

# Lower Thames Crossing

Technical Appraisal Report

Volume 2: Existing Conditions and Appraisal of Longlist Options

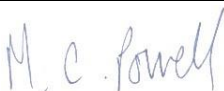
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This report has been prepared for Highways England in accordance with the terms and conditions of appointment stated in the PSF Framework Agreement (Lot 1, 2 and 5 award letters dated 6 April 2011). Halcrow Hyder JV cannot accept any responsibility for any use of or reliance on the contents of this report by any third party.

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| <p>The designs shown and described in this Technical Appraisal Report have been developed for the initial appraisal of options as part of the options phase, and may be subject to change in later stages of the scheme development.</p> |
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## Executive Summary

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For the Executive Summary refer to Volume 1 of this Technical Appraisal Report.

## Preamble

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This Technical Appraisal Report (TAR) describes the engineering, traffic, economic, safety, environmental, and operational appraisals of the longlist options for the Lower Thames Crossing (LTC) carried out to identify the shortlist of options. The information included is therefore what was available at that time and the level of detail, design and development of the route options is what was necessary and appropriate for the different stages of appraisal undertaken to identify the shortlist (refer to sections 1.3, 5.6, 5.7, 5.8 and 12 for details of the stages of appraisal).

The TAR is structured in three volumes as follows:

- i) Volume 1 Executive Summary
- ii) Volume 2 Existing Conditions and Appraisal of Longlist Options
- iii) Volume 3 Appendices

The structure of this volume of the TAR is as follows:

- Section 1 is the introduction and sets out the background to the scheme, summarises previous studies and the approach to the appraisal and sets out the planning brief.
- Section 2 sets out the existing conditions in the study area including: description of the locality, existing highway network, traffic, accidents, land use, industry, climate, drainage, geology, mining, public utilities, traffic control technology, maintenance access, environment, river operations and the Dartford Traffic Management Cell.
- Section 3 summarises future developments in the area including highway schemes, Dart Charge and housing and employment developments.
- Section 4 details the planning factors affecting the development and appraisal of the route options.
- Section 5 gives a brief description of all the route options that have been considered during the different stages of appraisal. It also describes how the routes were developed and gives details of the pre-longlist viability check (refer to Section 1.3) and the longlist that was subject to the following stages of appraisal using data reported in Sections 6, 7, 8, 9, 10 and 11.
- Section 6 provides details of the traffic appraisal carried out including details of the traffic modelling and analysis of the traffic impacts of the longlist routes.
- Section 7 sets out the estimated costs of the longlist options and gives details of how those costs were assessed.
- Section 8 gives order of magnitude construction programme durations for the longlist options.

- Section 9 provides the results of the economic appraisal of the longlist options and for comparison purposes also summarises the results of the economic appraisals of options from the previous AECOM study (refer to sections 1.1.3 and 5.1.2 for details of these options).
- Section 10 sets out the results of the environmental appraisal of the longlist options for the following topics: townscape/ landscape, historic environment, biodiversity, water environment, air quality and noise.
- Section 11 provides a high level engineering appraisal of the longlist options considering: buildability and construction, safety, operations, maintenance and repair and traffic control technology.
- Section 12 gives details of the results of the two stages of appraisal of the longlist (refer to section 1.3) using data from the appraisals set out in sections 6, 7, 8, 9, 10 and 11 and the reasons for not selecting route options for the shortlist.
- Section 13 summarises the stakeholder engagement undertaken to date.
- Section 14 describes the shortlisted routes in more detail.
- Section 15 includes the Appraisal Summary Tables for the shortlisted routes.
- Section 16 is the conclusions and recommendations and confirms the route options on the shortlist which will be subject to the more detailed appraisal that will be reported in the Pre-Consultation Scheme Assessment Report.
- Section 17 provides a glossary of terms used in the Technical Appraisal Report.
- Section 18 provides a list of documents referred to in the Technical Appraisal Report.
- Section 19 is a separate volume of appendices (TAR Volume 3).

# 1 Introduction

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## 1.1 Background

- 1.1.1 The original Dartford-Thurrock river crossing was opened in 1963 and was a single tunnel with an additional tunnel added in 1980. In 1991 the Queen Elizabeth II (QEII) Bridge was opened, with northbound traffic using the tunnels and southbound traffic using the bridge. This arrangement provides four lanes of traffic flow in each direction. In November 2014 Dart Charge, a free-flow electronic number plate recognition charging system, was introduced. This aims to improve the flow of traffic with the system becoming fully operational in June 2015. This system still permits a toll to be collected but does not involve the manual collection of tolls at toll booths.
- 1.1.2 The existing crossing suffers from significant congestion which has an impact on the surrounding road network. A number of studies have been commissioned in recent years by the Department for Transport (DfT) and the affected authorities: Kent County Council, Essex County Council and Thurrock Council. Over the course of these studies, a number of options for providing additional crossing capacity in the lower Thames area have been identified.
- 1.1.3 In 2009 the DfT commissioned consultants Parsons Brinckerhoff to carry out a study to look at options to relieve congestion at the Dartford-Thurrock river crossing. The study identified six possible locations and concluded that three options (A, B and C) offered the greatest benefits in terms of relieving congestion at the existing crossing and should be assessed further. The DfT appointed consultants AECOM in 2012 to investigate these options for a new Lower Thames Crossing. Following this assessment and a public consultation period (between May and July 2013) in December 2013 the DfT announced that there are sufficient grounds to disregard Option B. **Figure 1.1** shows the timeline of studies and option development.
- 1.1.4 The Secretary of State for Transport announced on 15 July 2014 the government's response to the May 2013 consultation on options for a new Lower Thames Crossing. The response confirmed that there is a need for a new crossing, that there is currently no clear preference on its location and that further work will be carried out to develop and appraise route options for both Locations A and C before choosing where to site a new crossing. Location A is at the existing crossing and Location C is a new route connecting the A2/ M2 near Gravesend with the A13 and M25 north of the Thames including C<sub>Variant</sub>, an improvement of the connection between the M20 Junction 6 and the M2 Junction 3. The response also stated that the government expects to consult on a proposed solution in late 2015 or early 2016.
- 1.1.5 In June 2014 Halcrow Hyder Joint Venture (HHJV) was appointed by Highways England to develop the scheme through the options phase of the project, including route option identification and selection. In the first three months HHJV collected reports and data from previous studies and work relevant to the scheme to obtain an appreciation and understanding of work carried out to date, key findings and risks.



The findings of the review established that previous studies had developed route options to a coarse level of detail, sufficient to determine feasibility and make initial assessments of environmental impacts, scheme costs and support an initial economic appraisal. Refinement and optimisation of engineering was limited. Data on which the assessments were based was predominantly determined through desk studies. **Appendix 1** discusses the route options considered in these studies and the outcome of their assessment.

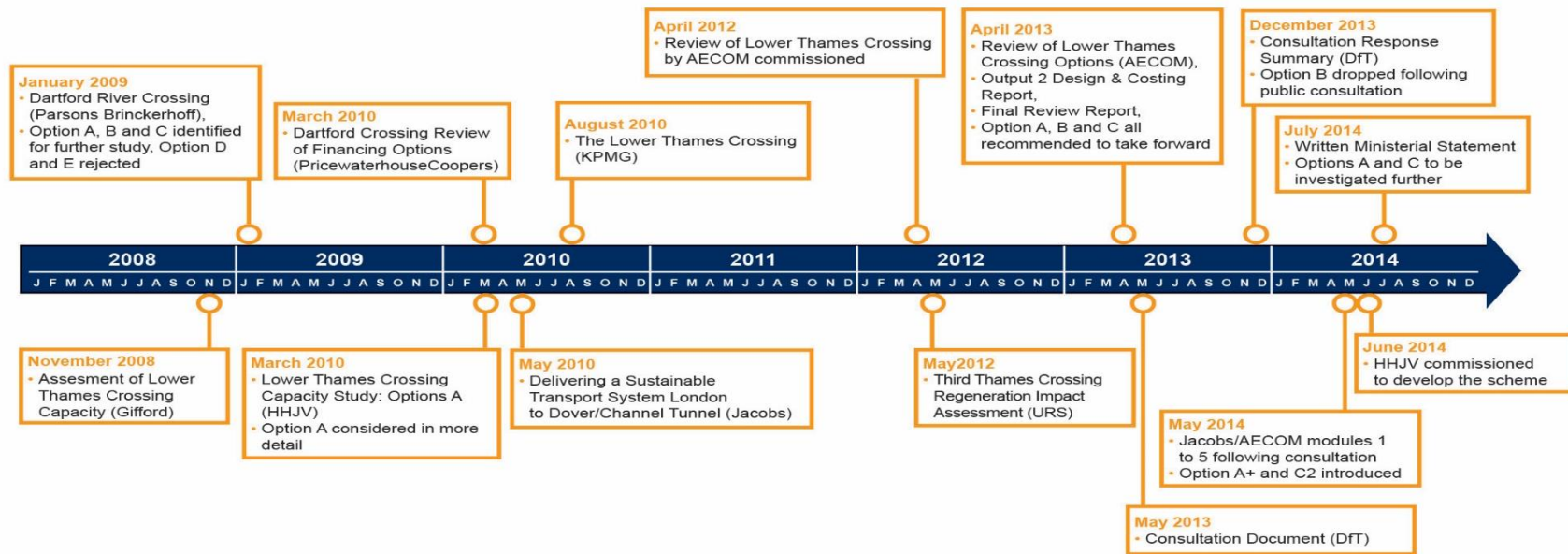


FIGURE 1.1 - TIMELINE OF STUDIES AND ROUTE OPTIONS DEVELOPMENT

## 1.2 Purpose of the Report

- 1.2.1 This report is produced as part of Highways England Project Control Framework (PCF) process during the Stage 1 (Route Option Identification) and included in the documentation reviewed at Stage Gateway Assessment Review 1 (SGAR 1) to agree the progress of the project to the next stage. The Technical Appraisal Report (TAR) brings together the engineering, traffic, economic, safety, environmental, and operational appraisals that form the basis of identifying which route options should be taken forward as the shortlist for consideration in the Scheme Assessment Report (SAR) PCF Stage 2 (Route Option Selection) to be reviewed at SGAR 2.

## 1.3 Appraisal Approach

- 1.3.1 The approach taken to the Stage 1 Options Identification and Stage 2 Options Selection process on Lower Thames Crossing (LTC) is shown in **Figure 1.2** below. The red arrow indicates the current stage i.e. completion of the appraisal of the longlist.



FIGURE 1.2 - OVERVIEW OF OPTIONS SELECTION PROCESS

- **Viability Check.** A list of route options has been developed for Locations A and C. Route options which performed poorly against the scheme objectives (as set out in the Client Scheme Requirements (refer to **Appendix 2**)) or were considered unviable (e.g. due to not being technically viable or having unacceptable environmental impacts) were not selected for the longlist (refer to sections 5.6, 5.7 and 5.8).
- **Appraisal of longlist.** A coarse appraisal of the longlist of route options has been undertaken. This appraisal was undertaken in two stages (refer to Section 12). The results of the coarse appraisal and the resulting shortlist of route options are described in this Technical Appraisal Report.
- **Appraisal of shortlist.** A more detailed engineering, traffic, economic, safety, environmental and operational appraisal of the shortlist route options will be undertaken and described in the Pre-Consultation SAR.
- **Public Consultation on options and proposed scheme.** Those shortlist routes that perform satisfactorily against the scheme

objectives and are considered viable, will be presented at public consultation. This will include the proposed scheme, being the route that Highways England considers to perform best overall. Following public consultation, a Preferred Option will be determined taking account of this appraisal and the responses to the public consultation. This will be reported in the Post-Consultation SAR which will also include the public consultation report.

- 1.3.2 This approach differs from the standard Project Control Framework (PCF) guidance, and has been agreed with the Highways England PCF Manager (refer to **Appendix 3**).
- 1.3.3 This report summarises all route options that have been considered in Locations A and C (including C<sub>variant</sub>). The report recommends the shortlist, which will be assessed in detail in Stage 2: Route Options Selection. At this stage a coarse level of appraisal has been carried out, sufficient to determine a route in terms of technical feasibility whilst taking account of the environmental and physical constraints including known planned developments. A number of the route options considered have not been selected and the reasons for this are explained in this report. The report includes schematic plans of all the route options considered, including for completeness those that have not been selected, and more detailed plans of the route options recommended for further appraisal for inclusion in the shortlist.

## 1.4 Planning Brief

- 1.4.1 The Planning Brief for the LTC is set out in the Client Scheme Requirements version 2.8 dated February 2015 included in **Appendix 2**. The scheme is defined as a nationally significant infrastructure project (NSIP) and will seek development consent under the provisions of the *Planning Act 2008*.

### Client Scheme Requirements

- 1.4.2 The Client Scheme Requirements project description provides a summary of the scheme location, challenges and issues that could influence the feasibility of a solution. In addition, the strategic case section of the Client Scheme Requirements sets out the need to provide additional capacity, improved resilience, support jobs and economic growth, minimise environmental impact and improve road safety on the road network sections covered by this scheme. It describes the route options to be assessed as well as specifying a number of transport, charging and environmental objectives that are to be achieved.
- 1.4.3 A summary of key objectives is shown below:

#### *Strategic*

- Promote economic growth
- Value for money, affordable, minimise whole life cost
- Funding in full/ part by charging

### *Transport*

- Reduce congestion at Dartford and approach roads, reliable, free-flowing
- Resilient
- Design standard commensurate with ambition and legacy of project
- Provide effective travel demand management (charging and road space management)
- Integrated asset strategy with existing crossing assets
- Safely support public transport and non-motorised users
- Compatibility with Transport for London (TfL) river crossing proposals
- Improve safety for road users

### *Charging and Environmental*

- Cost effective, flexible charging strategy
- Minimise adverse impact on health, safety and environment
- Help reduce impact of transport related emissions
- Preserve/ enhance quality of life (urban/ natural environments)
- Conform with UK/ EU legislation (air quality, protected species/ habitats)

## 2 Existing Conditions

### 2.1 Description of the Locality

#### Description of Locality

- 2.1.1 The study area covers a wide area to the east of London along the River Thames estuary running from Dartford to east of Gravesend. There are three Locations A, C and C<sub>Variant</sub> and their locality descriptions are given separately below.

#### Location A

- 2.1.2 This location runs along the route of the M25 and A282 from M25 Junction 2 south of the River Thames to M25 Junction 30 north of the River Thames. The location is primarily urban in nature and dominated by the QEII Bridge and other road and rail routes, including High Speed 1 (HS1), with heavy industries along the riverbank. South of the river there is a combination of residential properties and industrial developments in Dartford whilst north of the river the townscape is more industrial. The Mardyke runs across the location at its northern end just south of M25 Junction 30. There are private jetties on both north and south banks of the River Thames and a number of environmental designated areas.



PHOTO 1 - APPROACH TO DARTFORD CROSSING (SOUTH SIDE)

## Location C

- 2.1.3 This location runs from the A2 south of the River Thames covering an area from east of Gravesend to Higham. The location extends to the A127 north of the river with its western limits at the M25 stretching to Stanford-le-Hope in the east. South of the River Thames the western part of the location lies predominantly within the urban townscape dominated by Gravesend. The eastern part between Gravesend and Higham is green belt crossed by a number of existing roads and railway lines with HS1 in the south and the North Kent railway in the north towards the riverbank. The village of Shorne lies centrally within the green belt and Shorne Woods Country Park, with 288 acres of woodlands, lakes, wetlands and meadows just north of the A2 which runs along the southern limits of this location. There are ecologically designated sites and listed buildings throughout this area. The south and north bank of the River Thames have environmental designated areas of international importance.



**PHOTO 2 - LOOKING NORTH FROM  
SHORNEFIELD ROAD**



**PHOTO 3 - SHORNE WOODS  
COUNTRY PARK INFORMATION  
BOARD**

- 2.1.4 To the north of the River Thames the urban townscape in the western part of this location is dominated by Grays and Tilbury and crossed by a number of existing roads and railway lines. The eastern part is predominantly rural interspersed with villages. The A13 runs west/east and the A127 runs along the northern limits. The landscape is dominated by Tilbury Docks and Tilbury power station along with the associated infrastructure south of the A13. There are green belt areas both south and north of the A13 around the villages of Chadwell St Mary and East Tilbury in the south and South and North Ockendon, Orsett and Bulphan in the north. There are four areas of nationally important ancient woodland: Chadwell Wood, Brickbarn Wood, Brannetts/ Low Well Woods and Hangman's Wood within the study area along with a number of listed buildings and scheduled monuments.





**PHOTO 4 - LOOKING NORTH FROM FORT ROAD**



**PHOTO 5 - TILBURY POWER STATION**

### **CVariant**

- 2.1.5 This location runs along the route of the A229 from M20 Junction 6 to M2 Junction 3. The location predominantly lies within a rural landscape and is almost entirely located within the Kent Downs AONB. The surrounding landscape is of an agricultural nature with the settlements of Blue Bell Hill to the north and Sandling to the south. There are a number of listed buildings, scheduled monuments and the Wouldham to Detling Escarpment SSSI within the location.





PHOTO 6 - BLUE BELL HILL



PHOTO 7 - A229

### 2.1.6 The locations are shown in **Figure 2.1**:

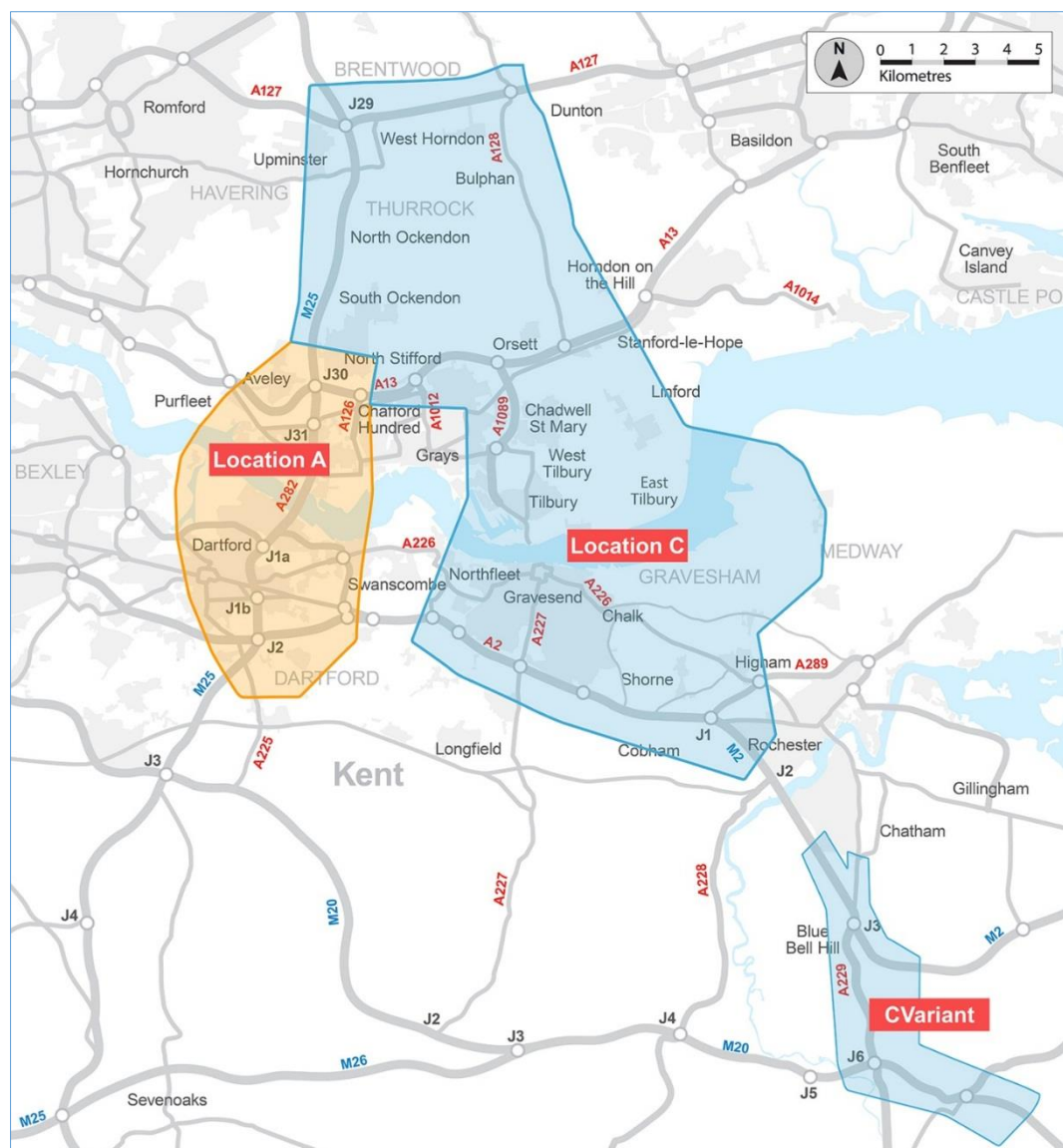


FIGURE 2.1 - LOCATIONS

## 2.2 Existing Highway Network

- 2.2.1 The highway network in the study area is shown in **Figure 2.2**.
- 2.2.2 The A282 forms the Dartford-Thurrock river crossing which is located within the Thames Gateway area, an area recognised as a priority by the Government for redevelopment and growth. The crossing plays an important role in the national connectivity of the strategic road network (SRN) connecting the M25 across the River Thames and provides the only river crossing on the SRN east of London.
- 2.2.3 The existing crossing consists of two bored tunnels for northbound traffic and a bridge for southbound traffic. The crossing serves traffic travelling to and from north of the River Thames to south London, Kent, Sussex and continental Europe via the Kent ports and the Channel Tunnel, whilst also serving local traffic.
- 2.2.4 On the A282 northbound there are three lanes and a hard shoulder through Junction 2, there is a one lane merge from the Junction 2 roundabout northbound on-slip and then a lane gain from the A2 westbound free-flow on-slip. The route then continues at four lanes through Junctions 1b and 1a. At the crossing there are two lanes in each tunnel which continue to the Junction 31 off-slip, with a lane drop. From Junction 31 to Junction 30 there are three lanes and a hard shoulder.
- 2.2.5 On the A282 southbound there are three lanes and a hard shoulder to the Junction 31 on-slip. There is a one lane gain from Junction 31 to provide four lanes on the QEII Bridge which continue through Junctions 1a and 1b. There is a one lane drop to provide an off-slip movement to Junction 2 joining the southbound on-slip from Junction 1b which goes to Junction 2. On the mainline there are three lanes running under the B260 overbridge. The mainline then widens to five lanes with a two lane drop to the A2 eastbound as a free-flow movement. Three lanes and hard shoulder continue on to the M25 southbound.
- 2.2.6 To the south east of the A282 is the A2 which connects into the M2 which provides a link towards the southeast and the M26 and M20 via the A229. The A2 also runs west from Junction 2 towards London.
- 2.2.7 The A2 is a four lane dual carriageway from the A282 Junction 2 to the M2 Junction 1 with 6 grade separated interchanges along this length at Bean (B255), Ebbsfleet (B259), Northfleet (B262) and three junctions for Gravesend with the middle junction connecting with the A227. The M2 then continues south east with four lanes east and westbound, except through interchanges where the number of lanes reduces to three in each direction, to its junction with the A229. The M2 then continues southeast towards Canterbury and Dover.
- 2.2.8 The A289 is a dual carriageway which connects Junction 1 on the M2 through to London Thamesport and Grain power station.
- 2.2.9 To the south of the River Thames there are several single carriageway roads including Lower Higham Road, A226 and Thong Lane. These roads provide a connection between Gravesend and the A2/ M2 and smaller villages including Shorne and Higham.

- 2.2.10 North of the River Thames there are three main A-roads, the A13, A1089 and A127. These roads form strategic commercial connections from the M25 to Tilbury Port and London Gateway Port (DP World) and connections to towns including Basildon, Tilbury, Grays, Corringham, Southend-on-Sea and Canvey Island.
- 2.2.11 East of the M25 the A13 runs west/east with 5 grade separated interchanges along this length at A126, A1012, A1089, A128 and A1014. The carriageway is predominantly dual three lanes between the M25 Junction 30 and the A128 Junction. The section between A128 and the A1014 is a two lane dual carriageway. There are plans to widen this section to three lanes as part of the London Gateway Port (DP World) development. The A13 also runs west from M25 Junction 30 to London.
- 2.2.12 The A1089 is a link between the A13 and Tilbury Port the majority of which is two lane dual carriageway with the southern end a single carriageway.
- 2.2.13 The A127, is an Essex County Council road, located towards the northern limit of the study area, is a two lane dual carriageway linking London to Southend-on-Sea. The A127 runs west and east from M25 Junction 29.
- 2.2.14 To the north of the River Thames there are several single carriageway roads including the A128, Fort Road, Brentwood Road, Orsett Road and Muckingford Road. These roads provide connections between Tilbury and the surrounding urban areas, East Tilbury, Orsett and north to the A127.
- 2.2.15 C<sub>variant</sub> covers the improvements to the A229 and its connections to the M2 at Junction 3 to the north and M20 to the south. Currently, the junction between the A229 and M2 is made through three roundabouts with various connections to local roads. Southbound, the A229 goes over the M2 and follows the downhill topography of the North Downs. At the southern end, it joins the M20 at Junction 6 by a roundabout, passes under the M20 and connects with local roads by another roundabout.
- 2.2.16 The A229 is a two-lane dual carriageway with a climbing lane northbound and additional lanes on approaches to junctions. There are a number of local roads adjacent and crossing the A229 by bridges and underpasses. Bus lay-bys are also present on the A229.
- 2.2.17 Recent Improvements to the network in the study area include the following schemes:
- M25 Junction 27 to Junction 30. Widening generally from three lanes to four lanes, carried out as part of the M25 DBFO. Opened in 2012.
  - M25 Junction 1b to Junction 3. Widening carried out in conjunction with the A2/ A282 Improvement. Opened in 2008.
  - A2/ A282 improvement incorporated viaducts linking A2 westbound to M25/ A282 northbound and M25/ A282 southbound to A2 eastbound, a free-flow slip road for traffic travelling from the A2 westbound onto the M25 southbound, and widening of the A2 from three to four lanes in each direction between the M25/ A282 and the Bean junction. Opened in December 2007.

- M25 Junction 30 Interim scheme. Minor improvements at Junction 30 to accommodate initial additional traffic from the London Gateway Port. Opened in 2013.

2.2.18 The M25 Junction 30/ A13 Congestion Relief Scheme is currently under construction having started in spring 2015. The scheme involves an on-line widening from dual three lanes to dual four lanes in both directions between Junction 30 and A126 Lakeside junction, improvements to Junction 30 slip roads and dedicated left turn lanes from the A13 westbound to the A282 southbound and M25 southbound to the A13 eastbound. The scheme is due to open in 2017.

***Future highway schemes:***

2.2.19 Transport for London (TfL) are consulting on three new river crossings west of the Dartford Crossing which are proposed to be sited at the locations listed below:

- Silvertown tunnel – anticipated to be open in 2022
- Gallions Reach ferry or bridge – potentially opening in 2022-2025
- Belvedere crossing – stated to be unlikely to be built before 2025-2030

2.2.20 Thurrock Council are currently preparing to upgrade the section of the A13 between the A128 junction at Orsett Cock and the A1014 junction from a two lane dual carriageway to a three lane dual carriageway as part of the London Gateway Port (DP World) development.



FIGURE 2.2 - HIGHWAY NETWORK IN THE STUDY AREA

## 2.3 Traffic

- 2.3.1 The section describes the existing traffic conditions, such as traffic flows, journey times, congestion and travel demand at and around the existing Dartford Crossing.
- 2.3.2 The assessment takes account of the implementation of Dart Charge, which aims to improve the flow of traffic and provide congestion relief for the next few years. Whilst the scheme was introduced on 30th November 2014, it is still in a state of transition and became fully operational in June 2015. Therefore to date the full impact of the scheme on traffic conditions has yet to be realised.
- 2.3.3 The assessment also considers how traffic conditions are expected to change by 2025 (the scheme opening year) and 2041 (the scheme design year) in the absence of any LTC scheme, based on the results from the LTC Version 1 (LTC v1) traffic model. This section reflects the Without Scheme option.

## Traffic Flows

- 2.3.4 Around 50 million vehicle trips are made at the Dartford Crossing each year.<sup>1</sup> Daily two-way traffic flows average around 141,000 vehicles per day (vpd) compared to the original design capacity of 135,000 vpd, although since 2003/04 the highest daily throughput each year has always been between 165,000 and 181,000 vpd<sup>2</sup>. This level of traffic has resulted in significant congestion, queuing traffic and an increasing inability to accommodate demand for the crossing.
- 2.3.5 **Figure 2.3** demonstrates the development of capacity and traffic flows over the history of the crossing since it first opened in 1963. It demonstrates that traffic flow growth has halted over the last decade where the crossing is at capacity.

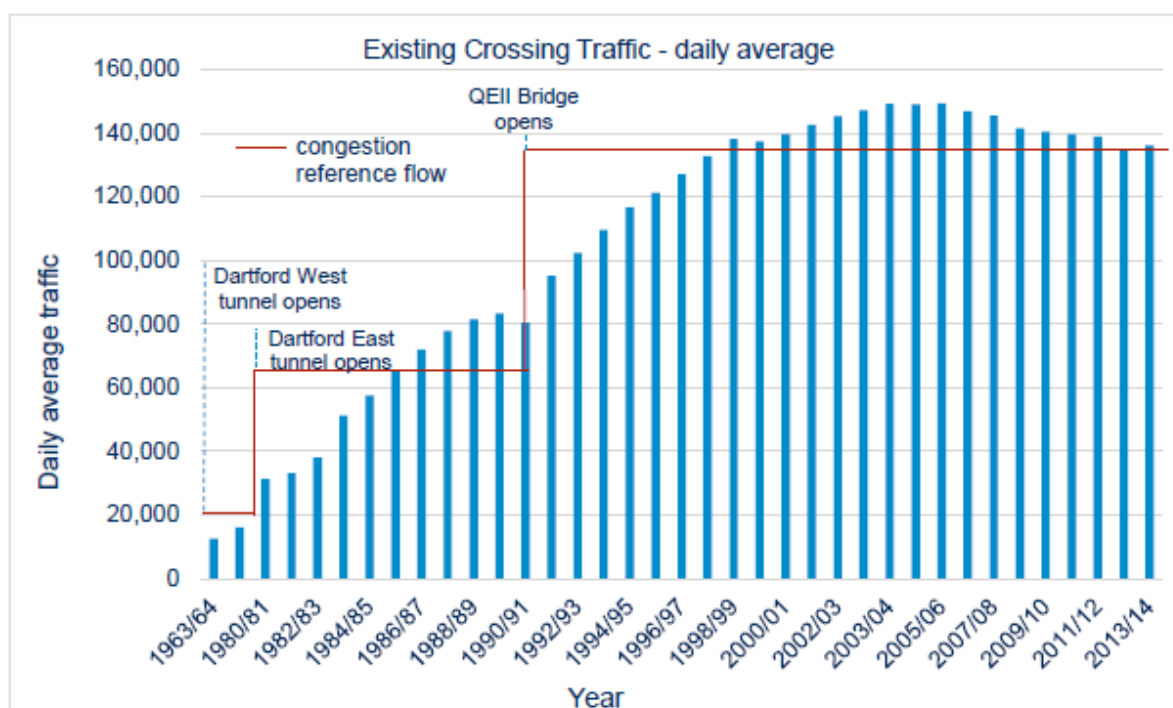


**FIGURE 2.3 - HISTORICAL CAPACITY CHANGES AND DAILY AVERAGE FLOWS AT DARTFORD CROSSING**

### *Flows at the Crossing*

- 2.3.6 **Table 2.1** presents, for the peak periods in both the northbound and southbound directions, hourly capacity, hourly traffic flows and demand, and the ratio of demand to flows for 2009 (the base year for the LTC v1 traffic model) and the modelled years of 2025 and 2041. PCUs are used here as the capacity is necessarily expressed in passenger car units (PCU), where HGVs are weighted at two units reflecting their contribution to traffic movement, thus the capacity may be composed of different levels of cars, LGVs and HGVs. Demand is an estimate of the number of vehicles on the road wanting to undertake journeys - this traffic will get over the crossing but where demand is higher than the capacity and traffic flows, a proportion will

<sup>1</sup> [https://www.gov.uk/government/uploads/system/uploads/attachment\\_data/file/365615/S140375\\_Traffic\\_Flow.pdf](https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/365615/S140375_Traffic_Flow.pdf)

<sup>2</sup> Dartford-Thurrock river crossing: traffic flow data, Annual traffic flow figures for the Dartford Crossing from 2003 to 2014 <https://www.gov.uk/government/publications/dartford-thurrock-river-crossing-traffic-flow>



face greater delays as they are not accommodated by the crossing within an average peak hour.

**TABLE 2.1 - CAPACITY, TRAFFIC PCU FLOWS AND THE RATIO OF DEMAND TO TRAFFIC FLOWS AT THE CROSSING <sup>3</sup>**

| Peak time           | 2009  | 2025  | 2041  |
|---------------------|-------|-------|-------|
| northbound capacity | 5,900 | 5,900 | 5,900 |
| northbound flows    | 5,643 | 5,900 | 5,900 |
| northbound demand   | 5,799 | 6,705 | 7,474 |
| demand: flows       | 103%  | 114%  | 127%  |
| southbound capacity | 6,687 | 6,687 | 6,687 |
| southbound flows    | 5,965 | 6,470 | 6,737 |
| southbound demand   | 6,227 | 6,953 | 7,531 |
| demand: flows       | 104%  | 107%  | 112%  |

- 2.3.7 **Table 2.1** shows that capacity constraints at the existing crossing cause delays for many users and suppress demand. LTC has the potential to release these constraints. **Table 2.1** shows that although more flows are using and being accommodated by the crossing in future years, as a result of the increased capacity provided from the Dart Charge scheme, there is an ever increasing level of demand that is not being met and thus there are further delayed journeys.
- 2.3.8 The breakdown of traffic in 2009 is shown in **Table 2.2**. An increasing share of future traffic is forecast to be HGVs, where the capacity constraint will interact with user demand elasticities. For example, alternatives, such as public transport and different patterns of travel, become more attractive for leisure journeys whilst business travel and freight rely on the crossing for in-time deliveries and efficient operation. This is demonstrated by the vehicle percentage shares using the crossing across the day in 2025 and 2041 as in **Table 2.3** below.

**TABLE 2.2 - HOURLY VEHICLE FLOWS**

| Hourly vehicle flows |              | AM    |       | INTER-PEAK |       | PM    |       |
|----------------------|--------------|-------|-------|------------|-------|-------|-------|
| YEAR                 | USER         | NB    | SB    | NB         | SB    | NB    | SB    |
| 2009                 | HGV          | 720   | 734   | 788        | 842   | 510   | 507   |
|                      | LGV          | 371   | 332   | 372        | 386   | 452   | 376   |
|                      | CAR BUSINESS | 1107  | 813   | 1131       | 1028  | 1039  | 940   |
|                      | CAR OTHER    | 2726  | 2105  | 1902       | 2097  | 3049  | 3636  |
|                      | TOTAL        | 4,923 | 3,985 | 4,193      | 4,353 | 5,050 | 5,458 |

NB = Northbound SB= Southbound

**TABLE 2.3 - PERCENTAGE VEHICLE TYPE**

| Shares |      | AM  |     | INTER-PEAK |     | PM  |    |
|--------|------|-----|-----|------------|-----|-----|----|
| YEAR   | USER | NB  | SB  | NB         | SB  | NB  | SB |
| 2009   | HGV  | 15% | 18% | 19%        | 19% | 10% | 9% |

<sup>3</sup> LTC v1 Strategic Traffic Model, NB AM peak hour, SB PM peak hour. Modelled today = 2009.

| Shares      |              | AM  |     | INTER-PEAK |     | PM  |     |
|-------------|--------------|-----|-----|------------|-----|-----|-----|
| YEAR        | USER         | NB  | SB  | NB         | SB  | NB  | SB  |
|             | LGV          | 8%  | 8%  | 9%         | 9%  | 9%  | 7%  |
|             | CAR BUSINESS | 22% | 20% | 27%        | 24% | 21% | 17% |
|             | CAR OTHER    | 55% | 53% | 45%        | 48% | 60% | 67% |
|             |              |     |     |            |     |     |     |
| <b>2025</b> | HGV          | 17% | 19% | 21%        | 20% | 12% | 11% |
|             | LGV          | 10% | 11% | 11%        | 11% | 13% | 10% |
|             | CAR BUSINESS | 20% | 20% | 26%        | 25% | 20% | 18% |
|             | CAR OTHER    | 52% | 49% | 42%        | 44% | 56% | 62% |
| <b>2041</b> | HGV          | 20% | 23% | 26%        | 23% | 15% | 13% |
|             | LGV          | 13% | 14% | 15%        | 15% | 17% | 14% |
|             | CAR BUSINESS | 19% | 19% | 23%        | 23% | 19% | 18% |
|             | CAR OTHER    | 48% | 44% | 36%        | 39% | 49% | 56% |

NB = Northbound SB= Southbound

2.3.9 The share of car traffic across the three periods of the day is reducing both northbound and southbound in 2025 and 2041 compared to 2009, whilst the HGV and LGV shares are increasing.

2.3.10 Further, **Table 2.4** below presents the growth in vehicle numbers by user type across these periods compared to 2009:

**TABLE 2.4 - GROWTH IN VEHICLE NUMBERS**

| Growth |              | AM        |            | INTER-PEAK |            | PM        |           |
|--------|--------------|-----------|------------|------------|------------|-----------|-----------|
|        |              | NB        | SB         | NB         | SB         | NB        | SB        |
| 2025   | HGV          | 19%       | 32%        | 28%        | 29%        | 22%       | 22%       |
|        | LGV          | 38%       | 59%        | 48%        | 56%        | 48%       | 57%       |
|        | CAR BUSINESS | -7%       | 25%        | 12%        | 31%        | 0%        | 10%       |
|        | CAR OTHER    | -3%       | 17%        | 7%         | 15%        | -3%       | -1%       |
|        | <b>TOTAL</b> | <b>2%</b> | <b>25%</b> | <b>16%</b> | <b>25%</b> | <b>4%</b> | <b>7%</b> |
| 2041   | HGV          | 38%       | 71%        | 53%        | 58%        | 48%       | 53%       |
|        | LGV          | 76%       | 122%       | 93%        | 120%       | 97%       | 118%      |
|        | CAR BUSINESS | -18%      | 27%        | -5%        | 29%        | -7%       | 11%       |
|        | CAR OTHER    | -14%      | 14%        | -10%       | 6%         | -17%      | -9%       |
|        | <b>TOTAL</b> | <b>0%</b> | <b>36%</b> | <b>12%</b> | <b>31%</b> | <b>2%</b> | <b>9%</b> |

NB = Northbound SB= Southbound

2.3.11 **Table 2.4** demonstrates that without LTC, the peak periods can only accommodate very limited growth in northbound traffic, which is composed of only HGV and LGV increases, whilst in the AM periods and inter-peak periods the southbound crossing can accommodate more growth in traffic.

2.3.12 By 2041 there is significant growth in HGV and LGV traffic, whilst car traffic decreases northbound across the whole day and non-business car travel only increases where there is southbound capacity (AM and inter-peak). The shoulder peaks are not modelled explicitly and therefore we are unable to make a judgement on how much of the car traffic is shifting into these one



hour time periods and how much is being deterred from making the journey altogether, given the inter-peak is also experiencing a fall in northbound car traffic.

2.3.13 **Figures 2.4 and 2.5** present average weekday hourly traffic flows (vertical axis) northbound and southbound respectively at the crossing in March 2013, 2014 and 2015 to demonstrate the profile of traffic through the whole day (hours – horizontal axis).

2.3.14 The data, which has been extracted from the Highways England Traffic Data Information System (TRADS), shows that traffic flows have increased southbound during the peak periods and, more recently, during the construction phase of Dart Charge, but that the impact on traffic flows northbound has been negligible.

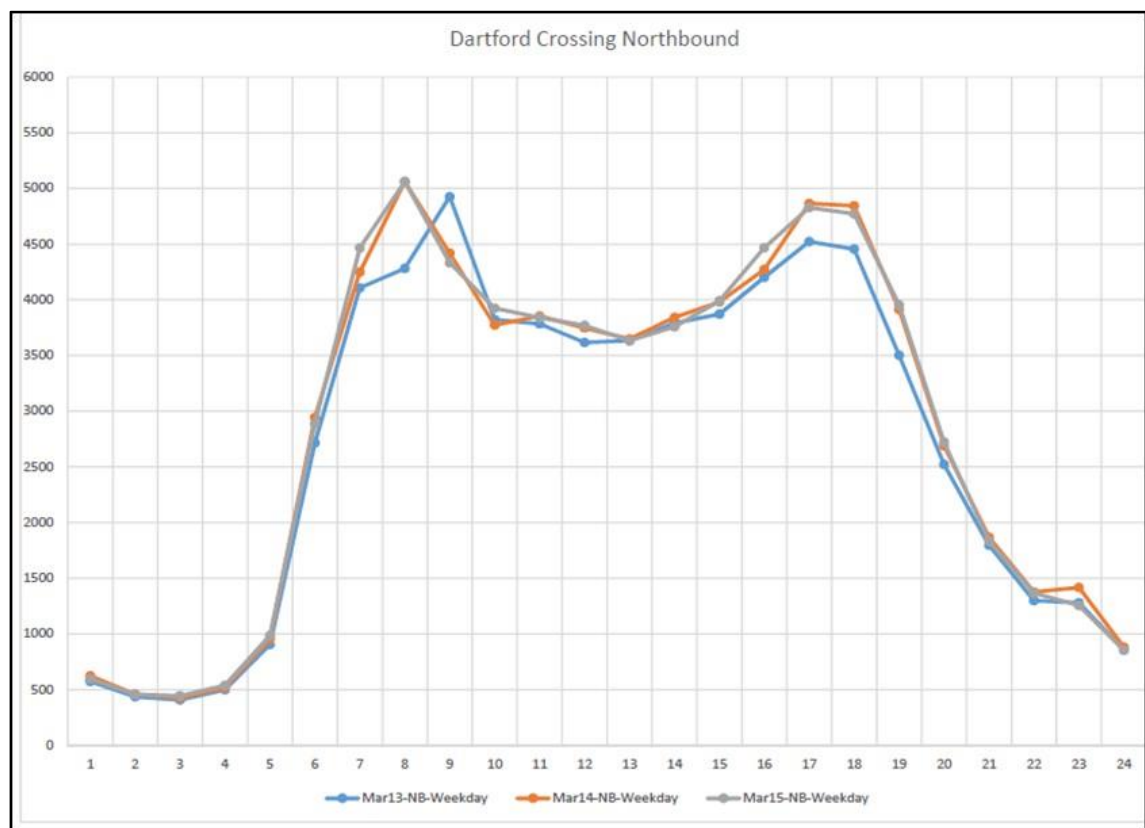


**FIGURE 2.4 - AVERAGE WEEKDAY HOURLY FLOWS AT THE DARTFORD CROSSING NORTHBOUND**

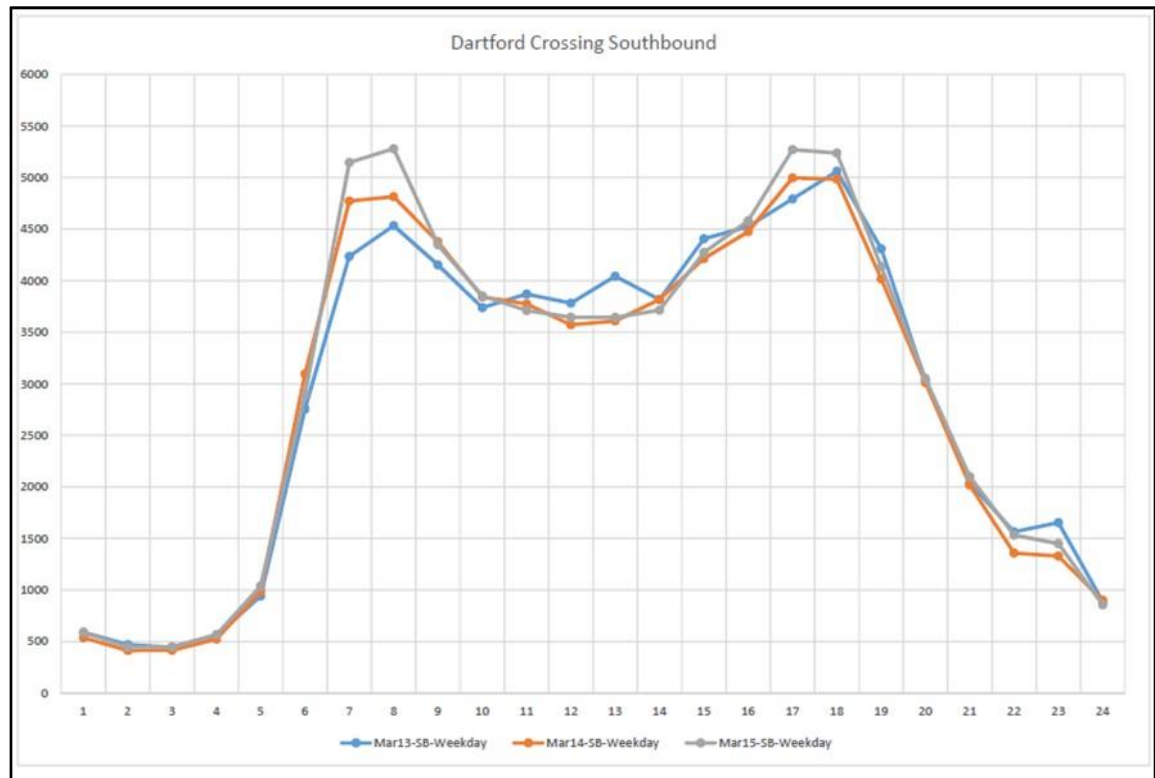


**FIGURE 2.5 - AVERAGE WEEKDAY HOURLY FLOWS AT THE DARTFORD CROSSING SOUTHBOUND**

### *Flows on key links*

2.3.15 It is also important to understand traffic conditions on key road links around the existing crossing and close to the location of the LTC route options. These links were chosen based on the level of current traffic flows, congestion levels and their strategic position within the road network relative to the existing crossing and LTC route options, the links included are:

- Existing Dartford Crossing (D-C)
- A2 west of Junction 2 to the east of A227 junction for eastbound and westbound
- A13 west of Junction 30 to before A176 junction for eastbound and westbound
- M25 Junction 1a - 1b
- M25 Junction 29 - Junction 30
- M25 Junction 3/ 4 - northbound and southbound through Junction 3 and Junction 4
- M25 Junction 6 - 7 - the A22 to Junction 6, and Junction 6 to Junction 7
- A127 - eastbound and westbound from / to Junction 29
- A12 - eastbound to Junction 28, westbound (after the A1023 junction) to Junction 28

- M20 - eastbound and westbound on M20, east of M26 link

2.3.16 **Figure 2.6** below demonstrates where flows and congestion have been measured (solid blue lines) for the included key links, where each link has been assessed in both directions except where shown.

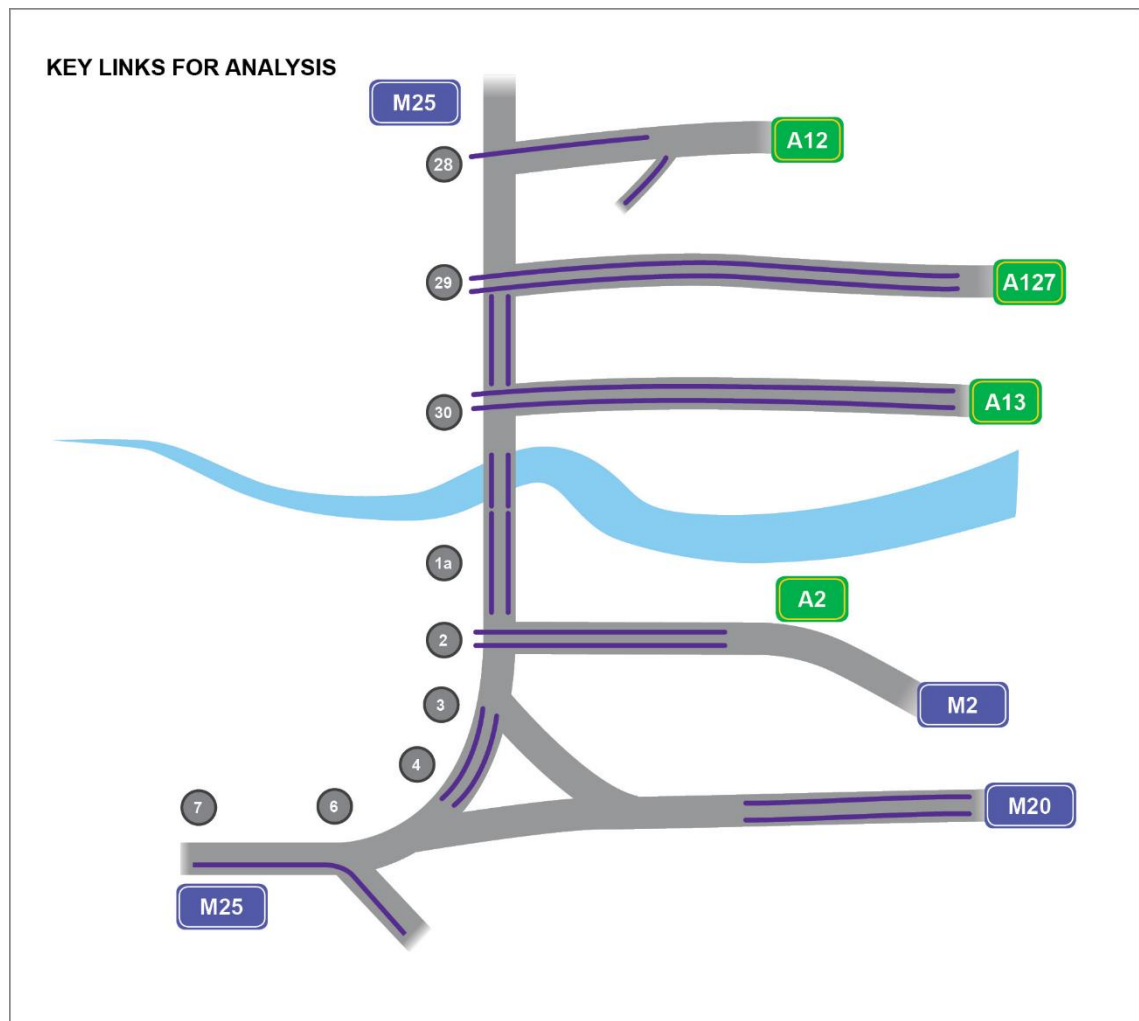


FIGURE 2.6 - KEY LINKS INCLUDED IN ANALYSIS

2.3.17 **Table 2.5** provides traffic flows in 2009, 2025 and 2041 on these key links in the AM, PM and inter-peak periods.

TABLE 2.5 - AVERAGE HOURLY VEHICLE FLOWS ALONG KEY LINKS

2009

| Time Period | D-C<br>N | D-C<br>S | A2<br>EB | A2<br>WB | A13<br>EB | A13<br>WB | J1A<br>N | J1A<br>S | J29-<br>30 N | J29-<br>30 S | J3/4<br>M25<br>S | J4/3<br>M25<br>N | J6-7 | A127<br>WB | A127<br>EB | A12<br>EB | Onto<br>A12 | M20<br>WB | M20<br>EB |
|-------------|----------|----------|----------|----------|-----------|-----------|----------|----------|--------------|--------------|------------------|------------------|------|------------|------------|-----------|-------------|-----------|-----------|
| AM          | 4923     | 3985     | 3291     | 4831     | 2848      | 2823      | 5535     | 4078     | 3675         | 3838         | 4060             | 3885             | 3465 | 3456       | 2702       | 2056      | 3192        | 4108      | 3142      |
| Inter-Peak  | 4193     | 4353     | 3454     | 3214     | 2406      | 2550      | 4402     | 4247     | 3545         | 3632         | 3139             | 3390             | 2456 | 2323       | 2509       | 1536      | 2015        | 2105      | 2478      |
| PM          | 5050     | 5458     | 5675     | 3912     | 3271      | 3460      | 5417     | 5033     | 4333         | 3721         | 4051             | 4137             | 3332 | 3735       | 2987       | 2156      | 2956        | 3573      | 3861      |

2025

| Time Period | D-C<br>N | D-C<br>S | A2<br>EB | A2<br>WB | A13<br>EB | A13<br>WB | J1A<br>N | J1A<br>S | J29-<br>30 N | J29-<br>30 S | J3/4<br>M25<br>S | J4/3<br>M25<br>N | J6-7 | A127<br>WB | A127<br>EB | A12<br>EB | Onto<br>A12 | M20<br>WB | M20<br>EB |
|-------------|----------|----------|----------|----------|-----------|-----------|----------|----------|--------------|--------------|------------------|------------------|------|------------|------------|-----------|-------------|-----------|-----------|
| AM          | 5044     | 4977     | 4390     | 5462     | 4171      | 3392      | 6644     | 5281     | 4858         | 4379         | 5485             | 4167             | 4039 | 3599       | 2998       | 2737      | 3306        | 4900      | 4008      |
| Inter-Peak  | 4845     | 5459     | 4569     | 4140     | 3197      | 3112      | 5883     | 5620     | 4440         | 4972         | 4292             | 4358             | 3110 | 2685       | 2878       | 1832      | 2790        | 2951      | 3282      |
| PM          | 5269     | 5852     | 6016     | 5708     | 3834      | 4731      | 7350     | 6133     | 4544         | 5885         | 4454             | 5560             | 3615 | 3759       | 3500       | 2226      | 3515        | 4454      | 4528      |

2041

| Time Period | D-C<br>N | D-C<br>S | A2<br>EB | A2<br>WB | A13<br>EB | A13<br>WB | J1A<br>N | J1A<br>S | J29-<br>30 N | J29-<br>30 S | J3/4<br>M25<br>S | J4/3<br>M25<br>N | J6-7 | A127<br>WB | A127<br>EB | A12<br>EB | Onto<br>A12 | M20<br>WB | M20<br>EB |
|-------------|----------|----------|----------|----------|-----------|-----------|----------|----------|--------------|--------------|------------------|------------------|------|------------|------------|-----------|-------------|-----------|-----------|
| AM          | 4904     | 5432     | 4680     | 5835     | 4565      | 3665      | 6928     | 5791     | 5369         | 4781         | 5694             | 5485             | 4145 | 3653       | 3244       | 2859      | 3244        | 5104      | 4230      |
| Inter-Peak  | 4695     | 5721     | 4937     | 4678     | 3567      | 3417      | 6054     | 5812     | 4773         | 5415         | 4612             | 4292             | 3435 | 2959       | 3235       | 1976      | 3004        | 3474      | 3811      |
| PM          | 5145     | 5963     | 6092     | 6096     | 4185      | 4669      | 7583     | 6561     | 4963         | 6373         | 4719             | 5780             | 3894 | 3326       | 3837       | 2504      | 3615        | 4754      | 4929      |

2.3.18 Recognising that in DfT's Road Traffic Forecasts 2015, national traffic on the SRN is predicted to grow between 29% and 60% by 2040, these average hourly flows show that between 2009 and 2041 there is:

- A range of positive growth rates across the key links included, some toward or above the upper range of the national traffic forecasts.
- Little change in the northbound crossing, other than an increase in the inter-peak flows to the tunnels' capacity. However, there is quite significant growth in flows using the southbound crossing in the AM and inter-peak from the 2009 base whereby the southbound becomes the dominant crossing flow across the day.
- Significant growth in the A2 westbound in the inter-peak and PM (56%) periods; and the eastbound direction for the AM and inter-peak periods (both around 40%).
- Significant growth in the A13 eastbound AM (60%) and inter-peak.
- Significant growth on Junction 29-30 southbound in the PM (71%).
- Significant growth on the M20 westbound in the inter-peak (65%).

#### *Journey Times*

2.3.19 **Table 2.6** presents average journey times and speeds between M25 Junction 29 and Junction 2 in the AM and PM peaks, in the northbound and southbound directions, using data:

- As recorded in 2015 based on information supplied by Highways England's M25 design, build, finance, operate (DBFO) contractor from the M25 travel time monitoring system (TTMS).
- As predicted in 2041 using the LTC v1 traffic model.

2.3.20 It shows that the average journey time increase between 2015 and 2041 is just under 4 minutes and the average speed reduction is 5.5 mph.

**TABLE 2.6 - AVERAGE JOURNEY TIMES AND SPEEDS BETWEEN M25 JUNCTIONS 29 AND 2**

|                         | 2015 (M25 TTMS) | 2041 (LTC Model) |
|-------------------------|-----------------|------------------|
| <b>NORTHBOUND</b>       |                 |                  |
| AM peak – time          | 17 mins         | 24 mins          |
| PM peak – time          | 21 mins         | 22 mins          |
| AM peak – average speed | 40 mph          | 29 mph           |
| PM peak – average speed | 32 mph          | 32 mph           |
| <b>SOUTHBOUND</b>       |                 |                  |
| AM peak – time          | 14 mins         | 15 mins          |
| PM peak – time          | 14 mins         | 16 mins          |
| AM peak – average speed | 50 mph          | 46 mph           |
| PM peak – average speed | 49 mph          | 42 mph           |

2.3.21 Average times tell one story, however it is important to understand the variability around this, where users are concerned with journey time reliability and the likelihood and length of delays.

- 2.3.22 Using the LTC v1 model estimates for 2009, 2025 and 2041, **Figure 2.7** (AM peak) and **2.8** (PM peak) compare the estimated free-flow times with the increasing delay time and slower speeds, over time, of journeys between M25 Junctions 2 and 30 using the northbound tunnels. The free-flow time is how long the journey would take under those conditions, in effect with the vehicles meeting the speed limit through the road sections. The total time is how long the journey is actually taking, the difference being 'delay time'.
- 2.3.23 **Figure 2.7** shows that the average delay is forecast to increase from just over 3 minutes (191 seconds) in 2009 to over 12 minutes in 2041 (739 seconds). At the same time, the average speed for congested parts of the journey decreases from 58kph down to 31kph.

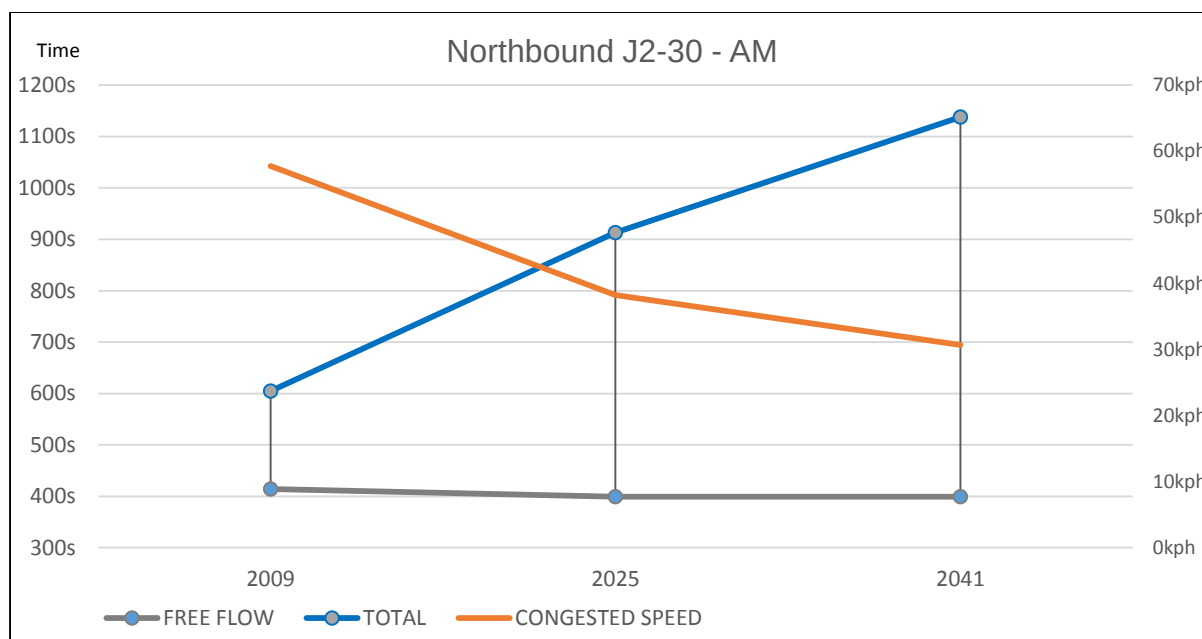


**FIGURE 2.7 - DELAY TIMES AND SPEEDS OF AM NORTHBOUND JOURNEYS BETWEEN M25 JUNCTIONS 2 AND 30**

- 2.3.24 **Figure 2.8** shows that delay times and speeds in the PM period also deteriorate but not quite as drastically as in the AM period.

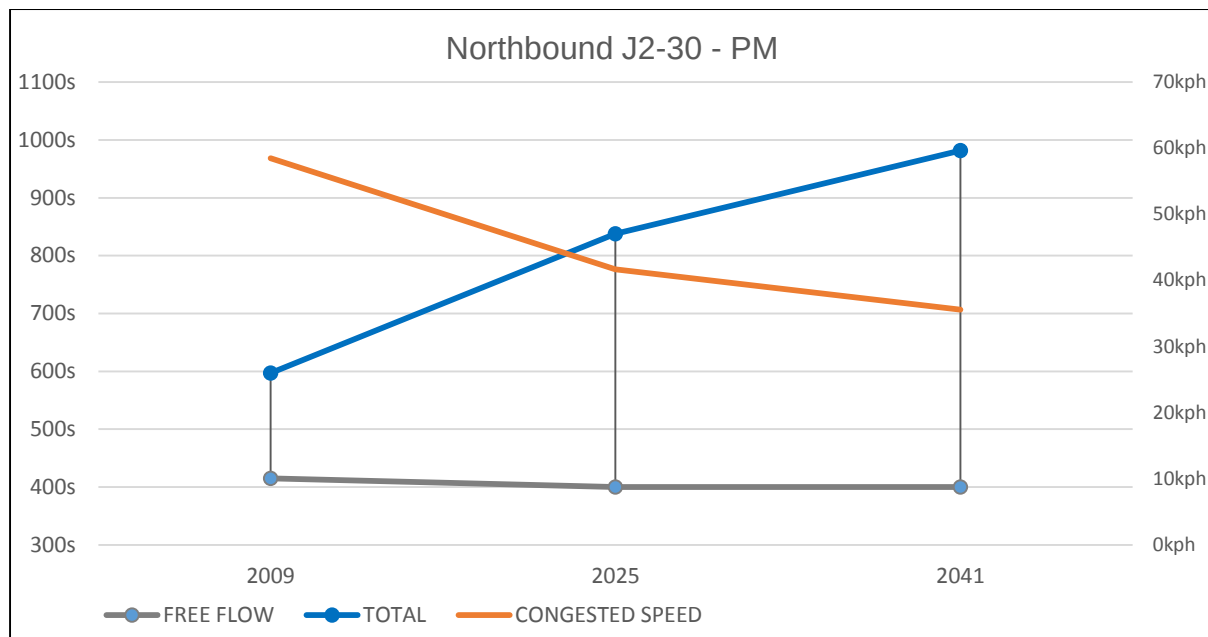


**FIGURE 2.8 - DELAY TIMES AND SPEEDS OF PM NORTHBOUND JOURNEYS BETWEEN M25 JUNCTIONS 2 AND 30**

### Journey Time Reliability

2.3.25 Between October 2011 and September 2012, the crossing was the least reliable section of the SRN. In the year to April 2012 only 60% of northbound journeys and 56% of southbound journeys were completed within the expected time.

Users experience the third highest level of delays across the SRN, with delays in excess of nine minutes experienced by almost half of users travelling in both directions. Highways England forecast that there is an 80% chance of drivers encountering congestion on the crossings and average speeds during peak times is between 21mph and 30mph. **Figure 2.9** shows the frequency of delays (in seconds) by the hour of the day.

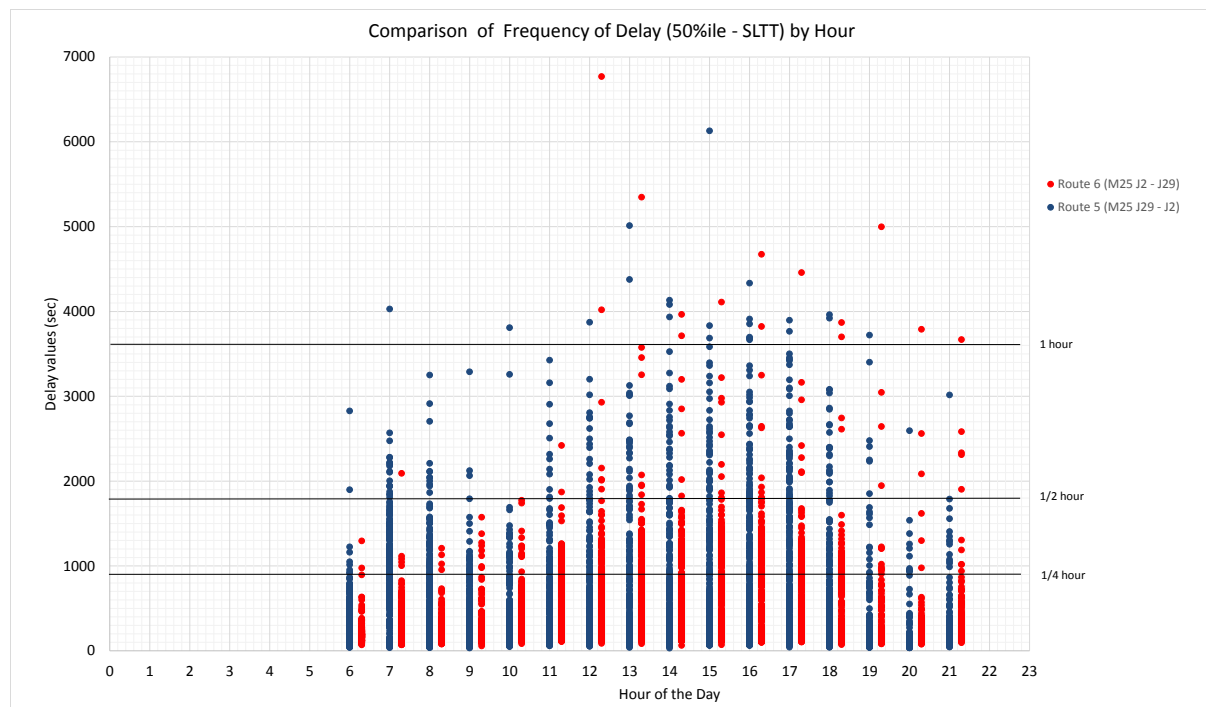


**FIGURE 2.9 - FREQUENCY OF DELAYS FOR JOURNEYS BETWEEN M25 JUNCTIONS 2 AND 30, NORTHBOUND AND SOUTHBOUND**

### *Congestion*

- 2.3.26 The Dartford Crossing, its approach roads and other surrounding roads suffer from some of the highest levels of traffic congestion on the Strategic Road Network. Congestion occurs when traffic levels on a road increase and begin to approach (or even exceed) the capacity of the road and is characterised by slower speeds, longer trip times, and increased levels of vehicle queueing.
- 2.3.27 Using data on two way traffic volumes and road capacity, both expressed in terms of hourly vehicle movements, from the LTC v1 traffic model, we have produced three measures of congestion (metrics) in 2009, 2025 and 2041 in the absence of LTC. The three measures are:
- A wider network area measure of congestion.
  - A measure of congestion at the existing Dartford Crossing.
  - A measure of congestion on key routes around the existing crossing.
- 2.3.28 The three measures are based on the ratio of traffic volumes to road capacity, which is referred to as the Volume over Capacity ratio (V/C) and can be considered as a proxy measure of congestion. The V/C ratio is expressed as a percentage i.e. a V/C ratio of 75% means that the volume of hourly traffic movements is 75% of the hourly movements that can be accommodated by the crossing or a road link. To produce the congestion metrics, the LTC v1 model and a Link Flow tool have been used to calculate V/C ratios for both the AM and PM peak hours in 2009, 2025 and 2041. These V/C ratios are then weighted by the number of trips (vehicle flows) at each link point and by time period, to produce the congestion metrics.



### *Wider network area congestion measure*

- 2.3.29 The V/C data used in producing the three congestion metrics covers an area that extends north/south from the M25 Junction 27 to the M25 Junction 6 and includes surrounding roads associated with the existing and potential future crossings, notably the M11 from Junction 27, the A12, A127, A13, A2 / M2, M20 and A21 (to M25 Junction 5) and M23 (to Junction 7). This allows congestion to be assessed across a wide area surrounding the crossings. The wider area V/C ratios reported below, which are based on all strategic links, northbound and southbound, in the area described above, show that congestion across the network is set to increase over time by 11 percentage points.

| Year | V/C % |
|------|-------|
| 2009 | 50.62 |
| 2025 | 57.85 |
| 2041 | 61.70 |

### *Congestion at the existing crossing*

- 2.3.30 The V/Cs at the Dartford Crossing (reported below) also show increasing levels of congestion over time in both directions. Congestion northbound reaches a saturation plateau (i.e. V/C reaches 100% but then does not increase significantly after that point) in 2025, whilst this does not occur southbound until 2041. V/Cs of over 85% indicate that a link is congested and liable to flow breakdown and delays in peak periods.

|      | Northbound % | Southbound % |
|------|--------------|--------------|
| 2009 | 94.9         | 90.5         |
| 2025 | 101.1        | 93.2         |
| 2041 | 101.2        | 100.4        |

### *Congestion on Dartford Crossing and surrounding key links*

- 2.3.31 The ten key links, listed earlier in Section 2.3.15, were used to show the congestion impact at different key points across the strategic road network at, and in the vicinity of, the Dartford Crossing.

- 2.3.32 **Table 2.7** reports peak time congestion metrics on these key links. The key findings are:

- Current traffic hotspots are the existing Dartford Crossing where both northbound and southbound links are projected to have V/Cs above 100% in 2041.
- The Junction 1a and 1b approach links are likewise heavily congested.
- Other congested routes are A13 eastbound, between Junction 6-7 of the M25, A127 both eastbound and westbound, and the A12 eastbound and A12 approach roads.

- 2.3.33 **Figures 2.10 to 2.12** demonstrate the congestion levels visually across the key links in 2009, 2025 and 2041.

**TABLE 2.7 - PEAK TIME CONGESTION METRICS ON KEY LINKS (V/C %)**

| Option | D-C<br>NB | D-C<br>SB | A2<br>EB | A2<br>WB | A13<br>EB | A13<br>WB | J1A<br>NB | J1A<br>SB | J29-<br>30<br>NB | J29-<br>30<br>SB | J3/4<br>M25<br>SB | J4/3<br>M25<br>NB | J6-7  | A127<br>WB | A127<br>EB | A12<br>EB | Onto<br>A12 | M20<br>WB | M20<br>EB |
|--------|-----------|-----------|----------|----------|-----------|-----------|-----------|-----------|------------------|------------------|-------------------|-------------------|-------|------------|------------|-----------|-------------|-----------|-----------|
| 2009   | 94.9      | 90.5      | 58.7     | 55.9     | 59.1      | 63.4      | 70.9      | 60.2      | 66.8             | 62.7             | 63.4              | 61.5              | 86.2  | 85.6       | 84.9       | 71.0      | 82.2        | 62.0      | 57.5      |
| 2025   | 101.1     | 93.2      | 65.7     | 70.5     | 74.3      | 69.1      | 90.9      | 75.3      | 58.8             | 64.0             | 78.7              | 76.7              | 98.4  | 91.7       | 88.4       | 85.1      | 91.7        | 75.0      | 70.2      |
| 2041   | 101.2     | 100.4     | 68.3     | 76.3     | 81.7      | 69.0      | 96.2      | 83.2      | 65.7             | 70.9             | 84.0              | 82.1              | 104.8 | 89.7       | 92.7       | 92.1      | 94.6        | 81.0      | 75.1      |

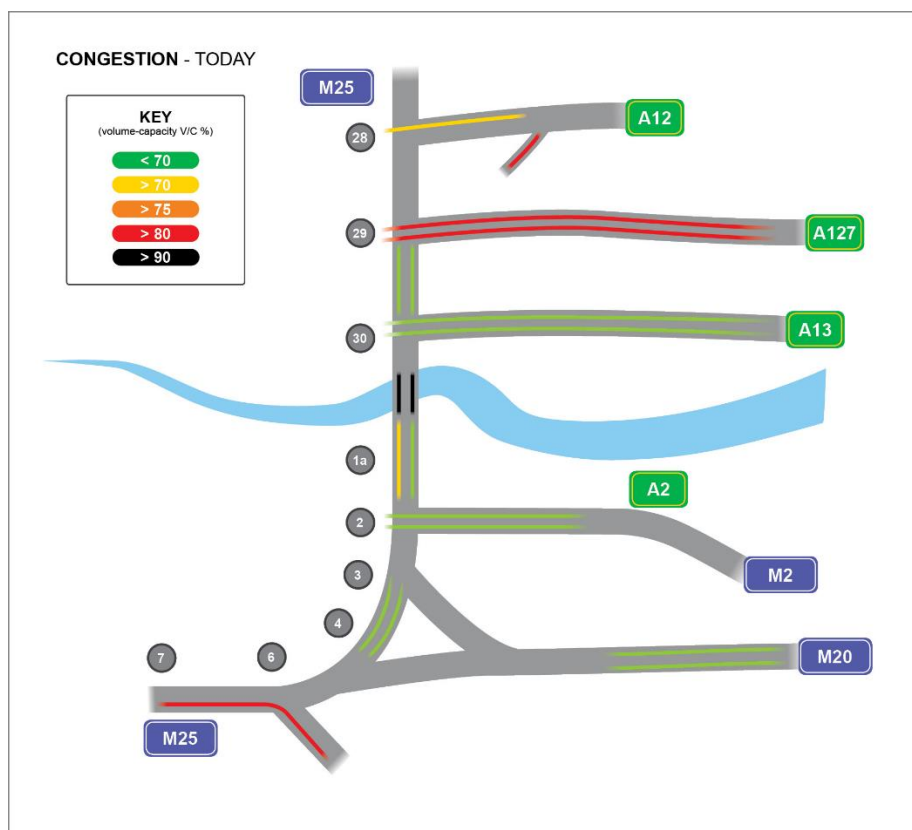


FIGURE 2.10 - CONGESTION ON KEY LINKS - TODAY (MODELLED 2009)

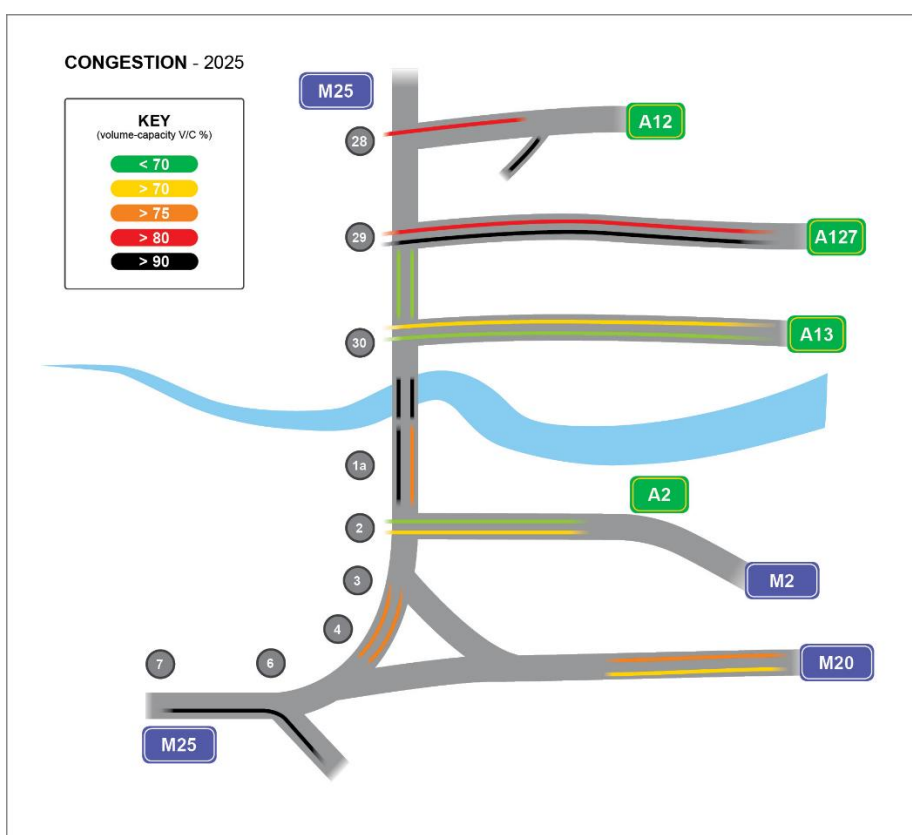


FIGURE 2.11 - CONGESTION ON KEY LINKS - 2025

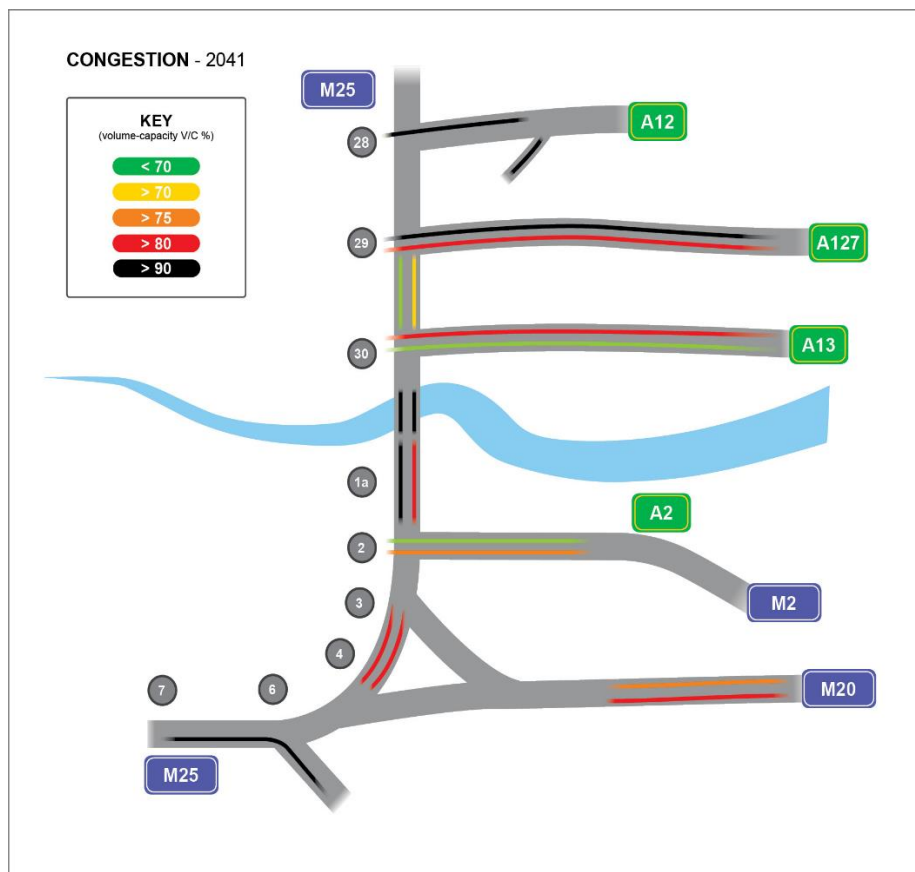


FIGURE 2.12 - CONGESTION ON KEY LINKS - 2041

## Demand

- 2.3.34 The following charts present the routes that traffic use to get to and from the Dartford crossing in the Without Scheme scenario.
- 2.3.35 **Figure 2.13** below demonstrates the origins and destinations of northbound traffic for the AM peak period for 2009 with future year changes in route importance demonstrated with shading:

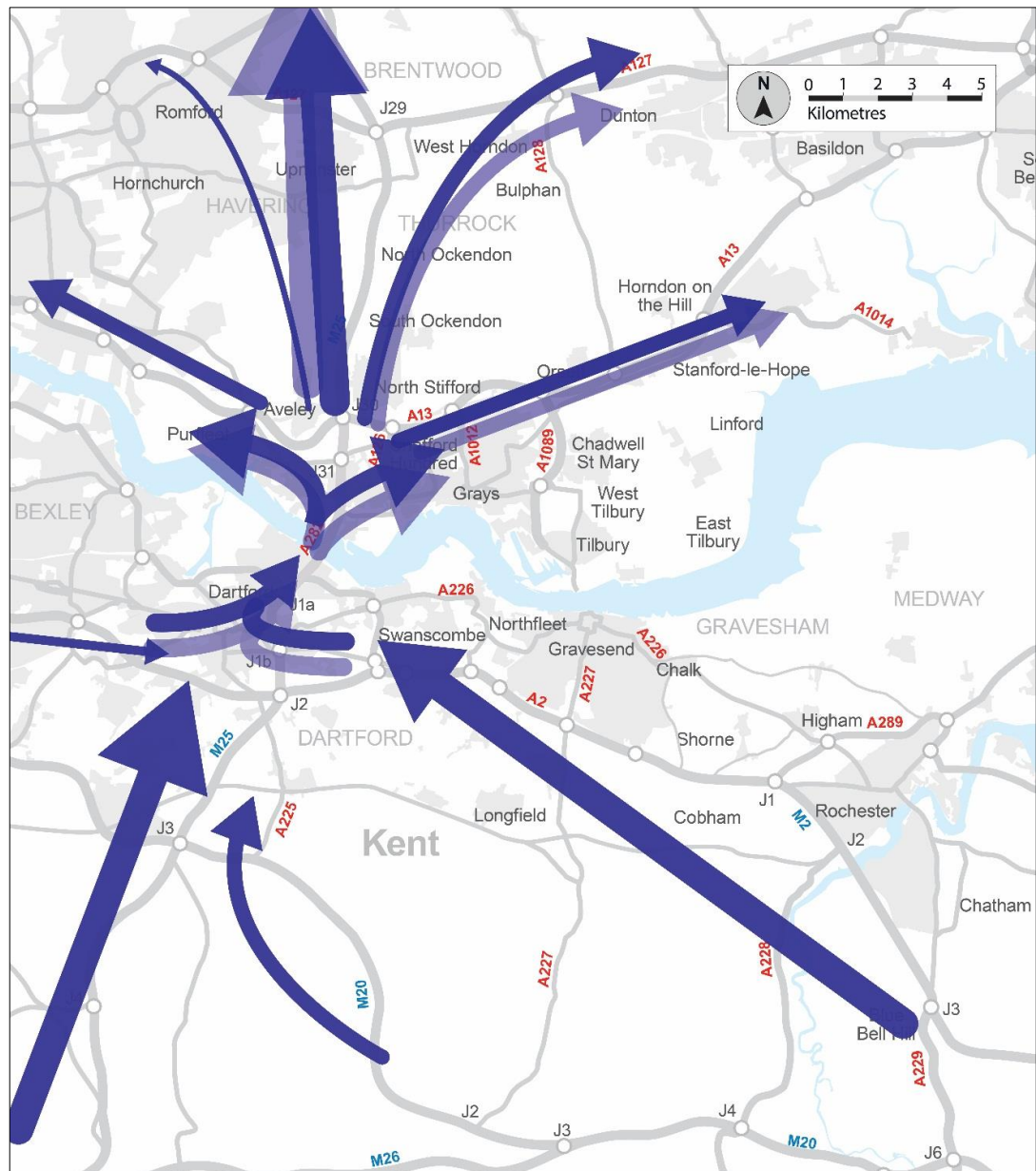


**FIGURE 2.13 - PATTERNS FOR THE AM PEAK NORTHBOUND TRAFFIC MOVEMENTS**

2.3.36 Total traffic growth on these routes is 22% by 2041.

2.3.37 The routes which become more/ less important by 2041 are as follows:

- South to crossing:
  - Junction 1a,1b (local) to crossing increase to 30% from 23%
- North from crossing:
  - Decrease in number of vehicles leaving at Junction 31 (local) from 35% to 24%
  - A13 east increase to 19% from 8%
  - Slight decrease A127 east
  - Slight increase M25 north

2.3.38 **Figure 2.14** then demonstrates these patterns for the PM peak southbound traffic movements:

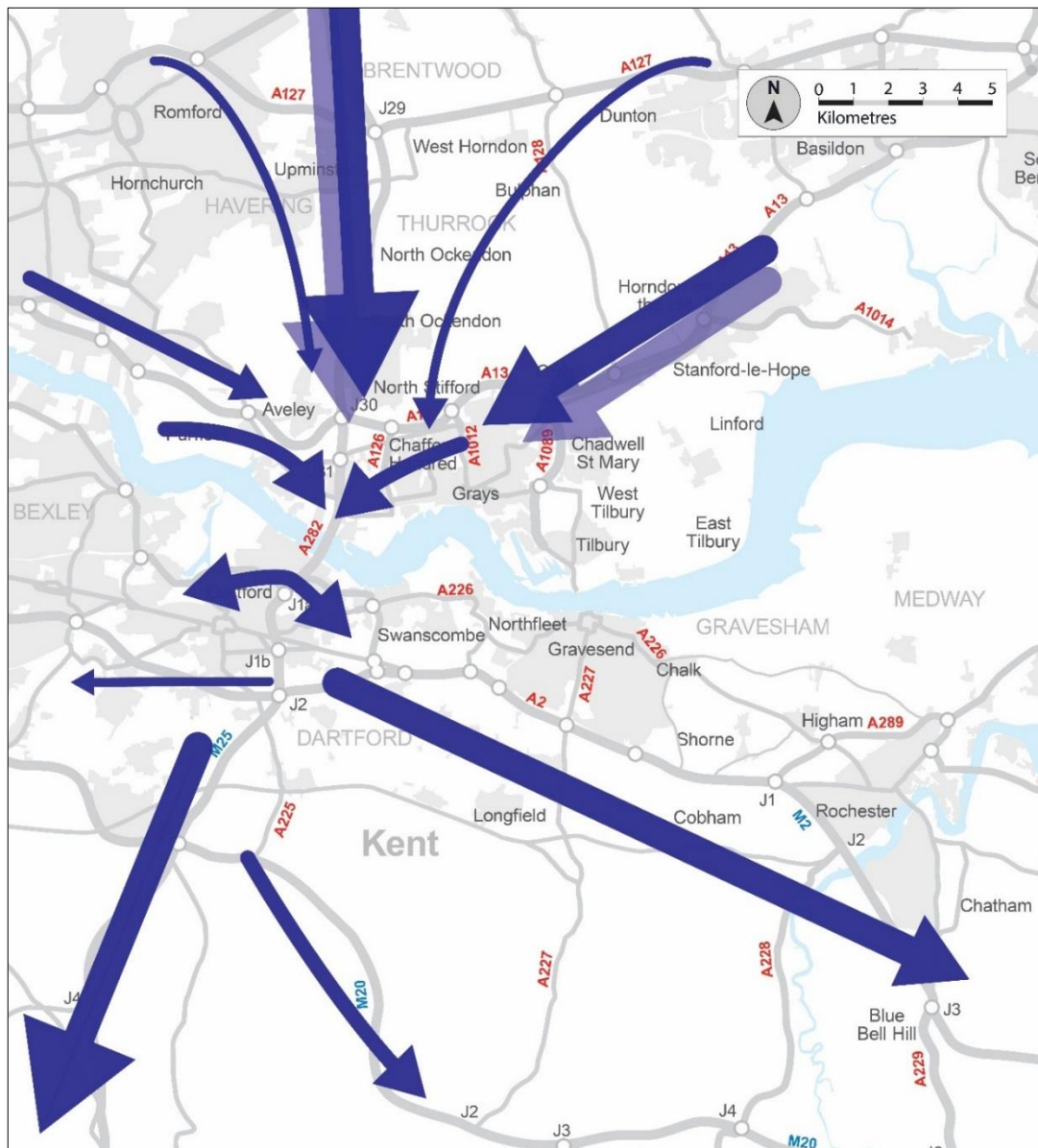


**FIGURE 2.14 - PATTERNS FOR THE PM PEAK SOUTHBOUND TRAFFIC MOVEMENTS**

2.3.39 Total traffic growth on these routes is 31% by 2041.

2.3.40 Routes which become more/less important by 2041:

- North to crossing:
  - A13 east falls to 20% from 25%
  - M25 increases to 37% from 32%
- South from crossing:
  - Similar shares

## Resilience and operational issues

- 2.3.41 Resilience refers to the ability of a road, or road network, to maintain a level of service for users, such as capacity, following an incident. A range of incidents may arise that disrupt the normal operation of traffic on the road such as traffic accidents, weather events etc. A large number of incidents occur on the existing Dartford Crossing and the crossing provides poor levels of resilience to these incidents.
- 2.3.42 The crossing has poor resilience when incidents occur with motorists experiencing significant variation in their journey times. As shown in **Table 2.8** between 2009 and 2013 the crossing was subject to approximately 450 closures a year (where one or more lanes were closed). The Highways England Customer Contact Centre (formerly HA Information Line (HAIL)) receives as many complaints from road users about the crossing as the rest of the London Orbital put together.

**TABLE 2.8 - APPROXIMATE NUMBERS OF CLOSURES AT DARTFORD CROSSING (BOTH DIRECTIONS) – 2009 TO 2013**

| Type of closure                                                                                                                                                       | Nature of closure |         |                 |                     |               |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|---------|-----------------|---------------------|---------------|
|                                                                                                                                                                       | 1 lane            | 2 lanes | 3 or more lanes | Carriageway Closure | Total Closure |
| Accidents                                                                                                                                                             | 166               | 77      | 15              | 14                  | 1             |
| Other Incidents <ul style="list-style-type: none"> <li>Abandoned vehicle</li> <li>Breakdown</li> <li>Obstruction</li> <li>People on road</li> <li>Spillage</li> </ul> | 578               | 122     | 8               | 25                  | 0             |
| Roadworks                                                                                                                                                             | 158               | 1019    | 73              | 169                 | 2             |
| Weather events                                                                                                                                                        | 0                 | 3       | 0               | 7                   | 0             |
| Total                                                                                                                                                                 | 902               | 1221    | 96              | 215                 | 3             |

Source: Highways England (2014) Lower Thames Crossing Case for Change

- 2.3.43 The existing configuration of the crossing and surrounding roads lead to high susceptibility to incidents, a poor safety track record, specific escorting arrangements; whilst the lack of crossing alternatives/ diversions further compounds these issues.
- 2.3.44 Configuration constraints, especially the northbound tunnels:
- West tunnel restrictions for oversize vehicles.



- Restricted hazardous goods vehicles (c2,400 per week) are escorted through the tunnels in multi-vehicle convoys. Some require full tunnel closures.
- Certain vehicles cannot travel in the tunnel (e.g. power station transformers) and require special arrangements.

2.3.45 Incidents are common:

- The crossing experienced 548 lane closures during 2014.
- 60% of all closures related to incidents such as breakdowns and other external factors.
- There was an average lane closure of 27 minutes until all affected lanes were re-opened.

2.3.46 Escorting

- The tunnel configuration constraints require vehicles carrying hazardous goods or abnormal loads to be escorted.
- On average there are approximately 100-150 vehicle escorts per day. The impact of these depends upon the nature of the escort, where they comprise: rolling road escorts, single vehicle escorts, and clear tunnel escorts.

2.3.47 Each escort disrupts the flow of traffic in the northbound direction for both affected vehicles through their waiting time and indirectly affect the traffic flow as a whole.

2.3.48 These issues are exacerbated where average daily two-way traffic flows have reached over 140,000 vehicles per day (vpd) which is higher than the original design capacity of 135,000; and flows over 160,000 vpd are also regularly experienced.

2.3.49 Operating at capacity has the implication that:

- When incidents occur, flow breakdown is compounded and delays are greater as the crossing is operating at, or above, capacity.
- The likelihood of closures dependent on time of day. During peak times, Junction 1a and Junction 31 can become congested extremely quickly.
- Recovery responses - congestion clearance times - are also dependent on the time of day and can be particularly long for the northbound, whilst southbound incidents clear quicker.

2.3.50 The lack of crossing alternatives and diversions means:

- With a partial closure, traffic is re-routed through unaffected sections. This takes time and reduces capacity in the opposite direction, e.g. closure of bridge requires diversion to east tunnel (with knock-on impact for northbound travel).
- With a full closure, traffic is re-routed through Blackwall Tunnel (30 miles/ 40mins away without additional congestion), whilst HGVs over the Blackwall height restriction of 4m will use the M25.



- There are impacts on the local areas where Dartford town centre can lock-up entirely and to the west traffic cascades into Bexley and Greenwich looking to cross the Thames.

## 2.4 Accidents

- 2.4.1 The worst performing sections of roads within the Lower Thames Crossing study area are to the south of the Dartford crossing which are some of the most unreliable sections on the route. Between M25 Junctions 5 and 1 the casualty rate is well above the national average for that class of road. From 30 November 2014 the toll booths have been removed from the crossing which results in free-flow tolling with Automatic Number Plate Recognition (ANPR) cameras now enforcing tolls as part of the Dart Charge scheme. There has been insufficient time to gather any reliable data for the performance of the Dartford crossing or collision rates since opening. The casualty rate on the A282 Dartford Crossing between Junctions 1 and 31, however, is over double the national average. The operation of free-flow at the Dartford crossing and the removal of toll barriers will have an effect on these collision patterns and will have to be re-assessed after there is a full year of traffic flow and accident data information available to determine the new collision and casualty rates.
- 2.4.2 The primary routes to and from Kent are the M26, M20, M2 and A2. The casualty rates on the M26, M20 and A2 are comparable with, although slightly higher than, the national average; however the M2 between Junctions 2 and 3 is well above the national average.
- 2.4.3 The primary routes towards Rayleigh, the A127 and A13, are generally close to or below national average with the exception of the A13 between the M25 and Lakeside which is above the national average.
- 2.4.4 The A1089 route to Tilbury Docks from the A13 is also well above the national average.
- 2.4.5 The collision issues already experienced on the M25 from Junctions 30 to 2 inclusive, along with those that may arise from the changing traffic patterns arising from the removal of the toll barriers and the introduction of free-flow charging, may become more significant due to the need to accommodate traffic growth in the Thames Gateway.
- 2.4.6 Existing collision issues on the A13 and A1089 will likely be exacerbated as substantial development in the Thames Gateway and the London Gateway Ports comes to fruition.
- 2.4.7 However, the future collision situation at these locations will depend upon the impact of the M25 Junction 30/ A13 Congestion Relief Scheme (refer to section 2.2.17) and the Thurrock A13 widening scheme (refer to section 2.2.19). The resultant impacts, under increased traffic levels, would need to be specifically modelled and the improvement works' impact observed.

## 2.5 Existing and Future Land Use

### Location A

#### *Existing Land Use*

- 2.5.1 The scheme area south of the River Thames lies within the Dartford District Council jurisdiction, within Kent County Council. The topography is relatively flat leading north to the River Thames, where infrastructure to support the QEII Bridge and Dartford tunnel portals is located. The large settlements of Swanscombe to the east, Crayford to the west and Darenth to the south surround Location A.
- 2.5.2 The predominant land use includes concentrated industrial and residential areas interspersed with existing road and rail infrastructure, including the M25, A282 and A206. The Littlebrook Power Station, Longreach Sewage Treatment Works, Bluewater Shopping Centre and Darenth Valley Hospital are located in close proximity to the existing highway alignments. Fuel storage depots and related large tanks are located along the southern bank of the River Thames. Lafarge quarry is located to the east of the study area within a large chalk pit.
- 2.5.3 The River Thames is currently crossed by the QEII Bridge and the existing Dartford Crossing tunnels between Purfleet and Dartford, to the west of the scheme area. The watercourse in this area is considered to be heavily modified by the present and historic industrial and transport infrastructure. There are several locations that are sensitive ecologically and protected by varying levels of legislation. To the east of the scheme area is the West Thurrock Lagoons and Marshes SSSI, close to the existing crossings. Located within the river channel are numerous piers and jetties that contribute to the surrounding industrial uses and freight terminals.
- 2.5.4 To the north of the River Thames, the route passes through Thurrock Unitary Authority. The settlements of Grays to the east and Purfleet to the west surround Location A. Topography is similar to the southern bank, being relatively flat. There is however a large rock-face created by quarrying activity along the western edge of the existing M25, prior to Junction 31. Continuing north, the topography includes the Mardyke, associated floodplain and areas of ancient woodland around Junction 31.
- 2.5.5 In continuation of the land use south of the river, the area is heavily developed for industrial, retail and residential land uses. Key features include Thurrock Services, Lakeside Retail Park and a large oil storage depot at Grays. Major transport infrastructure is present throughout the area including the existing M25, A282 bridge and tunnel, HS1 and the London, Tilbury and Southend railway lines and the A13 arterial route.

#### *Future Land Use*

- 2.5.6 The proposed London Paramount entertainment resort development, located on the Swanscombe Peninsula is in proximity to both Locations A and C and upon construction is proposed to be a major land use feature. This will be an entertainment resort including theme park rides, hotels and retail and catering space, a country park and river bus access

adjacent to the River Thames, as well as flood protection measures and landscaping throughout.

- 2.5.7 Ebbsfleet Garden City is a large mixed use development including residential, business, community and retail facilities located to the east of Bluewater.

### **Location C and C<sub>variant</sub>**

#### *Existing land use*

- 2.5.8 The scheme area on the southern bank of the River Thames is wholly located within the county of Kent. The landscape is characterised by the Kent Downs AONB to the south of the M2 crossing into areas of ancient woodland close to Shorne and low lying floodplain closer to the River Thames. The whole area is open countryside with scattered urban settlements, particularly Gravesend to the west and Rochester to the east. The topography of the area slopes from the existing A2 down towards the river. The A229 is currently on a steep gradient heading south, with a prominent chalk escarpment to the east from which the highway lies in cutting.
- 2.5.9 The predominant land use is agricultural, associated infrastructure and local roads are present throughout. The High Speed 1 (HS1) railway line in the south provides important transport links and the Thames and Medway Canal is also in close proximity, although is now used solely for recreation. Along the southern bank of the River Thames are internationally important wildlife sites, including Thames Estuary and Marshes Ramsar, SPA and SSSI. The Milton Rifle Range is also located in close proximity to the River Thames and is an area of open grassland and buried structures for use by the Metropolitan Police.
- 2.5.10 The characteristics of the Thames Estuary are predominantly intertidal mudflats, supporting large and internationally important populations of birds. The area is scattered with many small watercourses, drainage ditches and historic features, including Shornemead Fort, which has line of sight to East Tilbury Fort on the northern bank.
- 2.5.11 The scheme area north of the Thames Estuary is within the unitary authority of Thurrock and the Essex County boundary. The topography along the edge of the River Thames includes the location of further mudflats, moving into agricultural land and settlements further north. The area is relatively flat with extensive drainage ditches and watercourses throughout.
- 2.5.12 The area is characterised by large areas of open countryside interspersed with the urban developments of Purfleet, Grays, Chadwell St Mary, Tilbury and South Ockendon. Industrial assets including Tilbury power station, Tilbury docks and Tilbury sewage treatment works which are present along the immediate northern bank of the River Thames. Further north, the area returns to open countryside with many cultural heritage assets and historic landscapes/ townscape, especially around East Tilbury. The scheme area is intersected by several arterial commuter roads connecting Essex and environs with London, notably the A13, A1089 and the A127.

### *Future Land Use*

- 2.5.13 Major planning applications and significant developments include the London Gateway container port, to the east of the study area. Widening of the A13 north of Orsett is due to be completed as a condition of the London Gateway port development and is due for construction by 2018. There is a large housing estate proposed to be developed close to West Horndon in the north of the study area. Other major planning applications in the area include Rochester Airport to the south of the study area and proposed London Paramount on the Swanscombe Peninsula to the west.

## **2.6 Industry**

### **Dartford**

- 2.6.1 Dartford is a district of Kent lying south of the Thames, directly adjacent to the Greater London borough of Bexley. Currently, the district's primary industries in terms of employment are construction, retail, business administration and support, and health, which together employ over 57% of the population. Bluewater Shopping Centre is one of Dartford's largest single employers, providing over 8,000 jobs in the district.
- 2.6.2 Since 2009, the construction and business administration and support sectors have expanded most notably, with the former growing from below 10% of total employment share to nearly 15%. In absolute figures, this translates to approximately 4,000 additional jobs in the industry over the period. Similarly, business administration and support employment has grown by 3,000 jobs in the same timeline.<sup>4</sup>
- 2.6.3 Conversely, Dartford has the lowest employment share in public administration and defence of any district in the region, with less than 1%. This is a fifth of the national average, and a quarter of the London average. It also has the lowest share of education of any area in the region, barring Inner London.<sup>5</sup> The local authority recognises a decline in Dartford's traditional industries since 2000, namely manufacturing, agriculture and quarrying, as well as the growth in construction and service sector activities, which the core strategy for the district supports.<sup>6</sup>

### **Gravesham**

- 2.6.4 Gravesham is a district of northwest Kent, bordering Dartford on its east side. As of 2013, its primary sectors in terms of employment share are retail, education, health and business administration and support services, which provide approximately 45% of the district's jobs. None of these industries have grown notably in employment share since 2009, and indeed, business administration and support has declined somewhat. The area as a whole has been rather static in terms of employment share across sectors in that period, with no industry growing or declining by as much as 2%.<sup>7</sup>

<sup>4</sup> Business Register Employment Survey, NOMIS

<sup>5</sup> Business Register Employment Survey, NOMIS

<sup>6</sup> Dartford Core Strategy, Sep 2011. Accessed 28/5/15 <https://www.dartford.gov.uk/by-category/environment-and-planning2/new-planning-homepage/planning-policy/adopted-local-plan-1995>

<sup>7</sup> Business Register Employment Survey, NOMIS

- 2.6.5 Though it is only the fifth largest employer in Gravesham, the construction industry has an 8% share of jobs, nearly double the national average, and much larger than London's. It is the third largest in the region, behind Havering and Dartford. Conversely, the district has the fourth lowest share of professional, scientific and technical jobs in the region, ahead of only Dartford, Medway and Thurrock, all of which neighbour it.<sup>8</sup>
- 2.6.6 The local authority notes that Gravesham's local economy is one of the smallest in Kent, with declining traditional sectors and a lack of growth in the tertiary sector to replace these jobs. The current local plan seeks to encourage new employment in this sector, particularly promoting information technology and post-secondary education.<sup>9</sup>

### **Thurrock**

- 2.6.7 Thurrock is a unitary authority situated between Essex and London on the north bank of the Thames Estuary. It is part of the wider Thames Gateway South Essex development area. Key sectors by employment share include transport distribution and logistics, and retail and wholesale. In particular, Lakeside Shopping Centre provides a high proportion of all of Thurrock's retail employment. The Port of Tilbury is a key centre for logistics and distribution employment, with an additional 1,500 jobs expected to be created in the coming decade due to planned expansions.
- 2.6.8 Manufacturing, a former key employer, has declined by almost 10% over the last 15 years. In its place, employment in the retail and the motor trade has grown, though at slower rates than the decline in manufacturing.
- 2.6.9 The area is particularly lacking in information and communications, professional, scientific and technical jobs, and financial and insurance employment, having the lowest share of each of these sectors in the region. There has been no notable growth in any of these industries since 2000.<sup>10</sup>
- 2.6.10 The local authority plan to support employment and business growth in key sectors, particularly storage, freight transport and logistics, construction, and retail. They aim to encourage the creation of 26,000 new jobs between 2001 and 2026, and key Strategic Economic Hubs and other sites will supply approximately 456Ha (gross) of employment land, including circa 245ha at the London Gateway development.<sup>11</sup>

### **Medway**

- 2.6.11 Medway is a unitary authority south of the Thames between London and Kent, which was originally part of the County of Kent. Medway is still struggling to recover from the recession with unemployment at 10% in

<sup>8</sup> Business Register Employment Survey, NOMIS

<sup>9</sup> Gravesham Local Plan Core Strategy, Sep 2014. Accessed 28/5/15  
<http://www.gravesham.gov.uk/services/environment-and-planning/planning/planning-policy/local-plan-core-strategy>

<sup>10</sup> Business Register Employment Survey, NOMIS

<sup>11</sup> Thurrock Local Development Framework - Core Strategy and Policies for Management of Development, Jan 2015. Accessed 28/5/15 <https://www.thurrock.gov.uk/core-strategy-and-policies/about-core-strategy>

2013-14. This is much higher than the rest of the area, which ranges from 6% in Kent as a whole to 7.6% in Thurrock.<sup>12</sup>

- 2.6.12 In terms of industrial structure, Medway has a larger than average share of employment in transport and distribution, production, public administration, education, and health. Transport and distribution is a key industry for Medway, with high numbers of employees. In particular, large aggregates companies provide jobs through the operation of private importation terminals.<sup>13</sup>
- 2.6.13 As with the other localities in this area, Medway has markedly poor employment in the information and communications, professional, scientific and technical jobs, and financial and insurance sectors. The local authority is planning to encourage the creation of 20,000 new jobs, primarily in energy and environmental technologies, engineering and manufacturing, building products and construction (including off-site manufacture), health and social care, creative industries and tourism.<sup>14</sup>

## 2.7 Climate

- 2.7.1 The low-lying margins of the Thames Estuary have been subject to inundation from tides and storm surges for hundreds of years. Climate change is expected to increase the frequency and severity of these storm surges within the estuary and surrounding environment. There are several studies being completed at present by the Environment Agency (EA) to evaluate and model potential scenarios and propose strategies to defend the population centres along the estuary and ultimately London.
- 2.7.2 The Lower Thames Crossing project would also require detailed modelling and forecasting of expected increase in sea levels throughout the scheme area to enable robust design of any bridge height, the placement of piers and location of tunnel portals. It is presently predicted that the sea level range due to climate change is assumed to be as follows:
- 0.4m (60 years)
  - 0.6m (120 years)<sup>15</sup>
- 2.7.3 The design life of any crossing option for the Lower Thames Crossing is 120 years, with use potentially being for longer, therefore in accordance with the National Policy Statement for National Networks (NPSNN) the UK Climate Projections should be used, meaning the predicted rise in sea levels of 0.6m should be accounted for within the design specification of any crossing option.
- 2.7.4 It is also a requirement to demonstrate that *“there are no critical features of the design of new national networks infrastructure which may be seriously affected by more radical changes to the climate beyond that*

<sup>12</sup> Business Register Employment Survey, NOMIS

<sup>13</sup> Business Register Employment Survey, NOMIS

<sup>14</sup> Medway Local Development Framework – Submission Draft Core Strategy, Feb 2012. Accessed 28/5/15  
<http://www.medway.gov.uk/pdf/Submission%20CS%20amend%209%20feb%202012.pdf>

<sup>15</sup> Based upon UK Climate Projections for London. The expected sea level rise due to climate change at the two Locations is to be defined.

