Lower Thames Crossing

6.3 Environmental Statement Appendices
Appendix 14.6 - Flood Risk Assessment - Part 8

APFP Regulation 5(2)(a) and (5)(2)(e)

Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009

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Lower Thames Crossing

Appendix 14.6 - Flood Risk Assessment - Part 8

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1 Introduction

1.1 Context

1.1.1 This document forms Part 8 of the Flood Risk Assessment (the FRA) for the A122 Lower Thames Crossing (the Project).

1.1.2 The FRA forms Appendix 14.6 (Application Document 6.3) of the Environmental Statement.

1.2 Form of assessment

1.2.1 The FRA is presented in nine principal parts and one affiliated part. These parts and a brief description of their contents are detailed in Plate 1.1.

1.2.2 For the purposes of the FRA, the Project has been divided into five discrete flood risk catchments (Catchment EFR-1 to EFR-5). These catchments are listed in Table 1.1 and are presented in Drawing 00100.

Table 1.1 FRA catchments

Catchment	Title
EFR-1	South of River Thames
EFR-2	North Portal to Chadwell St Mary
EFR-3	A13 junction
EFR-4	Ockendon Link
EFR-5	North Section

1.2.3 All drawings referenced in this document can be found within Part 9 of the FRA.

1.3 Basis of assessment

1.3.1 The FRA is based on the design as presented in the Development Consent Order (DCO) application.

1.3.2 The FRA includes an assessment of flood risk for both the construction phase and the operational phase of the Project.

1.4 Design Principles

1.4.1 The Design Principles (Application Document 7.5) are embedded measures that have been developed through an iterative design process. The Design Principles are secured by Requirement 3 of Schedule 2 of the DCO.

1.4.2 Elements of the surface water drainage strategy that would be secured through the Design Principles are identified in this document. Design Principles relevant to the surface water drainage strategy are identified by an alpha-numerical reference code, for example, SX.X or LSP.XX.

1.5 Register of Environmental Actions and Commitments

1.5.1 Good practice and essential mitigation are included in the Register of Environmental Actions and Commitments (REAC), which forms part of Appendix 2.2: Code of Construction Practice (Application Document 6.3).

1.5.2 Each action and commitment in the REAC has a unique alpha-numerical reference code.

1.5.3 Where appropriate, the REAC reference codes for secured commitments and actions have been cross- referenced in this document. For example, the code for a Road Drainage and Water Environment commitment would be [RDWE0XX].

1.6 Technical summary

1.6.1 This part includes a technical summary of the FRA; the contents of this part is set out in Plate 1.2.

Plate 1.1 Form of the FRA

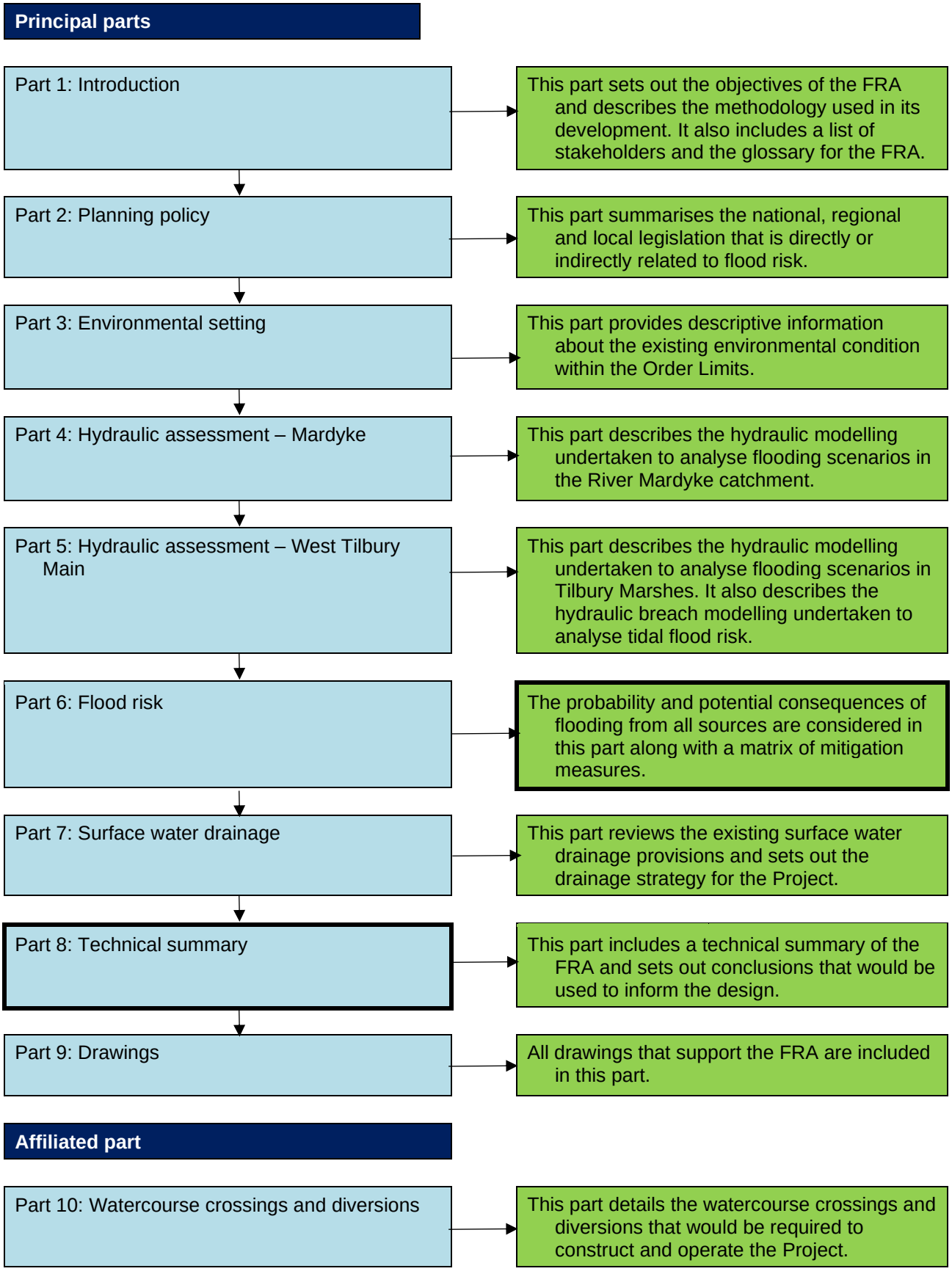
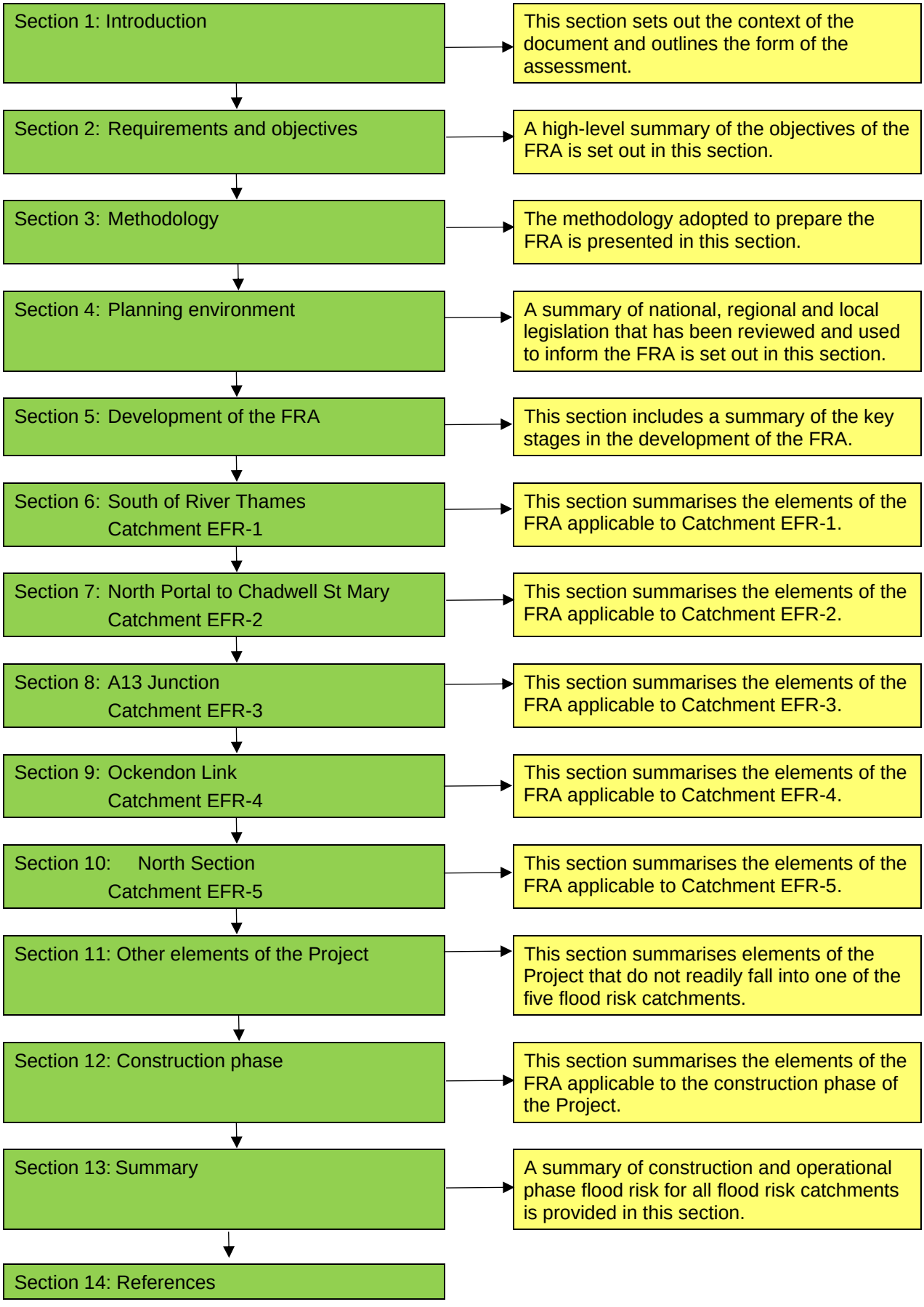


Plate 1.2 Form of Part 8 of the FRA



2 Requirements and objectives

2.1 Introduction

2.1.1 The requirement for preparing a flood risk assessment for the Project is set out in the following documents:

a. National Planning Policy Framework (NPPF) (Department for Levelling Up, Housing and Communities (DLUHC), 2021a).

b. National Policy Statement for National Networks (NN NPS) (Department for Transport, 2014)

c. Overarching National Policy Statement for Energy (EN-1) (Department of Energy and Climate Change (DECC), 2011)

d. Design Manual for Roads and Bridges (DMRB) LA 113 – Road drainage and the water environment (Highways England, 2020a)

2.1.2 An overview of the roles these documents perform in the planning process and an outline of their primary objectives is detailed below.

2.2 National Planning Policy Framework

2.2.1 The NPPF (DLUHC, 2021a) sets out Government policy on development and flood risk.

2.2.2 The NPPF requires that the developer should prepare and submit a flood risk assessment to demonstrate that the development shall be free of flood risk for its lifetime without increasing flood risk elsewhere, and, where possible, will reduce flood risk overall.

2.2.3 The NPPF is supported by planning practice guidance (PPG) (DLUHC, 2021b). The PPG provides guidance on a broad range of planning issues. The guidance category that advises how to take account of flood risk is presented in Flood risk and coastal change (DLUHC, 2022). This guidance sets out the main steps to be followed and the tests to be satisfied before planning permission can be granted for development in areas of flood risk

2.3 National Planning Policy for National Networks

2.3.1 The National Planning Policy for National Networks (NN NPS) (Department for Transport, 2014) sets out the need for, and Government's policies to deliver, development of Nationally Significant Infrastructure Projects (NSIPs) on the national road and rail networks.

2.3.2 The Secretary of State will use the NN NPS as the primary basis for making decisions on development consent applications for NSIPs in England.

2.3.3 Clause 5.92 of NPS NN requires that projects in Flood Zone 3 should be accompanied by a flood risk assessment.

2.3.4 The NPSNN states that flood risk assessment should identify and assess the risks of all forms of flooding to and from a project and demonstrate how these flood risks will be managed, taking climate change into account.

2.4 Overarching National Policy Statement for Energy

2.4.1 The Overarching National Policy Statement for Energy (NPS EN-1) is part of a suite of NPSs issued by the Secretary of State for Energy and Climate Change. It sets out the Government's policy for delivery of major energy infrastructure.

2.4.2 Clause 5.7.4 of NPS EN-1 requires that applications for energy projects in Flood Zone 3 should be accompanied by a flood risk assessment.

2.4.3 NPS EN-1 requires that the flood risk assessment should identify and assess the risks of all forms of flooding to and from the project and demonstrate how these flood risks will be managed, taking climate change into account.

2.5 DMRB LA 113

2.5.1 National Highways sets out its objectives for flood risk in DMRB LA 113 – Road drainage and the water environment (Highways England, 2020a).

2.5.2 This standard states that all projects on motorways and all-purpose trunk roads shall be designed to remain operational and safe for users in times of flood, result in no net loss of floodplain storage or impediment to water flows, and not increase flood risk elsewhere.

2.5.3 DMRB LA 113 states that a flood risk assessment shall be carried out in accordance with the NPPF (DLUHC, 2021a) and associated Planning Practice Guidance on Flood Risk and Coastal Change (DLUHC, 2021b).

2.6 Summary

2.6.1 The requirements of the above documents are generally harmonised.

2.6.2 The NPPF makes clear that it is not intended to contain specific policies for development of NSIPs where particular considerations can apply. The National Policy Statements (NN NPS and NPS EN-1) assume that function and provide transport and energy policy which will guide individual development brought under them.

2.6.3 Some of the legislation referred to in the four documents has been superseded, but this does not unduly diminish their objectives.

3 Methodology

3.1 General

3.1.1 The methodology adopted for the preparation of the FRA is generally regulated by the provisions of the documents listed in Section 2.1.

3.1.2 The principal tasks undertaken to meet the FRA's requirement to show that the development would be safe and would not increase flood risk elsewhere, are as follows:

a. Identification of potential sources of flooding

b. Sequential and Exception Tests

c. Assessment of climate change allowances

d. Determination of flood risk, pre- and post-development

e. Determination of flood mitigation measures

f. Determination of flood protection measures

g. Determination of flood resilience measures

h. Identification and management of residual flood risk

i. Development of a surface water drainage strategy

3.2 Informing the FRA

3.2.1 The sources of information used to inform the FRA are presented in Plate 3.1. The double-headed arrows in Plate 3.1 indicate a liaison-based relationship, with information flowing in both directions.

