown by vegetation.
Ordinary Watercourse 24 (tributary of Domsey Brook)	Ordinary Watercourse 24 has its source south of the A12, where it flows south-east towards Ordinary Watercourse 37, exhibiting a straightened planform as it passes arable agricultural land. It acts as a field drain.
Ordinary Watercourse 37 (tributary of Domsey Brook)	Ordinary Watercourse 37 has its source south of the A12, from where it flows south towards Domsey Brook, passing arable agricultural and managed recreational land, while exhibiting a largely straightened planform. The channel acts as a field drain and lacks significant depositional features and erosion, appearing overgrown by vegetation.
Ordinary Watercourse 38 (tributary of Domsey Brook)	Ordinary Watercourse 38 has its source immediately south of the A12, where it flows south before meandering east towards Domsey Brook. The channel has a largely straightened planform as it passes arable agricultural land. Desk-based hydromorphological observations were mostly obscured by riparian vegetation, but suggest the watercourse acts as a field drain.
Ordinary Watercourse 38b (tributary of Domsey Brook)	Ordinary Watercourse 38b has its source immediately south of the A12, where it flows south before meandering east towards Domsey Brook. The channel has a largely straightened planform as it passes arable agricultural land. Desk-based hydromorphological observations were mostly obscured by riparian vegetation but suggest the watercourse acts as a field drain.
Ordinary Watercourse 42 (potential tributary of Domsey Brook)	Ordinary Watercourse 42 is a drainage ditch originating south of the A12 near Potts Green. It flows in a southerly direction and exhibits a straightened planform.
Ordinary Watercourse 26 (potential tributary of Roman River)	Ordinary Watercourse 26 originates south-east of the A12, adjacent to Hall Chase. The channel has a straightened planform, passing arable agricultural land as it flows north towards Roman River. This acts as a field drain with no significant hydromorphological processes or depositional features present.
Roman River (Main River)	Roman River originates north of the A12, approximately 7km north-west of the proposed scheme in Willow Wood. From there, the watercourse passes through woodland and agricultural land before crossing the A12. Downstream of this, the channel flows through woodland, agricultural land and an urban area before its confluence with the River Colne. Hydromorphological observations suggest the channel has been straightened and realigned for the existing A12 (from 1973); its cross-section is trapezoidal. Flow is largely uniform; bed sediment comprises fine to coarse gravels.

Annex N Culvert schedule

Table N.1 Existing culverts

Culvert name	NGR	Existing culvert (retained/ extension/ abandoned)	Culvert type	Culvert dimensions (m)	Total proposed culvert length (m)	Approx. length of proposed culvert extension (m)	Culvert crossing (watercourse / ditch)	Comment
Section 1 Refer to Drainage and Surface Water Plans [TR010060/APP/2.13] Drawing numbers HE551497-JAC-LDC-SCHW-DR-D-0801 to 0807 for location of existing culverts								
CL-01B	TL7407707963	Existing to be retained	Pipe	0.9	52	-	Ordinary Watercourse 1b	Existing culvert is not affected by the proposed highway improvement works.
CL-01A	TL7406508302	Existing to be retained	Pipe	1.05	33	-	Ordinary Watercourse 1a	Existing culvert hydraulic capacity found to be adequate.
CL-01A.1	TL7409408299	Existing to be extended	Pipe	0.6	13	2	Ordinary Watercourse 1a	Proposed culvert extension for proposed pond access track. Existing culvert hydraulic capacity found to be adequate. Culvert extension will retain existing pipe culvert geometry and gradient.
CL-01	TL7407408687	Existing to be extended	Pipe	1.05	47	16	Ordinary Watercourse 1	Existing culvert hydraulic capacity found to be adequate. Proposed culvert length includes approximately 16m of culvert extension for online widening on southbound carriageway.

Culvert name	NGR	Existing culvert (retained/ extension/ abandoned)	Culvert type	Culvert dimensions (m)	Total proposed culvert length (m)	Approx. length of proposed culvert extension (m)	Culvert crossing (watercourse / ditch)	Comment
								Culvert extension will retain existing pipe culvert geometry and gradient.
CL-01.1	TL7412508673	Existing to be retained	Pipe	1.05	13	-	Ordinary Watercourse 1	Existing culvert hydraulic capacity assumed to be adequate. Culvert size assumed based on the upstream Culvert CL-01 that will need to be confirmed through drainage investigations. Should drainage investigations reveal that existing culvert hydraulic capacity is inadequate then proposed raising of the pond access track / Private Means of Access track could result in increased impedance of flood flows associated with the watercourse and result in increased flood levels upstream of the culvert, in between the raised access track (level: ~22.5mAOD) and the A12 on embankment (level: ~23.3mAOD). Environment Agency RoFSW mapping indicates that the area adjacent to Ordinary Watercourse 1 could be at risk of flooding in the range of 300 – 900mm depth in a 0.1% (1 in 1000) AEP event in the baseline scenario.