*projected in the latest set of UK climate projections.<sup>16</sup>* (NPSNN). In addition, if any adaptation measures of the scheme give rise to consequential impacts, then consideration of the impacts should be assessed using specialist guidance set out in the NPSNN (e.g. flooding, water resources, biodiversity, landscape and coastal change).

- 2.7.5 As the scheme progresses, detailed modelling will be completed and consultation with the EA and other stakeholders will progress to compile a full picture of the current hydraulic characteristics and those predictions into the future. The project team is undertaking a review of the EA's TE2100 plan, which presents recommendations for short, medium and long term management of the flood defence infrastructure, and *“sets out the strategic direction for managing flood risk in the Thames estuary to the end of the century and beyond. It sets out how the Environment Agency will continue to protect 1.25 million people and £200 billion worth of property from tidal flood risk<sup>17</sup>”* The hydraulic modelling completed by the Lower Thames Crossing will build upon data compiled for TE2100, in addition, the interaction between the recommendations of this plan and the Lower Thames Crossing project will be included within future scheme assessments.

## 2.8 Drainage

### Location A - Existing Surface Water Drainage

- 2.8.1 The roads in this location are generally drained via a kerb and gully system. The exception to this is the A282 underpass between Junctions 1b to 2, which is drained using a combined kerb and drainage system. The elevated section of the A126 by the Lakeside shopping centre also uses a combined kerb and drainage system. Most of the collected runoff discharges either directly into nearby ditches or via pipe networks. Some outfalls have been installed with oil separators for pollution control.
- 2.8.2 There are very few balancing ponds in this location, partly because of the general lack of space and the close proximity of some of the roads to the River Thames. From the existing records, the ponds located by Weston Avenue and A1090 St. Clements Way in West Thurrock appear to take surface water runoff from the adjacent roads including the A282. To the south of the River Thames, there is a small lagoon at Junction 1a on the M25.
- 2.8.3 There are two main watercourses, Rivers Darent and Mardyke, it is likely that the adjacent drainage networks discharge into these watercourses.

### Dartford Tunnels

- 2.8.4 The Dartford Tunnels consist of two bored tunnels, each carrying two-lane traffic with raised maintenance access footways located on both edges of the carriageway.
- 2.8.5 There are gullies located along one side of each tunnel.

<sup>16</sup> National Policy Statement for National Networks 2015

<sup>17</sup> (<https://www.gov.uk/government/publications/thames-estuary-2100-te2100/thames-estuary-2100-te2100> accessed 13th May 2015)

#### West Tunnel Surface Water

- Collects in the Mid-River Sump where the water level is controlled by pumps that discharge into the Kent Drainage Dyke and then into the River Thames.

#### East Tunnel Surface Water

- Collects in the Mid-River Sump where the water level is controlled by pumps that discharge into P2 pumping station and then into the River Thames.

#### West and East Tunnel Kent Approaches Surface Water

- Collects in the Portal Sumps where the water level is controlled by pumps that discharge into the Kent Drainage Dyke and then into the River Thames.

#### West and East Tunnel Essex Approaches Surface Water

- Collects in the Portal Sumps where the water level is controlled by pumps that discharge into the Essex Drainage Dyke and then into the River Thames.

#### **QEII Bridge**

- 2.8.6 The cable-stayed bridge carries four-lane traffic with no hard shoulders, and stretches from the old toll booths just north of Junction 1a (A206), across the River Thames, over two railway lines and A1090, to approximately 800m south of Junction 31.
- 2.8.7 The bridge is super-elevated with gullies located on one side of the carriageway. The gullies are then linked by collector pipes fitted on the underside of the bridge. Downpipes are located at some of the bridge piers, which convey the flow down to ground level. Rodding accesses are provided on all the downpipes for maintenance purpose. At ground level, there are oil separators installed for all the pier outlets for pollution control. There are no downpipes and outfall points at the bridge piers located in the River Thames.
- 2.8.8 All the pier outlets on the south viaduct discharge directly into a ditch that runs adjacent to the A282, and the ditch eventually outfalls into the River Thames.
- 2.8.9 For the north viaduct, the pier outlets furthest north drain to the first pumping station that is located between the two railway lines. The rising main from this pumping station runs in the south direction, which then outfalls to a gravity network. This continues draining towards the River Thames, with connections from the other pier outlets. At the last pier of the north viaduct just before the River Thames, the drainage network drains to a second pumping station. From it, two 600mm gravity pipes then outfall into the River Thames via an outlet structure consisting of a penstock chamber. The outlet pipes to the river are fitted with flap valves.



### Location A - Existing water bodies

- 2.8.10 There are a few watercourses in the area: River Darent and its tributary River Cray near Crayford and Dartford to the west of the main route; and Mardyke crossing the M25 just south of Junction 30. These, together with other smaller watercourses/ ditches, drain directly into the River Thames and are classified as main rivers by the EA.
- 2.8.11 Several ponds have been identified in the area, although it is not clear whether they are all for the purpose of surface water drainage due to limited availability of as-built drainage records.
- 2.8.12 The hydrodynamic nature of the River Thames has contributed to the presence of marshlands along both sides of the river.

### Location A - Flood mapping

- 2.8.13 **Figure 2.15** is a flood map obtained from the EA website that shows the risk of flooding in the vicinity of Location A. As would be expected, there are large areas by the River Thames, as well as along the main rivers, that are at risk of flooding. In particular the peninsulas in West Thurrock and north of Swanscombe, and also the land east of River Darent and up to the railway line have been identified as Flood Zones 2 and 3. However, these areas are being protected by the tidal defences currently in place along both banks of the River Thames and also for some distance along River Darent and River Cray.

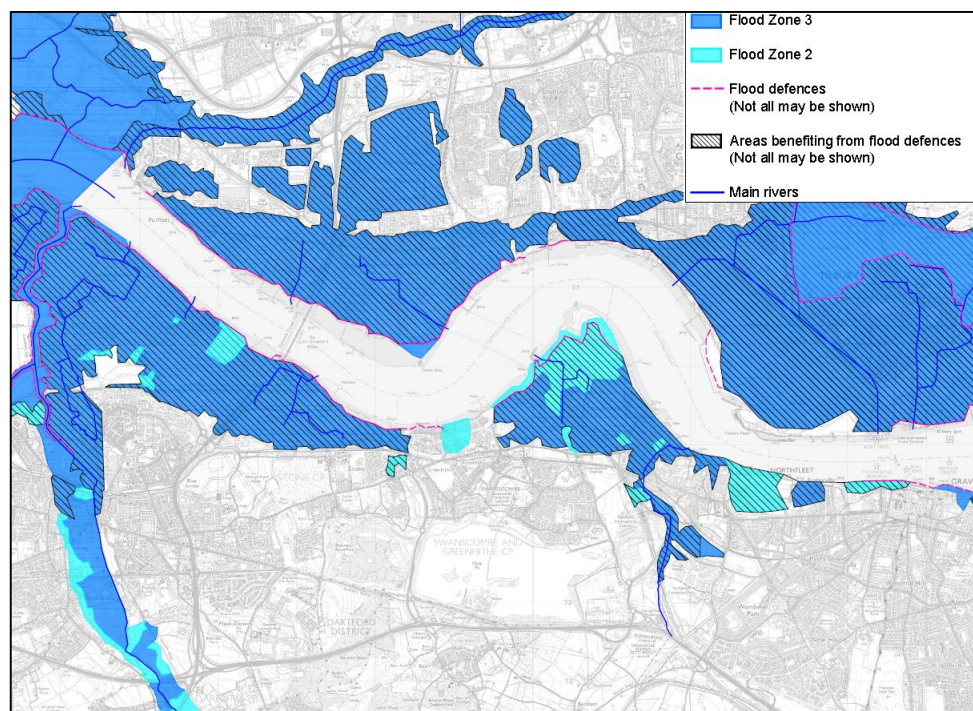


FIGURE 2.15 - FLOOD MAP LOCATION A

### Location A - Source Protection Zones

- 2.8.14 A map illustrating the groundwater source protection zones (SPZs) obtained from the EA website is shown in **Figure 2.16**.

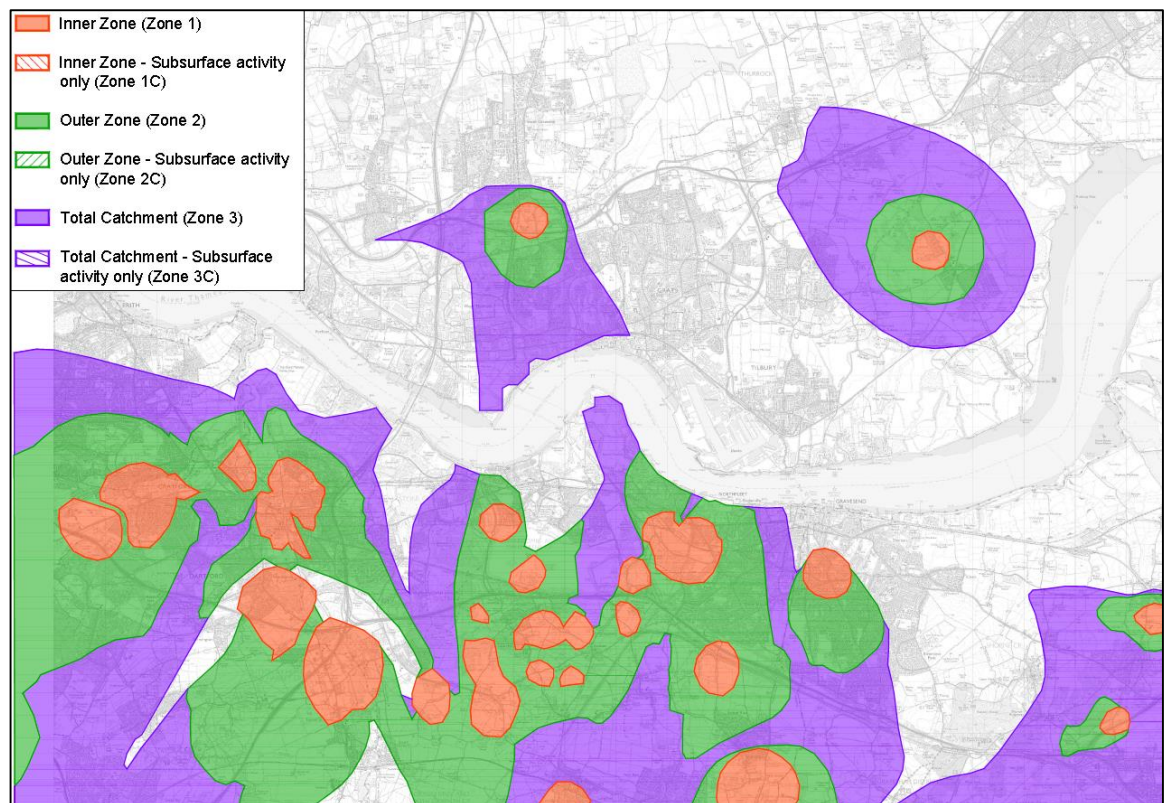


FIGURE 2.16 - GROUNDWATER SOURCE PROTECTION ZONES

### Location C - Existing Surface Water Drainage

- 2.8.15 The route options in Location C are predominantly greenfield sites so existing highway drainage provisions will only be encountered at junctions with existing roads.
- 2.8.16 New highway drainage provisions would be integrated with any existing highway drainage as far as is possible and practicable.
- 2.8.17 To facilitate an integrated approach, highway drainage records at proposed junction locations will be sought and augmented if necessary with site surveys.

### Location C - Water Bodies

- 2.8.18 Watercourses in Location C include a number of main rivers and ordinary water courses. Main rivers are shown in **Figures 2.17** and **2.18**. With the exception of Mardyke, watercourses are not generally named.
- 2.8.19 The concentration of watercourses in the marshes adjacent to the River Thames is naturally higher than other areas. The concentration of watercourses is particularly high in the marshes within the Ramsar site.
- 2.8.20 The watercourses in Location C present surface water drainage discharge options but water quality criteria and attenuation measures would need to be assessed in conjunction with the EA.
- 2.8.21 There are a number of surface water bodies in Location C but most appear to be low lying sites with little potential for highway drainage.



2.8.22 In addition the watercourses, a disused section of the Thames and Medway Canal runs west-east to the south of the River Thames.

### Location C - Flood mapping

2.8.23 The EA's interactive flood maps for planning show the risk of flooding from rivers and sea. Images of the flood maps in the vicinity of Location C are shown below.

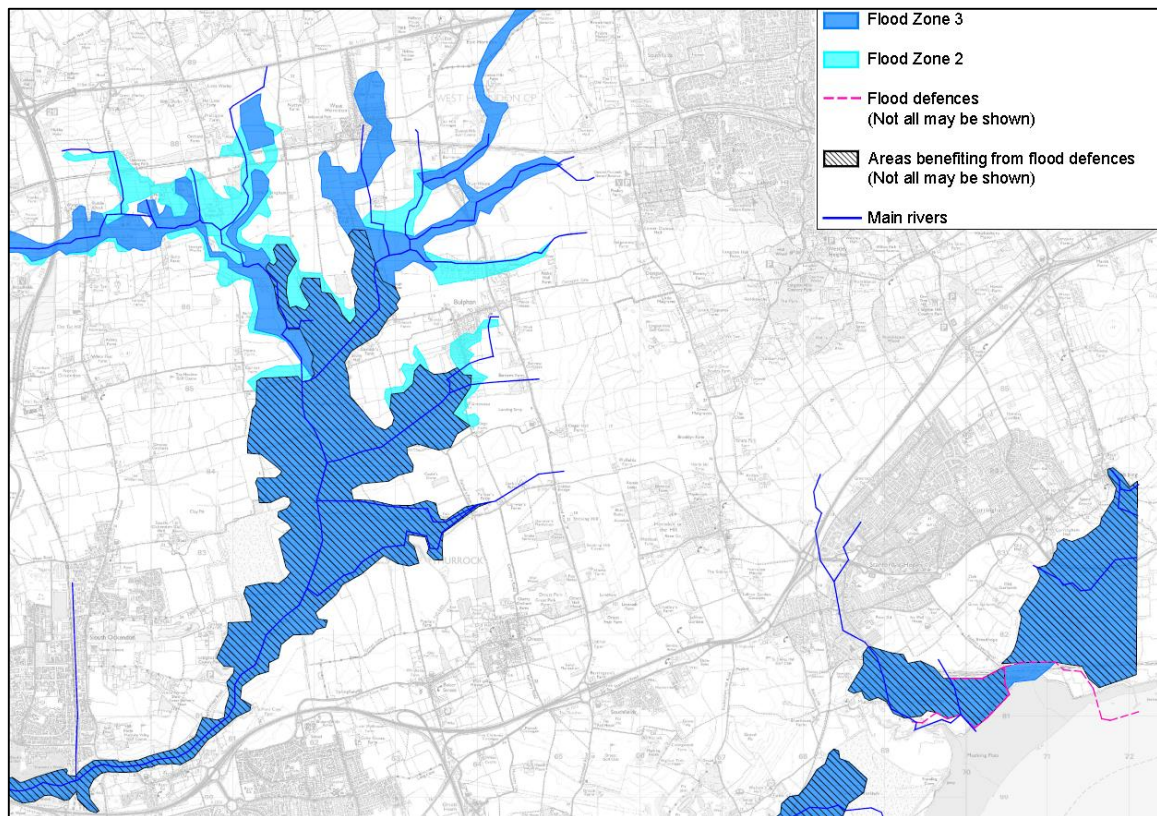


FIGURE 2.17 - FLOOD ZONES AND MAIN RIVERS LOCATION C - NORTH

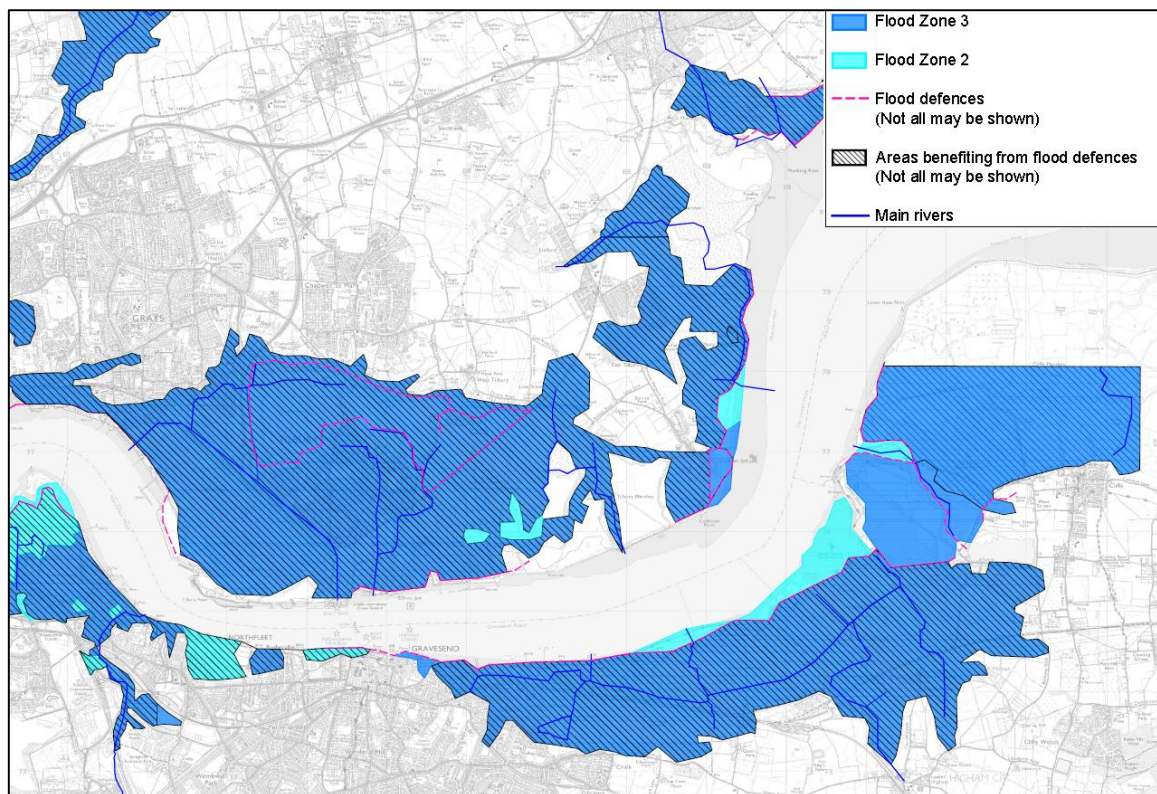


FIGURE 2.18 - FLOOD ZONES AND MAIN RIVERS LOCATION C - SOUTH

- 2.8.24 The images indicate that there is a high probability of flooding either side of the River Thames and along the main rivers (Flood Zone 3). High probability is defined as land having a 1 in 100 or greater chance of river flooding or a 1 in 200 or greater chance of flooding from the sea in any year.
- 2.8.25 Most of the land indicated as having a high risk probably benefits from flood defenses.

#### Location C - Source Protection Zones

- 2.8.26 The EA's interactive groundwater maps show SPZs. Images of the groundwater maps in the vicinity of Location C are shown in **Figure 2.19** below.
- 2.8.27 All Location C route options cross SPZs to a greater or lesser extent. Appropriate treatment trains would need to be adopted and agreed with the EA for surface water runoff discharges in the protection zones. If infiltration techniques were used in protection zones it would be necessary to demonstrate that such infiltration would not pollute the groundwater source.



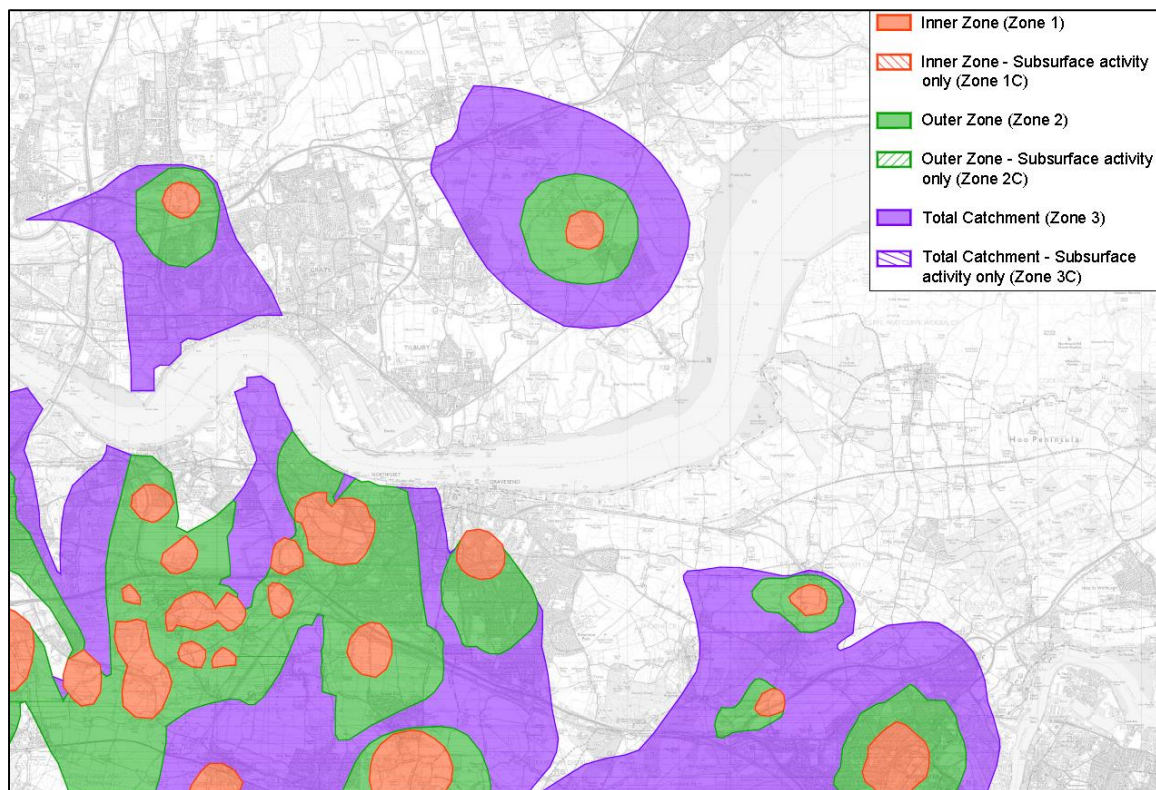


FIGURE 2.19 - SOURCE PROTECTION ZONES LOCATION C

**C<sub>Variant</sub> - Existing Surface Water Drainage**

- 2.8.28 Sections of the A229 that are kerbed collect surface water runoff using a combination of gullies and combined kerb drainage units. The kerbed sections of the highway are generally at junctions, on-slips and off-slips. Discharge locations and mechanisms for collected runoff are not currently known.
- 2.8.29 The majority of the A229 is unkerbed. Over-the-edge drainage is employed in the unkerbed sections of the highway. Some unkerbed sections have drainage channels with in-line outlets. Disposal of surface water runoff from unkerbed sections of the highway is not currently known but it is likely that infiltration is the key disposal mechanism (soakaways or drainage ditches).
- 2.8.30 New highway drainage provisions would be integrated with any existing highway drainage as far as is possible and practicable.
- 2.8.31 To facilitate an integrated approach, highway drainage records for the A229 will be sought and augmented if necessary with site surveys.

**C<sub>Variant</sub> - Surface Water Bodies**

- 2.8.32 Watercourses in C<sub>Variant</sub> include a number of main rivers but no ordinary watercourses. Main rivers are shown in **Figure 2.20**.
- 2.8.33 There are a number of ponds at the junction between the M20 and the A229. These ponds may be associated with the drainage at this junction.

2.8.34 The River Medway runs to the southwest of the junction between the M20 and the A229. It is possible that surface water runoff from the junction is discharged to the Medway.

### **C<sub>Variant</sub> - Flooding**

2.8.35 The EA's interactive flood maps for planning show the risk of flooding from rivers and sea. Images of the flood maps in the vicinity of C<sub>Variant</sub> are shown below, refer to **Figure 2.20**.

2.8.36 C<sub>Variant</sub> lies entirely in Flood Zone 1. Land in Flood Zone 1 is assessed as having less than 1 in 1,000 chance of river or sea flooding in any year.

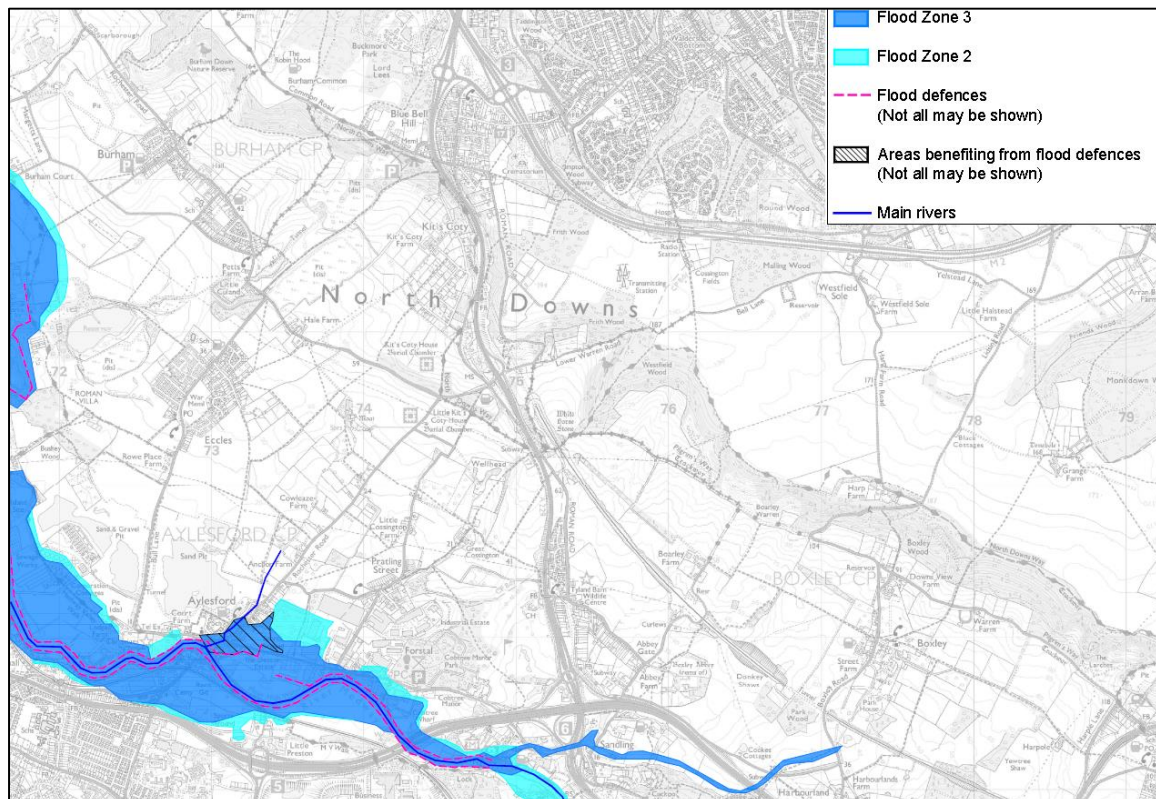


**FIGURE 2.20 – FLOOD ZONES AND MAIN RIVERS LOCATION C - NORTH**

### **C<sub>Variant</sub> - Source Protection Zones**

2.8.37 The EA's interactive groundwater maps show SPZs. Images of the groundwater maps in the vicinity of C<sub>Variant</sub> are shown in **Figure 2.21** below.

2.8.38 Appropriate treatment trains would need to be adopted and agreed with the EA for surface water runoff discharges in the protection zones. If infiltration techniques are used in protection zones it would be necessary to demonstrate that such infiltration will not pollute the groundwater source.



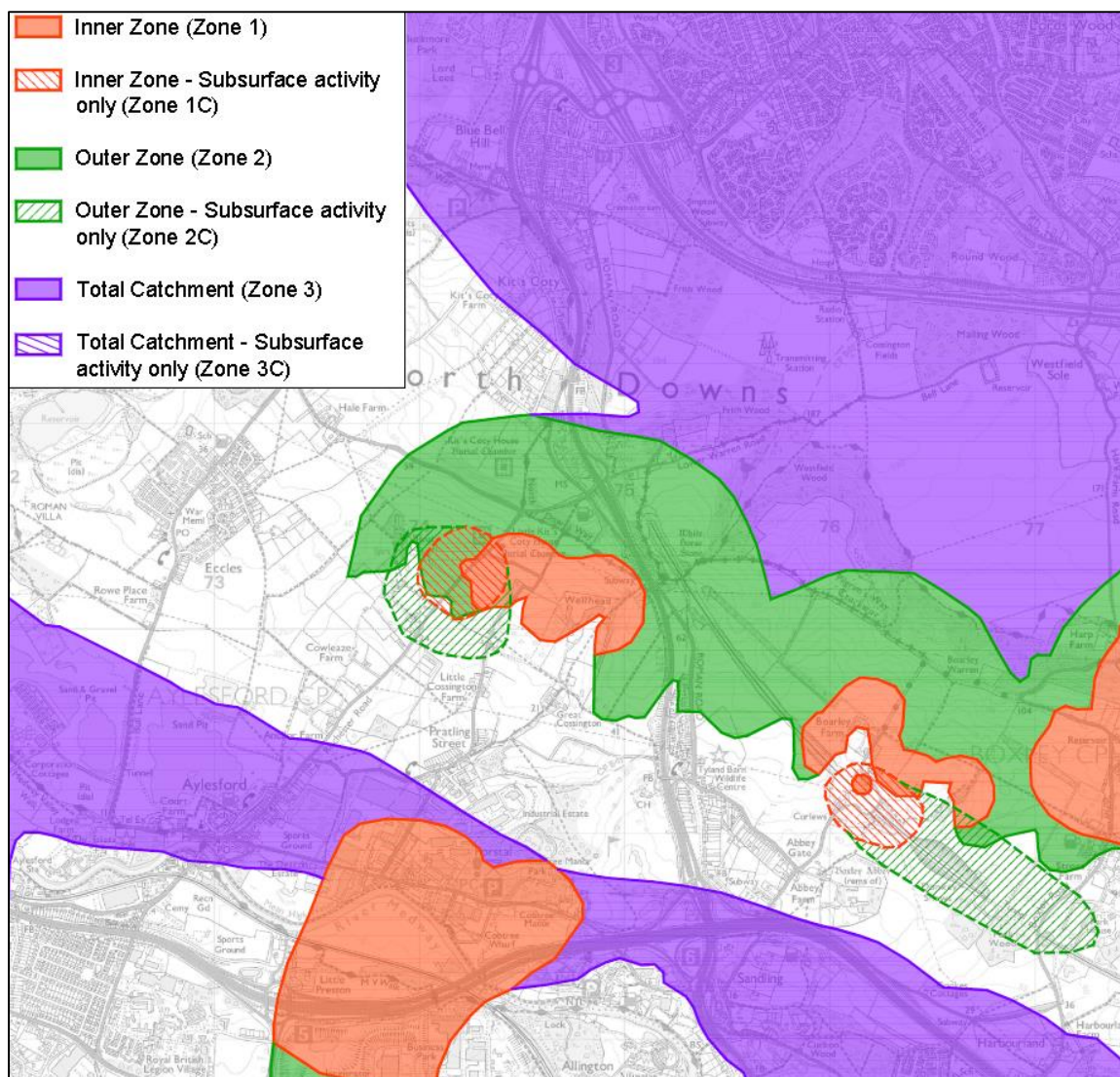


FIGURE 2.21 - SOURCE PROTECTION ZONES C VARIANT

## 2.9 Geology

2.9.1 The generalised geological succession of the study area is summarised in **Table 2.9** below with the distribution of the solid and drift deposits shown in the drawings in **Appendix 4**.

**TABLE 2.9 - GENERALISED GEOLOGICAL SUCCESSION**

| System/<br>Period | Series              | Group                                                       | Formation                                                                                                                      | General Description                                                                                                                                                                                                                                                                                                                                                                            | Stratigraphical<br>Thickness               |
|-------------------|---------------------|-------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------|
| Quaternary        | Holocene            | Superficial<br>Deposits                                     | Alluvium                                                                                                                       | Marine and Estuarine<br>Alluvium<br><br>Silt and clay with<br>lenses and beds of<br>peat, and seams of<br>sand and gravel.                                                                                                                                                                                                                                                                     | 1 - 20m                                    |
| Quaternary        | Pleistocene         | Superficial<br>Deposits<br><br>Thames<br>Valley<br>Deposits | Head Deposits<br><br>Terrace Gravels<br>(Taplow Gravel)<br>(Lynch Hill Gravel)<br>(Boyn Hill Gravel)<br>(Black Park<br>Gravel) | Undifferentiated, pebbly<br>sandy clay; some<br>gravel.<br><br>River Terrace Deposits<br>- Gravel, sandy and<br>clayey in part.                                                                                                                                                                                                                                                                | Variable<br><br>Variable                   |
| Palaeogene        | Eocene              | Thames<br>Group                                             | London Clay<br>Formation<br><br>Harwich<br>Formation                                                                           | Dark bluish to brownish<br>grey clay, containing<br>variable amounts of<br>fine-grained sand and<br>silt.<br><br>Cross-bedded shelly<br>sand (the Oldhaven<br>Beds) with a basal<br>pebble bed.                                                                                                                                                                                                | Up to 150m<br><br>0 - 12m                  |
| Palaeogene        | Palaeocene          | Lambeth<br>Group<br><br><br><br><br><br><br><br>No Group    | Woolwich<br>Formation<br><br>Upnor Formation<br><br><br><br><br>Thanet Sand<br>Formation                                       | The upper beds are<br>clay with shells,<br>ferruginous sand,<br>lignitic sand and lignite.<br>The lower beds are<br>coarse sand with pale<br>grey clay partings and<br>coarse gravel of black<br>flint.<br><br>Greenish to brownish<br>grey silty, fine-grained<br>sand, clayey and more<br>silty in lower part, with<br>a conglomerate of flint<br>pebbles and nodular<br>flints at the base. | 5-20m<br><br><br><br><br><br><br>Up to 32m |
| Cretaceous        | Upper<br>Cretaceous | Upper<br>Chalk<br>Group                                     | Undivided, mainly<br>Seaford Chalk<br><br>Lewes Chalk                                                                          | Fossiliferous nodular<br>chalk with bands of<br>nodular flints,<br>hardgrounds and marl<br>seams.<br><br>White chalk with hard<br>nodular beds.                                                                                                                                                                                                                                                | Up to 70m<br><br>20 – 40m                  |

*Notes: Excludes stratigraphical units that are absent from the study area.  
Stratigraphical thicknesses have been taken from Geological Maps.*

**2.9.2** The study areas for Locations A and C are situated on the southern limb of the London Basin syncline, which include the strata up to the Thames Group. The strata dips very gently to the northwest at generally less than



2 degrees. Unconformably overlying the Upper Chalk in the central part of the London Basin are Palaeogene deposits, which are mainly comprised of the Thanet Sand Formation and Lambeth Group, these are dominated by sands and clays. The Thames Group (mainly the London Clay Formation) is also present, although mainly in the area north of the Mardyke.

- 2.9.3 The Palaeogene and Late Cretaceous deposits are overlain in places by Quaternary deposits mainly of Alluvium (with peat lenses and beds), River Terrace and Head Deposits. The Alluvium deposits are most evident along the River Thames channel and subsidiary river channels, such as the Mardyke and the River Darent. The River Terrace Deposits are also present in places below the Alluvium to varying thicknesses. River Terrace Deposits dominate the hill tops and higher ground, especially to the north and also to the south of the River Thames valley.
- 2.9.4 In the north, generally north of the Mardyke channel, around Ockendon but also continuing eastwards to Orsett, the London Clay Formation is present below the River Terrace and Head Deposits. It is shown in outcrop in many places where there have been old quarries and pits. However, most of these areas are shown on the geological maps as Worked Ground (described as mainly chalk, sand and gravel pits with little or no fill), and as Worked Ground and Made Ground (described as wholly or partly backfilled pits). In the far north of the study, near Little Warley along the A127, the London Clay Formation outcrops at the surface.
- 2.9.5 South of the Mardyke Valley and north of the West Thurrock and Tilbury Marshes, the higher ground and hill tops consist of River Terrace Deposits overlying the Lambeth Group and Thanet Sand Formation; these in turn unconformably overlie the Upper Chalk Formation. In the West Thurrock area, where the land slopes gently towards the West Thurrock Marshes, the Upper Chalk is shown in outcrop. Although most of the area is shown as Worked Ground, which is described as mainly chalk, sand and gravel pits with little or no fill on the geological maps and Worked Ground and Made Ground, which is described as wholly or partly backfilled pits. Similarly on the south side of the River Thames Valley the Upper Chalk outcrops on the lower sides of the hills, although in the western area from Swanscombe to Dartford it is shown with hatching identifying Worked Ground and Worked Ground and Made Ground.

### **Location A Geology**

- 2.9.6 The geology of Location A has been divided into the following sections based on topography and geology:
- M25 Junction 30 to the north side of the West Thurrock Marshes
  - River Thames Valley
  - South of the Stone Marshes to the B2500/ A296
  - B2500/ A296 to the M25 Junction 2

*M25 Junction 30 to the north side of the West Thurrock Marshes*

- 2.9.7 The geology of the northern extent of Location A, around the M25 Junction 30, generally comprises the London Clay Formation unconformably overlying the Lambeth Group and Thanet Sand Formation of Palaeocene age, which in turn unconformably overlie the Upper Chalk. On the northern side of the M25 Junction 30 the London Clay Formation is present, but is shown on the geological maps with hatching representing Worked Ground and Made Ground, described as wholly or partly backfilled pits. The geological maps identify the thickness of the London Clay Formation as up to 150m thick, although due to historically worked pits the maximum thickness in the area is likely to be less.
- 2.9.8 In the Mardyke Valley, just south of Junction 30 of the M25, Holocene aged Alluvium (marine and estuarine) and Pleistocene aged Head and River Terrace Deposits (Lynch Hill and Taplow Gravels) overlie the Pre-Quaternary geology. The Quaternary drift deposits run generally along the route and slopes of the Mardyke Valley. The River Terrace Deposits are undifferentiated on the *BGS 1997 Inner Thames Estuary geological map*, but the *Romford 1996* and *Dartford 1998 geological maps* differentiate the deposits. The Taplow Gravels and Head Deposits generally occur along the Mardyke Valley, and the Lynch Hill Gravels occur on the higher parts of the valley sides and on the higher ground to the north of Junction 30. The Lambeth Group is shown to lie under Junction 30, but is shown on the geological maps with hatching representing Worked Ground and Made Ground (wholly or partly backfilled pits). Where the M25 crosses the Mardyke the *BGS 1997 Inner Thames Estuary geological map* shows the Alluvium deposits to be in the region of 7-8m thick on the northern and southern sides of the river valley.
- 2.9.9 Following the Location A south of the Mardyke, the London Clay Formation and Lambeth Group are absent and generally the area between the Mardyke and the West Thurrock Marshes is underlain by Upper Chalk. Although most of this area with the Upper Chalk is shown as Worked Ground (mainly chalk, sand and gravel pits with little or no fill) on the geological maps.
- 2.9.10 The Thanet Sand Formation is present on both the north and south sides of the Mardyke Valley and there are also some outliers of the Thanet Sand Formation deposits east of the Lakeside Retail Park and A126.

*River Thames Valley - from the West Thurrock Marshes to the southern side of the Stone Marshes*

- 2.9.11 Along this section of the route the geology comprises of the Upper Chalk Formation, which is overlain by a considerable thickness of Pre-Quaternary Pleistocene River Terrace Deposits (Taplow Gravel), Holocene Alluvium and Holocene to present day Tidal River Deposits along the River Thames channel and historic flood plain. Boreholes on the *BGS 1997 Inner Thames Estuary geological map* shows thickness of the Alluvium in the vicinity of the Dartford Crossing up to 12m on the

banks of the River Thames and generally thinning to the north and south over the extent of the West Thurrock and Stone Marshes.

- 2.9.12 Within the Alluvium there are significant lenses and beds of peat. Five distinct peat horizons have been identified. The *Geology Society of London's Special Memoirs* notes that the total thicknesses of peat beds exceeds 2m in large areas between the confluence of the rivers Thames and Lea and Tilbury. The peat deposits were laid down during the Holocene epoch of the last 10,000 years. In the River Thames there is a subcrop of Upper Chalk between the West Thurrock Marshes and the Swanscombe Marshes.

*South of the Stone Marshes to the B2500/ A296*

- 2.9.13 The geology of this area consists generally of the following sequence: Quaternary Boyn Hill Gravel overlying Thanet Sand Formation which unconformably overlies the Upper Chalk. The River Terrace deposits are generally found on the hilltops overlying the Thanet Sand Formation (Temple Hill and New Town areas), with Head Deposits on the hill sides. To the south of the New Town area, north of Temple Hill and around Stone Castle, Quaternary Boyn Hill Gravel and Head Deposits are present directly overlying the Upper Chalk. The Bluewater Retail Park is situated in the old Chalk Pit, where the Lewes Chalk was exposed, this was backfilled and engineered for the construction of the retail park. Most of the lower lying area is shown on the geological maps with Worked Ground and Made Ground (wholly or partly backfilled pits) above the Upper Chalk.

*B2500/ A296 to the M25 Junction 2*

- 2.9.14 The western side of this section consists of Taplow, Lynch Hill and Boyn Hill Gravels and Alluvium along the River Darent overlying Upper Chalk. Head Deposits are also present along the River Darent valley sides.
- 2.9.15 The area around Fleet Downs is directly underlain by Upper Chalk. Where the ground rises towards Darenth Wood and Bean, Lynch Hill and Taplow Gravels as well as undifferentiated River Terrace Deposits are encountered overlying the Thanet Sand Formation and Upper Chalk on the sides of the hill. Head deposits are found on the hillsides. On and near the top of the hill near Darenth Wood the Lambeth Group and Thanet Sand Formation outcrop, they unconformably overlie the Upper Chalk. In places the Taplow, Lynch Hill and Boyn Hill Gravels overlie the Lambeth Group and Thanet Sand Formation, particularly on the slope south west to the River Darent.

### **Location C Geology**

- 2.9.16 The geology of Location C has been divided into the following sections based on topography and geology:
- M25 Junction 29 to South Ockendon and Orsett
  - Orsett to West Tilbury and the Coalhouse Fort
  - River Thames Valley (Tilbury to Gravesend and Lower Higham)
  - Gravesend and Lower Higham to the A2 and A289

*M25 Junction 29 to South Ockendon and Orsett*

- 2.9.17 The geology of this area comprises Head Deposits, Alluvium and River Terrace Deposits overlying the London Clay Formation. West of the railway line, from Cranham Hall (south east of Upminster) southwards to Belhus Woods Country Park, River Terrace Deposits (Lynch Hill Gravel) overlie the London Clay Formation.
- 2.9.18 East of the railway line, from the M25 Junction 29 following the Mardyke Valley, Head Deposits dominate as the Quaternary cover above the London Clay Formation on the gently sloping valley sides, from the railway line in the west to beyond Bulphan in the east. River Terrace Deposits (Boyn Hill Gravel) are also present overlying the London Clay Formation in the North and South Ockendon area. There are many old clay pits in the area with the London Clay Formation noted on the geological maps. These old clay pits are shown as Worked Ground and Made Ground (described as wholly or partly backfilled pits). The London Clay Formation outcrops in the north around Little Warley and in the east on Sticking Hill, Horndon-on-the-Hill and other localised areas.
- 2.9.19 To the north east, just outside of Location C, it is noted that Glacial Till deposits are present between Upminster and the A127.

*Orsett to West Tilbury and the Coalhouse Fort*

- 2.9.20 In this area the geology continues to be topography-related, with the Lambeth Group overlain by River Terrace Deposits in many places on the highest ground. Underlying the Lambeth Group is the Thanet Sand Formation and then the Upper Chalk Group. The Thanet Sand Formation is generally overlain by River Terrace Deposits and outcrops in places along the lower slopes of the hills. Head Deposits generally occur lower down on the hillsides.
- 2.9.21 Eastwards, the land slopes down towards the River Thames Valley and the Mucking Marshes and East Tilbury Marshes. Here, Alluvium (ranging from approximately 5m to 11m thick) overlies the Thanet Sand Formation, which unconformably overlies the Upper Chalk.
- 2.9.22 To the east of Southfields the London Clay Formation was exposed in a Gravel Pit; this area is noted as Worked Ground (described as mainly chalk, sand and gravel or clay pits with little or no fill) and Worked Ground Made Ground (described as wholly or partly backfilled pits).

*River Thames Valley - Tilbury to Gravesend and Lower Higham*

- 2.9.23 In the low lying Marshes on either side of the River Thames the geology consists of Alluvium overlying Upper Chalk, although other Quaternary deposits such as the River Terrace Deposits may intervene in places. In the River Thames channel the Holocene Alluvium is overlain by more recent Intertidal and Marine Deposits of mud, sand and gravel. The Upper Chalk subcrops below the Alluvium (and possibly other Quaternary deposits) in the River Thames channel. Depths of the Alluvium have been proven in boreholes to generally range from 10 to 20m close to the River Thames and generally thin out to the north and south (ref. *Inner Thames Estuary – Pre-Quaternary and Quaternary*

*Geology, 1997*). Within the Alluvium five distinct peat horizons have been identified. The *Geological Society of London's Special Memoirs* notes that the total thicknesses of peat beds exceeds 2m in large areas between the confluence of the Rivers Thames and Lea and Tilbury, *Gravesend and Lower Higham to the A2 and A289*.

- 2.9.24 The geology of the majority of this area consists of the Upper Chalk Formation outcropping at the surface. The land rises from the River Thames at Gravesend and the Marshes in the east towards the A2 road. Lynch Hill River Terrace Deposits of limited extent are encountered directly south of the Marshes overlying the Upper Chalk. Around the area of Queen's Farm, south of Shorne Marshes, River Terrace Deposits (Taplow Gravel) are encountered overlying the Upper Chalk and the Thanet Sand Formation. Head Deposits are found in localised outcrops overlying the Upper Chalk on the lower parts of the hill sides.



**PHOTO 8 - SHORNE MARSHES (FROM THE SAXON SHORNE WAY - LOOKING SOUTH)**

- 2.9.25 The high ground from Cobham through the Shorne Wood Country Park to Higham consists of London Clay Formation and Harwich Formations at the highest parts, unconformably overlying the Lambeth Group and Thanet Sand Formation, which in turn unconformably overlie the Upper Chalk. The geological maps show that the London Clay Formation has been worked here in the vicinity of Shorne Wood. Head Deposits are also present on the lower parts of the hill sides. In the west of Location C similar geology is present on the high ground from Bean through Bethsam and New House to Windmill Hill.
- 2.9.26 Upper Chalk outcrops at the surface in the area from Istead Rise through Singlewell and Westcourt. Around Rosherville the upper chalk is also present, however the geological map identifies the area as Worked Ground (mainly chalk, sand and gravel or clay pits with little or no fill) and

Worked Ground and Made Ground (described as wholly or partly backfilled pits). To the west of Rosherville Boyn Hill Gravel and Alluvium are present close to the River Thames.

- 2.9.27 In the east of the area around Cliffe, Head Deposits overly the Upper Chalk on the high ground. In the Cliffe Marshes area Alluvium deposits overlie the Upper Chalk. Upper Chalk subcrops in the River Thames between Coalhouse Fort and Cliffe Fort.

### **C<sub>Variant</sub> Geology**

#### *Generalised Geological Succession*

- 2.9.28 C<sub>Variant</sub> is located across a major geological feature, the south facing escarpment of the North Downs.
- 2.9.29 From north to south, the route crosses a stratigraphic sequence of Cretaceous chalk forming the higher elevations of the Downs (to the north of the route) and the upper and middle geology of the escarpment overlying the Gault Clay and Lower Greensand at the foot of the escarpment (and at the southern section of the route).
- 2.9.30 Thin superficial deposits overlay some of the solid geology and comprise (in order of elevation from the top of the escarpment) Clay with Flints (on top of the escarpment), Head Formation on parts of the slope, and Alluvium associated with the nearby River Medway and its tributaries.
- 2.9.31 The generalised geological succession of the anticipated solid geology is tabulated below (**Table 2.10**) with the distribution of the solid and drift deposits shown in the drawings in **Appendix 5**.

**TABLE 2.10 - C<sub>VARIANT</sub> GEOLOGICAL SUCCESSION**

| Geological Age         | Group                   | Formation                                                                                                                                 | Description                                                                                                                                                                                                                                                                                                                                                       | Approximate Thickness (m) |
|------------------------|-------------------------|-------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------|
| Quaternary             | Superficial Deposits    | Head                                                                                                                                      | Clay, silt, sand and gravel (primarily flint).                                                                                                                                                                                                                                                                                                                    | Variable                  |
| Quaternary             | Superficial Deposits    | Alluvium                                                                                                                                  | Clay, silty, peaty, sandy.                                                                                                                                                                                                                                                                                                                                        | Variable                  |
| Quaternary and Neogene | Residual Deposits Group | Clay With Flints                                                                                                                          | Clay, silt, sand and gravel (primarily flint).                                                                                                                                                                                                                                                                                                                    | 2 to 10m                  |
| Upper Cretaceous       | White Chalk             | Seaford Chalk <sup>Up</sup><br>Lewes Nodular Chalk <sup>Up</sup><br>New Pit Chalk <sup>Mid</sup><br>Holywell Nodular Chalk <sup>Mid</sup> | White or white/ grey limestone with horizontal nodular flint bands and clay and marl horizons: <ul style="list-style-type: none"> <li>• Significant weathering to the upper deposits</li> <li>• Absence of flints below the top of the New Pit Chalk</li> <li>• Varying in strength and discontinuity spacing/ type</li> <li>• Plenus Marl at its base</li> </ul> | 100 to 150m               |



| Geological Age   | Group           | Formation                                                               | Description                                                                                                                                                                                                                                                   | Approximate Thickness (m) |
|------------------|-----------------|-------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------|
| Upper Cretaceous | Grey Chalk      | Zig Zag Chalk <sup>Low</sup><br>West Melbury Marly Chalk <sup>Low</sup> | White/ grey limestone with horizontal clay and marl horizons: <ul style="list-style-type: none"> <li>Significant weathering to the upper deposits</li> <li>Absence of flints</li> <li>Glauconitic Marl at its base</li> </ul>                                 | 50 to 60m                 |
| Upper Cretaceous | Gault           | Gault                                                                   | Pale to dark grey or blue-grey clay and mudstone.                                                                                                                                                                                                             | 30 to 60m                 |
| Lower Cretaceous | Lower Greensand | Folkestone<br>Sandgate<br>Hythe<br>Atherfield Clay                      | Yellow, medium-grained sand beds and 'doggers' sandstone.<br><br>Yellow, fine glauconitic sands, silts and silty clays.<br><br>Yellow, alternating sandy limestone (Ragstone) and sandy mudstone (Hassock).<br><br>Yellowish brown, pale grey sandy mudstone. | 60 to 90m                 |
|                  | Weald Group     | Weald Clay                                                              | Dark grey mudstones (shales) and mudstone with siltstone, sandstone, limestone and clay ironstones.                                                                                                                                                           | >25m                      |

### Geology

- 2.9.32 Chalk is a maximum thickness of typically 200m in the region. Chalk comprises the eroded exposed south facing ridge to the North Downs and dips into the North Downs and beneath the Thames Basin. Natural solution features are present within the chalk mainly from action of groundwater movement and groundwater fluctuation. Numerous dry valleys are expected along the chalk ridge. These may be partially or wholly in-filled with superficial material. A site investigation report from the construction of the Lord Lees overbridge at the northern extent details encountering a relatively extensive pattern of solution features at the west pier foundation.
- 2.9.33 Chalk naturally rests at a steeper angle than the underlying Gault and Lower Greensand hence the Gault and Greensand comprise the gentler slopes to the base of the North Downs leading to the Wealds of Kent (to the south). The thickness of the Gault varies but is expected to be between 40 and 60m in the region; the Lower Greensand also varies and is expected to be between 60 and 110m thick.
- 2.9.34 The North Downs are a product of post-Cretaceous folding which also generated numerous faulting throughout the Chalk Formation. These

were noted by Warren and Mortimore (2003)<sup>18</sup>, particularly towards the southern part of HS1 North Downs Tunnel (NDT) from Kits Coty and Bluebell Hill to the southern portal.

2.9.35 Faulting is also present in the Gault and Lower Greensand; BGS Sheet 288 indicate numerous faults, mostly orientated east-west with downthrows to the north. These are shown following the boundary of the Gault and Lower Greensand. The accompanying memoirs - *British Geological Survey (1963) - Topley (1875)* - suggest a 'line of disturbance' connecting the faulting which generally follows the M20 corridor between Junctions 6 and 7.

2.9.36 Three drift deposits are identified:

- Clay with flints directly overlays chalk and would be found at the higher elevations, i.e. to the north of the proposed route around Junction 3 of the M2 and the north part of the A229.
- Head deposits are a feature of sub-aerial slopes and are formed from the material accumulated by downslope movements (e.g. landslide, debris flow, solifluction, creep, etc.). Therefore Head Deposits are expected on the south facing slopes of the North Downs, along the A229 and along the M20 corridor.
- Alluvium and terrace material is expected locally to present and past river and stream beds. Alluvium is only specifically identified along the M20 corridor but should be anticipated in areas of flood plain and stream channels.

### *Route*

2.9.37 Junction 3 of the M2 (M2/ A229) to the north of the proposed works is located on top of the chalk ridge of the North Downs at an approximate elevation of +160m above ordnance datum (AOD). The M2 passes under the A229 with associated earthworks cut and fill.

2.9.38 From Junction 3, (going south) the route loosely follows the contour lines of the North Downs Chalk ridge but falls in elevation to approximately +50m AOD just north of Cobtree Manor Park Golf Course (the approximate boundary of the Grey Chalk and Gault Formation). As the existing route passes down the chalk ridge, major existing earthworks are present; mainly large chalk cuttings with some embankments.

2.9.39 From the golf course (at approximately +50m AOD) the land falls gently to the south to an approximate elevation of +25m AOD at Junction 7 of the M20/ A249 (the approximate boundary of the Gault and Lower Greensand). Consequently, between the golf course and Junction 6, the existing route is mostly on shallow embankment material and is expected to be over Gault Formation.

2.9.40 The A229 passes under Junction 6 (of the M20). Here the A229 is within cuttings and retaining structures and the M20 includes embankments. Junction 7 (M20/ A249) marks the approximate boundary of the Upper

<sup>18</sup> Chalk Engineering Geology- Channel Tunnel Rail Link and North Downs Tunnel. Quarterly Journal of Engineering Geology and Hydrogeology

and Lower Cretaceous (i.e. the boundary between the Gault and Lower Greensand) and the existing route of the M20 (between Junctions 6 and 7) loosely follows this (approximately east-west orientated) geological boundary. Between Junctions 6 and 7 of the M20 the route climbs between an approximate elevation of +25m AOD and +70m AOD. The route between Junctions 6 and 7 is mostly at grade with some cuttings.

## **2.10 Mining**

- 2.10.1 Quarrying of sand and gravel for building materials and the excavation of chalk and clay for the manufacturing of cement was extensive either side of the River Thames, the majority of which has now ceased. The chalk quarries, of which there are many between the A13 in the north and the A2 in the south, were up to 25m deep or more. Since the ceasing of the manufacturing of cement the quarries have either been backfilled with waste, left as water-filled lakes or been redeveloped for industrial, retail and residential development.
- 2.10.2 Chalk extraction in the area has not just been limited to open quarries. Numerous deneholes and even underground mines (beneath Dartford) are present throughout the area from the A13 to the A2. Deneholes comprise a small shaft excavated down to the chalk off which small adits were driven. The chalk mined in this way was undertaken in medieval times and was used for liming agricultural fields. Some deneholes are known to have been constructed pre-Roman times. The location of deneholes is very difficult to predict and several of these were encountered during the construction of HS1.
- 2.10.3 North of Junction 30 (M25), gravel and sand extraction was extensive. In many locations the underlying deposits of London Clay have been excavated in particular north of South Ockendon. Other areas of sand and gravel extraction have occurred, in particular near the A2 at Shorne and the surrounding land between East Tilbury and Chadwell St Mary. Information provided by the EA during previous studies suggests that the backfilled pits at Ockendon was licensed to accept hazardous waste in the form of asbestos.
- 2.10.4 Historic information on mining activities within the Area of Interest (AOI) of C<sub>Variant</sub> is scarce. Chelsea Speleological Society Records detail the presence of a denehole around Kits Coty, of unknown extents. Additional features infilled with flints and generally covered with flat stones are described on the hill above Kits Coty House and within the limits of Aylesford Common. Many of these backfilled deep pits are thought to be ancient burial chambers. In addition there are natural caves east of the A229 around Boxley in the face of an abandoned quarry. These caves are up to 3m wide and were formed along a fault in the chalk.
- 2.10.5 One landfill is present in the current extents around Frith Wood which, according to available EA information accepted inert waste. No information is available to whether the landfill was related to mining activities.

## 2.11 Public Utilities

- 2.11.1 Existing utility information has been obtained for Locations A and C. This process has identified the location and type of significant utility infrastructure within the vicinity of the route options within Location A and C. The information received has been reviewed against the route option alignments and where possible the alignments have been modified to avoid or reduce the impact on this infrastructure.

### Location A

- 2.11.2 On the south side of the River Thames is an existing high voltage overhead electricity line that originates from Littlebrook Power Station. The electricity line crosses over Junction 1a (A282) in the east-west direction and again at a skew in the north-west direction around the Fastrack bus route.
- 2.11.3 On the north side of the River Thames there are overhead electricity lines that cross the existing A282 between Junction 31 and Junction 30.
- 2.11.4 The main constraint with crossing the River Thames is that there is a National Grid underground power cable tunnel (the Dartford Cable Tunnel) crossing the river and running parallel approximately 120m to the west of the existing Dartford west tunnel that is understood to carry 400kV cables.
- 2.11.5 There is typical utility infrastructure within Location A, this includes low voltage cables, fibre optic cables, telephone lines and drainage pipes.

### Location C

- 2.11.6 The main constraints on the south side of the River Thames are overhead electricity lines and a major gas pipeline. Adjacent to the A2 near Cobham London Road services there is a large electricity pylon and associated overhead cables. These overhead cables go north over the A2, approximately 1km to the east of Chalk and then over the Thames and Medway Canal west of the railway sidings. There are overhead cables from the east which generally run parallel with the Thames and Medway Canal and these cables connect into a large pylon on the south bank of the River Thames to the east of the Metropolitan Police Specialist Training Centre. At this point the cables go beneath the river in a cable tunnel in a north westerly direction towards Tilbury power station. These overhead lines would affect all route options on the south side of the river, particularly bridge options where diversion of the overhead cables would likely be required. Sufficient clearance would need to be provided between any new construction and the existing cable tunnel to avoid risk of damage.
- 2.11.7 On a similar alignment to the overhead cables there is a National Grid gas pipeline that runs through the proposed junction on the A2, under the A2 and north east towards the river where it crosses the river via a tunnel towards Coalhouse Fort.
- 2.11.8 On the north side of the river there are a large number of overhead cables that originate at Tilbury power station and run north.

2.11.9 The gas pipeline from south of the river runs to the east and west of East Tilbury and then north, eventually crossing the A127 to the east of the A127/ A128 grade separated junction.

2.11.10 Within the corridor there is a significant amount of other utility infrastructure, this includes low voltage cables, fibre optic cables, telephone lines and sewer pipes.

**C<sub>Variant</sub>**

2.11.11 The main constraints are the two National Grid overhead 400kV lines which intersect the A229 at the following locations:

- South of the existing golf course access
- South of the Shell services on the southbound carriageway

2.11.12 The pylons for these cables are in close proximity to the existing carriageway, however it is not envisaged that diversions would be required.

2.11.13 There is a significant amount of other utility infrastructure, this includes electricity and fibre optic cables.

## **2.12 Traffic Control Technology**

### **Introduction**

2.12.1 Locations A and C tie into the existing Highways England network and therefore the existing technology assets. The potential impact of both locations on technology has been reviewed and is outlined below.

2.12.2 Both locations would involve a junction with the A13 which has both TfL and Highways England equipment installed, including shadow tolling equipment on the eastern section. Shadow tolling was introduced as an incentive to keep the road available for use and free of breakdowns, roadworks and accidents. The shadow tolling equipment is used to monitor the number of vehicles on the road and consists of cameras and traffic monitoring equipment.

2.12.3 C<sub>Variant</sub> links the M2 to the M20 and would require the widening of the A229, all of which contain Highways England equipment.

2.12.4 An assessment of the existing technologies was carried out as part of this TAR. The purpose of this assessment was to understand what existing roadside equipment is within the locations.

2.12.5 For the purposes of this document, the technology section will focus on two areas: the existing roadside technology and the existing communications and power network. This assessment is further broken down into each of the roads that are specific to each location.

### **Location A Existing Road Side Technology - ITS-Traffic Loops, VMS, CCTV**

#### *M25 north of Junction 3 to A282*

2.12.6 The M25 north of Junction 3 forms part of the M25 Controlled Motorways Scheme. This is a four-lane section of motorway which reduces to three

lanes after Junction 2. This scheme introduced VMSL without HSR between M25 Junction 2 (Darenth Interchange) and M25 Junction 3 (Swanley).

2.12.7 The following lists the existing equipment on this road:

- Non-Enforcement Advanced Motorway Indicators (AMI)
- Enforcement AMI
- Enforcement outstations
- Motorway Incident Detection and Automatic Signalling (MIDAS) loops and associated MIDAS Detector outstations
- Power outstations including electrical supply outstations
- Enhanced Message Sign (EMS) - 2x12 Portal type
- Ambient Light Monitor (ALM)
- Emergency Roadside Telephones (ERT)
- 2nd Generation Closed Circuit Television (CCTV) camera and outstations.
- Signal Transponder (ST)/ Telephone Responder (TR) outstations.
- Motorway Signal Mk 3 (MS3) Message Signs - 3x18 Cantilever type
- Roadside Controller outstations
- Meteorology fog detector equipment and outstation

#### A282

2.12.8 The A282 is an all-purpose trunk road (APTR) connecting the M25 at Junction 2 to the Dartford-Thurrock river crossing and the northern M25 at Junction 31. From Junction 2 to the river crossing there are 4 lanes in each direction, and from the crossing to Junction 31 there are 4 lanes in each direction, although the northbound carriageway is split. There are portal gantries on this section, some with fixed signage and some with non-enforcement AMIs.

2.12.9 The following lists the existing equipment on this road:

- Non-Enforcement AMI
- MIDAS Detector outstations
- Power outstations including electrical supply outstations
- EMSs - 2x12 Portal type
- ALM
- ERT
- 2nd Generation CCTV camera and outstations
- ST/ TR outstations



- Fixed Text Message Sign (FTMS) and outstations
- Variable Message Sign (VMS) and outstations - Rotating Plank type and Gantry Mounted Rotating Horizontal Prism
- MS3 Message Signs - 3x18 Cantilever type
- Motorway Signal Mk 1 (MS1) Message Signs - Entry Stop Signals and Matrix Signals
- Roadside Controller outstations

2.12.10 There is traffic counting equipment which is monitored by the National Traffic Control Centre (NTCC) and is used to provide Journey Time (JT) information this includes;

- Automatic Number Plate Recognition (ANPR) camera and outstation
- Traffic Measuring Equipment (TME) - Traffic monitoring equipment for NTIS
- Traffic Appraisal Modelling and Economics (TAME) equipment

*The M25 north of the existing Dartford Crossing up to the M25 Junction 29*

2.12.11 The M25 from Junction 31 northbound is a controlled motorway, which accommodates All Lane Running (ALR) and connects to the Dartford-Thurrock River crossing north of the River Thames and continues the London Orbital motorway.

2.12.12 The following lists the existing equipment on this road:

- Non-Enforcement AMI
- Combined Equipment Cabinet (CEC) - Enforcement
- MIDAS Detector outstations
- Power outstations including electrical supply outstations
- EMS's - 2x12 Portal type
- ALM
- ERT
- Cabling Marshalling Unit (CMU)
- 2nd Generation CCTV Camera and outstations
- ST/ TR outstations
- FTMS and outstations
- VMS and outstations - Rotating Plank type and Gantry Mounted Rotating Horizontal Prism
- MS3 Message Signs - 3x18 Cantilever type
- MS1 Message Signs - Entry Stop Signals and Matrix Signals

- Roadside Controller outstations
- ANPR cameras and outstations
- TME
- TAME equipment
- Meteorology Fog Detector equipment and outstation

### A13

2.12.13 The A13 is an APTR linking Central London with East London and South Essex. Its route largely follows that of the London, Tilbury and Southend Railway, and runs the entire length of the northern Thames Gateway area, terminating on the Thames Estuary at Shoeburyness.

2.12.14 Currently, the M25 Junction 30/ A13 Corridor Relieving Congestion Scheme is ongoing with a view to relieving congestion along the A13 corridor. This scheme is programmed for completion in autumn 2016.

2.12.15 The following lists the existing equipment on this road:

- Power outstations including electrical supply outstations
- EMS - 3x18 Cantilever type
- ANPR cameras and outstations
- TME
- TAME equipment

### **Location C Existing Road Side Technology – ITS-Traffic Loops, VMS, CCTV**

#### A1089

2.12.16 The A1089 connects the Port of Tilbury to the A13 at the Baker Street Interchange. The majority of this road is dual two-lane trunk road but there are areas of single carriageway nearer the port.

2.12.17 There does not appear to be any Highways England technology equipment on the A1089.

#### A2

2.12.18 The A2 is an APTR connecting London with Dover in Kent. This route has always been of importance as a connection between London and the sea trade and rail routes to Continental Europe.

2.12.19 The following lists the existing equipment on this road:

- Motorway Indicator Signals (MIS)
- MIDAS loop sites and MIDAS Detector outstations
- Power outstations including electrical supply outstations
- EMS - 2x12 Portal type
- ERT
- 2nd Generation CCTV Camera and outstations

- MS3 Message Signs - 3x18 Cantilever type
- MS1 Message Signs - Entry Stop Signals and Matrix Signals
- ANPR camera and outstation
- TME
- TAME equipment

## *M2*

2.12.20 The M2 in Kent acts as a bypass of the section of the A2 which runs through the Medway Towns, Sittingbourne and Faversham.

2.12.21 The following lists the existing equipment on this road:

- MISs
- MIDAS loop sites and MIDAS Detector outstations
- Power outstations including electrical supply outstations
- EMS - 2x12
- ALM
- ERT
- Telephone Responders
- 1st and 2nd Generation CCTV Camera and outstations
- MS3 Message Signs - 2x16 Cantilever type
- ANPR camera and outstation
- TME
- TAME equipment

## *A127*

2.12.22 The A127, also known as the Southend Arterial Road, is a major road connecting London with Southend-on-Sea in Essex.

2.12.23 There does not appear to be any Highways England technology equipment on the A127. The A127 is not part of the strategic road network the highways authority being Essex County Council.

## *A229*

2.12.24 The A229 is a major A road running north-south through Kent and is not part of the strategic road network the highways authority being Kent County Council.

2.12.25 The following lists the existing equipment on this road:

- Power outstations including electrical supply outstations
- EMS - 2x16 Portal type
- MS3 Message Signs - 4x15 Cantilever type
- ANPR cameras and outstations

### A289

2.12.26 The A289 connects Strood and Gillingham and forms the northern bypass of the Medway Towns incorporating the Medway Tunnel.

2.12.27 There does not appear to be any Highways England technology equipment on the A289.

### **Location A – Highways England Network Equipment**

#### *M25 north of Junction 3 to A282*

2.12.28 The following lists the existing network equipment on this road:

- Darenth Transmission Station (TS)
- Longitudinal copper cabling and outstations
- Longitudinal fibre optic cabling and outstations

#### *M25 north of the existing Dartford Crossing up to the M25 Junction 29*

2.12.29 The following lists the existing network equipment on this road:

- Longitudinal copper cabling and outstations
- Longitudinal fibre optic cabling and outstations

### A13

2.12.30 There is no NRTS communications network located on the A13.

### **Location C – Highways England Network Equipment**

#### A2

2.12.31 The following lists the existing equipment on this road:

- Longitudinal copper cabling and outstations.
- Longitudinal fibre optic cabling and outstations.

#### M2

2.12.32 The following lists the existing equipment on this road:

- Longitudinal copper cabling and outstations
- Longitudinal fibre optic cabling and outstations

### A229

2.12.33 The A229 is considered as an optical fibre and copper designated link on the NRTS network connecting Bluebell Hill TS to Detling TS.

#### *The Existing Crossing*

2.12.34 There is a copper and fibre connection through the existing tunnel which is managed, operated and maintained by Connect Plus. This is integrated into the Highways England network at interface points on either side of the crossing.

2.12.35 The existing crossing is operated from the Dartford Control Centre (DCC) which is located adjacent to the southern end of the crossing. There are two compounds where Highways England Traffic Officers and Traffic

Management (TM) crews are located to provide immediate assistance for incidents on the crossings. Additionally there are twelve observation points at the extents of the crossing which Highways England Traffic Officers can use to gain access to the crossing to assist road users.

- 2.12.36 The crossing is operated under a design, build, finance and operate (DBFO) contract.

#### **Location A - Power**

- 2.12.37 The existing roadside electrical equipment (message signs, signals, etc.) is powered from existing Distribution Network Operator (DNO) supply points. The DNO own and operate the distribution network of towers and cables that transfer electricity from the national transmission network to homes and businesses. In general, single phase power distribution is used for all roadside electrical equipment with the exception of lighting which uses a three phase power supply.

- 2.12.38 Existing electrical interface (EI) points to the DNO supply are located throughout Location A and are typically housed in Highways England type 609 cabinets. The additional equipment required for Location A would increase the load on existing EI and may require some additional supply points, consequently a detailed review of power supply arrangements in the locality would be required to optimise the scheme design.

#### **Location C - Power**

- 2.12.39 There are currently power supplies from the DNO on the M2, A2, A229 and A249 and, based on the maintenance records, they are fit for purpose for the limited equipment on these roads. There are no power cabinets on the A228 however there is a MIDAS site so there would be power available.
- 2.12.40 Adjacent to Location C there are power supplies at Brewers Road, Junction 3 of the M2 and throughout the A249, all of which may potentially be upgraded to facilitate increased loads.
- 2.12.41 Location C would require new power supplies to facilitate equipment on a new stretch of highway. These supplies would need to be procured from the DNO as they would be required within Location C.

#### **Communications Network**

- 2.12.42 The National Roads Telecommunications Services (NRTS) contract provides services across the Highways England roadside telecommunication network. The network links the roadside communication devices (ERT, CCTV, etc.) along the motorways and other main trunk roads in England, with the National Traffic Control Centre (NTCC) and a number of Regional Control Centre (RCC) for the Highways England Network.
- 2.12.43 Within the Dartford Crossing there is a communication link which is operated by the consortium Connect Plus via the Dartford Control Centre (DCC) which operates the systems within the tunnel.

2.12.44 The Dartford River Crossing is defined as the equipment from Junction 1a to 30 and is controlled separately to the RCCs by Connect Plus from the DCC. It is anticipated that with the introduction of Common Highways Agency Rijkswaterstaat Model (CHARM) that the operation of the DRC could change and could be integrated into one of the RCCs.

### **Other Equipment**

2.12.45 The Dart Charge scheme was introduced in November 2014. The scheme allows road users to pay the toll charge remotely and implemented a traffic management cell (refer to Section 2.23) to identify non-compliant vehicles and filter them away from the tunnels. The scheme has only recently been fully implemented and discussions with Connect Plus and Highway England are ongoing. Section 11.6 outlines the technology considerations for the new proposed locations.

2.12.46 There is equipment from 3rd party stakeholders within Location A and C which includes: Kent County Council, Essex County Council and Traffic Master. Currently, these are run independently from Highway England and it has been assumed that they would be retained. Integrating these as part of the LTC crossing operation has been considered and is shown in Section 11.6 of this document.

2.12.47 There is currently a northbound and a southbound depot which have a TM crew and Traffic Officers on site enable small incidents to be dealt with quickly on site. There are also 12 observation points where traffic offices are deployed to assist road users at the crossing. Communication to the traffic officers and TM crews is managed by Connect Plus via the DCC.

## **2.13 Maintenance Access**

2.13.1 Maintenance is carried out by the Asset Support Contract (ASC) team and the Regional Technology Maintenance Contractor (RTMC) on behalf of Highway England. At present the motorway network is accessed via short/medium term stops on the hard shoulder or under Traffic Management (TM) following the road space booking procedure. In areas where the network is operating ALR a permit system is in place.

2.13.2 At the Dartford Tunnel there is a routine maintenance plan which is undertaken by Connect Plus during planned closures. At the bridge there is a similar routine maintenance plan which is carried out during lane closures or full bridge closures.

### **Maintenance Lay-bys**

2.13.3 There are currently very few access lay-bys on the existing highway network within Locations A and C. There are emergency refuge areas on the M25 as part of the smart motorway scheme which are maintained by the Asset Support Contract (ASC) team.

### **Access Paths and Steps**

2.13.4 There are access paths, steps and hardstandings to communication equipment on the A2, M20 and M2. These are maintained by the ASC team.

### Access to Technology Assets

- 2.13.5 Current access to technology assets is carried out during short/ medium term stops on the hard shoulder or under Traffic Management (TM) following the roadspace booking procedure. Off-network access, currently used in some locations, requires liaison with the region's ASC team and third party stakeholders. In areas where the network is operating ALR a permit system is in place.
- 2.13.6 The existing Dartford crossing is maintained via a DBFO contract. There are interface agreements in place with the RTMC to allow co-ordination of maintenance and fault-repair activities.

## 2.14 Environment Overview

- 2.14.1 The River Thames runs through the centre of the study area with a diverse and highly designated environment both north and south of the river. Designated sites include the internationally important Thames Estuary and Marshes special protection area (SPA) and Ramsar site, a large number of nationally important ecological sites including sites of special scientific interest (SSSI) and areas of ancient woodland and the River Thames recommended Marine Conservation Zone. Nationally important heritage features include scheduled monuments such as Tilbury Fort and Coalhouse Fort Battery and Artillery Defences on the north side of the River Thames and a large number of listed buildings and conservation areas.



**PHOTO 9 - RIVER THAMES FROM SHORNE MARSHES  
(FROM THE SAXON SHORNE WAY - LOOKING WEST)**

- 2.14.2 To the south of the river there is also the nationally important Kent Downs Area of Outstanding Natural Beauty as well as Registered Parks and Gardens both north and south of the river. There are large population centres particularly Dartford, Grays and Tilbury as well as a



number of smaller settlements across the more rural parts of the study area. The key environmental features and the value of these are described in more detail in the subsequent sections of this report.



**PHOTO 10 - KENT DOWNS AREA OF OUTSTANDING NATURAL BEAUTY  
(PUBLIC FOOTPATH BETWEEN THE A2 AND SHORNE RIDGEWAY -  
LOOKING EAST TOWARDS GREAT CRABBLES WOOD)**

- 2.14.3 The high level environmental constraints map presented in **Appendix 6** shows the location and status of key environmental features across Location A, Location C and C<sub>Variant</sub> study areas.
- 2.14.4 The sections below have been informed by data gathering from a range of stakeholders and data sources which is still in progress. Therefore, the descriptions below are based on the information that is currently held.

## 2.15 Noise

### Location A - Noise

- 2.15.1 There are Noise Important Areas (NIAs) located throughout the southern section of the study area, in particular along the M25, A225, A2 and A282.
- 2.15.2 Key sensitive receptors south of the River Thames include the residential areas of Dartford which are located close to the existing transport infrastructure.
- 2.15.3 Key sensitive receptors north of the River Thames include the residential areas of West Thurrock, particularly around Junction 31, where they border the existing highway alignment. Further north is the Belhus Park registered park and garden, which could be considered sensitive to an increase in noise levels, however, given the close proximity to the existing M25 the park is already subject to background road noise.
- 2.15.4 Further sensitive receptors including schools, community facilities and hospitals are listed in **Table 2.11**.

### Location C - Noise

- 2.15.5 There are Noise Important Areas (NIAs) located throughout the southern section of the study area. In particular around the A2/ M2 junction south of Higham, this designation continues south along the M2 toward Rochester. Three further NIAs are designated along the A2 south of Gravesend.
- 2.15.6 Sensitive receptors within the southern section include residential areas, particularly Chalk, Thong, Shorne, Higham and the eastern suburbs of Gravesend. Along the southern bank of the River Thames are mudflats and other habitats that support large populations of birds; these areas should be considered sensitive due to the disturbance risk to these species.
- 2.15.7 There are four NIAs within the northern section of the study area, along the A13 and A1089, north of Grays and Chadwell St Mary.
- 2.15.8 Sensitive receptors throughout the northern section include the residential areas of Tilbury, Linford, East Tilbury, Orsett, West Horndon, North Ockenden, South Ockenden and North Stifford. East Tilbury Marshes along the bank of the River Thames, is considered sensitive due to the potential to disturb important bird populations.

**TABLE 2.11 - NOISE SENSITIVE RECEPTORS WITHIN THE STUDY AREA**

| Receptor Type | Name                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Total |
|---------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|
| Hospitals     | Location A <ul style="list-style-type: none"> <li>Livingstone Community Hospital</li> <li>Little Brook Hospital</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                               | 2     |
|               | Location C <ul style="list-style-type: none"> <li>Gravesham Community Hospital</li> <li>Orsett Hospital</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                       | 2     |
|               | Cvariant <ul style="list-style-type: none"> <li>Spire Alexandra Hospital</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                      | 1     |
| Schools       | Location A <ul style="list-style-type: none"> <li>York Road Junior Academy</li> <li>The Leigh Academy (Secondary and sixth form)</li> <li>St Albans Road Infant School</li> <li>Temple Hill Primary School</li> <li>Dartford Bridge Community Primary School</li> <li>Purfleet Primary School</li> <li>Aveley Primary School</li> </ul>                                                                                                                                                                                  | 7     |
|               | Location C <ul style="list-style-type: none"> <li>Singlewell Primary School</li> <li>St Georges C of E School</li> <li>Mayfield Grammer School</li> <li>Bronte School (Primary)</li> <li>Shorne C of E Primary School</li> <li>Bligh Junior and Infant School</li> <li>East Tilbury Infant School</li> <li>Palmer's College</li> <li>Cecil Road Primary School</li> <li>Shears Green Junior School</li> <li>Lansdowne Primary School</li> <li>Tilbury Manor Junior School</li> <li>Herringham Primary Academy</li> </ul> | 27    |

| Receptor Type        | Name                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Total |
|----------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|
|                      | <ul style="list-style-type: none"> <li>Chadwell St Mary Primary School</li> <li>Woodside Primary School</li> <li>Treetops School (Specialist school and college)</li> <li>Orsett Church of England Primary School</li> <li>West Horndon Primary School</li> <li>William Edwards Academy School (Secondary)</li> <li>Benyon Primary School</li> <li>Stifford Clays Primary School</li> <li>Tudor Primary School</li> <li>Manor Infant and Nursery School</li> <li>Woodlands Prep School</li> <li>Bulphan C of E Voluntary Controlled Primary School</li> <li>Cherubs Firststeps</li> <li>Chadwell St Mary Day Nursery</li> </ul>                                                                                                                                                                        |       |
|                      | Cvariant <ul style="list-style-type: none"> <li>Sandling Primary School</li> <li>Horsted Infant School</li> <li>Kings School Rochester Boathouse</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 3     |
| Community Facilities | Location A <ul style="list-style-type: none"> <li>One with Grace Church</li> <li>Holy Trinity Church</li> <li>St Vincents Church</li> <li>Winners Chapel International</li> <li>St Albans Church</li> <li>All Nations Evangelical Church</li> <li>St Michael's Church</li> <li>Aveley Christian Centre</li> <li>Purfleet Baptist Church</li> <li>Dartford Library</li> <li>Aveley Library</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                   | 11    |
|                      | Location C <ul style="list-style-type: none"> <li>St Mary's Church of England</li> <li>Chalk Church</li> <li>Shorne Methodist Church</li> <li>Shorne Parish Church</li> <li>Parish of St Peter and St Paul</li> <li>Parish Church of St Catherine</li> <li>St Mark's Church Rosherville</li> <li>Full Gospel Church</li> <li>The Church of Jesus Christ of Latter Day Saints</li> <li>Riverview Methodist Church</li> <li>Saint Joseph's Roman Catholic Church</li> <li>Saint Giles and All Saints Church</li> <li>All Saints Church</li> <li>Bulphan St Mary the Virgin</li> <li>St Peter's Church of England</li> <li>Moor Lane C of E Church</li> <li>Saint Nicholas Church</li> <li>South Ockendon Methodist Church</li> <li>St Mary's Church</li> <li>Gravesend Adult Education Centre</li> </ul> | 20    |
|                      | Cvariant <ul style="list-style-type: none"> <li>Walderslade Baptist Church</li> <li>St Andrew's Chapel</li> <li>Kingsway International Christian Centre</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 3     |

| Receptor Type                                | Name                                                                                                                                                                                                                                                                                                                                | Total |
|----------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|
| Ecological Designated Areas (SAC, SPA, SSSI) | Location A <ul style="list-style-type: none"> <li>Darenth Wood SSSI</li> <li>West Thurrock Lagoon and Marshes SSSI</li> <li>Purfleet Chalk Pits SSSI Inner Thames Marshes SSSI</li> </ul>                                                                                                                                           | 4     |
|                                              | Location C <ul style="list-style-type: none"> <li>Shorne and Ashenbank Woods SSSI</li> <li>Cobham Woods SSSI</li> <li>Great Crabbles Wood SSSI</li> <li>South Thames Estuary and Marshes SSSI</li> <li>Thames Estuary and Marshes SPA</li> <li>Thames Estuary and Marshes Ramsar</li> <li>Mucking Flats and Marshes SSSI</li> </ul> | 7     |
|                                              | C <sub>Variant</sub> <ul style="list-style-type: none"> <li>Woulding to Deltham Escarpment SSSI</li> <li>Peter's Pit SAC and SSSI</li> <li>North Downs Woodland SAC</li> </ul>                                                                                                                                                      |       |
| Landscape Designated Areas (AONB)            | Location C and C <sub>Variant</sub> <ul style="list-style-type: none"> <li>Kent Downs</li> </ul>                                                                                                                                                                                                                                    | 1     |

## 2.16 Local Air Quality

2.16.1 Baseline air quality information has been gathered from the following sources, to characterise the baseline air quality environment for Location A, C and C<sub>Variant</sub>:

- Boundaries of Air Quality Management Areas (AQMA)
- Department for Environment, Food and Rural Affairs (Defra) Pollution Climate Model (PCM) GIS data for latest available year (2012)
- Defra's Automatic Urban and Rural Network (AURN) continuous monitoring data
- Local Authority air quality monitoring data
- Highways England air quality monitoring data
- Location of receptors both human and ecological
- Boundaries of ecological sites

**Appendix 6** contains a drawing showing the AQMAs, Defra PCM links and monitoring locations close to Location A and C.

### Location A

#### *Air Quality Management Areas*

2.16.2 There are a number of Air Quality Management Areas (AQMAs) that have been designated close to Location A, as shown on the drawing in **Appendix 6**. Location A is within the Local Authorities of Dartford and Thurrock. Location A passes directly through one AQMA, designated by Dartford which is located along the A282 Dartford Tunnel approach road from Junction 1a to 300m south of Junction 1b. Dartford has also designated AQMAs on the major roads that cross Location A: the A226/B2500 and the A225. Location A also passes through Thurrock's AQMA

designated on the A13 and A1306 in Thurrock. The AQMAs have been designated for both exceedances of the annual mean nitrogen dioxide (NO<sub>2</sub>) objective and the 24hr PM<sub>10</sub> exceedances.

- 2.16.3 Although there are AQMAs that have been designated within Location A there is the potential for impacts on AQMAs designated in the wider area (refer to **Appendix 6**) dependent on the changes in traffic flows as a result of the various route options.

#### *Defra PCM Compliance Links*

- 2.16.4 There are a number of Defra PCM links that intersect Location A, which are the main east/ west routes: these include the A225, A226, A206 and A1306. The A282 between Dartford crossing and the M25 Junction 31 is also modelled by Defra as part of the reporting on compliance with the directive. The modelled concentrations in 2020 at these links are well below the EU Limit Values

#### *Monitoring*

- 2.16.5 There are no automatic monitoring stations located along Location A. There are however a number of NO<sub>2</sub> diffusion tubes located near Location A, with the majority of annual average NO<sub>2</sub> concentrations exceeding the EU Limit Value of 40µg/m<sup>3</sup>, shown in red on the drawing in **Appendix 6**. The majority of the diffusion tubes are located at the southern end of Location A in the borough of Dartford. The data for these diffusion tubes was obtained from Dartford Borough Council for the year 2010 and Highways England for the year 2013/ 14. Only one diffusion tube is located near Location A to the north of the River Thames in Thurrock. Data for this diffusion tube (supplied by Thurrock Council 2010) shows an annual average NO<sub>2</sub> concentration which also exceeds the EU Limit Value.

#### *Receptors*

- 2.16.6 Location A passes through a number of populated areas, from south to north including Dartford which is heavily populated with a large number of receptors located between Junction 1a and 2 on the A282. North of the River Thames there are very few receptors close to Location A with pockets of receptors located on the A13 at North Stifford. There is one ecological site located adjacent to Location A at Dartford Crossing. This ecological site, named the West Thurrock Lagoon and Marshes, is designated an SSSI (refer to the biodiversity section below). Receptors in the wider area are likely to be affected by route options within Location A given the impacts of the scheme on traffic flows.

### **Location C and C<sub>variant</sub>**

#### *Air Quality Management Areas*

- 2.16.7 There are a number of AQMAs that have been designated close to Location C as shown on the drawing in **Appendix 6**. Location C lies in the local authorities of Havering, Gravesham, Thurrock and Brentwood. Location C passes directly through two AQMAs. The first designated by Gravesham which is located along the area extending either side of the A2 within the borough. Location C also passes through Thurrock's

AQMA designated on the A13 and A1306 in Thurrock. The Havering AQMA encompasses the entire borough. The AQMA has been designated for both exceedances of the annual mean nitrogen dioxide (NO<sub>2</sub>) objective and the 24hr PM<sub>10</sub> exceedances.

- 2.16.8 C<sub>Variant</sub> extends further south and is within the boroughs of Maidstone Borough Council, Tonbridge and Malling Borough Council and Medway. Maidstone has declared an AQMA encompassing the entire Maidstone conurbation. Gravesham Borough Council has declared an AQMA extending either side of the A2 in the borough.
- 2.16.9 Although there are AQMA's that have been designated within Location C and C<sub>Variant</sub> there is the potential for impacts on AQMA's designated in the wider area (refer to drawing in **Appendix 6**) dependent on the changes in traffic flows as a result of the various route options.

#### *Defra PCM Compliance Links*

- 2.16.10 There are a number of Defra PCM links that intersect Location C, these include the A226, A126 and A1012. The modelled concentrations in 2020 at these links are well below the EU Limit Values.
- 2.16.11 In addition to Location C there are a number of PCM links that coincide with C<sub>Variant</sub> which includes the major roads around Chatham, A229, A230 and A2.

#### *Monitoring*

- 2.16.12 There are no automatic monitoring stations located along Location C. There are multiple NO<sub>2</sub> diffusion tubes located at the south end of Location C in the Borough of Gravesham. The majority of annual average NO<sub>2</sub> concentrations for these tubes located on or closest to the south end of Location C are below that of the EU Limit Value (refer to drawing in **Appendix 6**). The data for these diffusion tubes were supplied by Gravesham Council for the year 2014 and Highways England for the year 2013/ 14.
- 2.16.13 Location C passes through Thurrock, where monitored annual average NO<sub>2</sub> concentrations are higher. There are multiple diffusion tubes located along Location C within the Thurrock area that measured annual average NO<sub>2</sub> concentrations above the EU Limit Value (refer to drawing in **Appendix 6**). The diffusion tubes located at the north end of Location C have annual average concentrations of NO<sub>2</sub> lower than the EU Limit Value entering the Borough of Brentwood and the boundary of the Havering AQMA. Data for the Brentwood diffusion tubes was supplied by the Brentwood Borough Council for the year 2009.
- 2.16.14 In relation to C<sub>Variant</sub>, Maidstone Council operate an automatic monitoring station at a kerbside location next to the A229 in Maidstone. In 2014 this station recorded exceedances of the EU Limit Value for annual mean NO<sub>2</sub>. There were no recorded exceedances of PM<sub>10</sub>.

## Receptors

- 2.16.15 Location C passes through a number of populated areas, from south to north including Gravesham. There are also ecological sites including the Shorne and Ashenbank Woods and the Great Crabbles Wood which are designated SSSIs (refer to the biodiversity section below). North of the River Thames there are multiple receptors located on the A1089 at Tilbury and Orsett Heath, the A13 at North Stifford and the M25 at South Hockendon. There are very few receptors further north in Location C with a few pockets of receptors located on the A128 at Orsett, Bulphan and West Horndon. Receptors in the wider area are likely to be affected by Location C route options given the impacts of the scheme on traffic flows.
- 2.16.16 In addition C<sub>variant</sub> passes built up areas including Maidstone and Chatham.

## 2.17 Townscape/ Landscape

### Location A - Townscape

- 2.17.1 Location A study area straddles three of Natural England's National Landscape Character Areas<sup>19</sup>. The southern part of this location lies within the western part of 113: North Kent Plain. This part of the character area is heavily influenced by the urban area of Dartford. The area is an important transport corridor with major rail and road links connecting Kent's coastal towns with London. The central part of this location immediately adjacent to the River Thames falls within 81 Greater Thames Estuary, with the existing QEII Bridge and elevated approach roads forming a strong linear visual feature set against a large scale industrial townscape backdrop. Crayford marshes forms a relatively tranquil area in the west part of Location A. The north part of Location A falls within 111 Northern Thames Basin.
- 2.17.2 On the southern bank of the river, industry including the Littlebrook Power Station lies to the west of the QEII Bridge, the Crossways Business Park and other industrial land uses lie to the east. The elevated roads and pylons provide vertical scale within the townscape. The urban area of Dartford lies to the south of the River Thames and to the south of the A206. To the north of the A206, the industrial townscape is broken by the Littlebrook Nature Park that comprises two reclaimed lakes.
- 2.17.3 On the northern side of the River Thames, industrial land uses, road and rail infrastructure dominate the townscape. Two railway lines, High Speed 1 and the London Tilbury and Southend line, pass along the northern bank of the River Thames. The High Speed 1 railway line is elevated where it crosses the existing Dartford-Thurrock Crossing. The townscape is characterised by very large industrial units and storage containers located within compounds. Many of the industrial estates and the Lakeside Shopping Centre that lies to the east of the A282 have open landscaped areas and extensive car parking. The townscape north

<sup>19</sup> National Character Areas are prepared by Natural England and are guidance documents that can be used to inform decision-making. They are areas that share similar landscape characteristics and follow natural lines in the landscape rather than administrative boundaries.



of Junction 31 of the M25 contrasts with that to the south being smaller in scale, more rural in character and comprises the Mardyke Valley, smaller residential settlements such as Aveley and Belhus Park Registered Park and Garden.

- 2.17.4 A number of large scale developments are planned in the future that would modify the existing townscape.

### **Location C - Landscape**

- 2.17.5 The landscape within Location C is varied with a very different character south and north of the river. The C<sub>variant</sub> and the southern limits of Location C study area lie within the Kent Downs Area of Outstanding Natural Beauty (AONB) as shown on drawing in **Appendix 6**. Whilst farmland dominates a lot of the AONB it is also one of Britain's most wooded landscapes. This is evident within the study area by the designation of a number of areas of ancient woodland. This is apparent within the C<sub>variant</sub> study area and also in the area around the A2 within and surrounding the Cobham Hall Registered Park and Garden. This comprises 18th Century parkland, estate woodlands and a golf course. The A2, M2 junction and the High Speed 1 rail corridor are prominent, intrusive landscape features.
- 2.17.6 Location C straddles three Natural England National Character Areas: 113 North Kent Plain, 81 Greater Thames Estuary and 111 Northern Thames Basin. The southern part of Location C study area lies within 113 North Kent Plain and is characterised by open, low and gently undulating land that is highly productive agricultural (arable) land. The area has a strong urban influence. The River Thames and the southern and northern banks of the river lie within 81 Greater Thames Estuary. This is a remote and tranquil coastline landscape of shallow creeks, drowned estuaries, low-lying islands, mudflats and areas of tidal salt marsh. Historic military landmarks are characteristic features of this coastal landscape. The northern part of Location C lies within 111 Northern Thames Basin. The area is important for its biodiversity and geology. A key feature of this character type is the medieval pattern of small villages and dispersed farming settlement. The area is under great pressure from urbanisation.
- 2.17.7 The landscape character south of the A2 falls within the North Downs. This is a more open and rural landscape interspersed with smaller settlements such as Cobham. North of the A2 near to the M2 junction, the landscape is dominated by areas of woodland including Great Crabbles Wood, Shorne Woods Country Park, as well as small settlements such as Shorne and Thong. Between the A226 and the southern bank of the River Thames the landscape is less wooded and again quite rural in character which is in contrast to the more urban area of Gravesend that lies further west.
- 2.17.8 The River Thames corridor comprises raised dykes backed by expansive flat open marshlands with rough grazing and sparse scrub. Man-made elements including pylons, river traffic and jetties, as well as industry closer to the existing QEII Bridge form part of distant views.

- 2.17.9 Prominent features on the banks of the River Thames include a number of forts that are also designated scheduled monuments. The Heritage and Historic Resources section provides details about the historic landscape character and drawings in **Appendix 6** show the location of scheduled monuments.
- 2.17.10 North of the River Thames, the landscape in the eastern part of Location C is flat and open comprising extensive areas of marshland such as the East and West Tilbury Marshes and the Mucking Marshes. This open landscape includes small settlements of distinctive character (East Tilbury and West Tilbury) that are also designated as conservation areas and include a number of listed buildings (refer to drawing in **Appendix 6**). The western part of Location C is more urban in character with main roads (A1089, A13) and the settlements of Tilbury, Chadwell St Mary and Grays. North of the A13 the landscape is again very rural and open with small isolated settlements including Horndon-on-the-Hill, Orsett and Bulphan which again include a number of listed buildings.

### **C<sub>Variant</sub> - Landscape**

- 2.17.11 The C<sub>Variant</sub> is located between the southern suburban edge of Gillingham to the north and the northern suburban edge of Maidstone to the south. C<sub>Variant</sub> falls within National Landscape Character Area 119 North Downs and is characterised by the south facing chalk scarp slope and extensive areas of woodland. The south extent, to the south of the M20, falls within 120 Wealden Greensand. The latter is heavily influenced by suburban development. The A2, M20 and the interconnecting A229 are noticeable intrusive landscape features.
- 2.17.12 Local Landscape Character Assessments have been prepared by the local authorities and these will be used to inform the appraisal of the route options that are selected for the Shortlist.

## **2.18 Heritage and Historic Resources**

### **General - Heritage and Historic Resources**

- 2.18.1 As outlined in the Thames Gateway Historic Environment Characterisation study<sup>20</sup>, the Thames Gateway that lies at the centre of the study areas has been a vital corridor for trade, travel and industry throughout history and is a vitally important area for heritage assets. The Gateway comprises the river and inland areas that have been inhabited since prehistory and there is no period when the land has not been used. Whilst the area includes a large number of designated sites as outlined in the description below, the characterisation study and consultation with English Heritage and other stakeholders including Essex and Kent County Councils has confirmed that where there is an absence of archaeological remains, this is because they have not been found yet, rather than them being absent. There is, therefore, significant potential through this project to identify undiscovered archaeological remains.

<sup>20</sup> English Heritage, Kent CC and Essex CC, Thames Gateway Historic Environment Characterisation Project

### **Location A - Heritage and Historic Resources**

- 2.18.2 Within Location A there are a number of listed buildings located to the south of the river and within the eastern part of Location A around the A226 and the A2026. The nearest scheduled monument to the existing A282 is the Anglo Saxon Cemetery at Darenth Park. Parts of Location A also lie within an Archaeological Potential Area.
- 2.18.3 North of the River Thames, the designated assets comprise listed buildings with a number to the north of the A13 both east and west of Junction 30 of the M25. North of Junction 30 of the M25 and spanning the M25 lies the Belhus Park Grade 2 Registered Park and Garden. This is approximately 119 hectares in size and is bordered to the south and east by the small settlements of Aveley and South Ockendon and to the north by Belhus Woods Country Park. The M25 lies in a cutting which runs north-south through the eastern half of the park, separating the woodland areas from the open parkland.

### **Location C - Heritage and Historic Resources**

- 2.18.4 The Cobham Hall Registered Park and Garden occupies a significant area of Location C and lies to the south of the A2, close to the A2/ M2 intersection, at the east end of the village of Cobham (refer to drawing in **Appendix 6**). Within this park lies the Romano-British villa and 19<sup>th</sup> century reservoir scheduled monument, as well as a number of other listed buildings, the majority being Grade II listed and Cobham Hall itself that is Grade I listed. The village of Cobham is also designated a conservation area and includes a number of listed buildings (Grade I, II and II\*). To the north of the A2 there are a number of listed buildings around the settlement of Shorne as well as conservation areas at Shorne and Shorne Ridgeway. There are a number of listed buildings, mainly Grade II located along the A226 and a significant number within Gravesend, north of the A226 and bordering the south bank of the River Thames (refer to drawing in **Appendix 6**).
- 2.18.5 Along the banks of the River Thames, there are four prominent scheduled monuments: New Tavern Fort and Cliffe Fort on the southern bank and Tilbury Fort and Coalhouse Fort and Battery and artillery defences on the northern bank. Consultation with English Heritage has highlighted the value of the setting surrounding and between each of these sites which is relevant to the potential location of either a bridge crossing or the portals of a tunnel. The presence of existing industry in this area was also acknowledged as already impacting on the setting of these features.



**PHOTO 11 - COALHOUSE FORT SCHEDULED MONUMENT  
(FROM PUBLIC FOOTPATH AND NATIONAL CYCLE ROUTE 13 FROM THE WEST)**

- 2.18.6 North of the above monuments and in the eastern part of Location C there is a marshland landscape and the two distinctive villages of East Tilbury and West Tilbury that are also designated conservation areas. The setting and importance of these villages locally has been highlighted in discussions with English Heritage and Essex County Council. Around and in both of these settlements there are a number of listed buildings, primarily Grade II and II\*. North of the A1013 there are a number of listed buildings particularly near and within Horndon-on-the-Hill and Orsett. Between these settlements and the A127 designated heritage assets are more sporadic in their distribution.
- 2.18.7 There is a large scheduled monument at Orsett, a crop mark complex, as well as numerous listed buildings. The scheduled monument has already been impacted by the A13 and the A1089. North of the A13, there is less information regarding the archaeological remains, although at the junction of the A127 and the M25, a significant number of remains were identified when the site was used as a compound for the M25 widening.
- 2.18.8 However, as acknowledged above, the lack of designated assets is not a reflection on the lack of importance of this area or the presence of undiscovered archaeology. During a meeting with Essex County Council Historic Environment team, crop mark data was reviewed which demonstrated the extensive areas of archaeology within Location C, particularly around East and West Tilbury and in proximity to the Orsett, and north and south of the A13/ A1013.

#### **C<sub>Variant</sub> - Heritage and Historic Resources**

- 2.18.9 Within the C<sub>Variant</sub> study area, particularly the southern extent, east and west of the A229 and close to the connection with the M20, there are a number of listed buildings. East of the A229 and north of the M20 lies a

large scheduled monument, the Cistercian Abbey at Boxley, which also has a number of listed buildings surrounding it.

## 2.19 Biodiversity

### River Thames - Biodiversity

- 2.19.1 The River Thames is designated as a recommended Marine Conservation Zone although the MCZ is on hold at the moment as Defra has stated that there is a need to better understand the implications of the designation of the site on potential developments within the Thames Estuary. Key habitats and species of the MCZ comprise: intertidal sand/muddy sand, intertidal mixed sediments, subtidal coarse sediments, subtidal sand, subtidal mud, sheltered muddy gravels, tentacled lagoon worm (*Alkmaria romijni*), European eel (*Anguilla anguilla*) and Smelt (*Osmerus eperlanus*). The latter two species are UK Biodiversity Action Plan (BAP) priority species. The site is an important fish nursery and spawning ground.
- 2.19.2 Depending upon the type of crossing selected there is potential for the scheme to affect the hydrodynamics of the River Thames. To inform the appraisal of the route options an initial desk study and literature review has been completed to consider the potential estuary process impacts of a new river crossing. This has considered, in particular, the potential for geomorphological impacts with respect to the designated sites and land areas used by birds. This study has been conservative and has considered the potential for impacts to occur up to 8km from any crossing location.

### Location A - Biodiversity

- 2.19.3 There are a number of areas of ancient woodland along the A2 to the south of the River Thames with some of these areas forming the Darent Wood SSSI. This site comprises some of the most valuable areas of ancient semi-natural woodland in northwest Kent and includes several rare woodland types as well as a range of rare invertebrate fauna.
- 2.19.4 Within Location A the West Thurrock Lagoon and Marshes SSSI lies to the east of the existing QEII Bridge. This is one of the most important sites for wintering waders and wildfowl on the Inner Thames Estuary. The combination of extensive intertidal mudflats combined with a large and secure high tide roost attract waders in nationally important numbers, with significant populations of other bird species. The mudflats form the single largest intertidal feeding area, for wintering waders and wildfowl, on the inner Thames estuary. The site comprises two SSSI units. The condition of Unit 1 is Unfavourable - No change, with dunlin and redshank numbers being below threshold and the site subject to physical disturbance. The condition of Unit 2 is Unfavourable – Declining, with dunlin and redshank numbers below threshold and the intertidal mudflats and saltmarsh suffering from coastal squeeze. Bird populations at this nationally important site could be affected by direct habitat loss, changes to noise and light levels as well as any changes in the hydrodynamic regime or water quality.

- 2.19.5 The Inner Thames Marshes SSSI lies 3.2km upstream of the existing QEII Bridge. This forms the largest remaining expanse of wetland bordering the upper reaches of the Thames estuary. The site is of value for its diverse and ornithological interest and especially for the variety of breeding birds and the numbers of wintering wildfowl, waders, finches and birds of prey, with wintering teal populations reaching levels of international importance. The site also supports a wide range of wetland plants and insects with a restricted distribution in the London area. This site could be affected by changes to the hydrodynamic regime. The site is in Unfavourable - Declining condition with coastal squeeze being the factor affecting its condition.
- 2.19.6 The Purfleet Chalk Pits SSSI lies to the west of the A282 and comprises Mid-Pleistocene sand and gravel deposits overlying Chalk are exposed in a series of disused quarries at Purfleet, Essex.
- 2.19.7 There are areas of ancient woodland to the east of Junction 30 of the M25 as shown on the drawing in **Appendix 6**.

### **Location C - Biodiversity**

- 2.19.8 On the outer limits of the study area and to the west of the M2 and south of the M2/ A2 junction lies the Cobham Woods SSSI. This woodland and old parkland is representative of woods in North Kent which occur in part on acidic Thanet Sands and in part on chalk soils. The site supports an outstanding assemblage of plants which is also important for breeding birds. The woodland comprises mainly sweet chestnut with some coniferous plantations whilst the woodland is mature woodland with some clearings, of oak, sweet chestnut, beech, hornbeam, and other species.
- 2.19.9 The Shorne and Ashenbank Woods SSSI straddles the A2, to the south east of the residential area of Gravesend. This site is a complex of ancient and plantation woodland. The site supports an important and diverse invertebrate fauna especially beetles, true bugs and dragonflies. The site includes a number of areas of ancient woodland.
- 2.19.10 Great Crabbles Wood SSSI lies to the east of the Shorne and Ashenbank Woods SSSI and to the east of the settlement of Shorne. This site is representative of woods on North West Kent tertiary sediments; these comprise a succession of strata over Upper Chalk ranging from Blackheath gravels to Woolwich loams and Thanet sands which provide a range of soil types. This site is also coincident with a number of areas of ancient woodland. Sweet chestnut is the dominant species as well as a number of scarce plants including lady *Orchis purpurea* and man orchid *Aceras anthropophorum*.
- 2.19.11 Along the A2 there are a number of areas of ancient woodland that lie outside of the SSSIs. To the east of Shorne there are several local wildlife sites.
- 2.19.12 All of the above woodland sites are susceptible to and could be affected by changes in nitrogen deposition as a result of changing traffic flows.