3.3 Key stakeholders

3.3.1 The FRA was undertaken in consultation with a wide range of stakeholders. This ensured that the approach to flood risk adopted in the development of the FRA considered stakeholder needs from an early stage. The key stakeholders involved in the preparation of the FRA were:

a. Environment Agency

b. Lead Local Flood Authorities (LLFAs)

c. Utility companies

3.3.2 Dialogue with Environment Agency and LLFAs has been a key activity in the development of FRA.

Plate 3.1 Informing the FRA

4 Planning environment

4.1 Introduction

4.1.1 This section summarises current planning policy and legislation relating to flood risk that is relevant to the Project. Full details of relevant planning policy and legislation are in Part 2 of the FRA.

4.2 National legislation and policy documents

4.2.1 The following national policy documents and legislation were reviewed and used to inform the FRA.

a. EU Floods Directive (2007/60/EC)

b. The Flood Risk Regulations 2009

c. Flood and Water Management Act 2010

d. NPPF (DLUHC, 2021)

e. NN NPS (Department for Transport, 2014)

f. NPS EN-1 (DECC, 2011)

g. National flood and coastal erosion risk management strategy for England (Environment Agency, 2021)

h. Planning Practice Guidance – Flood Risk and Coastal Change (DLUHC, 2022)

4.3 Regional planning documents

4.3.1 The following regional planning documents were reviewed and used to inform the FRA:

a. Thames River Basin Management Plan (Environment Agency, 2018)

b. Thames Catchment Flood Management Plan (Environment Agency, 2009a)

c. North Kent Rivers Catchment Flood Management Plan (Environment Agency, 2009b)

d. South Essex Catchment Flood Management Plan – Summary Report (Environment Agency, 2009c)

e. Thames Estuary 2100 Plan (Environment Agency, 2012)

4.4 Local planning policy

Planning authorities

4.4.1 The following local planning authorities have jurisdiction over parts of the Project:

a. Gravesham Borough Council

b. Thurrock Council

c. London Borough of Havering

d. Brentwood Borough Council

e. Tonbridge and Malling Borough Council

f. Maidstone Borough Council

4.4.2 Kent County Council undertakes the role of LLFA for Gravesham Borough Council, Maidstone Borough Council and Tonbridge and Malling Borough Council.

4.4.3 Essex County Council is currently undertaking the role of LLFA on behalf of Thurrock Council for the Project.

4.4.4 The London Borough of Havering performs the role of LLFA for Brentwood Borough Council for the Project.

Kent (including Gravesham)

4.4.5 The following documents have been reviewed to assess the flood risk aspects of the planning environment in Kent:

a. Updating the SFRA (Kent Thameside Delivery Board, 2009)

b. Thameside Stage 1 Surface Water Management Plan (Kent County Council, 2013)

c. Kent Local Flood Risk Management Strategy 2017-2023 (Kent County Council, 2017)

d. Gravesham Local Plan Core Strategy (Gravesham Borough Council, 2014)

e. Drainage and Planning Policy Statement (Kent County Council, 2019)

f. The Kent Design Guide: Making It Happen – Sustainability (Drainage Systems) (Kent County Council, n.d.)

Thurrock

4.4.6 The following documents have been reviewed to assess the flood risk aspects of the planning environment in Thurrock:

a. Thurrock Strategic Flood Risk Assessment – Level 1 Report (Thurrock Level 1 SFRA) (Thurrock Council, 2018)

b. Thurrock Preliminary Flood Risk Assessment (Thurrock Council, 2011)

c. Core Strategy and Policies for Management of Development (Thurrock Core Strategy) (Thurrock Council, 2015)

d. Thurrock Local Flood Risk Management Strategy (Thurrock Council, 2015)

e. Thurrock Design Guide: Design Strategy SPD (Thurrock Design Guide) (Thurrock Council, 2017)

Local policy – London Borough of Havering

4.4.7 The following documents have been reviewed to assess the flood risk aspects of the planning environment in the London Borough of Havering:

a. Core Strategy and Development Control Policies Development Plan Document (London Borough of Havering, 2008)

b. Strategic Flood Risk Assessment – Level 1 (London Borough of Havering, 2014)

c. SuDS Developer Guide (London Borough of Havering, 2015)

d. Multi-Agency Flood Plan for London Borough of Havering (Havering Emergency Planning and Business Continuity Service, 2017).

e. The London Plan (Greater London Authority, 2021)

f. London Sustainable Drainage Action Plan (Greater London Authority, 2016b)

g. Havering Local Plan 2016–2031 (London Borough of Havering, 2021)

5 Development of the FRA

5.1 Decision-making process for planning

5.1.1 The decision-making process for planning applications where flood risk is a factor, is set out in the NPPF and the NN NPS

5.1.2 Both documents stipulate that a flood risk assessment shall be undertaken to support the planning application and that this assessment should include the following:

a. Application of the Sequential Test, and where necessary, application of the Exception Test

b. Details of flood alleviation measures included in the Project and assessment of residual flood risk

5.2 Sequential Test and Exception Test

5.2.1 The Project would lie primarily in Flood Zone 1 but would include three sections that cross Flood Zones 2, 3a and 3b.

5.2.2 The Project is regarded as essential infrastructure. The DLUHC guidance (DLUHC, 2022) notes that it is appropriate to construct essential infrastructure in Flood Zone 3.

5.2.3 The Sequential Test has been applied to the Project to ensure that it lies in areas with lower probability of flooding.

5.2.4 As the most viable alignment of the Project road includes four sections that cross Flood Zone 3, the Exception Test has also been applied to the Project.

5.2.5 As the Project is considered to provide wider sustainability benefits that outweigh flood risk, and will be safe for its lifetime without increasing flood risk elsewhere, it is deemed to satisfy the requirements of the Exception Test.

5.2.6 The evaluation criteria for the Exception Test also requires that overall flood risk is lowered where possible. Lowering flood risk overall would be achieved by reducing discharge rates from the existing retention ponds along the M25, and the creation of a wetland area in Orsett Fen.

5.2.7 To ensure that the provisions of Paragraph 5.109 of the NN NPS are satisfied:

a. The Project road would remain operational and safe for users by incorporating flood resilience and protection measures.

b. CFSAs would be incorporated in the design to ensure that there is no net loss in floodplain storage.

c. Flow paths would not be impeded so far as is practicable. Where flow paths are impeded, mitigation measures would be incorporated in the design to ensure continuity of flow.

5.3 Climate Change

5.3.1 Climate change has the potential to increase peak rainfall intensity. This results in a corresponding increase in the rate and volume of runoff being discharged to local watercourses and subsequently creates an escalation in flood risk. Furthermore, sea levels are also projected to increase as a result of climate change. Climate change allowances applied to the Project are summarised in the paragraphs below.

5.3.2 Peak rainfall intensity allowances of 40% and 20% respectively would be used for the purposes of carriageway drainage design.

5.3.3 The upper end and central peak rainfall intensity allowances of 40% and 20% respectively would be used for the purposes of highway drainage assets other than carriageway drainage. These figures include a 5% departure allowed by the Environment Agency (recorded in a Statement of Common Ground between National Highways and the Environment Agency in Application Document 5.4).

5.3.4 Peak river flow allowances of +6% and +11% were applied for assessment of the 2030 and 2130 ‘central’ climate scenarios.

5.3.5 The upper end peak river flow allowance (+48% in 2130) was applied to represent the ‘credible maximum’ climate change scenario.

5.3.6 The effect of a sea level rise at Southend on the River Thames extreme water levels (EWLs) at the Project location, was assessed based on an interpretation of outputs from the Environment Agency’s Thames Estuary 2100 modelled River Thames EWLs.

5.3.7 Sea level rise allowances at Southend for the ‘upper end’ and ‘higher central’ climate scenarios in 2130 are 1.57m and 1.17m respectively, relative to 2017.

5.3.8 The H++ sea level rise and storm surge allowance at Southend in 2130 is +2.13m relative to 2017

5.4 Sources of flood risk

5.4.1 The FRA has considered all sources of flood risk. These comprise the following:

a. Fluvial and tidal flooding

b. Surface water (pluvial) flooding

c. Groundwater flooding

d. Sewers

e. Water mains

f. Reservoirs

g. Canals

5.4.2 A summary of the risk of flooding from all sources for each flood risk catchment is summarised in Table 5.1.

Table 5.1 Summary of flood risk sources

Catchment	Fluvial	Tidal	Pluvial	Groundwater	Sewers	Reservoirs	Water mains	Canals
EFR-1	N	N/A	P	N	N	N/A	N	N
EFR-2	P	P	P	N	N	N/A	N	N/A
EFR-3	N	N/A	P	P	N	N/A	N	N/A
EFR-4	P	P	P	N	N	P	N	N/A
EFR-5	P	N/A	P	P	N	N/A	N	N/A

Legend
N/A - Not applicable
P - Potential
N - Negligible

5.5 Flood risk management strategy

5.5.1 The flood risk management strategy considers the suite of flood alleviation measures required to make the Project safe without increasing flood risk elsewhere. Flood alleviation measures for the Project have been divided into three categories:

a. Flood mitigation measures; these comprise those measures necessary to manage floodwater levels in a way that reduces the impact of flooding.

b. Flood protection measures; these comprise targeted measures necessary to protect a development and its users during a flood event.

c. Flood resilience measures; these comprise those measures necessary to ensure that a development and its users are less vulnerable to the effects of flooding.

5.5.2 These measures are sub-categorised as embedded, good practice and essential measures. Embedded measures are secured in the Design Principles (Application Document 7.5). Good practice and essential mitigation are secured through their inclusion in the REAC (Application Document 6.3, Appendix 2.2).

5.5.3 Natural flood management techniques would be incorporated in the Project where appropriate and practicable.

5.5.4 The alleviation measures and methods considered when developing the flood risk management strategy for the Project are summarised in Table 5.2

Table 5.2 Flood alleviation measures considered for the Project

Alleviation measure	Alleviation method	Alleviation category
Mitigation	Provision of compensatory flood storage	Essential
	Creation and restoration of wetlands	Embedded
	Surface water drainage provisions	Embedded
	Inclusion of flood relief channels	Essential
	Alterations to watercourse structures	Good practice
	Alterations to watercourse channels	Good practice
	Alteration of the floodplain	Essential
	Discharge rates reductions from existing flow attenuation structures	Good practice
Protection	Flood bunds	Essential
	Flood walls	Essential
Resilience	Construction of roads on viaducts	Embedded
	Construction of roads on embankments	Embedded
	Change to the road geometry	Embedded
	Inclusion of climate change allowances	Embedded
	Maintenance and inspection	Essential
	Residual uncertainties allowance	Essential

5.5.5 The natural flood management techniques that considered when developing the flood risk management strategy for the Project include:

a. Net reduction in the length of culverted watercourses

b. Reintroduction of meanders in watercourses

c. Naturalisation of watercourse beds (including those in culverted watercourses).

d. Planting trees (as part of the landscaping works)

5.6 Design flood and Project lifetime

5.6.1 The design flood for the Project is:

a. River flooding likely to occur with a 1% annual probability with an appropriate allowance for climate change.

b. Tidal flooding with a 0.5% annual probability with an appropriate allowance for climate change.

c. Surface water flooding likely to occur with a 1% annual probability with an appropriate allowance for climate change.

d. The North Portal flood protection bund has been designed to defend against tidal flooding likely to occur with a 0.1% annual probability with an appropriate allowance for climate change

5.6.2 The Project has adopted a climate change horizon of 2130. For an opening date of 2030, this equates to a lifetime for the Project of at least 100 years

5.6.3 Whilst the Project has been designed to remain operational in 2130 during the design flood, and the 0.1% AEP tidal flood, the only part of the Project design determined by flood risk considerations is the level of the flood protection bund at the North Portal. At other locations, the vertical alignment of the Project road is determined by other more stringent Project design constraints.

5.6.4 The flood protection bund at the North Portal would be readily adaptable to a higher level of protection if required (e.g. a more extreme climate change scenario or a longer Project lifetime), by raising the embankment protecting the tunnel.

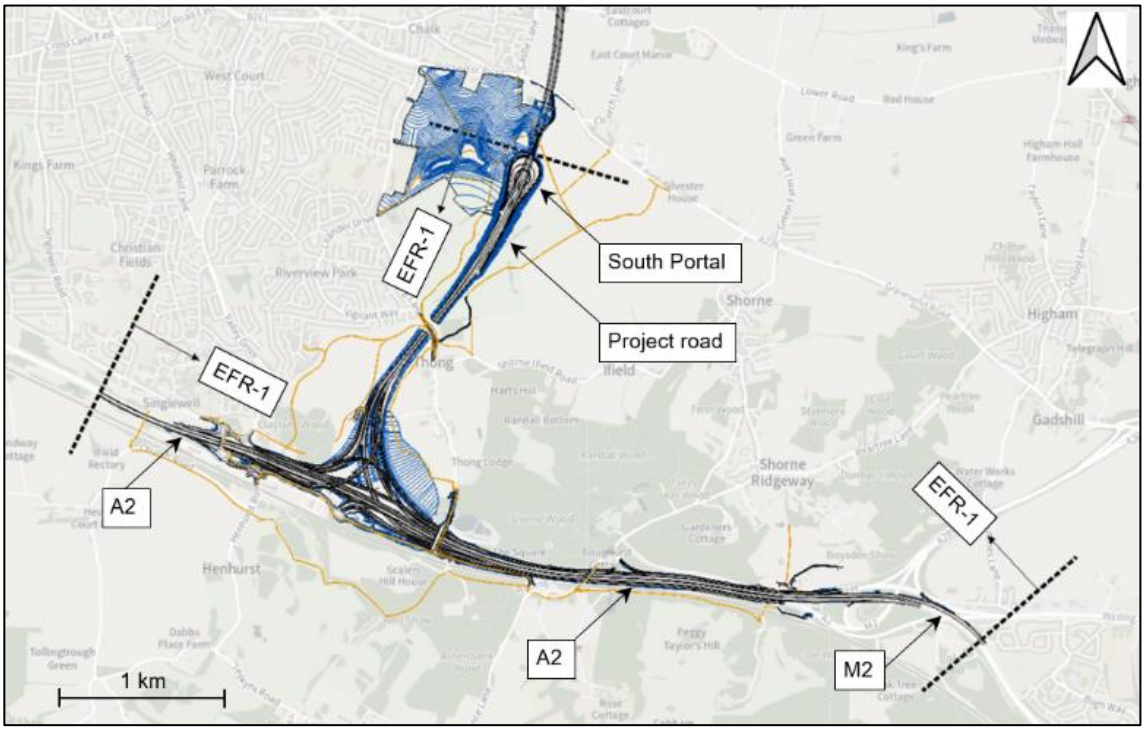
5.6.5 The Project would therefore be readily adaptable to a more extreme climate change scenario (including the credible maximum climate change scenario, as assessed in Part 5 of the FRA), or a longer Project lifetime than 100 years.