Culvert name	NGR	Existing culvert (retained/ extension/ abandoned)	Culvert type	Culvert dimensions (m)	Total proposed culvert length (m)	Approx. length of proposed culvert extension (m)	Culvert crossing (watercourse / ditch)	Comment
								It is anticipated that no mitigation measures would be required in this scenario as the area of increased flood levels (in between the pond access track / Private Means of Access and the A12) would contains no receptors classified as vulnerable to flooding under DMRB LA 113 guidance (Highways England, 2020a) and would remain within the proposed scheme's permanent land take, would be owned by National Highways, and consequently would not impact other parties. Flood levels could not reach a sufficient height to threaten the A12 (road level: ~23.3mAOD) as water would overtop the proposed access track (level: ~22.5mAOD) and prevent flood levels from reaching A12 road level.
CL-02	TL7409109117	Existing to be extended	Twin pipe	2 x 0.6	60	8	Ordinary Watercourse 2	Existing culvert hydraulic capacity found to be adequate. Proposed culvert length includes approximately 8m of culvert extension for proposed pond access track on the west of the mainline. Culvert extension will retain

Culvert name	NGR	Existing culvert (retained/ extension/ abandoned)	Culvert type	Culvert dimensions (m)	Total proposed culvert length (m)	Approx. length of proposed culvert extension (m)	Culvert crossing (watercourse / ditch)	Comment
								existing pipe culvert geometry and gradient.
CL-02A	TL7400909183	Existing to be retained	Twin pipe	2 x 0.6	51	-	Ordinary Watercourse 2	Existing culvert is not affected by the proposed highway improvement works.
CL-A138	TL7376509315	Existing to be retained	Pipe	1.2	80	-	Ordinary Watercourse 2	Existing culvert is not affected by the proposed highway improvement works.
CL-03A	TL7439709783	Existing to be extended	Pipe	0.3	85	9	Drainage culvert	Existing culvert hydraulic capacity found to be adequate. It should be noted that there is limited information for the existing culvert. As such, appropriate assumptions have been made with regards to the existing culvert capacity check that will need to be confirmed through drainage investigations. Proposed culvert length includes approximately 9m of culvert extension for online widening on southbound carriageway. Culvert extension will retain existing pipe culvert geometry and gradient. As per drainage connectivity survey, CL-03A discharges into a chamber on downstream side. In proposed case, the extended culvert will discharge into

Culvert name	NGR	Existing culvert (retained/ extension/ abandoned)	Culvert type	Culvert dimensions (m)	Total proposed culvert length (m)	Approx. length of proposed culvert extension (m)	Culvert crossing (watercourse / ditch)	Comment
								a drainage ditch which will be connected to Boreham Brook. The existing chamber on the d downstream of existing culvert will need to be demolished/abandoned.
CL-28	TL7815811455	Existing to be retained	Pipe	1.2	71	-	Ordinary Watercourse 28	Existing culvert hydraulic capacity found to be adequate for drainage catchment. However, it should be noted that there is potential for contributing flows from the overflow of the River Ter.
CL-07	TL7985312196	Existing to be extended	Pipe	0.375	80	28	Ordinary Watercourse 7	Culvert length includes approximately 28m of culvert extension for online widening on northbound carriageway. Culvert extension will retain existing pipe culvert geometry and gradient. The preliminary hydraulic assessment found that the existing 375mm diameter pipe culvert capacity is inadequate. It is noted that providing a larger diameter culvert would increase the flood risk downstream and will also be constrained by existing road levels. As there is low flood risk to the proposed road and any increases in flood risk are upstream of the proposed

Culvert name	NGR	Existing culvert (retained/ extension/ abandoned)	Culvert type	Culvert dimensions (m)	Total proposed culvert length (m)	Approx. length of proposed culvert extension (m)	Culvert crossing (watercourse / ditch)	Comment
								scheme within land to be acquired for the scheme, no flood compensation storage is proposed. Existing land areas that will flood more will either remain in scheme ownership or increases in risk will be agreed with the landowner.
Section 2 - Refer to Drainage and Surface Water Plans [TR010060/APP/2.13] Drawing numbers HE551497-JAC-LDC-SCHW-DR-D-0808 to 0812 for location of existing culverts								
CL-09	TL8251713388	Existing to be extended	Pipe	0.6	87	15	Ordinary Watercourse 9	Culvert length includes approximately 15m of culvert extension for online widening on southbound carriageway. Culvert extension will retain existing pipe culvert geometry and gradient. The discharge arrangement upstream of this existing culvert is unknown. As such, no hydraulic assessment has been undertaken at this stage. However, it is noted that the upstream catchment at this culvert is fully developed/urbanized and assumed to be drained through surface water drainage networks. Further investigation will be required to establish upstream catchments and to

Culvert name	NGR	Existing culvert (retained/ extension/ abandoned)	Culvert type	Culvert dimensions (m)	Total proposed culvert length (m)	Approx. length of proposed culvert extension (m)	Culvert crossing (watercourse / ditch)	Comment
								facilitate existing culvert hydraulic capacity checks.
CL-10	TL8299415131	Existing to be extended	Twin Pipe	2 x 0.9	52	20	Ordinary Watercourse 10	Existing culvert hydraulic capacity found to be adequate. Culvert length includes approximately 20m of culvert extension (twin pipes) for online widening on southbound carriageway. Culvert extension will retain existing pipe culvert geometry and gradient. The watercourse downstream of this culvert is required to be diverted/regraded. Further drainage investigations are required to confirm the existing culvert details at northbound carriageway and to verify assumptions currently made with regards to the culvert capacity checks.
CL-11A	TL8310615779	Existing to be retained	Pipe	0.6	50	-	Ordinary Watercourse 11	Existing culvert hydraulic capacity found to be adequate. Existing culvert arrangement at southbound carriageway will need to be confirmed through drainage investigations.
CL-12A	TL8335016065	Existing to be extended	Pipe	0.6	34	5	Ordinary Watercourse 12	Existing culvert hydraulic capacity found to be adequate. Culvert length includes approximately 5m of culvert extension for online widening on

