Lower Thames Crossing

6.3 Environmental Statement Appendices
Appendix 14.6 - Flood Risk Assessment - Part 10 (Clean version)

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

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Lower Thames Crossing

6.3 Environmental Statement Appendices Appendix 14.6 - Flood Risk Assessment - Part 10 (Clean version)

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1 Introduction

1.1 Context

1.1.1 This document forms Part 10 of the Flood Risk Assessment (the FRA) for the A122 Lower Thames Crossing (the Project).

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

a. Environmental Statement - Appendix 14.6 - Flood Risk Assessment - Part 1 [**APP-460**]

b. Environmental Statement - Appendix 14.6 - Flood Risk Assessment - Part 2 [**APP-461**]

c. Environmental Statement - Appendix 14.6 - Flood Risk Assessment - Part 3 [**APP-462**]

d. Environmental Statement - Appendix 14.6 - Flood Risk Assessment - Part 4 [**APP-463**]

e. Environmental Statement - Appendix 14.6 - Flood Risk Assessment - Part 5 [**APP-464**]

f. Environmental Statement - Appendix 14.6 - Flood Risk Assessment - Part 6 [**REP1-171**]

g. Environmental Statement - Appendix 14.6 - Flood Risk Assessment - Part 7 [**APP-466**]

h. Environmental Statement - Appendix 14.6 - Flood Risk Assessment - Part 8 [**APP-467**]

i. Environmental Statement - Appendix 14.6 - Flood Risk Assessment - Part 9 [**APP-468 - APP-476**]

j. Environmental Statement - Appendix 14.6 - Flood Risk Assessment – Part 10 [**APP-477**]

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 The sections that form this Part are detailed in Plate 1.2, along with a brief description of their contents.

1.2.3 For the purposes of the FRA, the Project has been divided into five discrete flood risk catchments; these catchments are listed in Table 1.1 and are shown on 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 and M25 Junction

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

1.3 Purpose

1.3.1 This document summarises how watercourse crossings and diversions would be addressed in each FRA catchment.

1.3.2 The objectives of this document are as follows:

a. Identify the location and structural form of all watercourse crossings

b. Identify appropriate watercourse diversions

c. Identify the location and function of hydraulic structures

d. Set the principles for the design, operation and maintenance of culverts

e. Support liaison with watercourse stakeholders

1.3.3 The diversions, crossings and hydraulic structures detailed in this document are based on the design as presented in the Development Consent Order (DCO) application.

1.3.4 Watercourse crossings and diversions would not normally form part of the FRA. However, as there is an affiliation between watercourses and flood risk, details of crossings and diversions have been included in the FRA.

1.4 Wetland habitat creation

1.4.1 In Catchments EFR-1 to EFR-5, the watercourse diversions, crossings and hydraulic structures generally relate to interventions attributable to the Project road and its embankments. In addition to these interventions, watercourses in the following two wetland habitat areas would be altered by the Project:

a. Mardyke Wetland

b. Coalhouse Point Wetland

1.4.2 Only the watercourse diversions, crossings and hydraulic structures in these two areas are considered in this document. Further details on the ecological aspects and design requirements of the mitigation are discussed in ES Chapter 8: Terrestrial Biodiversity (Application Document 6.1) [**APP-146**]

and the Outline Landscape and Ecology Management Plan (Application Document 6.7) [**REP4-140**].

1.5 Identification of crossings, diversions, and structures

1.5.1 Each crossing, diversion and hydraulic structure has been assigned a sequential seven-digit identification code. The form and structure of the identification code is detailed in Appendix A.

1.6 Register of Environmental Actions and Commitments

1.6.1 Good practice and essential mitigation are included in the Register of Environmental Actions and Commitments (REAC). The REAC forms part of Appendix 2.2: Code of Construction Practice (CoCP) (Application Document 6.3) [**REP6-038**]. Each action and commitment in the REAC has a unique alpha-numerical reference code.

1.6.2 Where appropriate, the REAC reference codes for secured commitments and actions have been cross-referenced in this document.

1.7 Design Principles

1.7.1 Embedded measures that have been developed through an iterative design process form the Design Principles (Application Document 7.5) [**REP6-046**]. The Design Principles are secured by Requirement 3 of Schedule 2 of the DCO.

1.7.2 Elements of the Project that would be secured through the Design Principles are identified in this document.

Plate 1.1 Form of the FRA

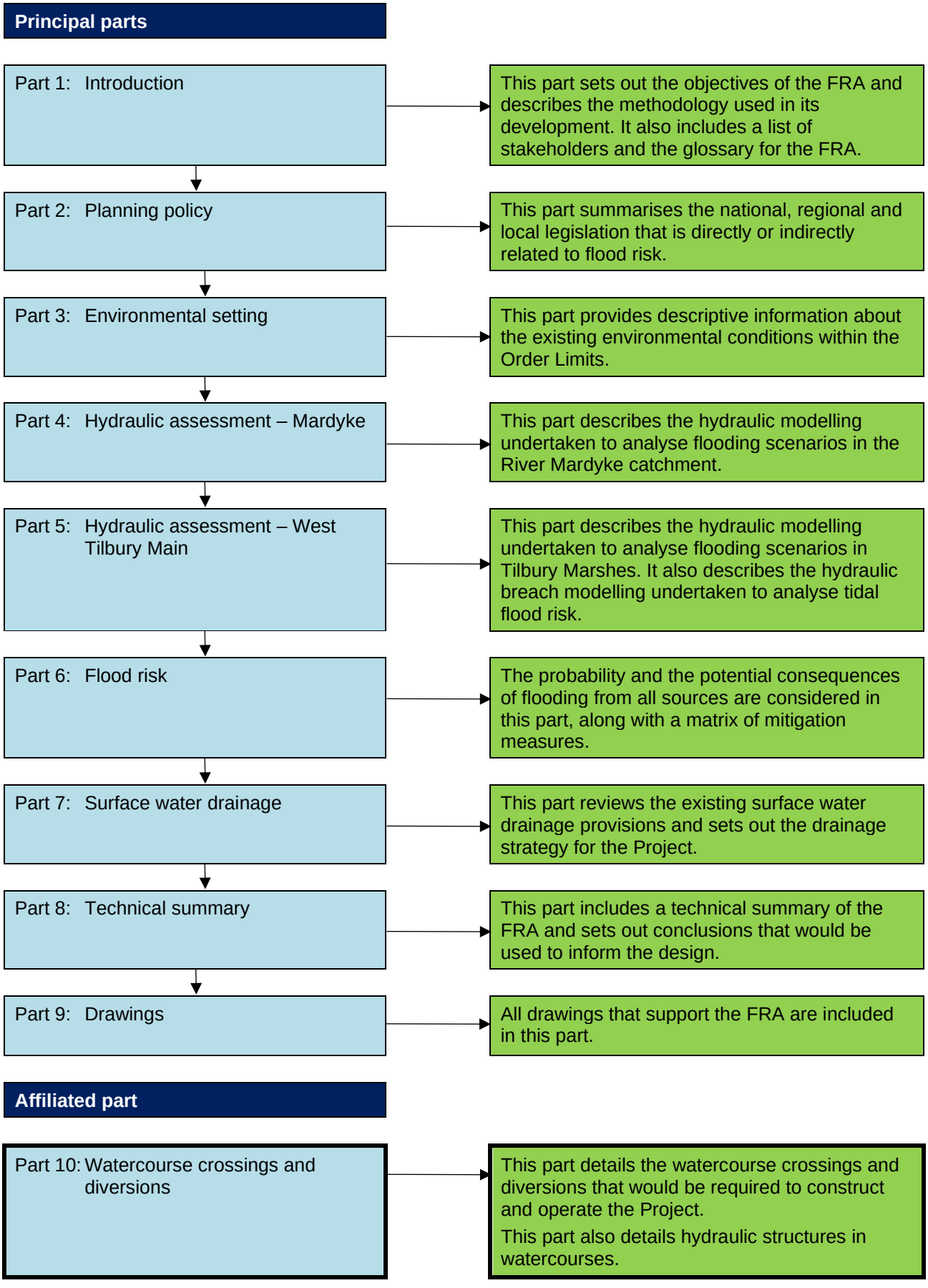
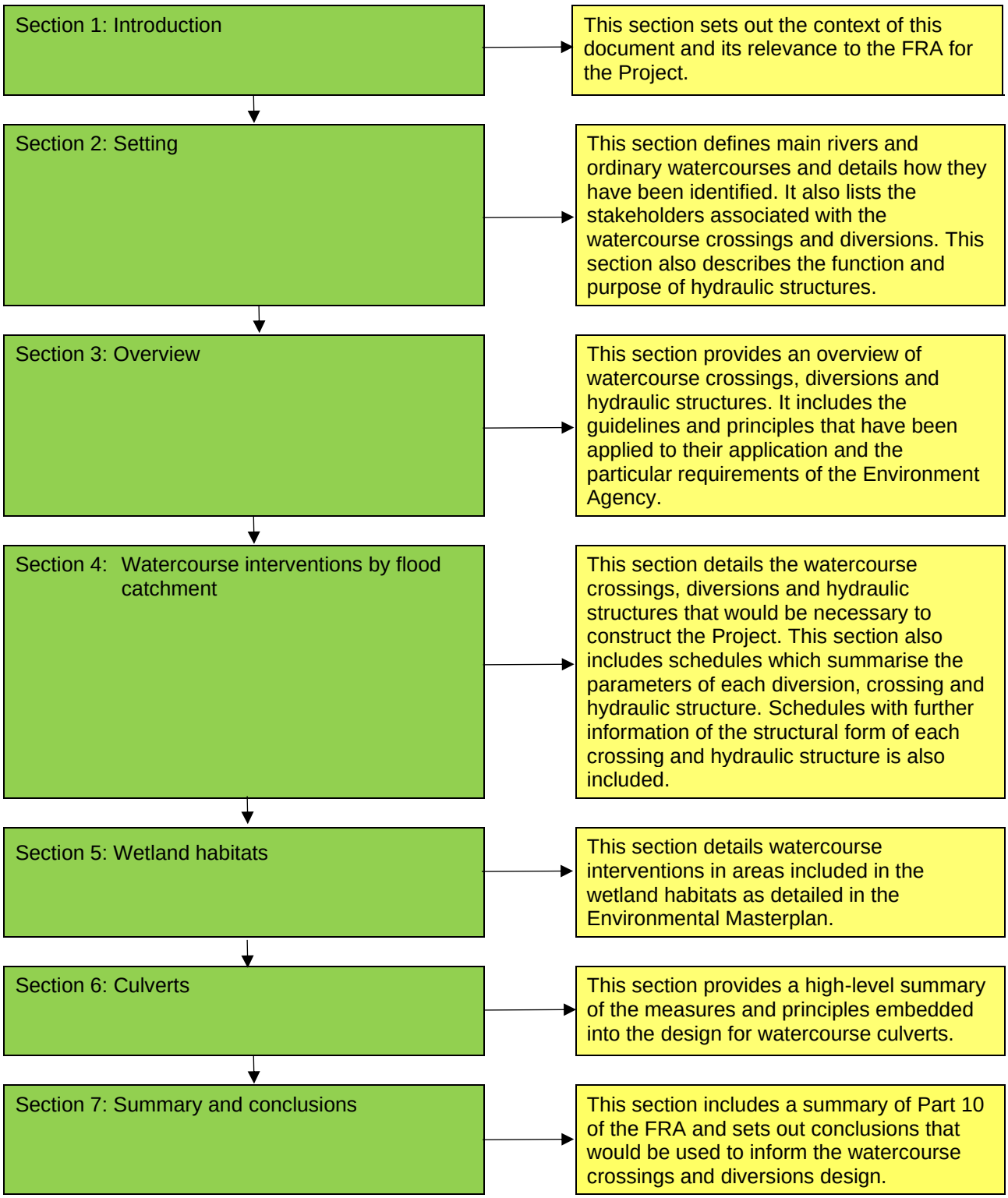


Plate 1.2 Form of Part 10 of the FRA



2 Setting

2.1 Definitions

2.1.1 The two types of watercourses recognised in statutory language are main rivers and ordinary watercourses.

2.1.2 Main rivers are usually larger rivers and streams, but also include some smaller watercourses. The Environment Agency carries out maintenance, improvement, or construction work on main rivers to manage flood risk at their discretion. The Environment Agency is also responsible for determining whether a watercourse, or part of a watercourse, is to be treated as a main river or part of a main river. The Department for Environment, Food and Rural Affairs (2017) has set out the principal criteria for determining whether a watercourse or part of a watercourse is suitable to become or to remain a main river or a part of a main river. The criteria are primarily directed at the management of flood risk and are as summarised in Table 2.1.

Table 2.1 Determination of main rivers

Criteria	Description
Flood consequence	A watercourse should be a main river if significant numbers of people and/or properties are liable to flood. This also includes areas where there are vulnerable groups and areas where flooding can occur with limited time for warnings.
Managing flooding across the catchment	A watercourse should be a main river where it could contribute to extensive flooding across a catchment. A watercourse should be a main river if it is required to reduce flood risk elsewhere or provide capacity for water flowing from, for example a reservoir, sewage treatment works or another river.

2.1.3 Ordinary watercourses include every river, stream, ditch, drain, cut, dyke, sluice, sewer (other than a public sewer) and passage through which water flows and which does not form part of a main river. Lead Local Flood Authorities (LLFA) and Internal Drainage Boards carry out flood risk management work on ordinary watercourses at their discretion.

2.2 Identification of watercourses

2.2.1 The Environment Agency's dataset has been used to determine the location of most watercourses likely to be affected by the works. Main rivers have been identified by reference to the Environment Agency's (2022) Main River Map.

2.2.2 The dataset does not include all ordinary watercourses defined in paragraph 0, for example, drainage ditches for agricultural land are not generally included.