6 South of River Thames (EFR-1)

6.1 Overview

6.1.1 The part of the Project to the south of the River Thames (Catchment EFR-1) would comprise elements of the A2 and M2, the junction between the Project road and the A2, and the section of the Project road between the junction and the South Portal (see Plate 6.1).

Plate 6.1 Catchment EFR-1



6.1.2 Catchment ERF-1 would fall entirely within Flood Zone 1 according to the Environment Agency's Flood Map for Planning (2022a).

6.1.3 The catchment would fall entirely within Gravesham Borough Council's administrative boundary, with Kent County Council performing the role of LLFA.

6.1.4 The part of the Project in Catchment EFR-1 would satisfy the provisions of the Sequential Test. (DLUHC, 2021a) (NN NPS, 2016)

6.2 Sources of flood risk

6.2.1 Sources of flood risk for Catchment EFR-1 are presented in Table 6.1.

Table 6.1 Sources of flood risk

Flood risk	Probability	Comment
Fluvial	N/A	There would be no risk of fluvial flooding in this catchment due to the absence of watercourses.
Tidal	N/A	There would be no risk of tidal flooding on account of the elevation of the catchment.

Flood risk	Probability	Comment
Surface water	P	The Environment Agency's map for long term flood risk from surface water (2022b) indicates that there would be a risk of surface water flooding in three isolated areas along the A2/M2 corridor. Surface water flooding in two of these areas will be mitigated by the proposed highway drainage provisions. At the third location, the part of the Project that crosses the area of surface water flooding (a new slip road on the A2/M2 corridor) would be elevated (viaduct) and would not be at risk. In addition to the above, some isolated pockets of surface water flooding within the curtilage of the Project road would be lost and some would be partially lost. This may cause a minor redistribution of surface water flooding beyond the curtilage of the Project road, but this is not considered to present a significant flood risk. Furthermore, any such redistribution would mostly lie within land for which National Highways would be seeking permanent acquisition.
Groundwater	N	There is currently no recorded evidence of groundwater flooding in this area; however, there is potential for shallow perched water to occur. If this shallow groundwater is intercepted there is potential for groundwater to emerge which may, in turn, form a source of flooding. Further details and assessment are provided in Appendix 14.5: Hydrogeological Risk Assessment (Application Document 6.3).
Reservoirs	N/A	Catchment EFR-1 would lie in areas that are not at risk of reservoir flooding.
Sewers	N	Trunk sewers and rising mains with potential to cause significant flooding would be diverted to accommodate the Project.
Water mains	N	All water mains with potential to cause significant flooding would be diverted to accommodate the Project.

Legend
N/A - Not applicable
N - Negligible
P - Potential

6.3 Flood mitigation

Embedded mitigation

6.3.1 Surface water flood risk from highway runoff would be mitigated by the inclusion of highway drainage provisions which would apply to all new and realigned roads in Catchment EFR-1. The surface water drainage provisions would be designed to prevent flooding in the highway without increasing risk elsewhere. Provision of highway drainage is secured in the Design Principles (Application Document 7.5).

6.4 Flood protection

6.4.1 Flood protection measures are not required in Catchment EFR-1.

Flood resilience

6.5 Embedded resilience

6.5.1 Where existing highway drainage provisions need to be expanded or upgraded to accommodate the Project, they would be designed in accordance with the latest DMRB standards. This would afford improved efficiency and robustness in the existing drainage system as the latest DMRB standards are more demanding than the standards in place at the time that the road was originally designed.

Essential resilience

6.5.2 The highway drainage design would include allowances for predicted climate change. Allowances for climate change in the highway drainage are secured in the Design Principles (Application Document 7.5).

Good practice resilience

6.5.3 Highway drainage assets would be inspected and maintained in accordance with the relevant provisions of DMRB GS 801 (Highways England, 2020b) and DMRB GM 701 (Highways England, 2020c), to ensure they continue to operate to their design standard. [RDWE012]

6.5.4 The existing and proposed infiltration basins included in the highway drainage design would incorporate infiltration trenches across their inverts, thereby promoting infiltration efficiency in the short term and maintaining desired infiltration rates in the longer term.

6.5.5 The two proposed cascading infiltration basins to the north-east of the South Portal would be overdesigned to allow for any reduction in efficiency in the upper tiers over time.

6.5.6 Measures would be incorporated in the drainage design to reduce the impacts that arise when flows occur that exceed the capacity of the drainage system (designing for exceedance).

6.6 Residual flood risk

6.6.1 Residual flood risks for Catchment EFR-1 along with associated mitigation measures are presented in Table 6.2:

Table 6.2 Catchment EFR-1 – Residual risks and mitigation

Ref	Residual risk	Mitigation measures
1	Overwhelming of the highway drainage network due to a severe storm event or a blockage may lead to onsite and/or offsite flooding.	Drainage asset inspections would be undertaken in accordance with relevant provisions of DMRB GS 801 Highways England, 2020b). [RDWE012] A planned, risk-based maintenance programme in accordance with the relevant provisions of DMRB GM 701 (Highways England, 2020c) would be established. [RDWE012] Planned maintenance interventions would ensure efficient operation of the drainage network.
2	Overtopping of the infiltration basins may occur in the event of a severe storm; this may lead to development of secondary flow paths with surface water flooding in lower-lying areas.	Drainage asset inspections would be undertaken and maintenance programmes would be established, all as described above. [RDWE012] Overland flow paths would be established to manage any exceedance flows where appropriate. [RDWE034] The infiltration basins have been located away from sensitive receptors to avoid potential risks resulting from residual impacts.
4	There is a risk of seepage if perched groundwater is encountered (e.g. in cuttings).	On account of their highly localised nature, identification of all occurrences of perched groundwater is difficult. If perched groundwater is encountered in cuttings, it would most likely occur as localised seepages only. This residual risk could be mitigated by provision of a drainage system incorporating appropriate edge of pavement detail, such as combined surface and sub-surface drains in line with DMRB CD 524 (Highways England, 2021a).
5	The use of infiltration systems in the drainage design may cause an increase in local groundwater levels due to enhanced recharge. This may cause local groundwater flooding.	The detailed assessment presented in Appendix 14.5: Hydrogeological Risk Assessment shows that the proposed infiltration basins would not cause mounding that would reach the ground surface.

6.7 Surface water drainage

Existing

6.7.1 Existing surface water runoff collection provisions along the A2/M2 corridor comprise a combination of concrete surface water channels, kerbed edge

channels and combined drainage and kerb systems. All surface water runoff is directed to infiltration basins for disposal.

Proposed

6.7.2 The proposed drainage strategy would primarily be based on the use of gravity drainage networks that outfall to infiltration basins. This drainage strategy is secured in the Design Principles (Application Document 7.5).

6.7.3 The drainage network that incorporates runoff from the South Portal ramp cannot be drained by gravity. This network would incorporate a pumping station and rising main to convey collected runoff to an infiltration basin. Use of pumping stations in drainage systems is secured in the Design Principles (Application Document 7.5).

6.7.4 The use of sustainable drainage systems (SuDS) would be adopted wherever appropriate. This requirement is secured in the Design Principles (Application Document 7.5). The underlying chalk formation in Catchment EFR-1 is favourable for SuDS features incorporating infiltration techniques.

6.7.5 Collection of runoff from new highways would be by means of one of the edge of pavement details specified in DMRB 524 (Highways England, 2021a). Runoff would be conveyed to infiltration basins by open drainage ditches where practicable and safe, and piped systems where not.

6.7.6 Three existing infiltration basins would be reconfigured and six new infiltration basins would be constructed to support the drainage network.

6.7.7 New infiltration basins and reconfigured infiltration basins would be designed as vegetated drainage systems in accordance with the provisions of DMRB CD 532 (Highways England, 2021b) [RDWE034]

6.7.8 Subject to any space constraints, infiltration basins would incorporate a sediment forebay with sufficient capacity to accommodate the first flush. The forebay would be lined with an impermeable membrane to reduce the risk of compromising groundwater quality by confining potentially contaminated runoff. [RDWE034]

6.7.9 Where space constraints preclude the use of a sediment forebay, a pollution control device would be included immediately upstream of any basin inlet. Typically, vortex separators would be used for pollution control. [RDWE034]

6.7.10 Where practicable, local topography would be used to integrate infiltration basins with the surrounding landscape. This requirement is secured by Design Principles LPS.17 and S2.06 (Application Document 7.5).

6.7.11 Networks with infiltration basins would include a method to isolate a harmful spillage before it reaches a basin, regardless of whether designated containment provision is made. Isolation (flow control) would be included upstream of each basin inlet, and would typically comprise a penstock. [RDWE034]

6.8 Catchment EFR-1 Conclusions

6.8.1 There is a potential risk from surface water flooding, but this risk can be designed out by adopting a holistic drainage design. Flood risk within Catchment EFR-1 from all other sources is negligible.

6.8.2 Flood mitigation would be limited to highway drainage for the Project road and the A2/M2 corridor.

6.8.3 Flood protection measures would not be required.

6.8.4 Flood resilience would be achieved by making allowances for climate change in the highway drainage design, establishing a planned inspection and maintenance programme, and by adopting good practice measures in the design of infiltration basins. Also, highway drainage provisions in retained parts of the A2/M2 corridor would be enhanced, thereby affording increased resilience against extreme storm events[1].

6.8.5 Residual risks have been identified and appropriate mitigation measures have been proposed.

6.8.6 The proposed drainage strategy would be based on the use of gravity drainage networks that outfall to infiltration basins. The drainage network that includes the ramp down to the South Portal will incorporate a pumping station with a rising main to convey collected runoff to an infiltration basin.

6.8.7 Measures would be incorporated in the drainage design to manage exceedance flows in drainage networks.

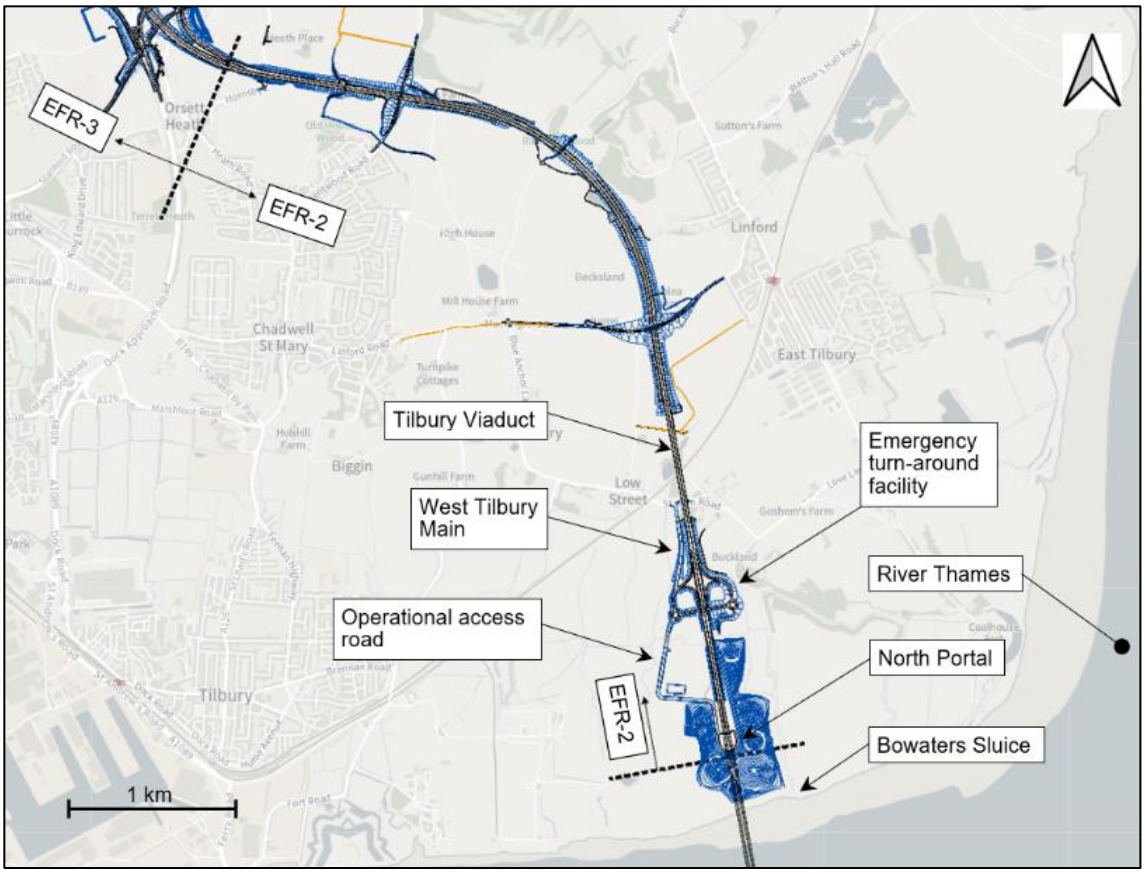
[1] Improvements to the existing drainage provisions of the A2/M2 corridor is not a Project objective; it would be an incidental benefit associated with provision of the new drainage assets. These new assets would be designed to comply with current National Highways standards, which are more demanding than the standards in place at the time of the original design. The scope of the improvements would extend to any reconfigured part of the existing A2/M2.

7 North Portal to Chadwell St Mary (EFR-2)

7.1 Overview

7.1.1 The part of the Project in Catchment EFR-2 comprises the North Portal approach, Tilbury Viaduct and the link road to the junction with the A13 and the A1089. Other Project works in EFR-2 include the tunnel service building at the North Portal, the North Portal service road and the emergency turn-around facility. The extents and principal elements of EFR-2 are presented in Plate 7.1.

Plate 7.1 Catchment EFR-2



7.1.2 According to the Environment Agency's (2022a) Flood Map for Planning, this catchment would lie primarily in Flood Zones 1 and 3. The parts of the Project that lie in Flood Zone 3 all benefit from existing flood defences.

7.1.3 The catchment would fall within Thurrock Council's administrative boundary. Essex County Council is currently undertaking the role of LLFA on behalf of Thurrock Council.