Culvert name	NGR	Existing culvert (retained/ extension/ abandoned)	Culvert type	Culvert dimensions (m)	Total proposed culvert length (m)	Approx. length of proposed culvert extension (m)	Culvert crossing (watercourse / ditch)	Comment
								southbound carriageway. Culvert extension will retain existing pipe culvert geometry and gradient. The watercourse downstream of this existing culvert is proposed to be diverted at CL-12B.
CL-12A.1	TL8359016263	Existing to be retained	Pipe	0.6	35	-	Ordinary Watercourse 12aa	Existing culvert hydraulic capacity found to be adequate. Existing culvert arrangement at southbound carriageway will need to be confirmed through drainage investigations. The watercourse downstream of this existing culvert is proposed to be diverted at CL-12B.
CL-15A	TL8423016790	Existing to be retained	Pipe	0.375	20	-	Ordinary Watercourse 15 (diversion)	Existing culvert hydraulic capacity found to be adequate. The downstream watercourse is proposed to be diverted. Chamber exists along the existing culvert length where the pipe size changes from 375mm diameter (upstream) to 500mm diameter (downstream).
				0.5	12			

Culvert name	NGR	Existing culvert (retained/ extension/ abandoned)	Culvert type	Culvert dimensions (m)	Total proposed culvert length (m)	Approx. length of proposed culvert extension (m)	Culvert crossing (watercourse / ditch)	Comment
CL-17	TL8455317066	To be abandoned	Pipe	1.05	37	-	Ordinary Watercourse 17	Existing culvert will be abandoned. Existing watercourse upstream of this culvert will be diverted and drained through proposed culverts CL-17B.1 and CL-17B.2.
Section 3 - Refer to Drainage and Surface Water Plans [TR010060/APP/2.13] Drawing numbers HE551497-JAC-LDC-SCHW-DR-D-0813 to 0821 for location of existing culverts								
CL-21	TL8630817822	Existing to be retained	Pipe	0.4 (CL-21-6)	54	-	Ordinary Watercourse 21	Chamber exists along the existing culvert route where the pipe size changes from 900mm diameter (upstream) to 450mm diameter (downstream). In addition to 450mm diameter pipe, there is another approx. 600mm diameter (downstream) pipe that runs further west from the existing culvert chamber and appears to ultimately outfall to River Blackwater. The preliminary hydraulic assessment found that existing pipe culvert capacity is inadequate. It is noted that providing a larger diameter culvert would increase the flood risk downstream and will also be constrained by proposed road levels. Flood mitigation measures in the form of flood storage is required.
				0.6 (CL-21-8)	231			

Culvert name	NGR	Existing culvert (retained/ extension/ abandoned)	Culvert type	Culvert dimensions (m)	Total proposed culvert length (m)	Approx. length of proposed culvert extension (m)	Culvert crossing (watercourse / ditch)	Comment
								The mitigation proposals also include the following: • Existing culverts (450mm/900mm diameter pipes) that run underneath A12 to be retained. • Existing 600mm diameter culvert that runs west would need to be abandoned. • New culverts (potential watercourse diversion) that runs further west and outfall to River Blackwater. As these new culverts will need to be constructed at greater depth, special construction techniques (e.g. auger boring/micro tunnelling) may be required. • New flood mitigation area upstream of A12.
				0.9 (CL-21-7)	58	-		
CL-21 (western part)	TL8630817822	Existing to be abandoned	Pipe	0.6 (CL-21-8)	231	-	Ordinary Watercourse 21	Existing 600mm diameter pipe culvert proposed to be abandoned.

Culvert name	NGR	Existing culvert (retained/ extension/ abandoned)	Culvert type	Culvert dimensions (m)	Total proposed culvert length (m)	Approx. length of proposed culvert extension (m)	Culvert crossing (watercourse / ditch)	Comment
CL-21A	TL8712318448	Existing to be abandoned	Pipe	0.9	90	-	Ordinary Watercourse 21a	Existing 900mm diameter pipe culvert proposed to be abandoned.
CL-24C	TL8786420290	Existing culvert to be extended	Pipe	0.225	24	-	Ordinary Watercourse 23	Proposed culvert will include new chamber and diversion of existing watercourse downstream of this new culvert. Proposed length includes 67m extension for 450mm diameter pipe. Preliminary hydraulic assessment found that existing pipe culvert capacity is inadequate. It is noted that providing larger diameter culvert would increase the flood risk downstream and will also be constrained by existing road levels. As a mitigation measure, flood storage is proposed immediately upstream of this culvert. Existing culvert arrangement will need to be confirmed through drainage investigations to verify the assumptions currently made in the hydraulic capacity checks.
				0.375	16	-		
				0.45	67	67		

Culvert name	NGR	Existing culvert (retained/ extension/ abandoned)	Culvert type	Culvert dimensions (m)	Total proposed culvert length (m)	Approx. length of proposed culvert extension (m)	Culvert crossing (watercourse / ditch)	Comment
CL-24D	TL8777920282	Existing to be retained	Pipe	0.225	9	-	Ordinary Watercourse 23	Preliminary hydraulic assessment found that existing pipe culvert capacity is inadequate. It is noted that providing larger diameter culvert would increase the flood risk downstream. Mitigation, in the form of over sized ditch, is therefore provided.
CL-26	TL9123623305	Existing to be retained	Pipe	0.45	40	-	Ordinary Watercourse 26	The preliminary hydraulic assessment found that existing 450mm diameter pipe culvert is inadequate. It is noted that providing a larger diameter culvert would increase the flood risk downstream and will also be constrained by existing road levels. As a mitigation measure, a flood mitigation area is proposed upstream of this culvert. Existing culvert arrangement would need to be confirmed through drainage investigations to verify the assumptions currently made in the hydraulic capacity checks.
CL-30	TL9278524367	Existing to be retained	Pipe	0.45	56	-	Drainage culvert (proposed ditch)	Existing culvert hydraulic capacity found to be adequate.