2.2.3 A water feature survey was carried out by the Project to identify ordinary watercourses not included within the Environment Agency's dataset. These are detailed in Appendix 14.2 (Application Document 6.3) [**APP-454** and **APP-455**].

2.2.4 A channel survey was undertaken on the following watercourses:

a. West Tilbury Main

b. Mardyke

c. Orsett Fen Sewer

d. Golden Bridge Sewer

2.3 Stakeholders

2.3.1 The stakeholders for watercourses are:

a. National Highways

b. Environment Agency

c. North Kent Marshes Internal Drainage Board

d. Kent County Council

e. Thurrock Council

f. Essex County Council[1]

g. London Borough of Havering

h. Brentwood Brough Council[2]

i. Network Rail

j. Thames and Medway Canal Association

k. Riparian landowners

2.3.2 A summary of the stakeholder meetings held, covering aspects of the highway drainage and the water environment, is shown in Table 14.1 of ES Chapter 14: Road Drainage and the Water Environment (Application Document 6.1) [**APP-152**].

2.4 Responsibilities of riparian landowners

2.4.1 Landowners have the responsibility to maintain all watercourses that run across their land.

2.4.2 For National Highways, this would include all watercourses within the highway boundary.

2.4.3 The maintenance responsibilities extend to any watercourse structure associated with the watercourse (e.g., culverts).

[1] Essex County Council is acting as LLFA on behalf of Thurrock Council.
[2] The London Borough of Havering is acting as LLFA on behalf of Brentwood Borough Council.

3 Overview

3.1 Crossings

3.1.1 The Project would involve the crossing of main rivers, ordinary watercourses and the Thames and Medway Canal. The following assumptions have been used to determine how watercourse crossings would be undertaken:

a. Watercourses that cross the tunnelled section of the Project would not be affected.

b. Bridges would be constructed over main rivers where practicable in accordance with the preference of the Environment Agency (2009).

c. Culverts would be used to convey ordinary watercourses under highways and where an open channel would necessitate an unacceptably deep cutting. Culverts would also be used to convey main rivers under highways in locations where bridges are not practicable. Further details on culverts are presented in Section 5.

d. Watercourses would be diverted where necessary to facilitate the crossings.

3.1.2 Hydraulic models have been developed to assess the impact that the Project would have on flood risk[3]. The modelling demonstrates that the proposed suite of flood alleviation measures would ensure that the Project, including main river crossings, would not lead to an increased flood risk.

3.1.3 Open span (viaduct) crossings have been incorporated into the design where feasible. These crossings have been designed using information from the hydraulic modelling and have been orientated to minimise disruption of key floodplain flow paths, maintain floodplain flow connectivity, and minimise afflux. The viaducts would avoid the need for watercourse diversions (i.e., existing channel profiles would be retained).

3.1.4 Field bridges would be constructed for tracks that need to cross watercourses. These tracks would include the following:

a. Access tracks for maintenance vehicles during the operation phase of the Project

b. Access tracks for agricultural vehicles

c. Footways, cycleways and bridleways for walkers, cyclists and horse riders

3.1.5 Field bridges would comply with the provisions of Standard Rules SR2015 No 28 - Installing a clear span bridge on a main river of up to 8 metres span and 4.2 metres width (Environment Agency, 2019).

[3] Refer to Part 4 of the FRA for details of the hydraulic assessment of the Mardyke and Part 5 for details of the hydraulic assessment of West Tilbury Main.

3.2 Diversions

3.2.1 The Project would involve the diversion of main rivers and ordinary watercourses. The reasons for diversions are as follows:

a. Where watercourses follow the Project road or realigned side roads

b. Where watercourses cut across the Project road or realigned side roads at oblique angles

c. Where the vertical alignment of the Project road is below existing watercourses (e.g. at the North Portal).

3.2.2 Diversion of watercourses is regarded as a last resort and would be avoided where practicable. This is an embedded measure that is secured by Design Principle LSP.12 (Application Document 7.5) [**REP6-046**].

3.2.3 Where practicable, diverted sections of watercourse would be naturalised. This is an embedded measure that is secured by Design Principle S9.10 (Application Document 7.5) [**REP6-046**].

3.3 Hydraulic structures

3.3.1 A hydraulic structure is a device designed to retain, regulate, or control the flow of water. They are considered to be passive structures as they operate without intervention under different amounts of water flow.

3.3.2 Hydraulic structures can be used in watercourses to manage flow of water between catchments or sub-catchments, where unregulated flows may cause or exacerbate downstream flooding.

3.4 Requirements of the Environment Agency

3.4.1 To allow standard Environment Agency maintenance plant[4] to pass beneath an overhead structure that crosses a main river (e.g., bridge or viaduct), the following criteria would need to be met:

a. The minimum vertical clearance from top of bank to the underside of the structure would be 4m (this requirement is secured by Design Principle S12.05 (Application Document 7.5) [**REP6-046**].

b. The minimum horizontal distance from the top of embankment to a bridge abutment or viaduct pier would be 8m (this requirement only applies to one side of the main river).

3.4.2 The Environment Agency may undertake maintenance of main rivers beneath structures if the minimum vertical clearance from top of bank to the underside of the structure is 10m.

[4] The Environment Agency typically uses a 24-tonne long reach excavator to undertake main river maintenance.

3.4.3 Enabling passage of Environment Agency maintenance vehicles is an embedded measure that is secured by Design Principle S12.05 (Application Document 7.5) [**REP6-046**].

3.5 Overview

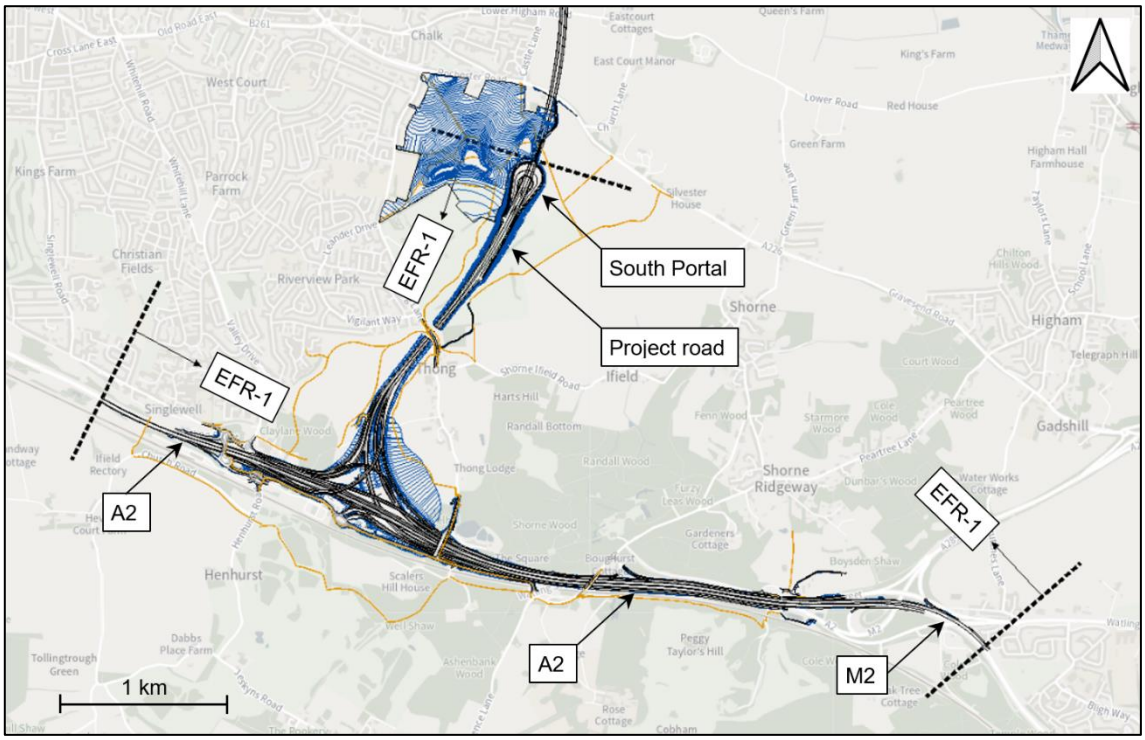
3.5.1 An overview of watercourse crossings and diversions is shown on Drawings 10200 to 10202. The location of the hydraulic structures is shown on Drawing 00180.

4 Watercourse interventions by flood catchment

4.1 South of River Thames (Catchment EFR-1)

4.1.1 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. The extents and principal elements of EFR-1 are presented in Plate 4.1.

Plate 4.1 Catchment EFR-1



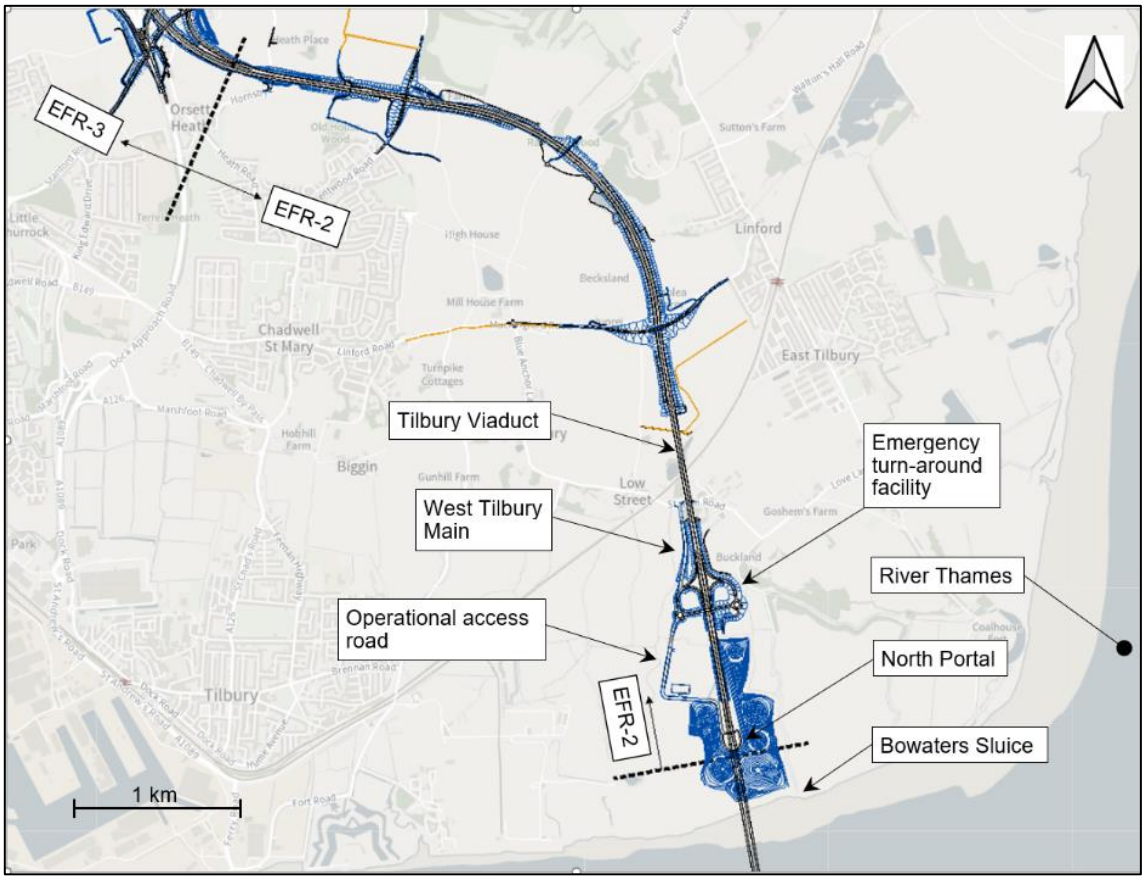
4.1.2 There are no main rivers or ordinary watercourses in Catchment EFR-1.

4.1.3 In the area immediately to the north of Catchment EFR-1, the Project road crosses the Thames and Medway Canal, a main river and several ordinary watercourses. The Project road would be in tunnel for all these crossings, which are therefore not considered further.

4.2 North Portal to Chadwell St Mary (Catchment EFR-2)

4.2.1 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 North Portal Tunnel Services Building, the road and the emergency turn-around facility. The extents and principal elements of EFR-2 are presented in Plate 4.2.

Plate 4.2 Catchment EFR-2



4.2.2 Crossings and diversions of watercourses in Catchment EFR-2 are detailed in Table 4.1 to Table 4.3.

Table 4.1 Watercourses – West Tilbury Main

Catchment EFR-2 – West Tilbury Main	
Watercourse name and reference	A. West Tilbury Main (main river) HE540039-CJV-EWE-ZZZ-MR-1N07ZZZ1
Drawing number	00211 00180
Crossing reference	X-EFR-2-01 (West Tilbury Main) X-EFR-2-02 (West Tilbury Main)
Diversion reference	D-EFR-2-01 (West Tilbury Main) D-EFR-2-02 (West Tilbury Main) D-EFR-2-03 (West Tilbury Main)
Structure reference	S-EFR-2-01 (West Tilbury Main)

Catchment EFR-2 – West Tilbury Main	
Crossings and diversions	The Project road would cross West Tilbury Main as it emerges from the tunnel. As a main river, the Environment Agency's preferred method of crossing West Tilbury Main would be an open span bridge. However, on account of local topography and the presence of contaminated ground, an open span bridge is not regarded as a viable option. A workshop was arranged with the Environment Agency to consider this crossing (December 2019) and concluded that a culvert represented the least worst option. This option would comprise a 46m long box culvert (X-EFR-2-01). The culvert would follow the path of the existing watercourse so far as is possible and practicable. Minimising the length of X-EFR-2-01 is an embedded measure that is secured by Design Principle S9.10 (Application Document 7.5) [**REP6-046**].
	To the east of the Project road, West Tilbury Main is crossed in three locations, and to the west in one location. All of these crossings are culvert crossings. The crossing to the west comprises a 700mm diameter culvert (see View 3 below). This culvert, which currently carries agricultural traffic across West Tilbury Main, would be removed. [RDWE046] [**REP6-038**] The crossing immediately to the east of the Project road incorporates a 1,000mm diameter culvert that is approximately 7m long (see View 2 below). This crossing serves a track that would be lost under the footprint of the Project road. As this culvert crossing would not be required during the operational phase of the Project, it would be removed. [RDWE046] [**REP6-038**] The next downstream crossing incorporates a 1,000mm diameter culvert (length unknown). This crossing does not appear on the Ordnance Survey drawings and its status is unknown. The crossing is for a track that that leads to a construction site. This construction site would be demobilised prior to commencement of the construction phase of the Project and the land that it occupies would become part of the northern tunnel entrance compound (for further details of construction compounds refer to Part 6 of the FRA). As this culvert crossing would not be required during the operational phase of the Project, it would be removed. The location of the culverts to be removed are presented on Drawing 10180. [RDWE046] [**REP6-038**] The crossing furthest to the east of the Project road would not be altered as part of the Project. However, as this crossing forms part of the construction haulage road, it may need to be strengthened. Any changes made to this crossing for strengthening purposes would be undertaken with full regard to the requirements of the Environment Agency.