7.1.4 As parts of the Project in Catchment EFR-2 lie in Flood Zone 3, an Exception Test has been undertaken. The Exception Test confirmed that construction of the Project in Flood Zone 3 would be acceptable subject to demonstration that the following evaluation criteria have been met:

a. The development provides wider sustainability benefits to the community that outweigh flood risk (DLUHC, 2021a).

b. The development will be safe for its lifetime, taking account of the vulnerability of its users, without increasing flood risk elsewhere, and where possible, will reduce flood risk overall (DLUHC, 2021a).

c. Any essential infrastructure project 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. (NN NPS, 2014)

7.1.5 Demonstration of how the test criteria have been met is detailed in full in Part 6 of the FRA.

7.2 Flood risk

7.2.1 Sources of flood risk for Catchment EFR-2 are presented in Table 7.1.

Table 7.1 Sources of flood risk

Flood risk	Probability	Comment
Fluvial	P	Fluvial flooding would occur when the flow through West Tilbury Main exceeds its capacity. West Tilbury Main discharges to the River Thames via Bowaters Sluice and is subject to tide locking.
Tidal	P	Tidal flooding would occur when tide levels in the River Thames are exceptionally high and when surge tides move up the Thames Estuary from the North Sea. The tidal flood mechanism would be overtopping or breaching of defences, resulting in the rapid onset of fast-flowing and deep-water flooding with little or no warning. Mechanical failure of sluice gates may also result in tidal flooding. Existing tidal flood defences in this catchment include: • Sea walls along the River Thames comprising earth embankments topped with concrete walls. • Bowaters Sluice and tidal wall where the West Tilbury Main outfalls to the River Thames. • Star Dam – An inland defense that prevents tidal flood water travelling between West Tilbury Marshes and East Tilbury Marshes.
Surface water	P	The Environment Agency's map for long term flood risk from surface water (2022b) indicates that this catchment lies in an area that is primarily at very low risk of surface water flooding. However, there are some areas at low, medium and high risk of surface water flooding; these areas generally follow watercourses, along roads (where overland drainage paths are interrupted) and in isolated pockets (local depressions). Some isolated pockets of surface water flooding within the curtilage of the Project road would be lost and some would be partially lost. This may cause a minor redistribution of surface water flooding beyond the curtilage of the Project road, but this is not considered to present a significant flood risk. Furthermore, any such redistribution would mostly lie within land for which National Highways would be seeking permanent acquisition.

Flood risk	Probability	Comment
Groundwater	N	The Project road would be in an area predominantly at low risk of groundwater flooding, however, there is potential for shallow perched water to occur. Further details and assessment are provided in Appendix 14.5: Hydrogeological Risk Assessment (Application Document 6.3).
Reservoirs	N	Catchment EFR-2 would lie in areas that are not at risk of reservoir flooding.
Sewers	N	Trunk sewers and rising mains with potential to cause significant flooding would be diverted to accommodate the Project.
Water mains	N	All water mains with potential to cause significant flooding would be diverted to accommodate the Project.

Legend
N/A - Not applicable
N - Negligible
P - Potential

7.3 Hydraulic modelling

7.3.1 The aim of the modelling is to inform the FRA and the design of the Project. To achieve this aim, a 1D/2D coupled Flood Modeller/TUFLOW model has been developed to assess flood risk to the Project and its impact on flooding elsewhere.

7.3.2 The modelling undertaken has developed fluvial flood hydrology for the West Tilbury Main catchment and downstream tidal conditions.

7.3.3 The hydraulic model has been constructed based on the channel survey data acquired for the Project, and LiDAR topographic data.

7.3.4 The flood maps generated by the hydraulic model have been used to analyse pre-development and post development fluvial flood risk in EFR-2. These flood maps have also been used to analyse the performance of flood alleviation measures. The flood maps generated with the hydraulic model are more detailed than the long term flood risk information map (Environment Agency, 2022b) and the flood map for planning (Environment Agency, 2022a) and include climate change allowances.

7.3.5 The most severe fluvial flood event assessed was the 0.1% annual exceedance probability (AEP) event with +26% peak river flow allowances for 2130. Simulation of this event demonstrated that the flood level (2.32mAOD with mitigation) would be substantially lower than the crest level of the flood protection measures (7.83 mAOD). The Project would therefore remain operational during such a fluvial flood event.

7.3.6 The depth difference plots for the 50%, 5% and 1% AEP fluvial events in 2130 with a +17% ‘central’ peak river flow allowance applied were assessed to determine the offsite impacts of the Project. The plots demonstrate that the mitigation measures and floodplain compensation specified provide the required mitigation and compensation.

7.3.7 The Environment Agency’s climate change guides for flood risk assessment (Environment Agency, 2022c) requires that maximum credible scenarios

should be considered for NSIPs. The credible maximum scenario for fluvial flooding is the 0.1% AEP event with +48% peak river flow allowances for 2130. Simulation of this event demonstrates that the flood level for the maximum credible event (2.33 mAOD) would be substantially lower than the crest level of the flood protection measures (7.83 mAOD). The proposed road would therefore not be impacted by fluvial flooding under the credible maximum scenario.

7.3.8 Tilbury breach models were used to simulate scenarios for a breach of the River Thames defences. Overtopping of the existing defences would occur if River Thames extreme water levels (EWLs) exceed the defence crest levels. The 0.1% AEP tidal event EWL in 2130 for East Tilbury Marshes (Project location) is 6.83 mAOD. The proposed protection at the North Portal is designed with a top level of 7.83mAOD (EWL plus a residual uncertainties allowance of 1m). The parts of the highway that do not benefit from the protection would be designed to be above 7.83 mAOD.

7.3.9 The EWL in the River Thames for the H++ event in 2130 would be 7.28mAOD. This is approximately 0.45m higher than the 0.1% AEP EWL at East Tilbury Marshes (6.83mAOD). If the H++ climate change scenario were realised, the Project could be adapted at this location by raising the protection to 8.28mAOD (the H++ EWL plus a residual uncertainties allowance of 1m).

7.3.10 Usually, floodplain compensation would be provided to replace the floodplain volume displaced by the Project on a hydraulically linked, level-for-level basis, with volumes displaced within level ranges, replaced within the same level ranges (referred to in this report as a conventional compensatory flood storage area (CFSA)). However, this is not possible in the West Tilbury Main catchment due to the low-lying, flat floodplain. To ensure that post-development flood risk would not exceed pre-development flood risk, a flow retention CFSA would be created. This would intercept flows in upstream catchments and release the retained water at a controlled rate.

7.4 Flood mitigation

Embedded mitigation

7.4.1 Surface water flood risk from highway runoff would be mitigated by inclusion of highway drainage provisions which would apply to all new roads in Catchment EFR-2. The surface water drainage provisions would be designed to prevent flooding in the highway without increasing risk elsewhere. Provision of highway drainage is secured in the Design Principles (Application Document 7.5).

Essential mitigation

7.4.2 It would be necessary to provide compensatory flood storage to offset the volume of existing floodplain storage displaced by the Project. A flow retention CFSA would be constructed to the north of the railway line (Tilbury Loop). [RDWE037]

7.4.3 The Project road would dissect a flow path running east to west across East Tilbury Marshes. To offset the loss of this flow path, flow capacity in the West Tilbury Main would be enhanced by making changes to structures that cross it.

These changes would comprise enlargement of one existing culvert and removal of two others. [RDWE046]

7.4.4 The removal and enlargement of the culverts as described in paragraph 6.2.11 would result in no change in conveyance for smaller events, but for larger events there will be an increase in conveyance. A two-stage flow control structure would be required to mitigate the impacts of larger events, while not changing the hydraulic behaviour during smaller events. [RDWE046]

7.5 Flood protection

Essential protection

7.5.1 Two sections of the Project road between the North Portal and the Tilbury Viaduct would be vulnerable to overtopping during a tidal flood event and would need to be protected.

7.5.2 The first vulnerable section would be a 265m long stretch that straddles West Tilbury Main. The protection would be keyed into the existing high ground around the North Portal and would tie-in with the earthworks for the emergency turn-around facility.

7.5.3 The flood protection level would be 7.83 mAOD. The form of construction would comprise an earth retaining wall with an earth mound behind it rising to the design flood level. The second vulnerable section would be along part of the northbound on-slip and southbound off-slip for the emergency turn-around facility. [RDWE029]

7.5.4 The protection would tie-in with the earthworks for the emergency turn-around facility and continue northwards until the level of the Project road matches the flood protection level (7.83 mAOD). The protection would be incorporated into the on-slip and off-slip formation (earthworks embankments). [RDWE029]

7.6 Flood resilience

Embedded resilience

7.6.1 To the north of Catchment EFR-2, the Project road would be on a viaduct or on high embankments. The level of the viaduct and embankments would be substantially higher than the flood protection level, thereby affording embedded flood resilience to this section of the road. [RDWE029]

Essential resilience

7.6.2 The design of the compensatory flood storage and the flood protection measures would include allowances for predicted climate change. [RDWE029] [RDWE037]

7.6.3 The highway drainage design would also include allowances for predicted climate change (Design Principles, Application Document 7.5).

Good practice resilience

7.6.4 Highway drainage assets would be inspected and maintained in accordance with the relevant provisions of DMRB GS 801 (Highways England, 2020b) and

DMRB GM 701 (Highways England, 2020c), to ensure they continue to operate to their design standard. [RDWE012]

7.6.5 Measures would be incorporated in the drainage design to reduce the impacts that arise when flows occur that exceed the capacity of the drainage system (designing for exceedance).

7.7 Residual flood risk

7.7.1 Residual flood risks for Catchment EFR-2 along with associated mitigation measures, are presented in Table 7.2.

Table 7.2 Catchment EFR-2 – Residual risks and mitigation

Ref.	Residual risk	Mitigation measures
1	Overwhelming of the highway drainage system due to a severe storm event or a blockage may result in onsite and/or offsite flooding and the potential for runoff to enter the tunnel (the entire section of highway in Catchment EFR-2 all slopes down towards the tunnel).	Drainage asset inspections would be undertaken in accordance with relevant provisions of DMRB GS 801 (Highways England, 2020b). [RDWE012] A planned, risk-based maintenance programme in accordance with the relevant provisions of DMRB GM 701 (Highways England, 2020c) would be established. [RDWE012] Planned maintenance interventions would ensure efficient operation of the drainage network (including pumping stations).
2	Overtopping of the retention ponds and detention basins that form part of the highway drainage system may occur in the event of a severe storm. This may lead to development of secondary flow paths with surface water flooding in lower-lying areas.	The capacity of retention ponds and detention basins would include provision for climate change allowances in accordance with the Environment Agency guidance. [RDWE035] [RDWE048] Drainage asset inspections would be undertaken and maintenance programmes would be established, all as described above. [RDWE012] Overland flow paths would be established where required, to manage any exceedance flows. [RDWE035] [RDWE048] The retention ponds and detention basins would be located away from sensitive receptors to avoid potential risks resulting from residual impacts.
3	Overtopping of the CFSA may occur in the event of a severe storm; this may lead to development of secondary flow paths with surface water flooding in lower-lying areas.	The design of the CFSA would include allowances for climate change in accordance with the latest Environment Agency guidance (Environment Agency, 2022c), thereby reducing residual risk of overtopping.
4	Overtopping of the flood protection due to a severe tidal event could result in inundation of the tunnel.	A tunnel safety consultation has been undertaken on emergency preparedness. This consultation establishes measures to be implemented during an incident.

Ref.	Residual risk	Mitigation measures
5	Structural failure (breach) of the flood protection measures could result in inundation of the tunnel.	A planned, risk-based maintenance programme would be established. [RDWE012] Mitigation measures for structural failure of the flood protection would involve periodic inspections. The inspection would assess the structural integrity of the protection. Any structural integrity issue identified would then trigger a maintenance response.
6	There is a risk of seepage if perched groundwater is encountered (e.g. in cuttings).	On account of their highly localised nature, identification of all occurrences of perched groundwater is difficult. If perched groundwater is encountered in cuttings, it would most likely occur as localised seepages only. This residual risk could be mitigated by provision of a drainage system incorporating an appropriate edge of pavement detail, such as combined surface and sub-surface drains in line with DMRB CD 524 (Highways England, 2021a).
7	Failure of Bowaters Sluice	For the West Tilbury Main hydraulic model, the Environment Agency advised that the Bowaters Sluice outfall is 75% blocked. To reflect its current condition, sensitivity runs were undertaken to compare pre-development model results with a 75% and 100% blockage of Bowaters Sluice outfall. Results for both blockage scenarios show similar maximum depths and maximum flood extents, which indicates that the impact of simulating a 100% blockage condition compared to 75% blockage, is minor. Given the insensitivity of the model results to the blockage condition, design model simulations apply a 100% blockage condition for the Bowaters Sluice tidal outfall (i.e., design simulations for West Tilbury Main have therefore been undertaken on the basis that this residual risk has been realised).
8	Breach of River Thames tidal flood defences	The 0.1% AEP tidal event EWL of the River Thames in 2130 with climate change allowances in East Tilbury Marshes (Project location) is 6.83mAOD. The proposed protection at the North Portal is designed with a top level of 7.83mAOD. The parts of the highway that do not benefit from the protection are also designed to be above 7.83mAOD.

7.8 Surface water drainage

Existing

7.8.1 The Project road in Catchment EFR-2 is new carriageway and thus would not impact any existing drainage networks.

Proposed

7.8.2 The proposed drainage strategy would primarily be based on the use of gravity drainage networks that discharge to retention ponds or detention basins that outfall to watercourses. This drainage strategy is secured in the Design Principles (Application Document 7.5).

7.8.3 The drainage network that incorporates runoff from the North Portal ramp cannot be drained by gravity. This network would incorporate a pumping station and rising main to convey collected runoff to a retention basin. Use of pumping stations in drainage systems is secured in the Design Principles (Application Document 7.5).

7.8.4 The use of sustainable drainage systems (SuDS) would be adopted wherever appropriate. This requirement is secured in the Design Principles (Application Document 7.5). The underlying ground formation in Catchment EFR-2 is not favourable for SuDS features incorporating infiltration techniques.

7.8.5 Collection of runoff from new highways would be by means of one of the edge of pavement details specified in DMRB 524 (Highways England, 2021a). Runoff would be conveyed to ponds and basins by open drainage ditches where practicable and safe, and piped systems where not.

7.8.6 Three retention ponds and one detention basin would be constructed to support the highway drainage in Catchment EFR-2.

7.8.7 Retention ponds and detention basins would be designed as vegetated drainage systems in accordance with the provisions of DMRB CD 532 (Highways England, 2021b). [RDWE035] [RDWE048]

7.8.8 Retention ponds and detention basins would incorporate a sediment forebay with sufficient capacity to accommodate the first flush. The forebay would be lined with an impermeable membrane to reduce the risk of compromising groundwater quality by confining potentially contaminated runoff. [RDWE035] [RDWE048]

7.8.9 In accordance with DMRB CD 532, pond capacities and discharge rates shall be agreed in consultation with the local land drainage authority[2]. Attenuation would be by means of a small diameter pipe, vortex controls, orifice plates or a combination thereof. Notwithstanding the above, the minimum discharge rate from new retention ponds shall be 1l/s. [RDWE035] [RDWE048]

7.8.10 Where practicable, local topography would be used to integrate the retention ponds and detention basin with the surrounding landscape. This requirement is secured by Design Principles LPS.17 and S2.06 (Application Document 7.5).

7.8.11 Networks with retention ponds or detention basins would include a method to isolate a harmful spillage before it reaches a watercourse, regardless of

[2] In EFR-2, the local land drainage authority is Essex County Council in their capacity as LLFA.

whether designated containment provision is made. Isolation (flow control) would be included downstream of each pond/basin outlet and would typically comprise a penstock. [RDWE035] [RDWE048]

7.9 Catchment EFR-2 Conclusions

7.9.1 The principal flood risks in Catchment EFR-2 are fluvial, tidal and surface water.

7.9.2 Flood mitigation would comprise the following:

a. Drainage provisions for the Project road and other roads and areas that would be affected by implementation of Project.

b. Alterations to West Tilbury Main (removal of two culverts, enlargement of one culvert and incorporation of a flow control structure.

c. Provision of a flow retention CFSA.