- 2.19.13 North of the A226, east of Gravesend and bordering the south bank of the River Thames lies the Thames Estuary and Marshes Ramsar site, SPA and SSSI. The extents of these sites are slightly different as shown by the shading on the drawing in **Appendix 6**. These sites support a complex of brackish, floodplain grazing marsh ditches, saline lagoons and intertidal saltmarsh and mudflat. These habitats together support internationally important numbers of wintering waterbirds. The saltmarsh and grazing marsh are of international importance for their diverse assemblages of wetland plants and invertebrates.
- 2.19.14 On the northern bank of the River Thames east of East Tilbury and south of Stanford-le-Hope lies the Mucking Flats and Marshes SSSI which is also coincident with the Thames Estuary and Marshes SPA and Ramsar.
- 2.19.15 There are also a number of areas of functional habitat associated with these sites. Functional habitat is the term used to describe an area of undesignated land lying beyond the boundary of a designated site that is used by designated bird populations for roosting, nesting or foraging. Our current interpretation of functionally linked land associated with the Thames Estuary and Marshes Ramsar, SPA and SSSI has been developed using Wetland Bird Survey Data and BTO dot density maps. At this stage of the project's development ornithological surveys have not been completed and on completion of such surveys during PCF stage 3 it is likely that a more extensive area of functional habitat will be developed. This interpretation will also be reviewed further with Natural England.
- 2.19.16 North of the River Thames within Location C there are some smaller isolated areas of ancient woodland and far fewer designated sites compared to south of the river. The only other SSSIs are two small sites to the west of the A1089, Hangman's Wood and Denehole's SSSI and Globe Pit SSSI. The Globe Pit SSSI is designated for geological reasons and is an important site for the interrelationship between archaeology and geology for its correlation of the Lower Palaeolithic chronology with the Pleistocene Thames Terrace sequence. Hangman's Wood and Denehole's SSSI comprises the remains of medieval chalk mines and is the most important underground hibernation site for bats in Essex. Three species have been recorded: Brown longeared bat *Plecotus auritus*, Natterer's bat *Myotis nattereri* and Daubenton's bat *Myotis daubentonii*.
- 2.19.17 At Junction 29 there are areas of ancient woodland and wildlife sites to the north west, north east and south west

#### **C<sub>variant</sub> - Biodiversity**

- 2.19.18 Within the C<sub>variant</sub> study area there are a number of areas of ancient woodland which are also coincident with local wildlife sites adjacent to the M2. The Wouding to Deltham Escarpment SSSI is bisected by the A229. This site is a 10km section of chalk escarpment that include representative examples of woodland, scrub and unimproved grassland habitats on chalk which support a number of rare and scarce species of plants and invertebrates. The Culand Pits are also of importance



because of their rich and unique fossil fauna which include a variety of fish and reptiles. This site is also sensitive to nitrogen deposition.

2.19.19 The Peter's Pit SAC and SSSI lies to the west of the Woulding to Escarpment SSSI and is a former chalk quarry. The site supports one of the largest populations of great crested newt *Triturus cristatus* in Britain. The areas of scrub at the site also support a number of breeding birds. To the west of this site lies the Holborough to Burham Marshes SSSI. This site lies along the flood plain of the River Medway, which at this point is still tidal. There are a variety of habitats including extensive reedbeds, open water, fen, grassland, scrub and woodland. The many different habitats support a wide variety of breeding birds and the site is also important for wintering wildfowl and waders. A number of scarce wetland plants occur and it is also a locality of a rare moth, a rare beetle, and three rare bee species.

2.19.20 The North Downs Woodland SAC lies 160m to the east of the A229. This site is designated for its Annex I beech forests and yew woods and also includes semi-natural dry grasslands and scrubland facies on calcareous substrates (important orchid sites). This is a high sensitivity site with high exposure to NOx from traffic.

#### **Location A - Water Environment**

##### *South of the River Thames*

2.19.21 Minor watercourses are found at Stone Marshes and parallel with the A282. There are also associated natural and man-made lakes and small ponds. To the west are the man-made lakes of Littlebrook Nature Park. Of local importance, these have some recreational (and potentially) biodiversity interest.

2.19.22 The south is underlain by the Principal Aquifer of the Seaford and Newhaven Chalk Formations. This is important for local and regional public water supplies, and for commercial and industrial use. The West Kent Darent and Cray Chalk water body currently has poor Water Framework Directive (WFD) status. The Chalk is overlain by Alluvium (a secondary aquifer) and by the Taplow and Boyn Hill Terrace Gravels which are "Secondary A" aquifers and may contain groundwater at shallow depth. Their WFD status is not defined. To the extreme south, Location A passes over SPZs 2, 3 and possibly 1 for public water supplies from the underlying Principal Aquifer. The SPZ is used by as a screening tool within The EA *Groundwater Protection: Principles and Practice* (GP3) policy which provides position statements with respect to permitted activities within these zones.

##### *River Thames and Immediate Environs*

2.19.23 The River Thames is of international importance with significant economic and social value. It carries commercial shipping, has significant biodiversity interest and is important for dilution of effluent discharges. The floodplain of the River Thames within Flood Zone 3 (0.05% or 1 in 200 or greater annual probability of flooding) extends circa 1.3 km to the south and circa 2.6 km to the north, where the floodplain is more extensive. The area benefits from the Thames tidal flood defences

(refer to drawing in **Appendix 6**). These are subject to the long term planning set out in Thames Estuary 2100 (TE2100 Plan, November 2012). Under TE2100, the area is within Action Zone 6, for which the adopted planning policy is “*Take further action to keep up with climate and land use change so that flood risk does not increase*”. The integrity of these defences (and their planning) is of regional and national importance. The estuarine/ transitional waters of the Thames Middle water body currently have a WFD status of moderate potential. Habitat and biodiversity interest is recognised in the Thames Estuary recommended Marine Conservation Zone (MCZ).

#### *North of the River Thames*

- 2.19.24 Within the defended part of the Thames floodplain, there are a number of watercourses within the West Thurrock Marshes including the West Thurrock “Main Sewer,” associated drainage and standing water features. These features are of local importance, with some potential biodiversity interest. Further north, adjacent to the A1306 and Thurrock Lakeside, there are man-made lakes with local recreational and amenity interest.
- 2.19.25 Just south of M25 Junction 30, there is the Mardyke and its associated floodplain. The Zone 3 floodplain (refer to section 2.19.23 above) is circa 350m wide and is also defended, forming part of the overall River Thames flood defences. The Mardyke is classified as a heavily modified water body under WFD and currently has poor potential WFD status.
- 2.19.26 The area is also underlain by the Principal Aquifer of the Seaford and Newhaven Chalk Formations, as above, important for local and regional public water supplies and local commercial and industrial use. Location A overlies SPZs 1, 2, and 3 in the extreme north east. The groundwater (WFD) water body is identified separately as the South Essex Thurrock Chalk, currently with WFD status of poor. The Chalk here is also overlain by the “Secondary A” aquifers of the Taplow and Lynch Hill Terrace Gravels. In part these form the Essex Gravels groundwater body, currently with poor WFD status.

### **Location C - Water Environment**

#### *South of the River Thames*

- 2.19.27 There are watercourses, drains and standing water associated with the South Thames Estuary and Marshes Ramsar site and SSSI with associated significant biodiversity interest. These include Shorne, Eastcourt, Great Clane Lane and Filborough Marshes. The Thames and Medway Canal is a WFD artificial water body with moderate potential.
- 2.19.28 The area is underlain by the Principal Aquifer of the Seaford and Newhaven Chalk Formations, important for local and regional public water supplies, and for commercial and industrial use. Currently the WFD status of the West Kent Darent and Cray Chalk water body is Poor. The chalk is overlain in parts by Alluvium which is a secondary aquifer and River Terrace Gravels which are “Secondary A” aquifers and may contain groundwater at shallow depth. Their WFD status is not defined.

To the extreme south, Location C passes over SPZs 2, 3 for public water supplies from the underlying Principal Aquifer.

#### *River Thames and Immediate Area*

- 2.19.29 At Location C the floodplain of the River Thames within Flood Zone 3 (0.05% or 1 in 200 or greater annual probability of flooding) extends circa 1.1km south of the southern shoreline across the Ramsar site and circa 2.3 km to the north across Tilbury Marshes where the floodplain is more extensive. Parts of the area benefit from the Thames tidal flood defences (refer to paragraph 2.19.23).

#### *North of the River Thames*

- 2.19.30 The northern end of Location C crosses the Mardyke flood plain and its associated water bodies. The flood plain (Zone 3) is up to 2km wide (varying according to the crossing point) and, as above, benefits from flood defences. There are a number of locally important and separately defined water bodies, including the "West Tilbury Main" within the Mardyke system, with variously poor or moderate potential WFD status.
- 2.19.31 West and East Tilbury Marshes and associated watercourses occur within the floodplain immediately north of the River Thames.
- 2.19.32 The area is also underlain by the Principal Aquifer of the Seaford and Newhaven Chalk Formations, important for local and regional public water supplies and local commercial and industrial use. To the east SPZs 1, 2, and 3 are present in the vicinity of Chadwell St Mary. The groundwater (WFD) water body is identified separately as the South Essex Thurrock Chalk, currently with poor WFD status. The Chalk here is also overlain in parts by Alluvium which is a secondary aquifer and by terrace gravels (Taplow, Lynch Hill and Boyn Terrace Gravels) which are "Secondary A" aquifers. In part these form the Essex Gravels WFD groundwater body, currently with poor status.

## **2.20 Integration**

### *Land-Use Policy*

- 2.20.1 The land-use policy context is provided by the transport and local plans of those local authorities for each location. Reference is also made to local authority corporate strategies, where relevant, to provide an overview of the strategic position on the proposed new Lower Thames Crossing. For Locations A, C and C<sub>variant</sub>, these areas cross the same local authority boundaries and therefore it is more appropriate to present the information on a local authority basis rather than by location.

### *European Policy*

- 2.20.2 The *Roadmap to a single European transport area - Towards a competitive and Resource Efficient transport system* supports the growth in transport through the provision of modern infrastructure, smart pricing and funding, whilst meeting the 60% emission reduction targets.
- 2.20.3 A key aim of the proposed Lower Thames Crossing is reducing congestion at one of the busiest parts of the national transport system

and through the increased capacity across the Lower Thames to reduce traffic congestion and delay.

- 2.20.4 The EU TEN-T Guidelines do not support European funding for the Lower Thames Crossing. As such, the A282 is not included within the defined core network corridor, as the primary focus for EU funding across Member States, as set out within the Guidelines.
- 2.20.5 As described above, the Thames Estuary and Marshes SPA and Ramsar sites as well as other European designated sites lie within the study areas. The *Habitats Directive* 92/43/EEC on the *Conservation of Natural Habitats and Wild Flora and Fauna* provides legal protection for habitats and species of European importance. The Directive is transposed into UK law by the *Conservation of Habitats and Species Regulations* 2010, as amended (hereafter referred to as the 'Habitats Regulations'). Regulation 61 of the *Habitats Regulations* requires the competent authority to make an 'Appropriate Assessment' of the implications for that site in view of its conservation objectives, before deciding to give consent for a plan or project which:
- Is likely to have a significant effect on a European site (either alone or in combination with other plans or projects).
  - Is not directly connected with or necessary to the management of that site.
- 2.20.6 In the light of the conclusions of the assessment, the competent authority may agree to the plan or project only after having ascertained that it will not adversely affect the integrity of the European site.
- 2.20.7 All plans and projects should identify any potential impacts early in the decision-making process and then either alter the plan or project to avoid them or introduce mitigation measures to the point where no adverse impacts remain.
- 2.20.8 During April 2015 a Supreme Court judgement on air quality was issued relating to the continued failure by the United Kingdom since 2010 to secure compliance with the limits for nitrogen dioxide levels set by European law, under the *Ambient Air Quality Directive* 2008/50/EC on ambient air quality and cleaner air for Europe. The UK has been divided into 43 air quality zones or agglomerations and within 40 out of the 43 zones, acceptable levels of nitrogen dioxide are being exceeded. There are no compliant zones in the south east. The UK was therefore found to be in breach of its obligations under the directive and the UK must, therefore, produce updated plans for all 40 zones by the end of 2015 to advise how they will secure compliance.

#### *National Policy*

- 2.20.9 The HM Treasury *National Infrastructure Plan* (2014) states the Government's aim to create a national network fit for the 21st century. In support of its objectives for the roads sector, the Lower Thames Crossing is included within the Government's Top 40 priority infrastructure investments. The plan highlights the expected increase in travel on the UK's strategic road network and notes that without the

required level of investment, this is likely to have a significant impact on levels of congestion.

- 2.20.10 The Department for Transport '*Action for Roads: A network for the 21st century*' (2013) maintains that well-connected road infrastructure with sufficient capacity is vital for economic success, although advises that the latest estimates show that traffic levels on strategic roads will be 24% higher in 2040 than today. The document goes on to say that without investment, conditions on the most important routes will worsen by then, with around 15% of the entire strategic road network experiencing regular peak-time congestion.
- 2.20.11 The NPSNN sets out the need for and Government's policies for nationally significant infrastructure projects (NSIPs) in England. The Statement recognises the significant role to be played by the national road network in supporting economic growth, highlighting that the pressure on the network is expected to increase. The need for development on the national networks to support national and local economic growth and regeneration, particularly within the most disadvantaged areas is also recognised. For these reasons the NPSNN advises that the Government has concluded that at a strategic level, there is a compelling need for development of the national road networks.
- 2.20.12 The NPSNN highlights the impact of traffic congestion on the economy and that forecast pressures on the road network is likely to be greatest in and around areas of high population density and along key inter-urban corridors. On the question of tolling, the Government considers this as a means of funding new road capacity on the strategic road network. Paragraph 3.25 of the NPSNN states that 'river and estuarial crossings will normally be funded by tolls or road user charges'.
- 2.20.13 The NPSNN provides planning guidance for promoters of nationally significant infrastructure projects on the road and rail networks and the basis for the examination by the Examining Authority and decisions by the Secretary of State. This guidance should inform the development of the Lower Thames Crossing scheme to ensure that all relevant issues are considered in its development, design and assessment.
- 2.20.14 The National Planning Policy Framework (NPPF), Department for Communities and Local Government (2012), sets out the Government's planning policies for England. Guidance is provided on the policy requirements regarding development within the green belt. Each of the locations for the new Lower Thames Crossing would pass through green belt land and therefore the necessary tests and policy compliances will need to be met.
- 2.20.15 The recently published *London Infrastructure Plan 2050 Update* (March 2015) notes the support for new river crossings to help regeneration in major growth areas in East London. More specifically, the accompanying *Transport Supporting Paper* identifies a transport requirement for a series of new river crossings in east London to overcome the major barrier effect constraining the potential of this region. The Paper also

highlights the role of the new Lower Thames Crossing in supporting, as a further transport requirement, 'the need for a world class hub airport within the Thames Estuary.'

*Essex County Council (Location A and C)*

- 2.20.16 The County's *Transport Strategy* (2011) aims to provide connectivity for Essex communities and international gateways, as well as reducing carbon dioxide emissions and improving air quality.

*Kent County Council (Location A, C and C<sub>variant</sub>)*

- 2.20.17 Kent County Council has taken a proactive stance in promoting a new Lower Thames Crossing, recognising the economic benefits of reducing traffic congestion and delay in delivering expected economic growth within the County. The Council has sought, through its *Strategic Policy Statement* (2014-2015) to secure funding to support Kent's infrastructure and economy. Although no direct funding has been forthcoming for the Lower Thames Crossing, significant private sector jobs and new homes are proposed within the area, which are likely to benefit from increased capacity on the Dartford crossing.
- 2.20.18 This position is highlighted within the Council's *Transport Delivery Plan for Kent* (2010), which recognises the need for the transport network to have sufficient capacity to accommodate a level of growth expected from a combination of the Thames Gateway, the growth area of Ashford and the growth points of Dover and Maidstone. The strategic importance attached to the proposed Lower Thames Crossing has been identified in the studies commissioned by the Council to examine the feasibility and benefits of the proposed crossing.
- 2.20.19 The *Kent and Medway Structure Plan* (2006) includes a policy commitment seeking the Government's support for a new Lower Thames Crossing, recognising at the same time, the need to protect the nationally important recommended Marine Conservation Zone to the east of Gravesend.

*Greater London Authority (Location A and C)*

- 2.20.20 The recent adopted *London Local Plan* (January 2015) seeks to ensure that appropriate resources, particularly for transport, are made available to secure the optimum development of the growth areas and corridors as a whole and those parts that lie within London and seeks to improve and expand London's international and national transport links. The plan also requires that development should not encroach within the green belt (which includes Location C). The *Mayor's Transport Strategy* (2010) seeks to provide new links to support development, including the new Lower Thames Crossing.

*Brentwood Borough Council (Location C)*

- 2.20.21 The Council, through its *Corporate Plan* (2014-2016) aims to promote economic growth and sustainable development within the Borough, along with infrastructure delivery. The Council's *Replacement Local Plan* (2005) provides the land use planning framework for the Borough and

includes policy guidance relating to development in the green belt, the safeguarding of woodlands and listed buildings.

*Dartford Borough Council (Location A)*

- 2.20.22 The Council's *Corporate Plan* (2013 - 2016) recognises the need for a long term solution to the Dartford crossing. Although not promoting construction of the Lower Thames Crossing, the Kent Thameside *Strategic Transport Programme* (forming part of the Council's LDF 2011) includes an investment package to support local infrastructure schemes within Dartford which are seen as benefitting from the new Lower Thames Crossing. The Council's *Core Strategy* (2026) seeks to ensure the protection and enhancement of the green belt.

*Gravesham Borough Council (Location C)*

- 2.20.23 The Council's *Corporate Business Plan* (2011- 15) sets out the Council's commitment to supporting high quality transport infrastructure. This aligns itself with the high levels of out-commuting to work within Gravesham, particularly to Dartford and Central London. In terms of transport modes, over half of working residents within Gravesham travel to work by car.
- 2.20.24 At the same time the delivery of development at Ebbsfleet and Eastern quarry would be supported through the provision of a new Lower Thames Crossing.
- 2.20.25 The Council's *Adopted Core Strategy* (2014) provides a range of policy guidance reflecting the potential impacts of the location options passing through the Borough. This includes protection of the green belt, the conservation and enhancement of the Kent Downs AONB, the protection and enhancement of the Borough's heritage assets and the protection of sites designated for their biodiversity value.
- 2.20.26 The strategy also highlights the importance of the Dartford Crossing as one of the UK's most important strategic connections, but draws attention to its overloading for large periods of the day. Following consultation by the Department for Transport in 2013 on three alternative options to address capacity issues on the Dartford crossing, the strategy notes the Council's objection to an option at Location C.

*Havering Borough Council (Location C)*

- 2.20.27 Havering Borough Council supports, through its *Corporate Plan* (2014 - 2015) good infrastructure and transport links to London and the surrounding areas. Traffic congestion is however recognised as a challenge within the Borough, particularly for road freight, highlighted by the Borough's strategic location to serve inbound and outbound freight from East Anglia, Essex, Kent and Sussex via the M25, A12 and A13.
- 2.20.28 The need for improved transport connectivity to and between key regeneration areas within Havering is recognised within the Council's *Local Implementation Plan* (2007). Havering is undergoing several major regeneration and development programmes which are expected by 2025 to have created 25,000 jobs and 4,000-5,000 new homes. The provision of a new Lower Thames Crossing would provide vital links into Havering.



2.20.29 The Council's *Adopted Core Strategy and Development Control Policies Development Plan* (2008) seeks the protection of the green belt, the maintenance and enhancement of the Borough's biodiversity and the preservation and enhancement of buildings of special architectural or historic importance all of which could be impacted directly or indirectly.

*Medway Council (Location C and C<sub>Variant</sub>)*

2.20.30 The *Medway Council Plan* (2014 - 2015) seeks to secure a local transport network to support regeneration, economic competitiveness and growth within the Borough. Key projects identified within Medway include Rochester Riverside, Chatham Town Centre and Rochester Airport. The proposed Lower Thames Crossing is seen as enabling this planned growth through enhancing connectivity locally and within the wider area.

2.20.31 Policies contained within the Council's *Local Plan* (2003) provide policy guidance against which to assess the impacts of the location options on the green belt and the Kent Downs AONB.

*Thurrock Borough Council (Location A and C)*

2.20.32 The Council, through its *Corporate Plan and Medium Term Financial Strategy* (2013 - 2016) states its intention to lobby for key infrastructure improvements including free-flowing tolls at the Dartford Crossing. The Council is also seeking to develop a regeneration and delivery plan for Grays, London Gateway, Lakeside Basin, Purfleet and Tilbury for which a new Lower Thames Crossing is seen as supporting Thurrock's development proposals.

2.20.33 The Council's *Adopted Core Strategy and Policies for Management of Development* (2011) aims to protect and enhance listed buildings and scheduled monuments and to sustain and enhance the open character of the green belt. The Council's *Transport Strategy* (2013 - 2026) aims to improve air quality, which may benefit from the new Lower Thames Crossing.

*London Borough of Bexley (Location A)*

2.20.34 A small part of Location A extends into the north-east corner of the Borough. The Council's *Adopted Core Strategy* (2012) is supportive of major new infrastructure proposals within or affecting the Borough. Similarly, the Council's *Local Implementation Plan* (2014/15 - 2016/17) seeks the development of improved transport systems that support regeneration and economic development within the Borough.

*Maidstone Borough Council (C<sub>Variant</sub>)*

2.20.35 A key priority for the Council, as set-out in its *Strategic Plan* (2011-15) is for Maidstone to have a growing economy. The Council's *Economic Development Strategy* (2008) aligns itself with this priority, seeking to improve the transport network to underpin economic growth, as well as serving local, regional and national markets. Consistent with this position, the Council, in a *Joint Integrated Transport Strategy* (2012) with Kent County Council seeks to ensure that the transport system supports the growth projected in the Core Strategy by facilitating economic prosperity.

2.20.36 The *Core Strategy* (2011) seeks to safeguard and maintain the character of the Borough's landscapes, including the Kent Downs AONB and to protect areas of ancient woodland from inappropriate development.

*Tonbridge and Malling Borough Council (C<sub>variant</sub>)*

2.20.37 The Council's *Economic Regeneration Strategy* (2015/16-2018/19) sets out the Council's funding priorities, including improvements on the M20 and M25. The location of the Borough close to the M25 and London markets would be further supported by improved network links through the provision of this route option. The Council's *Core Strategy* (2007) states that development would not be permitted that is detrimental to AONBs or harm SSSIs. The location option crosses the Kent Downs AONB and runs in close proximity to Wouldham and Detling Escarpment SSSI.

*South East Regional Policy*

2.20.38 The South East Local Economic Partnership (SE LEP) published a *Growth Deal and Economic Plan* (2014). The Plan includes a request for the Government's commitment to deliver specific national trunk road investments, including the Lower Thames Crossing.

## 2.21 River Operations

2.21.1 The River Thames is Britain's busiest inland waterway, handling an estimated 44m tonnes of cargo and contributing over £4bn to the economy in 2014. Each year thousands of commercial and leisure vessels pass within the Port of London's 95 miles of river and estuary between Teddington and the North Sea. Of these, over 10,000 larger vessels are guided by Thames pilots annually.

2.21.2 Marine traffic data produced by the Port of London Authority (PLA) was received from AECOM in August 2014. This data consisted of shipping activity from May 2011 up until June 2012 in each of the crossing locations considered at that time. Consequently, more recent data was requested from the Port of London Authority. This was received in January 2015 and contained data from the previous three years (May 2012 to January 2015).

2.21.3 The new data provided by the PLA suggests that marine traffic has not altered significantly over the past three years. Although movement of vessels larger than those that were previously recorded has been logged, these vessels are infrequent.

2.21.4 The raw marine traffic data has been analysed to produce a concise list of the following data for the 2014 return period:

- All of the vessels transiting the River Thames within each location and their key characteristics.
- The active jetties and wharves on the River Thames within or upstream of each location and their key traffic characteristics.
- The number of vessel movements along the River Thames to or from destinations within or upstream of the locations.

2.21.5 The following sections contain analysis of the data to provide an understanding of the nature of the river traffic passing both crossing locations.

#### Location A

2.21.6 The number of vessel movements along the River Thames at Location A are summarised in **Figure 2.22**:

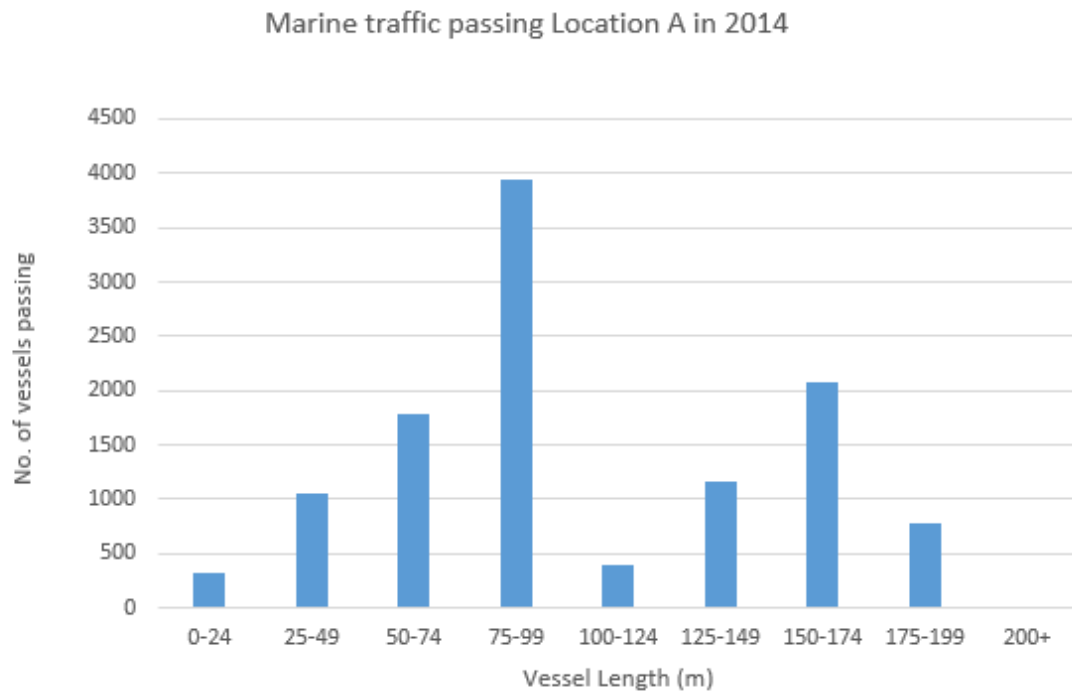


**FIGURE 2.22 - MARINE TRAFFIC LOCATION A**

2.21.7 The jetties and wharves receiving larger vessels are summarised in **Figure 2.23**:

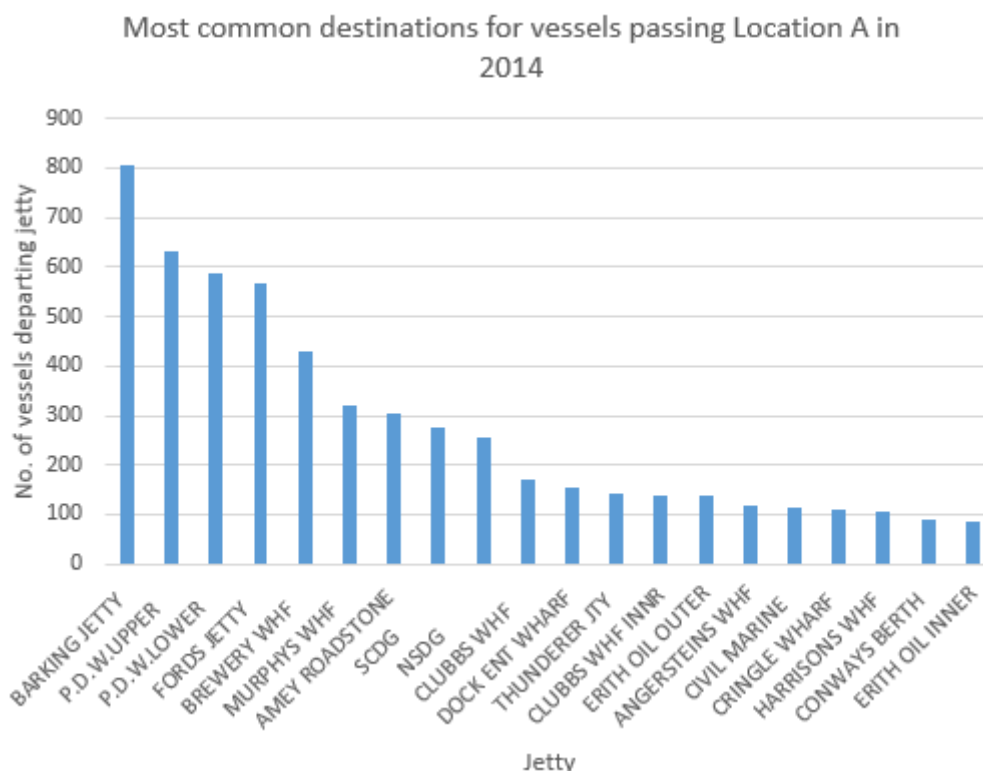


**FIGURE 2.23 - JETTY USAGE LOCATION A**

- 2.21.8 It is assumed that any new crossing of the River Thames at Location A would not impose any additional marine navigation restrictions beyond those already in place due to the existing tunnels and QEII Bridge. The number of jetties and wharves potentially permanently affected by a new crossing at Location A would therefore be limited to those either immediately adjacent to the existing crossing, due to loss of local access, or those to the east of the existing crossing, due to new navigation restrictions.
- 2.21.9 During construction temporary navigation restrictions may be required for larger vessels using adjacent jetties and wharves.
- 2.21.10 The largest vessel size recorded in the Location A region according to the new data is 53,160 DWT, this is slightly lower than what was previously recorded (58,020 DWT). The frequency of such vessels still remains low, with activity of vessels over 45,000 DWT only having occurred four times over the three year period (in October 2012, June 2013, September 2013, and November 2014). What appears to be of greater significance are those vessels of deadweight tonnage in the range 35,000 DWT to 40,000 DWT (Note: there were no vessels in the 40,000 to 45,000 DWT range). Such vessels were recorded passing under the existing crossing on 66 occasions, on average every 1-2 weeks. In 2014 however, activity seems to decrease with a large vessel only appearing every 6-8 weeks.

## Location C

2.21.11 The number of vessel movements along the River Thames at Location C are summarised in **Figure 2.24**:

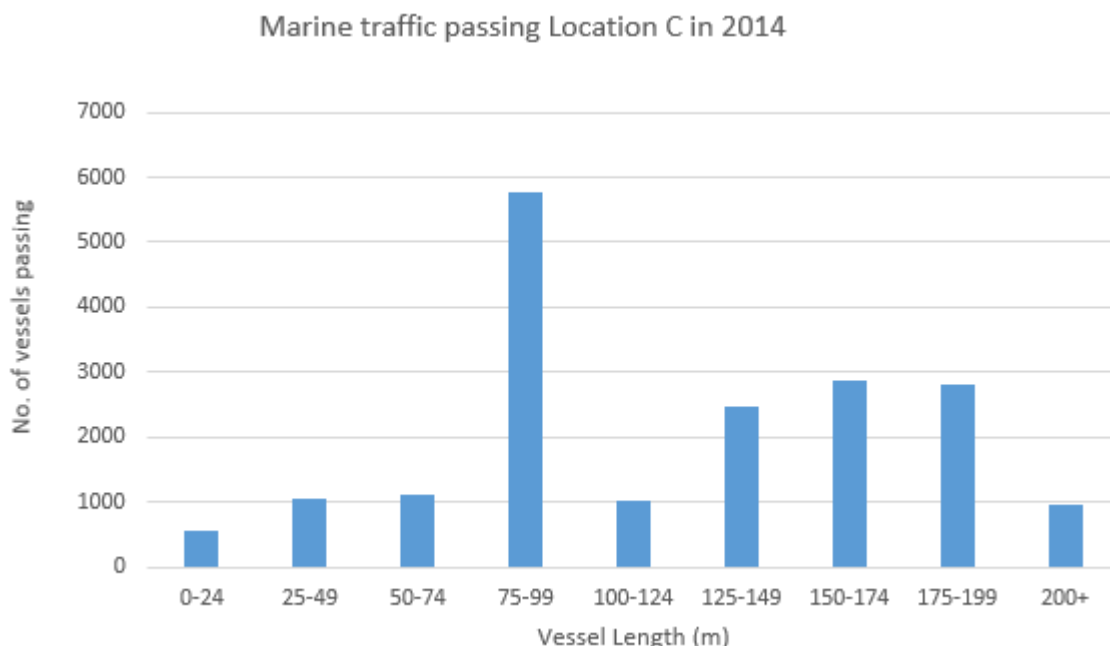


**FIGURE 2.24 - MARINE TRAFFIC LOCATION C**

2.21.12 The jetties and wharves receiving larger vessels are summarised in **Figure 2.25**:

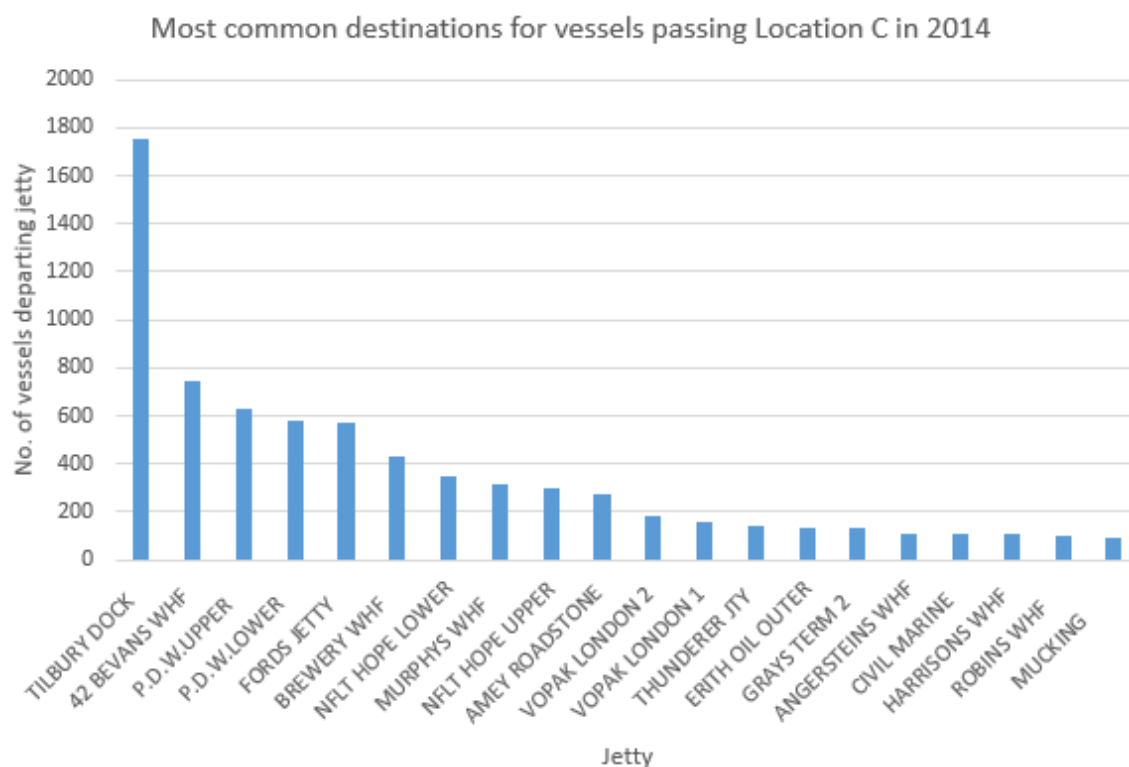


**FIGURE 2.25 - JETTY USAGE LOCATION C**

- 2.21.13 Any crossing of the River Thames at Location C would potentially impose additional marine navigation restrictions on vessels travelling to jetties and wharves upstream of the new crossing location and downstream of the existing Dartford-Thurrock crossing.
- 2.21.14 Location C has a more frequent and routine pattern of activity. The largest vessels generally remained in the 90,000–100,000 DWT bracket and their presence was recorded on 436 occasions. Therefore a vessel of this size would be either entering or leaving the Port of London, passing the proposed position of the Location C crossing, every 2-3 days on average. The largest vessels noted in the records were 124,479 DWT, however the movements of these are only recorded on six occasions (all in April of 2014).
- 2.21.15 An important factor when determining where to place bridge piers is the effect of vessel impact. The navigation channel width requirements would set a minimum span for the bridge between main piers, but it may be necessary to increase this span further to reduce the risk of vessel impact to an acceptable level. In some cases it may be necessary to remove the piers from the water altogether if vessel impact loads are too high to be reasonably resisted by the structure.
- 2.21.16 At present limited information is available on the future development anticipated in:
- The ports and berths along the River Thames.
  - The volume of marine traffic navigating the locations.
  - The size of the vessels navigating the locations.

#### **Future Marine Traffic**

- 2.21.17 Future marine traffic data will be obtained from the stakeholder engagement process and will be used in the quantitative and qualitative risk analysis studies to determine the air clearance and vessel impact criteria should a bridge crossing be selected for further development

## **2.22 Traffic Management (TM) Cell - Dart Charge**

- 2.22.1 The TM Cell is a mitigation for the risk that non-compliant vehicles enter the tunnels following the removal of the toll plaza charging booths. Over-height and dangerous goods vehicles were previously brought to a halt at the charging booths by traffic signals and lifting arm barriers, from which point they could be directed by operational staff accordingly. The TM Cell has replaced the booths that used to manage these non-compliant vehicles in a way that supports the free-flow benefits wherever possible.
- 2.22.2 The TM Cell came into operation on 15 June 2015 and is being refined in the light of operational experience. In addition, some features and facilities have not yet been deployed but these are being rolled out over the next few months.
- 2.22.3 The traffic management cell comprises roadside equipment (traffic signals, lifting arm barriers, ANPR cameras, electronic signs) which

require co-ordination by a control system and limited interfacing to existing systems. The primary purpose of the TM Cell is to:

- Detect over-sized vehicles (height, width, length) and, when detected, bring traffic to a halt and support the extraction of the non-compliant vehicle to the Kent Marshalling Area.
- Discriminate between:
  - Over-height vehicles which are too high for the west tunnel, but are low enough for the east tunnel
  - Over-over-height vehicles which are too high for both the east and west tunnels.
- Bring traffic to a halt and support the extraction of unauthorised dangerous goods vehicles to the Kent Marshalling Area, when this has been observed by an operator or detected by a hazardous goods vehicle detection system.
- Bring traffic to a halt in order to release a vehicle or convoy into either tunnel.
- Bring traffic to a halt and support the closure of either or both tunnels
- Meter traffic into either or both tunnels.

2.22.4 There are no connections from the TM Cell to the Highways England communications network due to the 'stand-alone' nature of the situation at Dartford.

2.22.5 Wherever possible, existing type-approved equipment has been used, including:

- Over-height sensors approved to TR 2515
- Traffic signals approved to TR 2206
- Signal controllers approved to TR 2500

2.22.6 Non Standard Equipment; ANPR – Automatic number plate recognition cameras have been deployed to support:-

- Event records – to associate identified vehicles with activations of the TM Cell.
- Hot lists – to allow dangerous goods vehicles that repeatedly ignore signing to be identified and managed.
- The 'check and allow' function.



## 3 Future Developments

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### 3.1 Introduction

- 3.1.1 This chapter summarises the future highway schemes and housing and employment developments that have been included in the LTC v1 traffic model.
- 3.1.2 A number of schemes and developments, both north and south of the Thames, have taken place since the LTC v1 traffic model was used in the 2013 Review. An even larger number of housing and employment developments are planned for the future. The scale of these developments is significant and has been driven, in part, by the continued growth and eastward expansion of London. The developments include:
- London Paramount Entertainment Resort – the largest leisure park development in Europe.
  - Ebbsfleet Garden City – provides 15,000 new homes.
  - Thames Gateway port – when fully built out this will be one of the largest container ports in Europe.
  - Barking Riverside – new housing developments.
  - Significant expansions planned at Bluewater and Lakeside retail parks.
  - Significant expansions planned at Tilbury and Sheerness Ports.
  - A large number of other housing and other developments across several local authorities.
- 3.1.3 However in carrying out the longlist appraisal there was insufficient time to include information about these developments in the LTC v1 traffic model and the assumptions about developments were largely unchanged from those included in the AECOM 2009 base year model used for the 2013 Review.

### 3.2 Highway Schemes

- 3.2.1 The production of the forecast road network used in the 2013 Review is described in a report by AECOM.<sup>21</sup> That report states that 170 road network schemes were considered of which 65 were included in the model as described in Appendix A of the AECOM report. HHJV has reviewed Appendix A and found that only 61 schemes were included in the model, as listed in **Table 3.1**.

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<sup>21</sup> AECOM (2013): Review of Lower Thames Crossing Options: Central Forecasts and Sensitivity Tests Report

**TABLE 3.1 - SCHEMES INCLUDED IN THE LTC V1 WITHOUT SCHEME ROAD NETWORKS**

|    | Scheme Name                                         | Comment                                                                    |
|----|-----------------------------------------------------|----------------------------------------------------------------------------|
| 1  | Dartford Thurrock River Crossing Free-flow Charging |                                                                            |
| 2  | M25 J16-23 Widening                                 | Included in 2009 Base Year                                                 |
| 3  | M25 Widening J1b-3                                  |                                                                            |
| 4  | M25 J27-30/ 31 Widening                             | Included in 2009 Base Year                                                 |
| 5  | M25 Junction 28 Improvements                        |                                                                            |
| 6  | Widening of M25 J12-15                              | Included in 2009 Base Year                                                 |
| 7  | Widening of M1 J6a-10                               | Included in 2009 Base Year                                                 |
| 8  | M1 J10-13 Hard Shoulder Running                     |                                                                            |
| 9  | M2 J2 Reconfiguration                               | Included in 2009 Base Year                                                 |
| 10 | M27 J3-4 Widening                                   | Included in 2009 Base Year                                                 |
| 11 | M40/ A404 Handy Cross Improvements                  | Included in 2009 Base Year                                                 |
| 12 | M42 J3a-7 Active Traffic Management                 | Included in 2009 Base Year                                                 |
| 13 | A11 Attleborough Bypass Dualling                    | Included in 2009 Base Year                                                 |
| 14 | A2 Bean to Cobham                                   | Included in 2009 Base Year                                                 |
| 15 | A414 Hastingwood Road                               |                                                                            |
| 16 | A47 Thorney Bypass                                  | Included in 2009 Base Year                                                 |
| 17 | A421 Great Barford Bypass                           | Included in 2009 Base Year                                                 |
| 18 | A428 Caxton Common to Hardwick Improvements         | Included in 2009 Base Year                                                 |
| 19 | A4146 Stoke Hammond and Linslade Western Bypass     | Included in 2009 Base Year                                                 |
| 20 | A505 Baldock Bypass                                 | Included in 2009 Base Year                                                 |
| 21 | A505 Luton East Corridor Dualling                   |                                                                            |
| 22 | A6 Elstow to Wilstead Dualling                      | Included in 2009 Base Year                                                 |
| 23 | A507 Ridgemont Bypass                               | Included in 2009 Base Year                                                 |
| 24 | A41 Hunton Bridge Developments                      | Not Included                                                               |
| 25 | A406 North Circular Road/ A10 Junction              | Included in 2009 Base Year                                                 |
| 26 | A11 Fiveways to Thetford                            | A section of the A11 has been removed in AECOM LTC model and not replaced. |
| 27 | A3 Hindhead                                         |                                                                            |
| 28 | A419 Blunsdon Bypass                                | Included in 2009 Base Year                                                 |
| 29 | A421 Bedford to M1 J13                              |                                                                            |
| 30 | A4010 Chapel Lane Junction Improvements             |                                                                            |
| 31 | A503 Finsbury Park                                  |                                                                            |
| 32 | A428 Bedford Western Bypass                         |                                                                            |
| 33 | A23 Handcross to Warninglid                         |                                                                            |
| 34 | M40 J1a/ M26 J16 Improvements                       | Included in 2009 Base Year                                                 |

|    | Scheme Name                                                    | Comment                                                       |
|----|----------------------------------------------------------------|---------------------------------------------------------------|
| 35 | M25 J12 and M3 New Road Layout                                 | Included in 2009 Base Year                                    |
| 36 | M4 J4 Improvement                                              | Included in 2009 Base Year                                    |
| 37 | A130/ A13 Sadlers Farm                                         |                                                               |
| 38 | A21 Tonbridge to Pembury Dualling                              |                                                               |
| 39 | A5 – M1 Dunstable Bypass                                       |                                                               |
| 40 | M25 J30                                                        |                                                               |
| 41 | M4 Junction 3-12 Hard Shoulder Running                         |                                                               |
| 42 | M3 Junction 2-4A Hard Shoulder Running                         |                                                               |
| 43 | West Thurrock Regeneration                                     |                                                               |
| 44 | A24 Horsham to Capel                                           |                                                               |
| 45 | A228 Main Road to Ropers Lane                                  | Included in 2009 Base Year                                    |
| 46 | M25 J5-6/7 Hard Shoulder Running                               |                                                               |
| 47 | M25 J23-27 Widening                                            |                                                               |
| 48 | Kender Street and Besson Street A2/ A202 Sydenham Road A212    |                                                               |
| 49 | Canning Town Roundabout to Signals                             |                                                               |
| 50 | M20 Junction 10a Improvements                                  |                                                               |
| 51 | A226 Thames Way Dualling                                       |                                                               |
| 52 | A226/ B255 London Road / St Clements Way Junction Improvements |                                                               |
| 53 | A226 Dartford Town Centre Ring Road Improvements               |                                                               |
| 54 | Gravesend Transport Quarter Phase 3 – Rathmore Road Link       |                                                               |
| 55 | Drovers Roundabout – M20 Junction 9 Improvements               | Insufficient network detail in the model to justify inclusion |
| 56 | A28/ A2 On slip road                                           | Insufficient network detail in the model to justify inclusion |
| 57 | A249 Iwade to Queenborough Improvements                        |                                                               |
| 58 | Chatham Ring Road Reconfiguration                              |                                                               |
| 59 | A289 Medway Tunnel – Four Elms Link                            |                                                               |
| 60 | A127 junction Improvements/ Basildon Enterprise Corridor       |                                                               |
| 61 | A13/ A1014 Junction Improvement                                | Added to the LTC v1 Without Scheme Road Networks              |

3.2.2 23 of these network schemes were included in the 2009 base year model.

3.2.3 A review of the scheme files used in producing the 2025 and 2041 networks confirms:

- 61 schemes listed as included.
- 23 are marked as included in the 2009 Base model.
- 33 are included in the 2025 and 2041 Without Scheme networks.
- 4 schemes listed in the documentation as included in the model were in fact not included. These are listed below. The omission of these schemes was not considered significant.
  - A41 Hunton Bridge Improvements – no evidence of any network changes at this junction.
  - A11 Fiveways to Thetford – Section of A11 removed but no new scheme included (resulted in a gap in the A11 in the model).
  - Drovers Roundabout – M20 J9 Improvements – insufficient network detail to justify this change.
  - A282/ A2 On-Slip Road – insufficient network detail to justify this change.

3.2.4 Only one additional scheme, A13/ A1014 Junction Improvement, was added to the current LTC v1 Without Scheme networks.

### **3.3 Dart Charge**

3.3.1 The AECOM report states in Section 2.3 that the potential effect of the Dartford Free-Flow Charging on crossing journey times, and on the average charge paid, has been included in the Lower Thames crossing forecasts.

3.3.2 In detail the following has been modelled to represent Dartford Free-Flow Charging conditions, as used for the Dart Charge Business Case, in the LTC v1 traffic model:

- Capacity Northbound 5,612 PCU per hour; southbound 6,687 PCU per hour.
- Southbound (30kph) toll booths removed; increasing capacity to that of the approach road.
- Northbound (30kph) toll booths removed but the tunnel standard acts as a constraint and traffic signalization has been modelled on the approach to represent the Traffic Management Cell (TMC).
- To model TMC data on the frequency and duration of interventions (to deal with over-height or unregistered dangerous goods) has been used to estimate signalling in the model to estimate the occurrence and duration of red lights.
- Assumed that TMC has a constant operational level with no efficiencies.

3.3.3 There is an assumed increase in capacity in the southbound direction but due to the introduction of traffic signals to represent the TMC in the northbound direction the capacity is reduced in LTC v1 forecast networks compared to the base year model.

## 3.4 Housing and Employment developments

- 3.4.1 The AECOM report explains that changes in travel demand are derived from forecasts of land use patterns based on population and employment data. Traveller trip ends, number of trips for each Origin and Destination, are based on the Department for Transport's (DfT) National Trip-End Model (NTEM) and National Car-Ownership Model (NatCOP) which are used to adjust base year travel demand. Freight growth assumptions are derived from DfT's National Transport Model and applied to the base year freight matrices directly. The report describes the process and data sources used to produce employment, households and population estimates for the traffic model. Three sources were used:
- NTEM version 6.2.
  - TfL's London Transportation Studies (LTS) model for the 33 boroughs of London.
  - Consultation with 11 local authorities - Brentwood, Basildon, Castle Point, Southend-on-Sea, Thurrock, Dartford, Gravesham, Medway, Sevenoaks, Tonbridge and Malling and Maidstone.
- 3.4.2 The link between the planning assumptions and the model inputs could not be found in the handover documentation from AECOM, although the planning data from Transport for London (TfL) was used for the London Borough forecasts. It is believed that headline planning data statistics which contain global, projected forecasts for the key districts were used as the overall development totals, with data for specific developments applied at a local level. The link between this information and the trip-end model is unclear and the numbers do not match precisely those in the trip-end model, although it is recognized that they are in the same sort of order.
- 3.4.3 In Section 2.4.8 the AECOM report states that local planning data was constrained by district to growth levels included in NTEM v6.2 in accordance with WebTAG guidance.

3.4.4 **Table 3.2** presents the comparison of growth between NTEM and local data for the period 2009 to 2025 prior to the application of this constraint. Following the application of this constraint the NTEM totals were adopted, with the more detailed trip patterns coming from the local data.

**TABLE 3.2 - LOCAL PLANNING DATA GROWTH FORECASTS (2009 TO 2025) COMPARED WITH NTEM 6.2 (REPLICATED FROM TABLE 2.1 AECOM REPORT)**

| Location              | NTEM 6.2   |        | Local Authorities |        | Difference (%) |      |
|-----------------------|------------|--------|-------------------|--------|----------------|------|
|                       | Households | Jobs   | Households        | Jobs   | Households     | Jobs |
| Basildon              | 5,430      | 8,423  | 6,501             | 8,423  | 20%            | 0%*  |
| Brentwood             | 2,743      | 5,445  | 2,090             | 4,000  | -24%           | -27% |
| Castle Point          | 3,925      | 1,472  | 1,865             | 2,117  | -52%           | 44%  |
| Dartford              | 15,849     | 14,652 | 14,395            | 22,610 | -9%            | 54%  |
| Gravesham             | 8,215      | 686    | 3,650             | 2,491  | -56%           | 263% |
| Maidstone             | 9,497      | 4,429  | 10,051            | 7,666  | 6%             | 73%  |
| Medway                | 18,168     | 2,491  | 15,494            | 15,634 | -15%           | 528% |
| Sevenoaks             | 3,081      | 5,179  | 2,718             | 5,180  | -12%           | 0%*  |
| Southend-on-Sea       | 11,605     | 5,693  | 5,079             | 10,635 | -56%           | 87%  |
| Thurrock              | 18,241     | 5,620  | 18,781            | 17,344 | 3%             | 209% |
| Tonbridge and Malling | 8,864      | 2,968  | 7,595             | 2,983  | -14%           | 1%   |
| Total (Districts)     | 105,609    | 57,059 | 88,219            | 99,083 | -16%           | 74%  |

\*Basildon and Sevenoaks District Councils provided NTEM derived employment forecasts

## 4 Planning Factors

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### 4.1 Planning Factors

- 4.1.1 As outlined within Sections 2.14 to 2.20 there are a large number of environmental constraints that need to inform and shape the delivery of the preferred scheme. A summary of the key issues associated with these constraints is provided in the following sections.
- 4.1.2 There are a large number of AQMAs and potentially sensitive receptors that could be affected by a new scheme. Detailed air quality and noise and vibration assessments will be required for the scheme to ensure that effects on sensitive receptors, both human and ecological, are understood in accordance with the NPSNN. There may be a requirement for noise mitigation such as acoustic barriers.
- 4.1.3 The townscape within Location A is already heavily influenced by industry and the existing QEII Bridge crossing and is therefore not considered a significant constraint to the scheme. However, a new bridge structure presents an opportunity to design an iconic structure that would require involvement of the Highways England Design Panel. Similarly, any new road infrastructure and planting would need to be designed in consultation with local authorities and statutory bodies.
- 4.1.4 The landscape within Location C is varied with a very different character south and north of the river. Part of the landscape lies within the Kent Downs AONB and there is potential for a new scheme either within or on the fringes of the AONB to have significant effects on landscape and visual amenity. C<sub>Variant</sub> lies within the AONB. Paragraph 5.152 of the NPSNN clearly states that there is a strong presumption against any significant road widening or the building of new roads in an AONB unless there is a compelling case for the new or enhanced capacity. The effects of the scheme on the special characteristics and qualities of the AONB would also need to be assessed.
- 4.1.5 The design of the scheme will be informed by Landscape and Visual Assessment and engagement will be required with statutory consultees and other stakeholders, potentially the Kent Downs AONB, depending upon the route option selected to ensure that robust mitigation is developed to protect both designated and undesignated landscapes and visual amenity. A new bridge structure presents an opportunity to design an iconic structure that would require involvement of the Highways England Design Panel.
- 4.1.6 There is the potential for direct (habitat loss) and indirect (nitrogen deposition) impacts on ancient woodland and SSSIs depending upon the route option selected. There are also risks associated with nitrogen deposition at the North Downs Woodland SAC within the C<sub>Variant</sub> study area. The NPSNN in paragraph 5.32 clearly outlines a presumption against the loss of ancient woodland and veteran trees. Similarly paragraphs 5.28 and 5.29 outline the importance of protecting SSSIs. Further site survey and assessment work would be required to

understand the potential effects and options for mitigation. This may include site surveys and air quality modelling to understand potential nitrogen deposition effects. Hydrodynamic modelling will also be required in the event of a bridge or immersed tube tunnel solution being pursued.

- 4.1.7 There is the potential for the selected route option to directly and indirectly impact the Thames Estuary and Marshes SPA and Ramsar site. Even if a route option avoids a direct impact on the land that falls within the designated area, there is a risk of impacting functionally linked land that is used by mobile species for which the sites are designated. An initial Habitat Regulations Assessment (HRA) screening exercise is in progress to inform the development of the route options and this must continue as the project progresses. This also reflects the requirements of paragraphs 4.22 to 4.25 of the NPSNN regarding HRA. Engagement with Natural England will be required to inform the HRA. There may be a requirement for compensatory habitat to be identified and identification of this land needs to be built into the project programme.
- 4.1.8 Ecological surveys would also need to be undertaken to inform the design and assessment of the scheme and this may identify protected and other notable species, for which more detailed surveys and mitigation measures may be required. For example, within the C<sub>Variant</sub> study area lies the Peter's Pit SAC and SSSI to the west of the Wouding to Escarpment SSSI which is a former chalk quarry that supports one of the largest populations of great crested newt *Triturus cristatus* in Britain. There is therefore the potential for great crested newt to be affected by a C<sub>Variant</sub> route option.
- 4.1.9 It is unlikely that there would be direct effects on designated cultural heritage assets associated with route options in Location A although there is the potential for undiscovered archaeological remains to be affected. Within Location C there is a far higher potential for direct and indirect effects on the large number of heritage assets that lie within this study area. Where possible the selected route option should avoid direct effects on these sites as suggested in paragraph 5.133 of the NPSNN. There are conservation areas designated in settlements north of the River Thames that are situated on areas of raised land and the views from these sites are also important to their setting and character e.g. East and West Tilbury and Horndon-on-the-Hill which again demonstrates the need for this to be considered in the design of the scheme e.g. the vertical alignment. Discussions with English Heritage and the County Archaeologists have highlighted that there is significant potential for undiscovered archaeological remains to be present particularly in areas north of the River Thames and there may therefore be a need for comprehensive assessment and evaluation of these remains. Further survey work and engagement with English Heritage and the County Archaeologists should continue as the scheme progresses.
- 4.1.10 The study areas are underlain by a Principal Aquifer and there are also SPZs present. There are also extensive areas of floodplain and valuable watercourses that need to be protected from adverse effects. The design team must also be cognisant of the requirements of the WFD with



the NPSNN stating that the Secretary of State will need to 'give impacts on the water environment more weight where a project would have adverse effects on the achievement of the environmental objectives established under the WFD'.

- 4.1.11 The EA also has a presumption against culverting because of the resultant loss of habitat and potential increase in flood risk.
- 4.1.12 A Flood Risk Assessment will also need to be completed and the team must have regard to the long term planning set out in Thames Estuary 2100 (TE2100 Plan, November 2012). There may be scope for the design of the project to complement and help to deliver key objectives outlined in this plan. Further engagement with the EA will be required.
- 4.1.13 For all of the locations there are also environmental opportunities. Depending upon the route option selected there is the potential for waste spoil generated by tunnelling to be re-used in a nearby habitat creation scheme. This has been achieved on other projects such as Crossrail. Approximately 4.5 million tonnes of spoil consisting of clay, chalk and gravel is being transported to Wallasea Island in Essex by barge, to help create 600ha of intertidal coastal habitat on an RSPB nature reserve for the Wallasea Island Wild Coast Project.
- 4.1.14 As noted in the text above there may also be scope to complement the objectives of the TE2100 plan through the scheme design.

## 5 Description of Route Options

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### 5.1 Development of Route Options

- 5.1.1 This section explains the approach taken by HHJV in developing technically feasible route options to be considered within the locations under consideration at this stage A, C and C<sub>Variant</sub>. The first step of this work involved the development and refinement of the previous concept designs for Locations A, C and C<sub>Variant</sub> as developed by AECOM as described below (refer to section 1.1.3 and **Appendix 1**). In the case of C<sub>Variant</sub> this involved looking at the concept in more detail to assess whether or not there were more cost effective solutions to the previously proposed option.
- 5.1.2 The AECOM options that had been developed at the end of their study were:
- Option A+ which was a development of the original Option A (a four lane crossing to the west of the existing crossing just connecting to Junctions 1a and 31). The development involved the widening of the A282 between Junctions 1a and 1b from dual four to dual five lanes, the provision of smart motorway technology between Junctions 1a and 2 (between Junctions 1b and 2 this was on the existing dual four lanes with no widening) and the addition of the AECOM/ Jacobs Option E1+9 for the improvement of M25 Junction 30 (refer to section 5.2.10 below for a more detailed description). Option A+ had either a bridge or a bored tunnel for the river crossing.
  - Option C2 which was a development of the original Option C. Option C ran from a junction with the A2/ M2 south of Shorne then east of Chalk to cross the river to the east of Tilbury and run to the east of Chadwell St Mary with a junction with the A13 west of the Orsett Cock junction before running to the west of Orsett and north of South Ockendon to join the M25 between Junctions 29 and 30. Option C had a bridge, bored tunnel and immersed tube tunnel for the river crossing. For Option C2 the junction with the A2 was moved further west close to the eastern edge of Gravesend and the crossing type was fixed as a longer bored tunnel to pass right under the Ramsar site.
  - C<sub>Variant</sub> was a widening of the A229 between M20 Junction 6 and M2 Junction 3 from dual two to dual three lanes. At M20 Junction 6 and M2 Junction 3 free-flow connections were provided between the motorways and the A229. In the case of M2 Junction 3 this included a 2km long tunnel with a gradient of 6% for southbound traffic. There were also other major structures at both motorway junctions.
- 5.1.3 More details of these options and other options considered by AECOM/ Jacobs are included in the AECOM *Final Review Report* – April 2013

and AECOM/ Jacobs *Technical Notes* (Modules) – May 2014 the findings of which are summarised in **Appendix 1**.

- 5.1.4 HHJV then considered high level alternative crossing alignments within Locations A and C. In the case of Location A this included consideration of alternative crossing sites that were not immediately adjacent to the existing Dartford crossing. For Location C this involved looking at alignments further afield than previous Location C route options to the western and eastern limits of the study area. The study areas are shown in **Figure 5.1**.

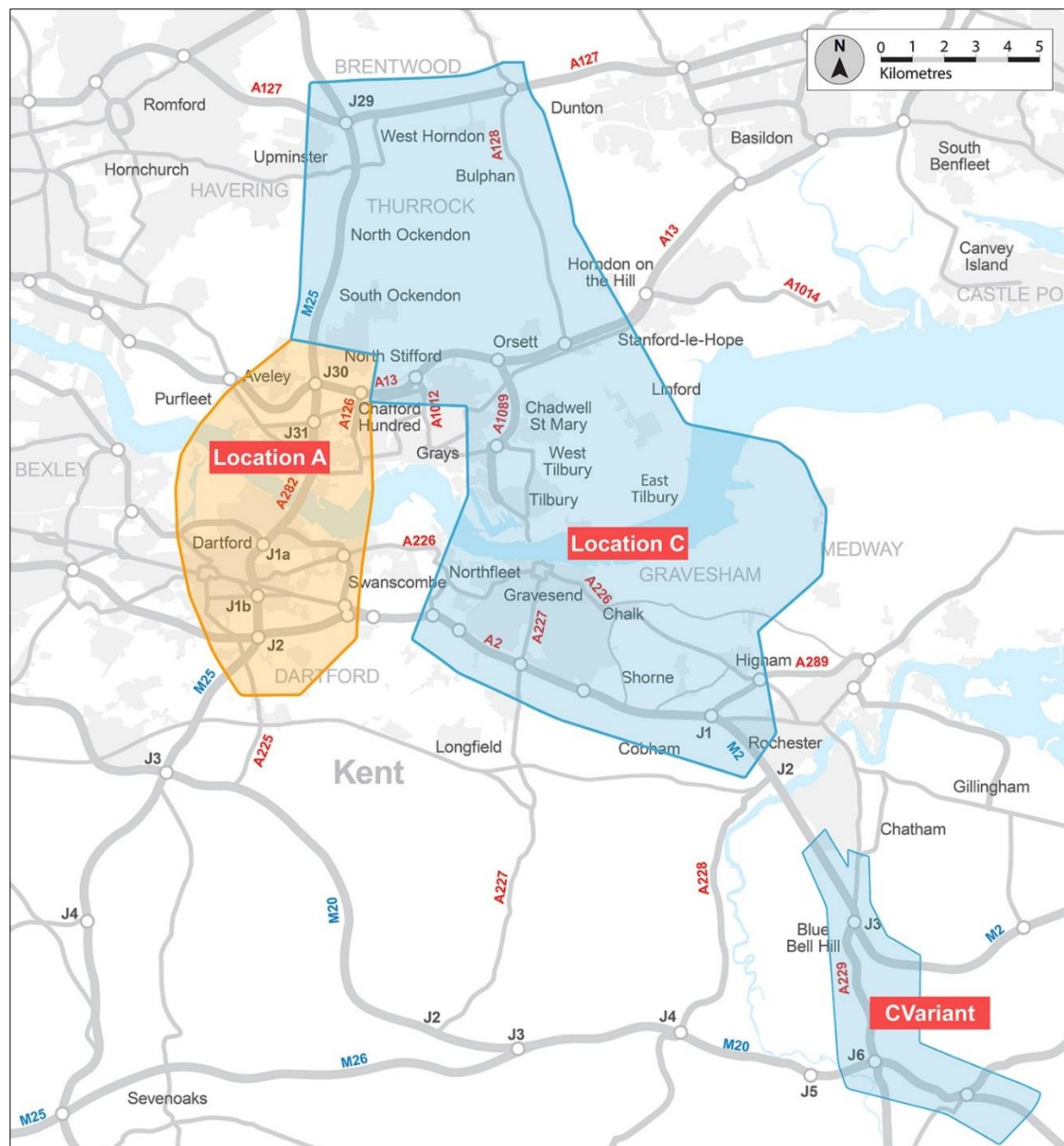


**FIGURE 5.1 - LOWER THAMES CROSSING STUDY AREAS**

- 5.1.5 For each location a number of route options were developed to a sufficient level to determine a route in terms of its technical feasibility whilst taking account of the environmental and physical constraints,

including known planned development where such data was available. A design speed and cross-section were assumed for a route and the alignment was then developed taking account of the constraints; environmental, physical (including known planned development), junctions and what impacts this could have on the geometry and crossing locations. The alignments, junctions and cross-sectional designs were carried out in accordance with the relevant DMRB standards.

- 5.1.6 As part of the route development horizontal and vertical designs were produced for those alignments considered likely to be feasible enabling more detailed comparisons between them to be undertaken.
- 5.1.7 Throughout this process a number of meetings and workshops were held by the project team also including representatives of DfT and Highways England to discuss the route options as they developed and agree the routes that should be taken forward for further assessment. The route options at the time of the meetings were tabled and comments were received from representatives of DfT, Highways England and project workstream members. These comments were taken into consideration in developing the routes to the next level.
- 5.1.8 At an initial longlist workshop it was agreed that the following elements would be used in developing the route alignments. The elements are shown in **Table 5.1** below and, from a highways perspective, the principles adopted to develop a potential route option are given against each element. This ensured each route was developed on a common basis.

**TABLE 5.1 - ROUTE ELEMENTS HIERARCHY**

| Element                      | Principle                                                                              |
|------------------------------|----------------------------------------------------------------------------------------|
| Location (A or C)            | A, C or C <sub>variant</sub>                                                           |
| Route (horizontal alignment) | In accordance with DMRB depending on the speed limit (design speed) or constraint      |
| Charging strategy            | All estuarial crossings are subject to user charges                                    |
| Link X-section (capacity)    | Dual Two All Purpose (D2AP) at this stage                                              |
| Junction location            | At all trunk roads and considered at local roads                                       |
| Junction type                | Free-flow and grade separation developed but not tested in traffic terms at this stage |
| Crossing type                | Bridge/ bored tunnel/ immersed tube tunnel                                             |

## 5.2 Location A Description of Route Options

- 5.2.1 Sixteen route options have been considered within Location A. There are two route options to the west of the existing Dartford crossing (A11 and A12), four route options to the east of the existing Dartford crossing (A3, A8, A13 and A14) and ten route options within the existing Dartford crossing corridor (A1, A2, A4, A5, A6, A7, A9, A10, A15 and A16).

Option A15 is considered as an alternative to the E1+9 Junction (refer to Section 5.2.10). The routes to the west and east of the existing crossing provide connectivity from the A13 and to the A2 bypassing the existing crossing and the A282.

- 5.2.2 These route options are summarised in **Table 5.2** and shown on **Figure 5.2** (dotted lines indicate tunnels).
- 5.2.3 For on-line route options the current overall design speed is set at 85kph which is consistent with the geometric constraints at the existing crossing including radii in the existing tunnels, the physical geometry of the radii between Junctions 1a and 1b (curvatures and visibility), the curvature and cross-section of the existing rail bridge at Bow Arrow Lane and the relative density of sequential merge and diverge points throughout the route.
- 5.2.4 An increase in A282 design speed from 85kph to 120kph (70mph) is impractical within the high density urban context of the existing and proposed on-line A282 route options. Not only would this present dimensional and driver behaviour/ traffic regulation difficulties, but also, a cross-sectional upgrade to full motorway standard would be inferred, with a considerable increase in the severity and complexity of geometrical relaxations and departures from standard. This would probably require substantially increased land purchase due to broader radii and wider visibility envelopes, increased earthworks cutting requirements through known landfill areas, and also necessitate an increase in structure size and number.
- 5.2.5 An increase to 120kph would also lead to a distinct speed disparity between M25/ A282 and A13 Junction 30 interchange. An inconsistent design speed strategy through the interchange links is undesirable with respect to driver expectation and discipline at the merges and diverges.
- 5.2.6 Widening of the A282 south of Junction 1b has also been considered. This would require: significant demolition of existing retaining walls, substantial land purchase, a large increase in potential departures in an existing constrained highway corridor, and necessitate an increase in the number of proposed structures and size. Consequentially the overall construction programme duration and potential disruption would be increased.

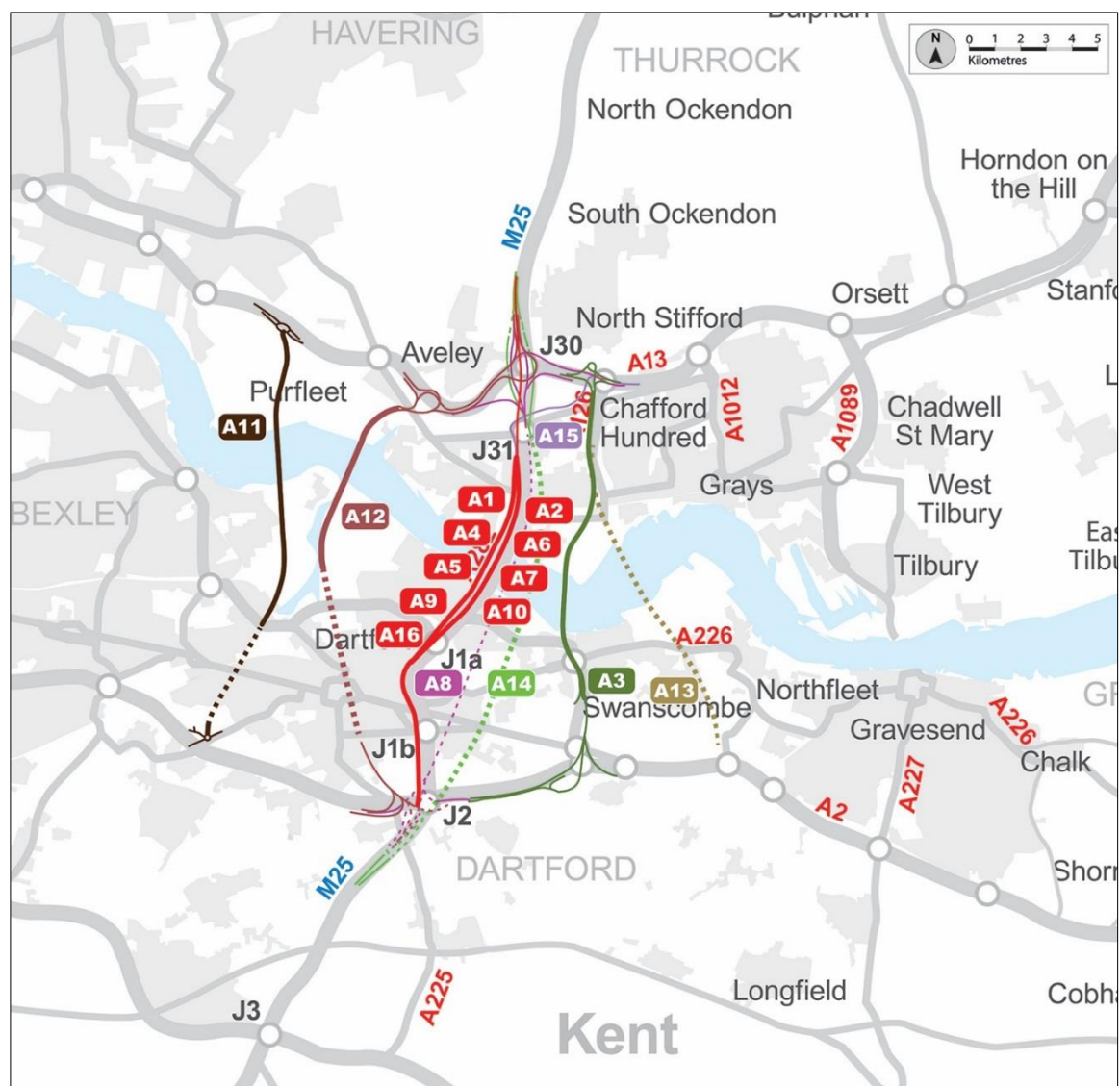


FIGURE 5.2 - LOCATION A ALL ROUTE OPTIONS

TABLE 5.2 - LOCATION A ROUTE OPTIONS SUMMARY

| Route Options | Route (horizontal alignment)                             | Charging Strategy | Link X-section (capacity)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Junction location                                                                | Junction type                                                                                                                   | Crossing type (bridge/ bored tunnel/ immersed tube tunnel) |
|---------------|----------------------------------------------------------|-------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------|
| A1            | M25 / J2 to M25 / J30                                    | At crossing       | Design speed of 85 km/h (50mph).<br>* M25 / J2 to A282 / J1b no widening only All Lane Running (D4)<br>* A282 / J1b to A282 / J1a widening to 5 lanes in each direction and All Lane Running<br>* A282 / J1a to A282 / J31: 6 lanes in each direction (new bridge and west tunnel northbound, east tunnel and QEII Bridge southbound)<br>* A282 / J31 to M25 / J30: widening to 5 lanes in each direction<br>* E1+9 Improvement scheme at M25 J30                                                                                                                                                                                                                                                                              | M25 / J2<br>A282 / J1b<br>A282 / J1a<br>M25 / J31<br>M25 / J30                   | Free-flow / grade separated<br>grade separated<br>grade separated<br>grade separated<br>free-flow / grade separated             | Bridge to the West of the existing crossing                |
| A2            | M25 / J2 to M25 / J30                                    | At crossing       | Design speed of 85 km/h (50mph).<br>* M25 / J2 to A282 / J1b no widening only All Lane Running<br>* A282 / J1b to A282 / J1a widening to 5 lanes in each direction and All Lane Running<br>* A282 / J1b to M25 / J30: 4 lanes in each direction no northbound access from J1a or southbound access from J31 (QEII Bridge northbound, new bridge southbound)<br>* A282 / J1a to A282 / J31: 2 lanes in each direction using west tunnel northbound and east tunnel southbound.). The existing east and west tunnels would serve local traffic by being connected to Junctions 1a and 31 and not the main four lanes of the A282<br>* A282 / J31 to M25 / J30: dual 4 lane (no widening)<br>* E1+9 Improvement scheme at M25 J30 | M25 / J2<br>A282 / J1b<br>A282 / J1a<br>M25 / J31<br>M25 / J30                   | Free-flow / grade separated<br>grade separated<br>free-flow / grade separated<br>grade separated<br>grade separated             | Bridge to the East of the existing crossing                |
| A3            | M25 / J2 via A2 to A2 / Bean Lane Jct to M25 J30 via A13 | At crossing       | Design speed of 120 km/h (70mph).<br>A2 upgrading (Assumed 2 no. additional lanes are required WB & EB)<br>New link: D2AP<br>A13 upgrading (Assumed 2 no. additional lanes are required WB & EB)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | M25 / J2<br>A2 / B255 Jct<br>A226 / B255 Jct<br>A206 / A13 Jct<br>A126 / A13 Jct | Free-flow / grade separated<br>free-flow / grade separated<br>grade separated<br>grade separated<br>free-flow / grade separated | Bridge                                                     |



| Route Options | Route (horizontal alignment) | Charging Strategy | Link X-section (capacity)                                                                                                                                                                                                                                                                                                                                                                                                                                             | Junction location                                              | Junction type                                                                                                       | Crossing type (bridge/ bored tunnel/ immersed tube tunnel)                     |
|---------------|------------------------------|-------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------|
| A4            | M25 / J2 to M25 / J30        | At crossing       | Design speed of 85 km/h (50mph).<br>* M25 / J2 to A282 / J1b no widening only All Lane Running (D4)<br>* A282 / J1b to A282 / J1a widening to 5 lanes in each direction and All Lane Running<br>* A282 / J1a to A282 / J31: 6 lanes in each direction (new tunnel and west tunnel northbound, east tunnel and QEII Bridge southbound)<br>* A282 / J31 to M25 / J30: widening to 5 lanes in each direction<br>* E1+9 Improvement scheme at M25 J30                     | M25 / J2<br>A282 / J1b<br>A282 / J1a<br>M25 / J31<br>M25 / J30 | Free-flow / grade separated<br>grade separated<br>grade separated<br>grade separated<br>free-flow / grade separated | Twin-bored tunnel to the west of the existing crossing                         |
| A5            | M25 / J2 to M25 / J30        | At crossing       | Design speed of 85 km/h (50mph).<br>* M25 / J2 to A282 / J1b no widening only All Lane Running (D4)<br>* A282 / J1b to A282 / J1a widening to 5 lanes in each direction and All Lane Running<br>* A282 / J1a to A282 / J31: 6 lanes in each direction (new tunnel and west tunnel northbound, east tunnel and QEII Bridge southbound)<br>* A282 / J31 to M25 / J30: widening to 5 lanes in each direction<br>* E1+9 Improvement scheme at M25 J30                     | M25 / J2<br>A282 / J1b<br>A282 / J1a<br>M25 / J31<br>M25 / J30 | Free-flow / grade separated<br>grade separated<br>grade separated<br>grade separated<br>free-flow / grade separated | single bored tunnel stacked (double deck) to the west of the existing crossing |
| A6            | M25 / J2 to M25 / J30        | At crossing       | Design speed of 85 km/h (50mph).<br>* M25 / J2 to A282 / J1b no widening only All Lane Running (D4)<br>* A282 / J1b to A282 / J1a widening to 5 lanes in each direction and All Lane Running<br>* A282 / J1a to A282 / J31: 6 lanes in each direction (new western tunnel and existing tunnels northbound, QEII Bridge and new eastern tunnel southbound)<br>* A282 / J31 to M25 / J30: widening to 5 lanes in each direction<br>* E1+9 Improvement scheme at M25 J30 | M25 / J2<br>A282 / J1b<br>A282 / J1a<br>M25 / J31<br>M25 / J30 | Free-flow / grade separated<br>grade separated<br>grade separated<br>grade separated<br>free-flow / grade separated | 2 single bored tunnels, one east and one west of existing crossing             |



| Route Options | Route (horizontal alignment)         | Charging Strategy | Link X-section (capacity)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Junction location                                              | Junction type                                                                                                       | Crossing type (bridge/ bored tunnel/ immersed tube tunnel)       |
|---------------|--------------------------------------|-------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------|
| A7            | M25 / J2 to M25 / J30                | At crossing       | Design speed of 85 km/h (50mph).<br>* M25 / J2 to A282 / J1b no widening only All Lane Running.<br>* A282 / J1b to A282 / J1a widening to 5 lanes in each direction and All Lane Running<br>* A282 / J1b to M25/J30: 4 lanes in each direction not connected to J1a or J31 (QEII Bridge northbound, new tunnel southbound)<br>* A282 / J1a to A282 / J31: 2 lanes in each direction using west tunnel northbound and east tunnel southbound (no connection to through lanes) The existing east and west tunnels would serve local traffic by being connected to Junctions 1a and 31 and not the main four lanes of the A282<br>* A282 / J31 to M25 / J30: dual 4 lane (no widening<br>* E1+9 Improvement scheme at M25 J30) | M25 / J2<br>A282 / J1b<br>A282 / J1a<br>M25 / J31<br>M25 / J30 | Free-flow / grade separated<br>grade separated<br>grade separated<br>grade separated<br>free-flow / grade separated | 4 Lane bored tunnel to the east of the existing crossing         |
| A8            | M25 / J2 to M25 / J30 to bypass A282 | At crossing       | Design speed of 120 km/h (70mph). D2AP<br>2 lane link from A8 Northbound to A13 EB (east of A126)<br>2 lane link from A13 westbound (west of A126) to A8 southbound                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | M25 / J2<br>M25 / J30                                          | Free-flow / grade separated not all movements<br>free-flow / grade separated not all movements                      | long bored tunnels connecting to J2 and J30                      |
| A9            | M25 / J2 to M25/J30                  | At crossing       | Design speed of 85 km/h (50mph).<br>* M25 / J2 to A282 / J1b no widening only All Lane Running (D4)<br>* A282 / J1b to A282 / J1a widening to 5 lanes in each direction and All Lane Running<br>* A282 / J1a to A282 / J31: 6 lanes in each direction (new tunnel and west tunnel northbound, east tunnel and QEII Bridge southbound)<br>* A282 / J31 to M25 / J30: widening to 5 lanes in each direction<br>* E1+9 Improvement scheme at M25 J30)                                                                                                                                                                                                                                                                          | M25 / J2<br>A282 / J1b<br>A282 / J1a<br>M25 / J31<br>M25 / J30 | Free-flow / grade separated<br>grade separated<br>grade separated<br>grade separated<br>free-flow / grade separated | 4 lane immersed tube tunnel to the west of the existing crossing |

| Route Options | Route (horizontal alignment)                                                | Charging Strategy | Link X-section (capacity)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Junction location                                              | Junction type                                                                                                           | Crossing type (bridge/ bored tunnel/ immersed tube tunnel)       |
|---------------|-----------------------------------------------------------------------------|-------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------|
| A10           | M25 / J2 to M25 / J30                                                       | At crossing       | Design speed of 85 km/h (50mph).<br>* M25 / J2 to A282 / J1b no widening only All Lane Running<br>* A282 / J1b to A282 / J1a widening to 5 lanes in each direction and All Lane Running<br>* A282 / J1b to M25 / J30: 4 lanes in each direction not connected to J1a or J31 (QEII Bridge northbound, new tunnel southbound)<br>* A282 / J1a to A282 / J31: 2 lanes in each direction using west tunnel northbound and east tunnel southbound (no connection to through lanes) The existing east and west tunnels would serve local traffic by being connected to Junctions 1a and 31 and not the main four lanes of the A282<br>* A282 / J31 to M25 / J30: dual 4 lane (no widening)<br>* E1+9 Improvement scheme at M25 J30) | M25 / J2<br>A282 / J1b<br>A282 / J1a<br>M25 / J31<br>M25 / J30 | Free-flow / grade separated<br>grade separated<br>grade separated<br>grade separated<br>free-flow / grade separated     | 4 lane immersed tube tunnel to the east of the existing crossing |
| A11           | M25 J2 to A2 / A2018 Jct to M25 J30 via A13                                 | At crossing       | Design speed of 120 km/h (70mph).<br>A2 upgrading (Assumed 2 no. additional lanes are likely to be required WB & EB)<br>New link: D2AP<br>A13 upgrading (Assumed 2 no. additional lanes are likely to be required WB & EB)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | M25 / J2<br>A2 / A2018<br>A13 new Jct<br>M25 / J30             | Free-flow / grade separated<br>at grade<br>separated<br>free-flow / grade separated                                     | Bridge Crossing with bored tunnel section under Dartford         |
| A12           | M25 / J2 to M25 J30 via A13                                                 | At crossing       | Design speed of 120 km/h (70mph). New link: D2AP<br>A13 upgrading (Assumed 2 no. additional lanes are likely to be required WB & EB)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | M25 / J2 new jct<br>A13 new Jct<br>M25 / J30                   | At grade/grade separated Free-flow -<br>Not all movements<br>free-flow / grade separated<br>free-flow / grade separated | Bridge crossing with bored tunnel section under Dartford         |
| A13           | M25 J2 via A2 to B259 / A2260 Jct to A126 / A13 Jct then via A13 to M25 J30 | At crossing       | Design speed of 120 km/h (70mph).<br>A2 upgrading Assumed 2 no. additional lanes are likely to be required WB & EB)<br>New link: D2AP<br>A13 upgrading (Assumed 2 no. additional lanes are likely to be required WB & EB)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | M25 / J2<br>A2 / B259 / A2260<br>A13 / A126<br>M25 / J30       | Free-flow / grade separated<br>at grade<br>separated<br>free-flow / grade separated                                     | long bored tunnel                                                |

| Route Options | Route (horizontal alignment)                                        | Charging Strategy | Link X-section (capacity)                                                                                                 | Junction location                                | Junction type                                                  | Crossing type (bridge/ bored tunnel/ immersed tube tunnel) |
|---------------|---------------------------------------------------------------------|-------------------|---------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------|----------------------------------------------------------------|------------------------------------------------------------|
| A14           | M25 800m south of Jct 2 to M25 1.3km north of Jct 30 to bypass A282 | At crossing       | Design speed of 120 km/h (70mph). D2AP with split into single bore tunnels for merge to and diverge from M25 at both ends | M25 800m south of Jct2<br>M25 1.3km north of J30 | Free-flow - Not all movements<br>Free-flow - Not all movements | long bored tunnels                                         |
| A15           | M25 Jct 31 to A13 / A126 Jct                                        | N/A               | Design speed of 85 km/h (50mph). D2AP 2 lane eastbound and 2 lane westbound link road                                     | M25 Jct 31 to A13 (East of A126 Jct)             | Free-flow                                                      | Link Road - alternative route to Jacobs/AECOM option E1+9  |
| A16           | A282 Jct 1a to Jct 31                                               | At crossing       | , Design speed of 85 km/h (50mph)<br>2 lane northbound tunnel junction 1a to junction 31                                  | A282 Jct 1a<br>A282 Jct 31                       | grade separated<br>grade separated                             | Single bored tunnel                                        |

**Route Option A1 - (Bridge - West)**

- 5.2.7 Route Option A1 has been developed from the original Option A from the AECOM/ Jacobs study with a proposed new bridge crossing on the west side of the existing west tunnel providing four new additional northbound lanes immediately upstream of the existing Dartford Crossing. In total a six-lane crossing would be provided in both directions. For northbound traffic, four new additional lanes on the new bridge and two lanes in the existing west tunnel. Southbound traffic would use the two lanes in the existing east tunnel and four lanes on the existing QEII Bridge. South of the river one lane would be added northbound and one lane dropped southbound at each of A282 Junctions 1a and 1b. The section between Junctions 1a and 1b would be widened from dual four lanes to dual five lanes. Similarly, north of the river one lane would be added southbound and one lane dropped northbound at each of the existing M25 Junctions 30 and 31.
- 5.2.8 The horizontal and vertical route alignment has been designed in accordance with DMRB TD9/93 Table 3 with a design speed of 85 km/h (50mph).
- 5.2.9 Between Junctions 2 and 1b smart motorway technology would be implemented on the existing four lanes. Between Junctions 1a and 1b smart motorway technology would be implemented on the widened dual five lane carriageway.
- 5.2.10 As part of Option A+, the AECOM/ Jacobs study details that the Option E1+9 would be required for the improvement of Junction 30 in association with a new crossing at Dartford. This option included a free-flow link for A282 northbound traffic connecting to the existing A13 eastbound east of the A126 Lakeside junction with a proposed link sweeping around Junction 30. The free-flow link would be on structure, crossing the Mardyke twice but would pass under the A13 and Junction 30 slip roads in an underpass. Free-flow connections would also be provided from M25 southbound to A13 eastbound and from A13 westbound to A282 southbound.
- 5.2.11 Option E1+9 has been further developed by HHJV since the AECOM/ Jacobs study and the M25 southbound to A13 eastbound free-flow link has been removed following development of a segregated left turn.

**Route Option A2 - (Bridge - East)**

- 5.2.12 Route Option A2 is a bridge crossing with a proposed four lane bridge for southbound traffic on the east side of the existing Dartford crossings and to the east of the existing QEII Bridge. The current arrangement for the QEII Bridge, is that it carries southbound traffic however with Route Option A2 it is proposed to carry northbound traffic and be connected to the existing northbound lanes of the A282. The existing east and west tunnels would serve local traffic by being connected to Junctions 1a and 31 and not the main four lanes of the A282.
- 5.2.13 The horizontal and vertical route alignment has been designed in accordance with DMRB TD9/93 Table 3 with a design speed of 85 km/h (50mph).

**Route Option A3 - Bridge**

- 5.2.14 Route Option A3 is a new route from the A2/ B255 Bean Junction to the A13/ A126 junction including a new dual two-lane bridge crossing located approximately 1.6km east of the existing Dartford crossing. Improvements would also be required to the A2 between M25 Junction 2 and the B255 Bean Junction (assumed two additional lanes in each direction) and the A13 between M25 Junction 30 and the A13/ A126 junction (assumed two additional lanes in each direction) including junction improvements. With Route Option A3 there is no direct connection to the Dartford crossing, and the existing QEII Bridge and, east and west tunnels remain unchanged.
- 5.2.15 The horizontal and vertical route alignment has been designed in accordance with DMRB TD9/93 Table 3 with a design speed of 120 km/h (70mph).

**Route Option A4 - (Bored Tunnel - West)**

- 5.2.16 Route Option A4 would have the same highway layout described above for Route Option A1, the only difference between the two options being the crossing type – Route Option A4 having a twin bored tunnel rather than a bridge. The northern approach of the new tunnel would pass under the HS1 viaduct and over the existing London, Tilbury and Southend railway.
- 5.2.17 The horizontal and vertical route alignment has been designed in accordance with DMRB TD9/93 Table 3 with a design speed of 85 km/h (50mph).

**Route Option A5 - Bored Tunnel**

- 5.2.18 Similar to Route Option A4, Route Option A5 is based on the original AECOM/ Jacobs Option A+ with a proposed four lane single bored tunnel crossing for northbound traffic on the west side of the existing crossing (west of the existing west tunnel). Connections north and south of the River Thames would be similar to Route Options A1 and A4.
- 5.2.19 This would be a large diameter single bored tunnel with a 2 x 2 stacked lane arrangement (two two lane carriageways one above the other) for northbound traffic. Together with the west tunnel this would form a six lane crossing for the northbound direction. Southbound traffic would use the QEII Bridge and the existing east tunnel.
- 5.2.20 The horizontal and vertical route alignment has been designed in accordance with DMRB TD9/93 Table 3 with a design speed of 85 km/h (50mph).

**Route Option A6 - Bored Tunnel**

- 5.2.21 This route option would comprise two bored tunnels, one each side of the existing crossing, each bore carrying two lanes of traffic, the one on the west being for northbound traffic and the one on the east for southbound traffic. It would retain the use of the existing QEII Bridge for southbound traffic and the tunnels for northbound traffic. Tie-ins for the new tunnels to the north would be into the M25 mainline and on- and off-slips south of M25 Junction 31.

- 5.2.22 The horizontal and vertical route alignment has been designed in accordance with DMRB TD9/93 Table 3 with a design speed of 85 km/h (50mph).

#### **Route Option A7 - Bored Tunnel**

- 5.2.23 This option is a twin-bored tunnel to the east of the existing QEII Bridge and is therefore effectively the same as Route Option A2 except for the crossing type. The traffic arrangements and connections would be the same as for Route Option A2 with the existing tunnels being used by local traffic between Junctions 1a and 31 only.

- 5.2.24 The horizontal and vertical route alignment has been designed in accordance with DMRB TD9/93 Table 3 with a design speed of 85 km/h (50mph).

#### **Route Option A8 - Bored Tunnel**

- 5.2.25 Route Option A8 is a dual two lane route through a 7km long bored tunnel below the River Thames between M25 Junction 2 to the south and M25 Junction 30 to the north.

- 5.2.26 At M25 Junction 2, there would be free-flow connections to the A2 for all movements to/ from the new tunnel, except that there would be no provision for:

- Southbound traffic through the tunnel to access the A2 westbound.
- A2 westbound traffic to travel northbound through the tunnel.

- 5.2.27 At M25 Junction 30, it would provide separate connections to both the M25 Junction 30 and the existing A13 eastbound and westbound, but there would be no provision for A13 eastbound traffic to travel southbound through the tunnel.

- 5.2.28 The horizontal and vertical D2AP route alignment has been designed in accordance with DMRB TD9/93 Table 3 with a design speed of 120 km/h (70mph).

#### **Route Option A9 - Immersed Tunnel**

- 5.2.29 Route Option A9 is the same as Route Options A1 and A4 but with the crossing type being instead an immersed tunnel option proposed to carry northbound traffic on the west side of the existing Dartford crossing (west of the existing west tunnel and existing QEII Bridge). The connectivity is the same as Route Options A1 and A4 but with different horizontal and vertical alignments.

- 5.2.30 The horizontal and vertical route alignment has been designed in accordance with DMRB TD9/93 Table 3 with a design speed of 85 km/h (50mph).

#### **Route Option A10 - Immersed Tunnel**

- 5.2.31 Route Option A10 is a four lane immersed tube tunnel option proposed to carry southbound traffic on the east side of the existing Dartford crossing (east of the existing QEII Bridge). This option is therefore effectively the same as Route Options A2 and A7 except for the crossing type. The traffic

arrangements and connections would be the same as for Route Option A2 with the existing tunnels being used by local traffic between Junctions 1a and 31 only.

- 5.2.32 The horizontal and vertical route alignment has been designed in accordance with DMRB TD9/93 Table 3 with a design speed of 85 km/h (50mph).

#### **Route Option A11 - Bored Tunnel and Bridge**

- 5.2.33 Route Option A11 is the most westerly route at Location A and would create a direct link, from the A2 to the A13 bypassing the A282. It would start at the A2/ A2018 junction and then run under the built-up area to the west of Dartford in a bored tunnel before emerging and crossing the River Thames on a bridge about 4.5km west of the existing crossing. The route would terminate at a new junction with the A13 west of the existing A13/ A1306 Wennington junction. Upgrades would also be required to the A2 between M25 Junction and the A2/ A2018 junction (assumed two additional lanes in each direction) and to the A13 between the new junction and M25 Junction 30 (assumed two additional lanes in each direction).
- 5.2.34 The horizontal and vertical route alignment has been designed in accordance with DMRB TD9/93 Table 3 with a design speed of 120 km/h (70mph).

#### **Route Option A12 - Bored Tunnel and Bridge**

- 5.2.35 Route Option A12 is a new route between M25 Junctions 30 and 2 about 3.4km west of the existing crossing. It would comprise a 2.9km twin-bored tunnel from the A2 south of Dartford leading to a 3km dual two-lane bridge and approach viaducts over the River Thames and then utilise the A13 eastwards to M25 Junction 30. There would be no direct connection to the Dartford Crossing, which would remain unchanged.
- 5.2.36 Route Option A12 would provide free-flow connections for all movements at M25 Junction 30. The A13 would be widened from dual two lane to dual four-lane between a new A13 free-flow junction and M25 Junction 30, where there would be a two lane merge from A13 to the northbound M25 and a two-lane southbound diverge from M25 westbound to the A13.
- 5.2.37 At M25 Junction 2, Route Option A12 would provide free-flow connections to the A2, but there would be no provision for southbound traffic to access the A2 eastbound.
- 5.2.38 The horizontal and vertical D2AP route alignment has been designed in accordance with DMRB TD9/93 Table 3 with a design speed of 120 km/h (70mph).

#### **Route Option A13 - Bored Tunnel**

- 5.2.39 Route Option A13 is the most easterly route within Location A. This is a proposed long dual two-lane bored tunnel about 3km east of the existing Dartford crossing connecting the A2/ B259 junction to the south with the A13 at the A13/ A126 junction to the north. This option would also require improvements to the A2 between M25 Junction 2 and the A2/ B259 junction (assumed two additional lanes in each direction) and the A13 between the

A13/ A126 junction and M25 Junction 30 (assumed two additional lanes in each direction). This route option would bypass the existing A282, there would be no direct connection to the Dartford Crossing, the existing QEII Bridge, east and west tunnels would therefore remain unchanged.

- 5.2.40 The horizontal and vertical route alignment has been designed in accordance with DMRB TD9/93 Table 3 with a design speed of 120 km/h (70mph).

#### **Route Option A14 - Bored Tunnel**

- 5.2.41 Route Option A14 comprises a new route approximately 800m to the east of the existing QEII Bridge bypassing the existing A282, M25 Junctions 2 and 30. The route would take the form of a 7.4km long dual two-lane bored tunnel with a merge and diverge directly connecting to the mainline M25 south of Junction 2 and north of M25 Junction 30. The tunnel would be a dual bore until just north of Junction 31 at which point it would become two single bores to pass either side of Junction 30 to then tie-in with the M25 north of Junction 30.

- 5.2.42 The horizontal and vertical D2AP route alignment has been designed in accordance with DMRB TD9/93 Table 3 with a design speed of 120 km/h (70mph).

#### **Route Option A15**

- 5.2.43 Route Option A15 is a partial option for the improvement of Junction 30 comprising two free-flow alternative links to Jacobs/ AECOM option E1+9 to cater for the north to eastbound traffic movement and west to southbound traffic movement between the A282 and the A13.
- 5.2.44 The A282 north to A13 east link would have an off-slip from the A282 northbound prior to Junction 30 and then cross over the A282 before running parallel to the A1306 and climbing to cross the A13 to the west of the A126 Lakeside junction and crossing over the railway to follow a similar merge alignment as Jacobs/ AECOM option E1+9.
- 5.2.45 The A13 west to A282 south link would follow a similar route as the north to east link with a diverge and merge on the A13 westbound and southbound A282 mainline respectively.
- 5.2.46 Route Option A15 is a variant rather than a standalone option, and could be combined with any route options that require capacity improvements on M25/ A282 Junction 30/ A13.
- 5.2.47 The horizontal and vertical D2AP route alignment has been designed in accordance with DMRB TD9/93 Table 3 with a design speed of 85 km/h (50mph).

#### **Route Option A16**

- 5.2.48 Route Option A16 would provide an additional two-lane bored tunnel for northbound traffic to the west of the existing west tunnel at the Dartford Crossing. The additional two lanes would be added at the A282 Junction 1a and dropped at M25 Junction 31.



- 5.2.49 This route option was developed to assess implementing improvements at both Locations A and C. It could be combined with any Location C route option.

### 5.3 Location C Description of Route Options

- 5.3.1 Location C would provide a new route linking the A2/ M2 near Gravesend to the M25. The route options would link into the M25 at either Junction 29, Junction 30 or at a location between the two junctions. The route options would include a new crossing to the east or west of Gravesend and would also provide a connection with the A13 and the possibility of other connections with the local road network.
- 5.3.2 Six main route options have been considered, these are shown in **Figure 5.3** and summarised in **Table 5.3**. All of the routes considered connect the A2/ M2 with the M25, with one route option utilising a section of the A127 and two route options utilising a section of the A1089 with one of these options also utilising a section of the A13.

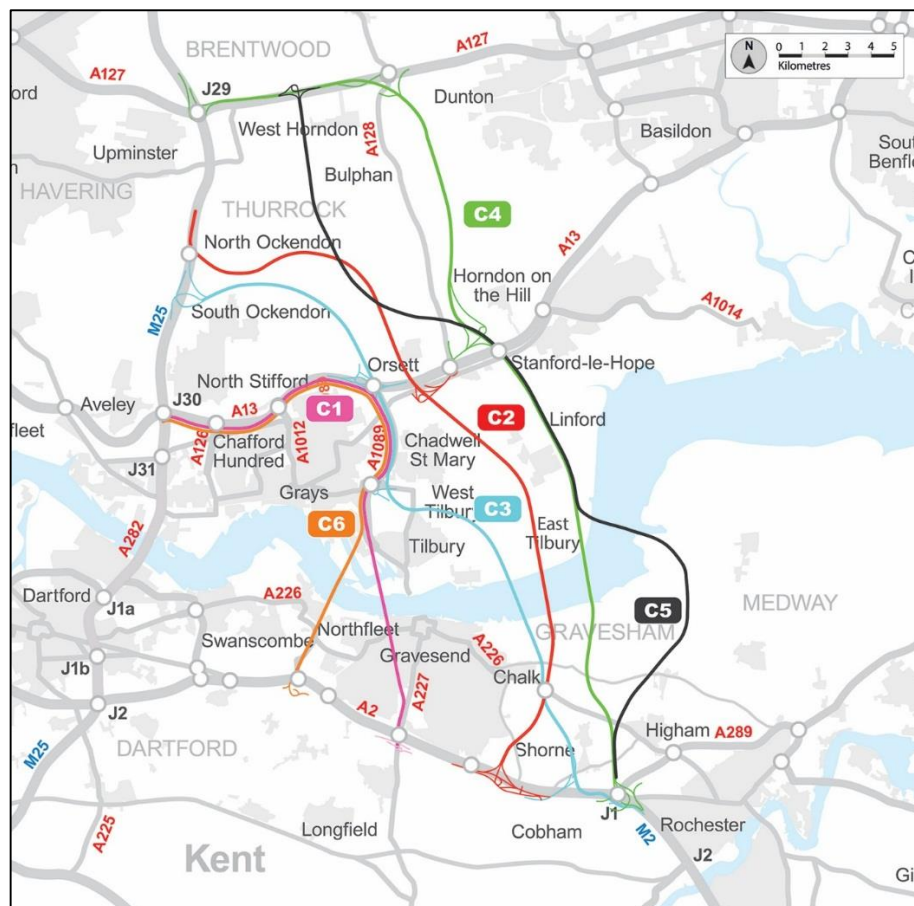


FIGURE 5.3 - LOCATION C MAIN ROUTE OPTIONS

- 5.3.3 There are three types of crossing that have been considered: immersed tube tunnel, bored tunnel and a bridge. These three crossing options do not all apply on each route option due to environmental or engineering constraints.
- 5.3.4 As part of the route development different types of junctions have been considered. Where practicable free-flow junctions have been developed and

grade separated junctions considered where a free-flow junction is not feasible.

TABLE 5.3 - LOCATION C ROUTE OPTIONS SUMMARY

| Route Reference | Route<br>(Horizontal Alignment)                                               | Charging Strategy | Link X-section (capacity)                                                                                                                                                                        | Junction Locations                                                       | Junction Type                                                                                                                                                                                     | Crossing Type Option                           |
|-----------------|-------------------------------------------------------------------------------|-------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------|
| C1              | A2 / A227 Jct to M25 Jct 30, using A1089 (widening) and A13 (widening)        | At crossing       | D2AP<br>A1089 widened to D4 A13 widened to D5 between A1089 and link roads to M25<br>Free-flow links to/from M25(N) and A13 (east of A126)                                                       | A2 / A227<br>A1089<br>A13-A1089<br>M25 Jct 30                            | Free-flow<br>Free-flow<br>Existing Free-flow<br>Free-flow to/from M25(N)                                                                                                                          | Bored Tunnel under Gravesend and Tilbury Docks |
| C2              | A2 east of Gravesend to M25 between Jct 29 and Jct 30                         | At crossing       | D2AP                                                                                                                                                                                             | A2<br>A226<br>Muckingford Road<br>A13 (Orsett Cock roundabout)<br>M25    | Free-flow<br>Grade separated to be considered<br>Grade separated to be considered<br>Link to Orsett Cock Roundabout<br>Free-flow                                                                  | Immersed Tube Tunnel , Bored Tunnel and Bridge |
| C3              | A2 east of Gravesend to M25 between Jct 29 and Jct 30, using A1089 (widening) | At crossing       | D2AP<br>Link to Brewers Road for access to A2 westbound<br>A1089 widened to D4                                                                                                                   | A2<br>A226<br>A1089<br>A13<br>M25                                        | Free-flow (except to A2 WB)<br>Grade separated to be considered<br>Grade separated<br>Free-Flow (Expansion of existing A13/A1089 junction)<br>Free-flow                                           | Immersed Tube Tunnel , Bored Tunnel and Bridge |
| C4              | M2 Jct 1 to M25 Jct 29, using A127 (widening)                                 | At crossing       | D2AP<br>Junction with A128 (south of A127/A128 junction)<br>A127 widened to D4<br>Closure of all local access roads to/from A127 (between M25 and A128)<br>New link road from M25 Jct 29 to B186 | M2 Jct 1<br>A226<br>East Tilbury Rd<br>A13<br>A127<br>M25 Jct 29         | Free-flow<br>Grade separated to be considered<br>Grade separated to be considered<br>Free-flow<br>Free-flow (to A127 Westbound, from A127 Eastbound)<br>Free-flow to/from M25(North)              | Bored Tunnel                                   |
| C5              | M2 Jct 1 to M25 Jct 29, using A127 (widening)                                 | At crossing       | D2AP<br>Junction with A128 (south of A127/A128 junction)<br>A127 widened to D4<br>Closure of all local access roads to/from A127 (between M25 and A128)<br>New link road from M25 Jct 29 to B186 | M2 Jct 1<br>A289<br>A226<br>East Tilbury Rd<br>A13<br>A127<br>M25 Jct 29 | Free-flow<br>Free-flow<br>Grade separated to be considered<br>Grade separated to be considered<br>Free-flow<br>Free-flow (to A127 Westbound, from A127 Eastbound)<br>Free-flow to/from M25(North) | Immersed Tube Tunnel , Bored Tunnel and Bridge |
| C6              | A2 / B259 Junction to M25 Junction 30, using A1089 and A13 (widening)         | At crossing       | D2AP<br>A1089 widened to D4 A13 widened to D5 between A1089 and link roads to M25<br>Free-flow links to/from M25(N) and A13 (east of A126)                                                       | A2 / B259<br>A1089<br>A13-A1089<br>M25 Jct 30                            | Free-flow or Grade separated<br>Free-flow or Grade separated<br>Existing Free-flow<br>Free-flow                                                                                                   | Bored Tunnel under Gravesend                   |

Note: design speed for all Location C route options is 120kph.

### **Route Option C1**

- 5.3.5 This route option would connect the A2/ A227 to the south of Gravesend to the M25 at Junction 30. The route has been developed with a bored tunnel beneath Gravesend, the River Thames and Tilbury docks. The bored tunnel would end to the north of Tilbury docks where the route would connect with the existing A1089. The proposal for this route is to utilise the A1089 to the intersection with the A13, where the existing junction would be used, and the route would then use the A13 from this junction through to Junction 30 on the M25. This route option would include widening of the A1089, A13 and improvements to the existing junction on the A13/ A1089. At Junction 30 the route would connect with the M25 via two slip roads on viaducts over the existing roads which would provide a direct connection with the M25 without the need for traffic to go through Junction 30.
- 5.3.6 The horizontal and vertical route alignment has been designed in accordance with DMRB TD9/93 Table 3 with a design speed of 120 km/h (70mph).