Culvert name	NGR	Existing culvert (retained/ extension/ abandoned)	Culvert type	Culvert dimensions (m)	Total proposed culvert length (m)	Approx. length of proposed culvert extension (m)	Culvert crossing (watercourse / ditch)	Comment
CL-32	TL9140223503	Existing to be abandoned	Pipe	0.3	70		Drainage culvert (existing ditch)	Existing pipe culvert proposed to be abandoned. Pipe size to be confirmed.
CL-IWR-1	TL8836217267	Existing to be retained	Pipe	0.3	13	-	Ordinary Watercourse 21	Assumed existing culvert. Existing culvert hydraulic capacity assumed to be adequate.
CL-IWR-9	TL8803117749	Existing to be extended	Pipe	0.3	68	10	Ordinary Watercourse 34b	Assumed existing pipe size. Existing culvert hydraulic capacity assumed to be adequate.
CL-IWR-4	TL8798217901	Existing to be retained	Pipe	0.9	243	-	Ordinary Watercourse 34c	Assume that the existing pipe culvert will be retained. It should be noted that this existing 900mm diameter pipe currently receives the flows from a significantly large upstream natural catchment and also provides flow conveyance to the highway drainage system at Inworth. The flows from the natural catchment would need to be restricted at upstream end of this culvert, and proposed mitigation measures would be required in the form of flood storage. The details of proposed flood storage (attenuation volume, size, location, etc.) would be

Culvert name	NGR	Existing culvert (retained/ extension/ abandoned)	Culvert type	Culvert dimensions (m)	Total proposed culvert length (m)	Approx. length of proposed culvert extension (m)	Culvert crossing (watercourse / ditch)	Comment
								confirmed through hydraulic modelling at subsequent design stage.
CL-IWR-7	TL8789418524	Existing to be retained	Pipe	0.45	56	-	Drainage culvert	Existing culvert hydraulic capacity assumed to be adequate.
CL-IWR-8	TL8804618162	Existing to be retained	Pipe	0.5	9	-	Ordinary Watercourse 34c	Assume that the existing pipe culvert will be retained. It should be noted that this existing culvert is at downstream of CL-IWR6 and CL-IWR4A and also receives the additional flows from the large field upstream of this culvert. The flows would need to be restricted at upstream end of this culvert and proposed mitigation measures would be required in the form of flood storage. The details of proposed flood storage (attenuation volume, size, location, etc.) would be confirmed through hydraulic modelling at subsequent design stage.

Table N.2 Proposed culverts

Culvert name	NGR	Culvert type	Culvert dimensions (m)	Total proposed culvert length (m)	Culvert crossing (watercourse/ ditch)	Comment
CL-02B	TL7412709120	Pipe	0.45	5	Drainage culvert (proposed ditch)	Drainage culvert required at new ditch crossing the proposed attenuation pond access road.
CL-28D	TL7835011754		Pipe	1.2	6	Ordinary watercourse 31 Culvert required at ordinary watercourse 31 crossing the proposed attenuation pond access road.
CL-07C	TL7982412246	Pipe	0.45	21	Ordinary Watercourse 7 (diversion)	For sizing this new culvert, flow is taken from existing retained culvert CL-07 as CL-07C is just upstream of CL-07. Minimum pipe culvert size of 450mm diameter considered in accordance with DMRB requirements. The proposed mitigation measures for CL-07 will also be the requirements for this culvert. The existing ditch upstream of this culvert proposed to be diverted to align with watercourse at CL-07. This culvert is included within the hydraulic modelling for CL-07.
CL-07B	TL7989112131	Pipe	0.6	12	Ordinary Watercourse 7	For sizing this new culvert, flow is taken from existing retained culvert CL-07 as CL-07B is just downstream of CL-07. Pipe culvert size of 600mm diameter considered to provide adequate hydraulic capacity. The proposed mitigation measures for CL-07 will also be the requirements for this culvert. This culvert is included within the hydraulic modelling for CL-07.
CL-J21A	TL7990612267	Pipe	0.45	33	Drainage culvert	Drainage culvert required for draining of open catchments confined between the A12 mainline and new junction 21.

Culvert name	NGR	Culvert type	Culvert dimensions (m)	Total proposed culvert length (m)	Culvert crossing (watercourse/ ditch)	Comment
					(proposed ditch)	
CL-J21B	TL8000812228	Pipe	0.45	41	Drainage culvert (proposed ditch)	Drainage culvert required for draining of open catchments confined between the A12 mainline and new junction 21.
CL-J21C	TL8019212442	Pipe	0.45	45	Drainage culvert (proposed ditch)	Drainage culvert required for draining of open catchments confined between the A12 mainline and new junction 21.
CL-J21D	TL8031312422	Pipe	0.45	31	Drainage culvert (proposed ditch)	Drainage culvert required for draining of open catchments confined between the A12 mainline and new junction 21.
CL-J21E	TL8044012667	Pipe	0.6	12	Drainage culvert (proposed ditch)	Drainage culvert required at new ditch crossing the proposed attenuation pond access road.
CL-J21F	TL8047212674	Pipe	0.6	9	Drainage culvert (proposed ditch)	Drainage culvert required at proposed ditch crossing existing road.
CL-J21G	TL 8032612569	Pipe	0.6	11	Drainage culvert	Drainage culvert required at new ditch crossing the proposed attenuation pond access road.