Catchment EFR-2 – West Tilbury Main	
	A new culvert crossing would be included on West Tilbury Main, to the west of the Project road (X-EFR-2-02). This culvert will match the cross section of X-EFR-2-01. It would carry a haul road across West Tilbury Main during the construction phase of the Project, and the operational access road during the operational phase. [RDWE046]
	The section of West Tilbury Main immediately upstream of X-EFR-2-01 would be diverted to avoid earthworks (embankments) for the Project road (D-EFR-2-01). The diversion would involve the elimination of two 90° bends, thereby resulting in a more natural watercourse alignment.
	A section of West Tilbury Main upstream of X-EFR-2-02 would be subject to a minor diversion to avoid earthworks (embankments) for the Project road (D-EFR-2-02).
	A section of the eastern branch of West Tilbury Main would be subject to a minor diversion to avoid earthworks (embankments) for the Project road (D-EFR-2-03).
Hydraulic structures	The hydraulic model indicated that for the post-development scenario without mitigation, the existing West Tilbury Main culverts limit conveyance of flood flows between the floodplain east and west of the Project road. These existing culverts would be removed or enlarged as part of the flood mitigation measures (see also above). This would result in no change in conveyance for smaller events, but for larger events there will be an increase in conveyance via the enlarged culvert (X-EFR-2-02). It was found that a two-stage structure is required to mitigate the impacts of larger events, whilst not changing the hydraulic behaviour during smaller events. This will be achieved by installing a hydraulic structure, with an inset thin plate notch to control flows at lower levels. [RDWE046] The thin plate notch would be supported on a frame, keyed into the watercourse embankments.
Schedules	Schedules with further details and key dimensions for the crossings, diversions and hydraulic structures referred to above are presented in Section 4.8.
Maintenance	A track would be provided to allow access to culvert X-EFR-2-01 for maintenance purposes. This track would branch off the emergency turnaround, immediately to the north of the North Portal. Maintenance access to X-EFR-2-would be gained by means of the track that it carries across the watercourse.

Catchment EFR-2 – West Tilbury Main

Image 4.1 EFR-2 – West Tilbury Main

View 1: West Tilbury Main

View 2: Upstream view of culvert crossing to the east of the Project road.

View 3: Upstream view of culvert crossing to the west of the Project road.

View 4: North view from the top of Bowaters Sluice showing West Tilbury Main.

View 5: South-west view showing the upstream face of Bowaters Sluice.

Table 4.2 Watercourses – Tilbury Viaduct

Catchment EFR-2 – Tilbury Viaduct	
Watercourse name and reference	B. Network of unnamed ordinary watercourses HE540039-CJV-EWE-ZZZ-OW-1N07ZZZ10 C. West Tilbury Main (main river) HE540039-CJV-EWE-ZZZ-MR-1N07ZZZ1
Drawing number	00212
Crossing reference	X-EFR-2-03
Diversion reference	D-EFR-2-04
Crossings and diversions	A network of unnamed ordinary watercourses crosses the Project to the south of the proposed viaduct in Tilbury. Most of this network would be lost under the Project road embankments. Diverting all the individual watercourses that form this network is not viable. However, part of an existing watercourse to the east of the Project road would be retained and then diverted to take it under the proposed viaduct. The diverted watercourse would discharge to West Tilbury Main (D-EFR-2-04). A culvert would be needed to accommodate the diverted watercourse where it passes beneath the slip road connecting the emergency turnaround to Station Road (X-EFR-2-03).
	West Tilbury Main is in culvert where it crosses Station Road. During a site investigation, it was observed that the culvert is blocked. The section of West Tilbury Main to the north of Station Road performs an important drainage function as it forms part of the flow path for runoff from the area to the north of the railway line. To ensure continued functionality of this flow path, the blockage in the culvert would be cleared and the section of West Tilbury Main running northward from Station Road would be re-established. [RDWE047] The location of the existing, blocked, Station Road culvert is presented on Drawing 00180.
Schedules	Schedules with further details and key dimensions for the crossings and diversions referred to above are presented in Section 4.8.
Maintenance	Lay-bys and access tracks would be included to facilitate maintenance of the culverts.

Catchment EFR-2 – Tilbury Viaduct
Image 4.2 EFR-2 – Tilbury Viaduct – Ordinary watercourse network



Views 1 to 3: Miscellaneous views of ordinary watercourse network (ref. watercourse B)

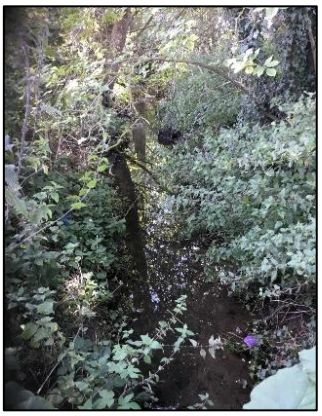
Table 4.3 Watercourses – Chadwell St Mary

Catchment EFR-2 – Chadwell St Mary	
Watercourse name and reference	D. Gobions Sewer (ordinary watercourse) HE540039-CJV-EWE-ZZZ-OW-1N09ZZZ1 E. Unnamed ditch HE540039-CJV-EWE-ZZZ-DI-1N09ZZZ1
Drawing number	00213 and 00214
Crossing reference	X-EFR-2-04 X-EFR-2-05 X-EFR-2-06
Diversion reference	D-EFR-2-05 D-EFR-2-06 D-EFR-2-07
Crossings and diversions	Gobions Sewer would be in culvert where it crosses the Project road (X-EFR-2-04). As the alignment of this watercourse is at an oblique angle to the Project road at the crossing point, it will be diverted to make the crossing shorter (D-EFR-2-05).

Catchment EFR-2 – Chadwell St Mary	
Crossings and diversions	Records indicate that two existing culverts discharge to a headwall located to the south-west of a pond (HE540039-CJV-EWE-ZZZ-PS-1N09ZZZ1). One of these culverts runs from the north, the other from the north-east. There is no information regarding the size, alignment, structural condition, operational status or ownership of these culverts. A brickwork headwall with two 900mm concrete pipes was identified during a site visit. The twin pipes are thought to be the outlet of the existing culverts, but this has not been confirmed. The headwall discharges to Watercourse D. Watercourse AD and ditch E are thought to be connected by the culvert running to the headwall from the north. Given the uncertainties about this culvert, it has been concluded that a new connection between watercourses D and ditch E would be established. This new connection would start at the downstream end of ditch E (where the existing culvert is assumed to originate) and flow to the upstream end of watercourse A (where the existing culvert is assumed to terminate). The connection would include a culvert to convey the watercourse under the Project road (X-EFR-2-06), two open channel sections (D-EFR-2-05) and a culvert to the convey the watercourse under Hoford Road (X-EFR-2-05).
Schedules	Schedules with further details and key dimensions for the crossings and diversions referred to above are presented in Section 4.8.
Maintenance	Lay-bys and/or maintenance access track would be included to facilitate maintenance of the culverts.

Catchment EFR-2 – Chadwell St Mary

Image 4.3 EFR-2 – Chadwell St Mary – Watercourses and ditches



View 1 and 2: Watercourse D
(HE540039-CJV-EWE-ZZZ-OW-1N09ZZZ1)

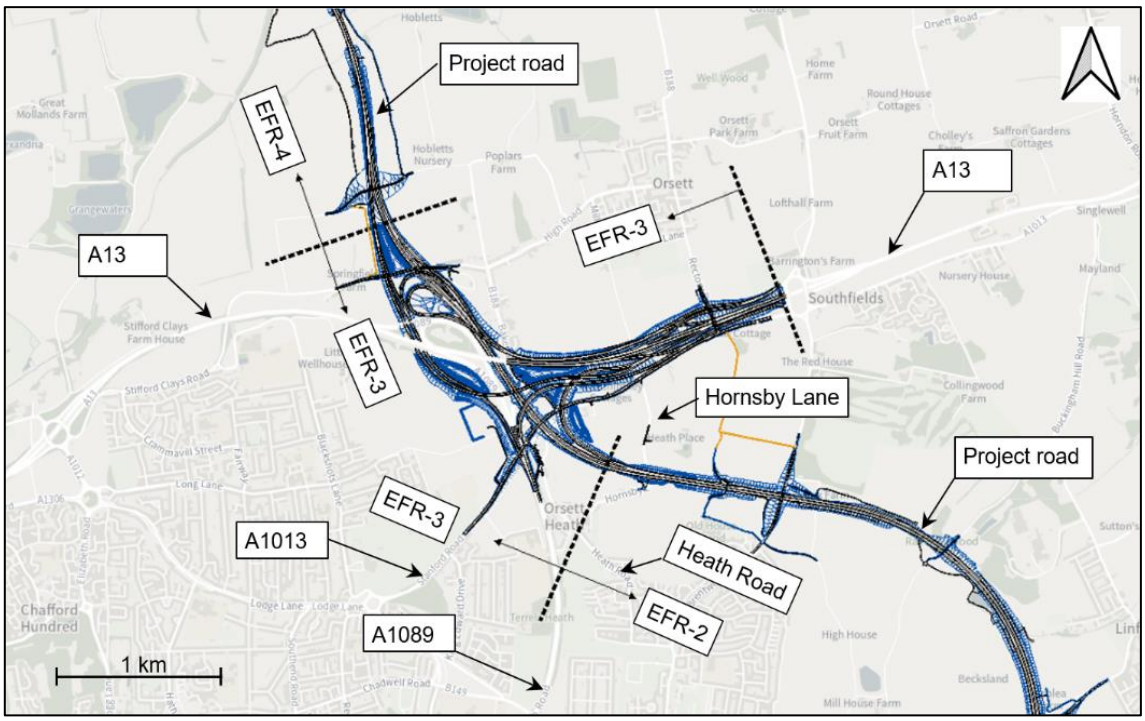
View 3: Watercourse E
HE540039-CJV-EWE-ZZZ-DI-1N09ZZZ1

View 4: Brickwork headwall

4.3 A13 junction (catchment EFR-3)

4.3.1 Catchment EFR-3 includes the split-level interchange between the Project road, the A13 and the A1089. The extents and principal elements of EFR-3 are presented in Plate 4.3.

Plate 4.3 Catchment EFR-3

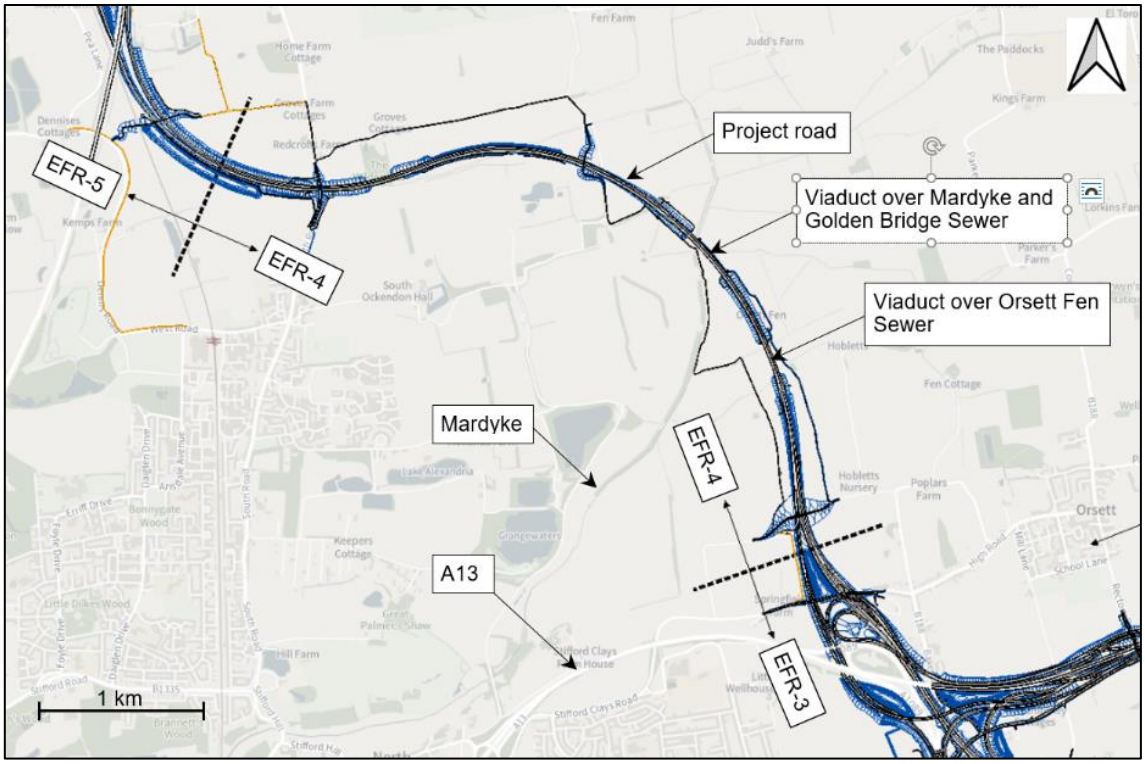


4.3.2 There are no main rivers or ordinary watercourses in the vicinity of the junction between the Project road and the A13 and the A1089.