### **Route Option C2**

- 5.3.7 This route option would connect the A2 to the east of Gravesend to the M25 between Junctions 29 and 30. The route would go to the north of Thong and the east of Chalk before crossing the river at the western end of the Ramsar site. Options with bridge, bored tunnel or immersed tube tunnels for the river crossing are considered.
- 5.3.8 To the north of the river the route would go to the west of East Tilbury and then intersect the A13 to the south west of Orsett. North of the A13 the route would go to the west of Orsett before turning west to go between South Ockendon and North Ockendon. The route would connect into the M25 between Junctions 29 and 30 via a free-flow junction.

The horizontal and vertical route alignment has been designed in accordance with DMRB TD9/93 Table 3 with a design speed of 120 km/h (70mph).

### **Route Option C3**

- 5.3.9 This route would connect the A2 to the east of Gravesend to the M25 between Junctions 29 and 30. This route would connect with the A2 in the vicinity of Shorne Woods Country Park.
- 5.3.10 North of the proposed junction the route would go to the west of Thong and east of Chalk before crossing the river towards Tilbury close to the western edge of the Ramsar site. Options for the crossing which have been considered are bridge, bored tunnel and immersed tube tunnel.
- 5.3.11 To the north of the river the route would go to the east of Tilbury power station and Tilbury before turning west to go to the north of Tilbury and south of Chadwell St Mary. It is proposed that the route would connect into the existing A1089 and utilise a section of this road up to the junction with the A13. It is proposed to widen this section of the A1089 between the connection and the existing junction with the A13 to dual four lanes. Improvements would be required at the existing A13 free-flow junction in order to provide for an all-movement junction and the widened A1089. North

of the A13 the route would go to the west of Orsett and turn west close to South Ockendon before connecting with the M25 between Junctions 29 and 30.

- 5.3.12 The horizontal and vertical route alignment has been designed in accordance with DMRB TD9/93 Table 3 with a design speed of 120 km/h (70mph).

#### **Route Option C4**

- 5.3.13 This route option would connect the M2 at Junction 1 to Junction 29 on the M25 using a section of the existing A127. To the south of the river the route would go from Junction 1 on the M2 between Shorne and Higham and run north towards the river to the west of the rail depot/ sidings near Queens Farm Road. This route option has only been considered with a bored tunnel crossing of the river in order to go beneath the Ramsar site on the south side of the river and Coalhouse Fort on the north side.
- 5.3.14 On the north side of the river the route would go to the east of East Tilbury towards the A13, where it would intersect using a new free-flow junction. North of the A13 the route would go to the east of Orsett and would then run parallel with the A128 on the east side. It is proposed to connect into the A127 with a new free-flow junction in the location of the existing grade separated junction with the A127 and A128. It is proposed to widen the A127 between the existing A127/ A128 junction and Junction 29 on the M25 to dual four lanes. At Junction 29 on the M25 a free-flow connection is proposed to enable vehicles to travel north on the M25 and also southbound vehicles on the M25 to connect onto the proposed route.
- 5.3.15 The horizontal and vertical route alignment has been designed in accordance with DMRB TD9/93 Table 3 with a design speed of 120 km/h (70mph).

#### **Route Option C5**

- 5.3.16 This route option has been considered as an alternative to Route Option C4 where only a bored tunnel is practicable. At this location a bridge and immersed tube tunnel options have also been considered as these are not practicable at the crossing location on Route Option C4 due to the constraints of the Ramsar site and Coalhouse Fort.
- 5.3.17 The alignment to the south of the river is significantly different to Route Option C4 as it requires the crossing to be further east along the river in order to avoid Coalhouse Fort. The route would utilise the same junction connection with the M2 as proposed in Route Option C4 but would have the river crossing in the vicinity of Cliffe Pools.
- 5.3.18 On the north side of the river the route would go to the east of East Tilbury and then north intersecting the A13 near St Cleres Hall Golf Club. North of the A13 the route would go northwest to the north of Orsett and then parallel with the A128 on the east side and then connect to the A127 via a proposed free-flow junction. It is proposed to utilise the A127 to connect the route with the M25 via Junction 29 as for Route Option C4. The A127 and M25 Junction 29 would require upgrading as part of this option, similar to the proposal in Route Option C4.

- 5.3.19 The horizontal and vertical route alignment has been designed in accordance with DMRB TD9/93 Table 3 with a design speed of 120 km/h (70mph).

### Route Option C6

- 5.3.20 This route option would connect the A2/ B259 with M25 Junction 30 utilising the A1089 north of Tilbury and to the east of Grays. The route has been developed with a bored tunnel beneath Gravesend, the River Thames and Tilbury docks. The bored tunnel would end to the north of Tilbury docks where the route would connect with the existing A1089. The proposal for this route is to utilise the A1089 to the intersection with the A13, where the existing junction would be used and the route would then use the A13 from this junction through to Junction 30 on the M25. The A1089 and A13 and associated junctions would require upgrading as part of this option, similar to the proposals for Route Options C1 and C3.
- 5.3.21 The horizontal and vertical route alignment has been designed in accordance with DMRB TD9/93 Table 3 with a design speed of 120 km/h (70mph).

## 5.4 Location C Combinations

- 5.4.1 In addition to the main route options there are numerous combinations of the main route options that can be considered. **Table 5.4** details each of the combinations that have been considered, their route reference number, the main routes which have been connected and the approximate location of the connection. These combination route options have not necessarily been developed to the same level of detail as the main route options and have been considered when sections of the main route are not suitable in terms of traffic, economics or the impact on constraints.

**TABLE 5.4 - LOCATION C ROUTE OPTION COMBINATIONS**

| Route Reference | Route Connection   | Connection Location                                |
|-----------------|--------------------|----------------------------------------------------|
| C7              | C1 to C3           | west of Chadwell St Mary                           |
| C8              | C2 to C3           | south of Chalk                                     |
| C9              | C2 to C4           | north west of East Tilbury                         |
| C10             | C2 to C3           | north west of Orsett                               |
| C11             | C3 to C2           | south east of Chalk                                |
| C12             | C3 to C1           | existing A13 junction                              |
| C13             | C3 to C2 to C3     | south east of Chalk and north west of Orsett       |
| C14             | C3 to C2 to C4     | south east of Chalk and south west of East Tilbury |
| C15             | C4 to C3           | south east of Chalk                                |
| C16             | C4 to C3 to C1     | south east of Chalk and the existing A13 junction  |
| C17             | C4 to C2           | east of Chalk                                      |
| C18             | C4 to C2 to C3     | north of Orsett and South Ockendon                 |
| C19             | C4 to C2, C3 or C9 | east of Chalk                                      |

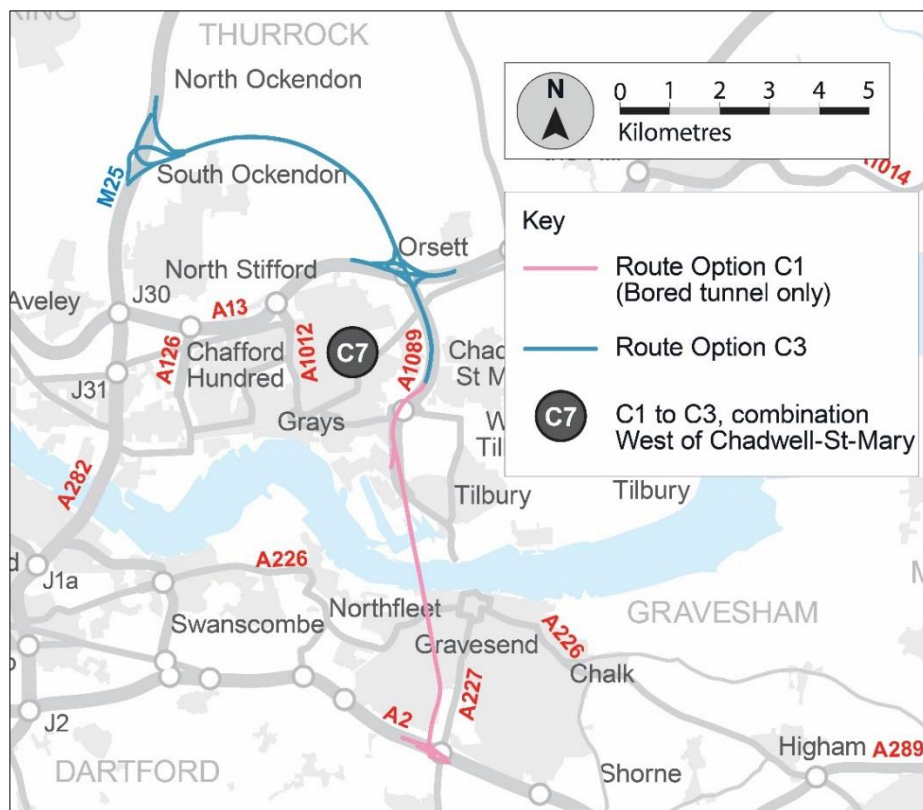


FIGURE 5.4 - ROUTE OPTION C1 COMBINATIONS

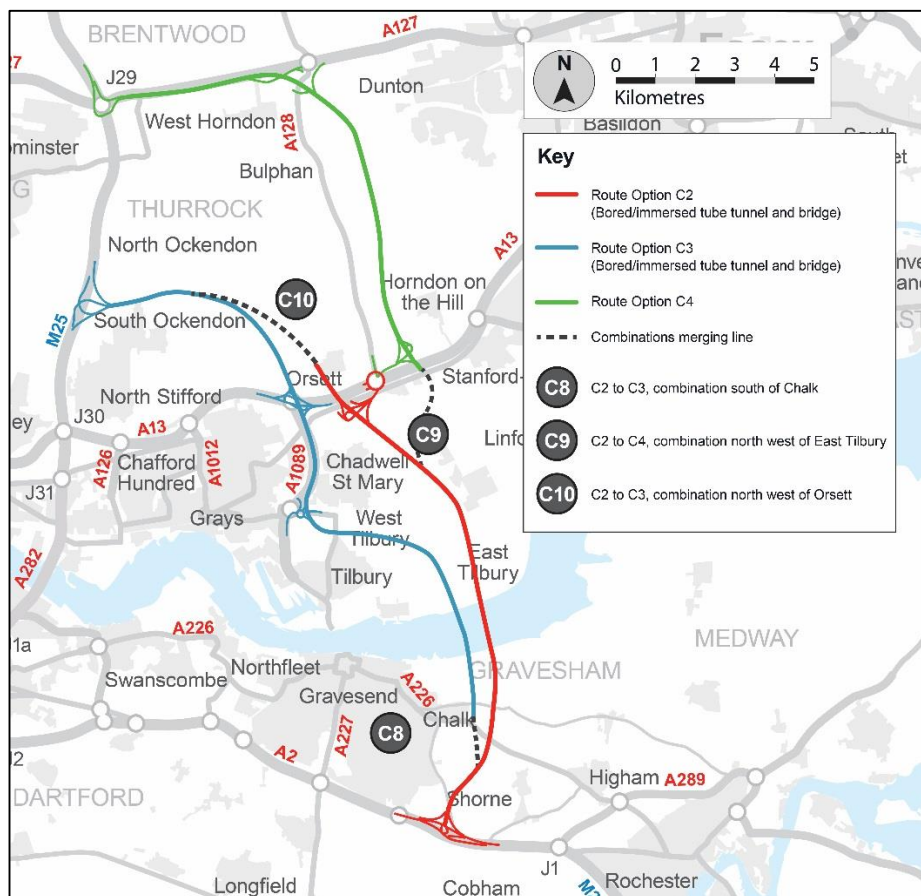


FIGURE 5.5 - ROUTE OPTION C2 COMBINATIONS



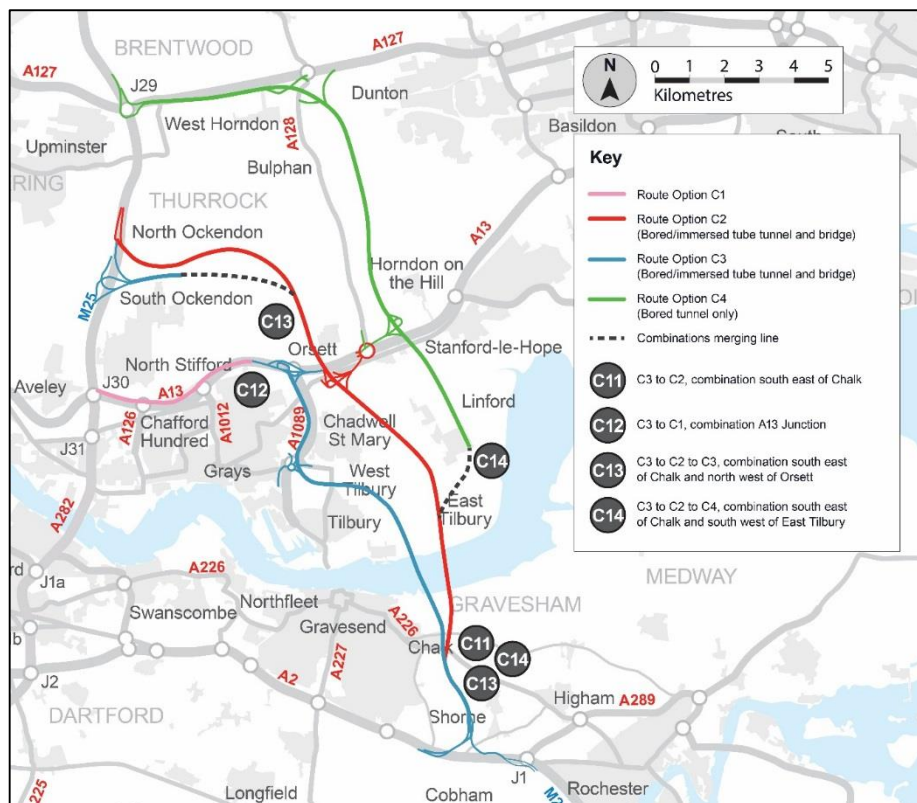


FIGURE 5.6 - ROUTE OPTION C3 COMBINATIONS

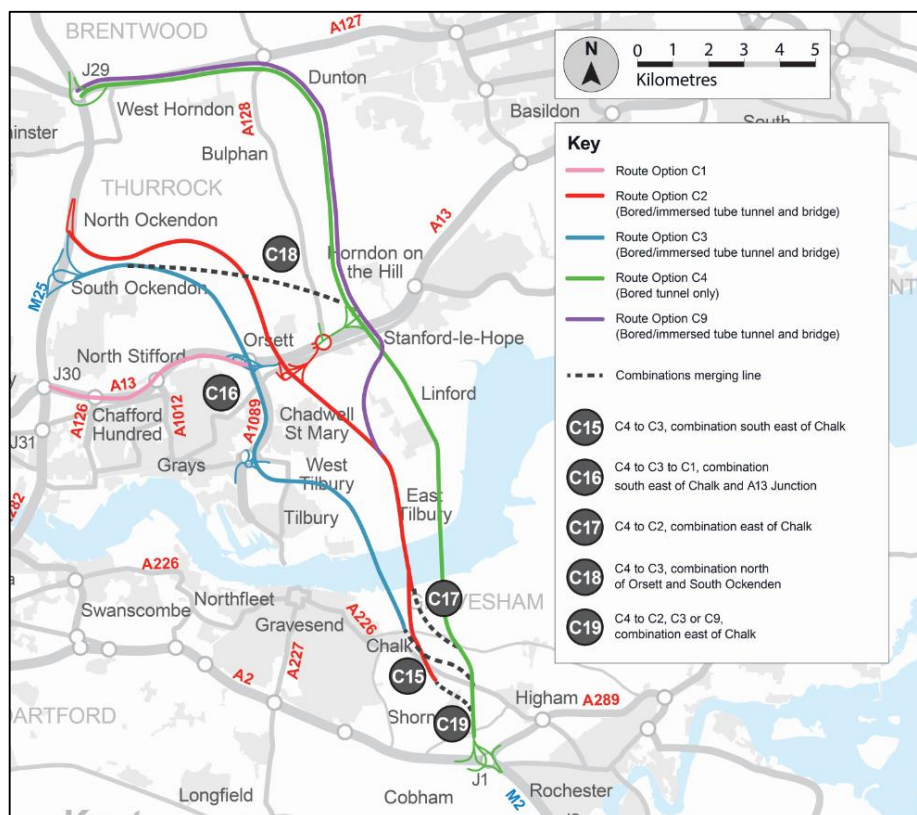


FIGURE 5.7 - ROUTE OPTION C4 COMBINATIONS



### **Route Option C1 Combinations**

- 5.4.2 Route Option C1 has one combination. The connection has been developed based on the route starting at the proposed connection with the A2 at the A2/A227 junction (refer to **Figure 5.4**).

#### *Combination Route Option C7*

- 5.4.3 The combination route for Route Option C7 would have a connection with the A2 at the existing junction with the A2 and A227. The river crossing option would be a bored tunnel which would take the route beneath Gravesend and Tilbury docks. North of Tilbury docks the route would utilise a section of the A1089 between Grays and Chadwell St Mary. At the A13 the main route would utilise the existing interchange and the A13 to the west of this junction to connect to Junction 30 on the M25. The A1089 and A13 would require upgrading as part of this option, as proposed for Route Options C1 and C3.

### **Route Option C2 Combinations**

- 5.4.4 Route Option C2 has three combinations. Connections have been developed based on all of the routes starting at the proposed connection with the A2 south east of Gravesend (refer to **Figure 5.5**).

#### *Combination Route Option C8*

- 5.4.5 This combination route connects Route Options C2 and C3 to provide a new route from the proposed junction with the A2 to the east of Gravesend through to the M25 between Junctions 29 and 30. The location of the connection is south of Chalk and would follow the proposed alignment for Route Option C3 north of Chalk across the river and on the north side of the river to the connection with the M25. This combination route could utilise the three river crossing options, immersed tube tunnel, bored tunnel and bridge.

#### *Combination Route Option C9*

- 5.4.6 This combination route connects Route Options C2 and C4 to the northwest of East Tilbury. The combination route would provide a new route from the proposed junction with the A2 to the east of Gravesend through to Junction 29 on the M25 utilising a section of the A127. This combination route could utilise the three river crossing options, immersed tube tunnel, bored tunnel and bridge.

#### *Combination Route Option C10*

- 5.4.7 This combination route connects Route Options C2 and C3 to the north west of Orsett. The combination route would provide a new route from the proposed junction with the A2 to the east of Gravesend through to the M25 between Junctions 29 and 30 where a free-flow junction is proposed. This combination route could utilise the three river crossing options, immersed tube tunnel, bored tunnel and bridge.

### **Route Option C3 Combinations**

- 5.4.8 Route Option C3 has four combinations. The connections have been developed based on all of the routes starting at the proposed connection with the A2 (refer to **Figure 5.6**).

*Combination Route Option C11*

- 5.4.9 This combination route connects Route Options C3 and C2 to provide a new route from the proposed junction with the A2 to the east of Gravesend through to the M25 between Junctions 29 and 30 where a new free-flow junction is proposed. The location of the connection is south east of Chalk and the proposed junctions would be the same as those detailed for Route Options C3 and C2. This combination route could utilise the three river crossing options, immersed tube tunnel, bored tunnel and bridge for Route Option C2.

*Combination Route Option C12*

- 5.4.10 This combination route connects Route Options C3 and C1 to provide a new route from the proposed junction with the A2 to the east of Gravesend through to the M25 Junction 30. The location of the connection is at the A13 junction and the proposed junctions would be the same as those detailed for Route Options C1 and C3. This combination route could utilise the three river crossing options, immersed tube tunnel, bored tunnel and bridge for Route Option C3.

*Combination Route Option C13*

- 5.4.11 This combination route connects Route Options C3, C2 and C3 to provide a new route from the proposed junction with the A2 to the east of Gravesend through to the M25 between Junctions 29 and 30. The locations of the connections are southeast of Chalk and northwest of Orsett. The junctions for this route would be the same as those proposed in routes C2 and C3. This combination route could utilise the three river crossing options, immersed tube tunnel, bored tunnel and bridge for Route Option C2.

*Combination Route Option C14*

- 5.4.12 This combination route connects Route Options C3, C2 and C4 to provide a new route from the proposed junction with the A2 to the east of Gravesend through to Junction 29 on the M25 utilising a section of the A127. Junction 29 on the M25 and the section of the A127 would require the same improvements described for Route Option C4. This combination route would utilise the three river crossing options, immersed tube tunnel, bored tunnel and bridge for Route Option C2.

**Route Option C4 Combinations**

- 5.4.13 Route Option C4 has five combinations. The connections have been developed based on all of the routes starting at the proposed connection with the M2 at Junction 1 (refer to **Figure 5.7**).

*Combination Route Option C15*

- 5.4.14 This combination route connects Route Options C4 and C3 to provide a new route from the proposed junction with the M2 Junction 1 through to the M25 between Junctions 29 and 30, utilising a section of the A1089 north of Tilbury to the interchange with the A13. This combination route would utilise the three river crossing options, immersed tube tunnel, bored tunnel and bridge for Route Option C3.

*Combination Route Option C16*

- 5.4.15 This combination route connects Route Options C4, C3 and C1 to provide a new route from the proposed junction with the M2 Junction 1 through to Junction 30 on the M25. The proposed junctions would be the same as those detailed for route C4, C3 and C1 and the route could utilise the three river crossing options, immersed tube tunnel, bored tunnel and bridge for Route Option C3.

*Combination Route Option C17*

- 5.4.16 This combination route connects Route Options C4 and C2 to provide a new route from the proposed junction with the M2 Junction 1 through to the M25 between Junctions 29 and 30. The junctions for this route would be the same as those proposed in routes C3 and C2 and the route could utilise the three river crossing options, immersed tube tunnel, bored tunnel and bridge for Route Option C2.

*Combination Route Option C18*

- 5.4.17 This combination route connects Route Options C4 and C3 to provide a new route from the proposed junction with the M2 Junction 1 through to the M25 between Junctions 29 and 30. The location of the connection is north of Orsett and South Ockendon. The junctions for this route would be the same as those proposed in Route Options C4 and C3 and the route would utilise a bored tunnel.

*Combination Route Option C19 (Southern Alternative)*

- 5.4.18 For the purposes of the traffic and economic appraisals this combination route was developed to connect Route Options C4, C2 and back to C4 to provide a new route from the proposed junction with the M2 Junction 1 through to the M25 Junction 29. The locations of the connections are south west of Chalk and northwest of East Tilbury. The junctions for this route would be the same as those proposed in Route Option C4 and the route could utilise a bored tunnel, immersed tube tunnel and bridge.
- 5.4.19 The section of C19 south of the River Thames could be combined with Route Options C2, C3 and C9 north of the river utilising the three crossing types.

## 5.5 C<sub>variant</sub> Description of Route Options

5.5.1 The C<sub>variant</sub> route options are shown in **Figure 5.8**.

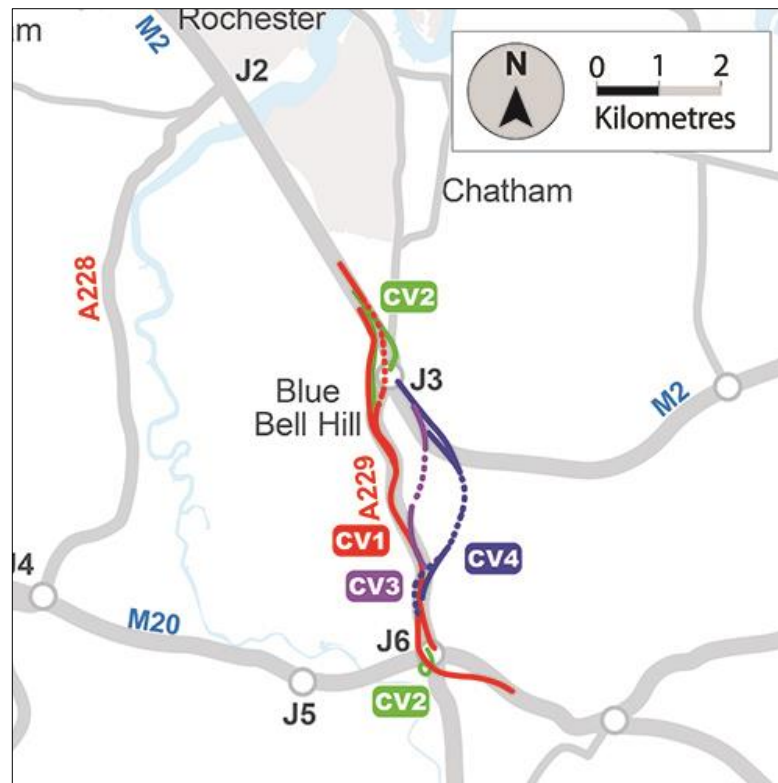


FIGURE 5.8 - C<sub>VARIANT</sub> ALL ROUTE OPTIONS

### Route Option CV1

- 5.5.2 This route option has been developed using a 70mph speed limit (120 km/h design speed) on the proposed free-flow links and the A229.
- 5.5.3 A viaduct approximately 700m long would be required for free-flowing westbound off the M20 onto the A229 northbound. Considerable adjustments to existing local roads, footbridges and structures would also be required.
- 5.5.4 The proposal is to widen the existing A229 to three lanes all-purpose dual carriageway with no hard shoulder both northbound and southbound along the A229. The A229 is proposed to be widened asymmetrically to the west so that the vertical and horizontal alignment fits with the surroundings.
- 5.5.5 A tunnel approximately 2.2km long would be required underneath the M2 in the southbound direction in order to link onto the A229. There are significant environmental constraints along the A229 relating to AONB and ancient woodland, and the gradient could be an issue to ensure tie-in with the A229 southbound. Northbound traffic on the A229 would require two new bridges approximately 500m long in total to connect to the M2 westbound.

### Route Option CV2

- 5.5.6 This route option entails a 40mph section (70 km/h design speed) which utilises the existing northbound slip road at the M20 Junction 6 (Running Horse Roundabout). It would remove the need for a viaduct at Junction 6 of

the M20. The details of the merge between the M20 and the A229 would need to be developed further and the possibility of making it free-flow would need to be investigated.

5.5.7 At the northern end a 50mph speed limit (85 km/h design speed) free-flowing link is proposed from the M2 eastbound onto a slip road that connects to the A229 southbound. No viaduct would be required for this link. In order to accommodate the proposed alignment, the following existing infrastructure would need to be removed:

- A229 overbridge just north of the M2
- A229 northbound section between the A2045 interchange and M2
- A2045 southbound off-slip and northbound on-slip
- B2097 interchange
- Reconfigure local roads

5.5.8 Northbound traffic on the A229 would require two new bridges approximately 500m long in total to connect to the M2 westbound.

5.5.9 The impact on the environment are significantly less when compared to other options due to the proposed works being relatively minor.

### **Route Option CV3**

5.5.10 At the southern end of the A229, Route Option CV1 is proposed whereby a viaduct approximately 700m long would be required for free-flowing link westbound off the M20 onto the A229 northbound.

5.5.11 At the northern end, this route option has been developed using a 70mph speed limit (120 km/h design speed) free-flowing link from the M2, south of Junction 3, to the A229 via an approximately 1.1km long tunnel, and viaducts approximately 500m and 900m long each at the northern and southern ends respectively of the proposed link.

5.5.12 The existing M2 Junction 3 roundabout is in close proximity to the proposed link and therefore would need to be removed in order to accommodate the proposed link and meet weaving standards. Removing the existing M2 Junction 3 would result in amendments to the M2 off/ on-slips and the local network in order to maintain current traffic movements.

5.5.13 The proposed link would cut through ancient woodlands, AONB and SSSI making this option highly sensitive to the environment.

### **Route Option CV4**

5.5.14 At the southern end of the A229, Route Option CV1 is proposed whereby a viaduct approximately 700m long would be required for free-flowing link westbound off the M20 onto the A229 northbound.

5.5.15 At the northern end, this option would be an approximately 3.0km long free-flowing link from the M2, south of Junction 3, to the A229 and has been developed using a 70mph speed limit (120 km/h design speed). It would require a 1.1km long tunnel in the northbound direction and 1.5km long tunnel in the southbound direction. There would also be proposed bridge over the M2 approximately 200m long.

- 5.5.16 Similar to Route Option CV3, the existing M2 Junction 3 roundabout is in close proximity to the proposed link and therefore would need to be removed in order to accommodate the proposed link and meet weaving standards. Removing the existing M2 Junction 3 would result in amendments to the M2 off-/ on-slips and the local network in order to maintain current traffic movements.
- 5.5.17 This option is similar to Route Option CV3 and has the same environmental issues. It would impact the environment by cutting through ancient woodlands, AONB and SSSI.

## **5.6 Pre-Longlist Appraisal Location A**

### *Route Option A3*

- 5.6.1 Route Option A3 is deemed not viable since in order to cater for strategic traffic, to maintain existing local traffic links to both Bluewater and Lakeside and to utilise the existing highway corridor, it would be necessary for the majority of Route Option A3 to be on elevated structure. Consequently this would significantly increase the overall construction cost of the alignment.
- 5.6.2 To the south at the location of the existing A2, in order to provide free-flow eastbound and westbound connectivity to the A2 the route alignment cannot be accommodated without impacting the proposed 'key' development site which is currently an existing quarry.
- 5.6.3 To the north of the River Thames there are significant issues in providing connectivity to the existing A13 and the separation of the route alignment adjacent to the A126, Chafford Hundred station and from the existing railway which runs parallel to the A126. The proposed gradients for the slip roads to and from the A13 would have to be in excess of 6% (the desirable maximum gradient) to provide clearance above the A126 and existing railway line.

### *Route Option A5*

- 5.6.4 For Route Option A5, a stacked single bore tunnel could be technically feasible and offer significant cost savings compared to a double bore tunnel, however Route Option A5 will not be considered as a separate option. Instead stacked single bore tunnels will be considered as variants to any double bore tunnel option, such as Route Option A4, that are taken forward for further development and assessment.
- 5.6.5 The initial assessment described below shows that this solution would be very difficult to implement at this location without significantly more detailed design assessment.
- 5.6.6 On the north side of the River Thames there is a tie-in point required above the London to Southend line and below HS1. This would be difficult to achieve with a single deck bore and is considered unrealistic with a double deck design. The double-deck tunnel layout lowers the tunnel base by 6m. Thus the requirements for the lower section of the stacked 2 x 2 lane tunnel to meet the tie-in point is a 10% instantaneous grade, which is outside standards for tunnel vertical grades. Traffic models have predicted large proportions of HGVs, which, together with such a steep gradient penalise tunnels in the form of higher ventilation costs and reduced lane capacity. The

EU directive for safety in tunnels state that longitudinal gradients above 5% shall not be permitted unless no other solution is geographically possible. The alternative to this would be to continue the lower bore under the railway but this has not been assessed in detail as it would significantly increase the cost.

- 5.6.7 A partially investigated alternative is a loop which, even at 85kph design speed and 7% super-elevation and a 360m radius, is one step below desirable minimum and has significant impact on existing property and infrastructure the north bank of the River Thames at the crossing point. Initial assessment concludes that there could be a viable alternative, however substantial further development work would be required to demonstrate that it is feasible. It would likely require an alternative double deck arrangement of tunnel, for example lower diameter horizontal radii, but this would affect (reduce) design speed and require possible multiple departures. Based on this initial assessment the complexity of the north tie-in has not been solved.

*Route Option A6*

- 5.6.8 Route Option A6 eastern tunnel would require an approximate 30m horizontal clearance from the existing QEII Bridge and approach structures. This would leave the scheme with a sizeable footprint, significantly impacting existing roads and associated business premises to the south and north of the River Thames such as Crossways Business Park, the A206 Crossways Boulevard, St Clements Way and the existing Lafarge-Tarmac cement and aggregate plant. In addition in order to tie-into the existing A282 before Junction 1a, the alignment would be required to be adjacent to the existing QEII Bridge approach structure. The proposed bore could therefore clash with and impact existing foundations. Internal access roads and other roads would require re-alignment, potentially causing significant disruption.
- 5.6.9 To the north of the River Thames the location of the existing HS1 and London to Southend railways within 160m of each other provide a significant constraint. The route alignment would be required to provide sufficient vertical clearance under HS1 and provide vertical clearance above the existing London to Southend railway line. During the initial development of the option it was not possible to determine whether or not this was possible at this location.
- 5.6.10 For the above reasons Option A6 is deemed not viable.

*Route Option A7*

- 5.6.11 Route Option A7 is deemed not viable due to the proposed alignment significantly impacting existing roads/ structures and associated business premises to the south and north of the River Thames. The reasoning and assessment of Route Option A7 are similar to Route Option A6 and, because the proposed twin bore tunnel would be wider than the single eastern bore of option A6, the impacts described are considered to be greater and therefore more significant.

### *Route Option A10*

- 5.6.12 This option would have similar impacts to those described above for Route Options A6 and A7. Route Option A10 would require an 80m horizontal clearance from the existing QEII Bridge and approach structures. This means that the impacts are likely to be greater than those for the other two options as a larger area would be affected and the option is therefore also deemed not viable.

### *Route Option A11*

- 5.6.13 Route Option A11 would require traffic to travel significant distances along both the A2 and A13 from the M25 to join the new crossing route and therefore is considered not to achieve the objective of providing an improved strategic route. In addition to this a significant part of the route is within the GLA (TfL) boundary and would potentially have an adverse impact on TfL's river crossing proposals, particularly that at Belvedere. Since Route Option A11 is within 5km of Belvedere, any crossing at this location would be likely to impact both project business cases. Furthermore, any junction with the A13 at the north end of the route would be located within the Wennington Marshes SSSI. For these reasons this route was not included in the longlist.

### *Route Option A13*

- 5.6.14 Route Option A13 is deemed not viable due to the proposed alignment significantly impacting proposed development sites, particularly near Ebbsfleet station, and existing roads and associated business premises to the south and north of the River Thames.
- 5.6.15 South of the River Thames, in order to avoid existing built up areas and future development proposals the south tunnel portal area would have to be situated so far south that connectivity to the A2 would be difficult to achieve. Alternatively the alignment would restrict the proposed development adjacent to Ebbsfleet Station and potentially impact on the station car park.
- 5.6.16 To the north of the River Thames there are significant issues in providing connectivity to the existing A13 and the separation of the route alignment adjacent to the A126, Chafford Hundred station and from the existing railway which runs parallel to the A126.
- 5.6.17 The south end of this route option was also considered to be in close proximity to Option B, which was previously rejected following the public consultation in December 2013.

## **5.7 Pre-Longlist Appraisal Location C**

### *Route Option C5*

- 5.7.1 This option is deemed not to be viable as it is considered that the environmental impacts would be higher than for the other route options in Location C and the benefits of this option are not significantly better than the other options. Each of the proposed route options have associated environmental constraints, but this route would affect a larger area of the Ramsar site north and south of the river and, to the south of the river, the route would be within an RSPB nature reserve as well as the Ramsar site.



- 5.7.2 As other route options in Location C have significantly lesser environmental impact it is considered that Route Option C5 should not be included in the longlist.

*Route Option C6*

- 5.7.3 This route option is deemed not to be viable for several reasons including the connection into the existing junction, vertical alignment and proposed development areas.
- 5.7.4 The connection to the existing A2 junction would be difficult due to the current arrangement. To be consistent with the other routes, a free-flow junction would need to be developed at this location which would require significant modifications to the existing junction and would be constrained by the existing route of the A2 and HS1. It would be difficult to re-align the A2 at this location due to the existing geometry of the A2. A grade separated junction option would have similar issues.
- 5.7.5 It is considered that there would be issues with the vertical alignment of the bored tunnel, especially near the junction with the A2/ B259. At this location the route would need to connect into the existing road network via a free-flow or grade separated junction and would then need to descend beneath HS1 at a sufficient depth to avoid any impact. It is considered that there is insufficient space to achieve the required geometry.
- 5.7.6 The area that the proposed junction and new road would be located in near the A2/ B259 is currently designated as a development zone. The proposed route would have a significant impact on this development zone and could prevent the future development of these sites. The previous work undertaken which looked into crossing options in Option Corridor B across the Swanscombe Peninsula concluded that any scheme in this area would have a significant detrimental impact on future developments and therefore Option Corridor B was withdrawn. Based on this decision it is considered that this route's impact on future development is significant enough to exclude it from the longlist.

## **5.8 Pre-Longlist Appraisal C<sub>variant</sub>**

*Route Option CV3*

- 5.8.1 This option is deemed not viable mainly due to the proposed alignment impacting the eastern fringe of the Blue Bell Hill village. Furthermore the existing M2 Junction 3 roundabout is in close proximity to the proposed link and therefore would need to be removed in order to accommodate the proposed link and meet weaving standards. Removing the existing M2 Junction 3 roundabout would result in amendments to the M2 off-/ on-slips and the local network in order to maintain current traffic movements. This is deemed to be unacceptable.

*Route Option CV4*

- 5.8.2 This route option has been deemed not viable for several reasons, including the route's impact on the environment, buildability and excessive construction cost.

- 5.8.3 This route option is similar to Route Option CV3 and is subject to the same environmental constraints. It would impact the environment by cutting through ancient woodlands, AONB and SSSI.
- 5.8.4 The existing M2 Junction 3 roundabout is in close proximity to the proposed link and therefore would need to be removed in order to accommodate the proposed link and meet weaving standards. Removing the existing M2 Junction 3 roundabout would result in amendments to the M2 off-/ on-slips and the local network in order to maintain current traffic movements. This is deemed to be unacceptable.

## **5.9 Longlist Route Options Location A**

5.9.1 The following route options are the longlist options:

- Route Option A1
- Route Option A2
- Route Option A4
- Route Option A8
- Route Option A9
- Route Option A12
- Route Option A14
- Route Option A15
- Route Option A16

## **5.10 Longlist Route Options Location C**

5.10.1 The following route options are the longlist options:

- Route Option C1 (including combination route options C7)
- Route Option C2 (including combination route options C8 to C10)
- Route Option C3 (including combination route options C11 to C14)
- Route Option C4 (including combination route options C15 to C19)

## **5.11 Longlist Route Options C<sub>variant</sub>**

5.11.1 The following route options are the longlist options:

- Route Option CV1
- Route Option CV2

## 6 Traffic Appraisal

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### 6.1 Introduction

6.1.1 The section sets out the traffic appraisal of the following longlist options:

- Route Option A1/ A4/ A9
- Route Option A2
- Route Option A16 (in combination with Route Option C4)
- Route Option C1
- Route Option C2
- Route Option C3
- Route Option C4
- Route Option C9
- Route Option C19
- Route Option C<sub>Variant</sub> in combination with Route Option A1
- Route Option C<sub>Variant</sub> in combination with Route Option C4

6.1.2 Route Options A8, A12 and A14 are not included in this section as they were not selected following the first stage appraisal of the longlist (refer to Section 12.2) without the need for the level of detailed traffic appraisal reported in this section. Route Option A15 is not specifically reported as it is not a full option but an alternative improvement for Junction 30.

6.1.3 With respect to Route Option C3 as a result of the first stage appraisal of the longlist the southern section of this option between the A2 and River Thames was not selected (refer to Section 12.3). Following this decision the route was modified to include the same alignment and A2 junction as Route Option C2 but the designation of the option was kept as Route Option C3. With the exception of the environmental appraisal reported in Sections 10.2.75 to 10.2.91 all the appraisal results for Route Option C3 reported in Sections 6, 7, 8, 9, 10 and 11 are for the modified version including the southern section of Route Option C2 and shown in **Figure 14.2**.

6.1.4 Combination options at Location C other than Route Option C9 and C19 are not included as they have not been separately appraised in the traffic model.

6.1.5 The two C<sub>Variant</sub> options have not been separately appraised as for the purposes of this appraisal option CV1 was considered to be representative of both options.

### 6.2 Traffic Data

6.2.1 The LTC v1 traffic model is based on the same traffic model as that used by AECOM for the 2013 Review as described in the 2013 Review *Model Capability Report*.<sup>22</sup> The 2013 Review model was itself based on the M25

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<sup>22</sup> AECOM (May 2013): Model Capability Report

Traffic Model, but had been enhanced to incorporate network data from local models, most notably Transport for London's (TfL) East London Highways Assignment Model (ELHAM), and more count and journey time data.

- 6.2.2 The M25 model had a base year of 2004 with demand derived from 2001 *London Area Travel Survey* (LATS) roadside interview surveys and traffic counts. The 2001 demand matrices had been uplifted to 2004 levels using matrix estimation techniques.

- 6.2.3 Various data sources were used to enhance the M25 model to produce the 2013 Review model. A short term forecast to 2009 was produced and this served as a 2009 base for the 2013 Review model and LTC v1 model.

#### *Network Data*

- 6.2.4 Network enhancements were made to the LTC v1 model using coding extracted from a local and sub-regional model (ELHAM) and Medway Traffic Model (MTM). MTM was used to enhance and supplement coding of the M2, particularly that at Junctions 1 and 5. The ELHAM model was used to enhance routes inside the M25. Junction coding, including saturation flows, signal timings and lane allocations, were adopted from ELHAM.

#### *Demand Data*

- 6.2.5 The 2009 demand matrices had been enhanced by AECOM to make best use of available local data. The 2009 forecasts from the M25 Model were used for the basis of AECOM's LTC 2009 model demand. The M25 Model 2009 freight matrices were retained.

#### *Transaction data*

- 6.2.6 Transaction data for the Dartford crossing was obtained by AECOM and used to derive counts on the crossing for use in the traffic model. The data was also used to derive average monetary tolls paid in each modelled time period used in both the assignment and demand models.

#### *Base Year Model Calibration and Validation*

- 6.2.7 Observed traffic and journey time data was obtained from a number of different models within the region with some strategic road network data having been extracted from Highways England's HATRIIS journey time database. The years for these data sources varied and therefore annualisation and seasonality factors have been applied. Network calibration was undertaken on a corridor basis and the model coding was deemed satisfactory for the purpose of the study. Assignment of the prior matrices demonstrated that the level of demand within the matrices was broadly consistent with the count data and the performance of the routing in the traffic model against the prior matrix was reasonable.
- 6.2.8 Validation of the post matrix estimation matrices showed that they broadly represented observed movements within the study area with screenline totals of 96%, 100% and 100% for the AM, inter-peak and PM peak periods respectively. At a strategic route level a good level of calibration was achieved with 81%, 86% and 84% in the AM, inter-peak and PM peak periods respectively. It was therefore accepted that the model represented a

reasonably accurate representation of traffic flows within the study area and was suitable for use in the LTC options phase.

- 6.2.9 HHJV has not made any changes to the 2013 Review base year model and therefore all documentation regarding that model remains current.
- 6.2.10 HHJV has used the 2013 Review model forecasts as the basis for the longlist assessment for the LTC Options Phase. HHJV has undertaken a review of the assumptions used in producing these forecasts<sup>23</sup>. Two model years are assessed, 2025, the opening year and a design year, typically 15 years later, but in the case of LTC, 2041, 16 years later. 2041 was selected as it is the maximum horizon year for current growth assumptions.
- 6.2.11 In summary, 60 new network schemes were listed as included in the Without Scheme of the 2013 Review model, of which 23 were included in the base year model and 33 included in the Without Scheme networks.<sup>24</sup> A review found that four network schemes, listed as being included in the network used to produce scheme forecasts, but there was no evidence that these schemes had been included in the network coding used to produce the forecasts. These four schemes were:
- A41 Hunton Bridge Improvements
  - A11 Fiveways to Thetford
  - M20 Junction 9 (Drivers Roundabout)
  - A282/ A2 on-slip
- 6.2.12 One additional scheme, A13/ A1014 junction improvements, was added to the current LTC v1 Without Scheme networks.
- 6.2.13 The effect of the Dart Charge scheme on crossing journey times and on the average charge paid, has been included in the Lower Thames crossing forecasts. Dart Charge (previously called the Dartford Free-Flow Charging (DFFC)) was modelled as follows:
- A capacity northbound of 5,612 pcu per hour and southbound of 6,687 pcu per hour.
  - Southbound (30kph) the toll booths were removed, increasing capacity to that of the approach road.
  - Northbound (30kph) the toll booths were removed but the tunnel standard acts as a constraint and traffic signalisation has been modelled on the approach to represent the operation of the Traffic Management Cell (TMC).
  - TMC data on the frequency and duration of interventions to deal with over -height or unregistered dangerous goods has been used to represent signalling in the model to estimate the occurrence and duration of red lights.

<sup>23</sup> HHJV (May 2015): HA540039-HHJ-ZZZ-TNT-TRA-034 LTC V1 Do Minimum Forecasting Assumptions (Draft)

<sup>24</sup> AECOM (April 2013): Review of Lower Thames Crossing Options: Central Forecasts and Sensitivity Tests Report

- It has been assumed that TMC has a constant operational level with no efficiencies.

- 6.2.14 There is an assumed increase in capacity in the southbound direction, but due to the introduction of traffic signals to represent the TMC in the northbound direction the capacity has been reduced in the forecast networks compared to the base year model.
- 6.2.15 Other than the above, HHJV has not made any changes to the modelling assumptions used in, or forecast demand matrices produced by, the 2013 review model.<sup>25</sup>

## 6.3 Traffic Analysis

- 6.3.1 This section assesses forecast traffic flows and journey times by options against the Without Scheme, for the modelled years 2025 and 2041, using the LTC v1 traffic assignment model. This allows the individual route options to be assessed comparatively for their impact upon traffic volumes, crossing journey times, crossing and network congestion and crossing resilience.
- 6.3.2 In advance of undertaking this more detailed analysis, three of the longlist options were not selected: A8, A12 and A14 (refer to **Figure 5.2**). All three options would include very long bored tunnels effectively bypassing the existing crossings at Dartford. Therefore common to all three options is their high capital costs relative to other A options. Traffic model runs for each option showed that flows were also low due to the bypassing of Junctions 1a, 1b and 31, in the case of A8 and A12. For example, the two way traffic flows in the peak periods for A8, A12 and A14 could be as low as 30% of the A1 crossing volumes. All three options were therefore not selected on the grounds of high capital cost and low traffic forecasts resulting in low BCRs.
- 6.3.3 This section focuses on presenting the change in traffic flows and journey times at the crossing. For each LTC route option data on traffic flow (vehicles per hour), V/C ratios (refer to section 2.3.28) and percentage of HGVs are presented by direction. A more detailed description of traffic flows on links on the local road networks will be included in the LTC v1 Traffic Forecasting Report.<sup>26</sup>
- 6.3.4 Journey times across the river will also be analysed to assess the changes across the route options. Only two north/ south routes are presented in the TAR, but east / west journey times along the A2, A13 and A127 will be assessed and presented as part of the v1 Traffic Forecasting Report.

### *Traffic Flows*

- 6.3.5 Traffic flows have been extracted for all the options for all movements that cross the River Thames, both using existing and new capacity. **Tables 6.1** (2025) and **6.2** (2041) present traffic flow, V/C and percentage of HGVs for each longlist route option.

<sup>25</sup> AECOM (April 2013): Review of Lower Thames Crossing Options: Central Forecasts and Sensitivity Tests Report

<sup>26</sup> HHJV: HA540039-HHJ-ZZZ-REP-TRA-005 LTC V1 Traffic Forecasting Report *forthcoming*.

TABLE 6.1 - TRAFFIC FLOW INFORMATION FOR 2025

| Route Option   | Direction     | AM    |      |      | IP    |      |      | PM    |      |      |
|----------------|---------------|-------|------|------|-------|------|------|-------|------|------|
|                |               | Flow  | V/C% | %HGV | Flow  | V/C% | %HGV | Flow  | V/C% | %HGV |
| Without scheme | NB            | 5,044 | 101  | 17   | 4,846 | 100  | 21   | 5,269 | 101  | 12   |
|                | SB            | 4,977 | 89   | 20   | 5,459 | 98   | 20   | 5,852 | 97   | 11   |
| A1 / A4 / A9   | NB - Tunnel   | 1,943 | 54   | 0    | 1654  | 46   | 0    | 2050  | 57   | 0    |
|                | NB - New      | 4,643 | 79   | 23   | 4350  | 77   | 27   | 5016  | 80   | 15   |
|                | SB - Tunnel   | 1,483 | 50   | 0    | 1787  | 61   | 0    | 1751  | 59   | 0    |
|                | SB – QEII     | 3,933 | 69   | 25   | 4209  | 74   | 27   | 4706  | 74   | 14   |
| A2             | NB - Tunnel   | 1,937 | 46   | 0    | 1724  | 41   | 0    | 2406  | 57   | 0    |
|                | NB – QEII     | 4,658 | 79   | 22   | 4215  | 74   | 27   | 4751  | 76   | 15   |
|                | SB - Tunnel   | 1,311 | 31   | 0    | 1455  | 34   | 0    | 1690  | 40   | 0    |
|                | SB - New      | 3,960 | 69   | 25   | 4334  | 75   | 25   | 4666  | 74   | 14   |
| C1             | NB – Tunnels  | 4,392 | 86   | 14   | 4145  | 84   | 18   | 4930  | 93   | 10   |
|                | NB – Opt C    | 2,764 | 69   | 16   | 2466  | 62   | 16   | 2831  | 66   | 9    |
|                | SB – QEII     | 4,404 | 78   | 18   | 4568  | 81   | 19   | 4682  | 77   | 10   |
|                | SB – Opt C    | 1,610 | 39   | 13   | 2229  | 53   | 11   | 2686  | 62   | 8    |
| C2             | NB - Tunnels  | 4,606 | 91   | 16   | 4351  | 87   | 18   | 5097  | 96   | 10   |
|                | NB – Opt C    | 2,490 | 61   | 14   | 2093  | 54   | 20   | 2453  | 58   | 10   |
|                | SB – QEII     | 4,516 | 74   | 18   | 4658  | 75   | 16   | 4767  | 72   | 8    |
|                | SB – Opt C    | 1,419 | 35   | 15   | 2073  | 53   | 20   | 2704  | 65   | 11   |
| C3             | NB - Tunnels  | 4,459 | 88   | 16   | 4251  | 85   | 18   | 5049  | 94   | 10   |
|                | NB – Opt C    | 2,776 | 68   | 13   | 2432  | 62   | 19   | 2674  | 63   | 10   |
|                | SB – QEII     | 4,452 | 78   | 18   | 4581  | 79   | 16   | 4777  | 77   | 8    |
|                | SB – Opt C    | 1,573 | 39   | 16   | 2280  | 59   | 20   | 2690  | 65   | 12   |
| C4             | NB - Tunnels  | 4,516 | 89   | 16   | 4337  | 87   | 17   | 5103  | 95   | 10   |
|                | NB – Opt C    | 2,848 | 69   | 14   | 2376  | 61   | 20   | 2687  | 64   | 10   |
|                | SB – QEII     | 4,479 | 73   | 18   | 4611  | 74   | 16   | 4733  | 71   | 8    |
|                | SB – Opt C    | 1,591 | 39   | 15   | 2347  | 60   | 19   | 3122  | 75   | 11   |
| C Variant – C2 | NB - Tunnels  | 4,596 | 91   | 16   | 4348  | 87   | 18   | 5103  | 96   | 10   |
|                | NB – Opt C    | 2,551 | 62   | 14   | 2164  | 55   | 19   | 2508  | 59   | 10   |
|                | SB – QEII     | 4,526 | 74   | 18   | 4661  | 75   | 16   | 4745  | 71   | 8    |
|                | SB – Opt C    | 1,470 | 36   | 15   | 2130  | 55   | 19   | 2785  | 66   | 11   |
| C Variant – A1 | NB - Tunnel   | 1,963 | 55   | 0    | 1674  | 46   | 0    | 2071  | 58   | 0    |
|                | NB - New      | 4,653 | 79   | 23   | 4356  | 77   | 27   | 5030  | 80   | 15   |
|                | SB - Tunnel   | 1,497 | 51   | 0    | 1801  | 61   | 0    | 1751  | 59   | 0    |
|                | SB – QEII     | 3,945 | 69   | 25   | 4219  | 74   | 27   | 4703  | 74   | 14   |
| C4 – A16       | NB - Existing | 1,781 | 43   | 40   | 1626  | 41   | 47   | 2397  | 50   | 21   |
|                | NB – New      | 2,951 | 70   | 0    | 2905  | 68   | 0    | 3140  | 74   | 0    |
|                | NB – Opt C    | 2,765 | 68   | 14   | 2,332 | 60   | 20   | 2,602 | 62   | 10   |
|                | SB - Existing | 4,516 | 74   | 18   | 4664  | 75   | 16   | 4799  | 72   | 8    |

| Route Option               | Direction    | AM    |      |      | IP   |      |      | PM   |      |      |
|----------------------------|--------------|-------|------|------|------|------|------|------|------|------|
|                            |              | Flow  | V/C% | %HGV | Flow | V/C% | %HGV | Flow | V/C% | %HGV |
|                            | SB – Opt C   | 1,584 | 39   | 15   | 2337 | 60   | 19   | 3104 | 74   | 11   |
| C2 – Differential charging | NB - Tunnels | 4,408 | 87   | 16   | 4142 | 83   | 18   | 4955 | 93   | 10   |
|                            | NB – Opt C   | 2,917 | 71   | 13   | 2535 | 64   | 18   | 3010 | 70   | 9    |
|                            | SB – QEII    | 4,374 | 72   | 18   | 4500 | 73   | 16   | 4531 | 68   | 9    |
|                            | SB – Opt C   | 1,787 | 44   | 14   | 2503 | 63   | 18   | 3161 | 75   | 10   |
| C9                         | NB - Tunnels | 4,523 | 89   | 16   | 4269 | 86   | 18   | 5047 | 94   | 10   |
|                            | NB – Opt C   | 2,699 | 66   | 13   | 2274 | 58   | 18   | 2673 | 63   | 9    |
|                            | SB – QEII    | 4,502 | 74   | 18   | 4637 | 75   | 16   | 4744 | 71   | 8    |
|                            | SB – Opt C   | 1,467 | 36   | 15   | 2166 | 55   | 18   | 2964 | 70   | 11   |
| C19                        | NB - Tunnels | 4,542 | 90   | 16   | 4344 | 87   | 17   | 5111 | 96   | 10   |
|                            | NB – Opt C   | 2,790 | 68   | 14   | 2343 | 60   | 20   | 2637 | 62   | 10   |
|                            | SB – QEII    | 4,494 | 73   | 18   | 4633 | 75   | 16   | 4769 | 72   | 8    |
|                            | SB – Opt C   | 1,542 | 38   | 15   | 2293 | 58   | 19   | 3386 | 73   | 11   |

### 6.3.6 Key highlights from the traffic flow information for Location A route options in 2025 are:

- Traffic flows have increased in both northbound and southbound directions across the river for all periods of the day compared to the without scheme.
- The traffic increase is more significant northbound (25-35% in each period) than southbound (around 10%), where compared to the without scheme the northbound has a greater release of capacity.
- V/C on the new crossings could be in excess of 75% although there are lower V/Cs on the existing tunnels.
- HGVs no longer use existing tunnels to cross the river.
- The QEII Bridge and new crossing have higher traffic flows and congestion levels than the existing tunnels.

### 6.3.7 Key highlights from the traffic flow information for Location C route options in 2025 are:

- The new crossings significantly increase total flows compared to the without scheme, where the northbound traffic increases by 40% or more in the peak periods, and the southbound increases around 20% in the AM and 30% in the PM.
- The new crossings have higher flows in the northbound direction compared to the southbound direction in the AM, and vice versa for the PM.
- There is a reduction in vehicles at the existing crossing; around 200-500 vehicles per hour in the AM, with little change on the existing crossings northbound in the PM and a small decrease in the southbound direction of around 100 vehicles.



- This reflects two responses of traffic demand and displacement, where traffic is generated as there is enhanced crossing capacity and of this new traffic some would use existing and some the new crossing; whilst some current traffic users would switch to use the new crossing.
- Location C options reduce the V/C on current infrastructure, where the Southbound experiences a greater reduction in congestion, whilst new crossings have V/C less than 75.

**TABLE 6.2 - TRAFFIC FLOW INFORMATION FOR 2041**

| Route Option   | Direction    | AM    |      |      | IP    |      |      | PM    |      |      |
|----------------|--------------|-------|------|------|-------|------|------|-------|------|------|
|                |              | Flow  | V/C% | %HGV | Flow  | V/C% | %HGV | Flow  | V/C% | %HGV |
| Without scheme | NB           | 4,905 | 101  | 20   | 4,695 | 101  | 26   | 5,145 | 101  | 15   |
|                | SB           | 5,432 | 100  | 23   | 5,721 | 105  | 23   | 5,963 | 101  | 13   |
| A1 / A4 / A9   | NB - Tunnel  | 2,595 | 72   | 0    | 2382  | 66   | 0    | 2644  | 73   | 0    |
|                | NB - New     | 4,749 | 85   | 29   | 4385  | 83   | 37   | 5214  | 86   | 19   |
|                | SB - Tunnel  | 2,042 | 69   | 0    | 2299  | 78   | 0    | 2075  | 70   | 0    |
|                | SB – QEII    | 4,167 | 76   | 32   | 4346  | 80   | 33   | 4741  | 77   | 17   |
| A2             | NB - Tunnels | 1,906 | 45   | 0    | 1837  | 43   | 0    | 2644  | 62   | 0    |
|                | NB – QEII    | 5,406 | 94   | 25   | 4869  | 89   | 32   | 5261  | 86   | 18   |
|                | SB - Tunnel  | 1,671 | 39   | 0    | 1825  | 43   | 0    | 1738  | 41   | 0    |
|                | SB - New     | 4,216 | 76   | 30   | 4583  | 82   | 29   | 4934  | 79   | 16   |
| C1             | NB - Tunnels | 4,729 | 94   | 17   | 4576  | 95   | 22   | 5036  | 97   | 13   |
|                | NB – Opt C   | 3,282 | 83   | 18   | 2918  | 75   | 20   | 3242  | 76   | 10   |
|                | SB – QEII    | 4,955 | 89   | 20   | 5014  | 90   | 19   | 4985  | 82   | 10   |
|                | SB – Opt C   | 1,898 | 48   | 18   | 2709  | 69   | 19   | 2924  | 70   | 11   |
| C2             | NB - Tunnels | 4,772 | 97   | 19   | 4648  | 97   | 22   | 5124  | 98   | 12   |
|                | NB – Opt C   | 2,965 | 73   | 15   | 2477  | 65   | 22   | 2839  | 68   | 11   |
|                | SB – QEII    | 5,077 | 85   | 21   | 5184  | 86   | 19   | 5088  | 78   | 10   |
|                | SB – Opt C   | 1,616 | 41   | 17   | 2420  | 63   | 22   | 2848  | 69   | 13   |
| C3             | NB - Tunnels | 4,735 | 96   | 19   | 4626  | 96   | 22   | 5109  | 98   | 12   |
|                | NB – Opt C   | 3,273 | 81   | 15   | 2825  | 74   | 21   | 3121  | 75   | 11   |
|                | SB – QEII    | 5,004 | 90   | 21   | 5100  | 90   | 19   | 5032  | 82   | 9    |
|                | SB – Opt C   | 1,769 | 45   | 18   | 2597  | 68   | 22   | 2895  | 71   | 14   |
| C4             | NB - Tunnels | 4,771 | 97   | 19   | 4662  | 97   | 22   | 5137  | 98   | 12   |
|                | NB – Opt C   | 3,318 | 82   | 15   | 2757  | 72   | 22   | 3014  | 72   | 12   |
|                | SB – QEII    | 5,042 | 85   | 21   | 5160  | 85   | 19   | 5071  | 77   | 10   |
|                | SB – Opt C   | 1,771 | 45   | 18   | 2694  | 70   | 22   | 3289  | 80   | 13   |
| Cvariant – C2  | NB - Tunnels | 4,764 | 97   | 19   | 4658  | 97   | 22   | 5120  | 98   | 12   |
|                | NB – Opt C   | 3,055 | 75   | 15   | 2538  | 66   | 21   | 2903  | 69   | 11   |
|                | SB – QEII    | 5,091 | 86   | 21   | 5187  | 86   | 19   | 5046  | 77   | 10   |
|                | SB – Opt C   | 1,666 | 42   | 17   | 2472  | 64   | 21   | 2975  | 72   | 12   |
|                | NB - Tunnel  | 2,610 | 73   | 0    | 2400  | 67   | 0    | 2660  | 74   | 0    |

| Route Option               | Direction    | AM    |      |      | IP    |      |      | PM    |      |      |
|----------------------------|--------------|-------|------|------|-------|------|------|-------|------|------|
|                            |              | Flow  | V/C% | %HGV | Flow  | V/C% | %HGV | Flow  | V/C% | %HGV |
| Cvariant – A1              | NB – New     | 4,750 | 85   | 29   | 4396  | 83   | 37   | 5229  | 86   | 19   |
|                            | SB - Tunnel  | 2,071 | 70   | 0    | 2304  | 78   | 0    | 2071  | 70   | 0    |
|                            | SB – QEII    | 4,169 | 76   | 32   | 4338  | 80   | 33   | 4743  | 77   | 17   |
| C4 – A16                   | NB - Tunnels | 2,048 | 51   | 46   | 1956  | 51   | 54   | 2659  | 57   | 25   |
|                            | NB – New     | 3,186 | 75   | 0    | 3193  | 75   | 0    | 3343  | 79   | 0    |
|                            | NB – Opt C   | 3,189 | 79   | 16   | 2,652 | 70   | 23   | 2,831 | 68   | 12   |
|                            | SB – QEII    | 5,112 | 86   | 21   | 5259  | 87   | 18   | 5190  | 79   | 9    |
|                            | SB – Opt C   | 1,765 | 45   | 18   | 2693  | 70   | 22   | 3281  | 80   | 13   |
| C2 – Differential charging | NB - Tunnels | 4,721 | 96   | 19   | 4594  | 96   | 22   | 5090  | 97   | 12   |
|                            | NB – Opt C   | 3,314 | 82   | 15   | 2878  | 74   | 20   | 3246  | 77   | 11   |
|                            | SB – QEII    | 5,008 | 84   | 21   | 5081  | 84   | 19   | 4934  | 76   | 10   |
|                            | SB – Opt C   | 1,913 | 48   | 16   | 2767  | 72   | 21   | 3188  | 77   | 12   |
| C9                         | NB - Tunnels | 4,749 | 96   | 19   | 4611  | 96   | 22   | 5107  | 98   | 12   |
|                            | NB – Opt C   | 3,197 | 79   | 15   | 2729  | 71   | 21   | 3028  | 72   | 11   |
|                            | SB – QEII    | 5,082 | 85   | 21   | 5183  | 86   | 19   | 5092  | 78   | 10   |
|                            | SB – Opt C   | 1,636 | 41   | 17   | 2543  | 66   | 21   | 3135  | 76   | 12   |
| C19                        | NB - Tunnels | 4,769 | 97   | 19   | 4669  | 97   | 21   | 5146  | 98   | 12   |
|                            | NB – Opt C   | 3,268 | 81   | 15   | 2731  | 72   | 23   | 2956  | 71   | 12   |
|                            | SB – QEII    | 5,059 | 85   | 21   | 5173  | 85   | 19   | 5083  | 77   | 10   |
|                            | SB – Opt C   | 1,710 | 43   | 17   | 2648  | 69   | 22   | 3250  | 79   | 13   |

### 6.3.8 Key highlights from the traffic flow information for Location A route options by 2041 are:

- Traffic flows have further increased in both northbound and southbound directions across the river.
- The HGV share rises slightly on all crossings and time periods, reflecting the value of enhanced capacity to strategic users in particular.
- V/C increases quite significantly for both the existing and new crossings: where A1/ A4/ A9 options have particularly increased congestion on new crossing movements, whilst under Route Option A2 the tunnel crossings do not experience much increase in congestion but the QEII Bridge becomes highly congested northbound. However, congestion remains significantly below the Without Scheme in both directions.

### 6.3.9 Key highlights from the traffic flow information for Location C route options by 2041 are:

- Traffic flows have further increased in both northbound (50-65% above the Without Scheme) and southbound (25-40% above the Without Scheme) directions across the river, and further beyond the

Location A route options, where the northbound capacity has been released further compared to the Without Scheme.

- The HGV share rises slightly on all crossings and time periods, reflecting the value of enhanced capacity to strategic users in particular.
- V/C increases quite significantly for both the existing and new crossings: where northbound tunnels and the QEII Bridge in particular have high congestion. However, congestion remains significantly below the without scheme in both directions.

6.3.10 Even for the With Schemes we find the traffic share of HGV users growing, though not to the level of the Without Scheme. The enhanced capacity enables growth in traffic levels from all users, however the increased share of HGV traffic reflects the higher marginal value of strategic network capacity to business operations and freight. Further, Kent and Essex already have a significant base in distribution and logistics business with further opportunity for this cluster to expand.

6.3.11 **Tables 6.3** and **6.4** below show the changes in flows on the key links (as defined in section 2.3.15) for the Do Nothing scenario and proposed options in 2025 and 2041.

**TABLE 6.3 - VEHICLE FLOWS GROWTH ON KEY LINKS FOR ROUTE OPTION SCHEMES VS WITHOUT SCHEME 2025**

| Route Option                   |    | D-C NB | D-C SB | Cross NB | Cross SB | A2 EB | A2 WB | A13 EB | A13 WB | J1A N | J1A S | J29-30 N | J29-30 S | J3/4 S | J4/3 N | J6-7 | A127 WB | A127 EB | A12 EB | Onto A12 | M20 WB | M20 EB |
|--------------------------------|----|--------|--------|----------|----------|-------|-------|--------|--------|-------|-------|----------|----------|--------|--------|------|---------|---------|--------|----------|--------|--------|
| A1, A4 and A9                  | AM | -62%   | -19%   | 30%      | 8%       | 1%    | 1%    | -7%    | 2%     | 12%   | 6%    | 13%      | 4%       | 1%     | 5%     | 0%   | 0%      | 0%      | 0%     | 0%       | 0%     | 0%     |
|                                | PM | -59%   | -4%    | 34%      | 10%      | 0%    | -1%   | -5%    | -6%    | 11%   | 0%    | 18%      | 4%       | 1%     | 2%     | 0%   | -7%     | 7%      | 1%     | 0%       | 6%     | 0%     |
| A2                             | AM | -62%   | n/a    | 31%      | 6%       | 2%    | 4%    | 0%     | 6%     | 14%   | 0%    | 13%      | 3%       | 0%     | 5%     | 0%   | 0%      | 0%      | 0%     | 0%       | -2%    | -1%    |
|                                | PM | -52%   | n/a    | 36%      | 9%       | 1%    | 2%    | 2%     | 1%     | 13%   | -2%   | 11%      | 2%       | 0%     | 2%     | 0%   | -7%     | 7%      | 0%     | 0%       | 4%     | 1%     |
| C1                             | AM | -13%   | -12%   | 42%      | 21%      | -1%   | -7%   | 1%     | 7%     | -12%  | -10%  | 13%      | 5%       | 1%     | 5%     | 0%   | 0%      | 0%      | 0%     | 0%       | -5%    | -1%    |
|                                | PM | -2%    | -6%    | 47%      | 26%      | -2%   | -5%   | 9%     | 8%     | -5%   | -18%  | 21%      | 1%       | 3%     | 1%     | 0%   | -10%    | 8%      | 2%     | 0%       | 4%     | 0%     |
| C2                             | AM | -9%    | -9%    | 31%      | 12%      | -2%   | -9%   | -4%    | -4%    | -10%  | -8%   | 6%       | 2%       | 1%     | 5%     | 0%   | 0%      | -1%     | 1%     | 0%       | -6%    | -1%    |
|                                | PM | 1%     | -4%    | 31%      | 16%      | -3%   | -6%   | -2%    | 0%     | -3%   | -17%  | 9%       | -6%      | 2%     | 1%     | 0%   | -10%    | 7%      | 2%     | 0%       | 4%     | 0%     |
| C3                             | AM | -12%   | -11%   | 35%      | 18%      | -5%   | -12%  | -5%    | -2%    | -11%  | -10%  | 4%       | -1%      | 1%     | 5%     | 0%   | 0%      | -2%     | 1%     | 0%       | -7%    | -1%    |
|                                | PM | 0%     | -4%    | 38%      | 22%      | -5%   | -11%  | -1%    | 3%     | -4%   | -18%  | 10%      | -7%      | 2%     | 1%     | 0%   | -11%    | 7%      | 2%     | 1%       | 3%     | -1%    |
| C4                             | AM | -10%   | -10%   | 36%      | 16%      | 1%    | -6%   | 2%     | -1%    | -11%  | -9%   | -12%     | -6%      | 1%     | 5%     | 0%   | 7%      | 3%      | 0%     | 0%       | -8%    | -2%    |
|                                | PM | 1%     | -5%    | 38%      | 23%      | -1%   | 0%    | 2%     | -1%    | -3%   | -17%  | -7%      | -18%     | 3%     | 2%     | 0%   | -4%     | 13%     | 1%     | 0%       | -2%    | -2%    |
| C <sub>variant</sub> - C2      | AM | -9%    | -9%    | 32%      | 13%      | 2%    | -6%   | -4%    | -4%    | -10%  | -8%   | 6%       | 2%       | 0%     | 5%     | 0%   | 0%      | -1%     | 1%     | 0%       | -11%   | -2%    |
|                                | PM | 1%     | -5%    | 32%      | 16%      | -1%   | 0%    | -2%    | 0%     | -3%   | -16%  | 9%       | -6%      | 2%     | 1%     | 0%   | -10%    | 7%      | 2%     | 0%       | -1%    | -3%    |
| C <sub>variant</sub> A1 bridge | AM | -65%   | -9%    | 28%      | 21%      | 0%    | -6%   | 3%     | -2%    | -9%   | -9%   | -11%     | -6%      | 1%     | 6%     | 0%   | 7%      | 3%      | 0%     | 0%       | -8%    | -2%    |
|                                | PM | -52%   | -4%    | 41%      | 12%      | -1%   | 1%    | 3%     | -1%    | 0%    | -18%  | -4%      | -18%     | 3%     | 3%     | 0%   | -5%     | 13%     | 1%     | 0%       | -2%    | -2%    |
| C4 - A16 single tunnel         | AM | -10%   | -10%   | 94%      | 17%      | 0%    | -6%   | 3%     | -1%    | -11%  | -9%   | -12%     | -6%      | 1%     | 5%     | 0%   | 7%      | 3%      | 0%     | 0%       | -8%    | -2%    |
|                                | PM | 1%     | -4%    | 97%      | 24%      | -1%   | 0%    | 2%     | -1%    | -3%   | -16%  | -7%      | -18%     | 3%     | 2%     | 0%   | -4%     | 13%     | 1%     | 0%       | -2%    | -2%    |
| C2 differential charging       | AM | -13%   | -12%   | 32%      | 14%      | -1%   | -9%   | -4%    | -3%    | -12%  | -11%  | 6%       | 2%       | 1%     | 5%     | 0%   | 0%      | -1%     | 1%     | 0%       | -6%    | -1%    |
|                                | PM | -2%    | -9%    | 35%      | 17%      | -2%   | -5%   | -2%    | -1%    | -4%   | -19%  | 9%       | -6%      | 3%     | 2%     | 0%   | -10%    | 7%      | 2%     | 0%       | 4%     | 0%     |
| C9 options                     | AM | -10%   | -10%   | 34%      | 15%      | 0%    | -9%   | 2%     | -3%    | -11%  | -9%   | -12%     | -6%      | 1%     | 5%     | 0%   | 7%      | 3%      | 0%     | 0%       | -6%    | -1%    |
|                                | PM | 0%     | -5%    | 36%      | 21%      | -2%   | -4%   | 0%     | -1%    | -3%   | -16%  | -6%      | -18%     | 3%     | 1%     | 0%   | -5%     | 12%     | 1%     | 0%       | 4%     | 0%     |
| C19 options                    | AM | -10%   | -10%   | 36%      | 16%      | 0%    | -6%   | 3%     | -1%    | -11%  | -9%   | -12%     | -6%      | 1%     | 5%     | 0%   | 7%      | 3%      | 0%     | 0%       | -8%    | -2%    |
|                                | PM | 1%     | -4%    | 38%      | 23%      | -1%   | 0%    | 2%     | -1%    | -3%   | -16%  | -7%      | -18%     | 3%     | 2%     | 0%   | -4%     | 13%     | 1%     | 0%       | -2%    | -2%    |

Note that for the change in Dartford Crossing flows, the A options may be using current infrastructure but if the direction has altered then this will be considered as new flows. For example, under A2 the QEII Bridge becomes a new northbound crossing flow, whilst only the west tunnel remains northbound where the eastbound tunnel is now southbound direction, and so A2's change in D-C flows compared to the without scheme flows is significant here.

TABLE 6.4 - VEHICLE FLOWS GROWTH ON KEY LINKS FOR ROUTE OPTION SCHEMES VS WITHOUT SCHEME 2041

| Route Option                   |    | D-C NB | D-C SB | Cross NB | Cross SB | A2 EB | A2 WB | A13 EB | A13 WB | J1A N | J1A S | J29-30 N | J29-30 S | J3/4 S | J4/3 N | J6-7 | A127 WB | A127 EB | A12 EB | Onto A12 | M20 WB | M20 EB |
|--------------------------------|----|--------|--------|----------|----------|-------|-------|--------|--------|-------|-------|----------|----------|--------|--------|------|---------|---------|--------|----------|--------|--------|
| A1, A4 and A9                  | AM | -49%   | -15%   | 45%      | 25%      | 8%    | 11%   | 2%     | 11%    | 24%   | 20%   | 30%      | 15%      | 5%     | 12%    | 3%   | 1%      | 7%      | 5%     | -2%      | 7%     | 6%     |
|                                | PM | -48%   | -4%    | 49%      | 16%      | 1%    | 7%    | 0%     | 0%     | 20%   | 8%    | 32%      | 13%      | 8%     | 6%     | 8%   | -8%     | 10%     | 12%    | 4%       | 15%    | 9%     |
| A2                             | AM | -62%   | n/a    | 45%      | 18%      | 8%    | 13%   | 10%    | 15%    | 26%   | 7%    | 27%      | 15%      | 4%     | 13%    | 3%   | 1%      | 7%      | 4%     | -3%      | 4%     | 5%     |
|                                | PM | -48%   | n/a    | 50%      | 14%      | 3%    | 9%    | 10%    | 3%     | 22%   | 2%    | 24%      | 11%      | 8%     | 6%     | 8%   | -3%     | 10%     | 12%    | 3%       | 14%    | 9%     |
| C1                             | AM | -6%    | 0%     | 59%      | 38%      | 6%    | 1%    | 11%    | 19%    | -2%   | 1%    | 30%      | 16%      | 6%     | 13%    | 3%   | 1%      | 9%      | 5%     | -2%      | 2%     | 5%     |
|                                | PM | 0%     | 0%     | 57%      | 35%      | 0%    | 3%    | 16%    | 12%    | -1%   | -7%   | 36%      | 12%      | 12%    | 6%     | 8%   | -5%     | 10%     | 12%    | 3%       | 12%    | 11%    |
| C2                             | AM | -5%    | 2%     | 53%      | 34%      | 7%    | -3%   | 5%     | 4%     | -1%   | 3%    | 18%      | 12%      | 5%     | 12%    | 3%   | 1%      | 8%      | 5%     | -2%      | 2%     | 4%     |
|                                | PM | 2%     | 2%     | 51%      | 36%      | 0%    | 2%    | 4%     | 0%     | 1%    | -5%   | 20%      | 3%       | 11%    | 6%     | 8%   | -5%     | 10%     | 13%    | 3%       | 11%    | 10%    |
| C3                             | AM | -6%    | 1%     | 59%      | 36%      | 2%    | -3%   | 5%     | 7%     | -2%   | 1%    | 17%      | 8%       | 5%     | 12%    | 3%   | 1%      | 9%      | 5%     | -2%      | 1%     | 4%     |
|                                | PM | 1%     | 1%     | 56%      | 35%      | -2%   | -3%   | 5%     | 6%     | 0%    | -7%   | 22%      | -2%      | 11%    | 6%     | 8%   | -6%     | 10%     | 13%    | 3%       | 11%    | 9%     |
| C4                             | AM | -5%    | 1%     | 60%      | 37%      | 8%    | 3%    | 10%    | 7%     | -1%   | 2%    | -1%      | 3%       | 5%     | 12%    | 3%   | 9%      | 14%     | 5%     | -2%      | 0%     | 3%     |
|                                | PM | 2%     | 2%     | 55%      | 43%      | 2%    | 6%    | 5%     | 1%     | 1%    | -6%   | 6%       | -8%      | 12%    | 6%     | 8%   | 5%      | 17%     | 12%    | 3%       | 9%     | 8%     |
| C <sub>variant</sub> - C2      | AM | -6%    | 2%     | 55%      | 36%      | 10%   | 1%    | 5%     | 5%     | -2%   | 3%    | 18%      | 12%      | 5%     | 12%    | 3%   | 1%      | 8%      | 5%     | -2%      | -7%    | 2%     |
|                                | PM | 1%     | 1%     | 52%      | 37%      | 2%    | 4%    | 4%     | 1%     | 0%    | -6%   | 20%      | 3%       | 9%     | 6%     | 8%   | -5%     | 10%     | 12%    | 3%       | 2%     | 5%     |
| C <sub>variant</sub> A1 bridge | AM | -7%    | -16%   | 87%      | 25%      | 17%   | 18%   | 10%    | 12%    | 24%   | 19%   | 29%      | 14%      | 4%     | 13%    | 3%   | 1%      | 8%      | 5%     | -2%      | -6%    | 2%     |
|                                | PM | -47%   | -5%    | 50%      | 16%      | 5%    | 15%   | 10%    | 2%     | 21%   | 7%    | 32%      | 10%      | 9%     | 6%     | 7%   | -3%     | 10%     | 11%    | 3%       | 4%     | 5%     |
| C4 - A16 single tunnel         | AM | -59%   | 3%     | 67%      | 38%      | 7%    | 3%    | 10%    | 7%     | 3%    | 2%    | 3%       | 3%       | 5%     | 14%    | 3%   | 9%      | 15%     | 5%     | -2%      | 0%     | 3%     |
|                                | PM | -47%   | 4%     | 68%      | 45%      | 1%    | 7%    | 6%     | 0%     | 8%    | -6%   | 12%      | -9%      | 11%    | 7%     | 8%   | 4%      | 17%     | 12%    | 3%       | 9%     | 8%     |
| C2 differential charging       | AM | -6%    | 1%     | 59%      | 39%      | 7%    | -3%   | 5%     | 5%     | -2%   | 2%    | 19%      | 12%      | 5%     | 13%    | 3%   | 1%      | 8%      | 5%     | -2%      | 2%     | 4%     |
|                                | PM | 1%     | -1%    | 58%      | 39%      | 1%    | 2%    | 4%     | 0%     | 0%    | -7%   | 20%      | 3%       | 11%    | 6%     | 8%   | -5%     | 10%     | 12%    | 3%       | 12%    | 10%    |
| C9 options                     | AM | -6%    | 2%     | 58%      | 35%      | 8%    | -3%   | 8%     | 6%     | -2%   | 3%    | -1%      | 4%       | 5%     | 12%    | 3%   | 9%      | 14%     | 5%     | -2%      | 2%     | 4%     |
|                                | PM | 1%     | 2%     | 54%      | 41%      | 1%    | 4%    | 2%     | 1%     | 1%    | -5%   | 6%       | -8%      | 12%    | 6%     | 8%   | 4%      | 16%     | 12%    | 3%       | 12%    | 11%    |
| C19 options                    | AM | -5%    | 2%     | 59%      | 36%      | 8%    | 3%    | 10%    | 7%     | -1%   | 2%    | -1%      | 4%       | 5%     | 12%    | 3%   | 9%      | 14%     | 5%     | -2%      | 0%     | 3%     |
|                                | PM | 2%     | 2%     | 54%      | 42%      | 2%    | 6%    | 5%     | 1%     | 1%    | -6%   | 6%       | -8%      | 12%    | 6%     | 8%   | 5%      | 17%     | 12%    | 3%       | 9%     | 8%     |

6.3.12 Key points from the tables, where percentage differences of +/-5% or more have been highlighted:

- All route option schemes significantly increase the vehicle flows undertaking a north and southbound crossing (combined Dartford Crossing and any new infrastructure) compared to the Without Scheme in 2025, and further in 2041.
- Northbound flows increase to a greater level than southbound where the capacity release compared to the Without Scheme is greater.
- There is little difference for all route options in 2025 across the M25 Junctions 3, 4 and 6-7, and for flows along the A12 further north of the crossing.
- By 2041, there remains little difference between the route options on the traffic volume impacts for M25 Junctions 3-4, and 6-7, and the A12.
- Junctions 1a-1b in both directions are typically falling by a significant amount under the Location C route options where traffic now has a viable alternative route, whilst Location A route options largely result in higher flows here. Although by 2041, the difference to the Without Scheme is less pronounced for the Location C route options.
- The M20 has different flow responses depending on the option location and how the option links to and from the crossing within the strategic road network. For example, Route Options C4, C9 and C19 have a crossing route starting further east and therefore they reduce the M20 flows further than other Location C (and A) route options.
- Likewise these Route Options, C4, C9 and C19, re-connect to the A127 and have a greater impact on flows on this link. Alternatively, Route Options C1, C2 and C3 add more traffic to the M25 Junctions 29-30.

6.3.13 The shares and growth of traffic by user types have also been looked at, to understand the impact of the route options.

6.3.14 Under the Without Scheme route options, the model forecasts reductions in the number of cars using the northbound crossing across the AM, inter-peak and PM, and the southbound crossing in the PM. Also, the traffic was increasingly composed of LGV and HGV vehicles, whilst cars were decreasing in their share.

6.3.15 Under the A and C locations, we find different traffic growth responses, compared to the without scheme, where new capacity is added, with traffic growth better accommodated than the Without Scheme.

6.3.16 As demonstrated by the **Tables 6.5 to 6.8** below, for an example Location A Route Option (A1/ A4/ A9) and Location C Route Option (C2), the With Schemes enable all user traffic, using either the existing or new crossings, to grow across the time periods for 2025 and 2041 compared to the model base (2009).

**TABLE 6.5 - ROUTE OPTION A1/A4/A9 CROSSING TRAFFIC SHARES BY USER TYPE**

|             |           | AM  |     | IP  |     | PM  |     |
|-------------|-----------|-----|-----|-----|-----|-----|-----|
|             |           | NB  | SB  | NB  | SB  | NB  | SB  |
| <b>2025</b> | HGV       | 16% | 19% | 20% | 19% | 11% | 10% |
|             | LGV       | 11% | 10% | 11% | 11% | 12% | 10% |
|             | CAR BUSIN | 24% | 20% | 28% | 25% | 21% | 18% |
|             | CAR OTHR  | 50% | 51% | 41% | 46% | 57% | 62% |
| <b>2041</b> | HGV       | 19% | 21% | 23% | 21% | 12% | 12% |
|             | LGV       | 14% | 13% | 16% | 14% | 17% | 13% |
|             | CAR BUSIN | 22% | 19% | 25% | 23% | 19% | 18% |
|             | CAR OTHR  | 46% | 47% | 36% | 42% | 52% | 57% |

6.3.17 The car traffic reduces as a share of total traffic under Route Option A1/ A4/ A9, with the increasing importance of the HGV and LGV traffic, reflecting the value of enhanced capacity to strategic users in particular, but not to the level of the Without Scheme.

**TABLE 6.6 - ROUTE OPTION A1/A4/A9 CROSSING TRAFFIC GROWTH**

|             |              | AM         |            | IP         |            | PM         |            |
|-------------|--------------|------------|------------|------------|------------|------------|------------|
|             |              | NB         | SB         | NB         | SB         | NB         | SB         |
| <b>2025</b> | HGV          | 44%        | 35%        | 49%        | 33%        | 48%        | 27%        |
|             | LGV          | 85%        | 64%        | 85%        | 66%        | 89%        | 65%        |
|             | CAR BUSIN    | 40%        | 33%        | 51%        | 44%        | 40%        | 23%        |
|             | CAR OTHR     | 20%        | 31%        | 28%        | 32%        | 32%        | 10%        |
|             | <b>TOTAL</b> | <b>33%</b> | <b>35%</b> | <b>43%</b> | <b>38%</b> | <b>40%</b> | <b>17%</b> |
| <b>2041</b> | HGV          | 88%        | 81%        | 101%       | 71%        | 91%        | 62%        |
|             | LGV          | 171%       | 140%       | 187%       | 142%       | 187%       | 134%       |
|             | CAR BUSIN    | 44%        | 44%        | 51%        | 50%        | 45%        | 29%        |
|             | CAR OTHR     | 23%        | 39%        | 28%        | 33%        | 33%        | 6%         |
|             | <b>TOTAL</b> | <b>48%</b> | <b>56%</b> | <b>62%</b> | <b>54%</b> | <b>55%</b> | <b>24%</b> |

6.3.18 Unlike the Without Scheme, no user group under this route option experiences a decrease in traffic levels for the AM, PM or inter-peak compared to the 2009 model base.

**TABLE 6.7 - ROUTE OPTION C2 CROSSING TRAFFIC SHARES BY USER TYPE**

|             |           | AM  |     | IP  |     | PM  |     |
|-------------|-----------|-----|-----|-----|-----|-----|-----|
|             |           | NB  | SB  | NB  | SB  | NB  | SB  |
| <b>2025</b> | HGV       | 15% | 17% | 18% | 17% | 10% | 9%  |
|             | LGV       | 11% | 9%  | 11% | 10% | 12% | 9%  |
|             | CAR BUSIN | 23% | 19% | 27% | 24% | 19% | 17% |
|             | CAR OTHR  | 51% | 54% | 43% | 49% | 59% | 64% |
| <b>2041</b> | HGV       | 18% | 20% | 22% | 20% | 12% | 11% |
|             | LGV       | 14% | 12% | 15% | 13% | 16% | 12% |
|             | CAR BUSIN | 21% | 18% | 25% | 23% | 18% | 17% |
|             | CAR OTHR  | 47% | 50% | 38% | 44% | 53% | 59% |

6.3.19 The car traffic reduces as a share of total traffic under Route Option C2, with the increasing importance of the HGV and LGV traffic, reflecting the value of enhanced capacity to strategic users in particular, but not to the level of the Without Scheme.

**TABLE 6.8 - ROUTE OPTION C2 CROSSING TRAFFIC GROWTH**

|             |              | AM         |            | IP         |            | PM         |            |
|-------------|--------------|------------|------------|------------|------------|------------|------------|
|             |              | NB         | SB         | NB         | SB         | NB         | SB         |
| <b>2025</b> | HGV          | 49%        | 39%        | 49%        | 38%        | 46%        | 38%        |
|             | LGV          | 104%       | 69%        | 93%        | 75%        | 98%        | 83%        |
|             | CAR BUSIN    | 48%        | 40%        | 56%        | 56%        | 41%        | 37%        |
|             | CAR OTHR     | 33%        | 53%        | 46%        | 57%        | 46%        | 32%        |
|             | <b>TOTAL</b> | <b>44%</b> | <b>49%</b> | <b>54%</b> | <b>55%</b> | <b>50%</b> | <b>37%</b> |
| <b>2041</b> | HGV          | 89%        | 83%        | 99%        | 79%        | 86%        | 74%        |
|             | LGV          | 192%       | 144%       | 186%       | 161%       | 186%       | 160%       |
|             | CAR BUSIN    | 50%        | 50%        | 56%        | 69%        | 41%        | 46%        |
|             | CAR OTHR     | 33%        | 58%        | 44%        | 60%        | 39%        | 29%        |
|             | <b>TOTAL</b> | <b>57%</b> | <b>68%</b> | <b>70%</b> | <b>75%</b> | <b>58%</b> | <b>45%</b> |

6.3.20 Similarly to A1/ A4/ A9, this With Scheme route option is able to accommodate demand from across user groups where all traffic types increase with the northbound and southbound crossings (current and new). Both the northbound and southbound has expanded capacity significantly so that traffic growth is experienced in both directions and in all modelled time periods, and is significantly higher than the Without Scheme. There is significant growth in HGV and LGV traffic under the route options, where HGVs in particular grew under Route Option C2. Route Option C2 also accommodates a higher level of overall traffic growth for 2025 and 2041 than A1/ A4/ A9.

### Journey times

6.3.21 Journey times have been extracted for all route options between M25 Junction 2 and M25 Junction 29; in both directions, for all time periods as shown in **Table 6.9**. **Table 6.10** show journey time savings compared to the Without Scheme for the route options, where the current Dartford Crossing tunnels remain northbound and the QEII Bridge remains southbound.

**TABLE 6.9 - CROSSING JOURNEY TIMES FOR 2025 AND 2041**

| Route Option   | Description    | Direction  | 2025     |          |          | 2041     |          |          |
|----------------|----------------|------------|----------|----------|----------|----------|----------|----------|
|                |                |            | AM       | IP       | PM       | AM       | IP       | PM       |
| Without Scheme | West tunnel    | Northbound | 00:19:25 | 00:17:14 | 00:17:55 | 00:23:30 | 00:21:16 | 00:20:35 |
|                | East tunnel    | Northbound | 00:19:26 | 00:16:57 | 00:17:59 | 00:23:24 | 00:21:22 | 00:20:40 |
|                | QEII           | Southbound | 00:12:07 | 00:13:17 | 00:13:24 | 00:13:44 | 00:16:02 | 00:14:58 |
| A1/A4/A9       | New - Option A | Northbound | 00:13:11 | -        | 00:13:20 | 00:14:58 | 00:14:13 | 00:14:37 |
|                | West tunnel    | Northbound | 00:10:04 | -        | 00:10:19 | 00:11:29 | 00:10:51 | 00:11:19 |
|                | East tunnel    | Southbound | 00:11:34 | -        | 00:12:18 | 00:12:35 | 00:14:06 | 00:13:52 |
|                | QEII           | Southbound | 00:11:33 | -        | 00:12:18 | 00:12:35 | 00:14:06 | 00:13:52 |
| A2             | West tunnel    | Northbound | 00:16:13 | 00:16:13 | 00:17:42 | 00:19:41 | 00:20:13 | 00:20:13 |
|                | QEII           | Northbound | 00:13:06 | 00:12:24 | 00:12:53 | 00:14:55 | 00:13:59 | 00:14:06 |



| Route Option                    | Description    | Direction  | 2025     |          |          | 2041     |          |          |
|---------------------------------|----------------|------------|----------|----------|----------|----------|----------|----------|
|                                 |                |            | AM       | IP       | PM       | AM       | IP       | PM       |
|                                 | East tunnel    | Southbound | 00:16:00 | 00:16:53 | 00:17:51 | 00:17:53 | 00:19:37 | 00:20:42 |
|                                 | New - Option A | Southbound | 00:11:20 | 00:11:52 | 00:12:02 | 00:11:59 | 00:13:05 | 00:12:57 |
| C1                              | West tunnel    | Northbound | 00:13:16 | 00:12:55 | 00:14:08 | 00:15:08 | 00:14:47 | 00:16:09 |
|                                 | East tunnel    | Northbound | 00:13:16 | 00:12:56 | 00:14:07 | 00:15:08 | 00:14:49 | 00:16:05 |
|                                 | QEII           | Southbound | 00:11:25 | 00:11:48 | 00:11:46 | 00:12:18 | 00:12:45 | 00:12:28 |
| C2                              | West tunnel    | Northbound | 00:13:25 | 00:12:51 | 00:14:13 | 00:16:14 | 00:15:24 | 00:16:01 |
|                                 | East tunnel    | Northbound | 00:13:23 | 00:12:50 | 00:14:10 | 00:16:16 | 00:15:18 | 00:15:59 |
|                                 | QEII           | Southbound | 00:11:26 | 00:11:40 | 00:11:40 | 00:12:28 | 00:12:54 | 00:12:31 |
| C3                              | West tunnel    | Northbound | 00:13:18 | 00:12:50 | 00:14:11 | 00:15:41 | 00:15:04 | 00:16:29 |
|                                 | East tunnel    | Northbound | 00:13:19 | 00:12:51 | 00:14:07 | 00:15:40 | 00:15:04 | 00:16:34 |
|                                 | QEII           | Southbound | 00:11:24 | 00:11:36 | 00:11:42 | 00:12:21 | 00:12:49 | 00:12:25 |
| C4                              | West tunnel    | Northbound | 00:12:54 | 00:12:32 | 00:14:00 | 00:15:01 | 00:14:40 | 00:16:10 |
|                                 | East tunnel    | Northbound | 00:12:52 | 00:12:31 | 00:14:00 | 00:15:04 | 00:14:33 | 00:16:07 |
|                                 | QEII           | Southbound | 00:11:19 | 00:11:24 | 00:11:22 | 00:12:17 | 00:12:25 | 00:11:54 |
| C <sub>variant</sub> + C2       | West tunnel    | Northbound | 00:13:18 | 00:12:48 | 00:14:18 | 00:15:45 | 00:15:15 | 00:16:22 |
|                                 | East tunnel    | Northbound | 00:13:17 | 00:12:48 | 00:14:13 | 00:15:52 | 00:15:22 | 00:16:20 |
|                                 | QEII           | Southbound | 00:11:25 | 00:11:36 | 00:11:35 | 00:15:48 | 00:12:50 | 00:12:23 |
| C <sub>variant</sub> + A1       | New - Option A | Northbound | 00:13:12 | 00:12:40 | 00:13:22 | 00:15:00 | 00:14:15 | 00:14:40 |
|                                 | West tunnel    | Northbound | 00:10:06 | 00:09:41 | 00:10:20 | 00:11:30 | 00:10:52 | 00:11:21 |
|                                 | East tunnel    | Southbound | 00:11:35 | 00:12:14 | 00:12:17 | 00:12:38 | 00:14:24 | 00:13:48 |
|                                 | QEII           | Southbound | 00:11:35 | 00:12:14 | 00:12:17 | 00:12:37 | 00:14:23 | 00:13:48 |
| C4 + A16                        | West tunnel    | Northbound | 00:11:51 | 00:11:31 | 00:12:34 | 00:12:56 | 00:12:30 | 00:13:41 |
|                                 | East tunnel    | Northbound | 00:11:51 | 00:11:31 | 00:12:33 | 00:12:56 | 00:12:30 | 00:13:41 |
|                                 | QEII           | Southbound | 00:11:20 | 00:11:25 | 00:11:23 | 00:12:22 | 00:12:32 | 00:12:00 |
| C2 bridge differential charging | West tunnel    | Northbound | 00:13:02 | 00:12:38 | 00:13:44 | 00:15:05 | 00:14:39 | 00:15:50 |
|                                 | East tunnel    | Northbound | 00:13:02 | 00:12:37 | 00:13:47 | 00:15:08 | 00:14:37 | 00:15:57 |
|                                 | QEII           | Southbound | 00:11:21 | 00:11:30 | 00:11:29 | 00:12:21 | 00:12:41 | 00:12:16 |
| C9                              | West tunnel    | Northbound | 00:12:56 | 00:12:29 | 00:13:54 | 00:14:45 | 00:14:14 | 00:15:53 |
|                                 | East tunnel    | Northbound | 00:12:55 | 00:12:30 | 00:13:52 | 00:14:44 | 00:14:21 | 00:15:56 |

| Route Option | Description | Direction  | 2025     |          |          | 2041     |          |          |
|--------------|-------------|------------|----------|----------|----------|----------|----------|----------|
|              |             |            | AM       | IP       | PM       | AM       | IP       | PM       |
|              | QEII        | Southbound | 00:11:21 | 00:11:27 | 00:11:25 | 00:12:23 | 00:12:30 | 00:11:59 |
| C19          | West tunnel | Northbound | 00:12:56 | 00:12:31 | 00:14:04 | 00:15:12 | 00:14:39 | 00:16:15 |
|              | East tunnel | Northbound | 00:12:55 | 00:12:32 | 00:14:04 | 00:15:04 | 00:14:37 | 00:16:17 |
|              | QEII        | Southbound | 00:11:20 | 00:11:26 | 00:11:25 | 00:12:21 | 00:12:28 | 00:11:57 |

TABLE 6.10 - CROSSING JOURNEY TIME SAVINGS FOR 2025 AND 2041

| Route Option  | Description    | Direction  | 2025     |          |          | 2041     |          |          |
|---------------|----------------|------------|----------|----------|----------|----------|----------|----------|
|               |                |            | AM       | IP       | PM       | AM       | IP       | PM       |
| A1/A4/A9      | New - Option A | Northbound | n/a      | n/a      | n/a      | n/a      | n/a      | n/a      |
|               | West tunnel    | Northbound | 00:09:21 |          | 00:07:36 | 00:12:01 | 00:10:25 | 00:09:16 |
|               | East tunnel    | Southbound | n/a      | n/a      | n/a      | n/a      | n/a      | n/a      |
|               | QEII           | Southbound | 00:00:34 |          | 00:01:06 | 00:01:09 | 00:01:56 | 00:01:06 |
| A2            | West tunnel    | Northbound | 00:03:12 | 00:01:01 | 00:00:13 | 00:03:49 | 00:01:03 | 00:00:22 |
|               | QEII           | Northbound | n/a      | n/a      | n/a      | n/a      | n/a      | n/a      |
|               | East tunnel    | Southbound | n/a      | n/a      | n/a      | n/a      | n/a      | n/a      |
|               | New - Option A | Southbound | n/a      | n/a      | n/a      | n/a      | n/a      | n/a      |
| C1            | West tunnel    | Northbound | 00:06:09 | 00:04:19 | 00:03:47 | 00:08:22 | 00:06:29 | 00:04:26 |
|               | East tunnel    | Northbound | 00:06:10 | 00:04:01 | 00:03:52 | 00:08:16 | 00:06:33 | 00:04:35 |
|               | QEII           | Southbound | 00:00:42 | 00:01:29 | 00:01:38 | 00:01:26 | 00:03:17 | 00:02:30 |
| C2            | West tunnel    | Northbound | 00:06:00 | 00:04:23 | 00:03:42 | 00:07:16 | 00:05:52 | 00:04:34 |
|               | East tunnel    | Northbound | 00:06:03 | 00:04:07 | 00:03:49 | 00:07:08 | 00:06:04 | 00:04:41 |
|               | QE2            | Southbound | 00:00:41 | 00:01:37 | 00:01:44 | 00:01:16 | 00:03:08 | 00:02:27 |
| C3            | West tunnel    | Northbound | 00:06:07 | 00:04:24 | 00:03:44 | 00:07:49 | 00:06:12 | 00:04:06 |
|               | East tunnel    | Northbound | 00:06:07 | 00:04:06 | 00:03:52 | 00:07:44 | 00:06:18 | 00:04:06 |
|               | QEII           | Southbound | 00:00:43 | 00:01:41 | 00:01:42 | 00:01:23 | 00:03:13 | 00:02:33 |
| C4            | West tunnel    | Northbound | 00:06:31 | 00:04:42 | 00:03:55 | 00:08:29 | 00:06:36 | 00:04:25 |
|               | East tunnel    | Northbound | 00:06:34 | 00:04:26 | 00:03:59 | 00:08:20 | 00:06:49 | 00:04:33 |
|               | QE2            | Southbound | 00:00:48 | 00:01:53 | 00:02:02 | 00:01:27 | 00:03:37 | 00:03:04 |
| Cvariant + C2 | West tunnel    | Northbound | 00:06:07 | 00:04:26 | 00:03:37 | 00:07:45 | 00:06:01 | 00:04:13 |

| Route Option                    | Description    | Direction  | 2025     |          |          | 2041     |          |          |
|---------------------------------|----------------|------------|----------|----------|----------|----------|----------|----------|
|                                 |                |            | AM       | IP       | PM       | AM       | IP       | PM       |
|                                 | East tunnel    | Northbound | 00:06:09 | 00:04:09 | 00:03:46 | 00:07:32 | 00:06:00 | 00:04:20 |
|                                 | QEII           | Southbound | 00:00:42 | 00:01:41 | 00:01:49 | 00:02:04 | 00:03:12 | 00:02:35 |
| C <sub>variant</sub> + A1       | New - Option A | Northbound | n/a      | n/a      | n/a      | n/a      | n/a      | n/a      |
|                                 | West tunnel    | Northbound | 00:09:19 | 00:07:33 | 00:07:35 | 00:12:00 | 00:10:24 | 00:09:14 |
|                                 | East tunnel    | Southbound | n/a      | n/a      | n/a      | n/a      | n/a      | n/a      |
|                                 | QEII           | Southbound | 00:00:32 | 00:01:03 | 00:01:07 | 00:01:07 | 00:01:39 | 00:01:10 |
| C4 + A16                        | West tunnel    | Northbound | 00:07:34 | 00:05:43 | 00:05:21 | 00:10:34 | 00:08:46 | 00:06:54 |
|                                 | East tunnel    | Northbound | 00:07:35 | 00:05:26 | 00:05:26 | 00:10:28 | 00:08:52 | 00:06:59 |
|                                 | QEII           | Southbound | 00:00:47 | 00:01:52 | 00:02:01 | 00:01:22 | 00:03:30 | 00:02:58 |
| C2 bridge differential charging | West tunnel    | Northbound | 00:06:23 | 00:04:36 | 00:04:11 | 00:08:25 | 00:06:37 | 00:04:45 |
|                                 | East tunnel    | Northbound | 00:06:24 | 00:04:20 | 00:04:12 | 00:08:16 | 00:06:45 | 00:04:43 |
|                                 | QEII           | Southbound | 00:00:46 | 00:01:47 | 00:01:55 | 00:01:23 | 00:03:21 | 00:02:42 |
| C9                              | West tunnel    | Northbound | 00:06:29 | 00:04:45 | 00:04:01 | 00:08:45 | 00:07:02 | 00:04:42 |
|                                 | East tunnel    | Northbound | 00:06:31 | 00:04:27 | 00:04:07 | 00:08:40 | 00:07:01 | 00:04:44 |
|                                 | QEII           | Southbound | 00:00:46 | 00:01:50 | 00:01:59 | 00:01:21 | 00:03:32 | 00:02:59 |
| C19                             | West tunnel    | Northbound | 00:06:29 | 00:04:43 | 00:03:51 | 00:08:18 | 00:06:37 | 00:04:20 |
|                                 | East tunnel    | Northbound | 00:06:31 | 00:04:25 | 00:03:55 | 00:08:20 | 00:06:45 | 00:04:23 |
|                                 | QEII           | Southbound | 00:00:47 | 00:01:51 | 00:01:59 | 00:01:23 | 00:03:34 | 00:03:01 |

6.3.22 Journey times are improved over the existing crossing route with improvements for both Location A options and Location C options.

- Modelled travel times for northbound tunnels under the Location C route options show an improvement of 6 minutes in 2025 and 7-8 minutes in 2041 compared to the Without Scheme scenario in the AM period (longest original journey time).
- The remaining northbound tunnel (westbound) for the Location A route options has an improvement of 9 minutes for A1/ A4/ A9 and 3 minutes for A2 in the AM peak.
- Modelled travel times in the southbound direction improve by only by 1-2 minutes for both Location A and C scenarios in 2025 and 2-3 minutes in 2041.

6.3.23 Option C4 and C4 + A16 deliver the best journey time savings on the QEII southbound, and option C4 + A16 delivers the best journey time savings

across the northbound tunnels, whilst Option A1/ A4/ A9 and C<sub>Variant</sub> plus A1 deliver the best savings on the west, northbound tunnel.

### Congestion

- 6.3.24 Section 2.3.27 explained the three metrics developed to assess the impact of the route options on congestion.
- 6.3.25 **Table 6.11** presents the impact of the LTC route options on congestion on key links 2025 and 2041 using trip weighted average V/C ratios. The last column presents for each route option a colour rating for these metrics, where, given the range of overall congestion for the route options, red indicates a 2041 V/C of above 84, orange over 80, and green up to 80 (rounded).

**TABLE 6.11 - THE IMPACT OF THE LTC ROUTE OPTIONS ON CONGESTION ON KEY LINKS 2025 AND 2041**

| Option                               | Overall (trip weighted) - 2025 | Overall (trip weighted) - 2041 | Colour coding |
|--------------------------------------|--------------------------------|--------------------------------|---------------|
| Without Scheme                       | 79.6                           | 84.1                           | Red           |
| A1 /A4/A9                            | 75.2                           | 81.1                           | Orange        |
| A2 (bridge east)                     | 76.8                           | 82.6                           | Orange        |
| C1 (bored tunnel)                    | 76.5                           | 82.0                           | Orange        |
| C2                                   | 76.3                           | 81.6                           | Orange        |
| C3                                   | 75.8                           | 81.2                           | Orange        |
| C4 (bored tunnel)                    | 75.2                           | 80.2                           | Green         |
| C variant + C2 bored tunnel          | 76.6                           | 81.5                           | Orange        |
| C variant + A1                       | 76.6                           | 82.4                           | Orange        |
| C4 + A16 single bore tunnel          | 73.8                           | 79.2                           | Green         |
| C2 bored tunnel differential tolling | 75.8                           | 81.4                           | Orange        |
| C9                                   | 75.2                           | 80.2                           | Green         |
| C19                                  | 75.3                           | 80.2                           | Green         |

- 6.3.26 Route Options C4, C4 + A16, C9 and C19 have the biggest impact in reducing congestion on the key links surrounding the Dartford Crossing, whilst A2, C1 and C<sub>Variant</sub> + A1 have the least impacts. Four options achieve a green rating.

**Tables 6.12 and 6.13** below provide a disaggregation of these overall congestion percentages for 2025 and 2041, for the Without Scheme and for each of the route options on the ten key links, covering both directions. Colour coding has been used to differentiate between different levels of congestion, and to show how options impact congestion levels at the different links compared to the Without Scheme.