Culvert name	NGR	Culvert type	Culvert dimensions (m)	Total proposed culvert length (m)	Culvert crossing (watercourse/ ditch)	Comment
					(proposed ditch)	
CL-09A	TL8258113380	Pipe	0.6	8	Ordinary Watercourse 9	Proposed culvert required at the existing ditch crossing at the proposed attenuation pond access road. Culvert size is assumed to be of similar size to existing culvert CL-09 located just upstream of this culvert.
CL-10B	TL8306015157		Pipe	2 x 1.2	5	Ordinary watercourse 10 Culvert required at ordinary watercourse 10 crossing the proposed WCH route.
CL-10A	TL8320015144		Pipe	0.45	7	Drainage Culvert (Proposed Swale) Drainage culvert required at proposed swale crossing proposed attenuation pond access road.
CL-11	TL8325515692	Pipe	1.5	115	Ordinary Watercourse 11	New culvert required for A12 due to offline section. Opportunity to use 1.2m diameter culvert subject to further discussions with maintenance authority.
CL-11B	TL8317115741	Pipe	1.5	61	Ordinary Watercourse 11	New culvert required due to offline section. Opportunity to use 1.2m diameter culvert subject to further discussions with maintenance authority.
CL-11C	TL8334215640	Pipe	1.5	70	Ordinary Watercourse 11	New culvert required due to offline section. Opportunity to use 1.2m diameter culvert subject to further discussions with maintenance authority.
CL-12B	TL8364016056	Pipe	1.2	76	Ordinary Watercourse 12 (diversion)	Proposed culvert capacity check includes catchments associated with watercourse diversions upstream of this culvert.

Culvert name	NGR	Culvert type	Culvert dimensions (m)	Total proposed culvert length (m)	Culvert crossing (watercourse/ ditch)	Comment
CL-13A	TL8386916311	Pipe	0.45	41	Drainage culvert (proposed ditch)	Drainage culvert required for draining the proposed ditch at the realigned Henry Dixon Road.
CL-13B	TL8389516251	Pipe	0.45	75	Drainage culvert (proposed ditch)	Drainage culvert required for draining the proposed ditch at the realigned Braxted Road.
CL-13C	TL8394616196	Pipe	0.45	83	Drainage culvert (proposed ditch)	Drainage culvert required for draining the proposed ditch at the realigned Braxted Road.
CL-13D	TL8404616281	Pipe	0.45	19	Drainage culvert (proposed ditch)	Drainage culvert required for draining the proposed ditch at the access road connecting Braxted Road.
CL-13E	TL8408816330	Pipe	0.45	9	Drainage culvert (proposed ditch)	Drainage culvert required for draining the proposed ditch at the access road connectingBraxted Road.
CL-15B	TL8426316861	Pipe	0.45	10	Drainage culvert (proposed ditch)	Drainage culvert required at the proposed ditch crossing the proposed attenuation pond access road.

Culvert name	NGR	Culvert type	Culvert dimensions (m)	Total proposed culvert length (m)	Culvert crossing (watercourse/ ditch)	Comment
CL-15C	TL8431116829	Pipe	0.45	10	Drainage culvert (proposed ditch)	Drainage culvert required due to spatial constraint for the proposed ditch between the proposed mainline alignment and new side road roundabout near Rivenhall.
CL-17B.1	TL8467917297	Pipe	1.2	35	Ordinary Watercourse 17 (diversion)	Proposed culvert capacity check includes catchments associated with proposed watercourse diversions upstream of this culvert.
CL-17B.2	TL8470617212	Pipe	1.2	98	Ordinary Watercourse 17 (diversion)	Proposed culvert crosses the mainline carriageway requires new chamber and additional culverted length at downstream (along southbound carriageway) to align with existing watercourse at CL-17. Total culvert length includes approximately 56m of culvert that crosses the mainline carriageway and approximately 70m of culvert that runs along the southbound carriageway.
CL-17B.3	TL8460917272	Pipe	0.6	5	Ordinary Watercourse 17 (diversion)	Culvert required for draining the diverted ditch/watercourse at proposed attenuation pond access road.
CL-17B.4	TL8456117065	Pipe	1.2	5	Ordinary Watercourse 17 (diversion)	Culvert required for draining the diverted ditch/watercourse at proposed attenuation pond access road. For sizing this new culvert, flow is taken from proposed culvert CL-17B.3 as it is located upstream of this culvert.
CL-17B.5	TL8467917297		Pipe	1.2	26	Ordinary watercourse 17 (diversion) Culvert required for watercourse crossing proposed side road (access to private land).

Culvert name	NGR	Culvert type	Culvert dimensions (m)	Total proposed culvert length (m)	Culvert crossing (watercourse/ ditch)	Comment
CL-17C	TL8528417693	Pipe	0.6	22	Drainage culvert (proposed ditch)	Drainage culvert required to maintain proposed ditch drainage at London Road crossing.
CL-18	TL8590317586	Pipe	0.6	24	Ordinary Watercourse 18 (diversion)	Assumed new culvert is required. Further drainage investigation will be required to confirm existing culvert details.
CL-18A	TL8584417544	Pipe	0.6	5	Ordinary Watercourse 18 (diversion)	Culvert required at proposed ditch crossing the proposed attenuation pond access road.
CL-21D	TL8626417738	Pipe	0.45	5	Drainage culvert (proposed ditch)	Drainage culvert required at proposed ditch crossing proposed pond access track.
CL-21-1	TL8606217710	Pipe	1.5	480	Ordinary Watercourse 21	This new culvert forms part of the mitigation measures required at Ordinary Watercourse 21. There will be a need for new chambers (5 Nos. of minimum 2.1m internal diameter) on line of proposed 1.5m diameter diverted culverted watercourse. The requirements for the chambers would need to be reviewed at subsequent design stages.
CL-21-2	TL8630017743	Pipe	0.8	50	Ordinary Watercourse 21	This new culvert forms part of the mitigation measures required at Ordinary Watercourse 21. This section of pipe culvert proposed to drain the southern catchment, runs underneath the proposed flood defence bund and connects to the new chamber located in the verge of southbound A12.