4.4 Ockendon link (Catchment EFR-4)

4.4.1 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 presented in Plate 4.4.

Plate 4.4 Catchment EFR-4



4.4.2 Crossings and diversions of watercourses in Catchment EFR-4 are detailed in Table 4.4 and Table 4.5.

Table 4.4 Watercourses – Orsett Fen and Mardyke

Catchment EFR-4 – Orsett Fen and Mardyke	
Watercourse name and reference	F. Orsett Fen Sewer (main river) HE540039-CJV-EWE-ZZZ-MR-1N11ZZZ1 G. Golden Bridge Sewer (main river) HE540039-CJV-EWE-ZZZ-MR-1N17ZZZ2 H. Mardyke (main river) 540039-CJV-EWE-ZZZ-MR-1N17ZZZ1 I. Unnamed ordinary watercourse (in two locations, I1 and I2) HE540039-CJV-EWE-ZZZ-OW-1N17ZZZ1 J. Unnamed ordinary watercourse HE540039-CJV-EWE-ZZZ-OW-1N17ZZZ6
Drawing number	00215 and 00216

Catchment EFR-4 – Orsett Fen and Mardyke	
Crossing reference	X-EFR-4-01 (Orsett Fen Sewer) X-EFR-4-02 X-EFR-4-03 (Golden Bridge Sewer) X-EFR-4-04 (Mardyke) X-EFR-4-05 X-EFR-4-06
Diversion reference	D-EFR-4-01
Crossings and diversions	A viaduct would be built to cross watercourses F and I1 (X-EFR-4-01and X-EFR-4-02). A second viaduct would be built to cross watercourses G and H (X-EFR-4-03 and X-EFR-4-04 respectively). Watercourses F, G, H and I1 would not need to be diverted to accommodate the Project.
	Culverts would be provided for watercourses J and I2. These watercourses would cross the Project road immediately to the north of the second viaduct (X-EFR-4-05 and X-EFR-4-06). If the current alignment of watercourse I2 is retained, it would change direction midway across the Project road. As culverts should be free of bends where possible, watercourse I2 would be realigned so that the reach that crosses the Project road is straight (D-EFR-4-01). The reach of watercourse E that would cross the Project road is straight so would not need to be realigned.
Schedules	Schedules with further details and key dimensions for the crossings and diversions referred to above are presented in Section 4.8.
Maintenance	Lay-bys and/or maintenance access track would be included to facilitate maintenance of the culverts and bridges.

Catchment EFR-4 – Orsett Fen and Mardyke

Image 4.4 EFR-4 – Orsett Fen Sewer, Golden Bridge Sewer and Mardyke

View 1: Mardyke (ref. H)

View 2: Mardyke (ref. H)

View 3: Orsett Fen Sewer (ref. F)

View 4: Orsett Fen Sewer (ref. F)

View 5: Golden Bridge Sewer (ref. G)

View 6: Golden Bridge Sewer (ref. G)

Catchment EFR-4 – Orsett Fen and Mardyke

Image 4.5 EFR-4 – Orsett Fen – Ordinary watercourses

View 7: Ordinary Watercourse (ref. I)
(HE540039-CJV-EWE-ZZZ-OW-1N17ZZZ1)

View 8: Ordinary Watercourse (ref. J)
(HE540039-CJV-EWE-ZZZ-OW-1N17ZZZ6)

View 9: Ordinary Watercourse (ref. I)
(HE540039-CJV-EWE-ZZZ-OW-1N17ZZZ)

View 10: Ordinary Watercourse (ref. J)
(HE540039-CJV-EWE-ZZZ-OW-1N17ZZZ6)

Table 4.5 Watercourses – South Ockendon

Catchment EFR-4 – South Ockendon	
Watercourse name and reference	K. Unnamed ordinary watercourse HE540039-CJV-EWE-ZZZ-OW-1N13ZZZ1
Drawing number	00217 00218
Crossing reference	X-EFR-4-07
Diversion reference	D-EFR-4-02 D-EFR-4-03 D-EFR-4-04
Crossings and diversions	Watercourse K flows in a west to east direction along a shallow valley; the Project road would also run along this shallow valley. Two watercourse reaches (760m and 220m) would be lost to the Project road where their alignments coincide. In addition to the lost reaches, the Project road would dissect the watercourse. Due to the low-lying nature of the highway, a culvert crossing to take the watercourse across the Project road would not be possible. It is therefore proposed to split this watercourse into two sections: one running to the north of the Project road and the other to the south. The section of the watercourse to the north would run along a new channel in an easterly direction from the Wilderness until it joins the original watercourse. The new length of watercourse would pick up the small watercourses that run through the Wilderness. This new section of channel would form D-EFR-4-02. As the section of the watercourse to the south of the highway would not be able to join up with an existing watercourse, it is proposed to discharge flows from this watercourse to a pond. Water from the pond would be dispersed through infiltration and evapotranspiration. The watercourse to the south of the highway would follow the existing watercourse channel where possible but would need to be diverted along two reaches: • Existing watercourse would be extended eastward to reach the proposed pond; this extension would take the form of a swale (D-EFR-4-03). • A new channel would be established to replace the reach of existing watercourse that would be lost to the Project road (D-EFR-4-04). Diversion D-EFR-4-04 would cross the approach road to a new bridge across the B186. A new culvert would be provided to take the diverted watercourse under the approach road (X-EFR-4-07).
Maintenance	Lay-bys and/or maintenance access tracks would be included to facilitate maintenance of the culverts.

Catchment EFR-4 – South Ockendon

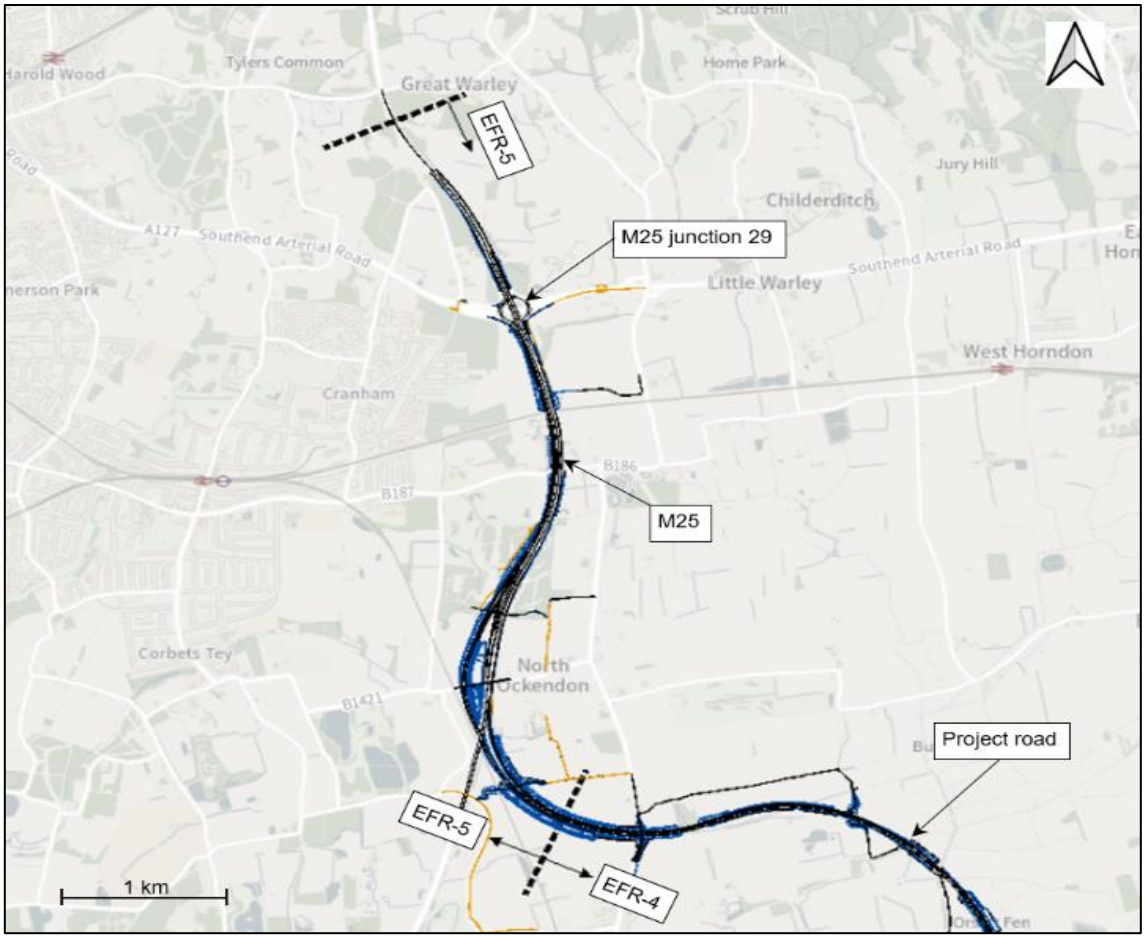
Image 4.6 EFR-4 – South Ockendon

View 1 and 2: Ordinary watercourse (Ref. K)
(HE540039-CJV-EWE-ZZZ-OW-1N13ZZZ1)

4.5 North Section (Catchment EFR-5)

4.5.1 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 presented in Plate 4.5.

Plate 4.5 Catchment EFR-5



4.5.2 Crossings and diversions of watercourses in Catchment EFR-5 are detailed in Table 4.6.

Table 4.6 Watercourses – M25

Catchment EFR-5 – Northern Section and M25 Junction	
Watercourse name and reference	L. Unnamed network of ditches HE540039-CJV-EWE-ZZZ-DI-1N14ZZZ2 M. West Mardyke (main river) HE540039-CJV-EWE-ZZZ-MR-1N17ZZZ4
Drawing number	00219 and 00210
Crossing reference	X-EFR-5-01 X-EFR-5-02
Diversion reference	D-EFR-5-01

Catchment EFR-5 – Northern Section and M25 Junction	
Crossings and diversions	Watercourse L comprises a network of ditches that lie to the south of the West Mardyke. This network would cross the Project road in two locations. At both these locations, the Project road would be in a deep cutting, meaning a simple culvert crossing is not possible. To bypass the cutting, the two main branches of the ditch network would be joined and diverted south until the level of the Project road (part of the M25 northbound on-slip) is high enough to enable the diversion to be culverted beneath it. Once across the Project road, the diversion would be routed in a northerly direction until it reaches the original watercourse. The diversion would include open channel and piped culverts (D-EFR-5-01). Piped culverts would be used where ground levels are significantly higher than the invert level of the diverted watercourse. The crossing of the Project road would be formed with two 300mm diameter pipes (X-EFR-5-01). The rationale for reducing the diameter and twinning this culvert is to enable the culvert to be built under the Project road at the earliest opportunity (i.e., to use a larger pipe for the crossing would drive the diversion further south before crossing the Project road).
	Work to be undertaken on the M25 as part of the Project would include widening both carriageways and the addition of an on-slip. The widened section of the M25 and the proposed slip road would both cross the West Mardyke. The width of the existing culvert that takes the M25 over the West Mardyke would be extended eastwards to accommodate the carriageway widening. The culvert would also be extended westward to carry the proposed on-slip over the West Mardyke (X-EFR-5-02). The culvert would span the gap between the slip road and widened carriageway (approximately 5.6m) but would be open-topped to allow daylight to reach the interior of the culvert. The cross section of the new sections of culvert would match the cross section of the existing culvert. Based on Product 4 data[5] from the Environment Agency, the flood level at the upstream end of the culvert under the M25 for the 1% annual exceedance probability (AEP) event with climate change allowances is 8.26mAOD. The Product 4 data also indicates that upstream of the culvert, the West Mardyke is out of channel for the same flood event. The soffit level of the culvert is approximately 9.80mAOD so there is sufficient freeboard (1.54m), however, the out-of-channel flow upstream of the crossing suggests that the culvert acts as a flow constraint. The flow that is out of channel covers open ground and woodland, and is not considered to represent a significant risk. Flood risk at the M25 crossing is covered in detail in Part 6 of the FRA.

[5] Product 4 data is prepared by the Environment Agency upon request and includes flood maps, levels and flows for a specific area. The Product 4 data prepared for the Project is presented as an annex to Part 6 of the FRA (EAn201876391).

Catchment EFR-5 – Northern Section and M25 Junction	
Schedules	Schedules with further details and key dimensions for the crossings and diversions referred to above are presented in Section 4.8.
Maintenance	Lay-bys and/or maintenance access track and inspection chambers would be included to facilitate maintenance of the culverts.