TABLE 6.12 - DISAGGREGATION OF THE CONGESTION CHANGES ON KEY LINKS IN 2025

| Option                      | D-C NB | D-C SB | A2 EB | A2 WB | A13 EB | A13 WB | J1A NB | J1A SB | J29-30 NB | J29-30 SB | J3/4 M25 SB | J4/3 M25 NB | J6-7 | A127 WB | A127 EB | A12 EB | Onto A12 | M20 WB | M20 EB |
|-----------------------------|--------|--------|-------|-------|--------|--------|--------|--------|-----------|-----------|-------------|-------------|------|---------|---------|--------|----------|--------|--------|
| Without Scheme              | 101    | 93     | 66    | 71    | 74     | 69     | 91     | 75     | 59        | 64        | 79          | 77          | 98   | 92      | 88      | 85     | 92       | 75     | 70     |
| A1 /A4/A9                   | 55     | 69     | 66    | 73    | 69     | 68     | 81     | 62     | 68        | 66        | 79          | 79          | 98   | 91      | 89      | 85     | 92       | 77     | 70     |
| A2 (bridge east)            | 69     | 71     | 67    | 75    | 73     | 72     | 85     | 75     | 66        | 66        | 79          | 79          | 98   | 92      | 88      | 85     | 92       | 75     | 70     |
| C1 (bored tunnel)           | 89     | 77     | 65    | 69    | 68     | 67     | 82     | 63     | 68        | 65        | 80          | 79          | 99   | 91      | 89      | 85     | 91       | 75     | 70     |
| C2                          | 93     | 73     | 63    | 66    | 73     | 72     | 84     | 64     | 64        | 62        | 80          | 79          | 98   | 91      | 88      | 86     | 92       | 74     | 69     |
| C3                          | 91     | 78     | 61    | 63    | 68     | 69     | 83     | 63     | 64        | 62        | 80          | 79          | 98   | 90      | 88      | 86     | 92       | 73     | 69     |
| C4 (bored tunnel)           | 92     | 72     | 64    | 69    | 76     | 72     | 84     | 64     | 53        | 55        | 80          | 79          | 98   | 85      | 81      | 85     | 92       | 71     | 69     |
| C variant + C2 bored tunnel | 93     | 73     | 64    | 69    | 73     | 72     | 84     | 64     | 64        | 62        | 79          | 79          | 98   | 91      | 88      | 86     | 91       | 73     | 70     |
| C variant + A1              | 56     | 72     | 69    | 79    | 73     | 71     | 81     | 78     | 68        | 65        | 79          | 79          | 98   | 92      | 88      | 85     | 92       | 74     | 69     |
| C4 + A16 single bore tunnel | 47     | 73     | 64    | 69    | 77     | 72     | 86     | 63     | 54        | 54        | 80          | 80          | 98   | 85      | 81      | 85     | 91       | 72     | 69     |
| C2 differential tolling     | 90     | 70     | 63    | 66    | 73     | 72     | 83     | 62     | 64        | 62        | 80          | 79          | 98   | 91      | 88      | 86     | 91       | 74     | 69     |
| C9                          | 92     | 73     | 63    | 67    | 76     | 72     | 84     | 64     | 53        | 55        | 80          | 79          | 98   | 84      | 81      | 85     | 91       | 74     | 70     |
| C19                         | 93     | 73     | 64    | 69    | 76     | 72     | 84     | 64     | 53        | 55        | 80          | 79          | 98   | 85      | 81      | 85     | 92       | 71     | 69     |

Colour grading: Dark red (>90), red (>80), amber (>75), yellow (>70), green (<70).

TABLE 6.13 - DISAGGREGATION OF THE CONGESTION CHANGES ON KEY LINKS IN 2041

| Option                      | D-C NB | D-C SB | A2 EB | A2 WB | A13 EB | A13 WB | J1A NB | J1A SB | J29-30 NB | J29-30 SB | J3/4 M25 SB | J4/3 M25 NB | J6-7 | A127 WB | A127 EB | A12 EB | Onto A12 | M20 WB | M20 EB |
|-----------------------------|--------|--------|-------|-------|--------|--------|--------|--------|-----------|-----------|-------------|-------------|------|---------|---------|--------|----------|--------|--------|
| Without Scheme              | 101    | 100    | 68    | 76    | 82     | 69     | 96     | 83     | 66        | 71        | 84          | 82          | 105  | 90      | 93      | 92     | 95       | 81     | 75     |
| A1 /A4/A9                   | 72     | 76     | 69    | 80    | 77     | 68     | 90     | 70     | 78        | 74        | 85          | 85          | 105  | 89      | 93      | 92     | 95       | 84     | 75     |
| A2 (bridge east)            | 80     | 78     | 69    | 82    | 81     | 69     | 94     | 81     | 75        | 73        | 85          | 85          | 105  | 90      | 93      | 92     | 94       | 82     | 75     |
| C1 (bored tunnel)           | 96     | 86     | 68    | 75    | 74     | 65     | 89     | 72     | 79        | 73        | 86          | 85          | 105  | 89      | 93      | 92     | 94       | 81     | 75     |
| C2                          | 98     | 82     | 66    | 72    | 79     | 68     | 91     | 74     | 72        | 69        | 86          | 84          | 105  | 89      | 93      | 93     | 94       | 81     | 75     |
| C3                          | 97     | 86     | 64    | 70    | 75     | 66     | 90     | 72     | 73        | 68        | 86          | 84          | 105  | 89      | 93      | 93     | 94       | 80     | 74     |
| C4 (bored tunnel)           | 98     | 81     | 67    | 75    | 81     | 69     | 91     | 73     | 60        | 62        | 86          | 84          | 105  | 80      | 85      | 93     | 94       | 79     | 74     |
| C variant + C2              | 98     | 81     | 67    | 74    | 79     | 68     | 91     | 74     | 72        | 69        | 85          | 84          | 105  | 89      | 93      | 92     | 94       | 77     | 74     |
| C variant + A1              | 72     | 77     | 71    | 85    | 81     | 69     | 90     | 86     | 78        | 73        | 85          | 85          | 104  | 90      | 93      | 92     | 94       | 77     | 74     |
| C4 + A16 single bore tunnel | 54     | 82     | 67    | 75    | 82     | 69     | 96     | 73     | 63        | 61        | 86          | 86          | 105  | 80      | 85      | 92     | 94       | 79     | 74     |
| C2 differential tolling     | 97     | 80     | 67    | 72    | 79     | 68     | 90     | 73     | 73        | 69        | 86          | 85          | 105  | 89      | 93      | 92     | 94       | 81     | 75     |
| C9                          | 97     | 82     | 67    | 72    | 80     | 68     | 91     | 74     | 60        | 62        | 86          | 84          | 105  | 80      | 85      | 92     | 94       | 81     | 75     |
| C19                         | 98     | 81     | 68    | 76    | 81     | 69     | 91     | 73     | 60        | 62        | 86          | 84          | 105  | 81      | 85      | 92     | 94       | 76     | 73     |

Note that these metrics cover current infrastructure. (i.e. C4 + A16 tunnel has a large decrease on current northbound Dartford Crossing (D-C) as these tunnels are used by local traffic (flows reduce significantly) and the new tunnel – not included in above – carries more traffic northbound). Where the traffic direction of current infrastructure is switched in any route options, the impact of this is included as per the new direction.

6.3.27 **Figures 6.1 to 6.4** demonstrate the range of congestion metrics in 2025 and 2041 by: i) LTC route option; and ii) by key link on the road network. The charts show (from bottom up) the minimum, 1st quartile, median, 3<sup>rd</sup> quartile and the maximum congestion metric. In each of these figures the left hand axis shows the Volume over Capacity ratio (V/C).

6.3.28 The key findings from **Figures 6.1** and **6.3** which show congestion by route option in 2025 and 2041 respectively, are:

- There are some differences in the median level of congestion between the LTC route options, with Route Options C1, C3, C<sub>variant</sub> and A1 having higher average congestion.
- Route Option C4 + A16 has a range of congestion values which are below those for other route options, indicating that the option has a better performance on congestion.
- Whilst Route Options A4, A9 and C2 have similar medians for congestion, overall Location A route options have a greater range between their low and high congestion points.
- There is not a great difference in congestion between the route options, although it is possible to identify route options which have a lower range and lower average compared to the without scheme.

6.3.29 The key finding from **Figures 6.2** and **6.4**, which show congestion for the key links in 2025 and 2041 respectively, is that:

- Congestion on some of the key links is largely unaffected by the With Scheme LTC route options – for example those circled in **Figure 6.2**, Junctions 3-4 of the M25, Junctions 6-7 (from A22) (which has very high congestion), the A12 and the M20 eastbound (which have low congestion).

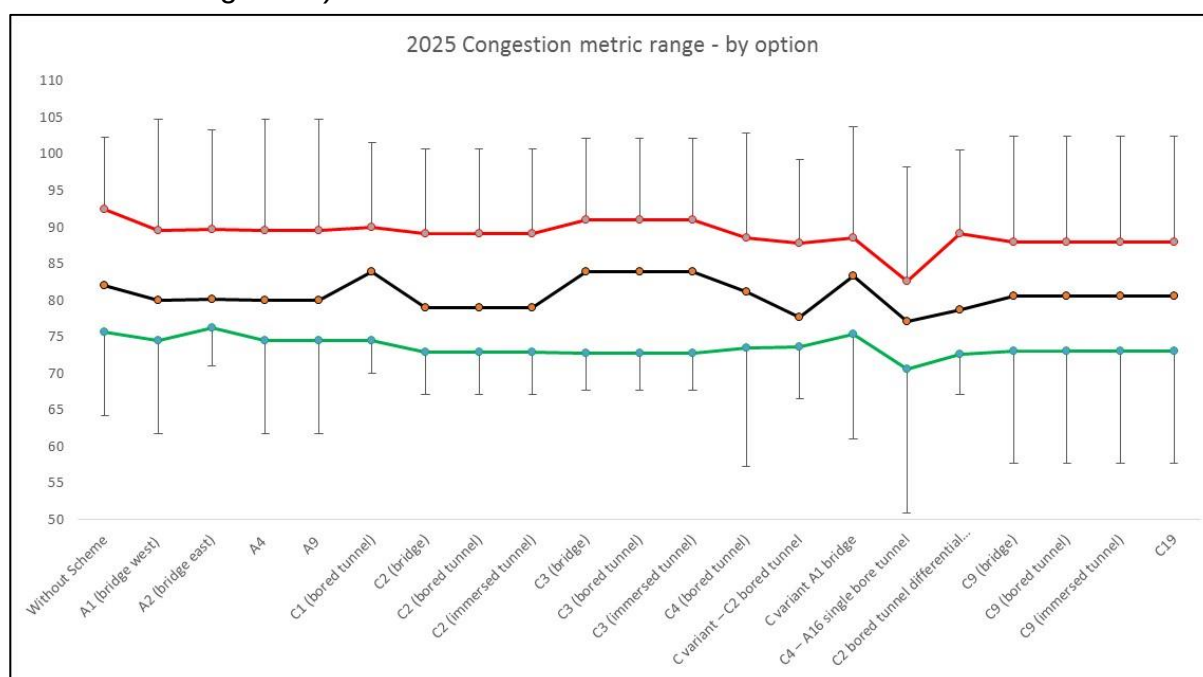


**FIGURE 6.1 - CONGESTION METRIC RANGE BY ROUTE OPTION 2025**

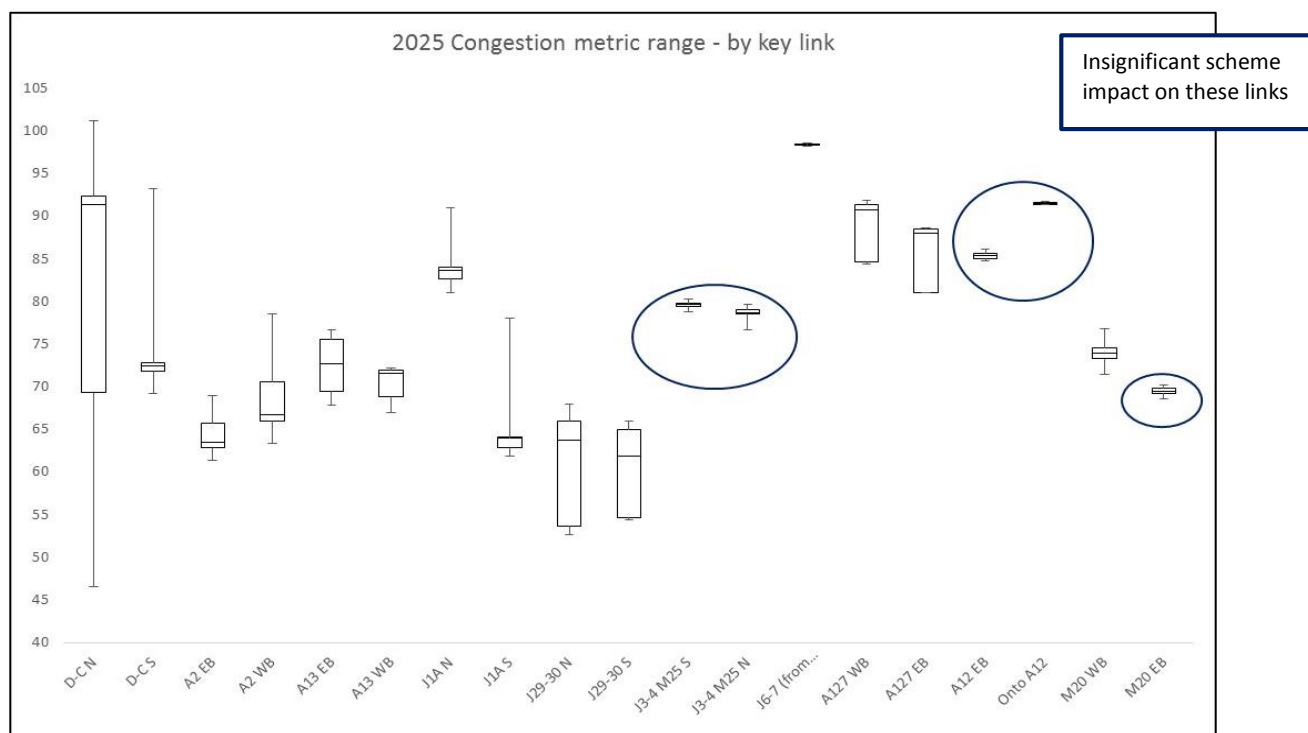


FIGURE 6.2 - CONGESTION METRIC RANGE BY KEY LINK 2025

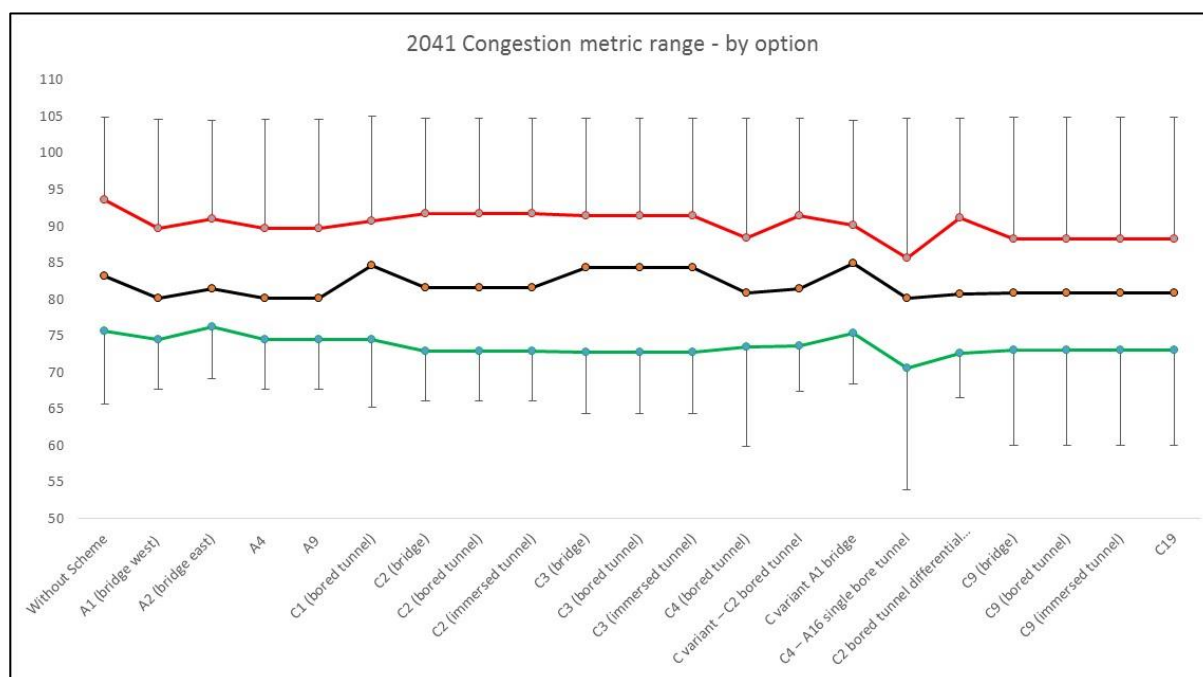


FIGURE 6.3 - CONGESTION METRIC RANGE BY ROUTE OPTION 2041



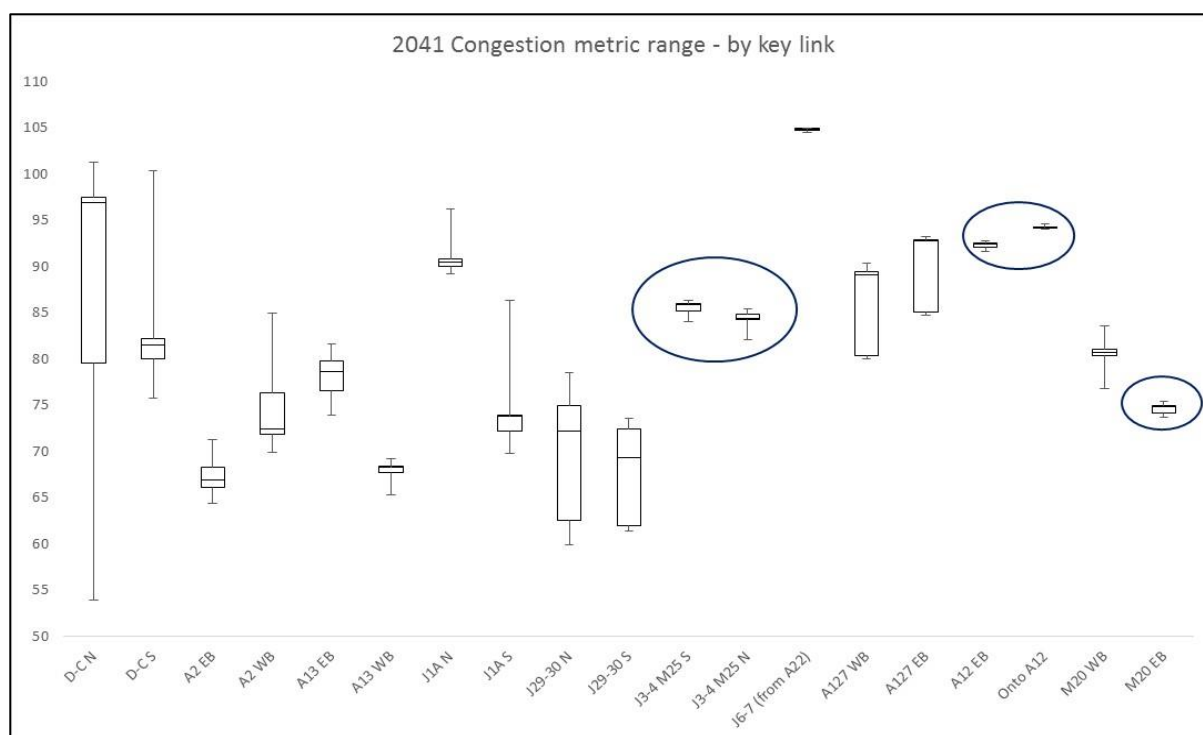


FIGURE 6.4 - CONGESTION METRIC RANGE BY KEY LINK 2041

6.3.30 **Table 6.14** below qualitatively summarises the impact of each of the route options on congestion across the modelled network. The design speeds of each option are set out in sections 5.2 and 5.3.

TABLE 6.14 - SUMMARY OF ROUTE OPTIONS ON CONGESTION

| Route Option   | Qualitative assessment                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Without Scheme | <ul style="list-style-type: none"> <li>Very high levels of congestion are present at the current Dartford Crossing where both northbound and southbound links are projected to have V/Cs above 100% in 2041.</li> <li>The Junction 1a and 1b approach links are likewise heavily congested.</li> <li>Other congested routes are A13 eastbound, between Junction 6&amp;7 of the M25, A127 both eastbound and westbound, and the A12 eastbound and A12 approach roads.</li> </ul>                                                                                                                                                                                                                         |
| A1 / A4 / A9   | <p>Dartford Crossing</p> <ul style="list-style-type: none"> <li>This is the third best route option in reducing congestion on the Dartford Crossing; reducing northbound more than southbound, though both reductions are significant</li> <li>The route option also enables significant congestion reductions at M25 Junction 1a in both directions</li> </ul> <p>Key surrounding links</p> <ul style="list-style-type: none"> <li>The route option reduces congestion on A13 in both directions</li> <li>But increases congestion significantly on M25 NB between Junctions 29 &amp; 30, only C1 performs as badly here</li> <li>The route option also adds congestion to the A2 westbound</li> </ul> |

| Route Option      | Qualitative assessment                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|-------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                   | <p>Further key links</p> <ul style="list-style-type: none"> <li>Across the full set of links, the only other notable impacts are at M25 Junctions 3-4 and M20 westbound with some increases in congestion</li> </ul> <p>Overall on key links congestion, it is a middle ranked route option compared to the other listed route options</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| A2 (bridge east)  | <ul style="list-style-type: none"> <li>Like A1, this route option results in an increase in congestion on the M20 westbound, whilst other route options generally reduce congestion here.</li> <li>It also worsens congestion on the A2 both directions and on M25 Junctions 29-30.</li> <li>It is the worst performing route option (alongside C<sub>variant</sub> A1 bridge) for the key links congestion metric, where it increases traffic along most of the roads connecting the north and south to the crossing.</li> <li>Has a big impact on current D-C congestion, as per all Location A route options, but less than other As</li> </ul>                                                                                                                                                                                                    |
| C1 (bored tunnel) | <ul style="list-style-type: none"> <li>Compared to other route options, this results in higher congestion on M25 Junction 29-30, 3-4 and Junction 6-7.</li> <li>It results in significantly higher congestion on the A13 links to its east with congestion on the 3 points to the east of the new crossing increasing to approximately 90% V/C compared to the Without Scheme of 57%, although to the west of the crossing A13 congestion is relieved with the road widening</li> <li>Traffic approaching the crossings increases from the M2 and A2 across the day, for the crossing start, and with significant traffic increase on M25 southbound in the PM, and M25 northbound in AM.</li> <li>For the key links congestion metric and on the key strategic links, Route Option C1 performs worse than other Location C route options.</li> </ul> |
| C2                | <ul style="list-style-type: none"> <li>Decreases congestion on the SB D-C by nearly 20%, but with a smaller impact on the NB tunnels. Produces V/C decreases along the A2 and A13, along with C3, is best among options here. Average option performance on reducing congestion at M25 Junctions 1A and 1B.</li> <li>Points where congestion increases compared to the Without Scheme option are M25 Junctions 29-30 and M25 Junctions 3-4 and A127 WB.</li> <li>A very similar performance across the key links and overall to C2 + C variant, where the only real difference is the M20 where C2 + C<sub>variant</sub> does incorporate specific improvements to A229 (M2-M20). C2 performs slightly better on the A2 compared to C2 + C<sub>variant</sub>.</li> </ul>                                                                              |
| C3                | <ul style="list-style-type: none"> <li>This route option performs less well than Route Option C2 and C4 on D-C southbound (reduces congestion by less), and leads to worse congestion on M25 Junctions 29-30.</li> <li>It performs better on the A2, where the crossing starts further east on the A2, and A13 than other options, where there is a free-flow interchange and it connects further up, in both directions.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                  |
| C4 (bored tunnel) | <ul style="list-style-type: none"> <li>Unlike Route Options C2 and C3, this route option reduces congestion on M25 Junction 29 to Junction 30 by joining the M25 further to the north. It also has a significant impact in</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |

| Route Option              | Qualitative assessment                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|---------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                           | <ul style="list-style-type: none"> <li>reducing congestion on A127, unlike Route Options C2 and C3.</li> <li>It decreases congestion on all key links in both directions.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| C <sub>variant</sub> + C2 | <ul style="list-style-type: none"> <li>This route option has a similar impact on congestion as Route Option C2, but it performs better (+4 percentage points difference) on the M20 with the A229 improvements and slightly better (few percentage points) overall.</li> </ul>                                                                                                                                                                                                                                                                                                                                                           |
| C <sub>variant</sub> + A1 | <ul style="list-style-type: none"> <li>This route option has a large impact in reducing congestion on the Dartford Crossing</li> <li>However the option results in increased congestion on A2, M25 Junction 1 southbound and M25 Junction 29-30 in both directions.</li> </ul>                                                                                                                                                                                                                                                                                                                                                           |
| C2 + A16 tunnel           | <ul style="list-style-type: none"> <li>This route option has the biggest impact in reducing congestion on Dartford Crossing, particularly northbound.</li> <li>It also decreases congestion on all key links in both directions.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                              |
| C2 differential charging  | <ul style="list-style-type: none"> <li>Compared to C2, the impact of differential charging depresses traffic levels, particularly in 2025, and results in slightly lower congestion levels on many of the links</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                               |
| C9                        | <ul style="list-style-type: none"> <li>This route option decreases congestion on all links by 2041, other than M25 Junction 3-4, in both directions.</li> <li>It produces small decreases in V/C for both directions on the A2 and A13.</li> <li>Unlike many of the other route options, it decreases congestion between M25 Junction 29 and Junction 30, benefiting from the C2 crossing points whilst the A2 interchange allows improved congestion reduction on the A2 westbound.</li> </ul>                                                                                                                                          |
| C19                       | <ul style="list-style-type: none"> <li>Like C9, this option decreases congestion on all key links in both directions by 2041, other than Junction 3-4.</li> <li>It produces small decreases in V/C for both directions on the A2 and A13.</li> <li>Unlike many of the other options, it decreases congestion between M25 Junction 29 and Junction 30, benefiting from the C2 crossing points whilst the A2 interchange (C4) allows improved congestion reduction on the A2 WB.</li> <li>Compared to C9, route option C19 has a bigger impact on reducing congestion on the M20, further than any other route option assessed.</li> </ul> |

### Resilience

- 6.3.31 Resilience refers to the ability of a road, or road network, to maintain a level of service for users, such as capacity, following an incident. A range of incidents may arise that disrupt the normal operation of traffic on the road such as traffic accidents, weather events, non-vehicular encroachment on to the road (e.g. by animals) etc. A large number of incidents occur on the existing Dartford Crossing and the crossing provides poor levels of resilience to these incidents.
- 6.3.32 At this stage, we have undertaken a high level assessment of resilience where the intended result is to provide a green, amber or red rating to each route option upon a reasonable basis. Next steps work will seek to assess various measures of resilience with specific data and analysis to better

provide differentiated findings for the crossings and ultimately resilience scoring between route option variants.

6.3.33 Five measures of resilience have been used to assess the impact of the longlist options on the resilience of the existing crossing:

- 1) Crossing options
- 2) Approach roads
- 3) Nature of crossing
- 4) Length of diversionary routes
- 5) Connections

6.3.34 These measures have been identified based on a wider set of resilience measures included in a 2010 study for the Highways Agency and the former East of England Development Agency.<sup>27</sup> We consider these five measures are the most important measures of resilience.

6.3.35 For some of these measures we have defined scores and scored each of the route options. For other measures we have provided qualitative comments about impact of the option against that measure.

#### *1. Crossing Options*

6.3.36 This measure refers to the number of crossing options faced by users at the crossing. The existing Dartford Crossing consists of two bored tunnels and the QEII Bridge. If an incident occurs on one of these crossings which restricts or closes one of the crossings, traffic management measures can be taken to route the traffic using the other crossings. However, it can take a considerable period of time to respond to incidents, to install and then remove diversionary measures.

6.3.37 The provision of an additional crossing at Location A would serve to further improve the choice of crossing options but these crossings remain at the same location point. Location C route options provide new crossings at new locations, providing greater choice. The scoring used is:

- 1 = New crossing infrastructure is on-line.
- 2 = New crossing infrastructure, with choice for users northbound and southbound.
- 3 = New crossing locations for northbound and southbound provided.

#### *2. Approach Roads*

6.3.38 This measure refers to the number of approach routes provided by the longlist options. Options that provide a significantly different route across the Thames, in terms of its alignment, and which do not use the existing crossing's approach roads are more likely to provide greater levels of resilience when an incident occurs on the existing crossing and vice versa.

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<sup>27</sup> Hyder (2010): Highways Agency Network Resilience and Adaptation Phase 1 Final Report

6.3.39 The proposed scores for the redundancy measure are:

1 = for one crossing

3 = for two crossings (reflecting the significant improvement provided)

6.3.40 Using this approach, Location A route options, which are all served by the same approach roads as the existing crossing, would all score 1 and Location C route options, which have different approach roads, would score 3. The combination of Option A1 and C<sub>Variant</sub> has been scored as 2.

*3. Nature of crossing*

6.3.41 The physical nature of the LTC crossing would influence the extent to which it can withstand different types of incidents. For example, bridges would be more vulnerable to high winds, while vehicle fires would have a greater impact on tunnels compared to bridges.

6.3.42 Given that there are a wide range of incidents, at this stage we can only provide qualitative comments about the impact of the route options against this measure. However, these are important in differentiation between route option variants.

*4. Length of diversionary routes*

6.3.43 When an incident occurs that causes traffic delays, drivers sometimes want to take diversionary routes rather than wait until the incident has been cleared and traffic can flow again.

6.3.44 Longlist route options that provide long diversionary routes compared to routes using the existing crossing are assumed to be worse than short diversionary routes across the River Thames. Diversionary routes depend on where the incident occurs, and where traffic is coming from and going to, however for an initial high level assessment we have simply assessed the length of diversion from the M25 before/ after the Dartford Crossing junctions (where this accounts for 30-40% of crossing traffic in the AM and PM peaks).

6.3.45 The proposed scoring is:

1 for diversions over 15km

1 to 2 for diversions between 5 and 15km

3 for diversions less than 5km

6.3.46 At this stage we introduced a 1.5 score for a set of options clustered around the 10km mark, to distinguish these which had diversionary routes just over 5km which have been scored 2.

6.3.47 The proposed scoring is:

1 for route options that use existing links to connect back to the M25.

2 for route options that use a mix of existing and new roads to connect back to the M25.

3 for route options that use new roads to connect back to the M25.

## 5. Connections

6.3.48 Options that allow LTC traffic to connect back to the M25 using new roads, and therefore avoid the use of existing roads with local traffic, are likely to provide improved resilience. The proposed scoring is:

1 for route options that use existing links to connect back to the M25.

2 for route options that use a mix of existing and new roads to connect back to the M25.

3 for route options that use new roads to connect back to the M25.

### Overall assessment

6.3.49 The overall assessment of the performance of the longlist route options on resilience will be a combination of scores, summed over the four scored measures of resilience.

6.3.50 The results section below presents the green/ amber/ red ratings derived from the indicative scores and includes qualitative comments for each route option. At this stage it was deemed that the colour ratings were more appropriate given the high level nature of the assessment where it was not possible to sufficiently differentiate between option variants in their scoring. Without an assessment on the nature of the crossing type, the resilience scores below do not represent the full picture.

6.3.51 **Table 6.15** presents results from an initial assessment of the four scored resilience measures for the longlist options. The combined score is then a sum of the 4 by / 3 scores (a maximum of 12), which has been translated to a green, amber and red evaluation.

**TABLE 6.15 - RESILIENCE ASSESSMENT FOR LTC ROUTE OPTIONS**

| Route option                           | Crossing options | Approach roads | Diversions | Connections | Combined Score (1 to 12) |
|----------------------------------------|------------------|----------------|------------|-------------|--------------------------|
| A1 (bridge west)                       | 2                | 1              | 3          | 1           | 7                        |
| A2 (bridge east)                       | 1                | 1              | 3          | 1           | 6                        |
| A4                                     | 2                | 1              | 3          | 1           | 7                        |
| A9                                     | 2                | 1              | 3          | 1           | 7                        |
| C1 (bored tunnel)                      | 3                | 3              | 2          | 1           | 9                        |
| C2                                     | 3                | 3              | 1.5        | 3           | 10.5                     |
| C3                                     | 3                | 3              | 1.5        | 2           | 9.5                      |
| C4 (bored tunnel)                      | 3                | 3              | 1          | 2           | 9                        |
| C <sub>variant</sub> – C2 bored tunnel | 3                | 3              | 1.5        | 3           | 10.5                     |
| C <sub>variant</sub> A1 bridge         | 2                | 2              | 3          | 1           | 8                        |
| C4 – A16 single bore tunnel            | 3                | 3              | 1.5        | 3           | 10.5                     |
| C2 bored tunnel differential charging  | 3                | 3              | 1.5        | 3           | 10.5                     |
| C9                                     | 3                | 3              | 1          | 2           | 9                        |
| C19                                    | 3                | 3              | 1          | 2           | 9                        |

Colour grading: Red (3-8), amber (8-10), green (10-12)

## 7 Detailed Cost Appraisal

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### 7.1 Introduction

- 7.1.1 The appraisal of Options A+ (one of the options from the 2013 AECOM report) and C2 (discussed in section 9.3) was carried out using cost estimates prepared by Highways England Commercial Services Division from drawings and other data relating to these options included in the AECOM Design and Costing Report and the subsequent Module Technical Notes prepared by Jacobs.
- 7.1.2 Highways England Commercial Services Division also prepared operation and maintenance cost estimates for Options A+ and C2 and these were used as the basis for operation and maintenance costs used in the economic appraisal reported in section 9.
- 7.1.3 Highways England Commercial Services Division provided information from their cost estimates, including work breakdown structures, to HHJV. This information was used by HHJV to prepare their own work breakdown structures to assess the costs of the longlist route options described in Section 5. In the preparation of the estimates HHJV liaised with Highways England Commercial Services Division to obtain rates and estimates for significant items that were not included in the A+ and C2 estimates, in particular rates for longer bored tunnels.
- 7.1.4 Following the comparison of the longlist options using the cost estimates as assessed by HHJV these assessments were provided to Highways England Commercial Services Division for their review. Highways England Commercial Services Division prepared their own assessment of the costs of the longlist options from this review and the resulting costs are set out in **Tables 7.1** and **7.2** below. These costs are the basis of the costs reported in the economic appraisal carried out for the comparison and appraisal of the route options as reported in Section 9. The results of Highways England Commercial Services Division's review, including their estimated costs for all the route options assessed and estimated operation and maintenance costs are included in **Appendix 7**. These costs were used in the economic appraisal reported in section 9.
- 7.1.5 The summary cost estimates were based on a very limited level of design data commensurate with early stage route option development. For ease of appraisal, single point (mid-range) estimates were prepared. Uncertainties around design, construction, programme etc implied a wide range of potential outturns for each route option with estimates being suitable solely for purposes of the route option appraisal. Further certified cost estimates will be prepared for purposes of the detail appraisal of route options.

## 7.2 Location A

7.2.1 The costs for the Location A longlist options as assessed by Highways England Commercial Services Division are set out in **Table 7.1** below: All costs are at a price base of Q2, 2011 prior to the application of inflation which has been applied from Q2, 2011 to the planned spend date.

**TABLE 7.1 - ASSESSED ESTIMATED COSTS FOR LOCATION A LONGLIST ROUTE OPTIONS**

| ROUTE OPTION                                   | A1 (bridge west with E1+9) | A1 (bridge west with A15) ** | A2 (bridge east with E1+9) * | A4 (bored tunnel west with E1+9) | A4 (bored tunnel west with A15) ** | A8 (long bored tunnel M25 J2 to J30) | A9 (immersed tunnel west with E1+9) | A9 (immersed tunnel west with A15) ** | A12 (West Route) | A14 (long bored tunnel) | A16 (2-lane bored tunnel west) |
|------------------------------------------------|----------------------------|------------------------------|------------------------------|----------------------------------|------------------------------------|--------------------------------------|-------------------------------------|---------------------------------------|------------------|-------------------------|--------------------------------|
| Base estimate (£b)                             | 1.40                       | 1.19                         | 1.52                         | 1.63                             | 1.42                               | 3.30                                 | 1.42                                | 1.20                                  | 4.25             | 3.16                    | 0.82                           |
| Unscheduled items (£b)                         | 0.06                       | 0.05                         | 0.07                         | 0.08                             | 0.07                               | 0.19                                 | 0.07                                | 0.05                                  | 0.24             | 0.19                    | 0.04                           |
| Risk Adjustment and uncertainty allowance (£b) | 0.30                       | 0.26                         | 0.33                         | 0.35                             | 0.31                               | 0.70                                 | 0.36                                | 0.31                                  | 0.90             | 0.67                    | 0.17                           |
| <b>CESS Subtotal (£b)</b>                      | <b>1.77</b>                | <b>1.49</b>                  | <b>1.92</b>                  | <b>2.07</b>                      | <b>1.79</b>                        | <b>4.19</b>                          | <b>1.84</b>                         | <b>1.57</b>                           | <b>5.40</b>      | <b>4.01</b>             | <b>1.03</b>                    |
| Inflation adjustment (£b)                      | 0.79                       | 0.65                         | 0.83                         | 0.97                             | 0.83                               | 2.30                                 | 0.85                                | 0.71                                  | 2.86             | 2.21                    | 0.48                           |
| Portfolio office risk adjustment (£b)          | 0.17                       | 0.14                         | 0.18                         | 0.20                             | 0.17                               | 0.40                                 | 0.18                                | 0.15                                  | 0.52             | 0.38                    | 0.10                           |
| <b>RET Adjustment subtotal (£b)</b>            | <b>0.96</b>                | <b>0.79</b>                  | <b>1.01</b>                  | <b>1.17</b>                      | <b>1.00</b>                        | <b>2.70</b>                          | <b>1.03</b>                         | <b>0.86</b>                           | <b>3.37</b>      | <b>2.59</b>             | <b>0.58</b>                    |
| <b>ESTIMATED OUT-TURN (£b)</b>                 | <b>2.73</b>                | <b>2.28</b>                  | <b>2.94</b>                  | <b>3.24</b>                      | <b>2.79</b>                        | <b>6.89</b>                          | <b>2.87</b>                         | <b>2.43</b>                           | <b>8.77</b>      | <b>6.60</b>             | <b>1.62</b>                    |

\* Route Option A2 was only assessed with an earlier (unmodified version of E1+9 at Junction 30)

\*\* The version of Route Option A15 assessed by Highways England Commercial Services Division was an earlier version with only a one-way eastbound connection. The later version described and discussed elsewhere in this Report is a two-way connection. HHJV have assessed the additional out turn cost of this option (based on the information provided by Highways England Commercial Services Division) to be almost £0.5b making the cost of this option when combined with Route Options A1, A4 and A9 virtually the same as with E1+9.



## 7.3 Location C

7.3.1 The costs for the Location C longlist options as assessed by Highways England Commercial Services Division are set out in **Table 7.2** below. All costs are at a price base of Q2, 2011 prior to the application of inflation which has been applied from Q2, 2011 to the planned spend date. Combination options at Location C other than Route Option C9 and C19 are not included as they have not been separately appraised. Only one representative C<sub>variant</sub> option (CV1) is included.

**TABLE 7.2 - ASSESSED ESTIMATED COSTS FOR LOCATION C LONGLIST OPTIONS**

| ROUTE OPTION                                   | C1 bored tunnel | C2 bridge   | *C2 bored tunnel | C2 immersed tunnel | C3 bridge   | C3 bored tunnel | C3 immersed tunnel | C4 bored tunnel | C9 bridge   | C9 bored tunnel | C9 immersed tunnel | C19 bridge  | C19 bored tunnel | C19 immersed tunnel | C variant   |
|------------------------------------------------|-----------------|-------------|------------------|--------------------|-------------|-----------------|--------------------|-----------------|-------------|-----------------|--------------------|-------------|------------------|---------------------|-------------|
| Base estimate (£b)                             | 2.18            | 1.44        | 1.54             | 1.53               | 1.58        | 1.58            | 1.61               | 2.33            | 1.72        | 1.82            | 1.81               | 1.84        | 1.87             | 1.96                | 0.25        |
| Unscheduled items (£b)                         | 0.12            | 0.07        | 0.09             | 0.09               | 0.08        | 0.09            | 0.09               | 0.13            | 0.09        | 0.10            | 0.10               | 0.09        | 0.10             | 0.11                | 0.01        |
| Risk Adjustment and uncertainty allowance (£b) | 0.46            | 0.30        | 0.32             | 0.32               | 0.33        | 0.33            | 0.34               | 0.49            | 0.36        | 0.38            | 0.38               | 0.39        | 0.39             | 0.41                | 0.05        |
| <b>CESS Subtotal (£b)</b>                      | <b>2.76</b>     | <b>1.81</b> | <b>1.95</b>      | <b>1.94</b>        | <b>1.99</b> | <b>2.00</b>     | <b>2.04</b>        | <b>2.95</b>     | <b>2.16</b> | <b>2.30</b>     | <b>2.29</b>        | <b>2.33</b> | <b>2.36</b>      | <b>2.48</b>         | <b>0.31</b> |
| Inflation adjustment (£b)                      | 1.49            | 0.93        | 1.00             | 0.98               | 1.01        | 1.02            | 1.02               | 1.49            | 1.08        | 1.15            | 1.13               | 1.16        | 1.18             | 1.22                | 0.11        |
| Portfolio office risk adjustment (£b)          | 0.26            | 0.17        | 0.18             | 0.18               | 0.19        | 0.19            | 0.19               | 0.28            | 0.20        | 0.22            | 0.22               | 0.22        | 0.22             | 0.23                | 0.03        |
| <b>RET Adjustment subtotal (£b)</b>            | <b>1.75</b>     | <b>1.10</b> | <b>1.18</b>      | <b>1.16</b>        | <b>1.20</b> | <b>1.21</b>     | <b>1.21</b>        | <b>1.76</b>     | <b>1.29</b> | <b>1.37</b>     | <b>1.38</b>        | <b>1.38</b> | <b>1.41</b>      | <b>1.46</b>         | <b>0.14</b> |
| <b>ESTIMATED OUT-TURN (£b)</b>                 | <b>4.51</b>     | <b>2.91</b> | <b>3.13</b>      | <b>3.09 *</b>      | <b>3.19</b> | <b>3.21</b>     | <b>3.25 *</b>      | <b>4.71</b>     | <b>3.45</b> | <b>3.67</b>     | <b>3.641 *</b>     | <b>3.71</b> | <b>3.77</b>      | <b>3.94 *</b>       | <b>0.45</b> |

\* Immersed tube tunnel costs for Route Options C2, C3, C9 and C19 include cut and cover tunnelling under the Ramsar site. Significant cost savings can be achieved if this is not required.

Refer to Section 12 for routes not selected and not included in this table.

## 8 Construction Programme Appraisal

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### 8.1 Introduction

- 8.1.1 All longlist options (refer to Sections 5.9, 5.10 and 5.11) are included in this section except Route Option A15, which is not a separate option but just an alternative option for the improvement of Junction 30 and the Location C combination options other than C9 and C19 which have not been separately appraised. Only one representative C<sub>variant</sub> option (CV1) is included in combination with Route Options A1 and C2.
- 8.1.2 Route Options C9 and C19 were the only combination options appraised as these were the only two combination options appraised in the traffic model, for which estimated costs were assessed and the subject to the economic appraisal reported in Section 9.

### 8.2 Assessment Approach

- 8.2.1 Order of Magnitude estimates of programme duration have been determined for longlist route options and are stated in the tables below. The estimates were produced for early route option comparative purposes only. They are based on a common assumption that the works are publicly funded and procured on a design and build basis. The durations relate to construction of the principal crossing structure works only. No assessment has been made at this stage of the works duration of the road connections either north or south of the crossing structure on the further assumption that it is possible to construct these works within the period estimated for the crossing structure works which represents the critical path for the design and construction of the route option.
- 8.2.2 Indicative outline programmes were initially developed for the baseline concepts for purposes of informing the cost estimating Order of Magnitude estimates. These options, A+ (bridge and twin-bored tunnel crossing options) and C2 (long twin bored tunnel crossing option only) were as reported in the previous studies by AECOM/ Jacobs and are described in outline in Section 5.1.2.
- 8.2.3 A simple process of extrapolation based on comparing key elements of the works (e.g. tunnel length, bridge main span length) was used as the basis for determining the works durations of each route option that was assessed. A comparison was also made with construction programme data obtained for a selection of other similar crossing projects to confirm that assumed durations were reasonable.
- 8.2.4 The scale and complexity of the crossing works mean that any concept will likely offer multiple choices on matters such as methods of construction, potential for duplication of key plant and equipment (e.g. using more than one TBM for bored tunnel construction), use of multiple work fronts etc. Such choices may improve efficiency and reduce construction time, with the potential to reduce scheme costs and improve other benefits that result from earlier works completion. For the purposes of this assessment a set of common assumptions were made to allow route options to be compared on a similar basis. Key assumptions included:

- Use of a single TBM for all twin-bored tunnel options bar the very long tunnel Route Options A8, A12, A14.
- Parallel construction of bridge towers.
- Sequential construction of bridge deck main span cantilevers.
- Use of a casting basin or dry dock local to the construction site for immersed tunnel construction.

8.2.5 Opportunities for reducing construction programme through alternative methods of working or design choices will be looked at in more depth in the next stage of development as appropriate and necessary to confirm the preferred route selection.

## 8.3 Order of Magnitude Programme Durations

8.3.1 Order of Magnitude estimates of design and construction duration used for the comparison and course assessment of route options are summarised in the tables below. Location A route option durations are provided in **Table 8.1**, Location C route option durations are provided in **Table 8.2**. In these tables the following abbreviations are used:

- BR = Bridge
- BT = Bored Tunnel
- LBT = Long Bored Tunnel
- IT = Immersed Tunnel

**TABLE 8.1 - ORDER OF MAGNITUDE ESTIMATES OF CONSTRUCTION DURATION FOR LOCATION A ROUTE OPTIONS**

| Route Option     | A1         | A2         | A4         | A8         | A9         | A12                | A14 | A16                 | C4BTA16 | A1 + CV    |
|------------------|------------|------------|------------|------------|------------|--------------------|-----|---------------------|---------|------------|
| Crossing         | BR<br>West | BR<br>East | BT<br>West | LBT J2-J30 | IT<br>West | BT +<br>BR<br>West | LBT | 2Lane<br>BT<br>West | 2xBT    | BR<br>West |
| Duration (years) | 4.0        | 4.0        | 4.5        | 7.0        | 4.0        | 6.0                | 7.0 | 4.0                 | 5.5     | 4.0        |

**TABLE 8.2 - ORDER OF MAGNITUDE ESTIMATES OF CONSTRUCTION DURATION FOR LOCATION C ROUTE OPTIONS**

| Route Option     | C1   | C2  | C2   | C2  | C3  | C3  | C3  |
|------------------|------|-----|------|-----|-----|-----|-----|
| Crossing         | BT   | BR  | BT   | IT  | BR  | BT  | IT  |
| Duration (years) | 6.25 | 4.5 | 5.25 | 4.0 | 4.5 | 5.0 | 4.0 |

| Route Option     | C4  | CV  | C2BT+CV | C9   | C9  | C9  | C2Br+CV |
|------------------|-----|-----|---------|------|-----|-----|---------|
| Crossing         | BT  | N/A | BT      | BT   | IT  | BR  | BR      |
| Duration (years) | 5.5 | 2.0 | 5.25    | 5.25 | 4.0 | 4.5 | 4.5     |

| Route Option     | C19  | C19 | C19 |
|------------------|------|-----|-----|
| Crossing         | BT   | IT  | BR  |
| Duration (years) | 5.25 | 4.0 | 4.5 |

Refer to Section 12 for routes not selected and therefore not included in these tables.

## 8.4 Reference Projects

8.4.1 Research of contract and construction durations of other selected crossing bridge and tunnel schemes is presented in the tables below for reference and comparison. **Table 8.3** refers to bridge schemes with cable-stayed crossings constructed, or under construction, over UK estuary or tidal waters. **Table 8.4** covers selected bored and immersed tunnel schemes including tunnels under the River Thames.

**TABLE 8.3 - BRIDGE CROSSING REFERENCE PROJECTS**

| Reference Project                                             | Crossing Description                                                                                     | Duration                                    |
|---------------------------------------------------------------|----------------------------------------------------------------------------------------------------------|---------------------------------------------|
| Queensferry Crossing, Firth of Forth, UK (under construction) | Cable-stayed bridge, two main spans of 650m, total crossing length (with approach viaducts) 2.6km        | 5 years, D and C contract, 2011 to 2016     |
| Mersey Gateway, River Mersey Estuary, UK (under construction) | Cable-stayed bridge, two main spans, 318m and 294m, total crossing length (with approach viaducts) 2.2km | 3.5 years, D and C under DBFO, 2014 to 2017 |
| Second Severn Crossing, Severn Estuary, UK (opened 1996)      | Cable-stayed bridge, 456m main span, total crossing length (with approach viaducts) 5.1km                | 4 years, D and C under DBFO, 1992 to 1996   |

**TABLE 8.4 - TUNNEL CROSSING REFERENCE PROJECTS**

| Reference Project                            | Crossing Description                                                  | Duration                            |
|----------------------------------------------|-----------------------------------------------------------------------|-------------------------------------|
| Silvertown. River Thames (under development) | Approximately 1km bored tunnel                                        | 4.5 years                           |
| Oresund Crossing, Denmark (opened 2000)      | Approximately 4km immersed tunnel including ramps                     | 5.5 years                           |
| HS1, Thames tunnel, UK (opened 2007)         | Approximately 2.5km twin- bored tunnel, dia 8.2m                      | 3.5 years (constructed with 2 TBMs) |
| Tyne Tunnel, River Tyne, UK (opened 2011)    | 0.36km Immersed tunnel section and 1.1km cut and cover tunnel section | 3 years                             |

## 9 Economic Appraisal

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### 9.1 Introduction

9.1.1 This chapter summarises the economic appraisal of LTC route options. It also includes:

- The 2013 Review appraisal carried out by AECOM of Options A, C and C<sub>Variant</sub>.
- HHJV's appraisal of A+ and C2.

9.1.2 In appraising the longlist of LTC options, HHJV undertook a two stage appraisal approach (refer to Section 12 for more details). This section also summarises:

- The appraisal of those route options included in the first stage appraisal: A8, A12 and A14.
- The appraisal of options included in the second stage appraisal (refer to section 9.5 for details of longlist options not specifically reported).

### 9.2 2013 Review appraisal of Locations A, C and C<sub>Variant</sub>

9.2.1 The 2013 Review included an appraisal by AECOM of the following options:<sup>28</sup>

- Location A - a new crossing at the site of the existing Dartford crossing.
- Location C - a new crossing to the east of Gravesend and Tilbury.
- C<sub>Variant</sub> - this added to Location C by including the widening of the A229 between the M2 and the M20 in Kent.

9.2.2 Each location included three crossing types: a bridge, bored tunnel and immersed tunnel.

9.2.3 AECOM developed an LTC traffic model for appraisal based on a range of models and data sources. The model was used to forecast traffic in 2025 and 2041 in the Do Minimum scenario and Do Something scenarios for each location. Using outputs from the traffic model, AECOM calculated transport and wider benefits and costs in line with the Department for Transport's WebTAG guidance. The appraisal of wider benefits included a fixed land use assumption. **Tables 9.1, 9.2 and 9.3** present the Net Present Values (NPVs) and Benefit Cost Ratios (BCRs) for Locations A and C without and with Wider Impacts (WI). The tables show that:

- Location A (bridge solution) has the highest BCRs (1.8 without WIs and 2.4 with WIs). The BCRs for all the other options and solutions range between 1.0 and 1.3 (without WIs) and between 1.4 and 2.0 (with WIs).
- C<sub>Variant</sub> solutions (without and with WIs) produce the most net benefits, with the C<sub>Variant</sub> bridge solution producing the greatest level of benefits. The Location A solutions produce the least benefits.

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<sup>28</sup> The Review also included Option B – a crossing in the vicinity of the Swanscombe Peninsula - but this was later discarded by the Department for Transport.

- Location A (immersed tunnel solution) has the lowest BCR without WIs and joint lowest BCR (along with Location A bored tunnel) with WIs. Location A immersed tunnel also produces the lowest level of benefits.

**TABLE 9.1 - COMPARISON OF NET PRESENT VALUES AND BENEFIT COST RATIOS 2025-2084 WITHOUT WIDER IMPACTS**

(NPVS ARE EXPRESSED IN £ MILLION, 2010 MARKET PRICES AND VALUES)

| Crossing type | Option A         |     | Option A+        |     | Option C         |     | Option C2        |     |
|---------------|------------------|-----|------------------|-----|------------------|-----|------------------|-----|
|               | NPV<br>£ million | BCR | NPV<br>£ million | BCR | NPV<br>£ million | BCR | NPV<br>£ million | BCR |
| Bridge        | 335              | 1.8 | 248              | 1.2 | 505              | 1.3 |                  |     |
| Bored Tunnel  | 59               | 1.1 | 92               | 1.1 | 414              | 1.2 | 590              | 1.4 |

**TABLE 9.2 - COMPARISON OF NET PRESENT VALUES AND BENEFIT COST RATIOS 2025-2084 WITH WIDER IMPACTS**

(NPVS ARE EXPRESSED IN £ MILLION, 2010 MARKET PRICES AND VALUES)

| Crossing type | Option A         |     | Option A+        |     | Option C         |     | Option C2        |     |
|---------------|------------------|-----|------------------|-----|------------------|-----|------------------|-----|
|               | NPV<br>£ million | BCR | NPV<br>£ million | BCR | NPV<br>£ million | BCR | NPV<br>£ million | BCR |
| Bridge        | 586              | 2.4 | 716              | 1.5 | 1667             | 2.0 |                  |     |
| Bored Tunnel  | 310              | 1.4 | 561              | 1.4 | 1576             | 1.9 | 1737             | 2.1 |

**TABLE 9.3 - COMPARISON OF WIDER IMPACTS PRESENT VALUES**

(£ MILLION, 2010 MARKET PRICES AND VALUES)

| Option A | Option A+ | Option C | Option C2 |
|----------|-----------|----------|-----------|
| 251      | 469       | 1,162    | 1,146     |

## 9.3 Appraisal of A+ and C2

- 9.3.1 Prior to the work to develop a longlist of options, HHJV carried out an appraisal of the two options (A+ and C2) referred to in the Secretary of State's 2014 announcement. These two options are described in section 5.1.2.
- 9.3.2 The appraisal used the same AECOM traffic model and the same fixed land use assumption and the same forecast model years as those used in the 2013 appraisal. Whilst a wider suite of economic appraisal tools was used, the discounted benefits and costs for A+ and C2 are reported in the same price base as those for Options A and C included in the 2013 appraisal. However there are a number of differences between the appraisals which mean that it is not valid to directly compare the appraisal results for Option A+ with those for Option A and the results for Option C2 with those for Option C.
- 9.3.3 Despite the above caveat, **Tables 9.1** and **9.2** above present the Net Present Values (NPVs) and Benefit Cost Ratios for Options A+ and C2 without and with Wider Impacts alongside those for Options A and C.

- 9.3.4 The sections below set out the main conclusions from the appraisal for Option A+ and Option C2 in relation to AECOM 2013 appraisal of Locations A, C and C<sub>Variant</sub>.
- 9.3.5 The appraisal found that in respect of costs, comparing A+ with A and C2 with C (bored tunnel):
- The Present Value of Costs (PVC) for the A+ bridge solution increased over threefold from £427m to £1,372 million.
  - The PVC costs for the A+ bored tunnel solution increased by over two times from £703m to £1,527 million.
  - The PVC costs for the C2 bored tunnel solution reduced by about 4% from £1,718m to £1,644 million.
- 9.3.6 The appraisal found that in respect of benefits, comparing A+ with A and C2 with C:
- The transport Present Value of Benefits (PVB) for Option A+ increased from £762m to £1,620m. This was largely due to an increase in business user benefits.
  - The PVB of Wider Impacts for Option A+ almost doubled from £251m to £469m. This was due to higher agglomeration benefits and increased output in imperfectly competitive markets,
  - The PVB of transport benefits for Option C2 increased by around 5% from £2,132m up to £2,234m,
  - The PVB of Wider Impacts for Option C2 did not change.
- 9.3.7 The appraisal found that in terms of BCRs:
- Without Wider Impacts the BCR for the Option A+ bridge solution fell from 1.8 down to 1.2 (Low Value for Money) and the BCR for the A+ bored tunnel remained constant at 1.1 (Low Value for Money),
  - With Wider Impacts the BCR for the Option A+ bridge solution fell from 2.4 down to just above 1.5 (Medium Value for Money) and the BCR for the A+ bored tunnel remained constant at 1.4 (Low Value for Money),
  - Without Wider Impacts the BCR for the Option C2 bored tunnel solution rose from 1.2 up to 1.4 (Low Value for Money),
  - With Wider Impacts the BCR for the Option C2 bored tunnel solution rose from 1.9 up to 2.1 (High Value for Money).

## 9.4 First stage appraisal: A8, A12 and A14

- 9.4.1 The first stage appraisal of the longlist of options is explained in section 12.1.
- 9.4.2 Options A8, A12 and A14 are described in section 5.2.
- 9.4.3 All three options are very costly in comparison to the congestion relief and benefit that they provide.
- 9.4.4 **Table 9.4** below presents the benefits and costs, in discounted present values, for the three options. It shows that all of the options have negative NPVs and BCRs less than 1.0 and therefore offer poor value for money and were not selected (refer to section 12).

**TABLE 9.4 - APPRAISAL RESULTS FOR ROUTE OPTIONS A8, A12 AND A14**

|          | Route Option |       |       |
|----------|--------------|-------|-------|
|          | A8           | A12   | A14   |
| PVB (£b) | 2.69         | 1.52  | 1.53  |
| PVC (£b) | 3.55         | 4.90  | 3.55  |
| NPV (£b) | -0.86        | -3.38 | -2.02 |
| BCR      | 0.8          | 0.3   | 0.4   |

## 9.5 Second Stage Appraisal: Economic Appraisal

- 9.5.1 This section summarises the economic appraisal of the remaining longlist route options undertaken for the second stage appraisal. The route options appraised were:
- A1 (bridge west)
  - A2 (bridge east)
  - A4 (bored tunnel west)
  - A9 (immersed tunnel west)
  - C1 (bored tunnel)
  - C2 (bridge)
  - C2 (bored tunnel)
  - C2 (immersed tunnel)
  - C3 (bridge)
  - C3 (bored tunnel)
  - C3 (immersed tunnel)
  - C4 (bored tunnel)
  - C<sub>Variant</sub> + C2 bored tunnel
  - C<sub>Variant</sub> + A1 Bridge



- C4 + A16 single bore tunnel
- C2 bored tunnel differential charging
- C9 (bridge)
- C9 (bored tunnel)
- C9 (immersed tunnel)
- C19 (bridge)
- C19 (bored tunnel)
- C19 (immersed tunnel)

9.5.2 Refer to Section 12 for explanation of options previously described which have not been selected and therefore not included in this list.

9.5.3 It is noted that the economic appraisal of Options A1, A4 and A9 reported is for the versions incorporating E1+9 for the improvement of Junction 30. The appraisal of the versions incorporating the alternative Option A15 for the improvement of Junction 30 is not reported as their costs are virtually the same as E1+9 (refer to footnote to **Table 7.1**) and this option was ultimately not considered technically viable (refer to section 12.4).

9.5.4 Economic appraisals were not carried out for other combination options (C7, C8 and C10 to C18).

9.5.5 The economic assessment reports the performance of each of these route options in terms of:

- User benefits
- Wider economic benefits

## 9.6 User Benefits

9.6.1 User benefits have been estimated using outputs from TUBA (travel time, vehicle operating costs, greenhouse gases, user charges, and change in indirect tax revenue), COBALT (change in accident numbers and costs) and QUADRO (for delays during programmed maintenance). The user impacts of delays during construction are not included as construction sequences have not been determined for the numerous options under consideration.

### Transport Economic Efficiency

9.6.2 HHJV followed a standard process, commonly used across Highways England schemes, for the appraisal of Transport Economic Efficiency (TEE) benefits. TUBA v1.9.4 was used, along with the standard economics file compatible with May 2014 release of the WebTAG databook. The following changes were made in the use of TUBA compared to the previous AECOM work.

- The matrices used were vehicle matrices from the five user class models (Without Scheme and Location A schemes) and six user class model (Location C schemes).
- The TUBA scheme files were set up to use HHJV calculated annualisation factors for the AM, inter-peak and PM peak periods, and also for the busy charged periods in the off-peak and at weekends.

- The separate non-business car matrices linked to use of the Dartford and Location C crossings were combined so as to provide a direct match to the Without Scheme Dartford Crossing non-business car matrices in the Location C TUBA runs.

- 9.6.3 Although the more complex construction solutions would open a little later than the simplest options, the appraisal period used in all cases was the WebTAG standard sixty years, from an opening year of 2025 through to 2084.
- 9.6.4 These changes permitted a straightforward TUBA run which could be checked using normal HHJV procedures. Following the run, the benefits which would accrue during the quieter, non-charged, off-peak and weekend periods were added by using factors derived from the annualisation factors.
- 9.6.5 The TUBA results formed the basis of the TEE (Transport Economic Efficiency), PA (Public Accounts) and AMCB (Annualised Monetary Costs and Benefits) tables, into which values resulting from the safety, maintenance delay and wider benefit assessments were inserted. To simplify the process, the present value for the scheme costs for each option was calculated within a spreadsheet rather than in TUBA. The WebTAG compliant process involved factoring back the inflation indexed prices provided from Highways England Commercial Services Division to the 2010 price base using the GDP deflator, and then discounting the expenditure programmed for each year to 2010 using the standard discount rate of 3.5%.
- 9.6.6 The Transport Economic Efficiency tables also included the results of the QUADRO maintenance delay assessment.

### **Safety Assessment**

- 9.6.7 The DfT has issued the COBALT program to forecast the economic costs and benefits associated with changing accident and casualty patterns following the provision of new or improved roads. HHJV used COBALT to refresh the safety assessment of the LTC options. The calculations were performed over all of the links in the simulation network of the traffic models, leading to the following significant differences to the previous AECOM work:
- Buffer links were excluded, as these are not modelled fully by SATURN.
  - Spigot links were excluded, as these are added to the model solely as a means of introducing traffic to the simulation area and are not 'real' links.
- 9.6.8 Some minor changes to the Without and With Scheme networks were necessary to reflect changes made to the traffic models particularly in the vicinity of M25 Junction 30 and M2 Junction 3.
- 9.6.9 Otherwise the COBALT input files were prepared directly using Access and Excel from the original AECOM spreadsheets. The accident rates for each link used by AECOM were retained.
- 9.6.10 In view of the extent of the network, the appraisal was for the most part undertaken using default accident rates for links and junctions combined. These rates were established in COBALT's predecessor program, COBA. This is a standard approach but does not take account of local conditions. The data collection and processing which would be required to use observed accident rates on a network of this size would be unrealistic at this stage in the development of the project.

- 9.6.11 However, COBA accident rates for some road types had been replaced by AECOM with rates they had derived in the free-flow charging study. This data was based on observed accident data collected in and around the Dartford - Thurrock area. These modified rates were retained in the COBALT runs.
- 9.6.12 Because of the size of the network it was found necessary for all options to run COBALT using a series of input files, to avoid memory problems during the runs. Results from the output files were summed to produce the final results for each route tested.
- 9.6.13 The results of this assessment generally show an increase in accident costs and numbers. Although the magnitude of these values may appear large, the increases are in reality very small by comparison with the baseline situation and must be taken in context with the increase in traffic made possible by the provision of additional cross Thames capacity.
- 9.6.14 It is considered to be likely that the network wide accident rate in terms of accidents per million vehicle kilometres would be little changed, and probably improved, as a result of providing extra capacity with safer, high standard roads.

*Results of the User Benefits Assessments*

- 9.6.15 The results of the user benefit assessments for the various options are summarised in **Table 9.5** which follows. The key indicators are the Net Present Value (NPV) and the initial Benefit Cost Ratio (BCR) which appear in the top half of each sheet. These statistics are derived from the Present Value of (transport user and provider) Benefits (PVB) and the Present Value of Costs. The latter comprises investment (construction and equipment) and operating (including maintenance) (O&M) costs, against which are offset the increase in revenue from charges resulting from the provision of an additional crossing. The O&M costs are calculated as a fixed proportion of the expected outturn cost supplied by Highways England Commercial Services Division. The total cost over a sixty year life has been calculated using the following factors:

- Location A bridges: 3.0%
- Location A tunnels 4.0%
- Location C schemes 6.5%

These are calculated as proportions of the discounted investment cost, as this was considered to be a sufficiently robust approach at the pre shortlist stage.

- 9.6.16 All figures reported in the following paragraphs are in 2010 prices discounted to 2010. Also, they include as an offset the effect of the additional charging revenue generated. The figures quoted are therefore lower than the discounted costs of the works etc themselves.
- 9.6.17 However, the figures do not include the impact of wider economic benefits, which are discussed in section 9.7.

TABLE 9.5 - ROUTE OPTIONS ASSESSED IN SECOND STAGE APPRAISAL

|                               | Route Options assessed in Second Stage Appraisal – Sheet 1 |                  |                   |                      |                   |             |                   |                      |             |                   |                      |                   |                             |
|-------------------------------|------------------------------------------------------------|------------------|-------------------|----------------------|-------------------|-------------|-------------------|----------------------|-------------|-------------------|----------------------|-------------------|-----------------------------|
| OPTION                        | A1 (bridge west)                                           | A2 (bridge east) | A4 (bored tunnel) | A9 (immersed tunnel) | C1 (bored tunnel) | C2 (bridge) | C2 (bored tunnel) | C2 (immersed tunnel) | C3 (bridge) | C3 (bored tunnel) | C3 (immersed tunnel) | C4 (bored tunnel) | C variant - C2 bored tunnel |
| Construction duration (years) | 4.0                                                        | 4.0              | 4.5               | 4.0                  | 6.25              | 4.50        | 5.25              | 4.00                 | 4.50        | 5.00              | 4.00                 | 5.50              | 5.25                        |
|                               |                                                            |                  |                   |                      |                   |             |                   |                      |             |                   |                      |                   |                             |
| ESTIMATED OUT-TURN (£b)       | 2.73                                                       | 2.94             | 3.24              | 2.87                 | 4.51              | 2.91        | 3.13              | 3.09 *               | 3.19        | 3.21              | 3.25 *               | 4.71              | 3.58                        |
|                               |                                                            |                  |                   |                      |                   |             |                   |                      |             |                   |                      |                   |                             |
| PVB (excluding WEBS) (£b)     | 1.62                                                       | 1.28             | 1.62              | 1.62                 | 1.98              | 2.46        | 2.46              | 2.46                 | 3.53        | 3.53              | 3.53                 | 4.41              | 3.09                        |
| PVC (£b)                      | 1.30                                                       | 1.49             | 1.62              | 1.41                 | 2.08              | 1.24        | 1.32              | 1.37                 | 1.32        | 1.30              | 1.39                 | 2.28              | 1.61                        |
| NPV (£b)                      | 0.32                                                       | -0.22            | 0.00              | 0.21                 | -0.10             | 1.22        | 1.14              | 1.09                 | 2.21        | 2.23              | 2.14                 | 2.14              | 1.48                        |
| Initial BCR**                 | 1.2                                                        | 0.9              | 1.0               | 1.1                  | 1.0               | 2.0         | 1.9               | 1.8                  | 2.7         | 2.7               | 2.5                  | 1.9               | 1.9                         |
| WEBS (£b)                     | 0.54                                                       | 0.49             | 0.54              | 0.54                 | 0.91              | 1.05        | 1.05              | 1.05                 | 1.23        | 1.23              | 1.23                 | 1.50              | 1.16                        |
| PVB (including WEBS) (£b)     | 2.16                                                       | 1.77             | 2.16              | 2.16                 | 2.89              | 3.51        | 3.51              | 3.51                 | 4.76        | 4.76              | 4.76                 | 5.91              | 4.25                        |
| PVC (£b)                      | 1.30                                                       | 1.49             | 1.62              | 1.41                 | 2.08              | 1.24        | 1.32              | 1.37                 | 1.32        | 1.30              | 1.39                 | 2.28              | 1.61                        |
| NPV (£b)                      | 0.86                                                       | 0.28             | 0.54              | 0.75                 | 0.81              | 2.27        | 2.19              | 2.14                 | 3.44        | 3.46              | 3.37                 | 3.63              | 2.64                        |
| Adjusted BCR**                | 1.7                                                        | 1.2              | 1.3               | 1.5                  | 1.4               | 2.8         | 2.7               | 2.6                  | 3.6         | 3.7               | 3.4                  | 2.6               | 2.6                         |

\* Immersed tube tunnel costs for Route Options C2, C3 and C9 include cut and cover tunnelling under the Ramsar site. Significant cost savings can be achieved if this is not required

\*\* Initial BCR excludes Wider Economic Benefits (WEBS). Adjusted BCR includes WEBS.

|                               | Route Options assessed in Second Stage Appraisal – Sheet 2 |                             |                                       |             |                   |                      |              |                    |                       |
|-------------------------------|------------------------------------------------------------|-----------------------------|---------------------------------------|-------------|-------------------|----------------------|--------------|--------------------|-----------------------|
| OPTION                        | C <sub>Variant</sub> + A1 Bridge                           | C4 + A16 single bore tunnel | C2 bored tunnel differential charging | C9 (bridge) | C9 (bored tunnel) | C9 (immersed tunnel) | C19 (bridge) | C19 (bored tunnel) | C19 (immersed tunnel) |
| Construction duration (years) | 4.0                                                        | 5.50                        | 5.25                                  | 4.50        | 5.25              | 4.00                 | 4.50         | 5.25               | 4.0                   |
|                               |                                                            |                             |                                       |             |                   |                      |              |                    |                       |
| ESTIMATED OUT-TURN (£b)       | 3.18                                                       | 6.33                        | 3.13                                  | 3.45        | 3.67              | 3.64 *               | 3.71         | 3.77               | 3.94                  |
|                               |                                                            |                             |                                       |             |                   |                      |              |                    |                       |
| PVB (excluding WEBS) (£b)     |                                                            | 4.61                        | 2.65                                  | 3.08        | 3.08              | 3.08                 | 4.13         | 4.13               | 4.13                  |
| PVC (£b)                      |                                                            | 3.22                        | 1.85                                  | 1.52        | 1.62              | 1.68                 | 1.64         | 1.63               | 1.83                  |
| NPV (£b)                      |                                                            | 1.39                        | 0.80                                  | 1.56        | 1.47              | 1.41                 | 2.49         | 2.50               | 2.30                  |
| Initial BCR**                 |                                                            | 1.4                         | 1.4                                   | 2.0         | 1.9               | 1.8                  | 2.5          | 2.5                | 2.3                   |
| WEBS (£b)                     |                                                            | 1.59                        | 1.13                                  | 1.26        | 1.26              | 1.26                 | 1.48         | 1.48               | 1.48                  |
| PVB (including WEBS) (£b)     |                                                            | 6.20                        | 3.78                                  | 4.34        | 4.34              | 4.34                 | 5.61         | 5.61               | 5.61                  |
| PVC (£b)                      |                                                            | 3.22                        | 1.85                                  | 1.52        | 1.62              | 1.68                 | 1.64         | 1.63               | 1.83                  |
| NPV (£b)                      |                                                            | 2.98                        | 1.93                                  | 2.82        | 2.72              | 2.66                 | 3.97         | 3.98               | 3.78                  |
| Adjusted BCR**                |                                                            | 1.9                         | 2.0                                   | 2.9         | 2.7               | 2.6                  | 3.4          | 3.4                | 3.1                   |

\* Immersed tube tunnel costs for Route Options C2, C3 and C9 include cut and cover tunnelling under the Ramsar site. Significant cost savings can be achieved if this is not required

\*\* Initial BCR excludes Wider Economic Benefits (WEBS). Adjusted BCR includes WEBS.

- 9.6.18 There are four options which are centered upon a crossing of the Thames at Location A, alongside the existing crossings. Of these, A1, A4 and A9 are similar schemes which lie to the west of the present crossings and are differentiated by the solution chosen: bridge, bored tunnel and immersed tunnel. They are therefore considered to perform identically in user benefit terms, with sixty year benefits (PVB) of £1.62bn.
- 9.6.19 In cost terms the bridge is cheapest with a PVC of £1.30bn, followed by the immersed tunnel at £1.41bn and the bored tunnel at £1.62bn. The resulting BCRs range from 1.2 down to 1.0. Using the Department for Transport's guidance all these options offer low value for money (VfM).
- 9.6.20 Scheme A2 is a bridge to the east of the existing structure. This has a PVB of £1.28bn, very much lower than the western crossings, a PVC of £1.49bn and a BCR of 0.9. This is because the costs for this arrangement noticeably exceeds the benefits. This option represents poor VfM.
- 9.6.21 From these initial comparisons based on user benefits, it seems that the best solution is a bridge west of the existing structures (A1). A2 is not likely to provide a satisfactory solution.
- 9.6.22 There are six basic routes which utilise a downstream crossing to the east of Gravesend. Options C1 and C4 have been modelled with a bored tunnel only. The other four have been modelled as bridge, bored tunnel and immersed tube tunnel. For each of the four, a single user benefit appraisal has been used regardless of structure type.
- 9.6.23 Looking at the bored tunnel options, the PVBs range from £4.41bn to £2.46bn, in the sequence C4, C19, C3, C9, C2 and C1.
- 9.6.24 The PVC range is from £1.30bn to £2.28bn in the sequence C3, C2, C9, C19, C1 and C4.
- 9.6.25 The resulting BCRs range from 2.7 to 1.0 in the sequence C3, C19, C4, C9, C2 and C1. C19 and C3 offer high VfM and C1 offers poor VfM. The remainder offer medium VfM.
- 9.6.26 As C19 ranks highly for BCR and PVB it may be one of the most attractive options, although C3 offers a slightly higher BCR at a lower cost. Option C19 has been modelled using all three crossing options. The PVB for each option is £4.13bn. The PVCs range from £1.63bn for the bored tunnel to £1.83bn for the immersed tunnel. This produces BCRs between 2.3 and 2.5. The bored tunnel is the best performer, all have a VfM in the high category.
- 9.6.27 Option C3 has been similarly treated. The PVB for each is £3.53bn. The PVCs range from £1.30bn for the bored tunnel to £1.39bn for the immersed tunnel. This produces BCRs between 2.5 and 2.7. All represent high VfM with the bored tunnel as the best performer.
- 9.6.28 Option C9 is considered next. The PVB for each solution is £3.08bn. The PVCs range from £1.52bn for the bridge to £1.68bn for the immersed tunnel. This produces BCRs from 2.0 reducing to 1.8. The bridge is the best performer with borderline high VfM, while the others represent medium VfM.
- 9.6.29 The last of the solutions using alternative structures is C2. The PVB in each case is £2.46bn. The PVCs range from £1.24bn for the bridge to £1.37bn for the immersed tunnel. This produces BCRs from 2.0 reducing to 1.8. As for C9,

the bridge is the best performer with borderline high VfM, while the others represent medium VfM.

- 9.6.30 A further test was made with a C2 bored tunnel plus C<sub>variant</sub>. This had a PVB of 3.09, a PVC of 1.61 and a BCR of 1.9, representing medium value for money. The BCR only slightly improved by comparison with the base situation, showing that the additional element and cost do not significantly improve the VfM of the scheme.
- 9.6.31 The final route test to report is of the C4 bored tunnel with an additional single bored tunnel at the Dartford crossing (A16). The PVB was 4.61, the PVC 3.22 and the BCR 1.4. This was at the top end of the low VfM range and a much poorer result than C4 alone. The addition of A16 was clearly poor value for money.
- 9.6.32 In addition to these tests, Option C2 bored tunnel was tested with differential charging (lower charges on the new crossing than at Dartford). The PVB was moderately higher (probably due to cheaper trips), while the PVC was approximately one third higher, due presumably to lower charge revenues. The resulting BCR was 1.4 (low VfM), compared with 1.9. Based on this initial VfM assessment, the use of differential charges therefore cannot be recommended.
- 9.6.33 In summary, these initial BCRs based on user benefits may not by themselves provide enough evidence for a firm selection. However, it appears that a bridge or bored tunnel is preferable to an immersed tube tunnel and that a crossing at the C location is capable of delivering more benefits and a higher initial BCR as anything at the A location. However, this comes at a greater capital cost.
- 9.6.34 Again, based on this initial assessment it is unlikely that either of the combinations tested will add significant value to the overall scheme,

## 9.7 Wider Economic Benefits

- 9.7.1 An assessment of Wider Impacts (WIs) for each of the longlisted route options has been carried out using the LTC Wider Impacts (WI) model.<sup>29</sup> This model is based on the Wider Impacts model used in the 2013 Review. However HHJV has updated the model with minor structural amendments; with changes to the calculation methodology for effective density and discounting, to be consistent with the Wider Impacts methodology in DfT's WebTAG guidance<sup>30</sup>, and in significantly reducing the model's running time.

### Type of impacts

- 9.7.2 The following wider impacts have been estimated for each of the LTC route options in line with WebTAG:
- WI1 - Agglomeration resulting from moves to more or less productive jobs.
  - WI2 - Output change in imperfectly competitive markets.
  - WI3 - Tax revenues arising from labour market impacts.
- 9.7.3 All benefits have been assessed over a 60 year appraisal period from 2025 to 2084.

<sup>29</sup> The terms Wider Economic Benefits (WEBs) and Wider Impacts (WI) are used interchangeably.

<sup>30</sup> DfT WebTAG guidance, Unit A2.1, Wider Impacts

## Data

9.7.4 The calculation of Wider Impacts relies on three different datasets.

- LTC Traffic model – demand and generalised cost<sup>31</sup> for every Origin-Destination (OD), across the whole day for the three modelled years and for every route option.
- DfT Wider Impacts dataset - forecasts of employment, GDP per Worker, labour supply and productivity elasticities, productivity index and tax rates.
- National Travel Survey – demand and travel time data for public transport and walking and cycling.

## Geography

9.7.5 The Wider Impacts model consists of 148 zones (129 in London, south east and east of England, 19 zones elsewhere). The generalised cost and demand data from the traffic model has been aggregated to these zones using demand weightings. Journey time changes have been masked to exclude those which do not have an origin or destination within Kent, Essex or certain London boroughs. The masking has been implemented to enable the net national Wider Impacts to be captured while avoiding spurious results from small changes in journey times in remote locations.

## WI1 Agglomeration

9.7.6 Agglomeration refers to the concentration of economic activity in an area and is measured using effective density. Where a transport scheme facilitates a reduction in journey times and therefore generalised cost<sup>32</sup>, this alters the accessibility of firms in an area to other firms and workers to deliver improvement in relative agglomeration. The benefits arise as businesses and their labour are better connected, yielding additional productivity through spill-over benefits such as improved labour market matching and the sharing of ideas, technology and best practice.

9.7.7 Changes in effective economic density<sup>33</sup> from the transport investment are translated into changes in productivity using an econometric relationship. Each area's change in productivity is then multiplied by its existing level of output, whereby the largest agglomeration impacts will likely occur in areas with significant decreases in generalised cost and a significant existing business base.

## WI2 Change in Output in Imperfectly Competitive Markets

9.7.8 A reduction in the costs of transport allows businesses to operate more efficiently - it allows them to raise their output due to a reduction in their business costs. This forms as an additional welfare impact, where in imperfectly competitive markets firms set prices above the marginal cost of production,

<sup>31</sup> Generalised cost is an aggregated cost that encompasses the monetary and non-monetary costs imposed on travellers for their entire journey. It includes both the monetised time element as well as financial costs associated with the trip such as fares and vehicle operating costs.

<sup>32</sup> The base demand was used to avoid counter-intuitive changes in generalised costs, by keeping the demand matrix fixed. This is consistent with DfT guidance.

<sup>33</sup> The effective density depends on the destination's employment level and generalised costs decayed by the distance parameter.



resulting in the increased (or decreased) output being valued more highly by consumers than the cost of producing this output.

- 9.7.9 The change in output in imperfectly competitive markets has been calculated based on the modelled value of business travel time savings. The calculations of these WI2 benefits assumes that 10% of the change in business costs is passed onto consumers as an additional welfare benefit. This Wider Impact is in addition to the business user benefits which are captured in the TUBA user benefits.

### **WI3 Tax Wedge on Labour Market Impacts**

- 9.7.10 Decisions about whether to take a job are based on the combination of wages and commuting costs. As the costs of commuting change, these decision can result in a potential increase or decrease in the supply of labour. Reductions in journey time or cost will increase the returns from the combination of working and commuting and are likely to result in greater labour supply. The benefits to the individual are assumed to be captured in user benefits. However the change in tax revenues that results from the labour market impacts is what is being captured as part of W13 calculations.

### **Results**

- 9.7.11 **Table 9.6** shows WIs for each of the longlist route options subject to more detailed appraisal as part of the second stage appraisal expressed in terms of Present Value of Benefits (PVBs). On average across all the route options, WI1 accounts for 75% of all the WEBs and WI2 around 24%. Route Option C4 generates the greatest level of WEBs. The option performs better when it is combined with others, such as Route Option C2. A combination of Route Option C4 and the A16 tunnel is likely to result in significant benefits relative to other route options considered.
- 9.7.12 Schemes at Location C generally have a higher percentage point increase in effective density in the study area, specifically in Kent and Essex. **Table 9.7** below demonstrates the shares of agglomeration benefits by area. Our findings show that Kent receives a significant share of the agglomeration benefits for options in both Locations A and C. For options in Location A, London is the second largest beneficiary after Kent with most of the benefits deriving from East London. For options in Location C, Essex is the second largest beneficiary after Kent which reflects the positioning of the crossing.
- 9.7.13 Kent having the largest agglomeration impacts, signifies that businesses in Kent capture the most benefit through the backward/ forward supply chain linkages and knowledge spillovers created as a result of reduction in average generalised cost unlocked by the schemes.
- 9.7.14 The summary of results for each route option follow on, where the route options ranked by total NPV of WIs, is as follows:
1. C4 + A16 single bore tunnel
  2. C19
  3. C4
  4. C9
  5. C3
  6. C<sub>variant</sub> + C2 bored tunnel
  7. C2 differential charging

- 8. C2
- 9. C1
- 10. C<sub>variant</sub> + A
- 11. A1/ A4/ A9
- 12. A2

- 9.7.15 **Appendix 8** contains maps that show the top 20 zones in terms of agglomeration benefits and effective density across the Do Something options. It is important to distinguish between agglomeration benefits and effective density because, due to an option, an area may become more accessible (an increase in effective density, the area is better connected) but the agglomeration benefits may be low if there are a low number of existing jobs in the area or a lower level of overall productivity (GVA) at present in the area.
- 9.7.16 It is important to note that small % changes in effective density (for example in the 0.5-1% area realised for several of the options) can produce large increases in WI1 as the change in effective density feeds through to productivity uplifts to the area's economic base.
- 9.7.17 It is also important to recognise that agglomeration impacts are not directly correlated with journey time benefits. In particular, where new journey opportunities arise from a new road network geometry, agglomeration may be supported even if trip making between these places is relatively small due to the areas having significant business bases.

TABLE 9.6 - WIDER BENEFITS ASSESSED IN SECOND STAGE APPRAISAL

| Wider Benefits Longlist (Price base: 2010 Appraisal period: 2025 to 2084, Unit: £million PVB) |               |                                           |                      |            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|-----------------------------------------------------------------------------------------------|---------------|-------------------------------------------|----------------------|------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Route options                                                                                 | Agglomeration | Output in imperfectly competitive markets | Labour supply impact | Total WEBs | Key findings                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| A1 / A4/ A9                                                                                   | 387           | 149                                       | 0.3                  | 536        | <ul style="list-style-type: none"> <li>· Largest increases in agglomeration forecast in Kent in particularly around Dartford and Medway Towns. In Essex, Basildon and Thurrock are also forecasted to have significant benefits. some negative impacts on Rochford and Southend with A13 and A127 traffic impacts,</li> <li>· Thurrock and Dartford rank amongst the highest for this route option</li> </ul>                                                                                     |
| A2                                                                                            | 371           | 116                                       | 1                    | 488        | <ul style="list-style-type: none"> <li>· Generates the least benefits of all route options considered for longlist WI modelling,</li> <li>· Largest increases in agglomeration are forecast for Medway and Basildon in 2025 whereas largest increases in effective density in Thurrock (up 0.5% by 2025),</li> <li>· For Dartford, Route Option A2 generates the least benefits compared to option options in Location A and C.</li> </ul>                                                        |
| C1                                                                                            | 702           | 210                                       | 1                    | 914        | <ul style="list-style-type: none"> <li>· Lowest WI benefits of the route options in Location C,</li> <li>· Largest increases in agglomeration are forecast in Kent, particularly around the Medway towns and Maidstone. The route option generates more benefits for Dartford than other route options in Location C.</li> <li>· Thurrock also gain significantly by C1. Its effective density rises by 0.85% and then 1.2% in 2041.</li> <li>· Results in dis-benefits for Gravesham.</li> </ul> |
| C2                                                                                            | 795           | 254                                       | 1                    | 1,049      | <ul style="list-style-type: none"> <li>· Largest increases in agglomeration are forecast in the Medway towns, Maidstone and Ashford in 2025. By 2041 Dartford is forecast to have the most WI1 of around £3.3m,</li> <li>· Largest increases in effective density are in Kent rather than Essex,</li> </ul>                                                                                                                                                                                       |

| Wider Benefits Longlist (Price base: 2010 Appraisal period: 2025 to 2084, Unit: £million PVB) |               |                                           |                      |            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|-----------------------------------------------------------------------------------------------|---------------|-------------------------------------------|----------------------|------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Route options                                                                                 | Agglomeration | Output in imperfectly competitive markets | Labour supply impact | Total WEBs | Key findings                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|                                                                                               |               |                                           |                      |            | <ul style="list-style-type: none"> <li>· In particular, Swale and Medway towns where effective economic density is forecast to rise by 1% and 0.9% respectively,</li> </ul>                                                                                                                                                                                                                                                                                                                |
| C3                                                                                            | 886           | 340                                       | 2                    | 1,227      | <ul style="list-style-type: none"> <li>· The largest increases in agglomeration in 2025 are gained by the Medway towns, while Swale ranks 4th (at £2.2m) and Thurrock is in the top 5 zones in 2041 (at £3.2m),</li> <li>· Swale is ranked top for effective density gains, estimated to become relatively more accessible than any other zone,</li> </ul>                                                                                                                                 |
| C4                                                                                            | 1,109         | 393                                       | 2                    | 1,504      | <ul style="list-style-type: none"> <li>· Largest WEBs compared to C1, C2 and C3.</li> <li>· The largest increases in agglomeration, like other route options in Location C is forecast for the Medway towns with agglomeration benefits of £3.3m rising to £5.1m,</li> <li>· Like Route Option C3, Swale is estimated to gain the greatest increase in effective density with its effective density increasing by 1.9% by 2, Basildon gains more under Route Option C4 than C3,</li> </ul> |
| C <sub>Variant</sub> + C2                                                                     | 859           | 299                                       | 1                    | 1,159      | <ul style="list-style-type: none"> <li>· The largest increases in agglomeration is the Medway towns where the agglomeration benefits increase from £1.4m in 2025 to nearly £2m by 2041. Ashford, Tonbridge, Malling and Dover also gain significantly,</li> <li>· By 2041, Shepway is expected to experience the greatest increase in effective density,</li> </ul>                                                                                                                        |

| Wider Benefits Longlist (Price base: 2010 Appraisal period: 2025 to 2084, Unit: £million PVB) |               |                                           |                      |              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|-----------------------------------------------------------------------------------------------|---------------|-------------------------------------------|----------------------|--------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Route options                                                                                 | Agglomeration | Output in imperfectly competitive markets | Labour supply impact | Total WEBs   | Key findings                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| <b>C<sub>Variant</sub> + A1</b>                                                               | 526           | 199                                       | 1                    | <b>726</b>   | <ul style="list-style-type: none"> <li>· Significantly lower WI benefits than combining C<sub>Variant</sub> with a route option in Location C.</li> <li>· The largest increases in agglomeration in 2025 is Maidstone, by 2041 the benefits to Dartford exceed all other areas (£3m generated from higher productivity).</li> <li>· Like C<sub>Variant</sub> + Route Option C2, this options generates higher benefits for Medway, Ashford, Tonbridge and Malling and Basildon.</li> <li>· In 2025, Maidstone and Shepway are expected to experience the greatest increase in effective density; by 2041 Dartford and Thurrock rank the highest, Areas such as Swale and Canterbury do not gain significantly from this route option.</li> </ul> |
| <b>C4 + A16</b>                                                                               | 1,177         | 407                                       | 2                    | <b>1,586</b> | <ul style="list-style-type: none"> <li>· The second highest WI benefits of the modelled route options,</li> <li>· The largest increases in agglomeration in 2025 and 2041 are Medway, Maidstone and Basildon,</li> <li>· In 2025, Swale, Medway Towns, Canterbury, Shepway and Thanet are expected to experience the greatest increase in effective density,</li> </ul>                                                                                                                                                                                                                                                                                                                                                                          |
| <b>C2 bored tunnel differential charging</b>                                                  | 854           | 277                                       | 1                    | <b>1,132</b> | <ul style="list-style-type: none"> <li>· Higher than the separate Route Option C2,</li> <li>· The largest increases in agglomeration in 2025 and 2041 are Medway, Maidstone and Ashford. Benefits in Swale and Canterbury are also expected to be higher at £1.2m each in 2025. In 2025, Swale is expected to experience the greatest increase in effective density,</li> </ul>                                                                                                                                                                                                                                                                                                                                                                  |

| Wider Benefits Longlist (Price base: 2010 Appraisal period: 2025 to 2084, Unit: £million PVB) |               |                                           |                      |              |                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|-----------------------------------------------------------------------------------------------|---------------|-------------------------------------------|----------------------|--------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Route options                                                                                 | Agglomeration | Output in imperfectly competitive markets | Labour supply impact | Total WEBs   | Key findings                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| C9                                                                                            | 956           | 299                                       | 2                    | <b>1,256</b> | <ul style="list-style-type: none"> <li>· Like other route options in location C, Medway Towns is forecast to benefit the greatest in 2025. However unlike many other route options, where Rochford and Southend-on-sea was dis-benefiting, Route Option C9, improves capacity along A127 and therefore results in benefits to Southend-on-Sea.</li> <li>· In 2025, Swale is expected to experience the greatest increase in effective density,</li> </ul> |
| C19                                                                                           | 1,100         | 378                                       | 2                    | <b>1,480</b> | <ul style="list-style-type: none"> <li>· Like other route options in Location C, the largest increases in agglomeration in 2025 is Medway; Maidstone and Basildon also benefit significantly.</li> <li>· Medway and Shepway are both expected to see the greatest change in effective density for 2025 and 2041,</li> </ul>                                                                                                                               |

Source: HHJV Analysis

**TABLE 9.7 - 2025 AGGLOMERATION BENEFITS BY REGION, £M**

| Zone name      | A1 / A4/ A9 | A2 (bridge east) | C1  | C2   | C3   | C4   | C <sub>Variant</sub> + C2 | C <sub>Variant</sub> + A1Bridge | C4 + A16 single bore tunnel | C2 bored tunnel differential charging | C9   | C19 |
|----------------|-------------|------------------|-----|------|------|------|---------------------------|---------------------------------|-----------------------------|---------------------------------------|------|-----|
| Essex*         | 2.6         | 2.5              | 5.2 | 5.5  | 4.5  | 8.1  | 5.3                       | 2.8                             | 8.6                         | 5.3                                   | 8.1  | 2.6 |
| Kent**         | 4.4         | 4.9              | 9.7 | 12.4 | 15.0 | 18.2 | 15.3                      | 7.5                             | 18.6                        | 13.6                                  | 13.2 | 4.4 |
| Total London   | 3.1         | 1.8              | 4.7 | 4.4  | 5.1  | 4.0  | 3.8                       | 0.4                             | 5.7                         | 5.4                                   | 5.0  | 3.1 |
| North London   | 0.2         | 0.2              | 0.5 | 0.5  | 0.7  | 0.9  | 0.6                       | 0.3                             | 0.9                         | 0.6                                   | 0.6  | 0.2 |
| South London   | 1.4         | 1.4              | 2.2 | 1.8  | 2.1  | 1.9  | 2.1                       | 1.5                             | 2.5                         | 2.4                                   | 2.2  | 1.4 |
| East London    | 1.3         | 0.2              | 1.8 | 1.8  | 2.1  | 0.9  | 1.0                       | 1.5                             | 1.9                         | 2.1                                   | 1.9  | 1.3 |
| Central London | 0.1         | -                | 0.2 | 0.2  | 0.3  | 0.3  | 0.2                       | 0.0                             | 0.3                         | 0.2                                   | 0.2  | 0.1 |
| Other          | 3.2         | 3.7              | 4.7 | 6.0  | 6.6  | 8.0  | 6.0                       | 3.6                             | 8.1                         | 6.3                                   | 6.5  | 3.2 |

\*Includes Thurrock and Southend-on-Sea which are unitary authorities

\*\*Includes Medway Towns which is a unitary authority Source: HHVJ Analysis

## 9.8 Appraisal Tables

9.8.1 **Appendix 9** includes, for each of the longlist route options, three standard WebTAG appraisal tables that provide key information as summarised in the Appraisal Summary Table included in section 15. The three appraisal tables are:

- Transport Economic Efficiency (TEE) – this reports the user benefits.
- Public Accounts (PA) – this reports the costs of the scheme.
- Annualised Monetary Costs and Benefits (AMCB) – this incorporates all monetized benefits and costs.

## 10 Environmental Appraisal

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### 10.1 Introduction

- 10.1.1 This section reports the environmental appraisal of all the Location A longlist options (refer to Section 5.9) except Route Option A16 which is effectively a two-lane version of the Route Option A4 tunnel.
- 10.1.2 At Location C all the longlist options (refer to Section 5.10) are reported apart from the combination options (except Route Options C9 and C19) as these options have not been separately appraised. The environmental impacts of these options would be the same as the main options on which they are based.
- 10.1.3 Only one representative longlist C<sub>variant</sub> option (CV1) (refer to section 5.11) is included as the environmental impacts of the two options would be broadly the same.

### 10.2 Environmental Appraisal

- 10.2.1 The environmental appraisal of the longlist of route options has been undertaken for the following topics:
- Landscape and townscape
  - Historic environment
  - Biodiversity
  - Water environment
  - Air quality
  - Noise
- 10.2.2 The topics considered in the appraisal are consistent with those in TAG Unit A3 *Environmental Impact Appraisal*.
- 10.2.3 The environmental appraisal for the landscape/ townscape, historic environment, biodiversity and water environment topics has been informed by a comprehensive desk study, initial engagement with statutory environmental bodies and initial site visits to understand the overall context of the area. The focus of the appraisal has been to identify key environmental showstoppers, risks and the likelihood of being able to mitigate the impacts identified. The contents of the NPSNN have also been used to inform the appraisal to make judgements about the likely risks associated with taking each option forward and the potential future environmental acceptability of an option.
- 10.2.4 For the noise appraisal, consideration was given to the different route alignments in relation to sensitive receptors for each location, potential for significant effects to occur and the likelihood of the requirement for mitigation. Using this information a judgement was made about whether the options would be likely to contravene the requirements of the NPSNN.
- 10.2.5 For air quality, a review of the route options was undertaken to determine whether any of the locations were likely to lead to a direct refusal following



the advice in the NPSNN. In the NPSNN it states that the Secretary of State (SoS) should refuse consent where, after taking into account mitigation, the air quality impacts of the scheme will:

- Result in a zone/ agglomeration which is currently reported as being compliant with the Air Quality Directive becoming non-compliant.
- Affect the ability of a non-compliant area to achieve compliance within the most recent timescales reported to the European Commission at the time of the decision.

10.2.6 To determine therefore whether any of the route options were likely to result in the SoS refusing the scheme the guidance in Interim Advice Note 175/13 was referred to, which provides the method of determining whether a scheme will be a risk to the UK's ability to comply with the EU Directive on ambient air quality. Defra is responsible for the assessment of whether a zone/ agglomeration complies with the Directive, which is undertaken by a combination of modelling and monitoring. The modelling that is used to inform compliance is used in scheme assessments to determine the compliance risk.

10.2.7 For each route option the traffic data was screened following the criteria in DMRB HA207/07 to determine the area that would be included in the air quality assessment. The Defra compliance links were then overlaid on the air quality study area to determine whether the various locations were likely to impact on the links that Defra use to inform compliance. The emissions for the Do Minimum and Do Something scenarios were calculated to determine whether there would be an increase or decrease in emissions (and hence a deterioration or improvement in air quality) and hence whether a location is likely to cause an agglomeration/ zone to become non-compliant or extend the date on which it will be in compliance (which would lead to a refusal by the SoS, as indicated in the NPSNN) or whether there will be an overall improvement in emissions on Defra's modelled links. Therefore, at this stage the method only determines whether under the current method of assessment, the route option would lead to the SoS refusing the scheme.

10.2.8 The HHJV *Appraisal Specification Report* provides further details of the appraisal approach used for environmental assessment of the route options.

10.2.9 Not all of the options described below were subject to the level of assessment above. A two-stage appraisal process has been adopted (refer to section 12 for more details) by the project team, whereby some options were discounted early in the process for a range of reasons. Where a high-level review only was completed of the options this is identified.

### **Route Option A1 - Bridge on the West Side of Existing Tunnel**

#### *Townscape*

10.2.10 This route option would lie within an existing urban townscape that is dominated by the existing QEII Bridge, industrial areas and other road and rail infrastructure. South of the River Thames new road infrastructure has the potential to impact on residential properties in Dartford and result in minor modifications to the existing townscape. In the context of the existing QEII

Bridge and the surrounding industrial landscape, a new bridge is only likely to have a minor additional townscape impact depending upon its design. North of the River Thames the townscape is dominated by industry and transport infrastructure, and therefore townscape impacts would be limited. However, there is potential for a greater impact on the townscape/ landscape at Mardyke Valley near Junction 30 of the M25 although this, too, is already affected by road infrastructure.

#### *Historic Environment*

- 10.2.11 For this route option there would be no direct effects on heritage resources and unlikely to be any indirect effects owing to the distance of designated assets from the route option.

#### *Biodiversity*

- 10.2.12 This route option would directly affect the recommended Thames Estuary Marine Conservation Zone as a result of the construction of the bridge piers. There is also a risk of indirect effects on the adjacent West Thurrock Lagoon and Marshes SSSI as a result of hydrodynamic changes. There is also potential for impacts on the Inner Thames Marshes SSSI that lies circa 3.2km upstream of the existing QEII Bridge as a result of hydrodynamic changes although this would require confirmation through modelling. A new crossing in this location could impact upon the qualifying species of the Thames Estuary and Marshes SPA and Ramsar site. There is a risk of direct effects and indirect effects as a result of nitrogen deposition on the areas of ancient woodland adjacent to Junction 30 of the M25. Ecological impacts therefore have the potential to be significant and require detailed assessment and mitigation.

#### *Water Environment*

- 10.2.13 The construction of crossings of the River Thames and Mardyke could result in changes to the river morphology and the sediment regime as well as impacts on the floodplain and flood defences. It is considered that Flood Risk Assessment and appropriate design of the structures could inform the design of proven mitigation measures to reduce these impacts.

#### *Air Quality and Noise*

- 10.2.14 For this route option there is likely to be an overall increase in emissions on Defra's PCM modelled links that would cause an overall worsening of air quality. However, this is unlikely to impact on the date that Defra has reported that the zone will be compliant. It is not possible to determine, at this stage, whether this route option would lead to a significant air quality impact at sensitive receptors. From a noise perspective there are existing noise important areas to the south of the existing QEII Bridge and there may be a requirement for noise mitigation if this route option were pursued.

### **Route Option A2 - Bridge on East Side of the Existing QEII Bridge**

#### *Townscape*

- 10.2.15 The effects would be very similar to those described for Route Option A1, refer to townscape text above.

*Historic Environment*

- 10.2.16 The effects would be very similar to those described for Route Option A1, refer to the historic environment text above.

*Biodiversity*

- 10.2.17 This option would directly affect the recommended Thames Estuary Marine Conservation Zone as a result of the construction of the bridge piers. There would also be a direct effect on the West Thurrock Lagoon and Marshes SSSI through land take for the bridge construction to the east of the existing QEII Bridge. There is the potential to reduce this impact through the design footprint, for example, wider bridge span or minimising the footprint within the SSSI. There is also the potential for indirect effects on the site as a result of hydrodynamic changes. There is also potential for impacts on the Inner Thames Marshes SSSI that lies circa 3.2km upstream of the existing QEII Bridge as a result of hydrodynamic changes although this would require confirmation through modelling. A new crossing in this location could impact upon the qualifying species of the Thames Estuary and Marshes SPA and Ramsar site.

*Water environment*

- 10.2.18 The effects would be very similar to those described for Route Option A1, refer to the water environment text above.

*Air Quality and Noise*

- 10.2.19 The effects would be very similar to those described for Route Option A1, refer to the air quality and noise text above.

**Route Option A4 - Bored Tunnel on West Side of Existing West Tunnel***Townscape*

- 10.2.20 This route option would lie within an existing urban townscape that is dominated by the existing QEII Bridge, industrial areas and other road and rail infrastructure. South of the River Thames new road infrastructure and a tunnel portal has the potential to impact on residential properties in Dartford and result in minor modifications to the existing townscape. North of the River Thames the townscape is dominated by industry and transport infrastructure and so townscape impacts would be limited.

*Historic Environment*

- 10.2.21 Refer to the text for Route Option A1.

*Biodiversity*

- 10.2.22 As this route option would be a bored tunnel it is assumed that any indirect/ disturbance effects on the Thames Estuary and Marshes SPA and Ramsar site could be mitigated. This route option would have no impacts on designated ecological sites either north or south of the river other than the risk of direct effects and indirect effects as a result of nitrogen deposition on the areas of ancient woodland adjacent to Junction 30 of the M25.

### *Water Environment*

- 10.2.23 The crossing of Mardyke has the potential to result in changes to watercourse morphology but it should be possible to mitigate these impacts through careful design. There may also be impacts on the floodplain and flood defences. The tunnel cutting and tunnel portals would also be located in the defended River Thames floodplain. A Flood Risk Assessment would need to be undertaken and this could inform the design of the scheme and associated structures to reduce any impacts.

### *Air Quality and Noise*

- 10.2.24 Refer to the text for Route Option A1.

### **Route Option A8 - Bored Tunnel**

- 10.2.25 This route option was discounted early in the optioneering process and so was only subject to a very high level review.

### *Townscape*

- 10.2.26 This route option would lie within an existing urban townscape that is dominated by the existing QEII Bridge, industrial areas and other road and rail infrastructure. As this route option is primarily a bored tunnel there would be very limited townscape impacts and they would be confined to the works and tie-ins associated with the tunnel portals.

### *Historic Environment*

- 10.2.27 No designated cultural heritage assets are likely to be significantly affected with the exception of a possible minor effect on the Belhus Park Registered Park and Garden associated with the tie-in works at Junction 30 although this site is already impacted by road infrastructure.

### *Biodiversity*

- 10.2.28 The biodiversity impacts of this route option would be limited to potential loss of areas of ancient woodland associated with tie-in works to the A13. There may also be potential nitrogen deposition effects as a result of changes in traffic flow that would need to be assessed further.

### *Water Environment*

- 10.2.29 There is the potential for the tunnel portals to impact upon flood risk as both would be sited within Flood Zone 3 and so a Flood Risk Assessment would be required to inform the scheme design.

### *Air Quality and Noise*

- 10.2.30 There is potential for air quality and noise impacts, both positive and negative, as a result of changes in traffic flows and construction of new road infrastructure. There are a large number of residential properties that could be affected and there are AQMAs and Noise First Priority Locations in the vicinity of this route option although it is recognised that this route option would be a bored tunnel.

## **Route Option A9 - Immersed Tube on the West Side of the Existing West Tunnel**

### *Townscape*

- 10.2.31 This route option would lie within an existing urban townscape that is dominated by the existing QEII Bridge, industrial areas and other road and rail infrastructure. South of the River Thames new road infrastructure and a tunnel portal has the potential to impact on residential properties in Dartford and result in minor modifications to the existing townscape. North of the River Thames the townscape is dominated by industry and transport infrastructure and so townscape impacts would be limited.

### *Historic Environment*

- 10.2.32 For this route option there would be no direct effects on heritage resources and unlikely to be any indirect effects owing to the distance of designated assets from the route option. However, there may be the potential to affect buried marine archaeology during the construction of the crossing. This would need further assessment and discussion with English Heritage.

### *Biodiversity*

- 10.2.33 This route option would directly affect the recommended Thames Estuary Marine Conservation Zone during the crossing construction. There is also the potential for an indirect effect on the West Thurrock Lagoon and Marshes SSSI, the Inner Thames Marshes SSSI and the Thames Estuary and Marshes SPA and Ramsar depending upon how the hydrodynamic regime may be altered either temporarily or permanently. This would require confirmation through modelling. There is also the potential for disturbance of mobile species associated with these sites during the construction works. There is a risk of direct effects and indirect effects as a result of nitrogen deposition on the areas of ancient woodland adjacent to Junction 30 of the M25.

### *Water Environment*

- 10.2.34 The crossing of Mardyke has the potential to result in changes to watercourse morphology but it should be possible to mitigate these impacts through careful design. There may also be impacts on the floodplain and flood defenses. The tunnel approaches and portals would also be located in the defended River Thames floodplain. A Flood Risk Assessment would need to be undertaken and this could inform the design of the scheme and associated structures to reduce any impacts. There is also the potential for short or medium term impacts on the River Thames morphology during the construction of the immersed tube but it is assumed that on completion the tunnel would be buried beneath the river bed and so there would be no long term impacts.