7.9.3 Flood protection would be required to protect the tunnel and low-lying parts of the highway from tidal flooding in two locations.

7.9.4 Flood resilience would be achieved by making allowances for climate change in the design of mitigation measures and flood protection measures and by establishing a planned maintenance programme.

7.9.5 The form of construction of the Project road in Catchment EFR-2 that lies in Flood Zone 3 would provide resilience against fluvial, tidal and surface water flood risk (embankments and viaducts).

7.9.6 The proposed drainage strategy would be based on the use of gravity drainage networks that outfall to retention ponds or detention basins.
The drainage network that includes the ramp down to the North Portal would incorporate a pumping station with a rising main to convey collected runoff to a retention pond.

7.9.7 Residual risks have been identified and appropriate mitigation measures proposed.

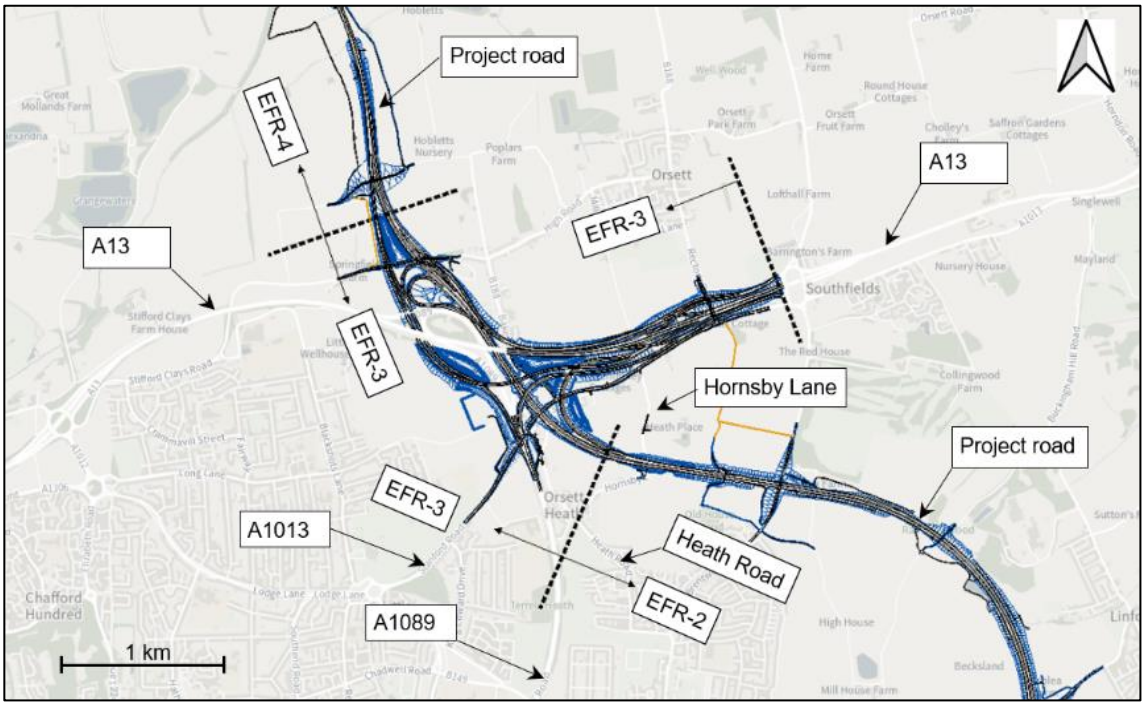
7.9.8 Measures would be incorporated in the drainage design to manage exceedance flows in drainage networks.

8 A13 junction (EFR-3)

8.1 Overview

8.1.1 Catchment EFR-3 would incorporate the split-level interchange between the Project road and the A13 and A1089. The extents and principal elements of EFR-3 are presented in Plate 8.1.

Plate 8.1 Catchment EFR-3



8.1.2 This catchment would fall entirely within Flood Zone 1 according to the Environment Agency's (2020a) Flood Map for Planning.

8.1.3 The catchment falls within Thurrock Council's administrative boundary. Essex County Council is currently undertaking the role of LLFA on behalf of Thurrock Council.

8.1.4 The part of the Project in Catchment EFR-3 would satisfy the provisions of the Sequential Test (ie it does not need to be moved to an area of lower flood risk) within the NPPF (DLUHC, 2021a). (NPSNN, 2016)

8.2 Flood risk

8.2.1 Sources of flood risk for Catchment EFR-3 are presented in Table 8.1.

Table 8.1 Sources of flood risk

Flood risk	Probability	Comment
Fluvial	N	Catchment EFR-3 would lie in areas that are at low risk of fluvial flooding.
Tidal	N/A	Catchment EFR3 would lie in areas that are not at risk of tidal flooding.
Surface water	P	The Environment Agency's map for long term flood risk from surface water (2021b) indicates that there would be a risk of surface water flooding in three isolated areas. Two of these areas would lie on roads that would be realigned to accommodate the Project road. Mitigation of risk in these areas could be achieved by ensuring that the realigned roads do not alter existing flow paths. In the third area, an overland flow path would be lost under the curtilage of the Project road. Surface water from the impacted flow path may flow onto the Project road. The highway drainage design would take account of overland flows to ensure that the risk of carriageway flooding is mitigated. Some of the isolated pockets of surface water flooding within the curtilage of the Project road would be lost and some would be partially lost. This may cause a minor redistribution of surface flooding beyond the curtilage of the Project road, but this is not considered to present a significant flood risk. Furthermore, any such redistribution would mostly lie within land for which National Highways would be seeking permanent acquisition.
Groundwater	P	Potential for groundwater seepage is inferred at the deepest cutting (the A13 westbound to southbound A122 link road), as the maximum groundwater levels recorded in the Thanet Formation are higher than the lowest road level here, over a road length of less than 100m. There is also potential for shallow perched water to occur. Further details and assessment are provided in Appendix 14.5: Hydrogeological Risk Assessment (Application Document 6.3).
Reservoirs	N/A	Catchment EFR-3 would lie in areas that are not at risk of reservoir flooding.
Sewers	N	Trunk sewers and rising mains with potential to cause significant flooding would be diverted to accommodate the Project.
Water mains	N	All water mains with potential to cause significant flooding would be diverted to accommodate the Project.

Legend
N/A – Not applicable
N - Negligible
P - Potential

8.3 Flood mitigation

Embedded mitigation

8.3.1 Surface water flood risk from highway runoff would be mitigated by inclusion of highway drainage provisions, which would apply to all new and realigned roads in Catchment EFR-3. The surface water drainage provisions would be designed to prevent flooding in the highway without increasing risk elsewhere. Provision of highway drainage is secured in the Design Principles (Application Document 7.5).

8.4 Flood protection

8.4.1 Flood protection measures are not required in Catchment EFR-3.

8.5 Flood resilience

Embedded resilience

8.5.1 Where existing highway drainage provisions need to be expanded or upgraded to accommodate the Project, they would be designed in accordance with the latest DMRB standards. This would afford improved efficiency and robustness in the existing drainage system as the latest DMRB standards are more demanding than the standards in place at the time the road was originally designed[3].

8.5.2 Infiltration basins included in the highway drainage design would incorporate infiltration trenches across their inverts, thereby promoting infiltration efficiency in the short term and maintaining desired infiltration rates in the longer term.

Essential resilience

8.5.3 The highway drainage design would include allowances for projected climate change. Allowances for climate change in the highway drainage are secured in the Design Principles (Application Document 7.5).

Good practice resilience

8.5.4 Highway drainage assets would be inspected and maintained in accordance with the relevant provisions of DMRB GS 801 (Highways England, 2020b) and DMRB GM 701 (Highways England, 2020c), to ensure they continue to operate to their design standard. [RDWE012]

8.5.5 Measures would be incorporated in the drainage design to reduce the impacts that arise when flows occur that exceed the capacity of the drainage system (designing for exceedance).

[3] Improvement to the existing drainage provisions of the A13 junction is not a Project objective; it would be an incidental benefit associated with provision of the new drainage assets. These new assets would be designed to comply with current National Highways standards, which are more stringent than the standards in place at the time of the original design. The scope of the improvements would extend to any reconfigured part of the existing junction.

8.6 Residual flood risk

8.6.1 The residual flood risks in Catchment EFR-3 would be detailed in Table 8.2.

Table 8.2 Catchment EFR-3 – Residual risks

Ref	Residual risk	Mitigation measures
1	Overwhelming of the highway drainage network due to a severe storm event or a blockage may lead to onsite and/or offsite flooding.	Drainage asset inspections would be undertaken in accordance with relevant provisions of DMRB GS 801 (Highways England, 2020b). [RDWE012] A planned, risk-based maintenance programme would be established in accordance with the relevant provisions of DMRB GM 701 (Highways England, 2020c). [RDWE012] Planned maintenance interventions would ensure efficient operation of the drainage network.
2	Overtopping of the retention ponds and/or infiltration basin may occur in the event of a severe storm; this may lead to development of secondary flow paths with surface water flooding in lower-lying areas.	Drainage asset inspections would be undertaken and maintenance programmes would be established, all as described above. [RDWE012] Planned maintenance interventions would ensure efficient operation of the infiltration basin. Overland flow paths would be established to manage any overtopped flows. [RDWE034] [RDWE035] The retention ponds and infiltration basin have been located away from sensitive receptors to avoid potential risks resulting from residual impacts.
3	There is a risk of seepage if perched groundwater is encountered (e.g. in cuttings).	On account of their highly localised nature, identification of all occurrences of perched groundwater is difficult. If perched groundwater is encountered in cuttings, it would most likely occur as localised seepages only. Potential for groundwater seepage is inferred at the deepest cutting (A13 westbound to southbound A122 link road), over a road length of less than 100m. This residual risk would be mitigated by provision of a drainage system incorporating an appropriate edge of pavement detail, such as combined surface and sub-surface drains in line with DMRB CD 524 (Highways England, 2021a).
4	Variable ground conditions may inhibit the operation of infiltration basins.	Mitigation measures discussed in Appendix 14.5: Hydrogeological Risk Assessment would ensure adequate operation of the infiltration basins.
5	Cuttings have the potential to alter groundwater flow direction and change the groundwater flow regime. This may lead to flooding elsewhere.	Appendix 14.5: Hydrogeological Risk Assessment indicates that the proposed cuttings are generally above the groundwater level in Catchment EFR-3. Also, groundwater collected by highway drainage would be removed or infiltrated to ground as part of the highway drainage system. Therefore, groundwater flooding would not be caused elsewhere as a consequence of the cuttings.

Ref	Residual risk	Mitigation measures
6	The use of infiltration systems in the drainage design may result in an increase in local groundwater levels due to enhanced recharge causing local groundwater flooding.	Assessment of the proposed infiltration systems, considering infiltration rates and local ground conditions, has demonstrated that mounding would not occur to unacceptable shallow levels (Appendix 14.5: Hydrogeological Risk Assessment). The residual risk of groundwater flooding due to enhanced recharge would therefore be low, so no mitigation measures are deemed necessary.

8.7 Surface water drainage

Existing

8.7.1 Existing drainage in Catchment EFR-3 comprises highway drainage for the A13 and the A1089 and across the interchange between these two roads. Existing drainage provisions on the A13 at the point where it would cross over the Project road comprise edge channels with gullies and collector drains.

Proposed

8.7.2 The proposed drainage strategy would primarily be based on the use of gravity drainage networks that discharge to retention ponds or infiltration basins that outfall to watercourses. This drainage strategy is secured in the Design Principles (Application Document 7.5).

8.7.3 The use of sustainable drainage systems (SuDS) would be adopted wherever appropriate. This requirement is secured in the Design Principles (Application Document 7.5). The underlying ground formation (chalk) in Catchment EFR-3 is favourable for SuDS features incorporating infiltration techniques.

8.7.4 Collection of runoff from new highways would be by means of one of the edge of pavement details specified in DMRB 524 (Highways England, 2021a). Runoff would be conveyed to retention ponds by open drainage ditches where practicable and safe, and piped systems where not.

8.7.5 One infiltration basin would be constructed to support the highway drainage in Catchment EFR-3. Most of the runoff from Catchment EFR-3 will be conveyed to retention ponds located in Catchment EFR-4 (see Section 8). Small isolated catchments that cannot readily be connected to the infiltration basin or the retention ponds in Catchment EFR-4 would be drained to swales. These swales would act as infiltration features rather than conveyance features. [RDWE034]

8.7.6 The infiltration basin would be designed as a vegetated drainage system in accordance with the provisions of DMRB CD 532 (Highways England, 2021b). [RDWE034]

8.7.7 A pollution control device would be included immediately upstream of any basin inlet. Typically, a vortex separator would be used for pollution control. [RDWE034]

8.7.8 Where practicable, local topography would be used to integrate the infiltration basin with the surrounding landscape. This requirement is secured by Design Principles LPS.17 and S2.06 (Application Document 7.5).

8.7.9 Networks with infiltration basins would include a method to isolate a harmful spillage before it reaches a basin. Isolation (flow control) would be included upstream of each basin inlet, typically in the form of a penstock. [RDWE034].

8.8 Catchment EFR-3 Conclusions

8.8.1 There is a potential risk from surface water flooding, but this risk can be designed out by adopting a holistic drainage design. Risk of flooding from all other sources within Catchment EFR-3 is negligible.

8.8.2 Flood mitigation would be limited to highway drainage for the Project road and the reconfigured parts of the A13 and the A1089.

8.8.3 Flood protection measures would not be required.

8.8.4 Flood resilience would be achieved by making allowances for climate change in the highway drainage design and establishing a planned inspection and maintenance programme. Also, highway drainage provisions on reconfigured parts of the A13 and A1089 would be enhanced, thereby affording increased resilience against extreme storm events.

8.8.5 The proposed drainage strategy would be based on the use of gravity drainage networks that outfall to infiltration basins and retention ponds.