Image 4.7 EFR-5 – Northern Section

Views 1 to 3: Miscellaneous views of West Mardyke

View 4: West view of West Mardyke culvert under M25

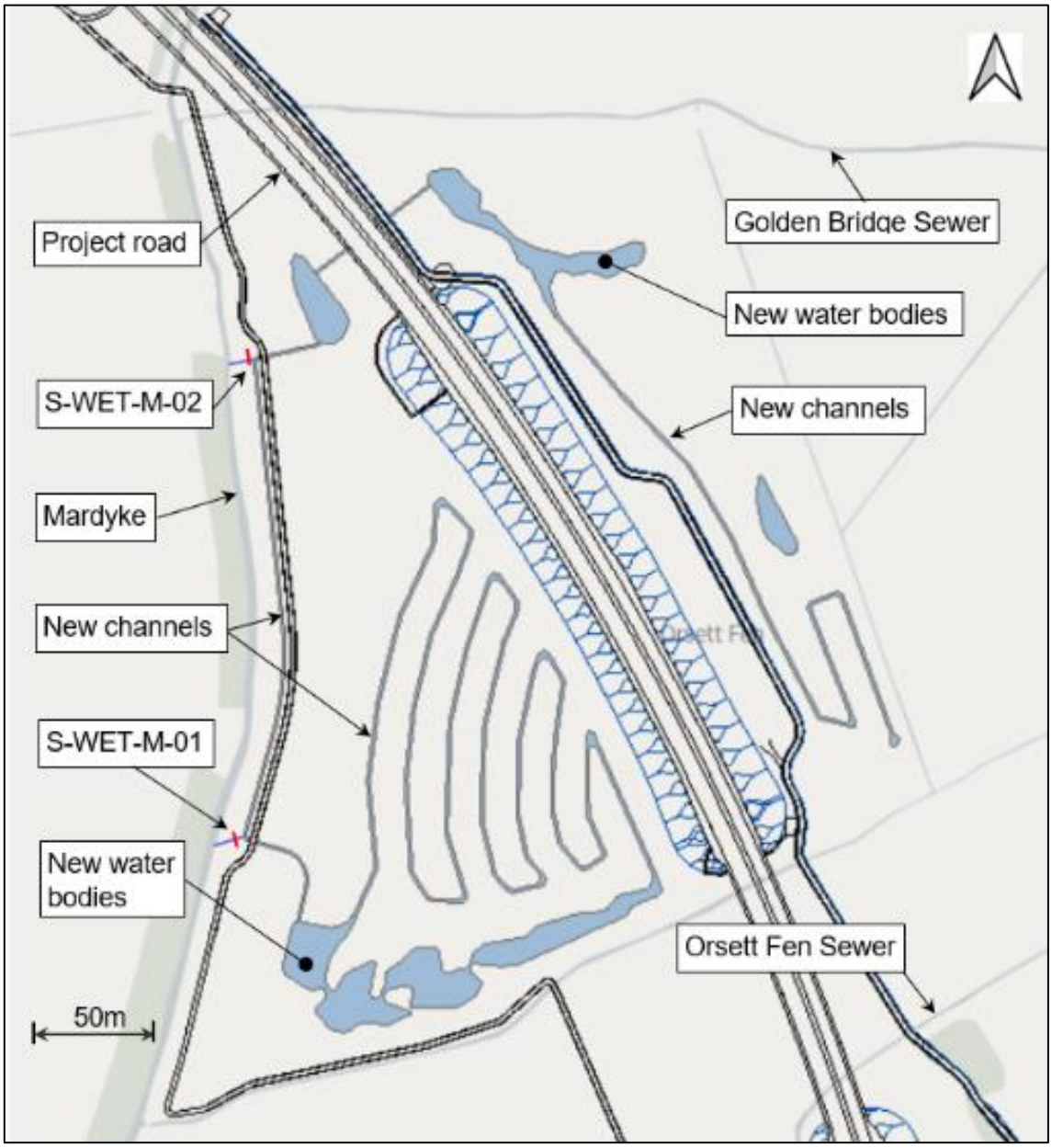
4.6 Mardyke wetland

Overview

4.6.1 The Project would result in the disturbance, and ultimate loss, of water vole habitat in Tilbury Marshes. A water vole conservation licence would be sought from Natural England to undertake work on the affected habitat. A licence would only be granted on condition that the associated mitigation works include creation or enhancement of alternative compensatory habitat, such that there will be a demonstrable net conservation gain for water voles.

4.6.2 To achieve this condition, a wetland area providing a suitable habitat for water voles would be established in the Mardyke flood plain. The provisional arrangement of the proposed wetland area is shown in Plate 4.6 . This is an embedded measure that is secured by Design Principle S12.06 (Application Document 7.5) [**REP6-046**].

Plate 4.6 Plan of the Mardyke Wetland



New watercourses

4.6.3 Creation of the wetland area will include the formation of approximately 3.22km of new watercourse and several new open water bodies.

4.6.4 Further details and key dimensions of new watercourses for Mardyke Wetland are presented in Section 4.8.

Hydraulic control structures

4.6.5 The watercourses in the wetland would be connected to the Mardyke in two locations. Hydraulic control structures (weirs) (S-WET-M-01 and S-WET-M-02) would be incorporated at both connection points to manage water levels in the wetland [RDWE050] such that the following apply:

a. Water will be retained in the wetland area when water levels in the Mardyke are low.

b. Water will flow over the weirs when the water level in the wetland area exceeds its maximum operational level. The maximum operational level is the maximum level at which the compensatory flood storage incorporated into the wetland would function as intended (see Parts 4 and 6 of the FRA for further details). The weir level in both structures is 2.10mAOD.

4.6.6 Further details on the hydraulic control structures for Mardyke Wetland are presented in Section 4.8.

4.7 Coalhouse Point Wetland

Overview

4.7.1 In order to mitigate adverse effects associated with the works supporting the North Portal construction, a wetland area would be established immediately to the west of Coalhouse Point, on the north embankment of the River Thames. The wetland would be recharged locally with brackish water from the Thames Estuary. The provisional arrangement of the proposed wetland is shown in Plate 4.7.

4.7.2 In line with REAC item HR011, the recharge of the wetlands will be delivered via one of two options:

a. Option 1. A formal agreement with Thurrock Council to release water on request from the Coalhouse Fort moat system.

b. Option 2. A self-regulating tide gate or equivalent structure, passable by eels, constructed (in accordance with HR011) in the sea wall, at approximately TQ686761, to allow regulated tidal exchange.

Watercourses

4.7.3 An existing watercourse runs in a straight line in a northerly direction from the leeward side of the tidal defence wall on the Thames Estuary. This existing watercourse discharges to an unnamed watercourse. This unnamed watercourse ultimately discharges to West Tilbury Main, flowing towards the Bowaters Sluice to the River Thames.

4.7.4 An existing watercourse runs in a straight line in a northerly direction from the leeward side of the tidal defence wall on the Thames Estuary. This existing watercourse discharges to an unnamed watercourse. This unnamed watercourse ultimately discharges to West Tilbury Main, flowing towards the Bowaters Sluice to the River Thames.

4.7.5 The alignment of this watercourse would be amended to form a more natural (meandering) channel. This channel would incorporate several branches.

4.7.6 Further details and key dimensions of the new and diverted watercourses for Coalhouse Point Wetland are presented in Section 4.8.

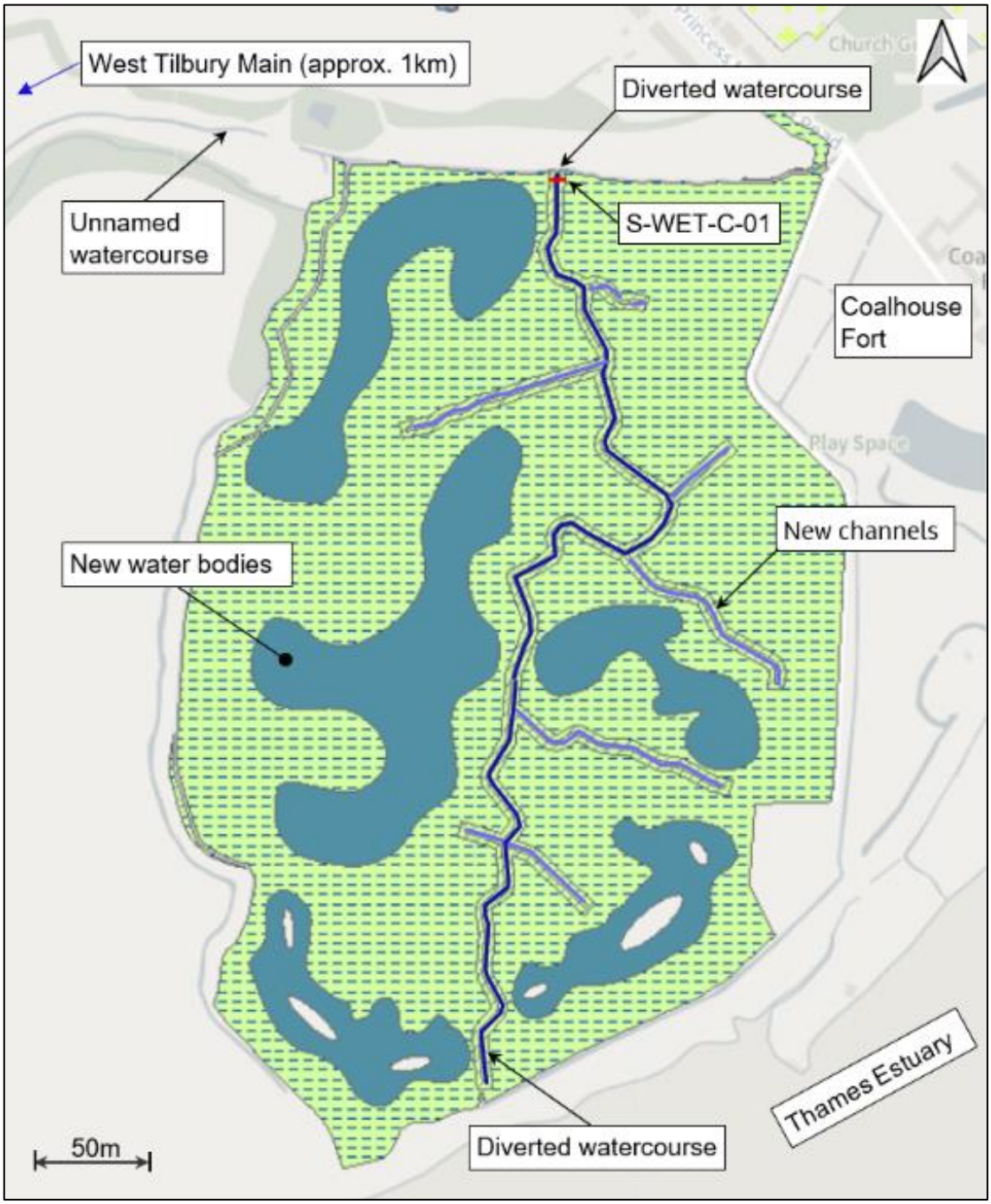
Hydraulic control structures

4.7.7 To ensure that water is retained in the wetland, a hydraulic control structure (weir) (S-WET-C-01) would be incorporated at the northern end of the diverted watercourse. [RDWE050]

4.7.8 The weir level will be set no higher than the lowest existing ground level in the wetland area (excluding the watercourse channel). This would ensure that there is no loss in floodplain storage.

4.7.9 Further details of the control structure for Coalhouse Point Wetland are presented in Section 4.8.

Plate 4.7 Coalhouse Point Wetland



4.8 Schedules

4.8.1 Table 4.7 summarises the watercourse crossings.

4.8.2 Table 4.8 summarises the watercourse diversions.

4.8.3 Table 4.9 summarises the additional watercourses.

4.8.4 Table 4.10 summarises the structural form of the watercourse crossings.

4.8.5 Table 4.11 and Table 4.12 summarise watercourse structures.

Table 4.7 Schedule of watercourse crossings

Crossing reference	Works No.[3] [REP4-038] [REP5-020]	Water feature ID [1]	Primary designation (and name)	Regulator	Type of crossing	Drawing reference
X-EFR-2-01	5M	HE540039-CJV-EWE-ZZZ-MR-1N07ZZZ1	Main river (West Tilbury Main)	Environment Agency	Concrete box culvert	00211
X-EFR-2-02	5M	HE540039-CJV-EWE-ZZZ-MR-1N07ZZZ1	Main river (West Tilbury Main)	Environment Agency	Concrete box culvert	00211
X-EFR-2-03	5N	HE540039-CJV-EWE-ZZZ-OW-1N07ZZZ10	Ordinary watercourse (Gobions Sewer)	Thurrock Council	Concrete pipe culvert	00212
X-EFR-2-04	6F	HE540039-CJV-EWE-ZZZ-OW-1N09ZZZ1	Ordinary watercourse (unnamed)	Thurrock Council	Concrete box culvert	00213
X-EFR-2-05[2]	6G	New watercourse	Ordinary watercourse (assumed)	Thurrock Council	Concrete pipe culvert	00213
X-EFR-2-06	6H	HE540039-CJV-EWE-ZZZ-DI-1N09ZZZ1	Ditch (unnamed)	Thurrock Council	Concrete pipe culvert	00214
X-EFR-4-01	8B	HE540039-CJV-EWE-ZZZ-MR-1N11ZZZ1	Main River (Orsett Fen Sewer)	Environment Agency	Viaduct	00215
X-EFR-4-02	8B	HE540039-CJV-EWE-ZZZ-OW-1N17ZZZ1	Ordinary watercourse (unnamed)	Thurrock Council	Viaduct	00215
X-EFR-4-03	8B	HE540039-CJV-EWE-ZZZ-MR-1N17ZZZ2	Main River (Golden Bridge Sewer)	Environment Agency	Viaduct	00215
X-EFR-4-04	8B	HE540039-CJV-EWE-ZZZ-MR-1N17ZZZ1	Main River (Mardyke)	Environment Agency	Viaduct	00216
X-EFR-4-05	8O	HE540039-CJV-EWE-ZZZ-OW-1N17ZZZ6	Ordinary watercourse (unnamed)	Thurrock Council	Concrete box culvert	00216
X-EFR-4-06	8P	HE540039-CJV-EWE-ZZZ-OW-1N17ZZZ1	Ordinary watercourse (unnamed)	Thurrock Council	Concrete box culvert	00216
X-EFR-4-07	8Q	HE540039-CJV-EWE-ZZZ-OW-1N13ZZZ1	Ordinary watercourse (unnamed)	Thurrock Council	Concrete box culvert	00217 and 00218
X-EFR-5-01	9W	HE540039-CJV-EWE-ZZZ-DI-1N14ZZZ2	Ditch (unnamed)	London Borough of Havering	Concrete pipe culvert	00220
X-EFR-5-02	9X	HE540039-CJV-EWE-ZZZ-MR-1N17ZZZ4	Main River (West Mardyke)	Environment Agency	Highway structure (bridge)	00220

Notes:

(1) For details on the water feature ID, refer to Appendix 14.2: Water Features Survey Factual Report (Application Document 6.3) [APP-454 and APP-455] of the ES.