### *Air Quality and Noise*

- 10.2.35 For this route option there is likely to be an overall increase in emissions on Defra's PCM modelled links that would cause an overall worsening of air quality. However, this is unlikely to impact on the date on which Defra has reported that the zone will be compliant. It is not possible to determine, at this stage, whether this route option would lead to a significant air quality

impact at sensitive receptors. From a noise perspective there are existing noise important areas to the south of the existing QEII Bridge and there may be a requirement for noise mitigation if this route option were pursued.

### **Route Option A12 - Bored Tunnel beneath Dartford and a Bridge Crossing of the River Thames**

- 10.2.36 This route option was discounted early in the optioneering process and so was only subject to a very high level review.

#### *Townscape*

- 10.2.37 There are no significant constraints associated with this route option owing to the existing urban characteristics of the area.

#### *Biodiversity*

- 10.2.38 This route option could directly affect the recommended Thames Estuary Marine Conservation Zone as a result of the construction of the bridge piers. There is also a risk of direct and indirect effects on the adjacent Inner Thames Marshes SSSI West as a result of habitat loss and hydrodynamic changes. A new crossing in this location could impact upon the qualifying species of the Thames Estuary and Marshes SPA and Ramsar site. There is a risk of direct effects and indirect effects as a result of nitrogen deposition on the areas of ancient woodland adjacent to Junction 30 of the M25. Ecological impacts therefore have the potential to be significant and require detailed assessment and mitigation.

#### *Historic Environment*

- 10.2.39 There is the potential for scheduled monuments, Grade I and II\* listed buildings and a conservation area in Purfleet to be directly affected by this route option and there is the potential for effects on their setting. Townscape impacts of this route option would be fairly limited as the infrastructure would be located in an area that is already impacted by roads and industry.

#### *Water Environment*

- 10.2.40 The construction of the crossing of the River Thames could result in changes to the river morphology and the sediment regime as well as impacts on the floodplain and flood defences. It is considered that Flood Risk Assessment and appropriate design of the structures could inform the design of proven mitigation measures to reduce these impacts. Mardyke and its floodplain would also be impacted by this route option.

#### *Air Quality and Noise*

- 10.2.41 There is the potential for air quality and noise impacts both positive and negative as a result of changes in traffic flows and construction of new road infrastructure. There are a large number of residential properties that could be affected and there are AQMAs and Noise First Priority Locations in the vicinity of this route option.

### **Route Option A14 - Long Bored Tunnel**

- 10.2.42 This route option was discounted early in the optioneering process and so was only subject to a very high level review.

*Townscape*

- 10.2.43 There are no significant constraints associated with this route option owing to the existing urban characteristics of the area and the fact the route option is a bored tunnel.

*Biodiversity*

- 10.2.44 As this route option is a long tunnel there would be no impacts on designated biodiversity assets. There may be the potential for nitrogen deposition effects on areas of ancient woodland depending upon the extent of traffic flow changes and where they occur on the traffic network.

*Historic Environment*

- 10.2.45 No designated heritage assets would be affected by this route option

*Water Environment*

- 10.2.46 The tunnel portals are located within Flood Zone 2 and there is potential for effects on groundwater through tunnel construction, however completion of a Flood Risk Assessment and a Hydrogeological Impact Assessment would inform the design process.

*Air Quality and Noise*

- 10.2.47 There is the potential for air quality and noise impacts both positive and negative as a result of changes in traffic flows and construction of new road infrastructure. There are a large number of residential properties that could be affected and there are AQMAs and Noise First Priority Locations in the vicinity of this route option.

**Route Option A15 - Alternative Junction 30/31 Improvement***Townscape*

- 10.2.48 There are no significant constraints associated with this option owing to the existing urban characteristics of the area. However, there would be a need for pylon diversions which may change the local townscape, albeit at a very small scale.

*Biodiversity*

- 10.2.49 There may be the potential for nitrogen deposition effects on areas of ancient woodland depending upon the extent of traffic flow changes and where they occur on the traffic network. There would also be direct effects on ancient woodland at the A13/ A126 junction.

*Historic Environment*

- 10.2.50 No designated heritage assets would be affected by this option

*Water Environment*

- 10.2.51 There are no significant water constraints associated with this option.

*Air Quality and Noise*

- 10.2.52 There is the potential for air quality and noise impacts both positive and negative as a result of changes in traffic flows and construction of new road infrastructure.

## **Route Option C1 - Bored Tunnel**

### *Landscape*

- 10.2.53 This route option would lie predominantly within an urban townscape dominated by the settlements of Gravesend and Grays. South of the River Thames, the new road infrastructure follows existing highway infrastructure from the A2 along the A227 before entering the tunnel portal. The widening of the existing roads has the potential to impact upon local residential properties on the southern perimeter of Gravesend. The connection with the A2 is also within Green Belt, but given the existing road infrastructure, any landscape changes are expected to be minimal.
- 10.2.54 North of the River Thames, the tunnel portal emerges in an area of Green Belt between Grays to the west and Chadwell St Mary to the east. However, the landscape in this area is dominated by the Tilbury Docks, power station and associated infrastructure. The route continues north along the existing A1089 and A13, where widening works may impact upon local residential properties and the setting of several listed buildings. Mitigation and sensitive landscaping techniques could be used to reduce setting impacts to the receptors. It is not expected that the bored tunnel crossing option would have any landscape or townscape impact other than the tunnel portals.

### *Biodiversity*

- 10.2.55 This route option does not directly affect any ecologically designated sites throughout the southern section prior to entering the bored tunnel. North of the River Thames the route alignment may result in direct impact on four areas of nationally important ancient woodland (Chadwell Wood, Brickbarn Wood, Brannetts/ Low Well Woods and Hangman's Wood). In addition to these direct impacts, any increase in traffic flows may result in air quality effects that would have indirect impacts on these four sites.

### *Historic Environment*

- 10.2.56 For this route option there would be no direct effects on heritage assets south of the River Thames. The northern tunnel portal may impact upon a Grade II listed building south west of Chadwell St Mary. Where the route continues north along the existing A1089 there may be setting impacts to two Grade II listed buildings. The connection with the A13 is over a nationally important scheduled monument, Cropmark complex, Orsett, however the area is already heavily disturbed by the existing junction arrangement. There would be a requirement for comprehensive assessment and evaluation in the event of this site being affected. Further listed buildings are present along the A13 close to North Stifford, any widening works would require mitigation and sensitive landscaping to minimise setting impact upon these properties. Where possible, the detailed routing should seek to avoid direct impacts.

### *Water Environment*

- 10.2.57 This option may have a significant impact to groundwater supply and local impacts on water resources. The tunnel portal south of the River Thames is located within a Source Protection Zone Level 2 (SPZ2). North of the River Thames, the route continues through an area at risk of flooding until it



connects with the M25 at Junction 30, where the existing A13 is widened through SPZ1,2 and 3. There are potential impacts upon the WFD classified waterbody, Mardyke, at this junction location. It is considered that a Flood Risk Assessment (FRA) and appropriate design of the structures could inform the design of proven mitigation measures to reduce these impacts.

#### *Air Quality and Noise*

- 10.2.58 For this route option there is likely to be an overall increase in emissions on Defra's PCM modelled links that would cause an overall worsening of air quality. However, this is unlikely to impact on the date that Defra has reported the zone will be compliant. It is not possible to determine, at this stage, whether this route option would lead to a significant air quality impact at sensitive receptors. From a noise perspective there are existing noise important areas close to the proposed tunnel portal south of the River Thames and along the A13 and A1089 north of the River Thames. Should this route option be pursued then there may be a requirement for noise mitigation.

### **Route Option C2 - Bored Tunnel**

#### *Landscape*

- 10.2.59 South of the River Thames, this option would have a minor intrusion into the Kent Downs AONB at the junction with the A2. However, this area is already impacted by the High Speed 1 and the A2. The route is entirely within green belt designated land and is predominantly agricultural with the scattered small settlements of Shorne, Thong and the eastern suburbs of Gravesend. The route is in close proximity to the Thong conservation area and Cobham Park Registered Park and Garden, in addition to the Grade II\* listed building, Chalk Church. To the north of the River Thames, the route continues through Green Belt, bypassing local small settlements of East Tilbury, Chadwell St Mary, Orsett and South Ockenden before connecting to the M25 at a new junction location. The route through this section could have an impact upon the setting of several listed buildings and historic landscapes. Mitigation and sensitive landscaping techniques could be used to reduce setting impacts to the receptors. The bored tunnel crossing option is expected to have minimal impacts to the existing landscape.

#### *Biodiversity*

- 10.2.60 This option would directly affect the nationally important Shorne and Ashenbank Woods SSSI to south of the A2 associated with a new junction arrangement. There would also be a small area of ancient woodland to the west of the SSSI affected by the junction arrangement. The bored tunnel option would be located south of the Thames Estuary and Marshes Ramsar/SPA and SSSI although there is the potential for this option to impact upon functionally linked land but this would need to be confirmed through survey and further desk study work. This would also be informed by further engagement with Natural England. North of the River Thames there are no designated sites, but the tunnel portal and route alignment could be located within functionally linked land (to the European sites) and so mitigation may be required to reduce impacts in this location.

### *Historic Environment*

- 10.2.61 For this route option there would be no direct effects on heritage assets south of the River Thames. There are several Grade II and Grade II\* listed buildings in proximity to the route, particularly, Chalk Church Grade II\* listed building and several included within the Thong Conservation Area. North of the River Thames, the tunnel portal emerges close to the nationally important scheduled monument, the Second World War anti-aircraft battery at Bowaters Farm. As the route continues north, there may be impacts on the setting of two further scheduled monuments (causewayed enclosure and Anglo-Saxon cemetery 500m east-north-east of Heath Place and Bishop Bonners Palace, Orsett) and several Grade II and II\* listed buildings. In addition, there may be a direct impact through land take to the scheduled monument, Springfield style enclosure and Iron Age enclosures south of Hill House, Baker Street north of Orsett. As the route continues north and westward, there are further scheduled monuments located in proximity to the new junction arrangement. It is envisaged that the works would require mitigation and sensitive landscaping to minimise setting impact upon all the listed properties and designated sites. There is also significant potential to impact upon undiscovered archaeological remains and there would be a need for comprehensive assessment and evaluation.

### *Water Environment*

- 10.2.62 This route option could create potential long term impacts on Mardyke (and tributaries) north of the River Thames. The morphology at Mardyke and tributary crossings could be affected, as well as long term loss of floodplain and a potential impact on flood defences. The tunnel portal on the northern bank would be located in Flood Zone 2 and the route passes through SPZ2 and SPZ3 close to Linford. It is considered that a Flood Risk Assessment and appropriate design of the structures could inform the design of proven mitigation measures to reduce impacts to these features.

### *Air Quality and Noise*

- 10.2.63 For this route option there is predicted to be an overall reduction in emissions on Defra's PCM modelled links leading to an overall improvement in air quality on these links. This would mean the scheme is low risk in relation to impacting on compliance. At this stage it is not possible to determine whether this route option would lead to a significant impact on air quality at sensitive receptors. From a noise perspective there could be potential increase in levels in an existing low noise area. This could impact upon sensitive receptors within the area, in particular Orsett Hospital in close proximity to the new junction arrangement with the A13.

## **Route Option C2 - Immersed Tube Tunnel**

### *Landscape*

- 10.2.64 Effects would be very similar to those reported for the bored tunnel option, refer to the text above.

### *Biodiversity*

- 10.2.65 This option would directly affect the nationally important Shorne and Ashenbank Woods SSSI to south of the A2 associated with a new junction

arrangement. There would also be a small area of ancient woodland to the west of the SSSI affected by the junction arrangement. The immersed tube tunnel would have short term impacts upon the European and nationally designated sites along the Thames Estuary, however, it is assumed that with appropriate mitigation the impacts would be minimised. This would need to be confirmed through hydrodynamic modelling. North of the River Thames there are no designated sites, but the cut and cover tunnel section and route alignment could be located within functionally linked land (to the European sites) and so mitigation may be required to reduce impacts in this location.

#### *Historic Environment*

- 10.2.66 Effects would be very similar to those reported for the bored tunnel option refer to the text above although there would also be the potential to affect marine archaeology associated with the in-river works.

#### *Water Environment*

- 10.2.67 This route option could create potential long term impacts on Mardyke (and tributaries) north of the River Thames. The morphology at the Mardyke and tributary crossings could be affected, along with long term loss of floodplain and a potential impact on flood defences. The cut and cover associated with the immersed tube tunnel would be located in Flood Zone 2 on both sides of the River Thames and the route passes through SPZ2 and SPZ3 close to Linford. A Flood Risk Assessment and appropriate design of the structures could inform the design of proven mitigation measures to reduce impacts to these features.

#### *Air Quality and Noise*

- 10.2.68 Refer to text for the bored tunnel above.

### **Route Option C2 - Bridge**

#### *Landscape*

- 10.2.69 South of the River Thames, this route option would impact upon the Kent Downs AONB at the junction with the A2. The route is entirely within Green Belt designated land and is predominantly agricultural with the scattered small settlements of Shorne, Thong and the eastern suburbs of Gravesend. The route is in close proximity to the Thong Conservation Area and Cobham Park Registered Park and Garden, in addition to the Grade II\* listed building, Chalk Church. The bridge crossing may impact upon the local landscape features due to the size, embankment profile and location close to several historic features, particularly creating setting issues and a landscape barrier between the scheduled monuments of Tilbury Fort and Coalhouse Fort. To the north of the River Thames, the route continues through Green Belt, bypassing local small settlements of East Tilbury, Chadwell St Mary, Orsett and South Ockenden before connecting to the M25 at a new junction location. The route through this section could have an impact upon the setting of several listed buildings and historic landscapes. Mitigation and sensitive landscaping techniques could be used to reduce setting impacts to the receptors.

### *Biodiversity*

- 10.2.70 This option would directly affect the nationally important Shorne and Ashenbank Woods SSSI to south of the A2 associated with a new junction arrangement. There would also be a small area of ancient woodland to the west of the SSSI affected by the junction arrangement. The bridge would directly impact upon the European and nationally designated sites along the Thames Estuary (Ramsar, SPA and SSSI) and the recommended Marine Conservation Zone through permanent placement of structures within the watercourse and designated sites. Mitigation and compensatory habitat may be required to mitigate the impact upon features of these sites and this would need to be confirmed through Habitats Regulations Assessment. North of the River Thames there are no designated sites, but the embankment and route alignment could be located within functionally linked land (to the European sites) and so mitigation may be required to reduce impacts in this location.

### *Historic Environment*

- 10.2.71 The effects of this route option would be very similar to those for the bored and immersed tube tunnel although there could be additional impacts as a result of the presence of a permanent bridge structure which could affect the setting of existing heritage assets along the River Thames.

### *Water Environment*

- 10.2.72 This route option could create potential long term impacts on Mardyke (and tributaries) north of the River Thames. The morphology at the Mardyke and tributary crossings could be affected, along with long term loss of flood plain and a potential impact on flood defences. The embankments associated with the bridge would be located in Flood Zone 2 on both sides of the River Thames and the route passes through SPZ2 and SPZ3 close to Linford. A Flood Risk Assessment and appropriate design of the structures could inform the design of proven mitigation measures to reduce impacts to these features.

### *Air Quality and Noise*

- 10.2.73 Refer to the text for the bored tunnel above.

## **Route Option C3 - Bored Tunnel**

- 10.2.74 It is noted that the appraisal described in Sections 10.2.75 to 10.2.91 is for the option as described in Sections 5.3.9 to 5.3.12 and shown in **Figure 5.3**. Once it had been decided not to select the southern section of this route option (refer to section 12.3) the southern section, including the junction with the A2 was changed to be the same as Route Option C2 but the designation of the option was still Route Option C3. The appraisal results for the final southern section of C3 are therefore the same as reported for Option C2.

### *Landscape*

- 10.2.75 South of the River Thames, this option would significantly impact upon the Kent Downs AONB causing a severance impact and direct loss. The route is entirely within green belt designated land and is predominantly agricultural with the scattered small settlements of Shorne, Thong and the eastern

suburbs of Gravesend. The route is in close proximity to the Shorne conservation area, the Cobham Park Registered Park and Garden and would also run in close proximity to a number of Listed Buildings, for example the Church of St Mary. It is not envisaged that the tunnel or associated portals would have any impact to the local landscape.

- 10.2.76 North of the River Thames, the route continues through green belt and joins the existing A1089 close to the settlements of Tilbury, Chadwell St Mary and Grays. The widening of the existing road has the potential to impact upon local residential properties and amenities. The route continues north, past Orsett before connecting to the M25 at a new junction location. The route through this section could have an impact upon the setting of several listed buildings and historic landscapes. Mitigation and sensitive landscaping techniques could be used to reduce setting impacts to Biodiversity.

#### *Biodiversity*

- 10.2.77 This option would directly affect the nationally important Shorne and Ashenbank Woods SSSI and ancient woodland. These would be significant effects. The bored tunnel option would be located south of the Thames Estuary and Marshes Ramsar/ SPA and SSSI although there is the potential for this option to impact upon functionally linked land. This would need to be confirmed through survey and further desk study work. Further engagement would also be needed with Natural England. North of the River Thames there are no designated sites, but the tunnel portal and route alignment could be located within functionally linked land (to the European sites) and so mitigation may be required to reduce impacts in this location.

#### *Historic Environment*

- 10.2.78 For this option there would be no direct effects on heritage assets south of the River Thames. There are several Grade II and Grade II\* listed buildings in proximity to the route, particularly, Chalk Church Grade II\* listed building and several included within the Shorne conservation area.
- 10.2.79 North of the River Thames, the route passes in close proximity to two Grade II listed buildings. In addition, there may be a direct impact through land-take to the scheduled monument, Cropmark complex, Orsett, and two further Grade II listed buildings, which are within the footprint of the proposed junction with the A13. As the route continues north and westward, there are two scheduled monuments located in proximity to the proposed alignment which could be directly impacted, Gatehouse and moat of South Ockenden Old Hall and Roman barrow 260m north east of South Ockendon Hall. It is envisaged that the works would require mitigation and sensitive landscaping to minimise setting impacts. It is not envisaged that this crossing type would impact upon heritage features.

#### *Water Environment*

- 10.2.80 This route option could create potential long term impacts on Mardyke (and tributaries) north of the River Thames. The morphology at the Mardyke and tributary crossings could be affected, along with long term loss of flood plain and a potential impact on flood defences. The tunnel portals would be located in Flood Zone 2 on both sides of the River Thames. It is considered that a Flood Risk Assessment and appropriate design of the structures could

inform the design of proven mitigation measures to reduce impacts to these features.

#### *Air Quality and Noise*

- 10.2.81 For this route option there is predicted to be an overall increase in emissions on Defra's PCM modelled links leading to an overall worsening of air quality however, this is unlikely to impact the date on which Defra has reported that the zone will be compliant. At this stage it is not possible to determine whether this route option would lead to a significant impact on air quality at sensitive receptors. From a noise perspective there could be potential increase in levels in an existing low noise area. This could impact upon sensitive receptors within the area, including the residential areas of Grays, Chadwell St Mary and Tilbury located along the existing A1089.

### **Route Option C3 - Immersed Tube Tunnel**

#### *Landscape*

- 10.2.82 Effects would be very similar to those reported for the bored tunnel, refer to the landscape text above.

#### *Biodiversity*

- 10.2.83 Effects would be very similar to those reported for the bored tunnel although the immersed tube tunnel would have direct effects on the Ramsar, SSSI, recommended MCZ and potential indirect effects on the SPA as a result of hydrodynamic changes. This would need to be considered further through a Habitats Regulations Assessment and be informed by further survey work and hydrodynamic modelling.

#### *Historic Environment*

- 10.2.84 Effects would be very similar to those reported for the bored tunnel, refer to the historic environment text above.

#### *Water Environment*

- 10.2.85 Effects would be very similar to those reported for the bored tunnel, refer to the water environment text above.

#### *Air Quality and Noise*

- 10.2.86 Effects would be very similar to those reported to the bored tunnel, refer to the air quality and noise text above.

### **Route Option C3 - Bridge**

#### *Landscape*

- 10.2.87 Effects would be similar to the tunnelled options except that the bridge crossing may impact upon the local landscape features due to the size, embankment profile and location close to several historic features, particularly creating setting issues and a landscape barrier between the scheduled monuments, Tilbury Fort and Coalhouse Fort.

### *Historic Environment*

- 10.2.88 Effects would be similar to the tunnelled options although as noted in the landscape section above there is potential for effects on scheduled monuments along the river.

### *Biodiversity*

- 10.2.89 Effects north and south of the crossing would be the same as the tunnelled options. The bridge would impact upon the European and nationally designated sites along the Thames Estuary (Ramsar, SPA and SSSI) and the recommended Marine Conservation Zone (rMCZ) through permanent placement of structures within the watercourse and designated sites. Mitigation and compensatory habitat may be required to mitigate the impact upon features of these sites and this would need to be considered further through the Habitats Regulations Assessment.

### *Water Environment*

- 10.2.90 This route option could create potential long term impacts on Mardyke (and tributaries) north of the River Thames. The morphology at the Mardyke and tributary crossings could be affected, along with long term loss of flood plain and a potential impact on flood defences. The bridge embankments would be located in Flood Zone 2 on both sides of the River Thames. A Flood Risk Assessment and appropriate design of the structures could inform the design of proven mitigation measures to reduce impacts to these features.

### *Air Quality and Noise*

- 10.2.91 Effects would be similar to those reported for the tunnelled options, refer to the text above.

## **Route Option C4 - Bored Tunnel**

### *Landscape*

- 10.2.92 South of the River Thames, this route option would impact upon the Kent Downs AONB at the junction with the M2/ A2. The route is entirely within green belt designated land and is predominantly agricultural with the scattered small settlements of Shorne, Higham and the western suburbs of Rochester. The route is in close proximity to the Shorne Conservation Area and also has a direct impact upon Cobham Park Registered Park and Garden through land-take. It is not envisaged that the tunnel or associated portals would have any long term impact to the local landscape. North of the River Thames, the route continues through Green Belt and close to the settlements of East Tilbury, Orsett, Horndon-on-the-Hill and Stanford Le Hope which are recognised as being locally distinctive. The route continues north, through agricultural land before joining the existing A127 close to West Horndon. Mitigation and sensitive landscaping techniques could be used to reduce setting and visual impacts to these receptors.

### *Biodiversity*

- 10.2.93 This route option would directly affect nationally important Great Crabbles Wood SSSI at the junction with the A2 and eleven nationally important areas of ancient woodland throughout the entire route. The bored tunnel option would be located south of the Thames Estuary and Marshes Ramsar/ SPA

and SSSI although there is the potential for this route option to impact upon functionally linked land but this would need to be confirmed through survey and further desk study work. This would also be informed by further engagement with Natural England. North of the River Thames the tunnel portals could be located within functionally linked land (to the European sites) and so mitigation may be required to reduce impacts in this location.

#### *Historic Environment*

- 10.2.94 For this route option there would be no direct effects on heritage assets south of the River Thames. There are several Grade II listed buildings in proximity to the route, particularly around Shorne and several included within the Shorne Conservation Area. North of the River Thames, the tunnel portal is located in close proximity and may have setting impacts to three scheduled monuments, the Second World War anti-aircraft battery at Bowaters Farm, Tilbury Battery and Coalhouse Fort battery and artillery defences. As the route continues northward there are several Grade II listed buildings in proximity, which may experience setting impacts. There are Grade II listed buildings within the proposed junction footprint with the A13, south of Horndon-on-the-Hill and within the junction footprint at the A127, north of West Horndon which would be directly impacted. There is also significant potential to impact upon undiscovered archaeological remains and there would be a need for comprehensive assessment and evaluation.

#### *Water Environment*

- 10.2.95 The junction with the A2 is within SPZ2 and could impact upon the groundwater system. The tunnel portal on the northern bank would be located in Flood Zone 2 and the route passes through SPZ2 and SPZ3 close to Linford. This route option could create potential long term impacts on Mardyke (and tributaries) north of the River Thames. The morphology at the Mardyke and tributary crossings could be affected, along with long term loss of flood plain and a potential impact on flood defences. A Flood Risk Assessment and appropriate design of the structures could inform the design of proven mitigation measures to reduce impacts to these features.

#### *Air Quality and Noise*

- 10.2.96 For this route option there is predicted to be an overall increase in emissions on Defra's PCM modelled links leading to an overall worsening of air quality however, this is unlikely to impact on the date Defra has reported the zone will be compliant. At this stage it is not possible to determine whether this route option would lead to a significant impact on air quality at sensitive receptors. From a noise perspective there could be potential increase in levels in an existing low noise area. This could impact upon sensitive receptors within the area, including the residential areas of Shorne, Higham, East Tilbury, Linford, Horndon-on-the-Hill and Bulphan.

### **Route Option C9 - Bored Tunnel**

#### *Landscape*

- 10.2.97 South of the river, and at the river crossing, the effects on landscape would be the same as for Route Option C2 with a bored tunnel. North of the river there would be changes to landscape character associated with new road



infrastructure that would be needed to ensure integration of the scheme into the landscape and to reduce potential visual intrusion for visual receptors.

#### *Biodiversity*

- 10.2.98 South of the river, and at the river crossing, the effects on biodiversity would be the same as the bored tunnel for Route Option C2. North of the river there would also be effects on a number of areas of ancient woodland along the A127.

#### *Historic Environment*

- 10.2.99 South of the river, and at the river crossing, the effects on historic environment would be the same as for Route Option C2. North of the river there would be potential for direct or setting impacts on listed buildings and potential to impact on a corridor of heritage significance west of East Tilbury. There would also be minor setting impacts on a Registered Park and Garden that lies adjacent to the A127.

#### *Water Environment*

- 10.2.100 The effects reported for the water environment section for Route Option C2 bored tunnel are comparable to those for Route Option C2. North of the river there is the potential for minor impacts to Mardyke and its tributaries.

#### *Air Quality and Noise*

- 10.2.101 For this route option there is predicted to be an overall increase in emissions on Defra's PCM modelled links leading to an overall worsening of air quality. However, this is unlikely to impact the date on which Defra has reported that the zone will be compliant. At this stage it is not possible to determine whether this route option would lead to a significant impact on air quality at sensitive receptors. From a noise perspective there could be potential increase in levels in an existing low noise area.

### **Route Option C9 - Bridge**

#### *Landscape*

- 10.2.102 South of the river and at the river crossing the effects on landscape would be the same as for Route Option C2 with a bridge. North of the river there would be changes to landscape character associated with new road infrastructure that would be needed to ensure integration of the Scheme into the landscape and to reduce potential visual intrusion for visual receptors.

#### *Biodiversity*

- 10.2.103 South of the river and at the river crossing the effects on biodiversity would be the same as the bridge for Route Option C2 with the potential for significant adverse biodiversity effects associated with the in-river structures. North of the river there would also be effects on a number of areas of ancient woodland along the A127.

#### *Historic Environment*

- 10.2.104 South of the river, and at the river crossing, the effects on historic environment would be the same as for Route Option C2 with likelihood of

setting impacts on historic structures along the banks of the River Thames. Impacts north of the river would be as described above for the bored tunnel.

*Water Environment*

- 10.2.105 The effects reported for the water environment section for Route Option C2 bridge are comparable to those for Route Option C2.

*Air Quality and Noise*

- 10.2.106 The air quality and noise results would be the same as for Route Option C9 bored tunnel.

**Route Option C9 - Immersed Tube**

*Landscape*

- 10.2.107 South of the river, and at the river crossing, the effects on landscape would be the same as for Route Option C2. North of the river there would be changes to landscape character associated with new road infrastructure that would be needed to ensure integration of the scheme into the landscape and to reduce potential visual intrusion for visual receptors.

*Biodiversity*

- 10.2.108 South of the river, and at the river crossing, the effects on biodiversity would be the same as the immersed tunnel for Route Option C2 with potentially significant adverse effects on the designated sites and their species. North of the river there would also be effects on a number of areas of ancient woodland along the A127.

*Historic Environment*

- 10.2.109 South of the river, and at the river crossing, the effects on historic environment would be the same as for Route Option C2. Impacts north of the river would be as described above for the bored tunnel.

*Water Environment*

- 10.2.110 The effects reported for the water environment section for Route Option C9 immersed tunnel are comparable to those for Route Option C2. North of the river there is the potential for minor impacts to Mardyke and its tributaries.

*Air Quality and Noise*

- 10.2.111 The air quality and noise results would be the same as for Route Option C9 bored tunnel.

**Route Option C19**

- 10.2.112 The effects of Route Option C19 would be the same as those reported for Route Option C9 at the crossing of and north of the River Thames. The main differences arise south of the River Thames from the start of the route at the M2/ A2 junction up to the river crossing.

*Landscape*

- 10.2.113 The route option would intrude slightly into the Kent Downs AONB and there is the potential for infrastructure outside of the AONB to be visible from receptors within it.

*Biodiversity*

- 10.2.114 There would be a direct impact on the Great Crabbles Wood SSSI and impacts on nationally important ancient woodland surrounding Shorne. There would also be impacts on local wildlife sites.

*Historic Environment*

- 10.2.115 There is the potential for setting impacts on a number of Listed Buildings although direct impacts are considered unlikely.

*Water Environment*

- 10.2.116 There are no significant water environment effects.

*Air Quality and Noise*

- 10.2.117 Effects would be as reported for Route Option C9.

**C**Variant*Landscape*

- 10.2.118 This route option features the widening of the existing A229, which lies predominantly within a rural landscape and is almost entirely located within the Kent Downs AONB. The surrounding landscape is of an agricultural nature with the settlements of Rochester to the north and Sandling to the south. However, road infrastructure is an intrusive feature of the existing landscape.

*Biodiversity*

- 10.2.119 The new junction arrangement at the northern connection with the M2 would have a major direct impact on the nationally important Bridge Woods ancient woodland. The existing A229 is located close to the Wouldham to Detling Escarpment SSSI which could be directly impacted by bridge extension works. In addition, the North Downs Woodlands SAC could be indirectly impacted due to decrease in air quality through increased traffic flow and it is already identified as a site that is very sensitive to nitrogen deposition.

*Historic Environment*

- 10.2.120 This route option could have setting impacts to three scheduled monuments: Kit's Coty House Long Barrow, Little Kit's Coty House Megalithic Tomb and White Horse Stone. There could be setting impacts on two Grade II listed buildings at Sandling and Tyland Farmhouse on Chatham Road.

*Water Environment*

- 10.2.121 This route option could have potential impacts on locally important water resources, however, it is assumed that these impacts could be mitigated.

*Air Quality and Noise*

For this route option there is predicted to be an overall reduction in emissions on Defra's PCM modelled links leading to an overall improvement in air quality on these links. This would mean the scheme is low risk in

relation to impacting on compliance. At this stage it is not possible to determine whether this route option would lead to a significant impact on air quality at sensitive receptors. From a noise perspective there could be potential increase in levels in an existing low noise area. This could impact upon sensitive receptors within the area, including the scattered residential properties throughout the route and the settlements at Sandling and Blue Bell Hill.

## 11 Engineering Appraisal

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### 11.1 Introduction

- 11.1.1 As the issues covered in this engineering appraisal section were not in general considered to be differentiators in the overall appraisal of the longlist route options this section only provides a high level summary comparison for options at Location A and Location C and does not provide separate appraisals for individual route options.

### 11.2 Buildability and Construction Impacts

#### Location A

- 11.2.1 The construction of the on-line route options at Location A (Route Options A1 and A4) would be challenging and would have the potential to cause significant disruption both to existing road users and residents and businesses in the local area. This is due to the constrained nature of the existing road within an urban environment.
- 11.2.2 A significant part of the works required would involve additions and modifications to the existing highway which as discussed in Section 2.3 carries very high volumes of traffic. The work would have to be carried out whilst maintaining the existing number of traffic lanes at peak times and there would be limited opportunities for lane closures. To achieve this it would be necessary to implement narrow lanes and impose a reduced temporary speed limit (probably 40mph). The available working space would be limited. A large number of traffic management phases and switches would be required to carry out the works. Even so, this would all result in significant disruption and delay to existing traffic leading to congestion and extended journey times.
- 11.2.3 Due to the urban environment surrounding the existing road there the construction of the new works at Location A would also have an impact on local residents and businesses. There would be potential impacts from construction noise and emissions such as dust which would have to be strictly controlled through the construction contract and would have an impact on the programme and cost of construction.
- 11.2.4 Routes used by construction traffic would also need to be strictly controlled to avoid the use of unsuitable routes through residential areas.
- 11.2.5 The construction of Route Option A1 (bridge) would also have an impact on users of the river and the adjacent jetties. These impacts would have to be managed and controlled through liaison with the Port of London Authority (PLA) and the owners and operators of the jetties.
- 11.2.6 The construction of Route Option A4 (bored tunnel) would generate a large amount of spoil for disposal. The handling of this material in this constrained area would be difficult and would need to be strictly managed and controlled.

#### Location C

- 11.2.7 A significant proportion of Route Options C2, C3, C9 and C19 would be “green field” and would therefore be easier and less disruptive to construct

than the route options at Location A. However, there would still be challenges and issues to address.

- 11.2.8 All of the route options would require junctions with existing highways (A2, A13 and M25). As discussed in section 2.3 all these routes carry high volumes of traffic. Construction of the junctions with these roads would therefore be subject to similar constraints to those described for the route options at Location A above. However, the impacts and resulting disruption would be more limited due to the localised nature of the works. The sites are also less constrained than the existing A282 giving greater scope to limit disruption. For example, it is proposed that the junction with the A2 on Route Options C2, C3 and C9 would be constructed by constructing an off-line diversion of the A2.
- 11.2.9 Route Options C3 and C9 involve the on-line widening of lengths of the A1089 and A127 which would require traffic management, lane and speed restrictions leading to potential disruption and delays to traffic.
- 11.2.10 As the area is generally more rural than at Location A there would be less impact on communities and businesses but there would still need to be controls and construction noise close to residential areas and the use of unsuitable rural roads by construction traffic.
- 11.2.11 The construction of a bridge or immersed tube tunnel would again have impacts on river users which would have to be controlled through liaison with PLA. However, the river is wider in this location and there are no jetties immediately adjacent to the site. On the other hand the vessels using the river at this location are larger than those at Location A.
- 11.2.12 The construction of a bored tunnel would again produce large volumes of material for disposal (including from the deep cutting south of the river). However, the space available for handling and processing this material is not constrained in the way it is at Location A.

## **11.3 Safety**

- 11.3.1 The following safety review of the various route options generally identifies the negative impacts of each which would need to be mitigated to a level that is reasonably practicable, however there would be positives that would more than negate some of these issues e.g. improved capacity, improved junction layouts, improved technology provision etc thereby ensuring that whichever route option is developed there would be a positive outcome towards safety for all populations.

### **Location A – General**

- 11.3.2 Location A route options involve widening and making use of the existing road which is highly constrained and includes a number of sub-standard features as well as closely spaced junctions with large weaving movements. The final Location A route option layout would have a varying number of lanes from 4 to 6 at the crossing, which would provide operational challenges as the design progresses. A specific assessment has been undertaken at the crossing in the form of a safety audit which has identified that there are no significant operational and safety concerns going forward.

### **Route Options A1 and A4**

- 11.3.3 Route Options A1 and A4 would not allow full access to the crossing from some access points especially from Junction 1a. During periods when the new crossing is closed due to an incident or extreme weather. Vehicles would not be able to access the crossing without following a diversion which would increase delays on the local network and lead to potential safety issues.
- 11.3.4 At Junction 1a northbound exit arm from the Littlebrook interchange the left turn radius is very tight for vehicles entering the north eastern exit arm of the Littlebrook interchange slip road from the Bridge Industrial Park this is combined with a short merge length onto that slip road. There is a significant amount of HGVs using this junction which would include foreign left hand drive vehicles with a reduced visibility for observing traffic whilst they are merging, resulting in possible side swipe type collisions.
- 11.3.5 At Junction 1a southbound entry arm to the Littlebrook interchange the southbound diverge leads into a 38.5m loop which tightens up further at the roundabout. This reduction in radius could lead to HGVs overturning. This is substandard as TD22/06 Table 4/2 states 50m minimum for a loop leading off a mainline APTR. Also the entry angle from the southbound exit slip road from the Thames crossing onto the Littlebrook interchange is approaching 90°, there would be potential when traffic flows are light for drivers to misinterpret the junction and make a left turn from the gyratory and go the wrong way up the slip road resulting in potential head-on collisions on a high speed road.
- 11.3.6 Between Junctions 1b and 1a both carriageways with the removal of the hard shoulder there would be a need to provide provision for emergency stops, this could result in more frequent lane closures increasing delays resulting in late lane changes which could lead to side swipes and rear-end shunt collisions.

### **Route Option A1/ A4 with Route Option A15**

- 11.3.7 As the A126 would be by-passed signing for drivers wishing to use the junction with the A13 eastbound would have to be told in advance of the Dartford crossing to use the appropriate lanes, this would add to the amount of legends on the direction signing.
- 11.3.8 The link road to the eastbound A126 and Junction 30 would also have to be signed in advance of the Dartford crossing to use the appropriate lanes as they cannot be accessed from the old crossing.
- 11.3.9 Junction 31 would also have to be signed in advance of the Dartford crossing to use the appropriate lanes as they cannot be accessed from the old crossing.
- 11.3.10 The three issues described above could lead to problems co-locating the direction signing with the technology signs e.g. MS4 signs and the directions signs being too small to read clearly due to a reduced 'x' height, resulting in late lane changes and possible side swipe type collisions.
- 11.3.11 Additional intelligent direction diversionary signing would be necessary before the Dartford crossing in the event of a closure to the western most

tunnel or bridge. In the event of a complete closure of this facility vehicle would not be able to access Junction 31, 30 or the eastbound A126 link road. Alternatives would have to be signed, this intelligent/ diversionary signing may have to extend to Junction 29 to allow for 'U' turning traffic, resulting in late lane changes and possible side swipe type collisions.

- 11.3.12 Short distances between diverges would make signing difficult. Some signs would have to be non-standard requiring sign authorisation from Highways England. This is primarily due to not being able to get the compliant  $\frac{1}{2}$  or  $\frac{1}{4}$  m and 1 or  $\frac{3}{4}$  m signs at the correct location and there is more than one junction that would have to be indicated from each sign, resulting in late lane changes and possible side swipe type collisions.

### **Route Option A1/ A4 with E1+9**

- 11.3.13 The link road to the eastbound A126 would also have to be signed in advance of the Dartford crossing to use Junction 31 as they could not be accessed from the old crossing which could lead to problems co-locating the direction signing with the technology signs e.g. MS4 signs and the directions signs being too small to read clearly due to a reduced 'x' height, resulting in late lane changes and possible side swipe type collisions.
- 11.3.14 Short distances between diverges would make signing difficult. Some signs would have to be non-standard requiring sign authorisation from Highways England. This is primarily due to not being able to get the compliant  $\frac{1}{2}$  or  $\frac{1}{4}$  m and 1 or  $\frac{3}{4}$  m signs at the correct location and there is more than one junction that would have to be indicated from each sign, resulting in late lane changes and possible side swipe type collisions.
- 11.3.15 Additional intelligent direction diversionary signing would be necessary before the Dartford crossing in the event of a closure to the western most tunnel or bridge. In the event of a complete closure of this facility vehicles would not be able to access Junction 30 or Junction 31, alternatives would have to be signed, this intelligent/ diversionary signing may have to extend to Junction 29 to allow for 'U' turning traffic, resulting in late lane changes and possible side swipe type collisions.
- 11.3.16 On the Junction 30 bypass link between A282 and A13 northbound the speeds on the northbound connector road between the A282 and the A13 could exceed the design speed, resulting in possible rear-end shunt and late lane change type collisions due to drivers driving above the speed limit.

### **Location C – General**

- 11.3.17 Since the route options in Location C are generally new build then the highway design should meet or closely meet current design standards, therefore the safety issues should be relatively minor. Operationally the main feature would be the river crossing for whichever option is chosen. There would not be any weather related closures of any tunnel options, however high level bridge crossings would be subject to high winds and potential closure would thereby be more likely and diversions to the existing Dartford crossings to the west would be required. However, it is currently assumed that any new bridge at Location C would have wind shielding which should mostly mitigate this issue.



### **Route Options C2, C3 and C9**

- 11.3.18 During periods when the new crossing is closed due to incident or extreme weather. Vehicles would not be able to access the crossing without following a diversion this would need to be clearly identified within a signing strategy for the scheme to avoid delays and potential safety issues on the local network.

### **Route Option C19**

- 11.3.19 Short distances between diverges at Junction 1 of the M2 would make signing difficult, some signs would have to be non-standard requiring sign authorisation from Highways England. This is primarily due to not being able to get the compliant  $\frac{1}{2}$  or  $\frac{1}{4}$  m and 1 or  $\frac{3}{4}$  m signs at the correct location and there is more than one junction that would have to be indicated from each sign, resulting in late lane changes and possible side swipe type collisions.

## **11.4 Operational Appraisal**

### **River Crossing - Bridge**

- 11.4.1 Other than regular inspections, repairs and maintenance work, the bridge does not have any daily normal operating procedures requiring input from the Maintaining Agent.
- 11.4.2 The bridge may be normally operated (used by vehicular and pedestrian traffic to maximum load levels) on a daily basis with no full time on site or off site input from the Maintaining Agent, under all normal weather conditions, 24 hours a day. High sided vehicles may be restricted from using the bridge during extreme wind events but this would be dependent on the provision and type of wind shielding. This will be investigated further as the design develops.
- 11.4.3 It is envisaged that there would be no restrictions applicable when applying lane closures. Lane closures for repair and maintenance work would be planned activities at the discretion of the Maintaining Agent.
- 11.4.4 Inspections, maintenance and repairs required would be carried out as part of normal operating procedure (refer to section 11.4).

### **River Crossing - Tunnels**

- 11.4.5 Bored and immersed tunnel solutions explored for the Lower Thames Crossing would provide a safe and effective means of crossing under the River Thames through a traffic route that has been designed to maintain the same characteristics of the approach roads where possible. Bored tunnels have been considered at Locations A and C, and immersed tunnels at Location C only. Each bore of the bored tunnels and cell of the immersed tunnels would contain a two lane carriageway and emergency walkways.
- 11.4.6 Tunnels would be designed to meet requirements set up by the *Road Tunnel Safety Regulations 2007 (RTSR)*, BD78/99 Design of Road Tunnels and the Client Scheme Requirements. Safety provisions and equipment would be provided and systems implemented to facilitate safe operation of the crossing. All the tunnels solutions considered at this stage have uni-directional traffic through each bore or cell. It has been assumed at this stage that not even during maintenance periods would the remaining bore or

cell operate with bi-directional traffic. The tunnels have been designed for a traffic forecast at 15 years after opening. In view of the national significance of these tunnels, it is suggested that an extended design horizon be considered.

- 11.4.7 The design speeds for roads in the tunnels are 85kph for Location A and 120kph for Location C. HGVs and DGVs would be allowed to cross freely unescorted during normal operation; oversize and special transports would have to report before attempting to cross; overheight vehicle detection systems would be in place on the tunnel approaches at both locations as a cost effective form of asset protection. It is assumed that at Location A, HGVs and DGVs would only be allowed to use the new tunnels as a means to reduce the risk, thereby freeing the existing Dartford Tunnels which would be used only by cars. However, it would still be necessary to retain the existing traffic management cell arrangement (refer to Section 2.23) to control access to the existing east tunnel by unauthorized or restricted vehicles. This tunnel would become lanes 5 and 6 of the new northbound carriageway. It would also be necessary to implement a similar system north of the river to control southbound restricted traffic entering the existing east tunnel which would become lanes 5 and 6 of the new southbound carriageway. This would be required for both the bored tunnel option (A4) and the bridge (A1).
- 11.4.8 The Traffic Control Centre would be responsible for the monitoring and management of the traffic during normal operation regimes, and during emergency conditions to ensure a rapid and coordinated response from the emergency services. Longitudinal ventilation has been assumed at this stage for all the tunnel solutions, hence traffic would not be allowed to build up inside the tunnels and the Control Centre would have to manage this. In normal free-flowing conditions at Location A, northbound traffic would pass through both new tunnels and the existing west tunnel. Southbound traffic would pass through the existing east tunnel and over the existing QEII Bridge. At Location C northbound traffic would pass through the west tunnel and southbound traffic through the east tunnel.
- 11.4.9 During emergency situations the Control Centre would need to coordinate not only the new crossing but the nearby network as well to ensure the best response. Response would vary depending on the situation but potentially could include a combination of the following:
- New traffic entering the tunnels would need to be prevented.
  - At the same time the tunnels would need to be cleared of traffic.
  - Emergency services would need to be informed.
  - Any non-automatic emergency systems would need to be activated. These would be achieved partially with lane closure signs; variable message signs; and manual control of the ventilation system.
- 11.4.10 In the case of the bored tunnel, people would be evacuated through the non-incident bore which would also be used by emergency services to reach the affected area, either crossing to the incident bore on foot through the pedestrian cross passages or through the vehicular cross passages.

11.4.11 For the immersed tube road users would be evacuated through the central cell which is located between the two traffic cells. In both cases users are expected to reach emergency doors and phones using the emergency walkways.

11.4.12 Some maintenance activities such as minor repairs, and routine breakdown recoveries for example, may need lane closures. However full tube closure would be required for maintenance or severe incidents; the Control Centre operator would need to coordinate planned/ unplanned closure with the rest of the road network in the area.

## 11.5 Maintenance and Repair Strategy for Civils Infrastructure

11.5.1 The overall purpose of inspection, testing and monitoring is to check that highway structures are safe for use and fit for purpose and to provide the data required to support effective maintenance management and planning.

11.5.2 Inspections as summarised in **Table 11.1**, and where required testing and monitoring, should:

- Observe and provide information on the current condition, performance and environment of a structure, e.g. severity and extent of defects, material strength and loading.
- Inform analyses, assessments and processes, e.g. change in condition, cause of deterioration, rate of deterioration, identification and quantification of maintenance needs, effectiveness of maintenance and structural capacity.
- Compile, verify and maintain inventory information, e.g. structure type, dimensions and location.

**TABLE 11.1 - SUMMARY OF INSPECTION TYPES WITH NOMINAL INTERVALS**

| Inspection Type                             | Nominal interval                                                                                                                                         | Description                                                                                                                                                                                                                                                                                                          |
|---------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Safety inspection (or routine surveillance) | At frequencies, not exceeding one month, which ensure timely identification of safety defects and reflect the importance of a particular route or asset. | Regular visual inspections to identify defects that are likely to create a danger to the public or staff or lead to unnecessarily high maintenance costs or disruption to traffic. These are carried out by cursory inspection from a slow moving vehicle or on foot.                                                |
| General inspection                          | 2 years                                                                                                                                                  | General inspections comprise a thorough visual inspection of representative parts of the civil infrastructure involving visual inspection from the ground level.<br>Report on the physical condition of all civil infrastructure elements visible from the ground level.                                             |
| Principal inspection                        | 6 years                                                                                                                                                  | A Principal inspection will comprise a close and detailed examination of all accessible parts of the tunnel involving close visual examination, within touching distance; utilising as necessary, suitable inspection techniques.<br>Report on the physical condition of all inspectable civil infrastructure parts. |

| Inspection Type    | Nominal interval          | Description                                                                                                                                       |
|--------------------|---------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------|
| Special inspection | Programmed or when needed | Detailed investigation (including as required inspection, testing and/ or monitoring) of particular areas of concern or following certain events. |

- 11.5.3 The purpose of maintenance planning and management is to enable the maintenance manager to develop and implement cost effective and sustainable maintenance plans while delivering the required asset performance and levels of service. The maintenance strategy would optimise opportunities presented by planned closures of the structures where needed and avoid unplanned closures where possible.
- 11.5.4 To keep the structure in a good state of repair and to avoid the need to replace items and employ specialist services it is necessary to frequently perform basic maintenance. Routine maintenance is minor work carried out on a regular or cyclic basis that helps to maintain the condition and functionality of the structures and reduce the need for other maintenance works.
- 11.5.5 Preventative maintenance (planned or unplanned) is work carried out to keep the infrastructure open and safe to use and maintain the condition of the structure by protecting it from deterioration or slowing down the rate of deterioration. By timely intervention, preventative maintenance reduces the need for essential work and/ or the likelihood of essential work arising prematurely in the future.
- 11.5.6 Major overhauls and refurbishment of elements such as tunnel fabric are undertaken on a basis that ensures the long term preservation of investment by acting on the agreed recommendations of the Principal Inspection reports
- 11.5.7 All of the route options being considered involve major items of civil infrastructure and would require comprehensive monitoring, inspection and maintenance plans to be developed if they are to remain in service for their expected design life and beyond. The route options involve extensive lengths of new highways, junctions, earthworks, bridges, tunnels drainage and other items of highways infrastructure including complex mechanical and electrical systems. All of these would require a programme of maintenance and periodic renewals. The maintenance requirement for the river crossing would be the largest and costliest component of the scheme. The general maintenance assessment requirements for the different types of principle structure forming the river crossing (bridge, bored tunnel or immersed tunnel) are discussed further in the paragraphs below.

### **River Crossing - Bridge**

#### **Access**

- 11.5.8 A range of facilities for inspections and maintenance of the structure will be considered as part of the route options development. These will include fixed access facilities throughout the bridge such as walkways, stairs, ladders and lifts in the towers. Due to the length and height of the bridge, motorised access will be considered for access to the underside of cable-stayed deck,

and specialist platforms for accessing the cables and external tower surfaces.

- 11.5.9 The strategy for the facilities is to ensure that for routine and preventative inspection and maintenance activities, as far as possible lane closures are avoided and disruption to traffic is minimized. Easy and safe access for inspection and maintenance personnel must be ensured.

***Wind and Structural Health Monitoring System (WASHMS)***

- 11.5.10 Structural health monitoring system are commonly installed on structures of such scale and strategic importance. These supplement the inspection and maintenance regime. The system should be designed such that it would enable monitoring of the bridge to provide feedback on the following:

- Carry out design and construction verification for selected primary structural elements.
- Verify loadings from strong winds, temperature, traffic, etc.
- Fatigue, vibration, force redistribution and displacement monitoring.
- Provide information for safety evaluation.
- Provide necessary information for maintenance planning.
- Provide traffic counting for actual numbers of vehicles and overload control.

- 11.5.11 The system would be able to provide assistance to the bridge maintenance program, in order to optimise the resources used for such works (e.g. minimize maintenance costs).

- 11.5.12 In order to obtain the balance between the quantity of data collected and the functionality described above, all measurement types would need to be carefully evaluated to reduce the number of sensor positions as far as possible only covering the most important and to assess the need for automatic data acquisition.

***Wind Shielding***

- 11.5.13 It is envisaged that wind shields would be provided along the edges of the high bridge to reduce disruption of traffic operation due to wind to increase the resilience of the crossing.

***Planned Cable Replacement***

- 11.5.14 The design should permit the removal and replacement of the stay cables and any cables used as tension ties for anchoring of the side spans. For this scenario at least one lane of traffic per carriageway would normally remain open during replacement operations. The location of the adjacent lanes may be chosen to lie anywhere between the vehicle barriers as required to facilitate the replacement operation.

***River Crossings - Tunnels***

- 11.5.15 Tunnel maintenance aims to sustain the tunnel assets in a safe and usable condition during the life of the structure and to ensure safe travelling of public and personnel, whilst obtaining best value for money. Maintenance

activities should be planned when possible to avoid traffic delays and minimise any adverse environmental impacts. Inspection frequencies and maintenance requirements would be in accordance with DMRB (BA72 *Maintenance of Road Tunnels* and BD78 *Design of Road Tunnels*) and procedures would comply with the RTSR and the European Directive 2004/54/EC. Typically maintenance activities can be divided into three types: planned or preventive maintenance; unplanned or reactive maintenance; and pre-planned ad hoc major repairs, replacements and/ or improvements. The tunnel maintenance strategy would be required to avoid unplanned tunnel closures through preventive maintenance and optimisation of tunnel closures. It needs to be noted that even when preventive maintenance is carried out in a very well structured way, the operator cannot avoid corrective interventions. Any scheduled closure should avoid peak hours, holidays and any other significant events, in order to cause the minimal disturbance to road users.

- 11.5.16 Maintenance requirement for the approach ramps and cut and cover sections would be as typical for such structures, as would the requirements for maintenance of the external facilities (control room, power supplies, switchgear, staff facilities etc).
- 11.5.17 In addition to the common maintenance activities inside the tunnel for the different solutions presented in this report, outside the immersed tunnel, and in areas exposed to river flows, the protective layer of rock armouring above the tunnels would require periodic checks to ensure that it has not been disturbed in any way.

## **11.6 Maintenance and Repair Strategy for Road Side Technology**

- 11.6.1 Locations A and C are different types of road and therefore the maintenance considerations for each option have been outlined separately below.

### **Location A**

- 11.6.2 The implementation of Location A includes all-lane running in the proposed smart motorway sections between Junctions 2 and 1a of the M25. All lane running scenarios have more complex maintenance access arrangements than other motorways, due to the lack of a hard shoulder. For example, access to equipment often requires road space booking and permit to work systems for maintenance access, together with night-time working. The presence of existing all lane running sections on the M25 means that the local technology maintainers are familiar with this kind of maintenance access arrangement, and as such the addition of smart motorways as part of this project should be relatively straightforward.
- 11.6.3 To minimise maintenance access restrictions it may be possible, as is the case with some existing technology infrastructure, to place technology equipment such that it can be accessed from outside on the motorway boundary. To enable this arrangement, one issue which would need to be addressed is responsibility for maintenance of the soft estate around cabinet locations. Area maintainers have a remit to undertake grass cutting and control of vegetation on the highway estate, and to allow maintenance

access this needs to include locations outside the motorway boundary when cabinets or access infrastructure are located there.

- 11.6.4 Given the timescales involved with the project, it is likely that the use of remote monitoring of roadside equipment will have become more commonplace by the time the scheme is implemented. Such systems have the potential to reduce the need for roadside working by providing greater fault diagnosis and fix capabilities to remote operators. Use of these systems should be explored as part of future phases of the project in order to minimise the need to roadside maintenance visits.

### **Location C**

- 11.6.5 Location C comprises of the installation of a new section of dual carriageway road with a reduced width hardstrip and lay-bys. The lay-bys would be constructed in accordance TD 69/07, which indicates approximately 2.5km spacing between lay-bys.
- 11.6.6 It is envisaged that the lay-bys would be used to access the technology equipment. Where possible technology equipment would be located in, or in close proximity to, the lay-bys. Where this is not possible access paths would be required with road restraint barrier in place to protect the Maintainers; consideration would also be given to locating equipment so that it can be accessed outside of the highways boundary (similar to Location A).

### *Maintenance Strategy*

- 11.6.7 Whichever option is taken forward a strategy would be implemented. The strategy would take into account the future requirements for improving maintenance access and remote access to repairing technology. The current approach used on the M25 north and south of the crossing would be the basis of the maintenance strategy, which would be refined to further improve methods of access and repair. This would cover the following areas:

- **Maintenance Philosophy**

To ensure that maintenance access to the technology is incorporated at the Operational concept stage and to incorporate the existing requirements and the new ALR for both Locations A and C.

- **Maintenance Task**

This would consist of reactive and proactive maintenance tasks, both would be determined by the process already established by the Maintainer and the technology manufacture. With the development of technology it is the intention to further develop the remote fault analysis and repair.

- **Traffic Management**

Reduce the need to access technology and improve the access and traffic management to be in place during existing closures for other maintenance.

- **Means of Access**

For each of the options the access considerations are listed above. For the crossing itself, it is envisaged that access to the crossing

would be based on the same principles as existing ALR sections using a permit system to access the network.

## **11.7 Traffic Control Technology Appraisal**

- 11.7.1 The technology requirements within Locations A and C differ based on the type of road proposed.
- 11.7.2 Location A would extend the smart motorways (SM) on the M25 to the A282 which is at present not a Motorway. The proposal would be to upgrade technology provision on the A282 based on the criteria outlined in Interim Advice Note (IAN) 161/13 - *Managed Motorways - All Lane Running*. At Location A there may be buildability issues with providing a smart motorway on this section of existing motorway which are being investigated and will be further considered during the next stage of design development. **Figure 11.1** illustrates a typical smart motorway scheme layout.
- 11.7.3 Location C provides a new section of dual carriageway with two lanes in each direction plus hardstrips. Consideration has been given to the technology provision provided on a dual carriageway and the recommendations are outlined in this section.

### **Location A - ITS-Traffic Loops, VMS, CCTV**

#### **VMS**

- 11.7.4 Variable message signs (VMS) would be provided and be capable of displaying the following information:
- Text messages
  - Advisory speed limits
  - Mandatory speed limits
  - Lane control aspects
  - Pictograms
- 11.7.5 Advanced Motorway Indicators (AMIs) would be required to be mounted on gantries for lane control purposes. Motorway Signal Mk 4 (MS4) message signs would also be required to act as repeater signs to reinforce the gantry mounted signals in providing lane control and speed limit control.
- 11.7.6 The diagram below provides an overview of a typical smart motorways scheme, showing gantry mounted and cantilever mounted signs and signals:



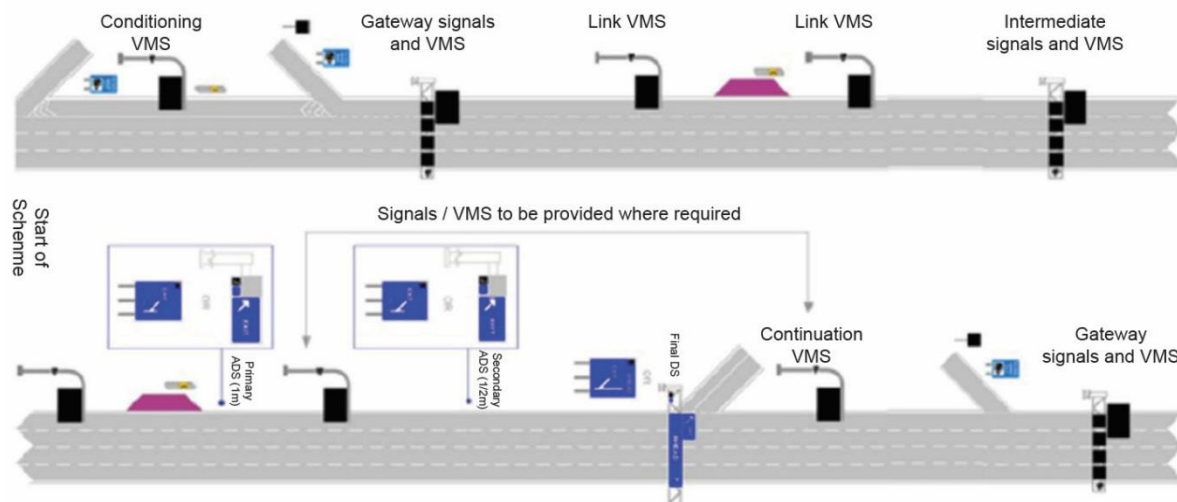


FIGURE 11.1 - TYPICAL SMART MOTORWAY SCHEME

### CCTV

- 11.7.7 Pan, tilt, zoom (PTZ) CCTV coverage of the main carriageway, refuge areas and maintenance hard standings (where provided) would be required as part of Location A to comply with IAN 161/13. To ensure that there are no blind spots, 100% coverage would be required.
- 11.7.8 As part of the detailed design the locations of the existing CCTV cameras will be reviewed to confirm if they are suitable.
- 11.7.9 At present CCTV technology is evolving and infra-red cameras are being deployed. A review of the current standards and type of camera to be installed would be undertaken during the detail design.

### Vehicle Detection

- 11.7.10 IAN 161/13 requires that a vehicle detection system must be provided, to include all running lanes, in support of:
- Traffic counting
  - Classification
  - Queue protection
  - VMSL
  - Congestion management
- 11.7.11 Typically this would be an induction loop system (MIDAS), however radar systems for vehicle detection are being introduced on the Highways England network, for smart motorway (SM) schemes and other major road projects.
- 11.7.12 As radar systems require reduced maintenance regimes, it is recommended that radar be considered for vehicle detection on the route options within Location A.

### Emergency Roadside Telephones

- 11.7.13 TA 73/97 - *Motorway Emergency Telephones* gives guidance on the siting of emergency roadside telephones (ERTs); the ERTs would be located in

accordance with TA 73/97 and the smart motorway standard IAN 161/13 which states that emergency roadside telephones (ERTs) must only be provided at:

- A hard shoulder within a junction (lane drop/ lane gain only).
- An Emergency Refuge Area (ERA).

#### *Enforcement*

11.7.14 In considering smart motorways for the route options within Location A, a compliance strategy would need to be developed. This would identify any enforcement requirements that would need to be included in the scheme. In order to display VMSL on a motorway, a statutory instrument (SI) must be in place to comply with legislation. As part of the scheme would include the A282, the extent of the smart motorway section of the scheme and the requirement for an SI will be investigated further in the SAR.

11.7.15 Typically, for smart motorway schemes, Highways England Digital Enforcement Camera System (HADECS) are used. The latest generation of this system, called HADECS 3 has been implemented on the M25 motorway between Junctions 5 and 7.

11.7.16 DGV compliance would also be required for route options within Location A involving a tunnel crossing. It is envisaged that the system required for this, would be similar to the existing DFFC scheme currently being implemented for the tunnels at the existing crossing.

#### *Journey Time Reliability*

11.7.17 Currently, on the A282 approach to the Dartford crossing, there are existing ANPR and traffic count loops, used for journey time reliability. This equipment is owned by the National Traffic Information Service (NTIS). As part of detail design, discussions would need to be held with NTIS to agree on any new requirements and to retain/ reinstate existing equipment.

#### **Location C - ITS-Traffic Loops, VMS, CCTV**

11.7.18 At present the technology proposals for Location C are based around a two-lane dual carriageway, however as this would link into a motorway network at the southern and northern extents, consideration may need to be given to providing a motorway standard communication design in accordance with DMRB.

#### *VMS*

11.7.19 The provision of signals on dual carriageways is dependent on a number of factors as outlined in various Highways England documents including;

- TA 83/05 - Guide to the use of Variable Message Signs for Strategic Traffic Management on Trunk Roads and Trunk Road Motorways.
- TD 18/85 - Criteria for the use of Gantries for Traffic Signs and Matrix Traffic Signals on Trunk Roads and Trunk Road Motorways.
- TD 46/05 - Motorway Signalling.

11.7.20 These documents do not reflect the current signals available including Motorway Signal Mk 4 (MS4) message signs which are being used on smart

motorways to provide lane control and speed limits in accordance with IAN 161/13.

- 11.7.21 For Location C it is proposed that a combination of the standards listed above and deployment of MS4s could be used to provide road users with information. This would include MS3s located at strategic junctions (with portal gantries at the approach to the tunnel) and MS4s in between junctions and on the approaches to non-strategic junctions. The spacing would be dependent on the line of sight, but would be approximately 1.5km as indicated in TD 46/05 for inter-junction MS3s.

#### *CCTV*

- 11.7.22 The requirement for CCTV in TD 17/85 *Criteria for the Provision of Closed Circuit Television on Motorways* is dependent on traffic flows, congestion and road layouts. However this standard has become obsolete in recent years and so current best practice is to provide 100% CCTV coverage in order to monitor incidents. Sight lines would need to be reviewed to provide the best locations for cameras.

#### *Vehicle Detection*

- 11.7.23 Radar systems have been used on SM, as opposed to more conventional induction loops, to provide MIDAS information. This minimises the impact on the road surface and reduces the maintenance requirements. It is recommended that radar detection linked to VMSs is used on the dual carriageway for all route options within Location C.

#### *Emergency Roadside Telephones*

- 11.7.24 TA 73/97 *Motorway Emergency Telephones* indicates that ERTs are located at 1.5km spacing with additional ERTs located at junctions. On dual carriageways with lay-bys, ERTs are located at lay-by sites which are spaced at approximately 2.5km in accordance with TD 69/07 *The Location and Layout of Lay-bys and Rest Areas*. Advancements in technology and in mobile phone coverage may reduce the requirement for ERT, however, at present it is assumed they would be installed at 1.5km spacing.

#### *Enforcement*

- 11.7.25 There is no requirement for HADECS on dual carriageways. However enforcement equipment such as the SPECS average speed camera system may reduce accident rates and should be discussed with the stakeholders.

The SPECS average speed camera systems utilise a video system with ANPR digital technology. These cameras are each fitted with infra-red illuminators fitted on gantries allowing the camera system to work in both day and night conditions.

#### *Journey Time Reliability*

- 11.7.26 Traffic count loops and ANPR cameras are used by NTIS to provide journey time reliability (JTR) information to road users. As part of the operation of the crossing, JTR information would be a key tool to providing the road user with the benefits of the scheme. Liaison with Highways England and NTIS will be required as part of the detailed design to provide the road user with the maximum benefits.

11.7.27 Locations A and C are based on compliant Highways England Standards, therefore no bespoke sub-systems are envisaged.

*Communication Networks*

11.7.28 Currently the National Roadside Telecommunication Service (NRTS) generally runs along the Highways England road network. For Location A this would need to be retained and upgraded to facilitate the new technology outstations required. For Location C a new network would need to be installed by NRTS. Both locations would require the network to be IP-compliant to allow for remote maintenance access.

*Power Network/ Communication Networks*

11.7.29 For Location A there is an existing power network which would need to be upgraded to facilitate the additional roadside equipment required. For Location C new power supplies would need to be procured from the DNO (UK Power Networks). The location of power supplies would be dependent on the location of the outstation equipment. Access to the new electrical interface cabinets would have to be agreed with the DNO and may require wayleaves to be purchased.

*Contractual Considerations*

11.7.30 It is uncertain what type of contract the scheme would be awarded under. There may be technology requirements to monitor the performance of the contract for example:

- Journey Time Monitoring system. Individual vehicle detection (ANPR) at strategic locations to monitor vehicle travel time compared to targets set in the contract.
- Back-up toll systems to monitor the efficiency against targets set in the contract.
- Vehicle detection for incident monitoring.
- Vehicle detection for flow rates.

11.7.31 There could also be a requirement for technology solutions which support the operation and maintenance aspects of the contract, these could include:

- Weather information systems for winter maintenance.
- Structural/ Acoustic monitoring for the main crossing.
- Back office systems such as Inspection and Maintenance Management Systems, Inventory Database, Radio Communications etc.
- Journey time systems and strategic diversion signing for Dartford river crossing closures or incident management.

11.7.32 Consideration will need to be given as to how the new crossing would integrate with the existing crossing and adjacent road network.

*Control Strategy*

11.7.33 Any operational strategy for the new crossing would need to consider the existing crossings as a whole to ensure that consistent information is being

presented to the road user through similar methods. For example, if one crossing has no barriers and no speed limits, it may be the preferred route for regular road users and could become more congested or suffer an increased incident rate.

- 11.7.34 Consideration would therefore have to be given to how congestion would be managed across all crossings, and how, using technology, vehicular movements would be controlled to reduce congestion and ensure free-flow of traffic over the crossings. Technology offers the potential to influence driver behaviour on the crossings.
- 11.7.35 Depending on the route option and crossing type chosen, there are also opportunities in the design of the new crossing to ease the movement of specific vehicle types (e.g. High-sided Goods Vehicles, Dangerous Goods Vehicles (DGV) and Non-Compliant Vehicles (NCV).
- 11.7.36 For example, a new bridge could be designed to allow the free passage of DGVs. Should the new crossing be a tunnel however, some classes of DGVs could be restricted from using the crossing. This is because the movement of DGVs through tunnels is dependent on an assessment of the risks involved and the safety systems present to deal with those risks. The risks presented by the most dangerous loads however are unlikely to be fully mitigated by the safety systems implemented, thus these kinds of loads are likely to be restricted from using a new tunnel, regardless of the route option chosen. As a result, a means of dealing with DGVs would be required at any new tunnel crossing.
- 11.7.37 NCVs are in the main over-height vehicles, and a new bridge or tunnel design could be designed to remove that issue. Should solutions in Location A be the chosen solution however, the issue of NCVs who incorrectly progress to the existing reduced-height west tunnel bore (rather than using the new crossing) would need to be addressed operationally via the control centre.
- 11.7.38 It is anticipated that NCVs would be identified and re-directed using a similar detection and filter arrangement to the Dart Charge scheme.
- 11.7.39 The crossing could potentially be operated via the Regional Control Centres, this provides continuity on the network and ensures that standardised equipment is used which has benefits to the road user and maintainers alike. However there would be a need to provide a local facility as a base for immediate assistance to incidents on the crossing, to help manage NCVs/ DGVs, and to provide welfare facilities for traffic officers. The issue of fail-over control would also need to be considered by any new design. For Location A, the existing control centre site could be used for this purpose. For Location C a small tunnel service building with welfare and Highways England Traffic Officer facilities is recommended. During subsequent stages of the project, further consideration will need to be given to the infrastructure requirements resulting from operational needs at the crossing.
- 11.7.40 The type of crossing will have an impact on the operation of the crossing, for example the issue of over-height vehicles would be less of an operational concern if a bridge structure is implemented instead of a tunnel. The

operation of the crossing would need to be considered in the context of the rest of the Highways England network.

#### *Strategic Information*

11.7.41 The National Technology Control Centre (NTCC) would develop diversion routes, and templates for incidents and other events based on the technology provided. This scheme gives the opportunity to use technology to influence how vehicles use the crossings, for example, there may be strategies which involve closing one or more of the crossings which would require technology solutions to complement any physical solutions.

#### *RCC Systems, Sub-Systems*

11.7.42 The new crossing would impact on the current Highways England Regional Control Centres (RCCs) at South Mimms and Godstone managing the eastern and south east regions respectively. Changes, such as updating the in-station equipment to include the new technologies and VMS strategies, would need to be assessed and discussed with Highways England.

#### *Charging*

11.7.43 It is envisaged that both Locations A and C would utilise a charging mechanism similar to the Dartford Free-Flow Charging (DFFC) scheme.

11.7.44 Typical charging technologies include:

- Vehicle identification and classification. It is assumed that the vehicle classification types would be comparable with the existing DFFC scheme.
- Automatic Number Plate Recognition (ANPR) cameras.
- Tag detection systems.
- Back office systems, depending on the contractual delivery methods the back office operations such as toll collection could be shared with the existing DFFC scheme.

11.7.45 Consideration needs to be given to the charging options, for example, dynamic charging, which could vary the charge rates based on peak traffic flows, congestion on the surrounding road networks (both Highways England and Local Authority), special events and types of vehicle.

#### *Technology Systems on the Crossing*

11.7.46 Consideration needs to be given to the provision of technology on the crossing and this would be dependent on the crossing structure, be it a bridge or a tunnel.

11.7.47 If the crossing is a bridge the following technology systems would benefit the road users:

- Wind speed and direction.
- Visibility to provide alerts of mist and fog.
- Air temperature.

- Road surface temperature to determine the possibility of ice on the carriageway.

11.7.48 If the crossing is a tunnel, BD 78/99 *Design of Road Tunnels* indicates that the following systems be implemented;

- Ventilation
- Tunnel lighting
- Drainage
- Fire safety engineering
- Traffic control, communication and information
- Plant monitoring and control
- Electrical power supply and distribution
- Services buildings and plant rooms

11.7.49 These are not exclusive lists and would be developed further during detail design.

#### **Future Technologies**

- Stopped Vehicle Detection (SVD) - this is currently undergoing trials and is expected to be rolled out on SM schemes in the near future.
- In vehicle telematics.
- Vehicle-to-vehicle communications.
- Mobile phone communications into vehicles.
- Floating vehicle data collection and use for route planning, links to industry users e.g. TomTom®.
- Road user charging per mile basis, type of vehicles.
- Black box recording in vehicles - links to roadside technology.
- Control room to vehicle communications to alert road users.
- Vehicle guiding technology to ensure vehicles stay within lanes and a safe distance from other vehicles.
- Upgrade of the Highways England in-station equipment, Common Highways England Rijkswaterstaat Model (CHARM).

## 12 Routes Not Selected

### 12.1 Introduction

12.1.1 The appraisal of the longlist options described in section 1.3 was carried out in two stages with more detailed appraisal being carried out at each stage. The stages of appraisal are explained in the following paragraphs.

12.1.2 The longlist routes are:

- Route Option A1
- Route Option A2
- Route Option A4
- Route Option A8
- Route Option A9
- Route Option A12
- Route Option A14
- Route Option A15
- Route Option A16
- Route Option C1 (including combination route options C7)
- Route Option C2 (including combination route options C8 to C10)
- Route Option C3 (including combination route options C11 to C14)
- Route Option C4 (including combination route options C15 to C19)
- Route Option CV1
- Route Option CV2

12.1.3 In the first stage appraisal of the longlist of options, a limited number of key criteria were used to assess certain routes which were considered likely to offer very poor value for money and/ or where there were environmental or other showstoppers with a view to eliminating these from further consideration. The criteria were:

- Value for money (cost against economic benefit).
- Significant environmental impact.
- Other significant impacts (such as congestion, network resilience or impact on planned or existing developments).

12.1.4 The second stage appraisal appraised the remaining options against a set of 21 criteria based on information drawn from the detailed appraisals discussed in sections 6 to 11. The criteria are set out in **Table 12.1** below.



**TABLE 12.1 - SECOND STAGE APPRAISAL CRITERIA**

| Main Criteria            | Sub-Criteria                                     |
|--------------------------|--------------------------------------------------|
| Strategic                | Fit with wider transport & government objectives |
|                          | Fit with other (regional) objectives             |
| Economic                 | Travel time savings                              |
|                          | Congestion (crossing)                            |
|                          | Resilience                                       |
|                          | Accident Benefits                                |
|                          | Wider economic benefits                          |
|                          | Impact on current/ planned infrastructure        |
| Economic (environmental) | Carbon emissions                                 |
|                          | Historic environment                             |
|                          | Biodiversity                                     |
|                          | Landscape & townscape                            |
|                          | Air quality                                      |
|                          | Noise                                            |
|                          | Water environment                                |
|                          | Construction disruption                          |
| Management               | Implementation timetable                         |
|                          | Practical feasibility                            |
| Financial                | Capital cost                                     |
|                          | O and M cost                                     |
| Commercial               | Revenue costs                                    |

## 12.2 Longlist Appraisal Stage 1 Location A

12.2.1 The Location A longlist options not selected following the first stage appraisal were A8, A12 and A14. The reasons for their not being selected are set out in the following paragraphs.

### *Route Option A8*

12.2.2 The total estimated cost of Route Option A8 is approximately more than double the total estimated cost of A+ produced by Highways England Commercial Services Division for the '*Value For Money Refresh of Options A+ and C2 Report*' in December 2014. This route option does not therefore provide best value for the benefits generated compared to other route options in Location A having an estimated BCR of about 0.8.

12.2.3 Route Option A8 would not cater for all traffic movements at M25 Junctions 2 and 30. Construction of viaducts and tunnels over and under the existing A2, M25 and A13 would present practical challenges and increase the delivery risk.

### *Route Option A12*

12.2.4 The total estimated cost of Route Option A12 is approximately more than three times the total estimated cost of A+ produced by Highways England Commercial Services Division for the '*Value For Money Refresh of Options*

A+ and C2 Report' issued in December 2014. This route option does not therefore provide best value for the benefits generated compared to other route options in Location A, having an estimated BCR of about 0.3.

12.2.5 Route Option A12 would not cater for all traffic movements at the existing M25 Junction 2. Construction of viaducts and tunnels over and under the existing A2 and M25 at Junction 2 would present practical challenges and increase the delivery risk.

12.2.6 The option would have an unacceptable impact on a proposed high quality residential development west of Purfleet.

#### *Route Option A14*

12.2.7 The total estimated cost of proposed Route Option A14 is currently approximately more than double the total estimated cost of A+ produced by Highways England Commercial Services Division for the 'Value For Money Refresh of Options A+ and C2 Report' issued in December 2014. This route option does not therefore provide best value for the benefits generated compared to other route options in Location A, having an estimated BCR of about 0.4.

## **12.3 Longlist Appraisal Stage 1 Location C**

12.3.1 The Location C longlist options not selected following the first stage appraisal were the southern connection to the A2 in Option C3 and Combination Options C11 to C14. The reasons for their not being selected are set out in the following paragraphs.

#### *Route Option C3*

12.3.2 The southern connection to the A2 is deemed not to be viable due to the significant environmental constraints in the vicinity. The proposed junction in the vicinity of Shorne Woods Country Park would result in permanent land take from, and direct impact on, SSSI and ancient woodland at Shorne/Brewers Wood. The alignment would also cut through a local wildlife site on the outskirts of Shorne.

12.3.3 Connection with the A2 would lie almost entirely within the Kent Downs AONB. The recently adopted National Networks National Policy Statement dictates that alternatives should be sought rather than develop infrastructure within an AONB. Given that there are feasible alternatives to connect with the A2, this connection would be unacceptable.

#### *Combination Route Options C11 to C14*

12.3.4 These combination route options have not been developed as the southern junction at the A2 on Route Option C3 has not been selected due to the significant environmental constraints.

## **12.4 Longlist Appraisal Stage 2 Location A**

12.4.1 The Location A longlist options not selected following the second stage appraisal were A2, A9, A15 and A16. The reasons for their not being selected are set out in the following paragraphs.

### *Route Option A2*

- 12.4.2 Route Option A2 has poor economic benefits, providing approximately two-thirds of the economic benefits of route options involving new crossings on the west side of the existing crossing. This route option would separate strategic and local traffic, with strategic traffic using the new and existing bridges, and local traffic using the existing tunnels. It is considered that this is the principal reason for the poor economic performance.
- 12.4.3 Route Option A2 would have a significant impact on commercial property to the south of the river both in terms of cost and potential impact on local jobs and the community. Properties affected include the Hilton Hotel Dartford Bridge and a number of businesses in the Crossways Business Park (Dachser, British Gas, Vital, Yodel and Thermo Fisher). To the north, this option would have a significant impact on the Lafarge-Tarmac cement and aggregate plant. The site is unique with both a safeguarded jetty for the import/ export of sea dredged aggregate supplying the London construction market and a rail siding used to transport cement. It is highly unlikely that this industry could be relocated elsewhere along the river. Tunnel options that would enable the route to be located beneath in particular the Lafarge-Tarmac site (A8/ A14) and avoid impacting its operation have not been selected and are discussed and referenced in section 12.2.
- 12.4.4 In addition this route option may impact upon the nationally important West Thurrock Lagoon and Marshes SSSI (through disturbance of qualifying species) on the north bank of the river more than other route options at Location A. Any bridge structure would require to run along the western boundary of the SSSI.

### *Route Option A9*

- 12.4.5 Immersed tube construction at this location is assessed as having greater impact on the river operations and carries far higher levels of engineering risk compared to construction of bridge or bored tunnel solutions (Route Options A1 and A4). This option is therefore not selected in favour of the bridge and bored tunnel options, these being assessed as most likely to provide better value and a lower risk of unacceptable impacts at this location.
- 12.4.6 The level of disruption to river traffic during construction may be expected to be high during excavation of the trench, immersion and placing of tunnel elements and backfilling. During these periods one-way operation of the navigation channel would be necessary together with a series of 24 hour closures during element placing operations. The river at Location A is narrow compounding disruption effects. There are also a number of busy jetties directly adjacent to the works where access would be constrained for considerable periods affecting commercial operations. Discussion was held with the PLA who had firmly rejected immersed tunnel construction at Location A in their 2013 consultation and whose views remained one of strong objection to such a solution.
- 12.4.7 Construction of an immersed tunnel at this location would present considerable engineering challenges. Alignment constraints mean construction would have to be carried out in a narrow corridor passing

between the existing road tunnels on the eastern side and the existing cable tunnel from Littlebrook Power Station on the western side. Of particular concern is the potential for the trench excavation to reduce overburden cover to these tunnels thereby inducing uplift stresses in the existing linings. This could potentially lead to damage of the tunnel's linings which could not be assessed without considerable further work. Substantial deep-founded canal structures were proposed as the best way to construct the end sections of tunnel. These structures would be complex, affect the river hydrodynamics (flooding and environmental impacts) and navigation as they would extend part way into the river. Only with considerable further work would it be possible to quantify the engineering and construction uncertainty and even then many of the more difficult risks would remain.

#### *Route Option A15*

- 12.4.8 Route Option A15 would have a considerable impact on a wide range of receptors during the construction works. The impact would be seen in land take, impact on businesses and local amenities, major service diversions and disruption to all road users. The challenge of diverting approximately 800m of existing pylons would be extremely difficult and costly to relocate cables and pylons. The diversion of these pylons and cables would have a significant lead time of 4 to 5 years.
- 12.4.9 Route Option A15 would have impacts on a number of businesses along its route, notably Harvey's, Essex Arena and potentially Smyth toy superstore. In addition Thurrock services would be significantly impacted due to complex traffic management and diversions which would be in place for long periods on the existing Arterial Road and the southbound approach link.
- 12.4.10 The impact on Junction 31 during the works would also be substantial. At Junction 31 major works would be required not just to the junction itself but to the main approach road from the east, Arterial Road. This would be likely to impact traffic exiting the roundabout to the east and thus cause further delays on a junction already congested with complex traffic management arrangements. This would also be likely to have an impact back onto the A282/ M25 both northbound and southbound and potentially onto the A13.
- 12.4.11 In reviewing the assessment criteria and construction challenges of Route Option A15, the total HHJV cost estimate for E1+9 and A15 are approximately the same magnitude. However, the total construction costs for A15 could increase after a further detailed assessment of land take, traffic management and diversion of major services. Route Option A15 does not therefore provide best value for the benefits generated compared to the alternative option E1+9.

#### *Route Option A16*

- 12.4.12 Route Option A16 (with Route Option C4) – a Location C route option (C4) combined with a two-lane tunnel northbound at Dartford (to unlock the capacity constraint provided by the existing tunnels which are sub-standard) has a very high capital cost approximately 25% more than Route Option C4 without providing commensurate incremental benefit over Route Option C4. This route option does not therefore provide best value for the benefits that this option generates. It is noted that Route Option C4 was used for this

combination appraisal as it had the highest benefits of the options under consideration at that time.

## 12.5 Longlist Appraisal Stage 2 Location C

12.5.1 The Location C longlist options not selected following the second stage appraisal were C1, C4 and Combination Options C7, C16, C17 and C18 and C<sub>Variant</sub>. The reasons for their not being selected are set out in the following paragraphs.

### *Route Option C1*

12.5.2 This route option is deemed not to be viable for a number of reasons. Feedback from bilateral meetings with both SAP members and industry does not favour Route Option C1 due to concerns relating to lack of resilience around the A13 and M25 Junction 30. There are additional technical challenges with this option with the presence of 30m deep piles within the dock area of the Port of Tilbury which the tunnel would have to pass below. Tilbury Docks are currently constructing a distribution park to the north of the docks with plans to extend this significantly over the next 2-3 years. To reduce impacts on the proposed development the tunnel portal would need to be located outside of the relevant area.

12.5.3 This option has a very high capital cost and poor economic benefits. The requirement for a major junction improvement at M25 Junction 30 and widening of the A13 would reduce the option's resilience, particularly once further planned development of London Gateway Port and Tilbury Docks takes place.

12.5.4 Although the option avoids the Ramsar site, there would be significant environmental impacts including a direct impact on Orsett Cropmarks nationally designated scheduled monument, potential direct impact on Chadwell Place Grade II listed building, setting impacts potentially to several Grade II listed buildings north and south of the River Thames and direct impacts on 3 to 4 areas of nationally important ancient woodland along the existing A1089 and A13.

### *Route Option C4*

12.5.5 This route option is deemed not viable as it has a very high capital cost associated with construction of a long bored tunnel, although it does provide high economic benefits. There are other alternative Location C route options which provide good economic benefits at lower cost.

12.5.6 In addition following discussion with English Heritage, the area containing the tunnel portal on the northern side of the River Thames could potentially be within an area of importance due to the nearby scheduled monuments.

### *Combination Route Option C7*

12.5.7 This route option has not been developed because Route Option C1 has not been selected as discussed above.

### *Combination Route Option C8*

- 12.5.8 Although this combination route option has not been specifically developed using the designation C8 it is in effect the modified version of Route Option C3 (refer to section 6.1.3) following the decision not to select the southern junction with the A2 for Route Option C3 and use the A2 junction and alignment south of the River Thames from Route Option C2 instead (refer to Section 12.3).

### *Combination Route Option C10*

- 12.5.9 This combination route option has not been developed as Route Options C2 and C3 are still current route options. It is sufficiently closely related to these two route options to be a potential future development of either option.

### *Combination Route Option C15 to C18*

- 12.5.10 These combination route options have not been developed as Route Option C19 (southern alternative) is considered to provide for these combinations as Route Option C19 has been designed to connect into any route option north of the River Thames.

## **12.6 Longlist Appraisal Stage 2 C<sub>variant</sub>**

- 12.6.1 Assessment using both the LTC Link Flow Schematic Tool and select link analysis has been undertaken. This analysis has shown that C<sub>variant</sub> when combined with a Location C route option has little impact on transferring M20 traffic onto the new crossing at Location C and reducing flows at the existing Dartford Crossing.
- 12.6.2 C<sub>variant</sub> would have a significant impact on the nationally important AONB. The National Networks National Policy Statement states that “There is a strong presumption against any significant road widening or the building of new roads and strategic rail freight interchanges in...AONBs, unless it can be shown there are compelling reasons for the new or enhanced capacity and with any benefits outweighing the costs significantly. Planning of the Strategic Road Network should encourage routes that avoid National Parks, the Broads and Areas of Outstanding Natural Beauty.”
- 12.6.3 The modified junction with the M2 option would have a major direct impact on the nationally important Bridge Woods ancient woodland. The existing A229 is located close to the Wouldham to Detling Escarpment Site of Special Scientific Interest (SSSI) which could be directly impacted, and the internationally important North Downs Woodlands Special Area of Conservation could be indirectly impacted due to decrease in air quality through increased traffic flow; Natural England has identified that this site is very sensitive to nitrogen deposition.
- 12.6.4 The estimated most likely outturn cost of C<sub>variant</sub> is £0.45b.
- 12.6.5 C<sub>variant</sub> in combination with C2 (Bored Tunnel) provides additional economic benefits of £0.6b (excluding WEBs) and £0.7b (including WEBs).
- 12.6.6 C<sub>variant</sub> in combination with A1 (Bridge) provides additional economic benefits of £0.5b (excluding WEBs) and £0.6b (including WEBs).

12.6.7 It is recommended that Option C<sub>variant</sub> is not selected. C<sub>variant</sub> has little impact on reducing traffic at the existing Dartford crossing and there is not a compelling traffic case for enhancing capacity of the A229. In accordance with the National Networks National Policy Statement there is a strong presumption against road widening in AONBs.

## 12.7 Shortlist Routes

12.7.1 The shortlist routes are:

- Route Option A1
- Route Option A4
- Route Option C2
- Route Option C3
- Route Option C9
- Route Option C19

## 13 Stakeholder Engagement

### 13.1 Summary of Engagement

- 13.1.1 Considerable engagement has been undertaken since September 2014 and the information obtained has played an important part in refining the options presented. A planned and focused approach to engagement has been adopted to ensure high quality and meaningful engagement, not only in providing opportunities for sharing complex and technical issues and information but also in terms of relationship building. Initial engagement has focused on those local authority stakeholders immediately impacted by the route options and other technical stakeholders that provide information for the technical development and appraisal of the options.

#### Stakeholder Advisory Panel (SAP)

- 13.1.2 The purpose of the LTC SAP is to help the Highways England draw upon local knowledge and understand stakeholders' needs, priorities and opinions with respect to LTC. The panel meets at key stages in the project and is designed to be a consultative and advisory group comprising officers of the organisations listed in the **Table 13.1** below.

**TABLE 13.1 - SAP MEMBERS**

| SAP Members                |                                                |
|----------------------------|------------------------------------------------|
| Basildon Borough Council   | Medway Council                                 |
| Brentwood Borough Council  | South East Local Economic Partnership (SELEP)  |
| Dartford Borough Council   | Southend Borough Council                       |
| Essex County Council       | Thames Gateway Kent Partnership                |
| Gravesham Borough Council  | Thames Gateway South Essex Partnership (TGSEP) |
| Kent County Council        | Thurrock Council                               |
| London Borough of Bexley   | Tonbridge and Malling Borough Council          |
| London Borough of Havering | Transport for London                           |
| Maidstone Borough Council  |                                                |

- 13.1.3 SAP was originally convened by the DfT. It was reconvened for the Options phase of the project with the first meeting held in December 2014, with an expanded membership (five new local authorities joined the panel).
- 13.1.4 Following the SAP meetings the project held bilateral meetings with panel members to obtain information on existing highway networks, development plans, information to feed into the traffic model and any other constraints that could potentially affect route option selection.
- 13.1.5 SAP meetings have been held at key stages of the project to share and discuss the emerging findings of the options development and appraisal work. Further meetings are planned. The project explained the staged approach to appraisal and criteria for each stage of the Options phase, seeking feedback on the process through the post-SAP bilateral meetings. SAP has welcomed engagement with the project through the options



appraisal process of the Lower Thames Crossing scheme and viewed this engagement as open, transparent and timely.

13.1.6 As the project has moved through the Options phase, SAP members have been given the opportunity to provide feedback on the proposed routes at key stages including the emerging longlist, longlist and emerging shortlist. Panel members will also have the opportunity to provide feedback on the shortlist and proposed approach to consultation. The views of SAP members have been considered throughout the Options phase.

13.1.7 Whilst SAP comprises officers, the project also plans to engage with council leaders and MPs in directly affected, neighbouring and regional areas.

### **Statutory and Environmental Bodies**

13.1.8 Throughout the Options phase, the project has also engaged with statutory and environmental bodies to share emerging findings of the options process and provide an overview of the approach to the environmental appraisal of the routes. These bodies comprise the Environment Agency, Historic England, Natural England and the Marine Management Organisation with involvement from the Kent Downs Area of Outstanding Natural Beauty, Essex and Kent County Archaeologists and the Greater London Archaeology Advisory Service who have been engaged through bilateral meetings. A meeting has also been held with the Royal Society for the Protection of Birds and ornithological data has been obtained from the British Trust for Ornithology.

13.1.9 Through this engagement the project has gained a detailed understanding of the environmental constraints associated with each of the route options, with discussions held on potential mitigation.

13.1.10 A Statutory Environmental Body (SEB) group comprising the Environment Agency, Historic England, Natural England and the Marine Management Organisation has met at key stages in the Options phase for the project.

13.1.11 Ongoing engagement with the SEBs throughout the appraisal process has facilitated discussion relating to the indicative form of crossing and other key elements including the environmental constraints mapping.

### **Traffic Modelling**

13.1.12 Briefings have been given to authorities both north and south of the river to share the approach to traffic modelling.

### **Transport for London (TfL)**

13.1.13 Regular meetings have been held with TfL to understand their proposals for new river crossings at Silvertown, Belvedere and Gallion's Reach and to share technical information and traffic modelling information.

### **Industry & Utilities**

13.1.14 Key major industry stakeholders have been identified to seek important technical information including constraints around existing assets, shipping details and future development plans. These include organisations such as Port of London Authority, London Gateway Port, Network Rail, HS1, RWE npower, Tilbury Docks, Lafarge-Tarmac, Hansons, Peel Ports, CRO Ports,

Vopak and the Port of Dover. Meetings have been held and the information obtained has informed the refinement of the route options. Meetings have also been arranged with the Ebbsfleet Development Corporation and Paramount London and information on predicted traffic flows associated with the Paramount development has been requested.

- 13.1.15 Requests have been submitted to utility companies for details of plant locations. This is being reviewed against the proposed routes to determine if any adjustments to the routes or utility diversions are required.
- 13.1.16 Bilateral meetings have also been held with National Grid and UK Power Networks to understand the impact of their assets on the proposed options.

## 14 Shortlist Route Options

### 14.1 Location A

14.1.1 Following the appraisal described in Section 12 the remaining shortlisted options at Location A are A1, the bridge to the west of the existing crossing and A4, the bored tunnel to the west of the existing crossing. These options are shown in **Figure 14.1**. Both options would include the improvement derived from the AECOM/ Jacobs Option E1+9 for the improvement of Junctions 30/ 31.

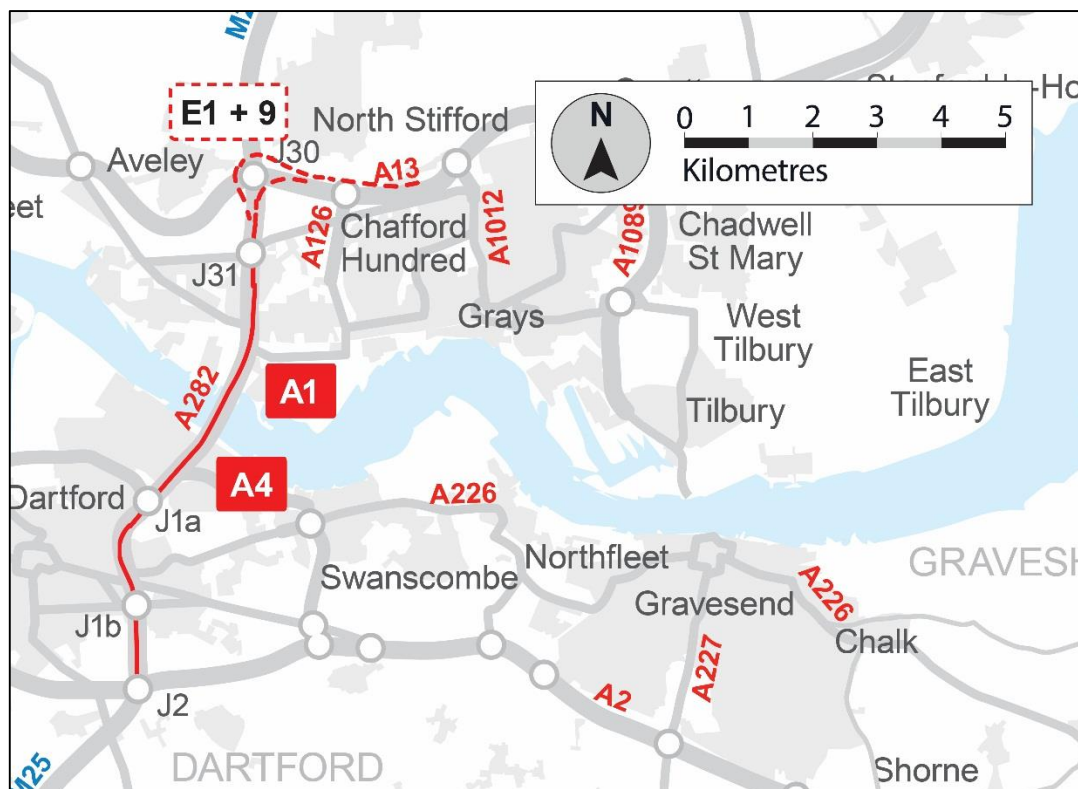


FIGURE 14.1 - LOCATION A SHORTLISTED ROUTES

#### Route Option A1

(Refer to **Appendix 10** for Plan and Profile drawings)

*Route Alignment (horizontal)*

14.1.2 The horizontal route alignment has been designed in accordance with DMRB TD9/93 Table 3. Minimum standards are explained in Section 5 of this report. The design speed used is 85 km/h (50mph).

14.1.3 The extent of Route Option A1 would be from Junction 2 of the M25/ A282 to Junction 30 of the M25 and include the following:

- Junction 2 - 1b no widening (smart motorway technology).
- Junction 1b -1a widening to 5 number lanes (smart motorway technology).
- Improvements to Junction 30 and the A13 (Option E1+9)

- 14.1.4 The new off-line route alignment would commence approximately 420m south of Junction 1a Littlebrook Interchange where it would join the existing A282 and pass under the A206 at chainage 450 and run over the existing Fastrack bus route at chainage 1130 and travel north. After crossing the River Thames, it would cross two existing railways - HS1 at chainage 3300 and the London to Southend line at chainage 3350. It would continue north and pass over the existing A1090 at chainage 3550 and join the existing M25 south of Junction 30 after crossing over M25 Junction 31 at chainage 4700.

*Route Alignment (vertical)*

- 14.1.5 Route Option A1 would cross a number of existing highways and railways such as A206, Fastrack bus route, two railway lines, A1090 and M25 Junction 31 and has been designed to provide where possible sufficient vertical clearances under structures to minimise any impact. The vertical alignment over the river is dictated by the navigation requirements. A vertical gradient of 4% has been used which is the desirable maximum grade for an all-purpose dual carriageway road in accordance with TD 9/93, Section 4. Further development would be required as additional information is received from stakeholders.

*Junctions*

- 14.1.6 There are four existing major junctions within Route Option A1 with grade separation namely A282 Junction 1b and A282 Junction 1a Littlebrook Interchange both with an overbridge over the mainline, M25 Junction 31 with an underbridge and M25 Junction 30 with an overbridge for the A13. The existing A282 Junction 1a would be upgraded with a proposed replacement of the existing A206 overbridge, and proposed roundabouts to the west and east of the mainline. The western roundabout would be connected to the mainline with a new slip road. At Junction 31, Route Option A1 would pass above the existing roundabout junction with widening of existing underbridges due to the increased number of lanes from the current four to five lanes.

*Highway Structures*

- 14.1.7 The opportunity to widen the A282 route between Junctions 2 and 1a is constrained by the existing retaining walls, formed from secant piles with ground anchors. It is considered impracticable, in terms of cost, traffic disruption, and potential land take to provide new retaining walls outside of the existing line. However, between Junctions 1b and 1a there is a need to widen the carriageway which is constrained by the Bow Arrow rail underbridge. This bridge would be widened on both elevations to both sides and the adjacent footbridge replaced. Junction 1a twin overbridges would be replaced with a two-span bridge. The pier, placed in the central reserve, would allow the maximum carriageway width for traffic merge/ diverge.
- 14.1.8 It is assumed that the north approach viaduct of the main river crossing would terminate in a similar location as the existing QEII Bridge abutment. This viaduct would cross the constraints of HS1, local London to Southend railway, and the A1090. North of the river, the new A282 alignment would require embankments/ retaining walls due to the limited width of available

road. The underbridges of Junction 31 would require widening over the junction, using the same form of construction as the existing bridges

- 14.1.9 The choice of main crossing to the west of the existing tunnel and QEII Bridge and the use of the existing A282 alignment, would require very few new structures or alterations to existing bridges. The main concern would be the construction of a new Junction 1a overbridge, probably off-line, to minimise traffic disruption. Method of construction would therefore dictate structural form, truss/ tied arch, or push launch could be considered.

#### *River Crossing*

(Refer to **Appendix 11** for Bridge drawing)

- 14.1.10 Route Option A1 river crossing would comprise a new bridge to the west (upstream) of the existing Dartford Tunnels. A 450m span cable-stayed bridge has been considered to match the existing QEII Bridge and to provide clear spans for navigation that would meet the Port of London Authority (PLA) requirements for shipping at the existing bridge.
- 14.1.11 Early engagement has been undertaken with PLA and based on these meetings, it is assumed any new bridge would be designed to meet the existing clearance requirements. The final requirements would be confirmed through an assessment of air draft that takes into account possible future vessel requirements from data to be requested through the stakeholder engagement.
- 14.1.12 The new bridge is assumed to carry an all-purpose road in accordance with TD27/05 with four 3.65m lanes northbound, 1.0m hard strips (no allowance for hard shoulders) and 0.6m verges. The final carriageway configuration would be subject to confirming the traffic requirements.
- 14.1.13 A study of satellite images of the site, followed by site visits and the feedback from the stakeholder engagement process, identified a number of physical constraints within Route Option A1 specific to providing a bridge at the proposed location. The key constraints on horizontal alignment for this route option are:
- Proximity to existing northbound bored tunnel  
To ensure there would be no risk of damage to the existing bored tunnel, a clear lateral distance not less than between the existing bridge and the east tunnel has been allowed between the foundation of a new bridge and the east tunnel.
  - Proximity to Dartford Cable Tunnel  
Dartford Cable Tunnel is located upstream and parallel to the existing tunnel. The horizontal alignment of the new bridge would be as far east as possible to provide the maximum clearance to Dartford Cable Tunnel.
  - Tie-in with Junction 1a on south side of the river  
Dart Charge has been introduced, therefore the existing toll plaza area could be utilised to modify the existing road network and Junction 1a to accommodate traffic from the new river crossing.

- Tie-in with existing tunnel exit ramps on north side of the river

The viaduct spans on the north side of the river would have to cross over HS1 viaduct and merge at-grade with the existing A282.

- Riverside jetties

On the north side of the river, there are two aggregate loading jetties (Civil and Marine Upper and Lower) which are within the vicinity of the bridge crossing. One of these would conflict with foundation for the north pylon. The second might be retained. On the south side of the river, there is a loading jetty (Littlebrook Power Station Main) which falls within the vicinity of the bridge crossing. Although Littlebrook Power Station has been decommissioned, and the jetty saw little use in 2014, RWE have plans to utilise the jetty in the future.

- Land for approach viaduct - south side

The land over which the south approach spans would be constructed is currently undeveloped and is within the existing boundary of land acquired for the existing bridge and tunnels. The main constraints on horizontal alignment within an otherwise clear corridor appear to be the existing control building and marshalling area, the existing tunnel vent shafts and portals and the bridge which carries the Fastrack bus route over the existing tunnel ramps. The control building would be demolished and require replacing, and the marshalling area would need to be reconfigured if still required. Fastrack would impose a potential constraint on the location of some of the piers and foundations for the approach viaduct of a new bridge, but the constraint would not present serious problems. Generally at this stage no assessment of land has been undertaken. Requirements and impacts on land will be assessed in detail as part of any future development of the scheme options.

- Land for approach viaduct - north side

The land over which the north approach spans would be constructed is currently used for aggregate and cement production and is within private ownership. A meeting has been held with the owners to understand their operations. The implications of the construction of a bridge on the operation of the site will need to be investigated further but it is likely that it would have a significant impact and possibly threaten the ongoing operation. This would be dealt with through compensation. The bridge approach viaduct would have to be aligned to the west of the existing tunnel vent shafts and portals.

#### 14.1.14 Constraints on vertical alignment are:

- Vertical navigation clearance requirements

The navigation clearance requirements at the existing bridge are shown on the PLA navigation charts. The 57.5m clearance envelope is offset from the centre of the existing main span by 205m. That offset was required to provide sufficient clearance to the soffit of the bridge deck and the south top corner of the 57.5m clearance envelope

with a 4% descent gradient for southbound bridge traffic into the toll plaza area.

- Horizontal navigation clearance requirements

The minimum span dimension required for the new river crossing bridge would be dictated by the navigation clearance to be agreed with the PLA, but would not be less than the existing QEII Bridge, i.e. 450m. It is possible, but considered unlikely, that a requirement for more than 450m may be requested to help safeguard interests of existing riverside frontage jetties and future marine traffic. The implication of this may be a longer main span, but this would be subject to discussions with stakeholders in order to establish new requirements as part of the engagement process.

- Approach gradients

For northbound traffic on a new bridge, the approach gradient from the re-configured toll plaza area with the redesigned Junction 1a is assumed to not exceed 4%. The summit of the crest curve on the new bridge would then have to be offset by about 120m to the north of midspan in order to provide sufficient clearance between the soffit of the bridge and the south corner of the 57.5m AOD clearance envelope.

The asymmetric profile of the road on the main span of the bridge would have an adverse effect on its visual appearance. The consequences of the asymmetric profile, or possibility of locating the crest curve symmetrically about the main navigation span will be investigated as part the development of any bridge option at this location.

- Clearances over HS1

The northern approach spans of a new bridge would have to pass over the HS1 viaduct. The minimum clearance between the HS1 rails and the existing QEII Bridge is between 6.6m and 6.7m. The HS1 viaduct continues to climb westwards as it passes under the north approach viaduct of the existing QEII Bridge and is therefore at a higher elevation as it passes under a new cross river bridge. This imposes a constraint on the vertical profile of the northern approach viaduct of the new bridge, limiting the gradient to 3.5%.

- Overhead HV Power lines on the south side

On the south side of the river, an overhead HV power distribution line passes over the south viaduct of the existing bridge and drops over the Option A1 route on a skew alignment at approximately the same location as the highest point on the new girder bridge which has recently been constructed to carry Fastrack over the existing tunnel ramps and under the southern viaduct of the existing QEII Bridge.

- Service Tunnel on the north side

On the north side of the river, the service tunnel for power cables would require to pass under the north viaduct of the existing bridge

and the Route Option A1 route on a skew alignment. The service tunnel could impose a constraint on the location of the foundations for the viaduct.

### **Route Option A4**

(Refer to **Appendix 12** for Plan and Profile drawings)

#### *Route Alignment (horizontal)*

14.1.15 The horizontal route alignment has been designed in accordance with DMRB TD9/93 Table 3. Minimum standards are explained in Section 5 of this report. The design speed used is 85 km/h (50mph speed limit).

14.1.16 The extent of Route Option A4 would be from Junction 2 of the M25/ A282 to Junction 30 of the M25 and include the following:

- Junction 2 - 1b no widening (smart motorway technology).
- Junction 1b -1a widening to 5 number lanes (smart motorway technology).
- Improvements to Junction 30 and the A13 (Option E1+9).

14.1.17 The new off-line route alignment would commence approximately 420m south of Junction 1a of Littlebrook Interchange where it joins the existing A282 and pass under the A206 at chainage 450 and run under the Fastrack bus route at chainage 680 and travel north. After crossing the River Thames, the tunnel would require a retaining feature from the north portal to tie-in to A282. The carriageway would pass under HS1 at chainage 2850 and above the London to Southend line at chainage 3350. The alignment would continue north and pass over the A1090 at chainage 3106 and join the existing M25 south of Junction 30 after crossing Junction 31 at chainage 4100m.