Culvert name	NGR	Culvert type	Culvert dimensions (m)	Total proposed culvert length (m)	Culvert crossing (watercourse/ ditch)	Comment
CL-21-3	TL8629717797	Pipe	1.0	30	Ordinary Watercourse 21	This new culvert forms part of the mitigation measures required at Ordinary Watercourse 21. This pipe culvert is proposed to connect the section between existing retained culvert and proposed diversions. Chambers will be required at either end of this pipe culvert (chambers requirements included as above for new 1.5m diameter pipe culvert).
CL-21-4	TL8632117802	Pipe	1.0	10	Ordinary Watercourse 21	This new culvert forms part of the mitigation measures required at Ordinary Watercourse 21. This pipe culvert is proposed to drain the eastern catchment and connects to the new chamber located on line of existing retained culvert.
CL-21-5	TL8634317719	Pipe	0.45	20	Ordinary Watercourse 21	This new culvert forms part of the mitigation measures required at Ordinary Watercourse 21. This pipe culvert is on line of existing Ordinary Watercourse 21 and drains the southern catchment. The pipe culvert runs underneath the proposed flood defence bund.
CL-21A	TL8712318448	Pipe	1.2	192	Ordinary Watercourse 21a	Existing 900mm diameter pipe culvert proposed to be abandoned. It is noted that providing larger diameter culvert would increase the flood risk downstream. As a mitigation measure, flood storage is proposed upstream of this culvert. Proposed culvert will include new chambers and diversion of existing watercourses upstream and downstream of this new culvert due to the proposed road geometry at this watercourse crossing. Total culvert length includes approximately 34m of culverted watercourse at south of mainline alignment, approximately 97m of culvert that crosses the mainline carriageway and proposed slip

Culvert name	NGR	Culvert type	Culvert dimensions (m)	Total proposed culvert length (m)	Culvert crossing (watercourse/ ditch)	Comment
						roads at junction 24 and approximately 131m of culverted watercourse at north of mainline alignment. As this new culvert will need to be constructed underneath the existing carriageway, special construction techniques (e.g. auger boring/micro tunnelling) may be required.
CL-21B	TL8776618603	Pipe	0.45	24	Drainage culvert (proposed ditch)	Proposed culvert is constrained by the road geometry.
CL-21C	TL8765618900	Pipe	0.6	13	Drainage culvert (proposed ditch)	Drainage culvert is required to maintain proposed ditch crossing at Inworth Road.
CL-21D			Pipe	0.45	10	Drainage culvert (proposed ditch) Drainage culvert is required to maintain proposed ditch crossing at Pond Access track.
CL-21E	TL8730818440	Pipe	0.45	5	Drainage culvert (proposed ditch)	Drainage culvert required at proposed ditch crossing proposed WCH route.
CL-23C	TL8774519784	Pipe	0.6	38	Drainage culvert (proposed ditch)	Requirement of culvert may change based upon existing A12 redundant pavement strategy.
CL-23D	TL8774219987	Pipe	0.6	17	Drainage culvert	Requirement of culvert may change based upon existing A12 redundant pavement strategy.

Culvert name	**NGR**	**Culvert type**	**Culvert dimensions (m)**	**Total proposed culvert length (m)**	**Culvert crossing (watercourse/ ditch)**	**Comment**	
					(proposed ditch)		
CL-23E	TL8773619535	Pipe	0.6	33	Drainage culvert (proposed ditch)	Requirement of culvert may change based upon existing A12 redundant pavement strategy.	
CL-23	TL8788719920	Pipe	0.6	54	Ordinary Watercourse 23	Proposed culvert includes catchment from existing watercourse diversion at CL-24C.	
CL-23A	TL8814819919	Pipe	0.6	11	Ordinary Watercourse 23	Proposed culvert includes catchment from existing watercourse diversion at CL-23.	
CL-23B	TL8804519781	Pipe	0.45	17	Drainage culvert (proposed ditch)	Drainage culvert required at proposed ditch crossing proposed farm access.	
CL-24	TL8830820462	Pipe	1.2	56	Ordinary Watercourse 24 (diversion)	Proposed culvert capacity checks include catchments from existing watercourse diversions.	
CL-24F	TL8778020276		Pipe	0.45	10	Ordinary watercourse 23	Proposed culvert to connect proposed ditch to existing chamber.
CL-24G	TL8778020276		Pipe	0.45	5	Ordinary watercourse 23	Proposed culvert to connect proposed oversized ditch provided as mitigation measure to existing chamber.

Culvert name	NGR	Culvert type	Culvert dimensions (m)	Total proposed culvert length (m)	Culvert crossing (watercourse/ ditch)	Comment
CL-29	TL8926721377	Pipe	0.6	45	Drainage culvert (proposed ditch)	Drainage culvert required at proposed ditch at realigned Easthope Road.
CL-29B	TL8948021189	Pipe	0.6	24	Drainage culvert (existing ditch)	Drainage culvert required for draining of open catchments at the proposed Easthorpe Road.
CL-29C	TL8951421198	Pipe	0.6	21	Drainage culvert (existing ditch)	Drainage culvert to maintain existing ditch drainage.
CL-29D	TL9051622518	Pipe	0.6	18	Drainage culvert (proposed ditch)	Drainage culvert required for proposed ditch crossing proposed attenuation pond access road.
CL-27	TL9059822181	Pipe	0.6	55	Drainage culvert (proposed ditch)	Drainage culvert to maintain proposed ditch drainage.
CL-27A	TL9091122375	Pipe	0.6	24	Drainage culvert (proposed ditch)	Drainage culvert required at proposed ditch crossing proposed farm access.
CL-27B	TL9105022501	Pipe	0.6	15	Drainage culvert	Drainage culvert required at proposed ditch crossing proposed farm access.