(2) X-EFR-2-05 would be a new watercourse and as such, does not have a water feature ID. It is assumed that this new watercourse would be designated as an ordinary watercourse.

(3) The drainage plans show additional work number references 6I, 6J, 8R, 8S, 8T, 8U, 8V and 9X. These are short culverts that will facilitate crossings of new highway drainage ditches created at the toe of earthworks embankments for access.

Table 4.8 Schedule of watercourse diversions

Diversion reference	Works No. [REP4-038] [REP5-020]	Water feature ID(1)	Abandoned length (m)		Diversion length (m)		Net gain in length (m)		Drawing reference
			In channel (a)	In culvert (b)	In channel (c)	In culvert (d)	In channel (c) – (a)	In culvert (d) – (b)	
D-EFR-2-01	5L	HE540039-CJV-EWE-ZZZ-MR-1N07ZZZ1	125	0	100	0	-25	0	00211
D-EFR-2-02	5L	HE540039-CJV-EWE-ZZZ-MR-1N07ZZZ1	23	0	20	0	-3	0	00221
D-EFR-2-03	5L	HE540039-CJV-EWE-ZZZ-MR-1N07ZZZ1	72	0	72	0	0	0	00221
D-EFR-2-04	5N	HE540039-CJV-EWE-ZZZ-OW-1N07ZZZ1	1,139	0	378	18	-761	18	00212
D-EFR-2-05	6F	HE540039-CJV-EWE-ZZZ-OW-1N09ZZZ1	186	0	112	178	-74	178	00213
D-EFR-2-06 (4)	6G	HE540039-CJV-EWE-ZZZ-OW-1N09ZZZ1	0	515	545	20	545	-495	00213 and 00214
D-EFR-2-07	6H	HE540039-CJV-EWE-ZZZ-DI-1N09ZZZ1	375	0	379	77	4	77	00214
D-EFR-4-01	8P	HE540039-CJV-EWE-ZZZ-OW-1N17ZZZ1	138	0	117	82	-21	82	00216
D-EFR-4-02	8V	HE540039-CJV-EWE-ZZZ-OW-1N13ZZZ1	0	0	1,074	0	1,074	0	00217
D-EFR-4-03	8Q	HE540039-CJV-EWE-ZZZ-OW-1N13ZZZ1	304	0	618	0	314	0	00218
D-EFR-4-04	8Q	HE540039-CJV-EWE-ZZZ-OW-1N13ZZZ1	1,058	0	868	57	-190	57	00218
D-EFR-5-01	9W	HE540039-CJV-EWE-ZZZ-DI-1N14ZZZ2	633	0	531	558	-102	558	00219
D-WET-C-01	E15	Coalhouse Point Wetland	760	0	1,725(5)	0	965	0	Plate 4.7 & 00180
							1,726	**475**	

Table 4.9 Additional watercourses(6)

Diversion reference	Works No. [REP4-038] [REP5-020]	Water feature ID(1)	Additional length (m)		Drawing reference
			In channel	In culvert	
D-EFR-2-01	E36 / FCA 3	Mardyke Wetland	3,220(7)	0	Plate 4.6 & 00181
			3,220	**0**	

Notes:

(1) For details on the water feature ID, refer to Appendix 14.2: Water Features Survey Factual Report (Application Document 6.3) [APP-454 and APP-455] of the ES.

(2) Minor local diversions may be required to enable watercourse to be aligned with culverts. These minor diversions have not been allocated a diversion reference and are not measured in this table.

(3) The net gain in channel length should be regarded as indicative as this summation does not take account of the size or biological diversity of individual watercourses.

(4) The net gain in culvert length should be regarded as indicative as this summation does not take account of the size or structural form of the culvert.

(5) The length of watercourse in Coalhouse Point Wetland comprises approximately 950m in the main channel and 775m in branches.

(6) Additional watercourses include new watercourses that do not form part of a diverted watercourse.

(7) This length of watercourse would be in channel, including the two connections to the Mardyke.

Table 4.10 Structural form of water crossings

Crossing reference	Works No. [REP4-038] [REP5-020]	Water feature ID (1)	Form of crossing	Structure length(2) (m)	Functional size (mm) (3) (4)		Structure reference
X-EFR-2-01	5M	HE540039-CJV-EWE-ZZZ-MR-1N07ZZZ1	Concrete box culvert	46	Height: 2,800	Width: 4,000	MNN0000051
X-EFR-2-02	5M	HE540039-CJV-EWE-ZZZ-MR-1N07ZZZ1	Concrete box culvert	15	Height: 2,800	Width: 4,000	MNN0000055
X-EFR-2-03	5N	HE540039-CJV-EWE-ZZZ-OW-1N07ZZZ10	Concrete pipe culvert	11	DN 900		N/A
X-EFR-2-04	6F	HE540039-CJV-EWE-ZZZ-OW-1N09ZZZ1	Concrete box culvert	178	Height: 1,700	Width: 1,550	MNN0000060
X-EFR-2-05	6G	New watercourse (5)	Concrete pipe culvert	20	DN 900		N/A
X-EFR-2-06	6H	HE540039-CJV-EWE-ZZZ-DI-1N09ZZZ1	Concrete pipe culvert	77	DN 900		N/A
X-EFR-4-01	8B	HE540039-CJV-EWE-ZZZ-MR-1N11ZZZ1	Viaduct	N/A	Minimum clearance at crossing: 4.0m(6)		N/A
X-EFR-4-02	8B	HE540039-CJV-EWE-ZZZ-OW-1N17ZZZ1	Viaduct	N/A	Minimum clearance at crossing: 4.0m(6)		N/A
X-EFR-4-03	8B	HE540039-CJV-EWE-ZZZ-MR-1N17ZZZ2	Viaduct	N/A	Minimum clearance at crossing: 4.0m(6)		N/A
X-EFR-4-04	8B	HE540039-CJV-EWE-ZZZ-MR-1N17ZZZ1	Viaduct	N/A	Minimum clearance at crossing: 4.0m(6)		N/A
X-EFR-4-05	8O	HE540039-CJV-EWE-ZZZ-OW-1N17ZZZ6	Concrete box culvert	82	Height: 1,960	Width: 1,000	MNN0000080
X-EFR-4-06	8P	HE540039-CJV-EWE-ZZZ-OW-1N17ZZZ1	Concrete box culvert	77	Height: 1,650	Width: 1,000	MNN0000081
X-EFR-4-07	8Q	HE540039-CJV-EWE-ZZZ-OW-1N13ZZZ1	Concrete box culvert	57	Height: 2,400	Width: 1,000	MNN0000082
X-EFR-5-01	9W	HE540039-CJV-EWE-ZZZ-DI-1N14ZZZ2	Concrete pipe culvert	87	2 x DN 300(7)		N/A
X-EFR-5-02	9X	HE540039-CJV-EWE-ZZZ-MR-1N17ZZZ4	Highway structure (bridge)	10	Match existing bridge dimensions		BRE0013569 – Extended
	9X		Highway structure (bridge)	20	Match existing bridge dimensions		BRN0000085 – New

Notes:

(1) For details on the water feature ID, refer to Appendix 14.2: Water Features Survey Factual Report (Application Document 6.3) [APP-454 and APP-455] of the ES.

(2) All structure lengths and widths are approximate.

(3) For viaducts, the clearance is measured from the underside of the bridge deck to bank level.

(4) The functional size of box culverts is the minimum dimensions of the culvert; actual culvert sizes may vary subject to these minimum dimensions being met.

(5) X-EFR-2-05 would be a new watercourse and as such, does not have a water feature ID.

(6) This minimum clearance is secured by Design Principle S12.05 (Application Document 7.5) [REP6-046].

(7) DMRB CD 529 (Highways England, 2020b) states that the minimum culvert size shall be 450mm. In order to reduce the length of the diversion, and thereby improve the hydraulic gradient, two 300mm diameter pipes have been used in place of a 450mm diameter pipe.

Table 4.11 Schedule of watercourse structures

Structure reference	Works No.	Water feature ID (1)	Primary designation (and name)	Regulator	Type of structure	Drawing reference
S-EFR-2-01	Ancillary works as per Schedule 1 of the draft Development Consent Order [**REP6-010**]	HE540039-CJV-EWE-ZZZ-MR-1N07ZZZ1	Main river (West Tilbury Main)	Environment Agency	Flow control	00180
S-WET-M-01	Ancillary works as per Schedule 1 of the draft Development Consent Order [**REP6-010**]	Mardyke Wetland	Mardyke Wetland	Thurrock Council	Level control	Plate 4.6 and 00181
S-WET-M-02	Ancillary works as per Schedule 1 of the draft Development Consent Order [**REP6-010**]	Mardyke Wetland	Mardyke Wetland	Thurrock Council	Level control	Plate 4.6 and 00181
S-WET-C-01	Ancillary works as per Schedule 1 of the draft Development Consent Order [**REP6-010**]	Coalhouse Point Wetland	Coalhouse Point Wetland	Thurrock Council	Level control	Plate 4.7 and 00180

Table 4.12 Form of watercourse structures

Structure reference	Works ID	Water feature ID (1)	Form of structure	Structure width(2) (m)	Approximate functional size (mm)	Structure reference
S-EFR-2-01	Ancillary works as per Schedule 1 of the draft Development Consent Order [**REP6-010**]	HE540039-CJV-EWE-ZZZ-MR-1N07ZZZ1	Notch plate weir mounted on a timber or concrete frame	7.5	Two-stage weir – Refer to Section 7 for details	MNN0000057
S-WET-M-01	Ancillary works as per Schedule 1 of the draft Development Consent Order [**REP6-010**]	Mardyke Wetland	Timber weir	7.5	N/A	N/A
S-WET-M-01	Ancillary works as per Schedule 1 of the draft Development Consent Order [**REP6-010**]	Mardyke Wetland	Timber weir	7.5	N/A	N/A
S-WET-C-01	Ancillary works as per Schedule 1 of the draft Development Consent Order [**REP6-010**]	Coalhouse Point Wetland	Timber weir	10.0	N/A	N/A

Notes:
(1) The structure would be the full channel width and keyed into the banks of the watercourse.
(2) All structure lengths and widths are approximate.

5 Culverts

5.1 Introduction

5.1.1 This section provides a high-level summary of the measures and principles embedded into the design for the proposed watercourse culverts.

5.2 Design guidance

5.2.1 Culverts would be designed to accommodate a 1 in 100-year storm event including allowances for climate change and a minimum 600mm freeboard.

5.2.2 Where included, mammal ledges would be set at a minimum level of 150mm above the 1 in 100-year storm event level, with a minimum 600mm headroom to the soffit of the culvert (see also Section 0).

5.2.3 The documents which inform the design of culverts comprise the following:

a. Design Manual for Roads and Bridges (DMRB) CD 356 Design of highway structures for hydraulic action (Highways England, 2020a)

b. DMRB CD 529 Design of outfall and culvert details (Highways England, 2020b)

c. Fluvial Design Guide – Chapter 8.6 ‘Culverting of watercourses’ (Environment Agency, 2009)

d. Culvert, screen and outfall manual (C786) (CIRIA, 2019)

e. Culvert Policy (Essex County Council, 2012)

5.2.4 The documents which inform the environmental considerations for culverts comprise the following:

a. DMRB LD 118 Biodiversity design (Highways England, 2020c)

b. Chapter 8: Terrestrial Biodiversity and Chapter 14: Road Drainage and the Water Environment (Application Document 6.1) [**APP-152**]

c. Figure 2.4: Environmental Masterplan (Application Document 6.2)

i. Environmental Statement - Figure 2.4 - Environmental Masterplan Sections 1 & 1A (1 of 10) [**REP4-124**]

ii. Environmental Statement - Figure 2.4 - Environmental Masterplan Section 2 (2 of 10) [**REP3-098**]

iii. Environmental Statement - Figure 2.4 - Environmental Masterplan Section 3 (3 of 10) [**REP2-018**]

iv. Environmental Statement - Figure 2.4 - Environmental Masterplan Section 4 (4 of 10) [**APP-162**]

v. Environmental Statement - Figure 2.4 - Environmental Masterplan Section 9 (5 of 10) [**REP4-127**]

vi. Environmental Statement - Figure 2.4 - Environmental Masterplan Section 10 (6 of 10) [**REP4-129**]

vii. Environmental Statement - Figure 2.4 - Environmental Masterplan Section 11 (7 of 10) [**REP2-024**]

viii. Environmental Statement - Figure 2.4 - Environmental Masterplan Section 12 (8 of 10) [**REP2-026**]

ix. Environmental Statement - Figure 2.4 - Environmental Masterplan Section 13 (9 of 10) [**REP2-028**]

x. Environmental Statement - Figure 2.4 - Environmental Masterplan Section 14 (10 of 10) [**REP2-031**]

5.3 Rationale for using culverts

Main rivers

5.3.1 Although the Environment Agency has a general policy against culverting, there are situations where culverting is unavoidable. The Project includes three culvert crossings on main rivers. The rationale for using culverts to cross main rivers is presented in Table 5.1.