14.1.18 Further development of the alignment would be required as additional information is received from stakeholders. The alignment is currently being revised to provide sufficient clearance to existing infrastructure foundations. The information received from stakeholders covers the existing road tunnels and shafts: the cable tunnel; tanks pile foundations; and the underground utilities. No information has yet been received regarding the foundation of the jetties.

#### *Route Alignment (vertical)*

14.1.19 The route would start at existing carriageway levels following existing contours until a trough begins at approximate chainage 600 into a 4% down grade. The tunnel portal would be at approximate chainage 800 where the crown intersects the existing ground, starting with a cut and cover section with the bored tunnel starting at chainage 1075. The route would continue to drop to maintain clearance below the River Thames with minimum one diameter ground cover to tunnel crown under the river.

14.1.20 A sag curve would enable the route to climb back up at 4%, with the bored section ending at chainage 2310m and the exit portal at approximate chainage 2535m. The vertical alignment must achieve confirmed clearance requirements under the HS1 viaduct and then pass over the London to



Southend line. Further clarification and confirmation regarding clearances is required from HS1 and Network Rail. The two railway lines are at chainage 2850m and 2910m respectively. The alignment would then pass over the A1090 and tie into existing ground level at approximate chainage 3400.

- 14.1.21 Further development of the alignment is required as additional information is received from stakeholders and will be addressed in the SAR.

#### *Junctions*

- 14.1.22 The junction arrangements for Route Option A4 are similar to Route Option A1.

#### *Highway Structures*

- 14.1.23 The widening of the existing structures between Junctions 1b and 1a and the replacement of the A206 twin overbridges at Junction 1a would be similar to the requirements of Route Option A1 and aid capacity and traffic weaving lengths prior to the main crossing. The approach to the southern portal (at chainage1200) would require a length of retaining wall and trough structure, which would need to support the Fastrack bus route overhead at chainage1150.
- 14.1.24 At the northern portal (2900) trough and retaining wall structures would take the route on the same vertical alignment as the existing tunnel approaches. A new viaduct would be required to take Route Option A4 under HS1 and over the London to Southend railway and the A1090. Construction methods would dictate the form of bridge designs adopted in order to minimise disruption to these important networks.
- 14.1.25 Retaining walls would be required up to Junction 31 to tie-in to the existing A282 embankment and to reduce land-take. At Junction 31, the existing bridges would need to be widened over the junction using a similar form of construction.
- 14.1.26 The improvement of A282 capacity from Junction 2 to Junction 30 would require new structures and modifications to existing bridges as described more fully in the section for Route Option A1 (refer to sections 14.1. 7 to 9).

#### *River Crossing*

(Refer to **Appendix 13** for Bored Tunnel drawing)

- 14.1.27 Route Option A4 would comprise two new-bored tunnels to the west (upstream) of the existing Dartford Tunnels. Two 1700m long twin tunnels have been considered comprising a main bored section of 1225m connected to an approximate 275m long cut and cover section on the south side of the river and a 250m section on the north side.
- 14.1.28 The existing marshalling areas and the Dartford Control Centre would need to be relocated both in the temporary and permanent condition. Engagement with stakeholders will be necessary to understand requirements and provide a suitable location to ensure the correct working during and after the works if a bored tunnel is to be constructed at Location A.
- 14.1.29 The new tunnels are assumed to carry an all-purpose road in accordance to BD78/99 and TD27/05 with two lanes northbound each. Provision would be

made for two 3.65m lanes and 1.20m walkways and a vertical clearance of 5.35m. The carriageway provisions are subject to confirming traffic requirements and further agreement of assumptions for hardstrips and verges consistent with modern tunnel provisions.

14.1.30 Desk studies and the feedback from the stakeholder engagement process have identified a number of physical constraints within Route Option A4 specific to providing two twin tunnels at the proposed location. The key constraints identified for the horizontal alignment of these route options are:

- Proximity to the existing west tunnel and shafts

It would be necessary to ensure that there is no risk of damage to the existing bored tunnel. Based on initial assessment a clear distance of 15m has been assumed between the new tunnel and the ventilation shaft on the south side. Confirmation of clearances and maximum allowed settlements is needed. On each side of the river there are two headhouses that contain an access shaft and passages to the tunnels, use of which has not been confirmed but a clearance of 15m has been assumed at this stage.

- Proximity to Dartford Cable tunnel

The Dartford Cable tunnel is located upstream and parallel to the existing road tunnels but at a constant depth of approximately 30m below ground surface. The minimum clearance with the proposed new tunnels is 20m and it increases as the tunnel moves north. At its closest location the cable tunnel is deeper than the projected new road tunnel.

- Tie-in with Junction 1a on south side of the river

Dart Charge has been introduced, therefore the existing toll plaza area could be utilised to modify the existing road network and Junction 1a to accommodate traffic from the new river crossing.

- Tie-in with existing tunnel exit ramps on north side of the river

The north portals would be located approximately parallel to the existing tunnels, the new road would have to cross under HS1 viaduct avoiding the existing piers and then over the London to Southend railway line to merge at-grade with the existing A282.

- Riverside jetties

On the north side of the river there are two aggregate loading jetties (Civil and Marine Upper and Lower) which are within the vicinity of the tunnel crossing, on the south side there is one jetty (Littlebrook Power Station). The proposed alignment goes directly beneath one of these although the exact depth of the jetty foundations is unknown at this stage and has been requested through the stakeholder engagement process.

- Land for approach - south side

The land under which the south approaches and cut and cover section would be constructed is currently within the existing boundary

of land acquired for the existing bridge and tunnels. The main constraints on horizontal alignment within an otherwise clear corridor appear to be the existing control building, the existing tunnel vent shafts and portals and the Fastrack bridge over the existing tunnel ramps. The control building would likely be demolished and require replacing. Generally at this stage no assessment of land has been undertaken. Requirements and impacts on land will be assessed in detail as part of any future development of the scheme options.

- Land for approach - north side.

The land under which the north approach and cut and cover sections would be constructed is currently used for aggregate and cement production and is within private ownership. As for Option A1, it is likely that the construction of a new bored tunnel would have significant impacts on the operation of the site or mean that it could no longer operate. It is considered that the impact of construction of a bored tunnel would be more than a bridge. The same compensation allowance as for Option A1 would apply. Other constraints are existing tunnel vent shafts and portals.

#### 14.1.31 Constraints on vertical alignment are:

- Approach gradients.

For northbound traffic on a new tunnel, the ramp gradient commencing the descent from under the Fastrack bus lane is assumed to not exceed 4%. The nadir of the tunnels would be located approximately in the centre under the river section. The symmetric profile of the road would then climb at 4% gradient to reach the ground level just before crossing under the HS1 viaduct.

- Clearances under HS1

The northern approach of the new tunnel would have to pass under the HS1 viaduct and over the existing railway. The HS1 viaduct climbs westwards as it passes under the north approach viaduct of the existing QEII Bridge. Current clearances based on the developed alignment is approximately 6.5m to the new road levels but requirements need to be confirmed through the stakeholder engagement process.

- Underground HV power lines on the south side

On the south side of the river, an underground HV power line passes from the power station to the west road tunnel at a presently unknown depth. The proposed route at this location would comprise a cut and cover section. Requirements for this power line need to be confirmed from the stakeholder but it is assumed a diversion or mitigation measures would need to be put in place.

### **Option E1+9**

(Refer to **Appendix 14** for Plan and Profile drawing)

- 14.1.32 Both Options A1 and A4 would include the improvements to Junctions 30/ 31 developed from the AECOM/ Jacobs E1+9 described in section 5.2.10. These are described in more detail in the following paragraphs.

#### **Option E1+9 Highway Alignment**

- 14.1.33 Horizontal and vertical alignments have been designed to the DMRB TD9/93 Table 3 for highway link design. The design speed has been taken as 85km/h (50mph) for an all-purpose road.
- 14.1.34 The main north to east traffic movement would diverge from the northbound A282 at a lane drop diverge, entering into a two-lane interchange link. The free-flow link would go north from Junction 31 to Junction 30 to where it would dip into the Mardyke Valley passing beneath the westbound A13 and Junction 30 slips. The link would then continue east over the M25 mainline and northern slips to tie-in to the existing A13 east of the A126 junction.
- 14.1.35 The north to eastbound link would be routed around the northern perimeter of the existing A126 dumbbell junction. The link would then pass beneath the existing railway via a new underpass and subsequently merge with the eastbound A13. This would require modifications to the B186 over-bridge.
- 14.1.36 The northbound Junction 31 to Junction 30 link would run parallel to the west of the existing northbound link. Both Junctions 30 and 31 would require modifications for the proposed link.
- 14.1.37 The westbound to southbound traffic movement would diverge from the A13 to A282, between the A126 dumbbell and Junction 30 slips, the link road would turn from westbound to southbound crossing the Mardyke Valley on a shallow viaduct whilst simultaneously passing beneath the realigned Junction 30 to Junction 31 link, this would include the service area access diverge. The link would merge with the southbound A282 as close as possible to Junction 30, with a lane gain merge.
- 14.1.38 The southbound Junction 30 to Junction 31 link, having passed over the Mardyke Valley on viaduct, and crossing over the westbound to southbound free-flow interchange link, would pass close to the edge of the Thurrock service area.
- 14.1.39 The southbound traffic would merge with the A282 southbound south of Junction 31 due to the restrictions of merge to merge spacing along the mainline.

#### *Option E1+9 Structures*

- 14.1.40 The Option E1+9 structures are summarised in **Table 14.1**.
- 14.1.41 All the structure details given in this section are indicative of potential solutions and are subject to change as the options are developed and appraised further.

TABLE 14.1 - OPTION E1+9 STRUCTURES

| Option E1+9 |                            |      |         |        |           |                        |
|-------------|----------------------------|------|---------|--------|-----------|------------------------|
| Ref.        | Name                       | Over | Under   | Length | Chainage  | Construction           |
| E9.1        | Mardyke Viaduct 1          | E1+9 | Mardyke | 225m   | 275-500   | Steel composite        |
| E9.2        | A13 Underpass              | A13  | E1+9    | 100m   | 675-775   | RC underpass box       |
| E9.3        | M25 Overbridge Junction 30 | E1+9 | M25     | 100m   | 1075-1175 | Steel Composite        |
| E9.4        | Mardyke Viaduct 2          | E1+9 | Mardyke | 450m   | 1700-2150 | Steel composite        |
| E9.5        | Railway Underpass          | Rlwy | E1+9    | 30m    | 2720-2750 | RC underpass box       |
| E9.6        | B186/ A13 Overbridge       | B186 | A13     | 60m    | @3150     | Steel comp ladder deck |

### Structure E9.1

14.1.42 Northbound M25 traffic, north of Junction 31, would exit onto a new viaduct over the adjacent new A282 slip road and continue on viaduct over the Mardyke and its flood plain. The viaduct is likely to be 225m in length with spans in the order of 35 to 60m. Construction would be similar to the existing A282 structures, namely steel composite deck with transverse integral steel girders at each pier to minimise deck construction depth. Substructure would be reinforced concrete piers supported on piled foundations and need to be controlled to prevent adverse impacts on the environment of the flood plain.

### Structure E9.2

14.1.43 The E1+9 link beneath the A13 western arm of Junction 30 would require a reinforced concrete box, using jacking techniques to minimise disruption. Box-jacking operation would be complex due to the A13 mainline and two adjacent slip roads which would dictate the depth of cover to the underpass roof. Significant land take and temporary works would be required for the launching pit.

14.1.44 International standards require the assessment of fire, ventilation, drainage, and escape routes to be undertaken based on geometry and the volume and type of traffic. Provision of the aforementioned systems should be envisaged for this modest length of underpass and would significantly increase the whole life costing (WLC) due to the maintenance liability. Headroom requirements would need to include allowance for these requirements and equipment.

### Structure E9.3

14.1.45 The E1+9 link would rise from A13 underpass on embankment before crossing the M25 north of Junction 30. The M25 overbridge would be of steel composite construction with RC piers and abutments. Location of the piers and the type of deck construction would be chosen to suit the method of construction over the live motorway. Bridge launching from one end could be considered over a series of motorway carriageway closures to minimise traffic disruption.

### *Structure E9.4*

- 14.1.46 The E1+9 would need to cross the Mardyke for a second time to the north of the existing A13 with the associated environmental issues raised by E9.1. The new viaduct would be 450m long, considerably longer than the existing A13 structure due to the new alignment following parallel to the length of the flood plain. The viaduct would be of continuous deck construction to minimise vulnerable details such as expansion joints. The length of structure and sensitive location could warrant incremental construction using overhead temporary gantries however the piled pier foundations would need access to the flood plain.
- 14.1.47 It has been assumed that the cutting within the ancient woodland to the north of the A13 would be open excavation and not require retaining structures.

### *Structure E9.5*

- 14.1.48 A short, 30m long reinforced concrete box underpass would be jacked beneath the existing rail line. Speed limits for the rail track would be in place during the jacking operations. Large excavations and thrust blocks would be required for the launching pit.

### *Structure E9.6*

- 14.1.49 The tie-in of E1+9 to the A13 would occur in the vicinity of the existing three-span B186 overbridge. It has been assumed that this structure would be demolished and replaced to allow greater latitude for vertical and horizontal highway alignment. The new structure would be approximately 60m long over the A13, with a 2 or 3 span arrangement. To minimise A13 traffic disruption, bridge launching or lifting-in of pre-assembled deck spans should be considered.

## **14.2 Location C**

- 14.2.1 Following the appraisal described in Section 12 the remaining shortlisted options at Location C are C2, C3, C9 and C19. These options are shown in **Figure 14.2**.
- 14.2.2 Following the decision during the second stage of appraisal not to select Route Option C4 it was recognised that this route had the best benefits of all the C options and that this was as a result of both the location of its junction with the A2/ M2 Junction 1 and its northern routing parallel to the A128 and making use of the A127. The decision not to select Route Option C4 was as a result of its high cost due to the inclusion of a long bored tunnel. Two alternative combination options (C9 and C19) were developed using the C2 crossing location and options. These options were appraised as a result of which both these options have been recommended for inclusion in the shortlist and are discussed in more detail in this section.
- 14.2.3 Route Option C9 starts with the same junction with the A2 as route Options C2 and C3 and follows the same alignment to the river before using the C2 crossing alignment and then running north west of East Tilbury to join the Route Option C4 alignment south of the A13.

14.2.4 Route Option C19 was developed and appraised as an alternative version of Route Option C9 using the Route Option C4 junction at A2/ M2 Junction 1 and then running north of Shorne to join the C2 alignment to the east of Chalk. However, this alignment south of the river could also be combined with Route Options C2 or C3. Therefore for the purposes of the shortlist C19 is considered as an alternative alignment south of the river to the A2/ M2.

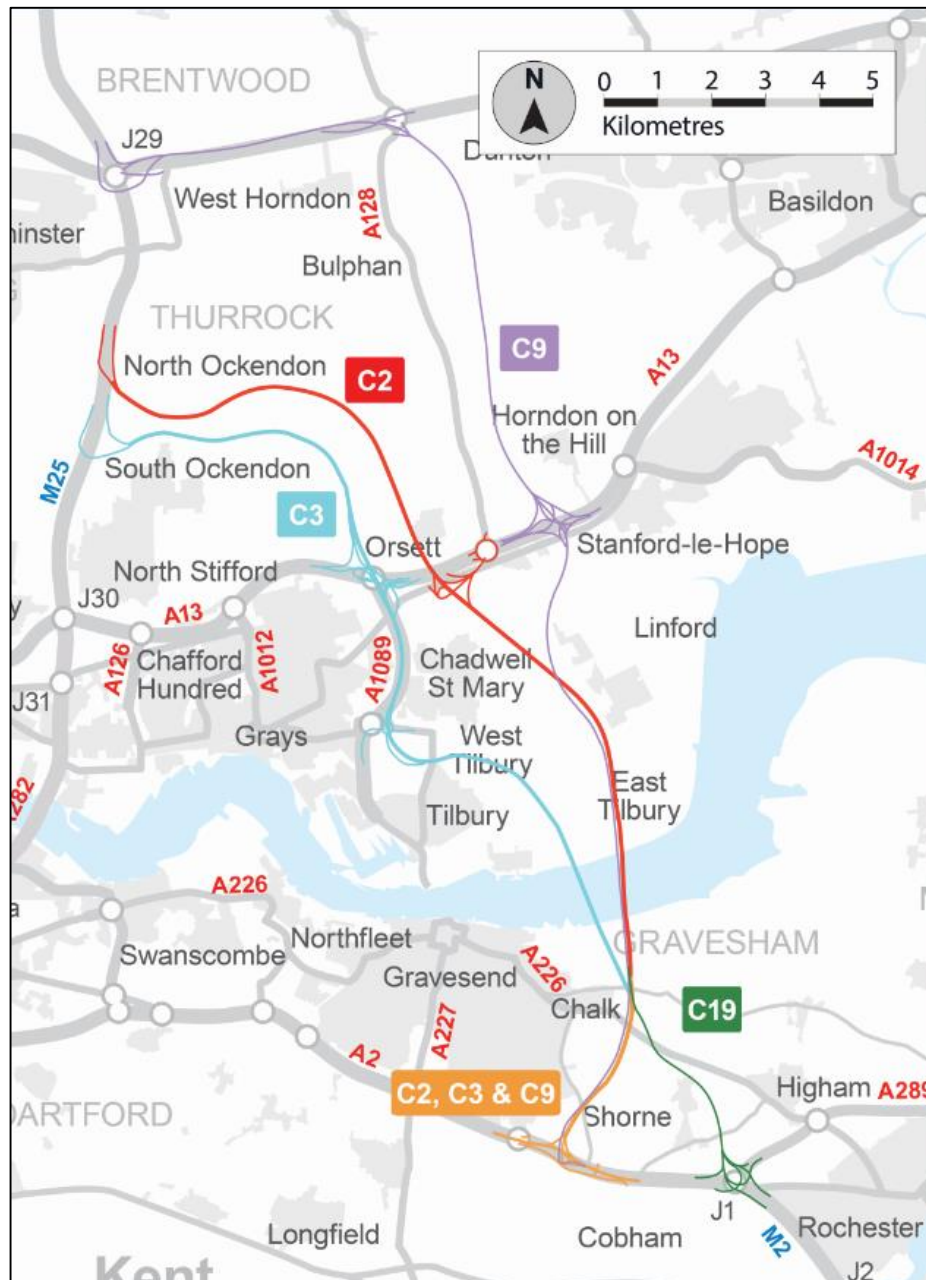


FIGURE 14.2 - LOCATION C SHORTLISTED ROUTES

## Route Option C2

(Refer to **Appendix 15** for Plan and Profile drawings)

- 14.2.5 This route would connect the A2 to the east of Gravesend to the M25 between Junctions 29 and 30.

### *Route Alignment (horizontal)*

- 14.2.6 Horizontal and vertical alignments have been designed to the DMRB TD9/93 Table 3 for highway link design. The design speed has been taken as 120km/h (70mph speed limit) for a dual two-lane all-purpose road.
- 14.2.7 To the south of the river the route would connect to the existing road network at the A2 to the south east of Gravesend in the area between Gravesend and Thong. The route would pass across Thong Lane between Gravesend and Thong and would cross Southern Valley Golf Club towards the A226. The route would cross the A226, the Thames Medway canal and the adjacent railway line before crossing the River Thames to the east of Tilbury power station.
- 14.2.8 On the north side of the river the route would go to the west of East Tilbury and then between Chadwell St Mary and Linford. The route would cross the A13 between the existing Orsett Cock interchange and the existing interchange of the A13 and A1089. North of the A13 the route would go to the east of the reservoir near Orsett Fen where the route turns to the west to go to the north South Ockendon. The route would connect with the M25 near the existing Ockendon Road (B1421) overbridge.

### *Route Alignment (vertical - bridge)*

- 14.2.9 The proposed connection with the A2 would be an all movement free-flow junction. The route to the north of the proposed junction would be on an embankment before moving into cutting to the west of Thong, which requires the route to pass beneath Thong Lane. The route would typically remain in cutting until it starts to rise approximately 200m south of Gravesend Road (A226). To the north of Gravesend Road the route would continue to climb on the approach to the bridge and cross over the river providing the minimum required clearance over the river's navigation channel.
- 14.2.10 To the north of the river the route would be elevated off the bridge and remain elevated across East Tilbury Marshes. In the area of Bowaters Farm the route would be on a small embankment or at existing ground level before rising up over Station Road and the railway line to the west of East Tilbury.
- 14.2.11 North of the railway there are small sections where the route would either be on an embankment or within cutting. Approaching the A13 the route would rise in order to pass over the A13 before descending into cutting approximately 200m to the south west of Orsett. The route would remain in cutting to the west of Orsett before rising onto an embankment to the east of the reservoir at Orsett Fen and remaining on embankment to the junction connection with the M25.

### *Route Alignment (vertical - bored tunnel)*

- 14.2.12 The vertical alignment for the bored tunnel option would connect to the A2 via the same junction arrangement as the bridge option and connect at the



same level. The route would move from embankment to deep cutting (up to 26m depth) where the route crosses Thong Lane and remain in cutting approaching Chalk and then move into the bored tunnel to the east of Chalk via a portal which would be located between the A226 and Lower Higham Road.

- 14.2.13 The tunnel would go beneath the railway and canal and would have one diameter cover approximately beneath the river bed level and would emerge at the other side of the river, to the north of the tunnel portal the route would remain in cutting before rising to embankment and to the west of East Tilbury the vertical alignment would be the same as that described for the bridge.

*Route Alignment (vertical - immersed tube tunnel)*

- 14.2.14 The vertical alignment for the approach roads for this route option would be approximately the same as for the bored tunnel. As the route continues northwards the vertical alignment would remain the same and the southern portal would be in the same location as the bored tunnel even though the immersed tunnel is much shallower under the river. The portal location arises because of the desire to keep below the environmentally sensitive Ramsar designated area.

- 14.2.15 On the north side of the river the portal would be located close to the northern riverbank. To the north of this point around Gravel Pit Farm the vertical alignment would be the same as for the bored tunnel and bridge.

*Junction - A2*

- 14.2.16 At the connection with the A2 an all movement free-flow junction has been developed. In order to locate the junction in this location and provide sufficient spacing from the existing junctions to the east and west it is proposed to re-align the existing A2 north over an approximate length of 2.5km. This re-alignment would enable the proposed junction to be located at a safe distance from the existing junction ensuring that the required weaving distances can be achieved. The re-alignment would also mitigate the impact of the proposed junction on the existing constraints within the vicinity of this junction, including the adjacent HS1.
- 14.2.17 The main issue with the free-flow interchange is the impact on the local roads and the connectivity with the A2. The proposal would remove the existing A2 eastbound merge from the roundabout with Hever Court Road and Valley Drive. In order to provide access for vehicles onto the eastbound A2 from this location a link road is proposed that would connect the roundabout (Henhurst Road) to the south of the A2 to the roundabout with Brewers Road. Vehicles would then access the eastbound A2 via the junction near Shorne Woods Country Park off Brewers Road.
- 14.2.18 Vehicles on the westbound A2 who currently access the junction at Henhurst Road would not be able to do this as with the proposed junction arrangement (the diverge) would be removed. Vehicles would have to exit the A2 at the off-slip onto the roundabout with Brewers Road before using the proposed access link road.

*Junction - A13*

14.2.19 At the A13 junction a direct connection with either a free-flow or grade separated junction is not deemed to be practicable as there is insufficient space between the junction with the A1089 and the existing grade separated junction at Orsett Cock. In order to achieve a direct connection one of these existing junctions would have to be re-located or a departure in weaving length would be required.

14.2.20 It is proposed to connect the new route with the A13 via an off-line grade separated junction which would provide a link to the Orsett Cock junction and also local connections with the A1013.

*Junction - M25*

14.2.21 At this location a free-flow junction is proposed (as it is not considered that a grade separated junction is practicable and would not meet the scheme objectives). Following traffic modelling it is proposed to only have north-facing slip roads which would provide access for northbound LTC vehicles onto the northbound M25 and M25 southbound vehicles onto LTC southbound. The traffic modelling indicates there is little demand for south-facing slip roads, however these could be included in order to increase the resilience of the route.

14.2.22 The proposed junction would require two structures over the railway and Ockendon Road (B1421) in order to accommodate the slip roads.

*Highway Structures*

14.2.23 The route would require the construction of a range of highway structures including crossings of the Tilbury Loop rail line, the Upminster and Grays Branch rail line, the A226, A13, A1013, B188, B186 and B1421. Several structures would also be required at each of the A2, A13 and M25 junctions. The structures are summarised in **Table 14.2** below:

**TABLE 14.2 - SUMMARY OF THE STRUCTURE TYPES AND LOCATIONS ROUTE OPTION C2**

| Structure Type                        | Mainline Structures   |                          |                 | Junction Structures |          |          | Whole Route Total<br>(assuming bored tunnel) |
|---------------------------------------|-----------------------|--------------------------|-----------------|---------------------|----------|----------|----------------------------------------------|
|                                       | Bored Tunnel Crossing | Immersed Tunnel Crossing | Bridge Crossing | A2                  | A13      | M25      |                                              |
| New rail bridges                      | 1                     | 1                        | 1               | 0                   | 0        | 1        | 2                                            |
| New road overbridges                  | 9                     | 9                        | 9               | 0                   | 0        | 0        | 9                                            |
| New road underbridges (up to 4 spans) | 6                     | 6                        | 6               | 1                   | 2        | 2        | 11                                           |
| New road viaducts (5 spans or more)   | 0                     | 0                        | 0               | 0                   | 0        | 1        | 1                                            |
| New footbridges                       | 3                     | 3                        | 3               | 0                   | 2        | 0        | 5                                            |
| New underpasses                       | 7                     | 7                        | 6               | 0                   | 0        | 1        | 8                                            |
| New main river bridges                | 2                     | 2                        | 2               | 0                   | 0        | 0        | 2                                            |
| Existing structures to be modified    | 0                     | 0                        | 0               | 0                   | 0        | 0        | 0                                            |
| Existing structures to be demolished  | 0                     | 0                        | 0               | 0                   | 0        | 0        | 0                                            |
| <b>Total</b>                          | <b>28</b>             | <b>28</b>                | <b>27</b>       | <b>1</b>            | <b>4</b> | <b>5</b> | <b>38</b>                                    |

- 14.2.24 All the structure details given in this section are indicative of potential solutions and are subject to change as the options are developed and appraised further.
- 14.2.25 The most significant structure associated with this route would be the proposed viaduct carrying the LTC westbound to M25 northbound slip road over the M25 and the Upminster and Grays Branch rail line. The length of the viaduct structure is determined by the extent of slip road located above the height at which embankment construction is deemed economic. At this location the M25 is located on an 8m high embankment and thus the proposed slip road would be up to 17m above existing ground level, which leads to an assumed viaduct length of 810m.
- 14.2.26 The viaduct structure would be required to cross the M25 in a single span, as the recent M25 widening works have reduced the median width such that there is insufficient space for a pier between carriageways. The assumed 50m typical span imply construction either by incremental launching or possibly by lifting in beams, although this would be likely to require weekend closures of one carriageway to erect temporary trestles and set up a suitable crane.
- 14.2.27 A notable feature of the route is that the A2 and A13 junctions would require the construction of relatively few structures, due to their locations with respect to the existing road network. The proposed free-flow junction layout with the A2 would require an LTC underbridge spanning the A2 main carriageway. However the highway layout for the junction concept envisages a permanent diversion of the A2 carriageway to the north, which would allow the underbridge structure to be constructed prior to the diversion with minimal impact on the live carriageway. Similarly the proposed A13 junction would be a “satellite” junction to the existing Orsett Cock roundabout, so the major structures would also be constructed away from live traffic.

*River Crossing - Bridge Option*

(Refer to **Appendix 16** for Bridge drawings)

- 14.2.28 At Location C, the navigation channel is as indicated on the PLA drawings and generally the same width as at Location A (approximately 305m). A 450m span cable-stayed bridge with a similar configuration to that proposed for Location A has been considered as a minimum to meet the navigation requirements. Longer spans generally increase construction cost but are expected to be needed to mitigate risk of ship collision with supports in the river. For the purposes of this TAR assessment and preliminary costing, a bridge with a longer main span of 800m has been considered as an upper bound for span length at this location.
- 14.2.29 The potential benefits of adopting a longer main span at Location C are:
- To reduce the size and cost of the main pylon foundations by locating them in shallower water depths where they would be less vulnerable to ship collision from the largest vessels.
  - To site the main pylon foundations in-shore of the existing jetties on the north and south sides of the river.

- To reduce impacts on the river hydrodynamics through having fewer supports in shallower water.
- To reduce impacts on the marine traffic though having fewer obstructions in the water and that would be further away from the designated navigation channel.

14.2.30 The consequence of a longer cable-supported span is an increase in cost and construction programme duration for the bridge, with changes at the most basic level being an increase in number and quantity of the stay cables and cable supported deck, and higher, and therefore more expensive, pylons and larger pylon foundations.

14.2.31 The new bridge is assumed to carry dual two-lane all-purpose (D2AP) road in accordance with TD27/05 with four 3.65m lanes northbound, 1.0m hard strips, a 2.5m central reserve and 0.6m verges. The final carriageway configuration would be subject to confirming the traffic requirements.

14.2.32 A study of satellite images of the site, followed by site visits and the feedback from the stakeholder engagement process, identified a number of physical constraints within Route Option C2 specific to providing a bridge at the proposed location. The key constraints on horizontal alignment for this route option are:

- Proximity to existing service tunnel

The Thames Cable Tunnel is located upstream and parallel to the proposed Route Option C2 alignment. Its line can be determined from the location of the north and south shafts where the overhead lines terminate and is further described in a paper (Haswell, C. K. *Thames Cable Tunnel*, 1970). The tunnel is at a depth of approximately 40m below datum and a clear lateral distance of not less than 50m has been assumed between the foundation of a new bridge and the location of the cable tunnel.

- Land for approach viaduct - south side

The land over which the south approach spans would be constructed is generally open, both natural and arable land. The main constraints on horizontal alignment is the Ramsar site and other designated sites, the Metropolitan Police Firing Range and the existing residential developments at Chalk. RSPB are understood to be the principal land owner. Meetings with RSPB and Regulators to determine the impact of the proposals are being arranged through the stakeholder engagement process. The strategic implications will be addressed as part of the further development of this route option together with further consideration of opportunities for adjusting the design to reduce the impacts if possible.

- Land for approach viaduct - north side

The land over which the north approach spans would be constructed is also generally open and undeveloped. The main constraints on horizontal alignment is an area of landfill. The arisings from any foundation excavation may require treatment or removal from site as contaminated material and would be considered as part of any route

option development with information to be obtained through the stakeholder engagement process.

- Environmental Constraints and Ramsar site

On the south riverbank the approach viaduct would pass through the western extent of the Ramsar site. The viability of obtaining approvals to this has not been investigated but will be as part of any route option development, where it will be necessary in order for any scheme to be accepted to agree suitable mitigation measures to reduce the construction and in service disturbance to levels acceptable to the Regulators and others.

#### 14.2.33 Constraints on vertical alignment:

- Vertical navigation clearance requirement

Navigation clearance requirements are based on a letter dated 16 April 2013 from PLA which stated a minimum aircraft of 75.19m AOD at this location. The clearances are approximately 20m higher than at Location A and would need to be agreed with PLA through the stakeholder engagement process. There is ongoing engagement with the PLA regarding this.

- Horizontal navigation clearance requirement

The minimum span dimension required for the new river crossing bridge would need to accommodate navigation clearances required by PLA and to meet future marine traffic requirements. The minimum acceptable span is assumed to be not less than the existing QEII Bridge, i.e. 450m. As the river is wider at this location than at Location A, and the size of marine vessels is greater, span and height requirements are expected to be greater than at Location A. Requirements to safeguard interests of existing riverside frontage jetties, river hydrodynamic impacts arising from the number, size and spacing of new supports placed in the river or in flood plain areas would also influence the design on span length. Based on presently available information, it has been assumed that options should include for an upper bound main span length sufficient to clear the low water channel which in the general area of Location C is approximately 800m wide.

- Approach gradients

The maximum approach and departure gradient is assumed to not exceed 4%. The summit of the crest curve on the new bridge is assumed to be located symmetrically about the main navigation which is visually preferred to an offset.

- Clearances over North Kent Railway Line

The southern approach spans of a new bridge would have to pass over the Hither Green Dartford and Rochester Line. The minimum clearance between the rails and the proposed bridge is understood to be a minimum of 4.78m but a clearance of 5.1m may be required. This will be confirmed in consultation with Network Rail.

- Clearances over Thames and Medway Canal

The southern approach spans of a new bridge would have to pass over the Thames and Medway Canal. The minimum clearance between the canal normal water level and the soffit of the bridge is typically 2.7m. As the canal is parallel and adjacent to the Hither Green Dartford and Rochester Line this will not be a critical vertical constraint on the alignment.

- Overhead HV power lines on the north and south sides

On both sides of the river, overhead HV power distribution line cross the proposed alignment of the approach viaducts. The overhead power lines would impose a severe constraint on the vertical alignment of any new bridge and the assumption is the lines would require diverting based on the developed alignment. Opportunities to avoid a diversion will be explored as part of the detail appraisal.

#### *River Crossing - Bored Tunnel Option*

(Refer to **Appendix 17** for Bored Tunnel drawing)

14.2.34 Route Option C2 would comprise two new twin-bored tunnels to the east (downstream) of Gravesend. The bored tunnel would start outside the Ramsar site, south of the river, and pass underneath it before reaching the ground on the north side. The twin-bored tunnel would carry two traffic lanes in each, one bore would be northbound and one southbound.

14.2.35 The potential benefits of adopting a bored tunnel at Location C are:

- To reduce impact on the Ramsar site as the bored section would pass beneath it, with no direct impact.
- To avoid impact on the Firing Range near the south riverbank.
- To avoid impacts on the river hydrodynamics through having no works in the water.
- To reduce impacts on the marine traffic through having no permanent obstructions across the river channel although it is noted tunnel muck away may be shifted off site by barge from a nearby jetty.

14.2.36 The carriageway provision in the new tunnels is assumed to be DMRB-compliant. All provision is made for dual two-lane all-purpose (D2AP) road, lanes 3.65m wide, and 1.0m emergency walkways. The final carriageway configuration would be subject to confirmation of the traffic requirements and further agreement of assumptions for hardstrips and verges consistent with modern tunnel provisions with design speeds of 120km/h.

14.2.37 A study of existing satellite images of the site, followed by site visits and the feedback from the stakeholder engagement process identified a number of physical constraints within Route Option C2 specific to construction of a tunnel at the proposed location. The key constraints on horizontal alignment for this route option are:

- Proximity to an existing service tunnel

The Thames Cable Tunnel across the River Thames is located upstream and parallel to the proposed Route Option C2 alignment. Its

alignment can be determined from the location of the north and south shafts, where the overhead lines terminate and is further described in a paper (Haswell, C. K., Thames Cable Tunnel, 1970). The cable tunnel is at a depth of approximately 40m below datum and a clear lateral distance to the a new proposed tunnels is considered adequate at this stage, especially as the cable tunnel would be deeper than the road tunnel at its closer locations.

- Land for approach road - south side

The main constraints on horizontal alignment are the Ramsar site, and the existing residential developments at Chalk. The proposed location of the south portal is beyond the southern boundary of the Ramsar so avoiding direct impacts on the designated sites and RSPB owned land that affect the bridge option discussed above.

- Land for approach - north side

A potential constraint on horizontal alignment is an area of landfill. Areas with contaminated material and/ or poor quality ground that may require ground treatment. This might induce change of the horizontal alignment regardless of the type of tunnel (immersed or bored). This will be considered as part of any route option development with information to be obtained through the stakeholder engagement process.

- Environmental Constraints and Ramsar site

On the south riverbank, the proposed route would pass beneath the western section of the Ramsar site with the portal located just south of the sites southern boundary. The entire section of the tunnel under this protected area would be bored. TBM technology allows for no direct impact either temporary or permanent,

- Proximity to Firing Range

The current understanding from stakeholder communications is that on the south side of the river the route passes through an important firing range which is attached to the Metropolitan Police firearms training centre. The current bored tunnel scheme would avoid disruption to this area altogether. It also is expected to clear the land that is understood to be owned by RSPB.

#### 14.2.38 Constraints on vertical alignment:

- Approach gradients

The maximum tunnel road gradient is assumed not to exceed 3.5%, to balance tunnel length with HGV traffic desirable values.

- Clearances under North Kent Railway Line

The southern part of the tunnels would pass underneath the existing railway. Clearances will be confirmed in consultation with Network Rail.

- Clearances under Thames and Medway Canal

The disused Medway canal is parallel and adjacent to the North Kent Railway Line. Clearances to the railway are more critical and hence the canal is not a significant constraint.

#### 14.2.39 Other engineering considerations are:

- Ground Conditions

Based on the geological sections, plus information from the existing adjacent cable tunnel project, the proposed alignment is designed for the major part of the bored tunnel to be within the chalk. Latest TBM technology would be required to deal with poor ground in the shallow end sections.

- Flooding

The areas near the tunnel portals are affected by frequent flooding and it will be necessary to carry out studies to determine how potential flooding would affect the works and the final structure. It is likely that the new portal areas would need to be protected from flooding with additional protection measures, especially on the north side as on the south side the portals are located on higher ground.

- Groundwater lowering

The cut and cover tunnels for the bored tunnel option would be expected to require extensive de-watering of deep excavations and the permeability of the existing soils and the accessibility of suitable cut-off strata will be key considerations in this regard. Geotechnical surveys together with in-situ and laboratory testing would be required to verify designs. Deep cut-off walls penetrating well into the chalk together with extensive grouting and deep well points and pumping are likely to be required.

#### *River Crossing - Immersed Tube Tunnel Option*

(Refer to **Appendix 18** for Immersed Tunnel drawing)

14.2.40 The route would pass under the River Thames in the same location as the bridge and bored tunnel options and is in a largely undeveloped area. The length of the tunnel is heavily dependent on the location selected for the south portal and in particular on the method of construction used to cross the environmentally sensitive Ramsar designated area. The current scheme employs a cut and cover tunnel with the ground being restored to its original level after construction. The north portal would be close to the northern riverbank and the overall closed tunnel length (i.e. the distance between portals) would be approximately 2.8kms.

14.2.41 From an engineering point of view this route location suits immersed tunnel construction and is one which arguably maximises the benefits of this method of construction. These include a shallow tunnel depth and lower vulnerability to poor ground conditions (as the foundation loading is only slightly greater than the weight of earth that is displaced). The disadvantages stem mainly from the disruptive effects on river navigation and the impact of the designated sites during the construction period. Discussions are ongoing with the PLA and Regulators on the acceptance of the option proposals.



14.2.42 The assumed trench excavation has been allowed to cut into the riverbanks on both sides and “wrap” around the end of the adjoining cut and cover/ transition structures. The riverbank flood protection bunds would need to be diverted temporarily to maintain flood protection and be reinstated on completion.

14.2.43 All recent UK immersed tunnels have required a casting basin to be provided in which the tunnel elements can be built before they are towed out, lowered into position and joined together before being backfilled. The casting basin floor has to be deep enough to enable the tunnel elements to be floated out when the basin is flooded. There is, potentially, space available nearby for an in situ excavated casting basin to be constructed although the land area required is significant and the environmental impact would also need to be assessed. Other options include using an existing casting basin remote from the site and towing the tunnel elements into position, with many alternatives being possible with longer sea towing operations from locations elsewhere in the UK or overseas.

14.2.44 The internal arrangements of the immersed tunnel section are similar to those described in the bored tunnel section; with provisions made for dual lane all-purpose (D2AP) road. The final carriageway configuration would be subject to confirmation of the traffic requirements and further agreement of assumptions for hardstrips and verges consistent with modern tunnel provisions with design speeds of 120km/h.

14.2.45 The constraints on horizontal alignment include;

- Proximity to existing service tunnel

The Thames Cable Tunnel has been identified in the area. According to the existing information the tunnel runs from Tilbury power station (Essex) to the east of Gravesend (Kent) near the riverside. This cable tunnel is located upstream of the proposed immersed tunnel and was bored through the chalk bedrock. The details of the tunnel depth and size are provided in a paper (Haswell, C. K. Thames Cable Tunnel, 1970). Confirmation of this and further data on the cable tunnel is being requested through the stakeholder engagement process. Current indications are that the cable tunnel is sufficiently far away not to be affected by immersed tunnel construction.

- Proximity to Ramsar site

The route passes through the western edge of the Ramsar and a SSSI designated area on the south side of the river. It is not possible to avoid the site altogether merely to minimise the intrusion. The current option involves lowering the alignment to pass through the site via a cut and cover tunnel. RSPB are understood to be the principal land owner and, as noted for the bridge option, meetings with RSPB and Regulators to discuss the impact of the proposals are being arranged through the stakeholder engagement process. Impacts and strategic implications will be addressed as part of the further development of this option where opportunities for adjusting the design to reduce the impacts where possible will be considered further.

- Proximity to Firing Range

On the south side of the river the route passes through an important firing range attached to the Metropolitan Police firearms training centre. The current scheme involves lowering the alignment to pass through the site via a cut and cover tunnel.

#### 14.2.46 Constraints on vertical alignment include:

- Maximum Approach Gradients

The approach gradient of the roadway on the south side of the river would be relatively flat due to the location of the portal to the south of the Ramsar site but a gradient of 4% has been considered on the north side to keep the overall length of the tunnel as short as possible. The 4% gradient allows the north portal to be located just to the north of the northern flood protection embankment.

- Level of Top of Tunnel

The top of the tunnel has to be covered with a layer of rock armouring to protect the tunnel from such undesirable incidents as a dragging or falling anchor from a passing ship. The top of the rock layer has to be below the level established for any future dredging of the river bed which the PLA may need to carry out to retain and possibly improve the draughts for passing ships. Dredging levels have been requested through the stakeholder engagement process but currently a level of 12m below Chart Datum is being considered. This is approximately 2 metres below the level of the existing navigation channel.

- Railway and Canal

On the south side of the river just to the south of the Ramsar site the route passes below the existing North Kent Railway Line and also below an existing disused canal (the Thames and Medway canal). The railway is located on a small elevated embankment and the canal in a shallow trench. Also in this area, there are overhead HV cables which run parallel to the canal and the rail track. The road would be accommodated in a cut and cover tunnel through this area and pass below these assets.

#### 14.2.47 Other engineering issues particular to the immersed tunnel option are:

- Bed Stability

The deepest water in the river is towards the northern riverbank on the inside of the bend and studies will be required to investigate historical movements of the river channel and investigate long term bed stability. Initial indications are that the river channel is stable but if this proves not to be the case more extensive rock armouring may be required.

- Ground Conditions

Very little information is currently available on the nature of the existing ground conditions and extensive geotechnical surveys and testing will be required. Information currently available (mainly from the cable tunnel contract) suggests that there is a relatively thick layer

of alluvial material overlying chalk bedrock. Initial indications are that the whole of the immersed tunnel would be founded within the chalk bedrock and should not be subject to excessive settlements. Any structures founded in the Alluvium however may need to be piled.

- Siltation and Erosion

The construction of an immersed tunnel would require extensive excavation of the bed of the river by dredging and subsequent backfilling. It is inevitable that some of these materials would be lost into the river flow during the construction process and studies will be required to determine where and how these materials would be deposited. Presently no information on river flows, suspended solids or other important parameters such as dissolved oxygen levels or salinity variations has been seen but studies commissioned by the EA under the TE2100 programme have now been obtained and are being reviewed. Surveys may be required to collect new information subject to the quality and relevance of data that can be obtained from these studies. Preliminary hydrodynamic modelling is planned for the next stage to support the assessment of hydrodynamic impacts and determination of hydrodynamic parameters.

- Flooding

Much of the land area through which Location C passes is affected by periodic flooding and it will be necessary to carry out studies to determine how flooding potential would be affected by the new works. It is likely that existing flood protection embankments and levels would have to be maintained both during the construction period and over the longer term. In addition the tunnel portal areas and any approach ramp areas would need to be protected from flooding.

- Groundwater Lowering

The cut and cover tunnels for the immersed tunnel option would be expected to require extensive de-watering of deep excavations and the permeability of the existing soils and the accessibility of suitable cut-off strata will be key considerations in this regard. Geotechnical surveys together with in-situ and laboratory testing would be required to verify designs. Deep cut-off walls penetrating well into the chalk together with extensive grouting and deep well points and pumping are likely to be required.

- Chalk Aquifer

The issue of contamination of the chalk aquifer by salt intrusion would need to be investigated (in conjunction with the EA). With previous immersed tunnel projects in the UK, membranes have been required over the tunnel to seal the aquifer on completion of backfilling.

### Route Option C3

(Refer to **Appendix 19** for Plan and Profile drawings)

- 14.2.48 This route would connect the A2 to the east of Gravesend to the M25 between Junctions 29 and 30.

#### *Route Alignment (horizontal)*

- 14.2.49 Horizontal and vertical alignments have been designed to the DMRB TD9/93 Table 3 for highway link design. The design speed has been taken as 120km/h (70mph speed limit) for a dual two-lane all-purpose road.
- 14.2.50 To the south of the river the route would connect to the existing road network at the A2 to the south east of Gravesend. This junction would be the same as proposed for Route Option C2 with the highway alignment to the north of the junction also the same. The proposed road alignment would deviate away from the Route Option C2 alignment to the southeast of Chalk where Route Option C3 would cross the river further west towards Tilbury power station.
- 14.2.51 On the north side of the river the route would go to the east of Tilbury and then turn west to go between the north of Tilbury and the south of Chadwell St Mary. The proposed route through this area has been developed to utilise a section of the A1089 between the Chadwell Bypass (B149) and the existing interchange between the A13 and the A1089. This section of the A1089 is a dual carriageway and would require upgrading with the provision of two additional lanes in each direction. Where the proposed route joins the A1089 there is an existing junction which connects the A1089 and the A126. This junction would need to be modified as the new route would be the main route and the A1089 and the A126 would need to connect into the new road.
- 14.2.52 North of this junction the proposed route would follow the A1089 to the interchange with the A13 where a new free-flow or grade separated junction is proposed which would provide connections for all movements. To the north of the A13 the route would pass to the west of Orsett and then turn to the west and would be north of South Ockendon before connecting with the M25 between Junctions 29 and 30 via a free-flow junction.

#### *Route Alignment (vertical - bridge)*

- 14.2.53 The route to the north of the proposed junction at the A2 would be the same as for Route Option C2 with the route changing around the A226 with this route option starting to rise towards the bridge to the north of the A226. North of the A226 and Chalk the route would climb on the approach to the bridge and cross over the river providing the minimum clearance over the river's navigation channel.
- 14.2.54 To the north of the river the route would be elevated off the bridge and remain elevated across West Tilbury Marshes. To the north of Tilbury the route would be at approximate ground level before connecting into the existing A1089 to the east of Grays where the A1089 intersects with the A126. The vertical alignment would then follow the existing A1089, further assessment of the A1089 would be required to determine if this section of carriageway needs modifications, if so this could require changes to the vertical alignment.

- 14.2.55 The route would intersect the A13 to the south west of Orsett and as such a junction is proposed at this location. The route would pass beneath the A13 and to the west of Orsett would enter a long section of cutting and embankments to the east and north of South Ockendon before rising to connect with the proposed free-flow junction at the M25.

*Route Alignment (vertical - bored tunnel)*

- 14.2.56 The vertical alignment for the bored tunnel option would connect to the A2 via the same junction arrangement as the bridge option and connect at the same level. To the north east of Thong the route would enter a long section of deep cutting (up to 26m depth) which would continue to the bored tunnel portal which would be located between the A226 and Lower Higham Road.
- 14.2.57 The tunnel would go beneath the railway and canal and then beneath the river before rising to come out near Cooper Shaw Road to the north east of Tilbury. The alignment would be the same from Cooper Shaw Road to the north east of Tilbury as described for the bridge option.

*Route Alignment (vertical - immersed tube tunnel)*

- 14.2.58 The vertical alignment for this crossing option at the A2 would be the same as the bridge and the bored tunnel.
- 14.2.59 The route would follow a similar vertical alignment to the bored tunnel with a long section of deep cutting to the north of Thong down to the tunnel portal which would be located between the A226 and Lower Higham Road. The tunnel would go beneath the railway and canal before going beneath the river.
- 14.2.60 North of the river the alignment would rise to existing ground level and would then follow the same vertical alignment as the bridge and bored tunnel option.

*Junction - A2*

- 14.2.61 This junction would be the same as Route Option C2 junction (refer to Sections 14.2.16 to 18).

*Junction - A1089*

- 14.2.62 In order to provide a connection with the A1089 a new junction would be required which would enable the new route to be the main north south route and would provide an at-grade roundabout which would connect with A1089 and the A126.
- 14.2.63 The proposed road alignment and junction location in this area would need to be reviewed following further discussions with Tilbury Port about the impact on London Distribution Park. Sections are currently under construction and there are future plans for expansion. These future plans would need to be assessed in detail.

*Junction - A13*

- 14.2.64 The junction with the A13, at the site of the existing junction between the A13 and A1089, is proposed to be an all-movement free-flow junction which would require a complex layout of slip roads, structures and loops in order to maintain existing and provide new traffic movements.

14.2.65 The location of the junction would have an impact on the local road, Baker Street (B188), and properties along this road near the A13. In addition the existing junction is located within a scheduled monument and the impacts on this designated area need to be investigated in detail.

#### *Junction - M25*

14.2.66 The proposed junction is very similar to that detailed for Route Option C2 junction with M25, except this junction is further south on the M25 (refer to Sections 14.2.21 and 22).

14.2.67 At this location a free-flow junction is proposed as it is not considered that a grade separated junction is practicable and would not meet the scheme objectives. Following traffic modelling it is proposed to only have north-facing slip roads which would provide access for northbound LTC vehicles onto the northbound M25 and M25 southbound vehicles onto LTC southbound. The traffic modelling indicates there is little demand for south-facing slip roads, however these could be included in order to increase the resilience of the route.

#### *Highway Structures*

14.2.68 The route would require the construction of a range of highway structures including crossings of the Tilbury Loop rail line, the Upminster and Grays Branch line, A226, A126, B149, A1013, A13 and B186. Further structures would be required at the junctions with the A2, A1089, A13 and M25. Finally the route would require the widening of the existing A1089 along a length of approximately 2.3km to accommodate the proposed dual four-lane carriageway. All existing highway structures on this section of the A1089 would require either significant modification or demolition and replacement. The structures are summarised in **Table 14.3** below.

14.2.69 All the structure details given in this section are indicative of potential solutions and are subject to change as the options are developed and appraised further.

**TABLE 14.3 - SUMMARY OF THE STRUCTURE TYPES AND LOCATIONS ROUTE OPTION C3**

| Structure Type                        | Mainline Structures   |                          |                 | Junction Structures |          |           |          | Whole Route Total (assuming bored tunnel) |
|---------------------------------------|-----------------------|--------------------------|-----------------|---------------------|----------|-----------|----------|-------------------------------------------|
|                                       | Bored Tunnel Crossing | Immersed Tunnel Crossing | Bridge Crossing | A2                  | A1089    | A13       | M25      |                                           |
| New rail bridges                      | 1                     | 1                        | 0               | 0                   | 0        | 0         | 2        | 3                                         |
| New road overbridges                  | 6                     | 6                        | 6               | 0                   | 0        | 0         | 1        | 7                                         |
| New road underbridges (up to 4 spans) | 4                     | 4                        | 4               | 1                   | 2        | 10        | 3        | 20                                        |
| New road viaducts (5 spans or more)   | 0                     | 0                        | 0               | 0                   | 0        | 1         | 0        | 1                                         |
| New footbridges                       | 3                     | 3                        | 3               | 0                   | 0        | 0         | 0        | 3                                         |
| New underpasses                       | 2                     | 2                        | 2               | 0                   | 0        | 0         | 0        | 2                                         |
| New main river bridges                | 2                     | 2                        | 2               | 0                   | 2        | 0         | 0        | 4                                         |
| Existing structures to be modified    | 2                     | 2                        | 2               | 0                   | 0        | 0         | 1        | 3                                         |
| Existing structures to be demolished  | 3                     | 3                        | 3               | 0                   | 0        | 0         | 0        | 3                                         |
| <b>Total</b>                          | <b>23</b>             | <b>23</b>                | <b>22</b>       | <b>1</b>            | <b>4</b> | <b>11</b> | <b>7</b> | <b>46</b>                                 |

14.2.70 The following existing structures would be affected by the route:

- B149 Wood View overbridge - a four-span reinforced concrete overbridge, which is assumed to be demolished and reconstructed.
- Terrells Heath Bridleway overbridge - a three-span prestressed box beam bridge carrying bridleway BR 112, which is assumed to be demolished and reconstructed.
- Terrells School Subway - a box underpass conveying footpath FP 108 beneath the A1089, which is assumed to require extending to the east.
- A1013 Stanford Road overbridge - a four-span reinforced concrete overbridge, which is assumed to be demolished and reconstructed.
- A13 overbridge - a four-span reinforced concrete bridge carrying the A13 over the A1089. The A1089 currently passes below the two central spans of this bridge and it is anticipated that ground retaining or stabilisation works would be required either behind or in front of the abutments to allow LTC slip roads to be pass through the two end spans.
- Ockendon rail bridge - a single span prestressed concrete beam bridge carrying the M25 over the Upminster and Grays Branch rail line. This structure may require extension and strengthening to accommodate the proposed southbound slip road from the M25 onto LTC.

14.2.71 The most complex structures required for this route would be those associated with the free-flow junction with the A13. In addition to the existing slip roads associated with the A1089 and A13 junction, the proposed slip roads would also cross Baker Street at three locations, Stiffords Clay Road at three locations and the A1013 Stanford Road at one location, requiring a total of ten highway underbridges and one viaduct structure. It has been assumed that the viaduct would be a seven-span structure carrying two slip roads over Baker Street, the A13 main carriageway and a southbound on-slip to the A1089, with typical spans of about 55m.

14.2.72 The structure at the A2 junction would be identical to that proposed for Route Option C2 and thus shares the same buildability benefits in that the structure can be constructed prior to the permanent diversion of the A2. The structures required at the proposed A1089 grade separated junction would also present no significant buildability challenges, since the proposed roundabout would be constructed off-line from the existing road network.

14.2.73 The junction with the M25 associated with this route would require the northbound slip road to cross the M25 on a significant skew angle. As with Route Option C2, it would not be possible to provide a median pier and hence a main span of approximately 82m would be required. However the height of the slip road approaches would be significantly lower at this location compared to Route Option C2, due the M25 being located at existing ground level. Consequently a three-span structure is proposed. As discussed above the southbound slip road has the potential to require modification to the existing Ockendon rail bridge, but future route option

development work will seek to minimise the impact by considering alternative locations for the slip road diverge.

*River Crossing - Bridge Option*

(Refer to **Appendix 16** for Bridge drawings)

- 14.2.74 The bridge structure option for the river crossing would be similar to the option described for Route Option C2 in terms of length, height, span, key constraints and engineering requirements. Refer to Sections 14.2.28 to 33 above for descriptions under Route Option C2 for details.

*River Crossing - Bored Tunnel Option*

(Refer to **Appendix 17** for Bored Tunnel drawing)

- 14.2.75 The bored tunnel river crossing structure for Route Option C3 would be very similar to Route Option C2 in terms of length and constraints. The proposed solution would comprise a 2.93km bored section with similar arrangements as proposed for Route Option C2 (refer to Sections 14.2.34 to 39 above).

*River Crossing - Immersed Tube Tunnel Option*

(Refer to **Appendix 18** for Immersed Tunnel drawing)

- 14.2.76 The immersed tunnel river crossing structure for Route Option C3 would be very similar to Route Option C2 in terms of length and constraints (refer to Sections 14.2.40 to 47 above). The proposed solution would comprise a 1.3km immersed section with similar arrangements as proposed for Route Option C2. To the south of the river there would be a cut and cover section approximately 1.3km in length. On the north side of the river the cut and cover section would be 250m in length.

**Route Option C9**

(Refer to **Appendix 20** for Plan and Profile drawings)

- 14.2.77 This route is a combination of Route Option C2 and the not selected C4 route option to the north of the A13. The route would connect the A2 to the east of Gravesend to the M25 at Junction 29.

*Route Alignment (horizontal)*

- 14.2.78 Horizontal and vertical alignments have been designed to the DMRB TD9/93 Table 3 for highway link design. The design speed has been taken as 120km/h (70mph speed limit) for a dual two-lane all-purpose road.
- 14.2.79 This route option would connect to the A2 at the same location as detailed for Route Option C2 and C3 and utilise the same junction. To the north of the junction the alignment would be the same as Route Option C2 and has the three crossing options, bored tunnel, immersed tube tunnel and bridge.
- 14.2.80 North of the river the route would go to the west of East Tilbury and then turn east to go north of East Tilbury and through the southeast edge of Orsett Golf Club. At the A13 there would be a proposed all movement free-flow junction which would be located between Orsett Cock Interchange and the grade separated junction with the A13 and B1007/ A1014.
- 14.2.81 To the north of the A13 the route would head north towards the A127 following a parallel alignment to the A128. The possibility of using the A128



has been investigated; however it was considered that widening this existing route was not practicable in terms of severing the local road connections and also the adverse impact to properties along the route. The parallel route to the A128 avoids these issues and it is proposed that at the A127 the new route would connect directly into the A127 making the new route the main route to Junction 29 on the M25. The existing A127 would connect into the new route via the existing grade separated junction between the A127 and A128. The A127 would have to be widened to dual four lanes up to Junction 29 to accommodate the additional traffic.

#### *Route Alignment (vertical)*

14.2.82 The vertical alignment from the A2 would be as detailed in for Route Option C2. This option has all three crossing options and the vertical alignments would be the same as Route Option C2.

14.2.83 North of the river towards the A13 the alignment would typically be on short sections of embankment and would pass over the Tilbury loop railway line as well as Station Road and Muckingford Road. At the A13 the route would pass over the A13 on viaduct and then north of the A13 the alignment would generally be on short sections of embankment.

14.2.84 At the A127 the route would connect into the existing dual carriageway and would utilise the existing road through to Junction 29.

#### *Junction - A2*

14.2.85 This junction would be the same as Route Option C2 junction (refer to Sections 14.2.16 to 18).

#### *Junction - A13*

14.2.86 The proposed junction at the A13 would be an all movement free-flow junction located between the existing Orsett Cock Interchange and the existing grade-separated junction with the A13 and B1007/ A1014. The junction would have a four level layout with a complex series of slip roads, loops and interchange links to the adjacent road network.

14.2.87 In order to locate the junction at the proposed location it would be necessary to remove the existing east-facing slip roads on the Orsett Cock interchange. This removes the issue of weaving lengths from the existing east-facing on- and off-slips at Orsett Cock to the LTC west-facing slip roads associated with this junction.

14.2.88 In order to compensate for the removal of the slip roads it would be necessary to utilise the existing road (A1013/ Stanford Road) which runs parallel with the A13 between Orsett Cock Interchange and the junction with the B1007/ A1014. Improvements on this road would be required to accommodate the additional traffic.

#### *Junction - A127*

14.2.89 At the A127 (which is an Essex County road) it is proposed to make the new road the main through route and utilise the existing A127 through to Junction 29 on the M25. It is proposed to utilise the existing grade-separated junction between the A127 and A128 in order to provide local connections to the A127 and other local roads. Improvements to the A127, including widening

by two lanes in both directions, would be required along the A127 and the proposed connection with the existing A128/ A127 junction. As a consequence of widening the A127, it would be necessary to provide alternative local access to the A127 as this would be removed. This could be in the form of new slip roads, link roads or a new bridge over the A127 to improve connectivity to both sides of the A127.

#### *Junction - M25*

- 14.2.90 At this junction it is proposed to maintain the existing grade-separated junction and construct two new link roads directly linking the new route with the M25. There would be a link road on a viaduct southwest of the existing junction over the existing road network which would take traffic onto the northbound M25. A dedicated link road from the M25 southbound would take traffic onto the A127/ LTC eastbound. This arrangement would mean that the majority of LTC traffic would be segregated from the existing roundabout and slip roads.

#### *Highway Structures*

- 14.2.91 The route would require the construction of a range of highway structures including crossings of the Tilbury Loop rail line, the Fenchurch Street and Shoeburyness rail line, the A226, A1013, A13, A128 and B186. Structures would also be required at each of the A2, A13, A127 and M25 junctions. Finally the route would require the widening of the existing A127 along a length of approximately 3.5km to accommodate the proposed dual four-lane carriageway, which would entail the replacement of two existing highway structures. The structures required are summarised in **Table 14.4** below.
- 14.2.92 All the structure details given in this section are indicative of potential solutions and are subject to change as the options are developed and appraised further.

**TABLE 14.4 - SUMMARY OF THE STRUCTURE TYPES AND LOCATIONS ROUTE OPTION C9**

| Structure Type                        | Mainline Structures   |                          |                 | Junction Structures |           |          |          | Whole Route Total (assuming bored tunnel) |
|---------------------------------------|-----------------------|--------------------------|-----------------|---------------------|-----------|----------|----------|-------------------------------------------|
|                                       | Bored Tunnel Crossing | Immersed Tunnel Crossing | Bridge Crossing | A2                  | A13       | A127     | M25      |                                           |
| New rail bridges                      | 2                     | 2                        | 2               | 0                   | 0         | 0        | 0        | <b>2</b>                                  |
| New road overbridges                  | 10                    | 10                       | 10              | 0                   | 3         | 1        | 0        | <b>14</b>                                 |
| New road underbridges (up to 4 spans) | 4                     | 4                        | 4               | 1                   | 3         | 1        | 1        | <b>10</b>                                 |
| New road viaducts (5 spans or more)   | 0                     | 0                        | 0               | 0                   | 2         | 0        | 2        | <b>4</b>                                  |
| Jacked box highway underbridges       | 0                     | 0                        | 0               | 0                   | 2         | 0        | 0        | <b>2</b>                                  |
| Cut and cover tunnel                  | 0                     | 0                        | 0               | 0                   | 2         | 0        | 0        | <b>2</b>                                  |
| New footbridges                       | 5                     | 5                        | 5               | 0                   | 1         | 0        | 0        | <b>6</b>                                  |
| New underpasses                       | 5                     | 5                        | 4               | 0                   | 0         | 0        | 0        | <b>5</b>                                  |
| New main river bridges                | 3                     | 3                        | 3               | 0                   | 0         | 0        | 0        | <b>3</b>                                  |
| Existing structures to be modified    | 0                     | 0                        | 0               | 0                   | 0         | 0        | 0        | <b>0</b>                                  |
| Existing structures to be demolished  | 2                     | 2                        | 2               | 0                   | 1         | 1        | 0        | <b>4</b>                                  |
| <b>Total</b>                          | <b>33</b>             | <b>33</b>                | <b>32</b>       | <b>1</b>            | <b>14</b> | <b>3</b> | <b>3</b> |                                           |

14.2.93 The following existing structures would be affected by the route:

- Saffron Garden overbridge - a four-span concrete slab bridge carrying a minor road over the A13. It is assumed that this bridge would be demolished and reconstruct this bridge in order to span over the diversion of the A1013 associated with the proposed A13 junction.
- Overbridge to the western arm of the A127/ A128 junction roundabout - a four-span prestressed beam bridge assumed to be demolished and reconstructed to accommodate an eastbound slip road from LTC onto the A127.
- B186 Warley Street - a four-span prestressed beam bridge spanning the A127 assumed to be replaced as part of the A127 widening works.
- Codham Hall access road - a three-span steel composite bridge spanning the A127 assumed to be replaced as part of the A127 widening works.

14.2.94 The structure at the A2 junction would be identical to that proposed for Route Option C2 and thus shares the same buildability benefits in that the structure can be constructed prior to the permanent diversion of the A2.

14.2.95 The proposal for the four-level junction with the A13 would require a number of complex structures. It is currently proposed, in the interests of minimising landscape impact and land-take, to construct only two levels above the existing A13 carriageway. This would require two tunnels of up to 230m length to be constructed below the level of the A13. Approximately 80m of each tunnel would be constructed by box-jacking beneath the A13 with cut and cover construction used for the adjacent sections of tunnel. A new overbridge would be constructed above the A13 to carry the LTC mainline, whilst two curved viaducts would form the highest level of the junction.

14.2.96 Finally as part of the proposed free-flow improvements at Junction 29 of the M25 two structures would be required crossing the M25 south of the existing junction roundabout and the A127 west of the existing roundabout. Due to the proximity of these structures to the existing junction, the structures would also need to span the slip roads leading to the roundabout, and hence viaduct structures are proposed. The length of the viaduct crossing the M25 is further increased to approximately 380m by the elevated nature of the slip road, which in turn is driven by the need to pass above the existing M25 embankment.

#### *River Crossing Structures*

(Refer to **Appendix 16** for Bridge drawings, **Appendix 17** for Bored Tunnel drawing and **Appendix 18** for Immersed Tunnel drawing)

14.2.97 Refer to Route Option C2 for river crossing options and descriptions (refer to sections 14.2.28 to 14.2.47).

#### **Route Option C19 (Southern Alternative)**

(Refer to **Appendix 21** for Plan and Profile drawings)

14.2.98 This route is an alternative to Route Options C2, C3 and C9 to the south of the River Thames. The route would connect into Junction 1 of the M2 and would go to the east of Shorne and then northwest towards Church Lane and Lower Higham Road. This route option could connect into any of the Route Options C2, C3 and C9 north of the river utilising all of the crossing options for these route options.

*Route Alignment (horizontal)*

14.2.99 Horizontal and vertical alignments have been designed to the DMRB TD9/93 Table 3 for highway link design. The design speed has been taken as 120km/h (70mph speed limit) for a dual 2 lane all-purpose road.

14.2.100 To the south of the river the route would connect to the existing road network at Junction 1 on the M2. To the north of this junction the route would go to the west of Great Crabbles Wood and east of Shorne. The route would turn northwest north of Shorne and then run west towards Chalk to join the alignment of Route Options C2, C3 or C9. All river crossings are available for this route and these would be as detailed in Route Options C2 and C9.

*Route Alignment (vertical)*

14.2.101 To the north of the junction with the M2 the alignment would have three sections of deep cutting between the M2 junction and where the alignment joins C2, C3 or C9 alignments to the south east of Chalk. The first deep cutting is across Peartree Lane to the west of Great Crabbles Wood. There would be a shorter section of cutting to the north east of Shorne near the Warren. The route would pass over the A226 and would then enter a deep cut towards the tunnel portal to the north of Church Lane for the two tunnel options.

*Junction - M2 Junction 1*

14.2.102 This would be a complex junction that would provide links to the M2, A2, and the A289 via a series of slip roads at different levels on new structures. The proposed layout would require five levels with the lowest being the existing A289 connection to the A2/ M2 and the highest being the proposed slip road from the A289 onto LTC northbound.

14.2.103 The proposed connections would have issues in terms of buildability and maintaining existing traffic movements during construction. The slip roads from LTC southbound onto the westbound A2 and the eastbound A289 would go through the edge of an area of ancient woodland (Great Crabbles Wood) to the north of the A289.

*Highway Structures*

14.2.104 The route would require the construction of several highway structures including crossings of A226 and a number of unclassified road and public rights of way. There would also be a number of significant structures required at the junction with the A2/ M2/ A289. The structures required are summarised in **Table 14.5** below.

14.2.105 All the structure details given in this section are indicative of potential solutions and are subject to change as the options are developed and appraised further.

**TABLE 14.5 - SUMMARY OF THE STRUCTURE TYPES AND LOCATIONS FOR THE SOUTHERN ALTERNATIVE (C19)**

| Structure Type                        | Mainline Structures   |                          |                 | Junction Structures | Whole Route Total<br>(assuming bored tunnel) |
|---------------------------------------|-----------------------|--------------------------|-----------------|---------------------|----------------------------------------------|
|                                       | Bored Tunnel Crossing | Immersed Tunnel Crossing | Bridge Crossing | A2 / M2 / A289      |                                              |
| New rail bridges                      | 0                     | 0                        | 0               | 0                   | <b>0</b>                                     |
| New road overbridges                  | 5                     | 5                        | 5               | 0                   | <b>5</b>                                     |
| New road underbridges (up to 4 spans) | 0                     | 0                        | 0               | 2                   | <b>2</b>                                     |
| New road viaducts (5 spans or more)   | 0                     | 0                        | 0               | 5                   | <b>5</b>                                     |
| Jacked box highway underbridges       | 0                     | 0                        | 0               | 1                   | <b>1</b>                                     |
| Cut and cover tunnel                  | 0                     | 0                        | 0               | 0                   | <b>0</b>                                     |
| New footbridges                       | 2                     | 2                        | 2               | 0                   | <b>2</b>                                     |
| New underpasses                       | 0                     | 0                        | 0               | 0                   | <b>0</b>                                     |
| New main river bridges                | 0                     | 0                        | 0               | 0                   | <b>0</b>                                     |
| Existing structures to be modified    | 0                     | 0                        | 0               | 0                   | <b>0</b>                                     |
| Existing structures to be demolished  | 0                     | 0                        | 0               | 1                   | <b>1</b>                                     |
| <b>Total</b>                          | <b>7</b>              | <b>7</b>                 | <b>7</b>        | <b>9</b>            | <b>16</b>                                    |

14.2.106 The following existing structure would be affected by the route:

- Three Crutches slip road overbridge - a two-span steel composite overbridge (constructed in 2003 as part of the M2 widening works) carrying the A2 westbound carriageway over the M2 main carriageway. A proposed LTC slip road would clash with the west abutment of this structure whilst a second slip road would be built behind the east abutment, passing underneath the A2. It is currently assumed that the existing overbridge would be demolished and a replacement structure constructed off-line in order to minimise disruption to the A2. Alternatively with further refinement of the slip road design it may be feasible to stop up the A2 westbound carriageway during the construction of the slip roads, providing a suitable diversion route could be agreed with the relevant local authorities. This approach would allow the existing bridge structure to be retained.

14.2.107 The southernmost junction of this route would require a number of major structures as it would be located at the existing junction between the A2, M2

and A289. The complexity of the junction would require five levels of slip roads and the heights of the slip roads would be further increased by the topographical dip located between the existing junction and the LTC mainline located on the Shorne to Highham ridge. A series of five viaducts are therefore proposed with lengths varying from 300m to 1000m and with pier heights up to 23m. Finally a jacked box underbridge would probably be required to allow the proposed A289 westbound to M2 southbound slip to pass below the existing A2 eastbound carriageway, as adjacent residential housing limits the scope for realignment of the A2.

#### *River Crossing Structures*

(Refer to **Appendix 16** for Bridge drawings, **Appendix 17** for Bored tunnel drawing and **Appendix 18** for Immersed Tunnel drawing)

- 14.2.108 This route option could utilise any of the proposed crossing options detailed previously for Route Option C2, C3 and C9 (refer to sections 14.2.28 to 47).

## 15 Appraisal Summary

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### 15.1 Appraisal Summary Tables (ASTs)

15.1.1 Appraisal Summary Tables for the shortlist options are set out in the following tables:

- A1 (bridge west) **Table 15.1**
- A4 (bored tunnel west) **Table 15.2**
- C2 (bridge) **Table 15.3**
- C2 (bored tunnel) **Table 15.4**
- C2 (immersed tunnel) **Table 15.5**
- C3 (bridge) **Table 15.6**
- C3 (bored tunnel) **Table 15.7**
- C3 (immersed tunnel) **Table 15.8**
- C9 (bridge) **Table 15.9**
- C9 (bored tunnel) **Table 15.10**
- C9 (immersed tunnel) **Table 15.11**
- C19 (bridge) **Table 15.12**
- C19 (bored tunnel) **Table 15.13**
- C19 (immersed tunnel) **Table 15.14**

TABLE 15.1 - APPRAISAL SUMMARY TABLE: OPTION A1-BRIDGE (E1+9), 60 YEAR APPRAISAL, 2025-2084

| Appraisal Summary Table |                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                             | Date produced: |           | 31-Jul-15              |                         | Contact:           |                                                 |
|-------------------------|--------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------|----------------|-----------|------------------------|-------------------------|--------------------|-------------------------------------------------|
| Name of scheme:         |                                      | Lower Thames Crossing Option A1-Bridge (AA15)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                             |                |           |                        |                         | Name               | Eamonn Colgan                                   |
| Description of scheme:  |                                      | A new trunk road connecting M25 Junction 2 to M25 Junction 30 via A13, with a 4 lane bridge crossing to the west of Dartford crossing, with option E1+9.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                             |                |           |                        |                         | Organisation       | Highways England                                |
|                         |                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                             |                |           |                        |                         | Role               | Project Sponsor                                 |
| Impacts                 |                                      | Summary of key impacts                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                             | Assessment     |           |                        |                         |                    |                                                 |
|                         |                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                             | Quantitative   |           |                        | Qualitative             | Monetary<br>£(NPV) | Distributional<br>7-pt scale/<br>vulnerable grp |
| Economy                 | Business users & transport providers | Large time benefits to business travellers, including freight, due to reduced congestion.<br><br>Small vehicle operating cost benefits also occur, likewise due to reduced congestion.<br><br>Small road toll disbenefit, as a few travellers are induced to shift from untolled alternatives, such as the Blackwall tunnel.                                                                                                                                                                                                                                                                                                                                                                                                 | Value of journey time changes (£)           |                | £1,401.4m |                        |                         | £1,468.7m          |                                                 |
|                         |                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Net journey time changes (£)                |                |           |                        |                         |                    |                                                 |
|                         |                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 0 to 2min                                   | 2 to 5min      | > 5min    |                        |                         |                    |                                                 |
|                         |                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | -£341.8m                                    | £518.4m        | £1,224.8m |                        |                         |                    |                                                 |
|                         | Reliability impact on Business users | Option relieves congestion on the Dartford crossing. Journey time reliability would thus improve.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                             |                |           |                        |                         |                    |                                                 |
|                         | Regeneration                         | Option expected to shift employment opportunities towards the Thames Gateway, mainly from other parts of London. Benefits expected to be concentrated in the London Thames Gateway in the shorter term with longer term growth in employment opportunities in the Kent and Essex Thames Gateway.                                                                                                                                                                                                                                                                                                                                                                                                                             |                                             |                |           |                        |                         |                    |                                                 |
|                         | Wider Impacts                        | <i>The largest wider economic impact is expected to be support for the agglomeration of business activity (W11). The benefit arises as businesses and its labour are effectively brought closer together and getting better connected, yielding additional productivity through spill-over benefits such as improved labour market matching and sharing of ideas and best practice. The value of these W11 is estimated at £15.3m in 2025, rising to £27.7m by 2041. The largest changes in agglomeration in 2025 are forecast in Kent there are also some negative impacts, particularly in Rochford and Southend-on-Sea. A significant changes in effective economic density in 2025 is seen in Thurrock and Dartford.</i> | Agglomeration                               |                | £473.0m   |                        |                         | £643m              |                                                 |
|                         |                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Output in imperfectly competitive markets   |                | £170.0m   |                        |                         |                    |                                                 |
|                         |                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Labour supply impact                        |                | £1.0m     |                        |                         |                    |                                                 |
| Environmental           | Noise                                | Minor increases in noise possibly requiring mitigation at existing important areas south of existing crossing                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Not possible to provide                     |                |           | Moderate Adverse       | Not possible to provide |                    |                                                 |
|                         | Air Quality                          | Overall increase in emissions on Defra's PCM modelled links, causing an overall worsening of air quality, however this is unlikely to impact on the date Defra has reported the zone will be compliant.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                             |                |           | Slight adverse         |                         |                    |                                                 |
|                         | Greenhouse gases                     | The option is forecast to result in an increase in both non-traded and traded carbon emissions.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Change in non-traded carbon over 60y (CO2e) |                | 2,481,530 |                        |                         | -£114.3m           |                                                 |
|                         |                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Change in traded carbon over 60y (CO2e)     |                | 4,315     |                        |                         |                    |                                                 |
|                         | Landscape                            | Not applicable                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                             |                |           | Not applicable         |                         |                    |                                                 |
|                         | Townscape                            | Minor intrusion into Mar Dyke valley around M25/J30. Visual impact of additional managed motorway infrastructure south of Dartford.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                             |                |           | Slight adverse         | Not Applicable          |                    |                                                 |
|                         | Historic Environment                 | No significant heritage impacts                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                             |                |           | Neutral                |                         |                    |                                                 |
|                         | Biodiversity                         | Affects recommended Thames Estuary Marine Conservation Zone and may also impact on the Thames Estuary & Marshes SPA (through disturbance of qualifying species) and potentially the West Thurrock Lagoon and Marshes SSSI as a result of hydrodynamic changes. Potential impacts on Ancient Woodland around Junction 30.                                                                                                                                                                                                                                                                                                                                                                                                     | Not applicable                              |                |           | Large/Moderate Adverse | Not Applicable          |                    |                                                 |
|                         | Water Environment                    | The construction of crossings of the River Thames and Mar Dyke could result in changes to the river morphology and the sediment regime as well as impacts on the floodplain and flood defences.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Not applicable                              |                |           | Slight adverse         | Not Applicable          |                    |                                                 |



| Impacts                   |                                                    | Summary of key impacts                                                                                                                                                                                                    | Assessment                                                                                                                              |           |              |                |                    |                                                 |
|---------------------------|----------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------|-----------|--------------|----------------|--------------------|-------------------------------------------------|
|                           |                                                    |                                                                                                                                                                                                                           | Quantitative                                                                                                                            |           |              | Qualitative    | Monetary<br>£(NPV) | Distributional<br>7-pt scale/<br>vulnerable grp |
| Social                    | Commuting and Other users                          | Significant benefits to consumer travellers, due to reduced congestion, partially offset by a smaller rise in vehicle operating costs. Small user charge disbenefit to other users.                                       | Value of journey time changes(£)                                                                                                        |           | £372.5m      |                | £255.9m            |                                                 |
|                           |                                                    |                                                                                                                                                                                                                           | Net journey time changes (£)                                                                                                            |           |              |                |                    |                                                 |
|                           |                                                    |                                                                                                                                                                                                                           | 0 to 2min                                                                                                                               | 2 to 5min | > 5min       |                |                    |                                                 |
|                           |                                                    |                                                                                                                                                                                                                           | -£278.4m                                                                                                                                | £206.4m   | £444.5m      |                |                    |                                                 |
|                           | Reliability impact on<br>Commuting and Other users | Option relieves congestion on the Dartford crossing. Journey time reliability would thus improve.                                                                                                                         | Not assessed                                                                                                                            |           |              | Not applicable | Not assessed       |                                                 |
|                           | Physical activity                                  | Not assessed                                                                                                                                                                                                              | Not applicable                                                                                                                          |           |              | Not assessed   | Not applicable     |                                                 |
|                           | Journey quality                                    | Not assessed                                                                                                                                                                                                              | Not applicable                                                                                                                          |           |              | Not assessed   | Not applicable     |                                                 |
|                           | Accidents                                          | The new additional crossing is forecast to increase traffic and thus a rise in the number and cost of accidents may be expected.                                                                                          | 4,347 additional accidents, including 70 fatalities, 532 serious and 6,158 slight casualties.                                           |           |              | Not applicable | -£232.8m           | Not assessed                                    |
|                           | Security                                           | Not assessed                                                                                                                                                                                                              | Not applicable                                                                                                                          |           |              | Not assessed   | Not applicable     | Not assessed                                    |
|                           | Access to services                                 | Not assessed                                                                                                                                                                                                              | Not applicable                                                                                                                          |           |              | Not assessed   | Not applicable     | Not assessed                                    |
|                           | Affordability                                      | Not assessed                                                                                                                                                                                                              | Not applicable                                                                                                                          |           |              | Not assessed   | Not applicable     | Not assessed                                    |
| Severance                 | Not assessed                                       | Not applicable                                                                                                                                                                                                            |                                                                                                                                         |           | Not assessed | Not applicable | Not assessed       |                                                 |
| Option and non-use values | Not assessed                                       | Not applicable                                                                                                                                                                                                            |                                                                                                                                         |           | Not assessed | Not applicable |                    |                                                 |
| Public<br>Accounts        | Cost to Broad Transport<br>Budget                  | The impacts upon the transport budget would be tw ofold; the capital cost of construction and the subsequent maintenance and operating cost of the infrastructure and revenue collected from the additional user charges. | Investment costs: £1,738.9m<br>Operating costs: £52.2m<br>Operator Revenue: -£490.8m (a benefit, offsetting cost over the longer term.) |           |              | Not applicable | £1,300.2m          |                                                 |
|                           | Indirect Tax Revenues                              | A tax revenue benefit to central government is forecast as a result of additional traffic using the road network and particularly the Dartford Crossing.                                                                  | Not applicable                                                                                                                          |           |              | Not applicable | -£221.3m           |                                                 |

TABLE 15.2 - APPRAISAL SUMMARY TABLE: OPTION A4-BORED TUNNEL (E1+9), 60 YEAR APPRAISAL, 2025-2084

| Appraisal Summary Table |                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                | Date produced:          |                | 31-Jul-15      |                | Contact:                |                                                 |
|-------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------|-------------------------|----------------|----------------|----------------|-------------------------|-------------------------------------------------|
| Name of scheme:         |                                                                                                                                                                                                                                                                | Lower Thames Crossing Option A4-Bored Tunnel (AA15)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                |                         |                |                |                | Name                    | Eamonn Colgan                                   |
| Description of scheme:  |                                                                                                                                                                                                                                                                | A new trunk road connecting M25 Junction 2 to M25 Junction 30 via A13, with a 4 lane twin-bored tunnel to the west of Dartford crossing with option A15 (M25 J31 to A13/A126 junction, 2 lane eastbound (one way) link road).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                |                         |                |                |                | Organisation            | Highways England                                |
|                         |                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                |                         |                |                |                | Role                    | Project Sponsor                                 |
| Impacts                 |                                                                                                                                                                                                                                                                | Summary of key impacts                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                | Assessment              |                |                |                |                         |                                                 |
|                         |                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                | Quantitative            |                |                | Qualitative    | Monetary<br>£(NPV)      | Distributional<br>7-pt scale/<br>vulnerable grp |
| Economy                 | Business users & transport providers                                                                                                                                                                                                                           | Large time benefits to business travellers, including freight, due to reduced congestion. Small vehicle operating cost benefits also occur, likewise due to reduced congestion. Small road toll disbenefit, as a few travellers are induced to shift from untolled alternatives, such as the Blackwall tunnel.                                                                                                                                                                                                                                                                                                                                                                                                               | Value of journey time changes(£)                                                                               |                         | £1,401.4m      |                |                | £1,468.7m               |                                                 |
|                         |                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Net journey time changes (£)                                                                                   |                         |                |                |                |                         |                                                 |
|                         |                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 0 to 2min                                                                                                      | 2 to 5min               | > 5min         |                |                |                         |                                                 |
|                         |                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | -£341.8m                                                                                                       | £518.4m                 | £1,224.8m      |                |                |                         |                                                 |
|                         | Reliability impact on Business users                                                                                                                                                                                                                           | Option relieves congestion on the Dartford crossing. Journey time reliability would thus improve.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                |                         |                |                |                |                         |                                                 |
|                         | Regeneration                                                                                                                                                                                                                                                   | Option expected to shift employment opportunities towards the Thames Gateway, mainly from other parts of London. Benefits expected to be concentrated in the London Thames Gateway in the shorter term with longer term growth in employment opportunities in the Kent and Essex Thames Gateway.                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                |                         |                |                |                |                         |                                                 |
|                         | Wider Impacts                                                                                                                                                                                                                                                  | <i>The largest wider economic impact is expected to be support for the agglomeration of business activity (W11). The benefit arises as businesses and its labour are effectively brought closer together and getting better connected, yielding additional productivity through spill-over benefits such as improved labour market matching and sharing of ideas and best practice. The value of these W11 is estimated at £15.3m in 2025, rising to £27.7m by 2041. The largest changes in agglomeration in 2025 are forecast in Kent there are also some negative impacts, particularly in Rochford and Southend-on-Sea. A significant changes in effective economic density in 2025 is seen in Thurrock and Dartford.</i> | Agglomeration                                                                                                  |                         | £473.0m        |                |                | £643.0m                 |                                                 |
|                         |                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Output in imperfectly competitive markets                                                                      |                         | £170.0m        |                |                |                         |                                                 |
|                         |                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Labour supply impact                                                                                           |                         | £1.0m          |                |                |                         |                                                 |
|                         | Environmental                                                                                                                                                                                                                                                  | Noise                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Slight increases in noise possibly requiring mitigation at existing important areas south of existing crossing | Not possible to provide |                |                | Slight Adverse | Not possible to provide |                                                 |
| Air Quality             |                                                                                                                                                                                                                                                                | Overall increase in emissions on Defra's PCM modelled links, causing an overall worsening of air quality, however this is unlikely to impact on the date Defra has reported the zone will be compliant.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                |                         |                | Slight Adverse |                |                         |                                                 |
| Greenhouse gases        |                                                                                                                                                                                                                                                                | The option is forecast to result in an increase in both non-traded and traded carbon emissions.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Change in non-traded carbon over 60y (CO2e)                                                                    |                         | 2,481,530      |                |                | -£114.3m                |                                                 |
|                         |                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Change in traded carbon over 60y (CO2e)                                                                        |                         | 4,315          |                |                |                         |                                                 |
| Landscape               |                                                                                                                                                                                                                                                                | Not applicable                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                |                         |                | Not applicable |                |                         |                                                 |
| Townscape               |                                                                                                                                                                                                                                                                | Works would generally be in keeping with the existing townscape.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                |                         |                | Slight adverse | Not Applicable |                         |                                                 |
| Historic Environment    |                                                                                                                                                                                                                                                                | No significant heritage impacts                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                |                         |                | Neutral        |                |                         |                                                 |
| Biodiversity            |                                                                                                                                                                                                                                                                | No effect on any locally-nationally designated resources. Assumed that any disturbance effects on SPA/Ramsar/SSSI species could be avoided through mitigation.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Not applicable                                                                                                 |                         |                | Neutral        | Not Applicable |                         |                                                 |
| Water Environment       | Potential long term but local impacts on Mar Dyke morphology at river crossings. Long term loss of floodplain and impact on flood defences. Potential impact on public groundwater supply and local impacts on water resources and WFD classified waterbodies. | Not applicable                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                |                         | Slight adverse | Not Applicable |                |                         |                                                 |

| Impacts                   |                                                    | Summary of key impacts                                                                                                                                                                                                                                                                                                                                                                                                                  | Assessment                                                                                                                             |           |              |                |                    |                                                 |
|---------------------------|----------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------|-----------|--------------|----------------|--------------------|-------------------------------------------------|
|                           |                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                         | Quantitative                                                                                                                           |           |              | Qualitative    | Monetary<br>£(NPV) | Distributional<br>7-pt scale/<br>vulnerable grp |
| Social                    | Commuting and Other users                          | Significant time benefits to consumer travellers would be due to reduced congestion and improved connectivity, although some short trips would experience disbenefit due to increased congestion around the crossing access locations. Large non-fuel vehicle operating cost disbenefit would be due to increased travel and lack of perception by consumer travellers. Small road toll disbenefit, as the new crossing will be tolled. | Value of journey time changes(£)                                                                                                       |           | £372.5m      |                | £255.9m            |                                                 |
|                           |                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                         | Net journey time changes (£)                                                                                                           |           |              |                |                    |                                                 |
|                           |                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                         | 0 to 2min                                                                                                                              | 2 to 5min | > 5min       |                |                    |                                                 |
|                           |                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                         | -£278.4m                                                                                                                               | £206.4m   | £444.5m      |                |                    |                                                 |
|                           | Reliability impact on<br>Commuting and Other users | Overall the option would improve reliability partly from congestion relief on the existing Dartford crossing and the new crossing.                                                                                                                                                                                                                                                                                                      | Not assessed                                                                                                                           |           |              |                | Not assessed       |                                                 |
|                           | Physical activity                                  | Not assessed                                                                                                                                                                                                                                                                                                                                                                                                                            | Not applicable                                                                                                                         |           |              | Not applicable | Not applicable     |                                                 |
|                           | Journey quality                                    | Not assessed                                                                                                                                                                                                                                                                                                                                                                                                                            | Not applicable                                                                                                                         |           |              | Not assessed   | Not applicable     |                                                 |
|                           | Accidents                                          | The new additional crossing is forecast to increase traffic and thus accidents.                                                                                                                                                                                                                                                                                                                                                         | 4,347 additional accidents, including 70 fatalities, 532 serious and 6,158 slight casualties.                                          |           |              | Not applicable | -£232.8m           |                                                 |
|                           | Security                                           | Not assessed                                                                                                                                                                                                                                                                                                                                                                                                                            | Not applicable                                                                                                                         |           |              | Not applicable | Not applicable     | Not assessed                                    |
|                           | Access to services                                 | Not assessed                                                                                                                                                                                                                                                                                                                                                                                                                            | Not applicable                                                                                                                         |           |              | Not assessed   | Not applicable     | Not assessed                                    |
|                           | Affordability                                      | Not assessed                                                                                                                                                                                                                                                                                                                                                                                                                            | Not applicable                                                                                                                         |           |              | Not assessed   | Not applicable     | Not assessed                                    |
| Severance                 | Not assessed                                       | Not applicable                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                        |           | Not assessed | Not applicable | Not assessed       |                                                 |
| Option and non-use values | Not assessed                                       | Not applicable                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                        |           | Not assessed | Not applicable |                    |                                                 |
| Public<br>Accounts        | Cost to Broad Transport Budget                     | The impacts upon the transport budget would be twofold; the capital cost of construction and the subsequent maintenance and operating cost of the infrastructure and revenue collected from the additional user charges.                                                                                                                                                                                                                | Investment costs: £2029.8m<br>Operating costs: £81.2m<br>Operator Revenue: -£490.5m (a benefit, offsetting cost over the longer term.) |           |              | Not applicable | £1,620.2m          |                                                 |
|                           | Indirect Tax Revenues                              | A tax revenue benefit to central government is forecast as a result of additional traffic using the road network and particularly the Dartford Crossing.                                                                                                                                                                                                                                                                                | Not applicable                                                                                                                         |           |              | Not applicable | -£221.3m           |                                                 |

TABLE 15.3 - APPRAISAL SUMMARY TABLE: OPTION C2D (BRIDGE), 60 YEAR APPRAISAL, 2025-2084

| Appraisal Summary Table |                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                                                         |                                             | Date produced: |                | 31-Jul-15         |                         | Contact:           |                                                 |
|-------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------|----------------|----------------|-------------------|-------------------------|--------------------|-------------------------------------------------|
| Name of scheme:         |                                                                                                                                                                                                                                                      | Lower Thames Crossing Option C2d (Bridge)                                                                                                                                                                                                                                                                                                                                               |                                             |                |                |                   |                         | Name               | Eamonn Colgan                                   |
| Description of scheme:  |                                                                                                                                                                                                                                                      | A new trunk road connecting the M25 (between Junction 29 and 30) with A2 via A13, with dual 2 lane crossing option of a bridge east of Gravesend. Similar to option C2, with merge of new link with A1013 west of Orsett Cock roundabout on A13 and closure of A1013 at Orsett Cock.                                                                                                    |                                             |                |                |                   |                         | Organisation       | Highways England                                |
|                         |                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                                                         |                                             |                |                |                   |                         | Role               | Project Sponsor                                 |
| Impacts                 |                                                                                                                                                                                                                                                      | Summary of key impacts                                                                                                                                                                                                                                                                                                                                                                  |                                             | Assessment     |                |                   |                         |                    |                                                 |
|                         |                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                                                         |                                             | Quantitative   |                |                   | Qualitative             | Monetary<br>£(NPV) | Distributional<br>7-pt scale/<br>vulnerable grp |
| Economy                 | Business users & transport providers                                                                                                                                                                                                                 | Large time benefits expected to business travellers, including freight, due to reduced congestion and improved connectivity. Small vehicle operating cost benefits also would occur, due to reduced congestion. Small road toll disbenefit, as the new crossing will be tolled.                                                                                                         | Value of journey time changes(£)            |                | £2,138.0m      |                   |                         | £2,537.6m          |                                                 |
|                         |                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                                                         | Net journey time changes (£)                |                |                |                   |                         |                    |                                                 |
|                         |                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                                                         | 0 to 2min                                   | 2 to 5min      | > 5min         |                   |                         |                    |                                                 |
|                         |                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                                                         | -£321.3m                                    | £637.9m        | £1,821.4m      |                   |                         |                    |                                                 |
|                         | Reliability impact on Business users                                                                                                                                                                                                                 | Option would relieve congestion on the existing Dartford crossing and would provide an alternative route with little congestion. Journey time reliability would thus improve.                                                                                                                                                                                                           |                                             |                |                |                   |                         |                    |                                                 |
|                         | Regeneration                                                                                                                                                                                                                                         | Widespread and significant changes to journey opportunities would be expected to shift employment opportunities eastwards, particularly benefiting the Kent and Essex Thames Gateway areas and other easterly parts of Kent and Essex.                                                                                                                                                  |                                             |                |                |                   |                         |                    |                                                 |
|                         | Wider Impacts                                                                                                                                                                                                                                        | The value of agglomeration benefits from option C2 is estimated at £28.2m in 2025, rising to £45.7m by 2041. The largest changes in agglomeration in 2025 are forecast in Medway Towns and Maidstone. The largest percentage changes in effective economic density are seen in Swale and Medway towns where effective economic density is forecast to rise by 1% and 0.9% respectively. | Agglomeration                               |                | £795.0m        |                   |                         | £1,049.0m          |                                                 |
|                         |                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                                                         | Output in imperfectly competitive markets   |                | £254.0m        |                   |                         |                    |                                                 |
| Labour supply impact    |                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                                                         | £1.0m                                       |                |                |                   |                         |                    |                                                 |
| Environmental           | Noise                                                                                                                                                                                                                                                | Likely to be noise increases in existing urban area, close to Orsett hospital near the new junction with the A13.                                                                                                                                                                                                                                                                       | Not possible to provide                     |                |                | Moderate Adverse  | Not possible to provide |                    |                                                 |
|                         | Air Quality                                                                                                                                                                                                                                          | Predicted overall reduction in emissions on Defra's PCM modelled links leading to an overall improvement in air quality on these links. This would mean the scheme is low risk in relation to impacting on compliance.                                                                                                                                                                  |                                             |                |                | Slight Beneficial |                         |                    |                                                 |
|                         | Greenhouse gases                                                                                                                                                                                                                                     | The option is forecast to result in an increase in both non-traded and traded carbon emissions.                                                                                                                                                                                                                                                                                         | Change in non-traded carbon over 60y (CO2e) |                | 5,177,011      |                   |                         | -£239.0m           |                                                 |
|                         |                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                                                         | Change in traded carbon over 60y (CO2e)     |                | 12,020         |                   |                         |                    |                                                 |
|                         | Landscape                                                                                                                                                                                                                                            | Route partially within the AONB although already affected by existing roads, changes to landscape character associated with new road infrastructure.                                                                                                                                                                                                                                    | Not Applicable                              |                |                | Moderate Adverse  | Not Applicable          |                    |                                                 |
|                         | Townscape                                                                                                                                                                                                                                            | Not applicable                                                                                                                                                                                                                                                                                                                                                                          | Neutral/slight adverse                      |                |                | Not applicable    |                         |                    |                                                 |
|                         | Historic Environment                                                                                                                                                                                                                                 | Direct impacts on nationally important Scheduled Monuments. Impact on the setting of a number of Listed Buildings and North Ockendon Conservation Area and Scheduled Monuments. Potential for setting impacts on riverside heritage features, direct impacts on undiscovered archaeological remains and on marine archaeology.                                                          |                                             |                |                | Large Adverse     |                         |                    |                                                 |
|                         | Biodiversity                                                                                                                                                                                                                                         | Route alignment directly affects a small part of the nationally important Shorne and Ashenbank Woods SSSI and ancient woodland (although already disturbed area). Direct effects on the Ramsar, SPA, SSSI and recommended Marine Conservation Zone.                                                                                                                                     | Not Applicable                              |                |                | Large Adverse     | Not Applicable          |                    |                                                 |
| Water Environment       | Significant impacts on the River Thames and local impacts on Mar Dyke morphology and sediment regime from bridge structures and river crossings. Potential significant impact on the floodplain and flood defences of Mar Dyke and the River Thames. | Not Applicable                                                                                                                                                                                                                                                                                                                                                                          |                                             |                | Slight Adverse | Not Applicable    |                         |                    |                                                 |

| Impacts                   |                                                    | Summary of key impacts                                                                                                                                                                                                                                                                                                                                                                                                                  | Assessment                                                                                                                               |           |              |                |                    |                                                 |
|---------------------------|----------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------|-----------|--------------|----------------|--------------------|-------------------------------------------------|
|                           |                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                         | Quantitative                                                                                                                             |           |              | Qualitative    | Monetary<br>£(NPV) | Distributional<br>7-pt scale/<br>vulnerable grp |
| Social                    | Commuting and Other users                          | Significant time benefits to consumer travellers would be due to reduced congestion and improved connectivity, although some short trips would experience disbenefit due to increased congestion around the crossing access locations. Large non-fuel vehicle operating cost disbenefit would be due to increased travel and lack of perception by consumer travellers. Small road toll disbenefit, as the new crossing will be tolled. | Value of journey time changes(£)                                                                                                         |           | £445.1m      |                | £54.0m             | Not assessed                                    |
|                           |                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                         | Net journey time changes (£)                                                                                                             |           |              |                |                    |                                                 |
|                           |                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                         | 0 to 2min                                                                                                                                | 2 to 5min | > 5min       |                |                    |                                                 |
|                           |                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                         | -£205.8m                                                                                                                                 | £180.7m   | £470.3m      |                |                    |                                                 |
|                           | Reliability impact on<br>Commuting and Other users | Overall the option would improve reliability partly from congestion relief on the existing Dartford crossing and the new crossing.                                                                                                                                                                                                                                                                                                      | Not assessed                                                                                                                             |           |              |                | Not assessed       |                                                 |
|                           | Physical activity                                  | Not assessed                                                                                                                                                                                                                                                                                                                                                                                                                            | Not applicable                                                                                                                           |           |              | Not applicable | Not applicable     |                                                 |
|                           | Journey quality                                    | Not assessed                                                                                                                                                                                                                                                                                                                                                                                                                            | Not applicable                                                                                                                           |           |              | Not assessed   | Not applicable     |                                                 |
|                           | Accidents                                          | The new additional crossing is forecast to increase traffic and thus accidents.                                                                                                                                                                                                                                                                                                                                                         | 7,543 additional accidents, including 91 fatalities, 705 serious and 11,107 slight casualties.                                           |           |              | Not assessed   | -£370.5m           |                                                 |
|                           | Security                                           | Not assessed                                                                                                                                                                                                                                                                                                                                                                                                                            | Not applicable                                                                                                                           |           |              | Not applicable | Not applicable     | Not assessed                                    |
|                           | Access to services                                 | Not assessed                                                                                                                                                                                                                                                                                                                                                                                                                            | Not applicable                                                                                                                           |           |              | Not assessed   | Not applicable     | Not assessed                                    |
| Affordability             | Not assessed                                       | Not applicable                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                          |           | Not assessed | Not applicable | Not assessed       |                                                 |
| Severance                 | Not assessed                                       | Not applicable                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                          |           | Not assessed | Not applicable | Not assessed       |                                                 |
| Option and non-use values | Not assessed                                       | Not applicable                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                          |           | Not assessed | Not applicable |                    |                                                 |
| Public<br>Accounts        | Cost to Broad Transport Budget                     | The impacts upon the transport budget would be twofold; the capital cost of construction and the subsequent maintenance and operating cost of the infrastructure and revenue collected from the additional user charges.                                                                                                                                                                                                                | Investment costs: £1,849.0m<br>Operating costs: £120.2m<br>Operator Revenue: -£728.6m (a benefit, offsetting cost over the longer term.) |           |              | Not applicable | £1,240.5m          |                                                 |
|                           | Indirect Tax Revenues                              | A tax revenue benefit to central government is forecast as a result of additional traffic using the road network and particularly the Dartford Crossing.                                                                                                                                                                                                                                                                                | Not applicable                                                                                                                           |           |              | Not applicable | -£477.0m           |                                                 |

TABLE 15.4 - APPRAISAL SUMMARY TABLE: OPTION C2D (BORED TUNNEL), 60 YEAR APPRAISAL, 2025-2084

| Appraisal Summary Table |                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                     |  |                                           | Date produced:                              |           | 31-Jul-15        |                   | Contact:                |                                                 |  |
|-------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|-------------------------------------------|---------------------------------------------|-----------|------------------|-------------------|-------------------------|-------------------------------------------------|--|
| Name of scheme:         |                                                                                                                                                                                                                                                                                                                                                                                                | Lower Thames Crossing Option C2d (Bored tunnel)                                                                                                                                                                                                                                                     |  |                                           |                                             |           |                  |                   | Name                    | Eamonn Colgan                                   |  |
| Description of scheme:  |                                                                                                                                                                                                                                                                                                                                                                                                | A new trunk road connecting the M25 (between Junction 29 and 30) with A2 via A13, with dual 2 lane crossing option of a twin-bored tunnel east of Gravesend. Similar to option C2, with merge of new link with A1013 west of Orsett Cock roundabout on A13 and closure of A1013 at Orsett Cock.     |  |                                           |                                             |           |                  |                   | Organisation            | Highways England                                |  |
|                         |                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                     |  |                                           |                                             |           |                  |                   | Role                    | Project Sponsor                                 |  |
| Impacts                 |                                                                                                                                                                                                                                                                                                                                                                                                | Summary of key impacts                                                                                                                                                                                                                                                                              |  |                                           | Assessment                                  |           |                  |                   |                         |                                                 |  |
|                         |                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                     |  |                                           | Quantitative                                |           |                  | Qualitative       | Monetary<br>£(NPV)      | Distributional<br>7-pt scale/<br>vulnerable grp |  |
| Economy                 | Business users & transport providers                                                                                                                                                                                                                                                                                                                                                           | Large time benefits expected to business travellers, including freight, due to reduced congestion and improved connectivity. Small vehicle operating cost benefits also would occur, due to reduced congestion. Small road toll disbenefit, as the new crossing will be tolled.                     |  |                                           | Value of journey time changes(£)            |           | £2,138.0m        |                   |                         | £2,537.6m                                       |  |
|                         | Net journey time changes (£)                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                     |  |                                           |                                             |           |                  |                   |                         |                                                 |  |
|                         | 0 to 2min                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                                                                     |  |                                           | 2 to 5min                                   | > 5min    |                  |                   |                         |                                                 |  |
|                         | -£321.3m                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                     |  |                                           | £637.9m                                     | £1,821.4m |                  |                   |                         |                                                 |  |
|                         | Reliability impact on Business users                                                                                                                                                                                                                                                                                                                                                           | Option would relieve congestion on the existing Dartford crossing and would provide an alternative route with little congestion. Journey time reliability would thus improve.                                                                                                                       |  |                                           |                                             |           |                  |                   |                         |                                                 |  |
| Regeneration            | Widespread and significant changes to journey opportunities would be expected to shift employment opportunities eastwards, particularly benefiting the Kent and Essex Thames Gateway areas and other easterly parts of Kent and Essex.                                                                                                                                                         |                                                                                                                                                                                                                                                                                                     |  |                                           |                                             |           |                  |                   |                         |                                                 |  |
| Wider Impacts           | <i>The value of agglomeration benefits from option C2 is estimated at £28.2m in 2025, rising to £45.7m by 2041. The largest changes in agglomeration in 2025 are forecast in Medway Towns and Maidstone. The largest percentage changes in effective economic density are seen in Swale and Medway towns where effective economic density is forecast to rise by 1% and 0.9% respectively.</i> |                                                                                                                                                                                                                                                                                                     |  | Agglomeration                             |                                             | £795.0m   |                  |                   | £1,049.0m               |                                                 |  |
|                         |                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                     |  | Output in imperfectly competitive markets |                                             | £254.0m   |                  |                   |                         |                                                 |  |
|                         |                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                     |  | Labour supply impact                      |                                             | £1.0m     |                  |                   |                         |                                                 |  |
| Environmental           | Noise                                                                                                                                                                                                                                                                                                                                                                                          | Likely to be noise increases in existing urban area, close to Orsett hospital near the new junction with the A13.                                                                                                                                                                                   |  |                                           | Not possible to provide                     |           |                  | Moderate Adverse  | Not possible to provide |                                                 |  |
|                         | Air Quality                                                                                                                                                                                                                                                                                                                                                                                    | There is predicted to be an overall reduction in emissions on Defra's PCM modelled links leading to an overall improvement in air quality on these links. This would mean the scheme is low risk in relation to impacting on compliance.                                                            |  |                                           |                                             |           |                  | Slight Beneficial |                         |                                                 |  |
|                         | Greenhouse gases                                                                                                                                                                                                                                                                                                                                                                               | The option is forecast to result in an increase in both non-traded and traded carbon emissions.                                                                                                                                                                                                     |  |                                           | Change in non-traded carbon over 60y (CO2e) |           | 5,177,011        |                   |                         | -£239.0m                                        |  |
|                         |                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                     |  |                                           | Change in traded carbon over 60y (CO2e)     |           | 12,020           |                   |                         |                                                 |  |
|                         | Landscape                                                                                                                                                                                                                                                                                                                                                                                      | Route partially within the AONB although already affected by existing roads, changes to landscape character associated with new road infrastructure.                                                                                                                                                |  |                                           | Not Applicable                              |           |                  | Moderate Adverse  | Not Applicable          |                                                 |  |
|                         | Townscape                                                                                                                                                                                                                                                                                                                                                                                      | Not applicable                                                                                                                                                                                                                                                                                      |  |                                           | Neutral/slight adverse                      |           |                  | Not applicable    |                         |                                                 |  |
|                         | Historic Environment                                                                                                                                                                                                                                                                                                                                                                           | Direct impacts on nationally important Scheduled Monuments. Impact on the setting of a number of Listed Buildings and North Ockendon Conservation Area and Scheduled Monuments. Potential setting impacts on riverside heritage features and direct impacts on undiscovered archaeological remains. |  |                                           |                                             |           |                  | Large Adverse     |                         |                                                 |  |
|                         | Biodiversity                                                                                                                                                                                                                                                                                                                                                                                   | Directly affects a small part of the nationally important Shorne and Ashenbank Woods SSSI and ancient woodland (although already disturbed area). Assumed that any disturbance effects on SPA species could be avoided through mitigation. Potential for depositional air quality effects.          |  |                                           | Not Applicable                              |           |                  | Moderate Adverse  | Not Applicable          |                                                 |  |
| Water Environment       | Potential long term impacts on Mar Dyke (and tributaries) morphology at river crossings and long term loss of floodplain and impact on flood defences. Potential local impacts on groundwater resources and WFD classified waterbody.                                                                                                                                                          |                                                                                                                                                                                                                                                                                                     |  | Not Applicable                            |                                             |           | Moderate Adverse | Not Applicable    |                         |                                                 |  |



| Impacts                   |                                                    | Summary of key impacts                                                                                                                                                                                                                                                                                                                                                                                                                  | Assessment                                                                                                                              |           |              |                |                    |                                                 |
|---------------------------|----------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------|-----------|--------------|----------------|--------------------|-------------------------------------------------|
|                           |                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                         | Quantitative                                                                                                                            |           |              | Qualitative    | Monetary<br>£(NPV) | Distributional<br>7-pt scale/<br>vulnerable grp |
| Social                    | Commuting and Other users                          | Significant time benefits to consumer travellers would be due to reduced congestion and improved connectivity, although some short trips would experience disbenefit due to increased congestion around the crossing access locations. Large non-fuel vehicle operating cost disbenefit would be due to increased travel and lack of perception by consumer travellers. Small road toll disbenefit, as the new crossing will be tolled. | Value of journey time changes(£)                                                                                                        |           | £445.1m      |                | £54.0m             | Not assessed                                    |
|                           |                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                         | Net journey time changes (£)                                                                                                            |           |              |                |                    |                                                 |
|                           |                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                         | 0 to 2min                                                                                                                               | 2 to 5min | > 5min       |                |                    |                                                 |
|                           |                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                         | -£205.8m                                                                                                                                | £180.7m   | £470.3m      |                |                    |                                                 |
|                           | Reliability impact on<br>Commuting and Other users | Overall the option would improve reliability partly from congestion relief on the existing Dartford crossing and the new crossing.                                                                                                                                                                                                                                                                                                      | Not assessed                                                                                                                            |           |              | Not applicable | Not assessed       |                                                 |
|                           | Physical activity                                  | Not assessed                                                                                                                                                                                                                                                                                                                                                                                                                            | Not applicable                                                                                                                          |           |              | Not assessed   | Not applicable     |                                                 |
|                           | Journey quality                                    | Not assessed                                                                                                                                                                                                                                                                                                                                                                                                                            | Not applicable                                                                                                                          |           |              | Not assessed   | Not applicable     |                                                 |
|                           | Accidents                                          | The new additional crossing is forecast to increase traffic and thus accidents.                                                                                                                                                                                                                                                                                                                                                         | 7,543 additional accidents, including 91 fatalities, 705 serious and 11,107 slight casualties.                                          |           |              | Not applicable | -£370.5m           | Not assessed                                    |
|                           | Security                                           | Not assessed                                                                                                                                                                                                                                                                                                                                                                                                                            | Not applicable                                                                                                                          |           |              | Not assessed   | Not applicable     | Not assessed                                    |
|                           | Access to services                                 | Not assessed                                                                                                                                                                                                                                                                                                                                                                                                                            | Not applicable                                                                                                                          |           |              | Not assessed   | Not applicable     | Not assessed                                    |
| Affordability             | Not assessed                                       | Not applicable                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                         |           | Not assessed | Not applicable | Not assessed       |                                                 |
| Severance                 | Not assessed                                       | Not applicable                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                         |           | Not assessed | Not applicable | Not assessed       |                                                 |
| Option and non-use values | Not assessed                                       | Not applicable                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                         |           | Not assessed | Not applicable |                    |                                                 |
| Public<br>Accounts        | Cost to Broad Transport Budget                     | The impacts upon the transport budget would be twofold; the capital cost of construction and the subsequent maintenance and operating cost of the infrastructure and revenue collected from the additional user charges.                                                                                                                                                                                                                | Investment costs: £1920.1m<br>Operating costs: £124.8m<br>Operator Revenue: -£728.6m (a benefit, offsetting cost over the longer term.) |           |              | Not applicable | £1,316.3m          |                                                 |
|                           | Indirect Tax Revenues                              | A tax revenue benefit to central government is forecast as a result of additional traffic using the road network and particularly the Dartford Crossing.                                                                                                                                                                                                                                                                                | Not applicable                                                                                                                          |           |              | Not applicable | -£476.9m           |                                                 |