8.8.6 Measures would be incorporated in the drainage design to manage exceedance flows in drainage networks.

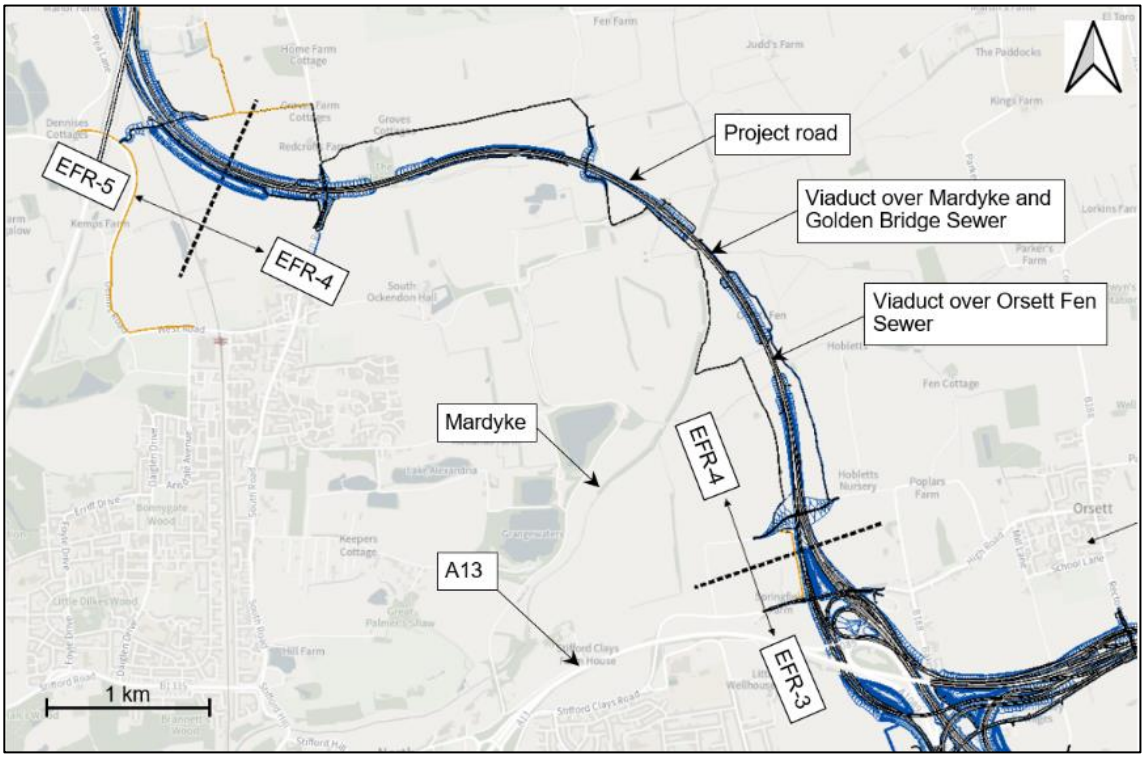
8.8.7 Residual risks have been identified and appropriate mitigation measures have been proposed.

9 Ockendon Link (EFR-4)

9.1 Overview

9.1.1 Catchment EFR-4 comprises the section of the Project road between its junctions with the A13 and the M25. The Project road is on embankments, in cuttings and on viaducts in Catchment EFR-4. The extents and principal elements of EFR-4 are shown in Plate 9.1.

Plate 9.1 Catchment EFR-4



9.1.2 According to the Environment Agency's (2020a) Flood Map for Planning, this catchment would lie primarily in Flood Zones 1 and 3. The parts of the Project that lie in Flood Zone 3 all benefit from existing flood defences.

9.1.3 The catchment would fall within Thurrock Council's administrative boundary. Essex County Council is currently undertaking the role of LLFA on behalf of Thurrock Council.

9.1.4 As parts of the Project in Catchment EFR-4 lie in Flood Zone 3, an Exception Test needs to be undertaken. The Exception Test confirmed that construction of the Project in Flood Zone 3 would be acceptable subject to demonstration that the following test evaluation criteria have been met.

a. The development provides wider sustainability benefits to the community that outweigh flood risk (DLUHC, 2021a).

b. The development will be safe for its lifetime, taking account of the vulnerability of its users, without increasing flood risk elsewhere, and where possible, will reduce flood risk overall (DLUHC, 2021a).

c. Any essential infrastructure project 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. (NPSNN, 2014).

9.1.5 Demonstration of how the test criteria have been met is detailed in full in Part 6 of the FRA.

9.2 Flood risk

9.2.1 Sources of flood risk for Catchment EFR-4 are presented in Table 9.1.

Table 9.1 Sources of flood risk

Flood risk	Probability	Comment
Fluvial	P	The Project road crosses three main rivers in EFR-4: • Mardyke • Orsett Fen Sewer • Golden Bridge Sewer Orsett Fen Sewer and Golden Bridge Sewer are tributaries of the Mardyke. A fourth main river, Stringcock Sewer, flows into the Mardyke just to the north of the Project. The Mardyke splits into the West Mardyke and East Mardyke just to the north of Stringcock Sewer. Fluvial flooding will occur when the flow through these main rivers exceeds their capacity. Tide locking at the point where the Mardyke discharges to the River Thames (Purfleet) could exacerbate fluvial flooding. When the Mardyke is tide locked, flooding in the tributaries will also be effectively tide locked, thus further exacerbating fluvial flooding.
Tidal	P	The primary tidal flood mechanism is failure of the Mardyke sluice gate at Purfleet, which may result in the rapid onset of fast flowing and deep-water flooding with little or no warning. The Mardyke sluice is a vertical hinged leaf-type gate. The Environment Agency is responsible for the maintenance of the sluice.
Surface water	P	According to the Environment Agency's long term flood risk map for surface water (2022b), the higher ground to the northern and southern extents is at very low risk of surface water flooding. The section across Orsett Fen (drained fenland) lies in areas at low, medium and high risk of surface water flooding. The areas at high risk of surface water flooding coincide with the functional floodplain of the Mardyke and its tributaries. Some isolated pockets of surface water flooding within the curtilage of the Project road would be lost and some would be partially lost. This may cause a minor redistribution of surface flooding beyond the curtilage of the Project road, but this is not considered to present a significant flood risk. Furthermore, any such redistribution would mostly lie within land for which National Highways would be seeking permanent acquisition.

Flood risk	Probability	Comment
Groundwater	P	In the most north-westerly part of Catchment EFR-4, the Project road is in an area of negligible risk from groundwater flooding. There is a low and moderate risk of groundwater flooding in the central and south-eastern parts of Catchment EFR-4. The source of groundwater flooding is associated with the functional floodplain of the Mardyke and its tributaries. Further details and assessment are provided in Appendix 14.5: Hydrogeological Risk Assessment (Application Document 6.3).
Reservoirs	P	The Environment Agency's map for long term flood risk from reservoirs (2022b) indicates that there is reservoir flood risk arising from the following: • Unnamed lake to the north-east of Grangewaters (Orsett Fen) • Church Lake (near Childerditch) • Stickling Hill Reservoir (Orsett Fen) • Hobletts Reservoir (Orsett Fen) The Environment Agency has identified four risk categories for a reservoir breach. In Catchment EFR-4, breach of reservoirs would be category C breaches. A category C breach poses negligible risk to life and causes limited damage; this includes flood-threatened areas that are 'inhabited' only occasionally. The flooding follows the local watercourses and the areas at risk for the Project are where the highway crosses the Mardyke, Golden Bridge Sewer and Orsett Fen Sewer. At the crossing points, the Project road would be on viaducts or embankments. The risk of flooding due to a reservoir breach along these elevated sections of the Project road would be negligible.
Sewers	N	Trunk sewers and rising mains with potential to cause significant flooding would be diverted to accommodate the Project.
Water mains	N	All water mains with potential to cause significant flooding would be diverted to accommodate the Project.

Legend
N - Negligible
P - Potential

9.3 Hydraulic modelling

9.3.1 The aim of the modelling is to inform the FRA and the design of the Project. To achieve this aim, a 1D/2D coupled Flood Modeller/TUFLOW model has been developed to assess flood risk to the Project and its impact on flooding elsewhere.

9.3.2 The modelling undertaken has developed fluvial flood hydrology for the Mardyke catchment as well as downstream tidal conditions.

9.3.3 The hydraulic model has been constructed based on the channel survey data acquired for the Project, and LiDAR topographic data.

9.3.4 The hydraulic model has been calibrated against the Environment Agency's available catchment flood data.

9.3.5 The flood maps generated by the hydraulic model have been used to analyse pre-development and post development fluvial flood risk in EFR-4. These flood maps have also been used to analyse the performance of flood alleviation measures. The flood maps generated with the hydraulic model are more detailed than the long term flood risk information map (Environment Agency, 2022a) and the flood map for planning (Environment Agency, 2022b).

9.3.6 The Environment Agency's climate change guidelines for flood risk assessment (Environment Agency, 2022c) require that maximum credible scenarios should be considered for NSIPs. The 0.1% AEP event with the upper end peak river flow allowance applied (+48%) in 2130 represents the credible maximum climate change scenario. The Project road would be more than 5m above the flood level during the credible maximum climate change scenario. The Project road would therefore remain operational during this event.

9.3.7 The Project requirement for fluvial flooding is that the proposed highway remains operational during the 0.5% AEP flood in 2130 with the higher central peak river flow allowance applied (+26%). As the highway would remain operational during the credible maximum scenario event, it can be concluded that the Project requirement of fluvial flooding has been fulfilled.

9.3.8 The depth difference plots for the 10%, 4% and 1% AEP events in 2130 with a +17% central peak river flow allowance applied, demonstrate that the mitigation measures and floodplain compensation specified provide the required mitigation and compensation to ensure that there are no offsite flooding effects.

9.3.9 Simulation results indicate that following a breach at Mardyke Sluice during the 0.1% AEP River Thames tidal event in 2130, flooding remains in channel at the point where the Project road crosses the Mardyke. As the flooding remains in channel for this event, it will have no impact on the Project and the Project will have no impact on breach flood risk elsewhere.

9.4 Flood mitigation measures

Embedded mitigation

9.4.1 Surface water flood risk from highway runoff would be mitigated by inclusion of highway drainage provisions, which would apply to all new roads in Catchment EFR-4. The surface water drainage provisions would be designed to prevent flooding in the highway without increasing risk elsewhere. Provision of highway drainage is secured in the Design Principles (Application Document 7.5).

Essential mitigation

9.4.2 It would be necessary to provide compensatory flood storage to offset the volume of existing floodplain storage displaced by the Project. The CFSAs would be in locations hydraulically connected to the displaced floodplain storage. Furthermore, the displaced floodplain volumes would be replaced on a level-for-level basis. The compensatory flood storage would be developed in conjunction with the restoration of a wetland in Orsett Fen (Mardyke Wetland). [RDWE037]

9.4.3 The embankment supporting part of the Project road would intercept an overland flow path across the Mardyke floodplain. To ensure that connectivity is

retained across the floodplain, a flood relief channel would be formed immediately to the west of the Mardyke at the point it crosses under the proposed viaduct. The channel would be approximately 10m wide and run for approximately 180m. The depth would vary and would be approximately 0.6m at its deepest. [RDWE040]

9.4.4 The restoration of the Mardyke Wetland and creation of the water vole habitat may result in the formation of a new flow path between Golden Bridge Sewer and the Mardyke during some storm events. To prevent the formation of a new flow path and maintain the local flow pattern between Golden Bridge Sewer and the Mardyke, a bund would be formed on the eastern side of the wetland. The bund would be approximately 185m long and would have a maximum elevation of approximately 3.64mAOD. [RDWE039]

9.5 Flood protection measures

9.5.1 There is no requirement to provide flood protection measures in Catchment EFR-4.

9.6 Flood reliance measures

Embedded resilience

9.6.1 The design requirement for fluvial flooding is for the highway to remain operational for the 0.5% AEP event for 2130 with a +17% central peak river flow allowance applied. As the Project road would be more than 5m higher than the flood level for the maximum credible scenario (0.1% AEP event for 2130 with the upper end peak river flow allowance of +48% applied), the design requirement for fluvial flooding can be considered to be fulfilled.

Essential resilience

9.6.2 The design of the compensatory flood storage and the flood protection measures would include allowances for predicted climate change. [RDWE037]

9.6.3 The highway drainage design would also include allowances for predicted climate change (Design Principles, Application Document 7.5).

Good practice resilience

9.6.4 Highway drainage assets would be inspected and maintained in accordance with the relevant provisions of DMRB GS 801 (Highways England, 2020b) and DMRB GM 701 (Highways England, 2020c), to ensure they continue to operate to their design standard. [RDWE012]

9.6.5 Measures would be incorporated in the drainage design to reduce the impacts that arise when flows occur that exceed the capacity of the drainage system (designing for exceedance).

Reducing flood risk elsewhere

9.6.6 The Project would include restoration of a wetland in Orsett Fen (Mardyke Wetland). In addition to providing part of the flood compensation requirement for Catchment EFR-4, this wetland may also mitigate flood risk further down the Mardyke.

Residual flood risk

9.6.7 Residual flood risks for Catchment EFR-4 along with associated mitigation measures are presented in Table 9.2.

Table 9.2 Catchment EFR-4 – Residual risks

Ref	Residual risk	Mitigation measures
1	Overwhelming of the highway drainage network due to a severe storm event or a blockage may lead to onsite and/or offsite flooding.	Drainage asset inspections would be undertaken in accordance with relevant provisions of DMRB GS 801 (Highways England, 2020b). [RDWE012] A planned, risk-based maintenance programme in accordance with the relevant provisions of DMRB GM 701 (Highways England, 2020c) would be established. [RDWE012] Planned maintenance interventions would ensure efficient operation of the drainage network.
2	Overtopping of the retention ponds may occur in the event of a severe storm; this may lead to development of secondary flow paths with surface water flooding in lower-lying areas.	Drainage asset inspections would be undertaken and maintenance programmes would be established, all as described above. [RDWE012] Planned maintenance interventions would ensure efficient operation of the retention ponds. Overland flow paths would be established to manage any overtopped flows. [RDWE035] The retention ponds have been located away from sensitive receptors to avoid potential risks resulting from residual impacts.
3	Overtopping of the flood compensation area may occur in the event of a severe storm; this may lead to development of secondary flow paths with surface water flooding in lower-lying areas.	Floodplain compensation areas have been located away from sensitive receptors to avoid potential risks resulting from residual impacts.
4	Failure of the connectivity channel to convey flows	A planned, risk-based maintenance programme would be established. [RDWE012] Periodic maintenance would be required to ensure that the channel is kept operational and clear of obstructions.
5	Reservoir breach	Reservoir safety is regulated through the Reservoirs Act 1975, as amended by the Flood and Water Management Act 2010. The Reservoirs Act 1975 requires that large reservoirs be inspected at least every 10 years by specially licensed civil engineers. The reservoir owner must act on any '*measures in the interests of safety*' identified in an inspection report. It is assumed that the reservoirs that would be a flood risk to the Project are operated in line with reservoir safety legislation.