Table 5.1 Culverts on main rivers

Main river	Crossing	Rational for inclusion of culverts
West Tilbury Main	X-EFR-2-01	This culvert would run under the Project road just as it emerges from the North Portal of the tunnel. The alignment of West Tilbury Main in relation to the location of the portal would be such that it would not be possible to construct a single span bridge over it. This crossing was discussed at a workshop with the Environment Agency in December 2019. The workshop concluded that although a culvert was not ideal, there was not a reasonable alternative.
West Tilbury Main	X-EFR-2-02	An existing culvert that would lie immediately to the west of the Project road comprises a DN1000 pipe (see Image 4.1 EFR-2 View 3). This culvert would limit conveyance of flows between the floodplains to the east and west of the Project road. As part of the flood alleviation measures proposed for the Project, this culvert would be replaced by a culvert with dimensions matching those of X-EFR-2-01.

Main river	Crossing	Rational for inclusion of culverts
West Mardyke	X-EFR-5-02	An existing culvert takes the West Mardyke under the M25. The Project includes widening part of the southbound carriageway of M25. This widening would include the section of the M25 that crosses the West Mardyke. The Project also includes adding a new slip road to the northbound carriageway of the M25. This slip road would cross the West Mardyke just before it joins the M25. At the crossing point, the slip road would lie immediately adjacent to the northbound carriageway. The Environment Agency agreed that the existing culvert could be extended at its current cross section to accommodate the widened section of the M25 and the slip road. The gap between the M25 and the slip road would incorporate an open section (window) to allow natural light to enter the culvert.

Ordinary watercourses

5.3.2 Although some ordinary watercourses would flow under proposed viaducts, the majority of ordinary watercourse crossings would use culverts.

5.3.3 Essex County Council's Culvert Policy (Essex County Council, 2012) notes that culverting is unavoidable where highways cross watercourses.

Selection process for culverts

5.3.4 Alternatives to culverts have been examined and would be adopted where practicable. The alternative options that have been considered are briefly outlined below:

a. Clear span structures to cross main rivers.

b. Diversion of a watercourse in order to avoid the need for a culvert.

c. Combined watercourses at crossings where possible, so that only one crossing point is needed.

5.4 Sizing of box culverts

5.4.1 Box culverts would be high enough to enable access by maintenance personnel (2.8m) where possible. Although most maintenance would be undertaken without entering a culvert (on account of it being classified as confined space), entry may be needed under particular circumstances (e.g., for a blockage that cannot be jet-washed). [RDWE013]

5.4.2 As a minimum, box culverts would be sized to accommodate the 1% AEP event with allowance for climate change. For culverts with mammal ledges, the freeboard would be 900mm and for culverts without mammal ledges, the freeboard would be 600mm). [RDWE013] [RDWE044]

5.4.3 As a minimum, box culverts would be sized to match the width of the watercourse that runs through them. An allowance of 500mm would be added to the bed width to accommodate culverts with a mammal ledge (see paragraph 5.8.8 and 5.8.9). As an absolute minimum, box culverts would be 1.0m wide. [RDWE013] [RDE044]

5.4.4 The size of box culverts given in Table 4.11 is the minimum functional size. Culvert cross sections that are greater than the functional size could be used; this could rationalise the number of different culvert cross section types that would need to be fabricated for the Project.

5.5 Removal of culverts

5.5.1 Where feasible, existing culverts would be broken out and the watercourse returned to open channel. Removal is regarded as good practice on account of the following:

a. Reinstatement of open channel watercourses affords biodiversity and hydromorphology benefits.

b. Improved hydraulic efficiency in the channel if the culvert acts as a constraint.

c. Elimination of maintainable assets offers safety and cost benefits.

5.6 Health and safety

5.6.1 A well-designed and maintained culvert should not present a significantly greater risk to life than the open watercourse it replaces.

5.6.2 The features of a culvert that influence the degree of hazard are summarised in Table 5.2 along with some high-level mitigation measures for the Project.

Table 5.2 Risks and mitigation for the Project culverts

Hazard	Risk	Mitigation
Size	Risk of blockage for small culverts.	The culverts would be large enough to secure a free-flowing state and to minimise the risk of blockage. [RDWE013]
Confined space	Risk of an accumulation of noxious or inflammable gas, or such gases could be released by stirring up sediment in the invert.	To mitigate this risk, maintenance operations would generally be undertaken without entering the culvert (e.g., jet-washing and closed-circuit television (CCTV) inspections). If there is a requirement for maintenance personnel to enter the culvert, the provisions of DMRB CS 450 (Highways England, 2020d) would be followed.

Hazard	Risk	Mitigation
Location	A culvert entrance that is near to a residential area but cannot be seen by passers-by is likely to attract children.	The Project culverts would not be located near any residential areas or schools.
Full flow	A culvert with a tendency to flow full in floods is potentially more hazardous because anyone swept into it may drown.	Culverts would be large enough to allow extra capacity during an extreme flood event. A minimum of 600mm freeboard would be secured, between the 1% AEP event flood level (inclusive of climate change) and the culvert soffit. [RDWE013]
Sharp bends	Sharp bends may reduce the hydraulic efficiency and increase the risk of debris getting trapped.	Culverts would be linear and bends at the inlet/outlet of the culverts would generally be avoided. However, if bends are unavoidable, long gradual bends would be adopted instead of sharp bends.
Personnel access to culvert entrances	Steep watercourse banks or highway embankments may present slip/fall hazard for maintenance personnel.	Safe access to culvert entrances would be provided by including stairways for slopes greater than 1 in 10.

5.7 Performance requirements

5.7.1 It is important to ensure that a culvert's performance requirements would be addressed as part of the design process. There are seven fundamental performance requirements:

a. Hydrology and hydraulics

b. Whole-life cost and carbon

c. Safety

d. Environment and geomorphology

e. Structural performance

f. Conveyance of debris

g. Constructability

5.7.2 These requirements would be addressed together to ensure the optimum culvert performance. Culvert performance requirements are summarised in Table 5.1 'Main considerations and corresponding design parameters' of the Culvert, screen, and outfall manual (C786) (CIRIA, 2019).

5.7.3 Consideration would also be given to maintenance and operations issues at detailed design.

5.8 Culvert alignment

Horizontal alignment

5.8.1 The Project culverts would be oriented to match the existing alignment of the watercourse in order to maintain existing hydraulic conditions, where practicable.

5.8.2 If the watercourse crosses the Project road at an oblique angle, the watercourse may need to be realigned to avoid excessive culvert lengths.

5.8.3 Culverts would generally be linear, but where bends have been deemed unavoidable, long slow bends would be adopted.

5.8.4 Where practicable, culvert alignment would be such that water enters and exits the culvert directly. Where it is not possible to align the culvert with the watercourse, the inlet and outlet would be designed in a way that minimises potential hydraulic problems.

5.8.5 The selected alignment for each culvert would be studied further on site, to make sure that there are no problems that could be readily avoided by minor changes to the line and location of the culvert.

Vertical alignment

5.8.6 The culvert invert should be set below the watercourse bed level. This allows for any future regrading of the watercourse and promotes the formation of more natural bed through the culvert (which helps to maintain ecological continuity).

5.8.7 For pipes, the depth from bed level to pipe invert level should be approximately 25% of the pipe diameter. For structures (box culverts), the bed depth should not be less than 150mm.

Mammal passage

5.8.8 All culverts would include a mammal ledge or dry culvert (overpass). [RDWE044]

5.8.9 Ledges would be a minimum 500mm wide with a minimum 600mm headroom to the soffit of the culvert and set at an appropriate level so that both the section in the culvert and the approach links remain dry for the majority of the time and are easily accessible from the watercourse bank, all in accordance with the recommendations of CIRIA C786 (2019)[6].

5.8.10 Dry culverts would be a minimum 600mm in diameter and set at a level above the 1 in 100-year flood level with allowances for climate change, all in accordance with the recommendations of CIRIA C786 (2019).

5.9 Maintenance considerations

5.9.1 Culverts would be inspected and maintained in accordance with the following documents [RDWE014]:

[6] CIRIA C786 (2019) does not specify what constitutes an appropriate level. For design purposes, mammal ledges would be set at 150mm above the 1 in 100-year storm event level with allowances for climate change.

a. DMRB GM 701: Asset delivery asset maintenance requirements (Highways England, 2020e)

b. DMRB GS 801: Asset delivery asset inspection requirements (Highways England, 2020f)

c. DMRB CS 450: Inspection of highway structures (Highways England, 2020d)

5.9.2 Lay-bys, access tracks and ramps, and working areas would be provided to facilitate maintenance of culverts.

5.9.3 Culverts would be accessible from both upstream and downstream where practicable.

5.9.4 Access/inspection chambers would be installed at suitable intervals where practicable.

5.9.5 Jet washing would generally be used for removal of sediment from culverts. Jet washing would not be undertaken between April and July, particularly for West Tilbury Main culverts, since elvers are likely to be found in the river during this period. Prior to jetting, a CCTV survey may be carried out to assess the work required and identify any potential defective areas. It should be noted that a small amount of sediment might be acceptable[7], or even beneficial, since it could provide a dry route for wildlife migration in low flow conditions.

5.10 West Tilbury Main culverts

Crossing at X-EFR-2-01

5.10.1 A technical note (TN) regarding the West Tilbury Main culvert design in relation to fish has been produced by the Project ecology team. The TN outlines current information on culvert design in relation to fish and provides a view on the proposed design for the West Tilbury Main culvert. A copy of the Technical Note is appended in Annex B. The TN concludes that it would be important to replicate the current hydraulic conditions of the existing river channel through the proposed culvert. This would facilitate the passage of the existing fish community (eels and minor fish species). [RDWE030]

5.10.2 There appears to be insufficient evidence to suggest that the length of the culvert would prevent fish migration; water depth, velocity (especially for elvers) and resting areas are much more important factors.

5.10.3 There is some evidence to suggest breaking up the light/dark interface at both the entrance and exit of the culverts is beneficial in encouraging fish migration. Some form of planting or screening to help break up any harsh light/dark interface would be considered in the design. [RDWE021]

5.10.4 EFR-2-01 would be partially submerged at its downstream end to prevent perching. [RDWE031]

5.10.5 A resting pool for coarse fish would be provided immediately downstream of the culvert, with a minimum depth of 300mm. [RDWE031]

[7] The determination of what is acceptable would be part of the performance assessment process.

Removal and alteration of culverts

5.10.6 Two existing culvert crossings on West Tilbury Main would be removed and one culvert crossing would be altered.

a. The existing culvert crossing immediately to the west of the Project road comprises a 1,000mm diameter pipe. On account of the size of this culvert, flow through West Tilbury Main is restricted. To improve the flow, the size of this culvert would be increased. The cross section of the new culvert crossing would match that of X-EFR-2-01. [RDWE046]

b. The two existing culvert crossings immediately to the east of the Project road would be removed. These two culverts would not be required during the operational phase of the Project and removing them will improve channel hydraulics and eliminate two maintainable assets. [RDWE046]

6 Hydraulic Structure S-EFR-2-01

6.1.1 To improve the West Tilbury Main flood flow path, the existing culvert to the west of the Project road would be enlarged (X-EFR-2-02) and two existing culverts immediately to the east of the Project road would be removed. These changes would result in an increase in conveyance through West Tilbury Main. [RDWE046]

6.1.2 As part of the flood mitigation strategy, the increase in conveyance resulting from large storm events would be controlled by establishing a flow control structure on West Tilbury Main (S-EFR-2-01). To fulfil the mitigation strategy, this control structure would also need to mimic the pre-development hydraulic behaviour of West Tilbury Main for lower return period flood events (i.e., up to the peak 2year return event). [RDWE046]

6.1.3 A two-stage structure that can mitigate the impacts of larger events, whilst not changing the hydraulic behaviour during smaller events was designed and tested using the hydraulic model (see Part 5 of the FRA). The two stages would comprise a notch to deal with flows from small events, beneath a wider opening to control flows from larger events.

6.1.4 The notch and opening would be formed in a galvanised mild steel (GMS) plate, or similar, which would form the primary part of the flow control structure.

6.1.5 An overpass pipe would be installed around the structure to enable safe passage of mammals. [RDWE044]

6.1.6 Using a GMS plate to form the required cross section would enable changes to be made to the channel profile in the future, should the need arise (futureproofing).

7 Summary and conclusions

7.1.1 The Project would involve 15 main watercourse crossings.

7.1.2 The Project would include 13 main watercourse diversions. Diversion of watercourses is regarded as a last resort and would be avoided where practicable.

7.1.3 Four hydraulic structures would be included in the Project. These structures will regulate flow through West Tilbury Main, flow from the Mardyke Wetland to the Mardyke (in two locations) and flow from the Coalhouse Point Wetland to an unnamed watercourse.

7.1.4 In addition, it is proposed to recharge the Coalhouse Point wetland using brackish water from the River Thames. This may be delivered via a self-regulating tidal gate or equivalent structure within the existing flood bund at Coalhouse Point.

7.1.5 Clear span bridges (viaducts) for crossing main rivers and ordinary watercourses would be used wherever practicable.

7.1.6 Where watercourse culverting and diversions cannot be avoided, best practice guidance on culverting and diverting watercourses would be followed.

7.1.7 There would be a net increase in length of watercourse channel of approximately 4.9km across the Project. However, the increase in channel length should be regarded as indicative as this figure does not take account of the size or biological diversity of individual watercourses.

7.1.8 There would be a net increase length of watercourse in culvert of approximately 475m across the Project. The increase in length of watercourse in culvert should be regarded as indicative as this figure does not take account of the size or structural form of the culvert.