Culvert name	NGR	Culvert type	Culvert dimensions (m)	Total proposed culvert length (m)	Culvert crossing (watercourse/ ditch)	Comment
					(proposed ditch)	
CL-26A	TL9131023214	Pipe	0.6	75	Ordinary Watercourse 26	For sizing this new culvert, flow is taken from existing retained culvert CL-26 as CL-26A is located upstream of CL-26. Pipe culvert size of 600mm diameter considered to provide adequate hydraulic capacity. It should be noted that the proposed mitigation measures for CL-26 will also be the requirements for this culvert. Although the culvert size is larger than CL-26, the flows would be restricted to meet the existing culvert capacity at CL-26.
CL-26B	TL9127823266	Pipe	0.6	14	Ordinary Watercourse 26	For sizing this new culvert, flow is taken from existing retained culvert CL-26 as CL-26B is just upstream of CL-26. Pipe culvert size of 600mm diameter considered to provide adequate hydraulic capacity. It should be noted that the proposed mitigation measures for CL-26 will also be the requirements for this culvert. Although the culvert size is larger than CL-26, the flows would be restricted to meet the existing culvert capacity at CL-26.
CL-26D	TL9134223175	Pipe	0.6	6	Ordinary Watercourse 26	For sizing this new culvert, flow is taken from existing retained culvert CL-26 as CL-26D is located upstream of CL-26 (culvert for existing ditch crossing proposed WCH route). Pipe culvert size of 600mm diameter considered to provide adequate hydraulic capacity. It should be noted that the proposed mitigation measures for CL-26 will also be the requirements for this culvert. Although the culvert size is larger than CL-26, the flows would be restricted to meet the existing culvert capacity at CL-26.

Culvert name	NGR	Culvert type	Culvert dimensions (m)	Total proposed culvert length (m)	Culvert crossing (watercourse/ ditch)	Comment
CL-26C	TL9125423264	Pipe	0.45	14	Ordinary Watercourse 26	Drainage culvert required for draining the open catchments confined at the proposed roundabout on existing A12 near junction 25. As a mitigation measure, flood storage is proposed upstream of this culvert. The details of proposed flood storage (attenuation volume, size, location, etc.) would be confirmed through hydraulic modelling.
CL-26E	TL9124323244	Pipe	0.45	9	Ordinary Watercourse 26	Drainage culvert upstream of CL-26C as the proposed ditch crosses proposed pond access road. It should be noted that the proposed mitigation measures for CL-26 will also be the requirements for this culvert.
CL-IWR-2	TL8811417692	Pipe	0.6	15	Ordinary Watercourse 34b	Pipe culvert size of 600mm diameter considered to provide adequate hydraulic capacity. It should be noted that the flows would need to be restricted at upstream end of this culvert and proposed mitigation measures would be required in the form of flood storage. The details of proposed flood storage (attenuation volume, size, location, etc.) would be confirmed through hydraulic modelling at subsequent design stage.
CL-IWR-5	TL8799617846	Pipe	0.6	11	Drainage culvert	Pipe culvert size of 600mm diameter considered to provide adequate hydraulic capacity. It should be noted that the flows would need to be restricted at upstream end of this culvert and proposed mitigation measures would be required in the form of flood storage. The details of proposed flood storage (attenuation volume, size, location, etc.) would be confirmed through hydraulic modelling at subsequent design stage.

Culvert name	NGR	Culvert type	Culvert dimensions (m)	Total proposed culvert length (m)	Culvert crossing (watercourse/ ditch)	Comment
CL-IWR-4A	TL8801218015	Pipe	0.9	5	Ordinary Watercourse 34c	For sizing this new culvert, flow is taken from existing retained culvert CL-IWR4 as this culvert is located downstream of CL-IWR4. Mitigation measures proposed at CL-IWR4 is also applicable to this culvert.
CL-IWR-6	TL8801518153	Pipe	0.6	8	Drainage culvert	Pipe culvert size of 600mm diameter considered to provide adequate hydraulic capacity. It should be noted that the flows would need to be restricted at upstream end of this culvert and proposed mitigation measures would be required in the form of flood storage. The details of proposed flood storage (attenuation volume, size, location, etc.) would be confirmed through hydraulic modelling at subsequent design stage.

N.1.2 The culvert schedule should be read in conjunction with Drainage and Surface Water Plans [TR010060/APP/2.13] Drawing numbers HE551497-JAC-LDC-SCHW-DR-D-0800 to 0821 and the following notes:

- Appropriate assumptions have been made where the existing drainage surveys have been found to be incomplete.
- Proposed culverts CL-17B.2, CL-21A, CL-24C and CL-21 (western alignment) will require new chambers to be constructed along the culverted length of the watercourse.
- Where applicable, minimum culvert size of 450mm diameter pipe has been considered for the proposed drainage culverts (to convey drainage/flows from new offline sections/pre-earthworks drainage ditches that are not Ordinary Watercourses) in line with the DMRB requirements.
- New culverts on Ordinary Watercourses and the drainage culverts with length over 12m have been designed to have minimum 1.2m diameter. It is noted that an exception to this design criteria is the new culverts that are required in line of existing smaller size culverts, and in such cases, a circular culvert of minimum pipe diameter of 450mm has been considered with appropriate mitigation measures.