Ref	Residual risk	Mitigation measures
6	There is a risk of seepage if perched groundwater is encountered (e.g. in cuttings).	On account of their highly localised nature, identification of all occurrences of perched groundwater is difficult. If perched groundwater is encountered in cuttings, it would most likely occur as localised seepages only. This residual risk would be mitigated by provision of a drainage system incorporating an appropriate edge of pavement detail, such as combined surface and sub-surface drains in line with DMRB CD 524 (Highways England, 2021a).
7	Cuttings have the potential to alter groundwater flow direction and change the groundwater flow regime. This may lead to flooding elsewhere.	Appendix 14.5: Hydrogeological Risk Assessment indicates that the proposed cuttings are above the groundwater level in Catchment EFR-4. Given the level of the cuttings in relation to groundwater level, the likelihood of groundwater flooding elsewhere is negligible. Details of groundwater flooding in the cutting at the junction between the Project road and the M25 is included in Section 11 (EFR-5).
8	Failure of sluice gate with the gate assumed to be stuck fully open and fully closed.	Simulation results from the hydraulic modelling indicated that, for a 1% AEP event with climate change allowances and the sluice gate fully closed, the difference in peak flood level would be negligible (± 10mm), and with the sluice gate stuck fully open, the difference in peak flood level would be minor adverse (>10mm and <50mm).
9	Breach of River Thames tidal flood defences at Mardyke sluice.	Breach of the River Thames tidal flood defences at Mardyke sluice have been simulated using the hydraulic model. The simulation results indicate that following a breach at Mardyke Sluice during the 0.1% AEP event with climate change allowances in 2130, flooding would remain in channel in Catchment EFR-4.

9.7 Surface water drainage

Existing

9.7.1 The Project road in Catchment EFR-4 is new carriageway and thus would not impact any existing drainage networks.

Proposed

9.7.2 The proposed drainage strategy would primarily be based on the use of gravity drainage networks that discharge to retention ponds. This drainage strategy is secured in the Design Principles (Application Document 7.5).

9.7.3 The use of sustainable drainage systems (SuDS) would be adopted wherever appropriate. This requirement is secured in the Design Principles (Application Document 7.5). The underlying ground formation in Catchment EFR-4 is not favourable for SuDS features incorporating infiltration techniques.

9.7.4 Collection of runoff from new highways would be by means of one of the edge of pavement details specified in DMRB 524 (Highways England, 2021a). Runoff would be conveyed to retention ponds by open drainage ditches where practicable and safe, and piped systems where not.

9.7.5 Four retention ponds would be constructed to support the highway drainage in Catchment EFR-4. Two of these basins would receive runoff from Catchment EFR-3. Small isolated catchments that cannot readily be connected to the retention ponds would be drained to swales. Theses swales act as infiltration features rather than conveyance features. The size of swales would need to take local geological condition which are not favourable for SuDS features using infiltration techniques. [RDWE034]

9.7.6 Retention ponds would be designed as vegetated drainage systems in accordance with the provisions of DMRB CD 532 (Highways England, 2021b). [RDWE035]

9.7.7 Retention ponds would incorporate a sediment forebay with sufficient capacity to accommodate the first flush. The forebay would be lined with an impermeable membrane to reduce the risk of compromising groundwater quality by confining potentially contaminated runoff. [RDWE035]

9.7.8 Where practicable, local topography would be used to integrate the retention ponds and detention basin with the surrounding landscape. This requirement is secured by Design Principles LPS.17 and S2.06 (Application Document 7.5).

9.7.9 In accordance with DMRB CD 532, pond capacities and discharge rates shall be agreed in consultation with the local land drainage authority[4]. Attenuation would be by means of a small diameter pipe, vortex controls, orifice plates or a combination thereof. Notwithstanding the above, the minimum discharge rate from new retention ponds shall be 1l/s. [RDWE035]

9.7.10 Networks with retention ponds would include a method to isolate a harmful spillage before it reaches a watercourse, regardless of whether designated containment provision is made. Isolation (flow control) would be included downstream of each pond/basin outlet, and would typically comprise a penstock. [RDWE035]

9.8 Catchment EFR-4 Conclusions

9.8.1 The principal flood risk in Catchment EFR-4 is fluvial flooding but there is also risk from surface water flooding.

9.8.2 Flood mitigation would comprise the following:

a. Drainage provisions for the Project road and other roads and areas that would be affected by implementation of Project

b. Provision of a flood relief channel to ensure that flow paths are not impeded

c. Construction of a conventional flood storage area

d. Alterations to the floodplain (bund to prevent formation of a new overland flow path)

[4] In EFR-4, the local land drainage authority is Essex County Council in their capacity as LLFA.

9.8.3 Flood protection would not be required.

9.8.4 Flood resilience would be achieved by making allowances for climate change in the design of mitigation measures and establishing a planned maintenance programme.

9.8.5 The form of construction of the part of the Project road in Catchment EFR-4 that lies in Flood Zone 3 will provide resilience against fluvial, tidal and surface water flood risk (embankments and viaducts).

9.8.6 Measures would be incorporated in the drainage design to manage exceedance flows in drainage networks.

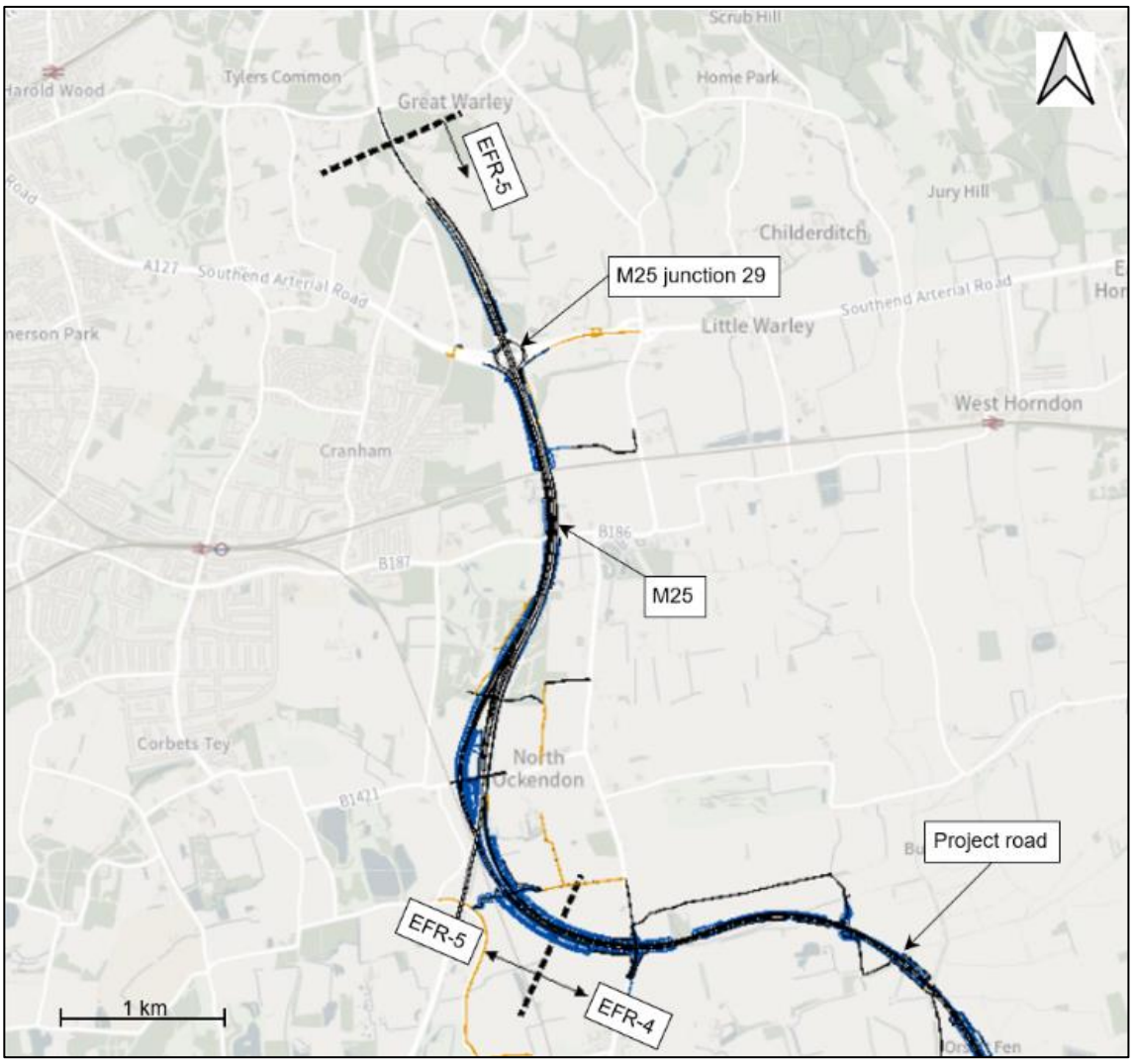
9.8.7 Residual risks have been identified and appropriate mitigation measures have been proposed.

10 North Section (EFR-5)

10.1 Overview

10.1.1 Catchment EFR-5 comprises the sections of the Project road between its junction with the M25 and M25 junction 29. The Project road is on embankments, in cuttings and on viaducts in Catchment EFR-5. The extents and principal elements of EFR-5 are presented in Plate 10.1.

Plate 10.1 Catchment EFR-5



10.1.2 According to the Environment Agency's (2020b) Flood Map for Planning, this catchment would lie primarily in Flood Zone 1 but extends to some Flood Zone 2 and 3 areas.

10.1.3 The catchment includes areas that lie in the administrative boundaries of Thurrock Council, London Borough of Havering and Brentwood Council. The London Borough of Havering is the LLFA for the part of Catchment EFR-5 that lies in its administrative boundary, and also performs the role of LLFA for Brentwood Council (this project only). Essex County Council is currently undertaking the role of LLFA on behalf of Thurrock Council.

10.1.4 As parts of the Project in Catchment EFR-5 lie in Flood Zone 3, an Exception Test needs to be undertaken. The Exception Test confirmed that construction of the Project in Flood Zone 3 would be acceptable subject to demonstration that the following test evaluation criteria have been met:

a. The development provides wider sustainability benefits to the community that outweigh flood risk (DLUHC, 2021).

b. The development will be safe for its lifetime, taking account of the vulnerability of its users, without increasing flood risk elsewhere, and where possible, will reduce flood risk overall (DLUHC, 2021).

c. Any essential infrastructure project 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 (NN NPS, 2014).

10.1.5 Demonstration of how the test criteria have been met is detailed in full in Part 6 of the FRA.

10.2 Flood risk

10.2.1 Sources of flood risk for Catchment EFR-5 are presented in Table 10.1.

Table 10.1 Sources of flood risk

Flood risk	Probability	Comment
Fluvial	P	The Project road crosses one main river in EFR-5, the West Mardyke. Fluvial flooding would occur when the flow through the main river exceeds its capacity. The Environment Agency's Map for long term flood risk from rivers or the sea (2022b) indicates that Catchment EFR-5 lies predominantly in areas that are at very low risk and low risk of fluvial flooding. The exception to this is where the Project crosses the West Mardyke floodplain, where there is low to high risk of fluvial flooding. The Project would be on embankments where it crosses the areas at medium and high risk of fluvial flooding. This form of construction would ensure that the Project road is at negligible risk of fluvial flooding.
Tidal	N/A	There would be no risk of tidal flooding on account of the elevation of the catchment.
Surface water	P	The Environment Agency's map for long term flood risk from surface water (2022b) indicates that this catchment lies in an area that is primarily at very low risk of surface water flooding. However, there are some areas at low, medium and high risk of surface water flooding; these generally fall within the West Mardyke floodplain. The Project would be on embankments where it crosses the areas at medium and high risk of surface water flooding. This form of

Flood risk	Probability	Comment
		construction would ensure that the Project road is at negligible risk of surface water flooding. Some isolated pockets of surface water flooding within the curtilage of the Project road would be lost and some would be partially lost. This may cause a minor redistribution of surface flooding beyond the curtilage of the Project road, but this is not considered to present a significant flood risk. Furthermore, any such redistribution would mostly lie within land for which National Highways would be seeking permanent acquisition.
Groundwater	N	For most of EFR-5, the GeoSmart (2020) flood risk mapping identifies the route to be in an area of negligible risk from groundwater flooding (predominantly of low risk). Through the central part of the catchment, and more or less coincident with the fluvial water flood risk associated with the West Mardyke, there are areas identified as low flood risk. However, the Phase 2 Ground Investigation has confirmed the presence of River Terrace Deposits at the proposed location of the cutting at the new junction with the M25. These deposits include granular materials. Groundwater monitoring has confirmed these deposits are water bearing with levels shallower than the proposed cutting. Appendix 14.5: Hydrogeological Risk Assessment presents a groundwater model of the potential effects on the groundwater levels and shows drawdown towards the cutting. Measures to reduce groundwater drawdown beyond the M25 cutting (e.g. through the implementation of seepage control) would be required. [REAC038] Further details and assessment are provided in Appendix 14.5: Hydrogeological Risk Assessment (Application Document 6.3).
Reservoirs	N/A	Catchment EFR-5 would lie in areas that are not at risk of reservoir flooding.
Sewers	N	Trunk sewers and rising mains with potential to cause significant flooding would be diverted to accommodate the Project.
Water mains	N	All water mains with potential to cause significant flooding would be diverted to accommodate the Project.

Legend
N/A - Not applicable
N - Negligible
P - Potential

10.3 Fluvial flood risk analysis

10.3.1 Although the Project road would remain operational for a fluvial flooding event, there would be some offsite impacts due to construction within the functional flood plain of the West Mardyke.

10.3.2 The hydraulic analysis and calculation of required compensatory flood storage is detailed in Calculation HE540039-CJV-EFR-GEN-CALC-ENV-0240, which is presented in Annex A of Part 6 of the FRA.

10.4 Flood mitigation

Essential mitigation

10.4.1 As EFR-5 includes development in the floodplain, it would be necessary to provide compensatory flood storage to offset the volume of existing flood storage that is lost to the Project. The CFSA would be a conventional one with level-for-level replacement of floodplain storage lost to the Project. [RDWE037]

Embedded mitigation

10.4.2 Surface water flood risk from highway runoff would be mitigated by inclusion of highway drainage provisions; these provisions would apply to all new and realigned roads in Catchment EFR-5. The surface water drainage provisions would be designed to prevent flooding in the highway without increasing risk elsewhere. Provision of highway drainage is secured in the Design Principles (Application Document 7.5).

10.5 Flood protection

10.5.1 Flood protection measures are not required in Catchment EFR-5.

10.6 Flood resilience

Embedded resilience

10.6.1 The minimum level of the Project road at the point where it crosses the West Mardyke would be several metres above the 1% AEP fluvial flood level with allowances for climate change. This will reduce fluvial and surface water to negligible levels.

Essential resilience

10.6.2 The design of the compensatory flood storage and the flood protection measures would include allowances for predicted climate change. [RDWE037]

10.6.3 The highway drainage design would also include allowances for predicted climate change (Design Principles, Application Document 7.5).

Good practice resilience

10.6.4 Highway drainage assets would be inspected and maintained in accordance with the relevant provisions of DMRB GS 801 (Highways England, 2020b) and DMRB GM 701 (Highways England, 2020c), to ensure they continue to operate to their design standard. [RDWE012]

10.6.5 Measures would be incorporated in the drainage design to reduce the impacts that arise when flows occur that exceed the capacity of the drainage system (designing for exceedance).