7.1.9 Works would be subject to the necessary consents from the Environment Agency and Lead Local Flood Authorities as appropriate.

References

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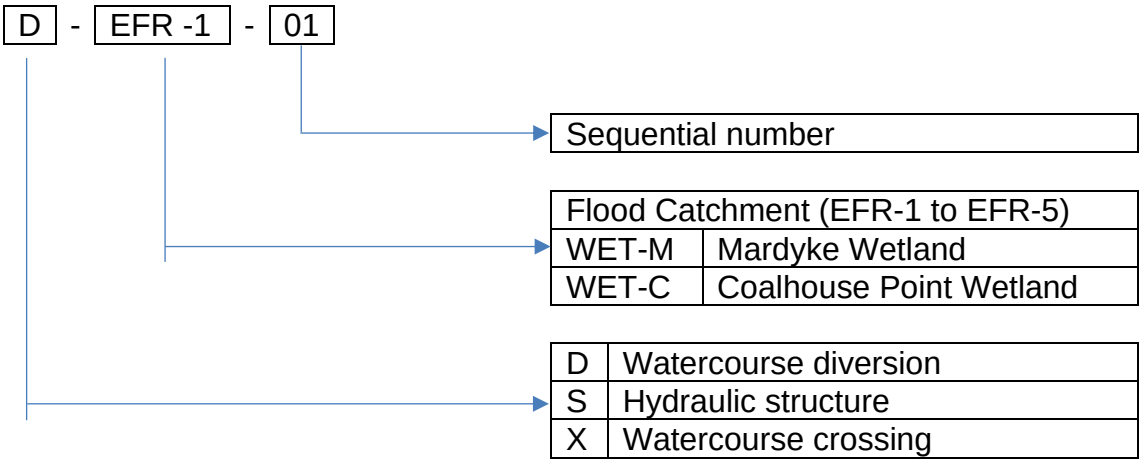
Appendices

Appendix A Identification Codes

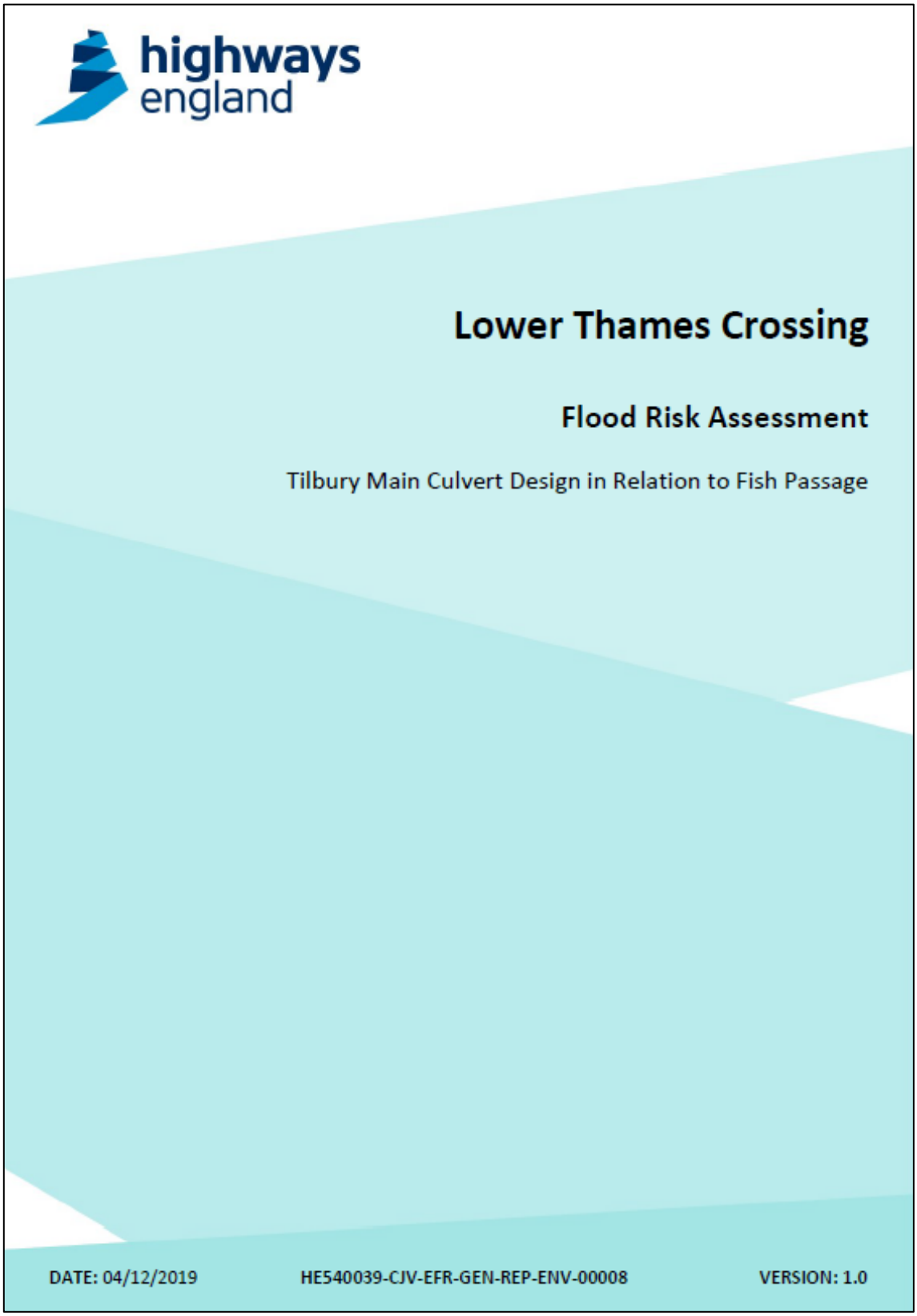
A.1 Form and structure

A.1.1 For the purposes of the FRA, the identification of crossings, diversions and hydraulic structures is portrayed by type of feature and by the flood catchment in which it lies.

A.1.1 The form and structure of the identification is set out below.



Appendix B Tilbury Main Culvert Design in Relation to Fish Passage



highways england

Lower Thames Crossing

Note on Tilbury Main culvert design in relation to fish passage

1 Introduction

This note outlines current information on culvert design in relation to fish and provides a view in the context of fish, on the proposed design for the Tilbury Main culvert. The note has drawn on available literature and includes reference to recent project examples where appropriate.

2 Guidance in relation to fish and culverts

It is suggested that the implementation of culverts can result in a reduction in biodiversity at sites, restrict the migration of certain fish species, whilst increasing the risk of flooding through blockages (IFM, undated).

Successful fish passage through culverts requires adequate swimming space, water depth and appropriate water velocities with no physical or behavioural barriers within the culvert. Many of the concerns in relation to fish can be avoided by implementing the follow general guidance (IFM, undated) which includes:

- Matching the culvert gradient to that of the existing watercourse. Any differences are likely to result in unacceptable hydraulic conditions at the head or tail of the culvert. The most common problem is at the downstream end where excessive erosion can occur, resulting in perching of the culvert.
- Drowning the downstream end of the culvert to a depth of at least 0.15-0.30m.
- Provision of a resting pool of sufficient size and depth immediately downstream of the culvert, with a minimum depth of 30cms for coarse fish. In some instances, a resting pool may also be required upstream as well.
- Aligning the culvert with the water course, i.e. no immediate change in direction at the head or tail of the structure. This minimises the length of culvert and provides a more stable hydraulic regime at the inlet and outlet. It does not necessarily prevent moving the watercourse.
- Ensuring that the approach conditions are within the cruising, i.e. sustained, swimming speed of the target fish species.
- Avoiding sharp light/dark interfaces at the culvert entrance and exit. Fish can be reluctant to pass a sudden change, and this can be avoided, for example, by the judicious planting of vegetation.
- Provision of low flow channel to provide sufficient depth to permit passage during lower flows.
- Use of culverts with a high roughness coefficient to encourage boundary layer effects. Where culverts are used there are various configurations that may be considered. In order of preference for fish passage these are: bottomless-arch culvert retaining the natural

stream bed; culvert with a depressed invert to permit natural stream-bed materials to lie on the bed and sufficient depth of water in which fish can swim etc; provision of a low flow channel and; provision of baffles within the culvert.

3 Tilbury Main considerations

The fish species assumed to be present in the Tilbury Main are European eels and coarse fish such as roach, dace and minor species. Adult eels migrate down rivers and out to sea to spawn, and the juveniles (elvers) migrate back up the rivers. Adult coarse fish migrate between river reaches to locate suitable spawning sites, whilst juveniles disperse actively and passively to suitable feeding areas (CIRIA, 2010).

The assumed species assemblage suggests that the required hydraulic conditions in the culvert need to be as a minimum (IFM, undated):

- flows less than 0.5 ms^{-1} for coarse fish (<25 cm in length)
- water depth of at least 0.1 m

There is a lack of data available on the movement of eels through culverts, including information about the maximum flow velocities that will facilitate passage. Due to the poor swimming ability of eels compared to coarse fish, water velocities in the culvert would likely need to be slower, especially for the upstream migration of elvers.

4 Culvert design

There a number of potential modified culvert designs which may facilitate improved fish passage, these include:

- Bottomless-arch culvert- either a bottomless arc culvert (Figure 1) of sufficient width or an oversized box culvert (Figure 2) set well below the bed level (>0.5m) which allows a natural channel form to develop and for sediments to accrete.

Figure 1. Bottomless arch culvert (IFM, undated).

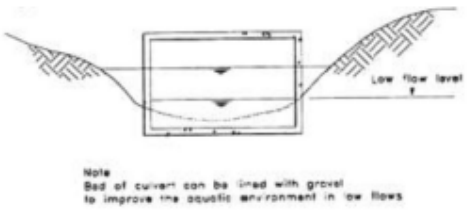


Figure 2. Box culvert set well below the bed level (IFM, undated).

- Low flow channels- low flow channel at the base of the culvert to allow for fish movement during periods of lower flow.

5 Flow considerations

Studies have shown that culverts with homogenous flow and moderate water velocities can impede adult eel movement. The installation of baffles can improve conditions and facilitate passage through culverts (Newbold et al, 2014). Baffles are structures placed on the bed of the culvert which are aimed at improving the flow conditions for fish by slowing water velocities and increasing the depth of water. However, baffles within culverts can trap debris increasing chances of blockages and therefore flooding. Types of baffles include (Figure 3) (Environment Agency, 2010b):

- Weir baffles; usually between 0.15-0.45m in height; used to create roughness. They are not recommended for slopes over 1%.
- Corner baffles; typically used in culverts with slopes between 1-2.5%.
- Notch baffles: particularly useful in wide (e.g. plate-arch) culverts where the slope is between 2.5- 5%. The central length of notch can be zero, thus giving two corner baffles.

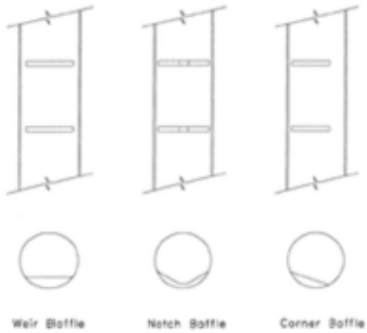


Figure 3. Different baffle designs (Environment Agency, 2010b).

6 Light conditions

A number of regulators have raised concerns with regard to lighting conditions within culverts, and the potential for influencing fish passage. The concerns are two-fold: a lack of light in longer culverts preventing passage altogether; and the light/dark interface at the entrance influencing the willingness of fish to enter a culvert.

One method of potentially addressing the issue of zero light in longer culverts, is using natural light in the form of “chimneys” or “wells” at intervals along the culvert. However, there are no apparent case studies on the effectiveness of light chimneys or wells in improving fish passage in long, dark culverts (CIRIA, 2010) and while many guidance documents advocate the

inclusion of light chimneys, there is no known guidance as to how these would be feasibly incorporated into a box culvert design (Jacobs, 2019).

An alternative to natural light sources, recommended by both the EA and The California Department of Transportation, is to provide artificial lighting in culverts greater than 46 metres, with spaces between light sources not exceeding 23m (Caltrans, 2006). On a recent project on the A96 in Scotland, where culverts greater than 50m in length were planned, the lack of evidence in relation to reduced light levels and fish passage resulted in the omission of light chimneys or artificial lighting in the final design. Instead, vegetation around the inlet and outlet was incorporated into the design to reduce any sudden light/dark interfaces. This position was not challenged by the regulator.

7 Passage aids

One concern from increased flows in culverts is the movement of poor swimming species such as eel. Juvenile eels migrating upstream close to the tidal limit will consist predominantly of elvers (60 to 90 mm) and 1-group fish (90 to 130 mm) (Solomon & Beach, 2004). Most upstream migration takes place between April and September, and although flows will be lower during these months they may still struggle to swim through culverts. Fish pass aids designed especially for eels can be installed. Passes for elvers usually incorporate some form of matrix (Figure 4) (i.e. bristles) where migration through the pass is made by crawling and climbing instead of swimming (Solomon & Beach, 2004).

Figure 4. Bristle eel pass (Environment Agency, 2011).

8 Discussion

In the context of the Tilbury Main it will be important to replicate the current hydraulic conditions of the existing river channel through the proposed culvert. This will facilitate the passage of the existing fish community, be that eels and/or coarse fish. Conditions that also encourage the establishment of natural bed habitat should also be considered.

There appears to be insufficient evidence to suggest that the length of the culvert would prevent fish migration- water depth, velocity (especially for elvers) and resting areas are much more important factors.

There is some evidence to suggest breaking up the light/dark interface at both the entrance and exit of the culverts is beneficial in encouraging fish migration. Some form of planting or screening to help breakup any harsh light/dark interface should be considered in the design.

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