N.1.3 Where existing culverts are proposed to be retained, their condition assessment (including defects identification and remediation work requirements) will be undertaken at subsequent design stages

Annex O Proposed construction elements and baseline fluvial and surface water flood risk

Annex P Culvert screening assessment

Table P.1 Culvert screening assessment

Culvert name	Existing culvert	Step 5. Assess risk and uncertainty*								Step 6. Next steps*	
		Receptor score	Pathway score	Source score	Risk Score	Receptor data quality	Pathway data quality	Source data quality	Data quality score	Risk	Next steps
CL-01B	To be retained	3.0	1.5	1.0	3.8	2.0	1.5	1.0	1.6	Medium	Do something (which may involve detailed assessment)
CL-01A	To be retained	1.0	1.5	1.0	1.3	2.3	1.5	1.0	1.8	Low	Do nothing
CL-01A.1	To be extended	1.0	1.5	1.3	1.4	2.3	1.5	1.3	1.9	Low	Do nothing
CL-01	To be extended	2.0	1.5	1.0	2.5	2.5	1.5	1.0	1.9	Medium	Do something (which may involve detailed assessment)
CL-01.1	To be retained	1.0	1.5	2.3	1.9	3.0	1.5	2.3	2.5	Low	Do nothing
CL-02	To be extended	2.0	1.5	1.3	2.8	3.0	1.5	1.3	2.2	Medium	Do something (which may involve detailed assessment)
CL-02A	To be retained	2.0	1.5	1.0	2.5	3.0	1.5	1.0	2.1	Medium	Do something (which may involve detailed assessment)
CL-A138	To be retained	3.0	1.5	1.3	4.1	3.0	1.5	1.3	2.2	Medium	Do something (which may involve detailed assessment)

Culvert name	Existing culvert	Step 5. Assess risk and uncertainty*								Step 6. Next steps*	
		Receptor score	Pathway score	Source score	Risk Score	Receptor data quality	Pathway data quality	Source data quality	Data quality score	Risk	Next steps
CL-03A	To be extended	2.0	1.5	1.3	2.8	3.0	1.5	1.3	2.2	Medium	Do something (which may involve detailed assessment)
CL-28	To be retained	3.0	1.5	1.3	4.1	3.0	1.5	1.3	2.2	Medium	Do something (which may involve detailed assessment)
CL-07	To be extended	3.0	1.5	1.3	4.1	3.0	1.5	1.3	2.2	Medium	Do something (which may involve detailed assessment)
CL-09	To be extended	2.0	1.5	1.3	2.8	1.0	1.5	1.3	1.2	Medium	Do something (which may involve detailed assessment)
CL-10	To be extended	3.0	1.5	1.3	4.1	1.0	1.5	1.3	1.2	Medium	Do something (which may involve detailed assessment)
CL-11A	To be retained	2.0	1.5	1.3	2.8	2.3	1.5	1.3	1.9	Medium	Do something (which may involve detailed assessment)
CL-12A	To be extended	2.0	1.5	1.3	2.8	3.0	1.5	1.3	2.2	Medium	Do something (which may involve detailed assessment)
CL-12A.1	To be retained	1.0	1.5	1.4	1.4	2.0	1.5	1.4	1.7	Low	Do nothing

Culvert name	Existing culvert	Step 5. Assess risk and uncertainty*								Step 6. Next steps*	
		Receptor score	Pathway score	Source score	Risk Score	Receptor data quality	Pathway data quality	Source data quality	Data quality score	Risk	Next steps
CL-15A	To be retained	3.0	1.5	1.0	3.8	3.0	1.5	1.0	2.1	Medium	Do something (which may involve detailed assessment)
CL-17	To be abandoned									Low	Do nothing
CL-21	To be retained	3.0	1.5	1.3	4.1	3.0	1.5	1.3	2.2	Medium	Do something (which may involve detailed assessment)
CL-21 (west)	To be abandoned									Low	Do nothing
CL-21A	To be abandoned									Low	Do nothing
CL-24C	To be extended	2.0	1.5	1.5	3.0	2.0	1.5	1.5	1.8	Medium	Do something (which may involve detailed assessment)
CL-24D	To be retained	2.0	1.5	1.5	3.0	1.0	1.5	1.5	1.3	Medium	Do something (which may involve detailed assessment)
CL-26	To be retained	2.0	1.5	1.3	2.8	2.0	1.5	1.3	1.7	Medium	Do something (which may involve detailed assessment)
CL-30	To be retained	1.0	1.5	1.5	1.5	2.0	1.5	1.5	1.8	Low	Do nothing
CL-32	To be abandoned									Low	Do nothing

Culvert name	Existing culvert	Step 5. Assess risk and uncertainty*								Step 6. Next steps*	
		Receptor score	Pathway score	Source score	Risk Score	Receptor data quality	Pathway data quality	Source data quality	Data quality score	Risk	Next steps
CL-IWR-1	To be retained	1.0	1.5	1.5	1.5	2.0	1.5	1.5	1.8	Low	Do nothing
CL-IWR-1A	To be retained	1.0	1.5	1.5	1.5	2.0	1.5	1.5	1.8	Low	Do nothing
CL-IWR-9	To be extended	2.0	1.5	1.5	3.0	1.0	1.5	1.5	1.3	Medium	Do something (which may involve detailed assessment)
CL-IWR-4	To be retained	1.0	1.5	1.5	1.5	2.0	1.5	1.5	1.8	Low	Do nothing
CL-IWR-7	To be retained	2.0	1.5	1.5	3.0	1.0	1.5	1.5	1.3	Medium	Do something (which may involve detailed assessment)
CL-IWR-8	To be retained	1.0	1.5	1.5	1.5	2.0	1.5	1.5	1.8	Low	Do nothing

** Steps 5 and 6 of the Environment Agency's (2019) Blockage Management Guide.*