10.7 Residual flood risk

10.7.1 Residual flood risks for Catchment EFR-5 along with associated mitigation measures are presented in Table 10.2.

Table 10.2 Catchment EFR-5 – Residual risk and mitigation

Ref	Residual risk	Mitigation measures
1	Overwhelming of the highway drainage network due to a severe storm event or a blockage, may lead to onsite and offsite flooding.	Drainage asset inspections would be undertaken in accordance with relevant provisions of DMRB GS 801 (Highways England, 2020b). [RDWE012] A planned, risk-based maintenance programme in accordance with the relevant provisions of DMRB GM 701 (Highways England, 2020c) would be established. [RDWE012] Planned maintenance interventions would ensure efficient operation of the drainage network. Overland flow paths would be established to manage exceedance flows.
2	Overtopping of the retention ponds may occur in the event of a severe storm; this may lead to development of secondary flow paths with surface water flooding in lower-lying areas.	Drainage asset inspections would be undertaken and maintenance programmes would be established, all as described above. [RDWE012] Planned maintenance interventions would ensure efficient operation of the retention ponds. Overland flow paths would be established to manage any overtopped flows. [RDWE35] The retention ponds have been located away from sensitive receptors to avoid potential risks resulting from residual impacts.
3	Overtopping of the flood compensation area may occur in the event of a severe storm; this may lead to development of secondary flow paths with surface water flooding in lower-lying areas.	Floodplain compensation areas have been located away from sensitive receptors to avoid potential risks resulting from residual impacts.
4	There is a risk of seepage if perched groundwater is encountered (e.g. in cuttings).	On account of their highly localised nature, identification of all occurrences of perched groundwater is difficult. If perched groundwater is encountered in cuttings, it would most likely occur as localised seepages only. This residual risk would be mitigated by provision of a drainage system incorporating an appropriate edge of pavement detail, such as combined surface and sub-surface drains in line with DMRB CD 524 (Highways England, 2021a).

10.8 Surface water drainage

Existing

10.8.1 Several existing drainage catchments along the M25 would be affected by the Project. These catchments discharge to the West Mardyke and ordinary watercourses.

Proposed

10.8.2 The proposed drainage strategy would be based on the use of gravity drainage networks that discharge to proposed or existing retention ponds. The exception to this would be at M25 junction 29, where multiple catchments will discharge directly to a watercourse without attenuation. This drainage strategy is secured in the Design Principles (Application Document 7.5).

10.8.3 The use of sustainable drainage systems (SuDS) would be adopted wherever appropriate. This requirement is secured in the Design Principles (Application Document 7.5). The underlying ground formation in Catchment EFR-5 is not favourable for SuDS features incorporating infiltration techniques.

10.8.4 Collection of runoff from new highways would be by means of one of the edge of pavement details specified in DMRB 524 (Highways England, 2021a). Runoff would be conveyed to retention ponds by open drainage ditches where practicable and safe, and piped systems where not.

10.8.5 Four existing (reconfigured) retention ponds and two new retention ponds would be constructed to support the highway drainage in Catchment EFR-5.

10.8.6 Retention ponds would be designed/reconfigured as vegetated drainage systems in accordance with the provisions of DMRB CD 532 (Highways England, 2021b). [RDWE035]

10.8.7 Retention ponds would be designed to have either 50% capacity available 24 hours after a 3.33% AEP storm event or have the capacity to store a subsequent 10% AEP storm event after a 3.33% AEP storm event. [RDWE035]

10.8.8 Retention ponds would incorporate a sediment forebay with sufficient capacity to accommodate the first flush. The forebay would be lined with an impermeable membrane to reduce the risk of compromising groundwater quality by confining potentially contaminated runoff. [RDWE035]

10.8.9 Where practicable, local topography would be used to integrate the retention ponds and detention basin with the surrounding landscape. This requirement is secured by Design Principles LPS.17 and S2.06 (Application Document 7.5).

10.8.10 Discharge rates from existing retention ponds would be reduced by at least 50%. [RDWE035]

10.8.11 In accordance with DMRB CD 532, pond capacities and discharge rates shall be agreed in consultation with the local land drainage authority[5]. Attenuation would be by means of a small diameter pipe, vortex controls, orifice plates or a combination thereof. Notwithstanding the above, the minimum discharge rate from new retention ponds shall be 1l/s. [RDWE035].

10.8.12 Networks with retention ponds would include a method to isolate a harmful spillage before it reaches a watercourse, regardless of whether designated containment provision is made.

[5] In EFR-5, the local land drainage authority is the London Borough of Havering in their capacity as LLFA.

10.9 Catchment EFR-5 Conclusions

10.9.1 The principal flood risks in Catchment EFR-5 are fluvial and surface water.

10.9.2 Flood mitigation would comprise the following:

a. Drainage provisions for the Project road and other roads and areas that would be affected by implementation of the Project.

b. Conventional compensatory flood storage would be included to offset any loss of floodplain storage as a result of the Project.

10.9.3 Flood protection would not be required.

10.9.4 Flood resilience would be achieved by making allowances for climate change in the design of mitigation measures and establishing a planned maintenance programme.

10.9.5 The form of construction of the part of the Project road in Catchment EFR-5 that lies in Flood Zone 3 will provide resilience against fluvial, tidal and surface water flood risk (embankments and viaducts).

10.9.6 Measures would be incorporated in the drainage design to manage exceedance flows in drainage networks

10.9.7 Residual risks have been identified and appropriate mitigation measures have been proposed.

11 Other elements of the Project

11.1 Introduction

11.1.1 This section includes details of flood risk associated with parts of the Project that do not readily fit into the five flood catchments.

11.2 TE2100 Plan

11.2.1 The Project has been reviewed with regard to its potential impact on the TE2100 Plan. The review concluded that the ability to implement the TE2100 Plan would not be affected by the Project. The finding of this review is detailed in Table 11.1

Table 11.1 Impact of the Project on the TE2100 Plan

Policy unit	Policy
North Kent Marshes	The Project road will be in tunnel where it crosses under the existing tidal defences and will not impact any work proposed under the TE2100 Plan.
Purfleet, Grays and Tilbury	There are no existing formal flood defences immediately upstream and downstream of the point where the Project road crosses the Thames Estuary. Existing ground levels adjacent to the estuary are high enough to make it safe from tidal flooding. Any formal defences constructed along this part of the estuary would need to take account of the tunnel if they incorporate deep cut-off walls.

Notes:
The 'Purfleet, Grays and Tilbury' unit includes West Tilbury Marshes.
Coalhouse Point Wetland would lie in an area that is not included in the TE2100 Plan (see Section 10.3 for further details).

11.3 Coalhouse Point Wetland

11.3.1 The area identified for creation of this wetland is not included in the TE2100 Plan and therefore does not have a TE2100 recommended policy. The area to the south of the proposed wetland includes tidal defences adjacent to the River Thames. These are in poor condition and provide only a low standard of protection.

11.3.2 Brackish water for the wetland would be sourced from the River Thames by a water inlet with self-regulating valve, or equivalent structure. The gate/structure would be formed within, or partly within, the existing tidal defences and would be designed to allow ingress and egress of eels. [HR010] [HR011]

11.3.3 The existing watercourse that would continue to run through the wetland is connected to a watercourse that eventually discharges to West Tilbury Main. A level control structure (weir) would be established at the end of the wetland watercourse to retain the brackish water in the wetland.

11.3.4 The existing tidal defences are overtopped relatively frequently as the defence crest level is between the Mean High Water Springs level and 1-year return period River Thames flood level in 2030. The frequency of overtopping is projected to increase during the Project design lifespan (2130) due to sea level rise.

11.3.5 The impacts of a breach of the existing tidal defences adjacent to the River Thames on the proposed wetland area would be qualitatively similar to overtopping. If a breach occurred when River Thames water levels were similar to the defence crest level, inundation would be more rapid than during overtopping and velocities would be higher locally. If a breach occurred during significantly higher River Thames water levels, the landward side of the defence would already be inundated and therefore the impacts of a breach would be insignificant.

11.3.6 The proposed wetland design would include earthworks and control of water levels within the wetland area. The proposed earthworks would result in a lowering of existing levels only. Normal water levels in the wetland area would be managed to be no higher than existing ground levels with no reduction in available floodplain storage during a flood event. The proposed wetland design would therefore not increase flood risk impacts following overtopping or a breach of the existing River Thames flood defence.

11.4 Energy infrastructure

Nationally Important infrastructure Projects

11.4.1 The Government's policy for delivery of major energy infrastructure is set out in a suite of National Policy Statements. Flood risk associated with major energy infrastructure is set out in NPS ES-1, Overarching National Policy Statement for Energy.

11.4.2 There are four energy infrastructure NSIPs in the Project, all of which are located in areas that are at negligible risk of fluvial flooding (AEP ≤ 0.1%).

11.4.3 Climate change in accordance with the Environment Agency guidance on climate change allowances for flood risk assessments (2022c) has been applied to the Project. NPS EN-1 (2011) notes that this guidance is acceptable for assessing the impact of climate change energy infrastructure.

Construction of energy infrastructure

11.4.4 To construct the energy infrastructure, it would be necessary to work in floodplains.

11.4.5 The Contractor would establish emergency response measures for construction activities in floodplains. [RDWE022]

11.4.6 Installation of pipework and cables by open trench techniques creates corridors of surface clearance and excavation that can potentially affect watercourses, aquifers and areas prone to flooding. Trenching could cause inadequate or excessive drainage, interference with groundwater flow pathways and flooding. Impacts during construction would be mitigated and the ground would be reinstated after construction. An assessment of construction-related flood risks and any associated mitigation measures would be undertaken by the

Contractor. The assessment would also include a review of remedial risks and proposed mitigation measures. [RDWE001] [RDWE022]

11.4.7 For watercourse crossings, pipework and cabling would be installed by trenchless techniques.

12 Construction phase

12.1 Introduction

12.1.1 Construction would be supported by temporary works, comprising site facilities, temporary structures for construction and a network of haul roads, site roads and utilities.

12.2 Construction phase FRA

12.2.1 The Contractor would be responsible for preparing a site-specific flood risk assessment to demonstrate that the site set up and temporary works comply with the requirements of the NPPF (DLUHC, 2021a). [RDWE001] [RDWE022].

12.3 Working locations

12.3.1 The location of temporary works and construction-related activities is primarily determined by the alignment of the Project road.

12.3.2 Temporary works and construction activities would be undertaken in Flood Zone 1 where possible but due to the alignment of the Project road, working in Flood Zone 3 would necessary.

12.3.3 As working in Flood Zone 3 would be necessary, the Contractor would demonstrate that the site would be safe for the workforce during times of flooding. [RDWE022]

12.3.4 Site facilities in Flood Zones 2 and 3 would be limited to the following:

a. Water-compatible facilities

b. Flood-resilient facilities

c. Flood repairable facilities

12.4 Climate change

12.4.1 Climate change allowances would be based on a construction completion date of 2030.

12.5 Surface water drainage

12.5.1 Surface water drainage would be provided for surfaced roads and yards, buildings and any other hard or impermeable surfaces. Depending upon the final site layout, berms and bunds may be constructed to manage surface water runoff. Typically, this would be done to protect watercourses, prevent ponding and to keep general runoff separate from contaminated runoff. [RDWE006]

12.5.2 Cut-off drains would be provided in working areas to ensure that construction phase runoff does not result in offsite flooding.

12.5.3 The construction phase flood risk assessment would be used to develop safe systems of working in flood risk areas. [RDWE022]

12.5.4 The Contractor would establish a planned maintenance programme to keep the site drainage system in good working order. [RDWE002]

12.6 Compensatory flood storage areas

12.6.1 The provision of CFSAs would depend upon the nature of the temporary works deployed by the Contractor's programme.

12.6.2 Use of the CFSAs to be provided for the operational phase of the Project would be allowed provided that the volume of displaced floodplain storage does not exceed the compensation provided.

12.6.3 Additional compensatory storage would be added to suit the Contractor's programme or method of working if necessary. The areas available for provision of CFSAs are shown on Drawings 00180, 00181 and 00182.

13 Summary

13.1.1 A summary of construction and operational phase[6] flood risk for all EFR catchments is provided in Table 13.1.

[6] The operational phase represents the period when all construction works are completed and the Project is open to traffic.

Table 13.1 Summary of construction and operational phase flood risk

All EFRs Project stage	Flood risk receptor and value	Mitigation	Residual impact magnitude	Significance of residual effect
Construction	Surface water (rainfall runoff and land drainage) - medium importance south of River Thames High importance north of River Thames	Appropriate work site drainage systems and maintenance. [RDWE001] [RDWE006] [RDWE002]	No change	Neutral
Operation		Highway drainage provisions for all new and realigned roads incorporating climate change resilience subject to appropriate maintenance regime. [RDWE034] [RDWE035] [RDWE048] [RDWE012]	Negligible to minor beneficial in EFR-1	Neutral to slight beneficial

EFR-1 Project stage	Flood risk receptor and value	Mitigation	Residual impact magnitude	Significance of residual effect
Construction	Defended floodplain of River Thames (very high importance)	Appropriate layout of a small satellite construction compound sited in the floodplain and monitoring of the defences during construction. [RDWE022] [RDWE007]	No change	Neutral

EFR-2 Project stage	Flood risk receptor and value	Mitigation	Residual impact magnitude	Significance of residual effect
Construction	Defended floodplain of River Thames (very high importance)	Appropriate layout of construction compounds sited in the floodplain and monitoring of the defences during construction. [RDWE022] [RDWE007]	No change	Neutral
Construction	West Tilbury Main – medium importance	Provision of compensatory flood storage to offset loss of storage in the floodplain. [RDWE037]	Negligible	Neutral to slight adverse
Operation	Project road – very high	Protection of the North Portal using raised flood defences and construction of the road on viaduct. [RDWE029]	No change	Neutral
Operation	West Tilbury Main – medium	Improve flow through West Tilbury Main to offset loss of an existing flow path. [RDWE046]	No change	Neutral

EFR-4 Project stage	Flood risk receptor and value	Mitigation	Residual impact magnitude	Significance of residual effect
Operation	Mardyke – high	Provision of flood relief channel, minor localised land raising and compensatory flood storage to offset loss of storage in the floodplain. [RDWE040] [RDWE039] [RDWE037] Wetland restoration in Orsett Fen.	Minor beneficial	Slight beneficial
Operation	Orsett Fen Sewer and Golden Bridge Sewer – medium		Negligible	Neutral

EFR-5 Project stage	Flood risk receptor and value	Mitigation	Residual impact magnitude	Significance of residual effect
Operation	West Mardyke – high	Provision of compensatory flood storage to offset loss of storage in the floodplain, and reduction in highway drainage discharge rates. [RDWE037] [RDWE035]	Moderate beneficial	Moderate beneficial

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