TABLE 15.5 - APPRAISAL SUMMARY TABLE: OPTION C2D (IMMERSED TUBE TUNNEL), 60 YEAR APPRAISAL, 2025-2084

| Appraisal Summary Table |                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                                                                                                                         |                                             | Date produced: |                | 31-Jul-15                |                         | Contact:                                        |                  |
|-------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------|----------------|----------------|--------------------------|-------------------------|-------------------------------------------------|------------------|
| Name of scheme:         |                                                                                                                                                                                                                                        | Lower Thames Crossing Option C2d (Immersed tube tunnel)                                                                                                                                                                                                                                                                                                                                 |                                             |                |                |                          |                         | Name                                            | Eamonn Colgan    |
| Description of scheme:  |                                                                                                                                                                                                                                        | A new trunk road connecting the M25 (between Junction 29 and 30) with A2 via A13, with dual 2 lane crossing option of a immersed tube tunnel east of Gravesend. Similar to option C2, with merge of new link with A1013 west of Orsett Cock roundabout on A13 and closure of A1013 at Orsett Cock.                                                                                      |                                             |                |                |                          |                         | Organisation                                    | Highways England |
|                         |                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                                                                                                                         |                                             |                |                |                          |                         | Role                                            | Project Sponsor  |
|                         |                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                                                                                                                         |                                             |                |                |                          |                         |                                                 |                  |
| Impacts                 |                                                                                                                                                                                                                                        | Summary of key impacts                                                                                                                                                                                                                                                                                                                                                                  | Assessment                                  |                |                |                          |                         |                                                 |                  |
|                         |                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                                                                                                                         | Quantitative                                |                |                | Qualitative              | Monetary<br>£(NPV)      | Distributional<br>7-pt scale/<br>vulnerable grp |                  |
| Economy                 | Business users & transport providers                                                                                                                                                                                                   | Large time benefits expected to business travellers, including freight, due to reduced congestion and improved connectivity. Small vehicle operating cost benefits also would occur, due to reduced congestion. Small road toll disbenefit, as the new crossing will be tolled.                                                                                                         | Value of journey time changes(£)            |                | £2,138.0m      |                          |                         | £2,537.6m                                       |                  |
|                         |                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                                                                                                                         | Net journey time changes (£)                |                |                |                          |                         |                                                 |                  |
|                         |                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                                                                                                                         | 0 to 2min                                   | 2 to 5min      | > 5min         |                          |                         |                                                 |                  |
|                         |                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                                                                                                                         | -£321.3m                                    | £637.9m        | £1,821.4m      |                          |                         |                                                 |                  |
|                         | Reliability impact on Business users                                                                                                                                                                                                   | Option would relieve congestion on the existing Dartford crossing and would provide an alternative route with little congestion. Journey time reliability would thus improve.                                                                                                                                                                                                           |                                             |                |                |                          |                         |                                                 |                  |
|                         | Regeneration                                                                                                                                                                                                                           | Widespread and significant changes to journey opportunities would be expected to shift employment opportunities eastwards, particularly benefiting the Kent and Essex Thames Gateway areas and other easterly parts of Kent and Essex.                                                                                                                                                  |                                             |                |                |                          |                         |                                                 |                  |
|                         | Wider Impacts                                                                                                                                                                                                                          | The value of agglomeration benefits from option C2 is estimated at £28.2m in 2025, rising to £45.7m by 2041. The largest changes in agglomeration in 2025 are forecast in Medway Towns and Maidstone. The largest percentage changes in effective economic density are seen in Swale and Medway towns where effective economic density is forecast to rise by 1% and 0.9% respectively. | Agglomeration                               |                | £795.0m        |                          |                         | £1,049.0m                                       |                  |
|                         |                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                                                                                                                         | Output in imperfectly competitive markets   |                | £254.0m        |                          |                         |                                                 |                  |
|                         |                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                                                                                                                         | Labour supply impact                        |                | £1.0m          |                          |                         |                                                 |                  |
| Environmental           | Noise                                                                                                                                                                                                                                  | Likely to be noise increases in existing urban area, close to Orsett hospital near the new junction with the A13.                                                                                                                                                                                                                                                                       | Not possible to provide                     |                |                | Moderate Adverse         | Not possible to provide |                                                 |                  |
|                         | Air Quality                                                                                                                                                                                                                            | There is predicted to be an overall reduction in emissions on defra's PCM modelled links leading to an overall improvement in air quality on these links. This would mean the scheme is low risk in relation to impacting on compliance.                                                                                                                                                |                                             |                |                | Slight Beneficial        |                         |                                                 |                  |
|                         | Greenhouse gases                                                                                                                                                                                                                       | The option is forecast to result in an increase in both non-traded and traded carbon emissions.                                                                                                                                                                                                                                                                                         | Change in non-traded carbon over 60y (CO2e) |                | 5,177,011      |                          | -£239.0m                |                                                 |                  |
|                         |                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                                                                                                                         | Change in traded carbon over 60y (CO2e)     |                | 12,020         |                          |                         |                                                 |                  |
|                         | Landscape                                                                                                                                                                                                                              | Route partially within the AONB although already affected by existing roads, changes to landscape character associated with new road infrastructure.                                                                                                                                                                                                                                    | Not Applicable                              |                |                | Moderate Adverse         | Not Applicable          |                                                 |                  |
|                         | Tow nscape                                                                                                                                                                                                                             | Not applicable                                                                                                                                                                                                                                                                                                                                                                          | Neutral/slight adverse                      |                |                | Not applicable           |                         |                                                 |                  |
|                         | Historic Environment                                                                                                                                                                                                                   | Direct impacts on nationally important Scheduled Monuments. Impact on the setting of a number of Listed Buildings and North Ockendon Conservation Area and Scheduled Monuments. Potential for setting impacts on riverside heritage features, direct impacts on undiscovered archaeological remains and on marine arcaeology.                                                           |                                             |                |                | Large Adverse            |                         |                                                 |                  |
|                         | Biodiversity                                                                                                                                                                                                                           | Route alignment would affect Shorne and Ashenbank Woods SSSI and several areas of ancient woodland. Direct effects on Rasmar and SSSI, recommended MCZ with potential effects on SPA as a result of alterations to the hydrodynamic regime.                                                                                                                                             | Not Applicable                              |                |                | Very Large/Large Adverse | Not Applicable          |                                                 |                  |
| Water Environment       | Potential long term impacts on Mar Dyke (and tributaries) morphology at river crossings and long term loss of flood plain and impact on flood defences. Potential local impacts on groundwater resources and WFD classified waterbody. | Not Applicable                                                                                                                                                                                                                                                                                                                                                                          |                                             |                | Slight Adverse | Not Applicable           |                         |                                                 |                  |



| Impacts                   |                                                    | Summary of key impacts                                                                                                                                                                                                                                                                                                                                                                                                                  | Assessment                                                                                                                              |           |              |                |                    |                                                 |
|---------------------------|----------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------|-----------|--------------|----------------|--------------------|-------------------------------------------------|
|                           |                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                         | Quantitative                                                                                                                            |           |              | Qualitative    | Monetary<br>£(NPV) | Distributional<br>7-pt scale/<br>vulnerable grp |
| Social                    | Commuting and Other users                          | Significant time benefits to consumer travellers would be due to reduced congestion and improved connectivity, although some short trips would experience disbenefit due to increased congestion around the crossing access locations. Large non-fuel vehicle operating cost disbenefit would be due to increased travel and lack of perception by consumer travellers. Small road toll disbenefit, as the new crossing will be tolled. | Value of journey time changes(£)                                                                                                        |           | £445.1m      |                | £54.0m             | Not assessed                                    |
|                           |                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                         | Net journey time changes (£)                                                                                                            |           |              |                |                    |                                                 |
|                           |                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                         | 0 to 2min                                                                                                                               | 2 to 5min | > 5min       |                |                    |                                                 |
|                           |                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                         | -£205.8m                                                                                                                                | £180.7m   | £470.3m      |                |                    |                                                 |
|                           | Reliability impact on<br>Commuting and Other users | Overall the option would improve reliability partly from congestion relief on the existing Dartford crossing and the new crossing.                                                                                                                                                                                                                                                                                                      | Not assessed                                                                                                                            |           |              |                | Not assessed       |                                                 |
|                           | Physical activity                                  | Not assessed                                                                                                                                                                                                                                                                                                                                                                                                                            | Not applicable                                                                                                                          |           |              | Not applicable | Not applicable     |                                                 |
|                           | Journey quality                                    | Not assessed                                                                                                                                                                                                                                                                                                                                                                                                                            | Not applicable                                                                                                                          |           |              | Not assessed   | Not applicable     |                                                 |
|                           | Accidents                                          | The new additional crossing is forecast to increase traffic and thus accidents.                                                                                                                                                                                                                                                                                                                                                         | 7,543 additional accidents, including 91 fatalities, 705 serious and 11,107 slight casualties.                                          |           |              | Not assessed   | -£370.5m           |                                                 |
|                           | Security                                           | Not assessed                                                                                                                                                                                                                                                                                                                                                                                                                            | Not applicable                                                                                                                          |           |              | Not applicable | Not applicable     | Not assessed                                    |
|                           | Access to services                                 | Not assessed                                                                                                                                                                                                                                                                                                                                                                                                                            | Not applicable                                                                                                                          |           |              | Not assessed   | Not applicable     | Not assessed                                    |
| Affordability             | Not assessed                                       | Not applicable                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                         |           | Not assessed | Not applicable | Not assessed       |                                                 |
| Severance                 | Not assessed                                       | Not applicable                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                         |           | Not assessed | Not applicable | Not assessed       |                                                 |
| Option and non-use values | Not assessed                                       | Not applicable                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                         |           | Not assessed | Not applicable |                    |                                                 |
| Public<br>Accounts        | Cost to Broad Transport Budget                     | The impacts upon the transport budget would be twofold; the capital cost of construction and the subsequent maintenance and operating cost of the infrastructure and revenue collected from the additional user charges.                                                                                                                                                                                                                | Investment costs: £1969.3m<br>Operating costs: £128.0m<br>Operator Revenue: -£728.6m (a benefit, offsetting cost over the longer term.) |           |              | Not applicable | £1,368.7m          |                                                 |
|                           | Indirect Tax Revenues                              | A tax revenue benefit to central government is forecast as a result of additional traffic using the road network and particularly the Dartford Crossing.                                                                                                                                                                                                                                                                                | Not applicable                                                                                                                          |           |              | Not applicable | -£476.9m           |                                                 |

TABLE 15.6 - APPRAISAL SUMMARY TABLE: OPTION C3 (BRIDGE), 60 YEAR APPRAISAL, 2025-2084

| Appraisal Summary Table                   |                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                             |           | Date produced: |                    | 31-Jul-15               |                    | Contact:                                        |                  |
|-------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------|-----------|----------------|--------------------|-------------------------|--------------------|-------------------------------------------------|------------------|
| Name of scheme:                           |                                                                                                                                                                                                                                                                         | Lower Thames Crossing Option C3( Bridge)                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                             |           |                |                    |                         |                    | Name                                            | Eamonn Colgan    |
| Description of scheme:                    |                                                                                                                                                                                                                                                                         | A new trunk connecting A2 (2km east of Gravesend) to M25 between Junction 29 and Junction 30, using A1089 (upgrading), with dual 2 lane crossing option of a bridge.                                                                                                                                                                                                                                                                                                            |                                             |           |                |                    |                         |                    | Organisation                                    | Highways England |
|                                           |                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                             |           |                |                    |                         |                    | Role                                            | Project Sponsor  |
| Impacts                                   |                                                                                                                                                                                                                                                                         | Summary of key impacts                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                             |           | Assessment     |                    |                         |                    |                                                 |                  |
|                                           |                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                             |           | Quantitative   |                    | Qualitative             | Monetary<br>£(NPV) | Distributional<br>7-pt scale/<br>vulnerable grp |                  |
| Economy                                   | Business users & transport providers                                                                                                                                                                                                                                    | Large time benefits expected to business travellers, including freight, due to reduced congestion and improved connectivity. Small vehicle operating cost benefits also would occur, due to reduced congestion. Small road toll disbenefit, as the new crossing will be tolled.                                                                                                                                                                                                 | Value of journey time changes(£)            |           | £2,757.5m      |                    |                         | £3,396.7m          |                                                 |                  |
|                                           |                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Net journey time changes (£)                |           |                |                    |                         |                    |                                                 |                  |
|                                           |                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 0 to 2min                                   | 2 to 5min | > 5min         |                    |                         |                    |                                                 |                  |
|                                           |                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | -£240.6m                                    | £684.9m   | £2,313.2m      |                    |                         |                    |                                                 |                  |
|                                           | Reliability impact on Business users                                                                                                                                                                                                                                    | Option would relieve congestion on the existing Dartford crossing and would provide an alternative route with little congestion. Journey time reliability would thus improve.                                                                                                                                                                                                                                                                                                   |                                             |           |                |                    |                         |                    |                                                 |                  |
|                                           | Regeneration                                                                                                                                                                                                                                                            | Widespread and significant changes to journey opportunities would be expected to shift employment opportunities eastwards, particularly benefiting the Kent and Essex Thames Gateway areas and other easterly parts of Kent and Essex.                                                                                                                                                                                                                                          |                                             |           |                |                    |                         |                    |                                                 |                  |
|                                           | Wider Impacts                                                                                                                                                                                                                                                           | In 2025 Medway towns is expected to generate the largest agglomeration benefit. Around £2.2m. Although Swale ranks 4th in the total agglomeration benefits however it is expected to see the greatest change in effective density, making it more accessible than any other modelled zone. Additionally the benefits to Dartford are expected to increase more significantly and is expected to rank in the top 5 for 2041 with a total Agglomeration benefits of £3.2 million. | Agglomeration                               |           | £886.0m        |                    | £1,227.0m               |                    |                                                 |                  |
| Output in imperfectly competitive markets |                                                                                                                                                                                                                                                                         | £340.0m                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                             |           |                |                    |                         |                    |                                                 |                  |
| Labour supply impact                      |                                                                                                                                                                                                                                                                         | £1.0m                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                             |           |                |                    |                         |                    |                                                 |                  |
| Environmental                             | Noise                                                                                                                                                                                                                                                                   | Large noise increases predicted in an existing low noise environment                                                                                                                                                                                                                                                                                                                                                                                                            | Not possible to provide                     |           |                | Moderate Adverse   | Not possible to provide |                    |                                                 |                  |
|                                           | Air Quality                                                                                                                                                                                                                                                             | There is likely to be an overall increase in emissions on Defra's PCM modelled links, causing an overall worsening of air quality, however this is unlikely to impact on the date Defra has reported the zone will be compliant.                                                                                                                                                                                                                                                |                                             |           |                | Slight Adverse     |                         |                    |                                                 |                  |
|                                           | Greenhouse gases                                                                                                                                                                                                                                                        | The option is forecast to result in an increase in both non-traded and traded carbon emissions.                                                                                                                                                                                                                                                                                                                                                                                 | Change in non-traded carbon over 60y (CO2e) |           | 6,060,120      |                    | -£278.3m                |                    |                                                 |                  |
|                                           |                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Change in traded carbon over 60y (CO2e)     |           | 13,941         |                    |                         |                    |                                                 |                  |
|                                           | Landscape                                                                                                                                                                                                                                                               | Significant intrusion into the Kent Downs AONB and significant changes to landscape character. Bridge structure would change the landscape character of the Greater Thames Marshes Nature Improvement Area.                                                                                                                                                                                                                                                                     |                                             |           |                | Large Adverse      |                         |                    |                                                 |                  |
|                                           | Townscape                                                                                                                                                                                                                                                               | Not applicable                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Neutral/slight adverse                      |           |                | Not applicable     | Not Applicable          |                    |                                                 |                  |
|                                           | Historic Environment                                                                                                                                                                                                                                                    | Multiple effects on the setting of Scheduled Monuments and Listed Buildings (largely Grade II), as well as potential direct effect on Scheduled Monument at Orsett and disturbance in an area of high archaeological potential at Orsett. Potential for effects on setting of riverside heritage features                                                                                                                                                                       |                                             |           |                | Large Adverse      |                         |                    |                                                 |                  |
|                                           | Biodiversity                                                                                                                                                                                                                                                            | Route alignment directly affects Ramsar Site, SSSI and the recommended MCZ. Shorne and Ashenbank Woods SSSI would also be directly affected and several areas of ancient woodland and as a result of depositional effects. Potential for hydrodynamic effects on the Ramsar and SPA.                                                                                                                                                                                            | Not applicable                              |           |                | Very Large Adverse | Not Applicable          |                    |                                                 |                  |
| Water Environment                         | Potential significant impacts on River Thames and local impacts on Mar Dyke morphology and sediment regime from bridge structures. Potential significant, long term impacts on regional/ nationally important River Thames and Mar Dyke flood plain and flood defences. | Not applicable                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                             |           | Slight Adverse | Not Applicable     |                         |                    |                                                 |                  |

| Impacts                   |                                                    | Summary of key impacts                                                                                                                                                                                                                                                                                                                                                                                                                  | Assessment                                                                                                                               |           |              |                |                    |                                                 |
|---------------------------|----------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------|-----------|--------------|----------------|--------------------|-------------------------------------------------|
|                           |                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                         | Quantitative                                                                                                                             |           |              | Qualitative    | Monetary<br>£(NPV) | Distributional<br>7-pt scale/<br>vulnerable grp |
| Social                    | Commuting and Other users                          | Significant time benefits to consumer travellers would be due to reduced congestion and improved connectivity, although some short trips would experience disbenefit due to increased congestion around the crossing access locations. Large non-fuel vehicle operating cost disbenefit would be due to increased travel and lack of perception by consumer travellers. Small road toll disbenefit, as the new crossing will be tolled. | Value of journey time changes(£)                                                                                                         |           | £667.6m      |                | £196.7m            |                                                 |
|                           |                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                         | Net journey time changes (£)                                                                                                             |           |              |                |                    |                                                 |
|                           |                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                         | 0 to 2min                                                                                                                                | 2 to 5min | > 5min       |                |                    |                                                 |
|                           |                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                         | -£196.5m                                                                                                                                 | £236.9m   | £627.1m      |                |                    |                                                 |
|                           | Reliability impact on<br>Commuting and Other users | Overall the option would improve reliability partly from congestion relief on the existing Dartford crossing and the new crossing.                                                                                                                                                                                                                                                                                                      | Not assessed                                                                                                                             |           |              |                | Not assessed       |                                                 |
|                           | Physical activity                                  | Not assessed                                                                                                                                                                                                                                                                                                                                                                                                                            | Not applicable                                                                                                                           |           |              | Not applicable | Not applicable     |                                                 |
|                           | Journey quality                                    | Not assessed                                                                                                                                                                                                                                                                                                                                                                                                                            | Not applicable                                                                                                                           |           |              | Not assessed   | Not applicable     |                                                 |
|                           | Accidents                                          | The new additional crossing is forecast to increase traffic and thus accidents.                                                                                                                                                                                                                                                                                                                                                         | 7,164 additional accidents, including 94 fatalities, 984 serious and 12,374 slight casualties.                                           |           |              | Not applicable | -£362.3m           |                                                 |
|                           | Security                                           | Not assessed                                                                                                                                                                                                                                                                                                                                                                                                                            | Not applicable                                                                                                                           |           |              | Not applicable | Not applicable     | Not assessed                                    |
|                           | Access to services                                 | Not assessed                                                                                                                                                                                                                                                                                                                                                                                                                            | Not applicable                                                                                                                           |           |              | Not assessed   | Not applicable     | Not assessed                                    |
|                           | Affordability                                      | Not assessed                                                                                                                                                                                                                                                                                                                                                                                                                            | Not applicable                                                                                                                           |           |              | Not assessed   | Not applicable     | Not assessed                                    |
| Severance                 | Not assessed                                       | Not applicable                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                          |           | Not assessed | Not applicable | Not assessed       |                                                 |
| Option and non-use values | Not assessed                                       | Not applicable                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                          |           | Not assessed | Not applicable |                    |                                                 |
| Public<br>Accounts        | Cost to Broad Transport Budget                     | The impacts upon the transport budget would be twofold; the capital cost of construction and the subsequent maintenance and operating cost of the infrastructure and revenue collected from the additional user charges.                                                                                                                                                                                                                | Investment costs: £2,000.7m<br>Operating costs: £130.0m<br>Operator Revenue: -£810.8m (a benefit, offsetting cost over the longer term.) |           |              | Not applicable | £1,320.0m          |                                                 |
|                           | Indirect Tax Revenues                              | A tax revenue benefit to central government is forecast as a result of additional traffic using the road network and particularly the Dartford Crossing.                                                                                                                                                                                                                                                                                | Not applicable                                                                                                                           |           |              | Not applicable | -£580.6m           |                                                 |

TABLE 15.7 - APPRAISAL SUMMARY TABLE: OPTION C3 (TWIN-BORED TUNNEL), 60 YEAR APPRAISAL, 2025-2084

| Appraisal Summary Table                   |                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Date produced:                                                                                                                                                                  |              | 31-Jul-15      |                  | Contact:                |                    |                                                 |
|-------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|----------------|------------------|-------------------------|--------------------|-------------------------------------------------|
| Name of scheme:                           |                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Lower Thames Crossing Option C3( Twin-bored tunnel)                                                                                                                             |              |                |                  |                         | Name               | Eamonn Colgan                                   |
| Description of scheme:                    |                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | A new trunk connecting A2 (2km east of Gravesend) to M25 between Junction 29 and Junction 30, using A1089 (upgrading), with dual 2 lane crossing option of a twin-bored tunnel. |              |                |                  |                         | Organisation       | Highways England                                |
|                                           |                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                 |              |                |                  |                         | Role               | Project Sponsor                                 |
| Impacts                                   |                                                                                                                                                                                                                                       | Summary of key impacts                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                 | Assessment   |                |                  |                         |                    |                                                 |
|                                           |                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                 | Quantitative |                |                  | Qualitative             | Monetary<br>£(NPV) | Distributional<br>7-pt scale/<br>vulnerable grp |
| Economy                                   | Business users & transport providers                                                                                                                                                                                                  | Large time benefits expected to business travellers, including freight, due to reduced congestion and improved connectivity. Small vehicle operating cost benefits also would occur, due to reduced congestion. Small road toll disbenefit, as the new crossing will be tolled.                                                                                                                                                                                                 | Value of journey time changes(£)                                                                                                                                                |              | £2,757.5m      |                  |                         | £3,396.7m          |                                                 |
|                                           |                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Net journey time changes (£)                                                                                                                                                    |              |                |                  |                         |                    |                                                 |
|                                           |                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 0 to 2min                                                                                                                                                                       | 2 to 5min    | > 5min         |                  |                         |                    |                                                 |
|                                           |                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | -£240.6m                                                                                                                                                                        | £684.9m      | £2,313.2m      |                  |                         |                    |                                                 |
|                                           | Reliability impact on Business users                                                                                                                                                                                                  | Option would relieve congestion on the existing Dartford crossing and would provide an alternative route with little congestion. Journey time reliability would thus improve.                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                 |              |                |                  |                         |                    |                                                 |
|                                           | Regeneration                                                                                                                                                                                                                          | Widespread and significant changes to journey opportunities would be expected to shift employment opportunities eastwards, particularly benefiting the Kent and Essex Thames Gateway areas and other easterly parts of Kent and Essex.                                                                                                                                                                                                                                          |                                                                                                                                                                                 |              |                |                  |                         |                    |                                                 |
|                                           | Wider Impacts                                                                                                                                                                                                                         | In 2025 Medway towns is expected to generate the largest agglomeration benefit. Around £2.2m. Although Swale ranks 4th in the total agglomeration benefits however it is expected to see the greatest change in effective density, making it more accessible than any other modelled zone. Additionally the benefits to Dartford are expected to increase more significantly and is expected to rank in the top 5 for 2041 with a total Agglomeration benefits of £3.2 million. | Agglomeration                                                                                                                                                                   |              | £886.0m        |                  |                         | £1,227.0m          |                                                 |
| Output in imperfectly competitive markets |                                                                                                                                                                                                                                       | £340.0m                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                 |              |                |                  |                         |                    |                                                 |
| Labour supply impact                      |                                                                                                                                                                                                                                       | £1.0m                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                 |              |                |                  |                         |                    |                                                 |
| Environmental                             | Noise                                                                                                                                                                                                                                 | Large noise increases predicted in an existing low noise environment                                                                                                                                                                                                                                                                                                                                                                                                            | Not possible to provide                                                                                                                                                         |              |                | Moderate Adverse | Not possible to provide |                    |                                                 |
|                                           | Air Quality                                                                                                                                                                                                                           | There is likely to be an overall increase in emissions on Defra's PCM modelled links, causing an overall worsening of air quality, however this is unlikely to impact on the date Defra has reported the zone will be compliant.                                                                                                                                                                                                                                                |                                                                                                                                                                                 |              |                | Slight Adverse   |                         |                    |                                                 |
|                                           | Greenhouse gases                                                                                                                                                                                                                      | The option is forecast to result in an increase in both non-traded and traded carbon emissions.                                                                                                                                                                                                                                                                                                                                                                                 | Change in non-traded carbon over 60y (CO2e)                                                                                                                                     |              | 6,060,120      |                  |                         | -£278.3m           |                                                 |
|                                           |                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Change in traded carbon over 60y (CO2e)                                                                                                                                         |              | 13,941         |                  |                         |                    |                                                 |
|                                           | Landscape                                                                                                                                                                                                                             | Significant intrusion into the Kent Downs AONB and significant changes to landscape character.                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                 |              |                | Large Adverse    |                         |                    |                                                 |
|                                           | Townscape                                                                                                                                                                                                                             | Not applicable                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                 |              |                | Not applicable   | Not Applicable          |                    |                                                 |
|                                           | Historic Environment                                                                                                                                                                                                                  | Multiple effects on the setting of Scheduled Monuments and Listed Buildings (largely Grade II), as well as potential direct effect on Scheduled Monument at Orsett and disturbance in an area of high archaeological potential at Orsett.                                                                                                                                                                                                                                       |                                                                                                                                                                                 |              |                | Large Adverse    |                         |                    |                                                 |
|                                           | Biodiversity                                                                                                                                                                                                                          | Route alignment would affect Shorne and Ashenbank Woods SSSI and several areas of ancient woodland. Assumed that any disturbance effects on SPA species could be avoided through mitigation. Potential for depositional air quality effects.                                                                                                                                                                                                                                    | Not applicable                                                                                                                                                                  |              |                | Moderate Adverse | Not Applicable          |                    |                                                 |
| Water Environment                         | Potential long term impacts on Mar Dyke (and tributaries) morphology at river crossings and long term loss of floodplain and impact on flood defences. Potential local impacts on groundwater resources and WFD classified waterbody. | Not applicable                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                 |              | Slight Adverse | Not Applicable   |                         |                    |                                                 |

| Impacts                   |                                                    | Summary of key impacts                                                                                                                                                                                                                                                                                                                                                                                                                  | Assessment                                                                                                                              |           |              |                |                    |                                                 |
|---------------------------|----------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------|-----------|--------------|----------------|--------------------|-------------------------------------------------|
|                           |                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                         | Quantitative                                                                                                                            |           |              | Qualitative    | Monetary<br>£(NPV) | Distributional<br>7-pt scale/<br>vulnerable grp |
| Social                    | Commuting and Other users                          | Significant time benefits to consumer travellers would be due to reduced congestion and improved connectivity, although some short trips would experience disbenefit due to increased congestion around the crossing access locations. Large non-fuel vehicle operating cost disbenefit would be due to increased travel and lack of perception by consumer travellers. Small road toll disbenefit, as the new crossing will be tolled. | Value of journey time changes(£)                                                                                                        |           | £667.6m      |                | £196.7m            |                                                 |
|                           |                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                         | Net journey time changes (£)                                                                                                            |           |              |                |                    |                                                 |
|                           |                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                         | 0 to 2min                                                                                                                               | 2 to 5min | > 5min       |                |                    |                                                 |
|                           |                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                         | -£196.5m                                                                                                                                | £236.9m   | £627.1m      |                |                    |                                                 |
|                           | Reliability impact on<br>Commuting and Other users | Overall the option would improve reliability partly from congestion relief on the existing Dartford crossing and the new crossing.                                                                                                                                                                                                                                                                                                      | Not assessed                                                                                                                            |           |              |                | Not assessed       |                                                 |
|                           | Physical activity                                  | Not assessed                                                                                                                                                                                                                                                                                                                                                                                                                            | Not applicable                                                                                                                          |           |              | Not applicable | Not applicable     |                                                 |
|                           | Journey quality                                    | Not assessed                                                                                                                                                                                                                                                                                                                                                                                                                            | Not applicable                                                                                                                          |           |              | Not assessed   | Not applicable     |                                                 |
|                           | Accidents                                          | The new additional crossing is forecast to increase traffic and thus accidents.                                                                                                                                                                                                                                                                                                                                                         | 7,164 additional accidents, including 94 fatalities, 984 serious and 12,374 slight casualties.                                          |           |              | Not applicable | -£362.3m           |                                                 |
|                           | Security                                           | Not assessed                                                                                                                                                                                                                                                                                                                                                                                                                            | Not applicable                                                                                                                          |           |              | Not applicable | Not applicable     | Not assessed                                    |
|                           |                                                    | Not assessed                                                                                                                                                                                                                                                                                                                                                                                                                            | Not applicable                                                                                                                          |           |              | Not assessed   | Not applicable     | Not assessed                                    |
| Not assessed              |                                                    | Not applicable                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                         |           | Not assessed | Not applicable | Not assessed       |                                                 |
| Not assessed              |                                                    | Not applicable                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                         |           | Not assessed | Not applicable | Not assessed       |                                                 |
| Option and non-use values | Not assessed                                       | Not applicable                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                         |           | Not assessed | Not applicable |                    |                                                 |
| Public<br>Accounts        | Cost to Broad Transport Budget                     | The impacts upon the transport budget would be twofold; the capital cost of construction and the subsequent maintenance and operating cost of the infrastructure and revenue collected from the additional user charges.                                                                                                                                                                                                                | Investment costs: £1983.7m<br>Operating costs: £128.9m<br>Operator Revenue: -£810.8m (a benefit, offsetting cost over the longer term.) |           |              | Not applicable | £1,301.9m          |                                                 |
|                           | Indirect Tax Revenues                              | A tax revenue benefit to central government is forecast as a result of additional traffic using the road network and particularly the Dartford Crossing.                                                                                                                                                                                                                                                                                | Not applicable                                                                                                                          |           |              | Not applicable | -£580.6m           |                                                 |

TABLE 15.8 - APPRAISAL SUMMARY TABLE: OPTION C3 (IMMERSED TUBE TUNNEL), 60 YEAR APPRAISAL, 2025-2084

| Appraisal Summary Table                   |                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |  |  | Date produced:                              |           | 31-Jul-15 |                    | Contact:                |                                                 |  |
|-------------------------------------------|-----------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|--|---------------------------------------------|-----------|-----------|--------------------|-------------------------|-------------------------------------------------|--|
| Name of scheme:                           |                                         | Lower Thames Crossing Option C3( Immersed tube tunnel)                                                                                                                                                                                                                                                                                                                                                                                                                          |  |  |                                             |           |           |                    | Name                    | Eamonn Colgan                                   |  |
| Description of scheme:                    |                                         | A new trunk connecting A2 (2km east of Gravesend) to M25 between Junction 29 and Junction 30, using A1089 (upgrading), with dual 2 lane crossing option of a immersed tube tunnel.                                                                                                                                                                                                                                                                                              |  |  |                                             |           |           |                    | Organisation            | Highways England                                |  |
|                                           |                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |  |  |                                             |           |           |                    | Role                    | Project Sponsor                                 |  |
| Impacts                                   |                                         | Summary of key impacts                                                                                                                                                                                                                                                                                                                                                                                                                                                          |  |  | Assessment                                  |           |           |                    |                         |                                                 |  |
|                                           |                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |  |  | Quantitative                                |           |           | Qualitative        | Monetary<br>£(NPV)      | Distributional<br>7-pt scale/<br>vulnerable grp |  |
| Economy                                   | Business users & transport providers    | Large time benefits expected to business travellers, including freight, due to reduced congestion and improved connectivity. Small vehicle operating cost benefits also would occur, due to reduced congestion. Small road toll disbenefit, as the new crossing will be tolled.                                                                                                                                                                                                 |  |  | Value of journey time changes(£)            |           | £2,757.5m |                    |                         | £3,396.7m                                       |  |
|                                           |                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |  |  | Net journey time changes (£)                |           |           |                    |                         |                                                 |  |
|                                           |                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |  |  | 0 to 2min                                   | 2 to 5min | > 5min    |                    |                         |                                                 |  |
|                                           |                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |  |  | -£240.6m                                    | £684.9m   | £2,313.2m |                    |                         |                                                 |  |
|                                           | Reliability impact on Business users    | Option would relieve congestion on the existing Dartford crossing and would provide an alternative route with little congestion. Journey time reliability would thus improve.                                                                                                                                                                                                                                                                                                   |  |  |                                             |           |           |                    |                         |                                                 |  |
|                                           | Regeneration                            | Widespread and significant changes to journey opportunities would be expected to shift employment opportunities eastwards, particularly benefiting the Kent and Essex Thames Gateway areas and other easterly parts of Kent and Essex.                                                                                                                                                                                                                                          |  |  |                                             |           |           |                    |                         |                                                 |  |
|                                           | Wider Impacts                           | In 2025 Medway towns is expected to generate the largest agglomeration benefit. Around £2.2m. Although Swale ranks 4th in the total agglomeration benefits however it is expected to see the greatest change in effective density, making it more accessible than any other modelled zone. Additionally the benefits to Dartford are expected to increase more significantly and is expected to rank in the top 5 for 2041 with a total Agglomeration benefits of £3.2 million. |  |  | Agglomeration                               |           | £886.0m   |                    | £1,227.0m               |                                                 |  |
| Output in imperfectly competitive markets |                                         | £340.0m                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |  |  |                                             |           |           |                    |                         |                                                 |  |
| Labour supply impact                      |                                         | £1.0m                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |  |                                             |           |           |                    |                         |                                                 |  |
| Environmental                             | Noise                                   | Large noise increases predicted in an existing low noise environment                                                                                                                                                                                                                                                                                                                                                                                                            |  |  | Not possible to provide                     |           |           | Moderate Adverse   | Not possible to provide |                                                 |  |
|                                           | Air Quality                             | There is likely to be an overall increase in emissions on Defra's PCM modelled links, causing an overall worsening of air quality, however this is unlikely to impact on the date Defra has reported the zone will be compliant.                                                                                                                                                                                                                                                |  |  |                                             |           |           | Slight Adverse     |                         |                                                 |  |
|                                           | Greenhouse gases                        | The option is forecast to result in an increase in both non-traded and traded carbon emissions.                                                                                                                                                                                                                                                                                                                                                                                 |  |  | Change in non-traded carbon over 60y (CO2e) |           | 6,060,120 |                    | -£278.3m                |                                                 |  |
|                                           | Change in traded carbon over 60y (CO2e) |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |  |  | 13,941                                      |           |           |                    |                         |                                                 |  |
|                                           | Landscape                               | Significant intrusion into the Kent Downs AONB and significant changes to landscape character.                                                                                                                                                                                                                                                                                                                                                                                  |  |  |                                             |           |           | Large Adverse      |                         |                                                 |  |
|                                           | Townscape                               | Not applicable                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |  |  |                                             |           |           | Not applicable     | Not Applicable          |                                                 |  |
|                                           | Historic Environment                    | Multiple effects on the setting of Scheduled Monuments and Listed Buildings (largely Grade II), as well as potential direct effect on Scheduled Monument at Orsett and disturbance in an area of high archaeological potential at Orsett. Potential effects on marine archaeology.                                                                                                                                                                                              |  |  |                                             |           |           | Large Adverse      |                         |                                                 |  |
|                                           | Biodiversity                            | Route alignment would affect Shorne and Ashenbank Woods SSSI and several areas of ancient woodland. Direct effects on Ramsar and SSSI, recommended Marine Conservation Zone with potential effects on SPA as a result of alterations to the hydrodynamic regime.                                                                                                                                                                                                                |  |  | Not applicable                              |           |           | Very Large Adverse | Not Applicable          |                                                 |  |
|                                           | Water Environment                       | Potential long term impacts on Mar Dyke (and tributaries) morphology at river crossings and long term loss of floodplain and impact on flood defences. Potential local impacts on groundwater resources and WFD classified waterbody.                                                                                                                                                                                                                                           |  |  | Not applicable                              |           |           | Slight Adverse     | Not Applicable          |                                                 |  |



| Impacts                   |                                                    | Summary of key impacts                                                                                                                                                                                                                                                                                                                                                                                                                  | Assessment                                                                                                                               |           |              |                |                    |                                                 |
|---------------------------|----------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------|-----------|--------------|----------------|--------------------|-------------------------------------------------|
|                           |                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                         | Quantitative                                                                                                                             |           |              | Qualitative    | Monetary<br>£(NPV) | Distributional<br>7-pt scale/<br>vulnerable grp |
| Social                    | Commuting and Other users                          | Significant time benefits to consumer travellers would be due to reduced congestion and improved connectivity, although some short trips would experience disbenefit due to increased congestion around the crossing access locations. Large non-fuel vehicle operating cost disbenefit would be due to increased travel and lack of perception by consumer travellers. Small road toll disbenefit, as the new crossing will be tolled. | Value of journey time changes(£)                                                                                                         |           | £667.6m      |                | £196.7m            |                                                 |
|                           |                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                         | Net journey time changes (£)                                                                                                             |           |              |                |                    |                                                 |
|                           |                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                         | 0 to 2min                                                                                                                                | 2 to 5min | > 5min       |                |                    |                                                 |
|                           |                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                         | -£196.5m                                                                                                                                 | £236.9m   | £627.1m      |                |                    |                                                 |
|                           | Reliability impact on<br>Commuting and Other users | Overall the option would improve reliability partly from congestion relief on the existing Dartford crossing and the new crossing.                                                                                                                                                                                                                                                                                                      | Not assessed                                                                                                                             |           |              |                | Not assessed       |                                                 |
|                           | Physical activity                                  | Not assessed                                                                                                                                                                                                                                                                                                                                                                                                                            | Not applicable                                                                                                                           |           |              | Not applicable | Not applicable     |                                                 |
|                           | Journey quality                                    | Not assessed                                                                                                                                                                                                                                                                                                                                                                                                                            | Not applicable                                                                                                                           |           |              | Not assessed   | Not applicable     |                                                 |
|                           | Accidents                                          | The new additional crossing is forecast to increase traffic and thus accidents.                                                                                                                                                                                                                                                                                                                                                         | 7,164 additional accidents, including 94 fatalities, 984 serious and 12,374 slight casualties.                                           |           |              | Not applicable | -£362.3m           |                                                 |
|                           | Security                                           | Not assessed                                                                                                                                                                                                                                                                                                                                                                                                                            | Not applicable                                                                                                                           |           |              | Not applicable | Not applicable     | Not assessed                                    |
|                           | Access to services                                 | Not assessed                                                                                                                                                                                                                                                                                                                                                                                                                            | Not applicable                                                                                                                           |           |              | Not assessed   | Not applicable     | Not assessed                                    |
| Affordability             | Not assessed                                       | Not applicable                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                          |           | Not assessed | Not applicable | Not assessed       |                                                 |
| Severance                 | Not assessed                                       | Not applicable                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                          |           | Not assessed | Not applicable | Not assessed       |                                                 |
| Option and non-use values | Not assessed                                       | Not applicable                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                          |           | Not assessed | Not applicable |                    |                                                 |
| Public<br>Accounts        | Cost to Broad Transport Budget                     | The impacts upon the transport budget would be twofold; the capital cost of construction and the subsequent maintenance and operating cost of the infrastructure and revenue collected from the additional user charges.                                                                                                                                                                                                                | Investment costs: £2,068.0m<br>Operating costs: £134.4m<br>Operator Revenue: -£810.8m (a benefit, offsetting cost over the longer term.) |           |              | Not applicable | £1,391.6m          |                                                 |
|                           | Indirect Tax Revenues                              | A tax revenue benefit to central government is forecast as a result of additional traffic using the road network and particularly the Dartford Crossing.                                                                                                                                                                                                                                                                                | Not applicable                                                                                                                           |           |              | Not applicable | -£580.6m           |                                                 |

TABLE 15.9 - APPRAISAL SUMMARY TABLE: OPTION C9-BRIDGE, 60 YEAR APPRAISAL, 2025-2084

| Appraisal Summary Table |                                      |                                                                                                                                                                                                                                                                                                                                                                                          |                                             |              | Date produced: |                          | 04-Jun-15               |                    | Contact:                                        |                  |  |
|-------------------------|--------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------|--------------|----------------|--------------------------|-------------------------|--------------------|-------------------------------------------------|------------------|--|
| Name of scheme:         |                                      | Lower Thames Crossing Option C9 (Bridge)                                                                                                                                                                                                                                                                                                                                                 |                                             |              |                |                          |                         |                    | Name                                            | Eamonn Colgan    |  |
| Description of scheme:  |                                      | A combination of option C2d and C4d, using A2 interchange from option C2d and A13, A127 and M25 interchanges from option C4d.                                                                                                                                                                                                                                                            |                                             |              |                |                          |                         |                    | Organisation                                    | Highways England |  |
|                         |                                      |                                                                                                                                                                                                                                                                                                                                                                                          |                                             |              |                |                          |                         |                    | Role                                            | Project Sponsor  |  |
|                         |                                      |                                                                                                                                                                                                                                                                                                                                                                                          |                                             |              |                |                          |                         |                    |                                                 |                  |  |
| Impacts                 |                                      | Summary of key impacts                                                                                                                                                                                                                                                                                                                                                                   |                                             | Assessment   |                |                          |                         |                    |                                                 |                  |  |
|                         |                                      |                                                                                                                                                                                                                                                                                                                                                                                          |                                             | Quantitative |                |                          | Qualitative             | Monetary<br>£(NPV) | Distributional<br>7-pt scale/<br>vulnerable grp |                  |  |
| Economy                 | Business users & transport providers | Large time benefits expected to business travellers, including freight, due to reduced congestion and improved connectivity. Small vehicle operating cost benefits also would occur, due to reduced congestion. Small road toll disbenefit, as the new crossing will be tolled.                                                                                                          | Value of journey time changes(£)            |              | £2,578.1m      |                          |                         | £2,989.9m          |                                                 |                  |  |
|                         |                                      |                                                                                                                                                                                                                                                                                                                                                                                          | Net journey time changes (£)                |              |                |                          |                         |                    |                                                 |                  |  |
|                         |                                      |                                                                                                                                                                                                                                                                                                                                                                                          | 0 to 2min                                   |              | 2 to 5min      |                          |                         |                    |                                                 | > 5min           |  |
|                         |                                      |                                                                                                                                                                                                                                                                                                                                                                                          | -£287.0m                                    |              | £683.8m        |                          |                         |                    |                                                 | £2,181.3m        |  |
|                         | Reliability impact on Business users | Option would relieve congestion on the existing Dartford crossing and would provide an alternative route with little congestion. Journey time reliability would thus improve.                                                                                                                                                                                                            |                                             |              |                |                          |                         |                    |                                                 |                  |  |
|                         | Regeneration                         | Widespread and significant changes to journey opportunities would be expected to shift employment opportunities eastwards, particularly benefiting the Kent and Essex Thames Gateway areas and other easterly parts of Kent and Essex.                                                                                                                                                   |                                             |              |                |                          |                         |                    |                                                 |                  |  |
|                         | Wider Impacts                        | The modelled agglomeration benefit of Options C9 is forecast to be £956m. Similarly to the other Option C's Medway Towns is forecast to benefit the greatest in 2025. However by 2041, Basildon is expected to have the largest agglomeration benefits. Likewise Swale is expected to see the greatest change in effective density for both 2025 and 2041.                               | Agglomeration                               |              | £956.0m        |                          |                         | £1.256m            |                                                 |                  |  |
|                         |                                      |                                                                                                                                                                                                                                                                                                                                                                                          | Output in imperfectly competitive markets   |              | £299.0m        |                          |                         |                    |                                                 |                  |  |
|                         |                                      |                                                                                                                                                                                                                                                                                                                                                                                          | Labour supply impact                        |              | £2.0m          |                          |                         |                    |                                                 |                  |  |
| Environmental           | Noise                                | Large noise increases predicted in an existing low noise environment                                                                                                                                                                                                                                                                                                                     | Not possible to provide                     |              |                | Moderate Adverse         | Not possible to provide |                    |                                                 |                  |  |
|                         | Air Quality                          | There is likely to be an overall increase in emissions on Defra's PCM modelled links, causing an overall worsening of air quality, however this is unlikely to impact on the date Defra has reported the zone will be compliant.                                                                                                                                                         |                                             |              |                | Slight Adverse           |                         |                    |                                                 |                  |  |
|                         | Greenhouse gases                     | The option is forecast to result in an increase in both non-traded and traded carbon emissions.                                                                                                                                                                                                                                                                                          | Change in non-traded carbon over 60y (CO2e) |              | 5,859,718      |                          |                         | -£270.5m           |                                                 |                  |  |
|                         |                                      |                                                                                                                                                                                                                                                                                                                                                                                          | Change in traded carbon over 60y (CO2e)     |              | 13,277         |                          |                         |                    |                                                 |                  |  |
|                         | Landscape                            | Route partially within the AONB although already affected by existing roads, changes to landscape character associated with new road infrastructure.                                                                                                                                                                                                                                     | Not Applicable                              |              |                | Moderate Adverse         | Not Applicable          |                    |                                                 |                  |  |
|                         | Townscape                            | Not applicable                                                                                                                                                                                                                                                                                                                                                                           |                                             |              |                | Not applicable           |                         |                    |                                                 |                  |  |
|                         | Historic Environment                 | Direct impact upon a Grade II Listed Building by the junction with the A127, as well as the potential for direct or setting impacts upon other Listed Buildings. Potential setting impact on a nationally important Scheduled Monument and a corridor of heritage significance west of East Tilbury. Potential effects on two Registered Parks and Gardens albeit minor setting impacts. |                                             |              |                | Moderate Adverse         |                         |                    |                                                 |                  |  |
|                         | Biodiversity                         | Directly affects a small part of the nationally important Shorne and Ashenbank Woods SSSI, the Claylane Woods ancient woodland and several other areas of ancient woodland along A127. There would be direct effects on the Ramsar, SSSI and SPA as well as the recommended MCZ associated with the bridge structure in the river.                                                       | Not Applicable                              |              |                | Very Large/Large Adverse | Not Applicable          |                    |                                                 |                  |  |
|                         | Water Environment                    | Potential long term impacts on morphology of several Mar Dyke tributaries at river crossings and long term loss of flood plain and impact on flood defences. Potential local impacts on groundwater resources and WFD classified waterbody.                                                                                                                                              | Not Applicable                              |              |                | Slight Adverse           | Not Applicable          |                    |                                                 |                  |  |



| Impacts                   |                                                    | Summary of key impacts                                                                                                                                                                                                                                                                                                                                                                                                                  | Assessment                                                                                                                               |           |              |                |                    |                                                 |
|---------------------------|----------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------|-----------|--------------|----------------|--------------------|-------------------------------------------------|
|                           |                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                         | Quantitative                                                                                                                             |           |              | Qualitative    | Monetary<br>£(NPV) | Distributional<br>7-pt scale/<br>vulnerable grp |
| Social                    | Commuting and Other users                          | Significant time benefits to consumer travellers would be due to reduced congestion and improved connectivity, although some short trips would experience disbenefit due to increased congestion around the crossing access locations. Large non-fuel vehicle operating cost disbenefit would be due to increased travel and lack of perception by consumer travellers. Small road toll disbenefit, as the new crossing will be tolled. | Value of journey time changes(£)                                                                                                         |           | £572.8m      |                | £136.5m            |                                                 |
|                           |                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                         | Net journey time changes (£)                                                                                                             |           |              |                |                    |                                                 |
|                           |                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                         | 0 to 2min                                                                                                                                | 2 to 5min | > 5min       |                |                    |                                                 |
|                           |                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                         | -£207.8m                                                                                                                                 | £193.9m   | £586.8m      |                |                    |                                                 |
|                           | Reliability impact on<br>Commuting and Other users | Overall the option would improve reliability partly from congestion relief on the existing Dartford crossing and the new crossing.                                                                                                                                                                                                                                                                                                      | Not assessed                                                                                                                             |           |              |                | Not assessed       |                                                 |
|                           | Physical activity                                  | Not reassessed                                                                                                                                                                                                                                                                                                                                                                                                                          | Not applicable                                                                                                                           |           |              | Not applicable | Not applicable     |                                                 |
|                           | Journey quality                                    | Not reassessed                                                                                                                                                                                                                                                                                                                                                                                                                          | Not applicable                                                                                                                           |           |              | Not assessed   | Not applicable     |                                                 |
|                           | Accidents                                          | The new additional crossing is forecast to increase traffic and thus accidents.                                                                                                                                                                                                                                                                                                                                                         | 6,256 additional accidents, including 84 fatalities, 568 serious and 9,653 slight casualties.                                            |           |              | Not applicable | -£315.4m           |                                                 |
|                           | Security                                           | Not reassessed                                                                                                                                                                                                                                                                                                                                                                                                                          | Not applicable                                                                                                                           |           |              | Not applicable | Not applicable     | Not assessed                                    |
|                           | Access to services                                 | Not reassessed                                                                                                                                                                                                                                                                                                                                                                                                                          | Not applicable                                                                                                                           |           |              | Not assessed   | Not applicable     | Not assessed                                    |
| Affordability             | Not reassessed                                     | Not applicable                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                          |           | Not assessed | Not applicable | Not assessed       |                                                 |
| Severance                 | Not reassessed                                     | Not applicable                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                          |           | Not assessed | Not applicable | Not assessed       |                                                 |
| Option and non-use values | Not reassessed                                     | Not applicable                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                          |           | Not assessed | Not applicable |                    |                                                 |
| Public<br>Accounts        | Cost to Broad Transport Budget                     | The impacts upon the transport budget would be twofold; the capital cost of construction and the subsequent maintenance and operating cost of the infrastructure and revenue collected from the additional user charges.                                                                                                                                                                                                                | Investment costs: £2,163.5m<br>Operating costs: £140.6m<br>Operator Revenue: -£785.2m (a benefit, offsetting cost over the longer term.) |           |              | Not applicable | £1,518.9m          |                                                 |
|                           | Indirect Tax Revenues                              | A tax revenue benefit to central government is forecast as a result of additional traffic using the road network and particularly the Dartford Crossing.                                                                                                                                                                                                                                                                                | Not applicable                                                                                                                           |           |              | Not applicable | -£543.1m           |                                                 |

TABLE 15.10 - APPRAISAL SUMMARY TABLE: OPTION C9 - TWIN BORED TUNNEL, 60 YEAR APPRAISAL, 2025-2084

| Appraisal Summary Table                   |                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                     |                                             | Date produced: |                | 31-Jul-15              |                         | Contact:           |                                                 |
|-------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------|----------------|----------------|------------------------|-------------------------|--------------------|-------------------------------------------------|
| Name of scheme:                           |                                                                                                                                                                                                                                             | Lower Thames Crossing Option C9 (twin bored tunnel)                                                                                                                                                                                                                                                                                                                 |                                             |                |                |                        |                         | Name               | Eamonn Colgan                                   |
| Description of scheme:                    |                                                                                                                                                                                                                                             | A combination of option C2d and C4d, using A2 interchange from option C2d and A13, A127 and M25 interchanges from option C4d.                                                                                                                                                                                                                                       |                                             |                |                |                        |                         | Organisation       | Highways England                                |
|                                           |                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                     |                                             |                |                |                        |                         | Role               | Project Sponsor                                 |
| Impacts                                   |                                                                                                                                                                                                                                             | Summary of key impacts                                                                                                                                                                                                                                                                                                                                              |                                             | Assessment     |                |                        |                         |                    |                                                 |
|                                           |                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                     |                                             | Quantitative   |                |                        | Qualitative             | Monetary<br>£(NPV) | Distributional<br>7-pt scale/<br>vulnerable grp |
| Economy                                   | Business users & transport providers                                                                                                                                                                                                        | Large time benefits expected to business travellers, including freight, due to reduced congestion and improved connectivity. Small vehicle operating cost benefits also would occur, due to reduced congestion. Small road toll disbenefit, as the new crossing will be tolled.                                                                                     | Value of journey time changes(£)            |                |                | £2,578.1m              |                         | £2,989.9m          |                                                 |
|                                           |                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                     | Net journey time changes (£)                |                |                |                        |                         |                    |                                                 |
|                                           |                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                     | 0 to 2min                                   | 2 to 5min      | > 5min         |                        |                         |                    |                                                 |
|                                           |                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                     | -£287.0m                                    | £683.8m        | £2,181.3m      |                        |                         |                    |                                                 |
|                                           | Reliability impact on Business users                                                                                                                                                                                                        | Option would relieve congestion on the existing Dartford crossing and would provide an alternative route with little congestion. Journey time reliability would thus improve.                                                                                                                                                                                       |                                             |                |                |                        |                         |                    |                                                 |
|                                           | Regeneration                                                                                                                                                                                                                                | Widespread and significant changes to journey opportunities would be expected to shift employment opportunities eastwards, particularly benefiting the Kent and Essex Thames Gateway areas and other easterly parts of Kent and Essex.                                                                                                                              |                                             |                |                |                        |                         |                    |                                                 |
|                                           | Wider Impacts                                                                                                                                                                                                                               | The modelled agglomeration benefit of Options C9 is forecast to be £956m. Similarly to the other Option C's Medway Towns is forecast to benefit the greatest in 2025. However by 2041, Basildon is expected to have the largest agglomeration benefits. Likewise Swale is expected to see the greatest change in effective density for both 2025 and 2041.          | Agglomeration                               |                | £956.0m        |                        | £1.256m                 |                    |                                                 |
| Output in imperfectly competitive markets |                                                                                                                                                                                                                                             | £299.0m                                                                                                                                                                                                                                                                                                                                                             |                                             |                |                |                        |                         |                    |                                                 |
| Labour supply impact                      |                                                                                                                                                                                                                                             | £2.0m                                                                                                                                                                                                                                                                                                                                                               |                                             |                |                |                        |                         |                    |                                                 |
| Environmental                             | Noise                                                                                                                                                                                                                                       | Large noise increases predicted in an existing low noise environment                                                                                                                                                                                                                                                                                                | Not possible to provide                     |                |                | Moderate Adverse       | Not possible to provide |                    |                                                 |
|                                           | Air Quality                                                                                                                                                                                                                                 | Predicted overall increase in emissions on Defra's PCM modelled links, causing an overall worsening of air quality, however this is unlikely to impact on the date Defra has reported the zone will be compliant.                                                                                                                                                   |                                             |                |                | Slight Adverse         |                         |                    |                                                 |
|                                           | Greenhouse gases                                                                                                                                                                                                                            | The option is forecast to result in an increase in both non-traded and traded carbon emissions.                                                                                                                                                                                                                                                                     | Change in non-traded carbon over 60y (CO2e) |                | 5,859,718      |                        | -£270.5m                |                    |                                                 |
|                                           |                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                     | Change in traded carbon over 60y (CO2e)     |                | 13,277         |                        |                         |                    |                                                 |
|                                           | Landscape                                                                                                                                                                                                                                   | Route partially within the AONB although already affected by existing roads, changes to landscape character associated with new road infrastructure.                                                                                                                                                                                                                | Not Applicable                              |                |                | Moderate Adverse       | Not Applicable          |                    |                                                 |
|                                           | Townscape                                                                                                                                                                                                                                   | Not applicable                                                                                                                                                                                                                                                                                                                                                      |                                             |                |                | Not applicable         |                         |                    |                                                 |
|                                           | Historic Environment                                                                                                                                                                                                                        | Direct impact upon a Grade II Listed Building by the junction with the A127, as well as the potential for direct or setting impacts upon other Listed Buildings. Potential setting impact on a Scheduled Monument and a corridor of heritage significance west of East Tilbury. Potential effects on two Registered Parks and Gardens albeit minor setting impacts. |                                             |                |                | Moderate Adverse       |                         |                    |                                                 |
|                                           | Biodiversity                                                                                                                                                                                                                                | Directly affects a small part of the nationally important Shorne and Ashenbank Woods SSSI, the Claylane Woods ancient woodland and several other areas of ancient woodland along A127. Assumed that any disturbance effects on SPA species could be avoided through mitigation.                                                                                     | Not Applicable                              |                |                | Moderate/Large Adverse | Not Applicable          |                    |                                                 |
| Water Environment                         | Potential long term impacts on morphology of several Mar Dyke tributaries at river crossings and long term loss of flood plain and impact on flood defences. Potential local impacts on groundwater resources and WFD classified waterbody. | Not Applicable                                                                                                                                                                                                                                                                                                                                                      |                                             |                | Slight Adverse | Not Applicable         |                         |                    |                                                 |

| Impacts                   |                                                    | Summary of key impacts                                                                                                                                                                                                                                                                                                                                                                                                                  | Assessment                                                                                                                               |           |              |                |                    |                                                 |
|---------------------------|----------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------|-----------|--------------|----------------|--------------------|-------------------------------------------------|
|                           |                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                         | Quantitative                                                                                                                             |           |              | Qualitative    | Monetary<br>£(NPV) | Distributional<br>7-pt scale/<br>vulnerable grp |
| Social                    | Commuting and Other users                          | Significant time benefits to consumer travellers would be due to reduced congestion and improved connectivity, although some short trips would experience disbenefit due to increased congestion around the crossing access locations. Large non-fuel vehicle operating cost disbenefit would be due to increased travel and lack of perception by consumer travellers. Small road toll disbenefit, as the new crossing will be tolled. | Value of journey time changes(£)                                                                                                         |           | £572.8m      |                | £136.5m            |                                                 |
|                           |                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                         | Net journey time changes (£)                                                                                                             |           |              |                |                    |                                                 |
|                           |                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                         | 0 to 2min                                                                                                                                | 2 to 5min | > 5min       |                |                    |                                                 |
|                           |                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                         | -£207.8m                                                                                                                                 | £193.9m   | £586.8m      |                |                    |                                                 |
|                           | Reliability impact on<br>Commuting and Other users | Overall the option would improve reliability partly from congestion relief on the existing Dartford crossing and the new crossing.                                                                                                                                                                                                                                                                                                      | Not assessed                                                                                                                             |           |              |                | Not assessed       |                                                 |
|                           | Physical activity                                  | Not reassessed                                                                                                                                                                                                                                                                                                                                                                                                                          | Not applicable                                                                                                                           |           |              | Not applicable | Not applicable     |                                                 |
|                           | Journey quality                                    | Not reassessed                                                                                                                                                                                                                                                                                                                                                                                                                          | Not applicable                                                                                                                           |           |              | Not assessed   | Not applicable     |                                                 |
|                           | Accidents                                          | The new additional crossing is forecast to increase traffic and thus accidents.                                                                                                                                                                                                                                                                                                                                                         | 6,256 additional accidents, including 84 fatalities, 568 serious and 9,653 slight casualties.                                            |           |              | Not applicable | -£315.4m           |                                                 |
|                           | Security                                           | Not reassessed                                                                                                                                                                                                                                                                                                                                                                                                                          | Not applicable                                                                                                                           |           |              | Not applicable | Not applicable     | Not assessed                                    |
|                           | Access to services                                 | Not reassessed                                                                                                                                                                                                                                                                                                                                                                                                                          | Not applicable                                                                                                                           |           |              | Not assessed   | Not applicable     | Not assessed                                    |
| Affordability             | Not reassessed                                     | Not applicable                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                          |           | Not assessed | Not applicable | Not assessed       |                                                 |
| Severance                 | Not reassessed                                     | Not applicable                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                          |           | Not assessed | Not applicable | Not assessed       |                                                 |
| Option and non-use values | Not reassessed                                     | Not applicable                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                          |           | Not assessed | Not applicable |                    |                                                 |
| Public<br>Accounts        | Cost to Broad Transport Budget                     | The impacts upon the transport budget would be twofold; the capital cost of construction and the subsequent maintenance and operating cost of the infrastructure and revenue collected from the additional user charges.                                                                                                                                                                                                                | Investment costs: £2,254.0m<br>Operating costs: £146.5m<br>Operator Revenue: -£785.2m (a benefit, offsetting cost over the longer term.) |           |              | Not applicable | £1,615.3m          |                                                 |
|                           | Indirect Tax Revenues                              | A tax revenue benefit to central government is forecast as a result of additional traffic using the road network and particularly the Dartford Crossing.                                                                                                                                                                                                                                                                                | Not applicable                                                                                                                           |           |              | Not applicable | -£543.1m           |                                                 |

TABLE 15.11 - APPRAISAL SUMMARY TABLE: OPTION C9-IMMERSED TUBE TUNNEL, 60 YEAR APPRAISAL, 2025-2084

| Appraisal Summary Table                   |                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                             | Date produced: |                | 31-Jul-15                |                         | Contact:           |                                                 |
|-------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------|----------------|----------------|--------------------------|-------------------------|--------------------|-------------------------------------------------|
| Name of scheme:                           |                                                                                                                                                                                                                                             | Lower Thames Crossing Option C9 (Immersed tube tunnel)                                                                                                                                                                                                                                                                                                                                                                                             |                                             |                |                |                          |                         | Name               | Eamonn Colgan                                   |
| Description of scheme:                    |                                                                                                                                                                                                                                             | A combination of option C2d and C4d, using A2 interchange from option C2d and A13, A127 and M25 interchanges from option C4d.                                                                                                                                                                                                                                                                                                                      |                                             |                |                |                          |                         | Organisation       | Highways England                                |
|                                           |                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                             |                |                |                          |                         | Role               | Project Sponsor                                 |
| Impacts                                   |                                                                                                                                                                                                                                             | Summary of key impacts                                                                                                                                                                                                                                                                                                                                                                                                                             |                                             | Assessment     |                |                          |                         |                    |                                                 |
|                                           |                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                             | Quantitative   |                |                          | Qualitative             | Monetary<br>£(NPV) | Distributional<br>7-pt scale/<br>vulnerable grp |
| Economy                                   | Business users & transport providers                                                                                                                                                                                                        | Large time benefits expected to business travellers, including freight, due to reduced congestion and improved connectivity. Small vehicle operating cost benefits also would occur, due to reduced congestion. Small road toll disbenefit, as the new crossing will be tolled.                                                                                                                                                                    | Value of journey time changes(£)            |                |                | £2,578.1m                |                         | £2,989.9m          |                                                 |
|                                           |                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Net journey time changes (£)                |                |                |                          |                         |                    |                                                 |
|                                           |                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 0 to 2min                                   | 2 to 5min      | > 5min         |                          |                         |                    |                                                 |
|                                           |                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                    | -£287.0m                                    | £683.8m        | £2,181.3m      |                          |                         |                    |                                                 |
|                                           | Reliability impact on Business users                                                                                                                                                                                                        | Option would relieve congestion on the existing Dartford crossing and would provide an alternative route with little congestion. Journey time reliability would thus improve.                                                                                                                                                                                                                                                                      |                                             |                |                |                          |                         |                    |                                                 |
|                                           | Regeneration                                                                                                                                                                                                                                | Widespread and significant changes to journey opportunities would be expected to shift employment opportunities eastwards, particularly benefiting the Kent and Essex Thames Gateway areas and other easterly parts of Kent and Essex.                                                                                                                                                                                                             |                                             |                |                |                          |                         |                    |                                                 |
|                                           | Wider Impacts                                                                                                                                                                                                                               | The modelled agglomeration benefit of Options C9 is forecast to be £956m. Similarly to the other Option C's Medway Towns is forecast to benefit the greatest in 2025. However by 2041, Basildon is expected to have the largest agglomeration benefits. Likewise Swale is expected to see the greatest change in effective density for both 2025 and 2041.                                                                                         | Agglomeration                               |                | £956.0m        |                          | £1.256m                 |                    |                                                 |
| Output in imperfectly competitive markets |                                                                                                                                                                                                                                             | £299.0m                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                             |                |                |                          |                         |                    |                                                 |
| Labour supply impact                      |                                                                                                                                                                                                                                             | £2.0m                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                             |                |                |                          |                         |                    |                                                 |
| Environmental                             | Noise                                                                                                                                                                                                                                       | Large noise increases predicted in an existing low noise environment                                                                                                                                                                                                                                                                                                                                                                               | Not possible to provide                     |                |                | Moderate Adverse         | Not possible to provide |                    |                                                 |
|                                           | Air Quality                                                                                                                                                                                                                                 | There is likely to be an overall increase in emissions on Defra's PCM modelled links, causing an overall worsening of air quality, however this is unlikely to impact on the date Defra has reported the zone will be compliant.                                                                                                                                                                                                                   |                                             |                |                | Slight Adverse           |                         |                    |                                                 |
|                                           | Greenhouse gases                                                                                                                                                                                                                            | The option is forecast to result in an increase in both non-traded and traded carbon emissions.                                                                                                                                                                                                                                                                                                                                                    | Change in non-traded carbon over 60y (CO2e) |                | 5,859,718      |                          | -£270.5m                |                    |                                                 |
|                                           |                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Change in traded carbon over 60y (CO2e)     |                | 13,277         |                          |                         |                    |                                                 |
|                                           | Landscape                                                                                                                                                                                                                                   | Route partially within the AONB although already affected by existing roads, changes to landscape character associated with new road infrastructure.                                                                                                                                                                                                                                                                                               | Not Applicable                              |                |                | Moderate Adverse         | Not Applicable          |                    |                                                 |
|                                           | Townscape                                                                                                                                                                                                                                   | Not applicable                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                             |                |                | Not applicable           |                         |                    |                                                 |
|                                           | Historic Environment                                                                                                                                                                                                                        | Direct impact upon a Grade II Listed Building by the junction with the A127, as well as the potential for direct or setting impacts upon other Listed Buildings. Potential setting impact on a nationally important Scheduled Monument and a corridor of heritage significance west of East Tilbury. Potential effects on two Registered Parks and Gardens albeit minor setting impacts.                                                           |                                             |                |                | Moderate Adverse         |                         |                    |                                                 |
|                                           | Biodiversity                                                                                                                                                                                                                                | Route alignment directly affects a small part of the nationally important Shorne and Ashenbank Woods SSSI, the Claylane Woods ancient woodland and several other areas of ancient woodland along A127. There would be direct effects on the recommended MCZ and potential effects on the Ramsar and SSSI depending upon the footprint and extent of cut and cover works. Potential for effects on the SPA from land take and hydrodynamic effects. | Not Applicable                              |                |                | Very Large/Large Adverse | Not Applicable          |                    |                                                 |
| Water Environment                         | Potential long term impacts on morphology of several Mar Dyke tributaries at river crossings and long term loss of flood plain and impact on flood defences. Potential local impacts on groundwater resources and WFD classified waterbody. | Not Applicable                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                             |                | Slight Adverse | Not Applicable           |                         |                    |                                                 |

| Impacts                   |                                                    | Summary of key impacts                                                                                                                                                                                                                                                                                                                                                                                                                  | Assessment                                                                                                                                |           |              |                |                    |                                                 |
|---------------------------|----------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------|-----------|--------------|----------------|--------------------|-------------------------------------------------|
|                           |                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                         | Quantitative                                                                                                                              |           |              | Qualitative    | Monetary<br>£(NPV) | Distributional<br>7-pt scale/<br>vulnerable grp |
| Social                    | Commuting and Other users                          | Significant time benefits to consumer travellers would be due to reduced congestion and improved connectivity, although some short trips would experience disbenefit due to increased congestion around the crossing access locations. Large non-fuel vehicle operating cost disbenefit would be due to increased travel and lack of perception by consumer travellers. Small road toll disbenefit, as the new crossing will be tolled. | Value of journey time changes(£)                                                                                                          |           | £572.8m      |                | £136.5m            |                                                 |
|                           |                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                         | Net journey time changes (£)                                                                                                              |           |              |                |                    |                                                 |
|                           |                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                         | 0 to 2min                                                                                                                                 | 2 to 5min | > 5min       |                |                    |                                                 |
|                           |                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                         | -£207.8m                                                                                                                                  | £193.9m   | £586.8m      |                |                    |                                                 |
|                           | Reliability impact on<br>Commuting and Other users | Overall the option would improve reliability partly from congestion relief on the existing Dartford crossing and the new crossing.                                                                                                                                                                                                                                                                                                      | Not assessed                                                                                                                              |           |              |                | Not assessed       |                                                 |
|                           | Physical activity                                  | Not reassessed                                                                                                                                                                                                                                                                                                                                                                                                                          | Not applicable                                                                                                                            |           |              | Not applicable | Not applicable     |                                                 |
|                           | Journey quality                                    | Not reassessed                                                                                                                                                                                                                                                                                                                                                                                                                          | Not applicable                                                                                                                            |           |              | Not assessed   | Not applicable     |                                                 |
|                           | Accidents                                          | The new additional crossing is forecast to increase traffic and thus accidents.                                                                                                                                                                                                                                                                                                                                                         | 6,256 additional accidents, including 84 fatalities, 568 serious and 9,653 slight casualties.                                             |           |              | Not applicable | -£315.4m           |                                                 |
|                           | Security                                           | Not reassessed                                                                                                                                                                                                                                                                                                                                                                                                                          | Not applicable                                                                                                                            |           |              | Not applicable | Not applicable     | Not assessed                                    |
|                           | Access to services                                 | Not reassessed                                                                                                                                                                                                                                                                                                                                                                                                                          | Not applicable                                                                                                                            |           |              | Not assessed   | Not applicable     | Not assessed                                    |
| Affordability             | Not reassessed                                     | Not applicable                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                           |           | Not assessed | Not applicable | Not assessed       |                                                 |
| Severance                 | Not reassessed                                     | Not applicable                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                           |           | Not assessed | Not applicable | Not assessed       |                                                 |
| Option and non-use values | Not reassessed                                     | Not applicable                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                           |           | Not assessed | Not applicable |                    |                                                 |
| Public<br>Accounts        | Cost to Broad Transport<br>Budget                  | The impacts upon the transport budget would be twofold; the capital cost of construction and the subsequent maintenance and operating cost of the infrastructure and revenue collected from the additional user charges.                                                                                                                                                                                                                | Investment costs: £2,313.3m<br>Operating costs: £1150.4m<br>Operator Revenue: -£785.2m (a benefit, offsetting cost over the longer term.) |           |              | Not applicable | £1,678.5m          |                                                 |
|                           | Indirect Tax Revenues                              | A tax revenue benefit to central government is forecast as a result of additional traffic using the road network and particularly the Dartford Crossing.                                                                                                                                                                                                                                                                                | Not applicable                                                                                                                            |           |              | Not applicable | -£543.1m           |                                                 |

TABLE 15.12 - APPRAISAL SUMMARY TABLE: OPTION C19-BRIDGE, 60 YEAR APPRAISAL, 2025-2084

| Appraisal Summary Table |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                              |  |                                           | Date produced:                              |           | 31-Jul-15 |                          | Contact:                |                                                 |                  |
|-------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|-------------------------------------------|---------------------------------------------|-----------|-----------|--------------------------|-------------------------|-------------------------------------------------|------------------|
| Name of scheme:         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Lower Thames Crossing Option C19 - bridge                                                                                                                                                                                                                                                                                                                                                                                                    |  |                                           |                                             |           |           |                          | Name                    |                                                 | Eamonn Colgan    |
| Description of scheme:  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Option C2d crossing using C4d junctions with A2, A13, A127 and M25, and free flow links to/from A289.                                                                                                                                                                                                                                                                                                                                        |  |                                           |                                             |           |           |                          | Organisation            |                                                 | Highways England |
|                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                              |  |                                           |                                             |           |           |                          | Role                    |                                                 | Project Sponsor  |
| Impacts                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Summary of key impacts                                                                                                                                                                                                                                                                                                                                                                                                                       |  |                                           | Assessment                                  |           |           |                          |                         |                                                 |                  |
|                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                              |  |                                           | Quantitative                                |           |           | Qualitative              | Monetary<br>£(NPV)      | Distributional<br>7-pt scale/<br>vulnerable grp |                  |
| Economy                 | Business users & transport providers                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Large time benefits expected to business travellers, including freight, due to reduced congestion and improved connectivity. Small vehicle operating cost benefits also would occur, due to reduced congestion. Small road toll disbenefit, as the new crossing will be tolled.                                                                                                                                                              |  |                                           | Value of journey time changes(£)            |           | £3,052.2m |                          | £3,778.8m               |                                                 |                  |
|                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                              |  |                                           | Net journey time changes (£)                |           |           |                          |                         |                                                 |                  |
|                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                              |  |                                           | 0 to 2min                                   | 2 to 5min | > 5min    |                          |                         |                                                 |                  |
|                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                              |  |                                           | -£168.9m                                    | £692.7m   | £2,528.5m |                          |                         |                                                 |                  |
|                         | Reliability impact on Business users                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Option would relieve congestion on the existing Dartford crossing and would provide an alternative route with little congestion. Journey time reliability would thus improve.                                                                                                                                                                                                                                                                |  |                                           |                                             |           |           |                          |                         |                                                 |                  |
| Regeneration            | Widespread and significant changes to journey opportunities would be expected to shift employment opportunities eastwards, particularly benefiting the Kent and Essex Thames Gateway areas and other easterly parts of Kent and Essex.                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                              |  |                                           |                                             |           |           |                          |                         |                                                 |                  |
| Wider Impacts           | Out of all the Options considered so far in this study, Option C19 has the highest agglomeration benefits. The total agglomeration is estimated to be £1,206 million. Similarly to the other Option C's Medway Towns is forecast to benefit the greatest in 2025. Additionally Maidstone, Ashford along with Basildon, are all significantly benefiting from this option. Likewise Medway and Shepway are both expected to see the greatest change in effective density for both 2025 and 2041. |                                                                                                                                                                                                                                                                                                                                                                                                                                              |  | Agglomeration                             |                                             | £1,206.0m |           | £1,612m                  |                         |                                                 |                  |
|                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                              |  | Output in imperfectly competitive markets |                                             | £404.0m   |           |                          |                         |                                                 |                  |
|                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                              |  | Labour supply impact                      |                                             | £2.0m     |           |                          |                         |                                                 |                  |
| Environmental           | Noise                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Large noise increases predicted in an existing low noise environment                                                                                                                                                                                                                                                                                                                                                                         |  |                                           | Not possible to provide                     |           |           | Moderate Adverse         | Not possible to provide |                                                 |                  |
|                         | Air Quality                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Predicted overall increase in emissions on Defra's PCM modelled links, causing an overall worsening of air quality, however this is unlikely to impact on the date Defra has reported the zone will be compliant.                                                                                                                                                                                                                            |  |                                           |                                             |           |           | Slight Adverse           |                         |                                                 |                  |
|                         | Greenhouse gases                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | The option is forecast to result in an increase in both non-traded and traded carbon emissions.                                                                                                                                                                                                                                                                                                                                              |  |                                           | Change in non-traded carbon over 60y (CO2e) |           | 6,599,432 |                          | -£304.7m                |                                                 |                  |
|                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                              |  |                                           | Change in traded carbon over 60y (CO2e)     |           | 15,255    |                          |                         |                                                 |                  |
|                         | Landscape                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Route partially within the AONB although already affected by existing roads, changes to landscape character associated with new road infrastructure.                                                                                                                                                                                                                                                                                         |  |                                           | Not Applicable                              |           |           | Moderate Adverse         | Not Applicable          |                                                 |                  |
|                         | Townscape                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Not applicable                                                                                                                                                                                                                                                                                                                                                                                                                               |  |                                           |                                             |           |           | Not applicable           |                         |                                                 |                  |
|                         | Historic Environment                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Direct impact upon a Grade II Listed Building by the junction with the A127, as well as the potential for direct or setting impacts upon other Listed Buildings. Potential setting impact on a nationally important Scheduled Monument and a corridor of heritage significance west of East Tilbury. Potential effects on two Registered Parks and Gardens albeit minor setting impacts and setting impacts on Listed Buildings near Shorne. |  |                                           |                                             |           |           | Moderate Adverse         |                         |                                                 |                  |
|                         | Biodiversity                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Route alignment directly affects a small part of the nationally important Great Crabbles Wood SSSI and areas of ancient woodland around Shorne and along the A127. There would be direct effects on the Ramsar, SSSI and SPA as well as the recommended MCZ associated with the bridge structure in the river.                                                                                                                               |  |                                           | Not Applicable                              |           |           | Very Large/Large Adverse | Not Applicable          |                                                 |                  |
|                         | Water Environment                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Potential long term impacts on morphology of several Mar Dyke tributaries at river crossings and long term loss of flood plain and impact on flood defences. Potential local impacts on groundwater resources and WFD classified waterbody.                                                                                                                                                                                                  |  |                                           | Not Applicable                              |           |           | Slight Adverse           | Not Applicable          |                                                 |                  |



| Impacts                   |                                                    | Summary of key impacts                                                                                                                                                                                                                                                                                                                                                                                                                  | Assessment                                                                                                                               |           |              |                |                    |                                                 |
|---------------------------|----------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------|-----------|--------------|----------------|--------------------|-------------------------------------------------|
|                           |                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                         | Quantitative                                                                                                                             |           |              | Qualitative    | Monetary<br>£(NPV) | Distributional<br>7-pt scale/<br>vulnerable grp |
| Social                    | Commuting and Other users                          | Significant time benefits to consumer travellers would be due to reduced congestion and improved connectivity, although some short trips would experience disbenefit due to increased congestion around the crossing access locations. Large non-fuel vehicle operating cost disbenefit would be due to increased travel and lack of perception by consumer travellers. Small road toll disbenefit, as the new crossing will be tolled. | Value of journey time changes(£)                                                                                                         |           | £728.5m      |                | £320.8m            |                                                 |
|                           |                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                         | Net journey time changes (£)                                                                                                             |           |              |                |                    |                                                 |
|                           |                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                         | 0 to 2min                                                                                                                                | 2 to 5min | > 5min       |                |                    |                                                 |
|                           |                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                         | -£144.8m                                                                                                                                 | £209.5m   | £663.8m      |                |                    |                                                 |
|                           | Reliability impact on<br>Commuting and Other users | Overall the option would improve reliability partly from congestion relief on the existing Dartford crossing and the new crossing.                                                                                                                                                                                                                                                                                                      | Not assessed                                                                                                                             |           |              |                | Not assessed       |                                                 |
|                           | Physical activity                                  | Not reassessed                                                                                                                                                                                                                                                                                                                                                                                                                          | Not applicable                                                                                                                           |           |              | Not applicable | Not applicable     |                                                 |
|                           | Journey quality                                    | Not reassessed                                                                                                                                                                                                                                                                                                                                                                                                                          | Not applicable                                                                                                                           |           |              | Not assessed   | Not applicable     |                                                 |
|                           | Accidents                                          | The new additional crossing is forecast to increase traffic and thus accidents.                                                                                                                                                                                                                                                                                                                                                         | 5,612 additional accidents, including 79 fatalities, 490 serious and 8,846 slight casualties.                                            |           |              | Not applicable | -£284.9m           |                                                 |
|                           | Security                                           | Not reassessed                                                                                                                                                                                                                                                                                                                                                                                                                          | Not applicable                                                                                                                           |           |              | Not applicable | Not applicable     | Not assessed                                    |
|                           | Access to services                                 | Not reassessed                                                                                                                                                                                                                                                                                                                                                                                                                          | Not applicable                                                                                                                           |           |              | Not assessed   | Not applicable     | Not assessed                                    |
| Affordability             | Not reassessed                                     | Not applicable                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                          |           | Not assessed | Not applicable | Not assessed       |                                                 |
| Severance                 | Not reassessed                                     | Not applicable                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                          |           | Not assessed | Not applicable | Not assessed       |                                                 |
| Option and non-use values | Not reassessed                                     | Not applicable                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                          |           | Not assessed | Not applicable |                    |                                                 |
| Public<br>Accounts        | Cost to Broad Transport Budget                     | The impacts upon the transport budget would be twofold; the capital cost of construction and the subsequent maintenance and operating cost of the infrastructure and revenue collected from the additional user charges.                                                                                                                                                                                                                | Investment costs: £2,326.4m<br>Operating costs: £151.2m<br>Operator Revenue: -£835.6m (a benefit, offsetting cost over the longer term.) |           |              | Not applicable | £1,642.0m          |                                                 |
|                           | Indirect Tax Revenues                              | A tax revenue benefit to central government is forecast as a result of additional traffic using the road network and particularly the Dartford Crossing.                                                                                                                                                                                                                                                                                | Not applicable                                                                                                                           |           |              | Not applicable | -£620.0m           |                                                 |

TABLE 15.13 - APPRAISAL SUMMARY TABLE: OPTION C19-TWIN BORED TUNNEL, 60 YEAR APPRAISAL, 2025-2084

| Appraisal Summary Table                   |                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |  | Date produced:                              |           | 31-Jul-15              |                         | Contact:                                        |                  |
|-------------------------------------------|-----------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|---------------------------------------------|-----------|------------------------|-------------------------|-------------------------------------------------|------------------|
| Name of scheme:                           |                                         | Lower Thames Crossing Option C19-twin bored tunnel                                                                                                                                                                                                                                                                                                                                                                                                                                                     |  |                                             |           |                        |                         | Name                                            | Eamonn Colgan    |
| Description of scheme:                    |                                         | Option C2d crossing using C4d junctions with A2, A13, A127 and M25, and free flow links to/from A289.                                                                                                                                                                                                                                                                                                                                                                                                  |  |                                             |           |                        |                         | Organisation                                    | Highways England |
|                                           |                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |  |                                             |           |                        |                         | Role                                            | Project Sponsor  |
| Impacts                                   |                                         | Summary of key impacts                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |  | Assessment                                  |           |                        |                         |                                                 |                  |
|                                           |                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |  | Quantitative                                |           | Qualitative            | Monetary<br>£(NPV)      | Distributional<br>7-pt scale/<br>vulnerable grp |                  |
| Economy                                   | Business users & transport providers    | Large time benefits expected to business travellers, including freight, due to reduced congestion and improved connectivity. Small vehicle operating cost benefits also would occur, due to reduced congestion. Small road toll disbenefit, as the new crossing will be tolled.                                                                                                                                                                                                                        |  | Value of journey time changes(£)            |           | £3,052.2m              |                         | £3,778.8m                                       |                  |
|                                           |                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |  | Net journey time changes (£)                |           |                        |                         |                                                 |                  |
|                                           |                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |  | 0 to 2min                                   | 2 to 5min | > 5min                 |                         |                                                 |                  |
|                                           |                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |  | -£168.9m                                    | £692.7m   | £2,528.5m              |                         |                                                 |                  |
|                                           | Reliability impact on Business users    | Option would relieve congestion on the existing Dartford crossing and would provide an alternative route with little congestion. Journey time reliability would thus improve.                                                                                                                                                                                                                                                                                                                          |  |                                             |           |                        |                         |                                                 |                  |
|                                           | Regeneration                            | Widespread and significant changes to journey opportunities would be expected to shift employment opportunities eastwards, particularly benefiting the Kent and Essex Thames Gateway areas and other easterly parts of Kent and Essex.                                                                                                                                                                                                                                                                 |  |                                             |           |                        |                         |                                                 |                  |
|                                           | Wider Impacts                           | <i>Out of all the Options considered so far in this study, Option C19 has the highest agglomeration benefits. The total agglomeration is estimated to be £1,206 million. Similarly to the other Option C's Medway Towns is forecast to benefit the greatest in 2025. Additionally Maidstone, Ashford along with Basildon, are all significantly benefiting from this option. Likewise Medway and Shepway are both expected to see the greatest change in effective density for both 2025 and 2041.</i> |  | Agglomeration                               |           | £1,206.0m              |                         | £1,256.0m                                       |                  |
| Output in imperfectly competitive markets |                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |  | £404.0m                                     |           |                        |                         |                                                 |                  |
| Labour supply impact                      |                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |  | £2.0m                                       |           |                        |                         |                                                 |                  |
| Environmental                             | Noise                                   | Large noise increases predicted in an existing low noise environment                                                                                                                                                                                                                                                                                                                                                                                                                                   |  |                                             |           | Moderate Adverse       | Not possible to provide |                                                 |                  |
|                                           | Air Quality                             | Predicted overall increase in emissions on Defra's PCM modelled links, causing an overall worsening of air quality, however this is unlikely to impact on the date Defra has reported the zone will be compliant.                                                                                                                                                                                                                                                                                      |  |                                             |           | Slight Adverse         |                         |                                                 |                  |
|                                           | Greenhouse gases                        | The option is forecast to result in an increase in both non-traded and traded carbon emissions.                                                                                                                                                                                                                                                                                                                                                                                                        |  | Change in non-traded carbon over 60y (CO2e) |           | 6,599,432              | -£304.7m                |                                                 |                  |
|                                           | Change in traded carbon over 60y (CO2e) |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |  | 15,255                                      |           |                        |                         |                                                 |                  |
|                                           | Landscape                               | Route partially within the AONB although already affected by existing roads, changes to landscape character associated with new road infrastructure.                                                                                                                                                                                                                                                                                                                                                   |  |                                             |           | Moderate Adverse       | Not Applicable          |                                                 |                  |
|                                           | Townscape                               | Not applicable                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |  |                                             |           | Not applicable         |                         |                                                 |                  |
|                                           | Historic Environment                    | Direct impact upon a Grade II Listed Building by the junction with the A127, as well as the potential for direct or setting impacts upon other Listed Buildings. Potential setting impact on a nationally important Scheduled Monument and a corridor of heritage significance west of East Tilbury. Potential effects on two Registered Parks and Gardens albeit minor setting impacts and setting impacts on Listed Buildings near Shorne.                                                           |  |                                             |           | Moderate Adverse       |                         |                                                 |                  |
|                                           | Biodiversity                            | Route alignment directly affects a small part of the nationally important Great Crabbles Wood SSSI and areas of ancient woodland around Shorne and along the A127. Assumed that any disturbance effects on SPA species could be avoided through mitigation.                                                                                                                                                                                                                                            |  |                                             |           | Moderate/Large Adverse | Not Applicable          |                                                 |                  |
|                                           | Water Environment                       | Potential long term impacts on morphology of several Mar Dyke tributaries at river crossings and long term loss of flood plain and impact on flood defences. Potential local impacts on groundwater resources and WFD classified waterbody.                                                                                                                                                                                                                                                            |  |                                             |           | Slight Adverse         | Not Applicable          |                                                 |                  |



| Impacts                   |                                                    | Summary of key impacts                                                                                                                                                                                                                                                                                                                                                                                                                  | Assessment                                                                                                                               |           |              |                |                    |                                                 |
|---------------------------|----------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------|-----------|--------------|----------------|--------------------|-------------------------------------------------|
|                           |                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                         | Quantitative                                                                                                                             |           |              | Qualitative    | Monetary<br>£(NPV) | Distributional<br>7-pt scale/<br>vulnerable grp |
| Social                    | Commuting and Other users                          | Significant time benefits to consumer travellers would be due to reduced congestion and improved connectivity, although some short trips would experience disbenefit due to increased congestion around the crossing access locations. Large non-fuel vehicle operating cost disbenefit would be due to increased travel and lack of perception by consumer travellers. Small road toll disbenefit, as the new crossing will be tolled. | Value of journey time changes(£)                                                                                                         |           | £728.5m      |                | £320.8m            |                                                 |
|                           |                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                         | Net journey time changes (£)                                                                                                             |           |              |                |                    |                                                 |
|                           |                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                         | 0 to 2min                                                                                                                                | 2 to 5min | > 5min       |                |                    |                                                 |
|                           |                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                         | -£144.8m                                                                                                                                 | £209.5m   | £663.8m      |                |                    |                                                 |
|                           | Reliability impact on<br>Commuting and Other users | Overall the option would improve reliability partly from congestion relief on the existing Dartford crossing and the new crossing.                                                                                                                                                                                                                                                                                                      | Not assessed                                                                                                                             |           |              |                | Not assessed       |                                                 |
|                           | Physical activity                                  | Not reassessed                                                                                                                                                                                                                                                                                                                                                                                                                          | Not applicable                                                                                                                           |           |              | Not applicable | Not applicable     |                                                 |
|                           | Journey quality                                    | Not reassessed                                                                                                                                                                                                                                                                                                                                                                                                                          | Not applicable                                                                                                                           |           |              | Not assessed   | Not applicable     |                                                 |
|                           | Accidents                                          | The new additional crossing is forecast to increase traffic and thus accidents.                                                                                                                                                                                                                                                                                                                                                         | 5,612 additional accidents, including 79 fatalities, 490 serious and 8,846 slight casualties.                                            |           |              | Not applicable | -£284.9m           |                                                 |
|                           | Security                                           | Not reassessed                                                                                                                                                                                                                                                                                                                                                                                                                          | Not applicable                                                                                                                           |           |              | Not applicable | Not applicable     | Not assessed                                    |
|                           | Access to services                                 | Not reassessed                                                                                                                                                                                                                                                                                                                                                                                                                          | Not applicable                                                                                                                           |           |              | Not assessed   | Not applicable     | Not assessed                                    |
| Affordability             | Not reassessed                                     | Not applicable                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                          |           | Not assessed | Not applicable | Not assessed       |                                                 |
| Severance                 | Not reassessed                                     | Not applicable                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                          |           | Not assessed | Not applicable | Not assessed       |                                                 |
| Option and non-use values | Not reassessed                                     | Not applicable                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                          |           | Not assessed | Not applicable |                    |                                                 |
| Public<br>Accounts        | Cost to Broad Transport Budget                     | The impacts upon the transport budget would be twofold; the capital cost of construction and the subsequent maintenance and operating cost of the infrastructure and revenue collected from the additional user charges.                                                                                                                                                                                                                | Investment costs: £2,313.8m<br>Operating costs: £150.4m<br>Operator Revenue: -£835.6m (a benefit, offsetting cost over the longer term.) |           |              | Not applicable | £1,628.6m          |                                                 |
|                           | Indirect Tax Revenues                              | A tax revenue benefit to central government is forecast as a result of additional traffic using the road network and particularly the Dartford Crossing.                                                                                                                                                                                                                                                                                | Not applicable                                                                                                                           |           |              | Not applicable | -£620.0m           |                                                 |

TABLE 15.14 - APPRAISAL SUMMARY TABLE: OPTION C19-IMMERSED TUBE TUNNEL, 60 YEAR APPRAISAL, 2025-2084

| Appraisal Summary Table                   |                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                             | Date produced: |                | 31-Jul-15                |                         | Contact:           |                                                 |
|-------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------|----------------|----------------|--------------------------|-------------------------|--------------------|-------------------------------------------------|
| Name of scheme:                           |                                                                                                                                                                                                                                             | Lower Thames Crossing Option C19 - immersed tube tunnel                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                             |                |                |                          |                         | Name               | Eamonn Colgan                                   |
| Description of scheme:                    |                                                                                                                                                                                                                                             | Option C2d crossing using C4d junctions with A2, A13, A127 and M25, and free flow links to/from A289.                                                                                                                                                                                                                                                                                                                                                                                           |                                             |                |                |                          |                         | Organisation       | Highways England                                |
|                                           |                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                             |                |                |                          |                         | Role               | Project Sponsor                                 |
|                                           |                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                             |                |                |                          |                         |                    |                                                 |
| Impacts                                   |                                                                                                                                                                                                                                             | Summary of key impacts                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                             | Assessment     |                |                          |                         |                    |                                                 |
|                                           |                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                             | Quantitative   |                |                          | Qualitative             | Monetary<br>£(NPV) | Distributional<br>7-pt scale/<br>vulnerable grp |
| Economy                                   | Business users & transport providers                                                                                                                                                                                                        | Large time benefits expected to business travellers, including freight, due to reduced congestion and improved connectivity. Small vehicle operating cost benefits also would occur, due to reduced congestion. Small road toll disbenefit, as the new crossing will be tolled.                                                                                                                                                                                                                 | Value of journey time changes(£)            |                | £3,052.2m      |                          |                         | £3,778.8m          |                                                 |
|                                           |                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Net journey time changes (£)                |                |                |                          |                         |                    |                                                 |
|                                           |                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 0 to 2min                                   | 2 to 5min      | > 5min         |                          |                         |                    |                                                 |
|                                           |                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | -£168.9m                                    | £692.7m        | £2,528.5m      |                          |                         |                    |                                                 |
|                                           | Reliability impact on Business users                                                                                                                                                                                                        | Option would relieve congestion on the existing Dartford crossing and would provide an alternative route with little congestion. Journey time reliability would thus improve.                                                                                                                                                                                                                                                                                                                   |                                             |                |                |                          |                         |                    |                                                 |
|                                           | Regeneration                                                                                                                                                                                                                                | Widespread and significant changes to journey opportunities would be expected to shift employment opportunities eastwards, particularly benefiting the Kent and Essex Thames Gateway areas and other easterly parts of Kent and Essex.                                                                                                                                                                                                                                                          |                                             |                |                |                          |                         |                    |                                                 |
|                                           | Wider Impacts                                                                                                                                                                                                                               | Out of all the Options considered so far in this study, Option C19 has the highest agglomeration benefits. The total agglomeration is estimated to be £1,206 million. Similarly to the other Option C's Medway Towns is forecast to benefit the greatest in 2025. Additionally Maidstone, Ashford along with Basildon, are all significantly benefiting from this option. Likewise Medway and Shepway are both expected to see the greatest change in effective density for both 2025 and 2041. | Agglomeration                               |                | £1,206.0m      |                          |                         | £1,256.0m          |                                                 |
| Output in imperfectly competitive markets |                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | £404.0m                                     |                |                |                          |                         |                    |                                                 |
| Labour supply impact                      |                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | £2.0m                                       |                |                |                          |                         |                    |                                                 |
| Environmental                             | Noise                                                                                                                                                                                                                                       | Large noise increases predicted in an existing low noise environment                                                                                                                                                                                                                                                                                                                                                                                                                            | Not possible to provide                     |                |                | Moderate Adverse         | Not possible to provide |                    |                                                 |
|                                           | Air Quality                                                                                                                                                                                                                                 | Predicted overall increase in emissions on Defra's PCM modelled links, causing an overall worsening of air quality, however this is unlikely to impact on the date Defra has reported the zone will be compliant.                                                                                                                                                                                                                                                                               |                                             |                |                | Slight Adverse           |                         |                    |                                                 |
|                                           | Greenhouse gases                                                                                                                                                                                                                            | The option is forecast to result in an increase in both non-traded and traded carbon emissions.                                                                                                                                                                                                                                                                                                                                                                                                 | Change in non-traded carbon over 60y (CO2e) |                | 6,599,432      |                          | -£304.7m                |                    |                                                 |
|                                           |                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Change in traded carbon over 60y (CO2e)     |                | 15,255         |                          |                         |                    |                                                 |
|                                           | Landscape                                                                                                                                                                                                                                   | Route partially within the AONB although already affected by existing roads, changes to landscape character associated with new road infrastructure.                                                                                                                                                                                                                                                                                                                                            | Not Applicable                              |                |                | Moderate Adverse         | Not Applicable          |                    |                                                 |
|                                           | Townscape                                                                                                                                                                                                                                   | Not applicable                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                             |                |                | Not applicable           |                         |                    |                                                 |
|                                           | Historic Environment                                                                                                                                                                                                                        | Direct impact upon a Grade II Listed Building by the junction with the A127, as well as the potential for direct or setting impacts upon other Listed Buildings. Potential setting impact on a nationally important Scheduled Monument and a corridor of heritage significance west of East Tilbury. Potential effects on two Registered Parks and Gardens albeit minor setting impacts and setting impacts on Listed Buildings near Shorne.                                                    |                                             |                |                | Moderate Adverse         |                         |                    |                                                 |
|                                           | Biodiversity                                                                                                                                                                                                                                | Route alignment directly affects a small part of the nationally important Great Crabbles Wood SSSI and areas of ancient woodland around Shorne and along the A127. Direct effects on the recommended MCZ and potential effects on the Ramsar and SSSI depending upon the footprint and extent of cut and cover works. Effects on the SPA from land take and hydrodynamic effects.                                                                                                               | Not Applicable                              |                |                | Very Large/Large Adverse | Not Applicable          |                    |                                                 |
| Water Environment                         | Potential long term impacts on morphology of several Mar Dyke tributaries at river crossings and long term loss of flood plain and impact on flood defences. Potential local impacts on groundwater resources and WFD classified waterbody. | Not Applicable                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                             |                | Slight Adverse | Not Applicable           |                         |                    |                                                 |

| Impacts                   |                                                    | Summary of key impacts                                                                                                                                                                                                                                                                                                                                                                                                                  | Assessment                                                                                                                               |           |              |                |                    |                                                 |
|---------------------------|----------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------|-----------|--------------|----------------|--------------------|-------------------------------------------------|
|                           |                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                         | Quantitative                                                                                                                             |           |              | Qualitative    | Monetary<br>£(NPV) | Distributional<br>7-pt scale/<br>vulnerable grp |
| Social                    | Commuting and Other users                          | Significant time benefits to consumer travellers would be due to reduced congestion and improved connectivity, although some short trips would experience disbenefit due to increased congestion around the crossing access locations. Large non-fuel vehicle operating cost disbenefit would be due to increased travel and lack of perception by consumer travellers. Small road toll disbenefit, as the new crossing will be tolled. | Value of journey time changes(£)                                                                                                         |           | £728.5m      |                | £320.8m            |                                                 |
|                           |                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                         | Net journey time changes (£)                                                                                                             |           |              |                |                    |                                                 |
|                           |                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                         | 0 to 2min                                                                                                                                | 2 to 5min | > 5min       |                |                    |                                                 |
|                           |                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                         | -£144.8m                                                                                                                                 | £209.5m   | £663.8m      |                |                    |                                                 |
|                           | Reliability impact on<br>Commuting and Other users | Overall the option would improve reliability partly from congestion relief on the existing Dartford crossing and the new crossing.                                                                                                                                                                                                                                                                                                      | Not assessed                                                                                                                             |           |              |                | Not assessed       |                                                 |
|                           | Physical activity                                  | Not reassessed                                                                                                                                                                                                                                                                                                                                                                                                                          | Not applicable                                                                                                                           |           |              | Not applicable | Not applicable     |                                                 |
|                           | Journey quality                                    | Not reassessed                                                                                                                                                                                                                                                                                                                                                                                                                          | Not applicable                                                                                                                           |           |              | Not assessed   | Not applicable     |                                                 |
|                           | Accidents                                          | The new additional crossing is forecast to increase traffic and thus accidents.                                                                                                                                                                                                                                                                                                                                                         | 5,612 additional accidents, including 79 fatalities, 490 serious and 8,846 slight casualties.                                            |           |              | Not applicable | -£284.9m           |                                                 |
|                           | Security                                           | Not reassessed                                                                                                                                                                                                                                                                                                                                                                                                                          | Not applicable                                                                                                                           |           |              | Not applicable | Not applicable     | Not assessed                                    |
|                           | Access to services                                 | Not reassessed                                                                                                                                                                                                                                                                                                                                                                                                                          | Not applicable                                                                                                                           |           |              | Not assessed   | Not applicable     | Not assessed                                    |
| Affordability             | Not reassessed                                     | Not applicable                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                          |           | Not assessed | Not applicable | Not assessed       |                                                 |
| Severance                 | Not reassessed                                     | Not applicable                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                          |           | Not assessed | Not applicable | Not assessed       |                                                 |
| Option and non-use values | Not reassessed                                     | Not applicable                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                          |           | Not assessed | Not applicable |                    |                                                 |
| Public<br>Accounts        | Cost to Broad Transport Budget                     | The impacts upon the transport budget would be twofold; the capital cost of construction and the subsequent maintenance and operating cost of the infrastructure and revenue collected from the additional user charges.                                                                                                                                                                                                                | Investment costs: £2,506.8m<br>Operating costs: £162.9m<br>Operator Revenue: -£835.6m (a benefit, offsetting cost over the longer term.) |           |              | Not applicable | £1,834.1m          |                                                 |
|                           | Indirect Tax Revenues                              | A tax revenue benefit to central government is forecast as a result of additional traffic using the road network and particularly the Dartford Crossing.                                                                                                                                                                                                                                                                                | Not applicable                                                                                                                           |           |              | Not applicable | -£620.0m           |                                                 |

## 16 Conclusion and Recommendations

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### 16.1 Options for Shortlist

16.1.1 It is recommended that the following Route Options are included in the shortlist for detailed appraisal:

- Route Option A1
- Route Option A4
- Route Option C2
- Route Option C3
- Route Option C9
- Route Option C19 (alternative alignment south of the river that could be used with each of Route Options C2, C3 and C9 with any of the three crossing types)

16.1.2 The following crossing types apply to the above Route Options:

- Route Option A1 – Bridge
- Route Option A4 – Bored Tunnel
- Route Option C2 – Bridge, Bored Tunnel or Immersed Tunnel
- Route Option C3 – Bridge, Bored Tunnel or Immersed Tunnel
- Route Option C9 – Bridge, Bored Tunnel or Immersed Tunnel

16.1.3 The recommended shortlisted options are shown in **Figure 16.1**.

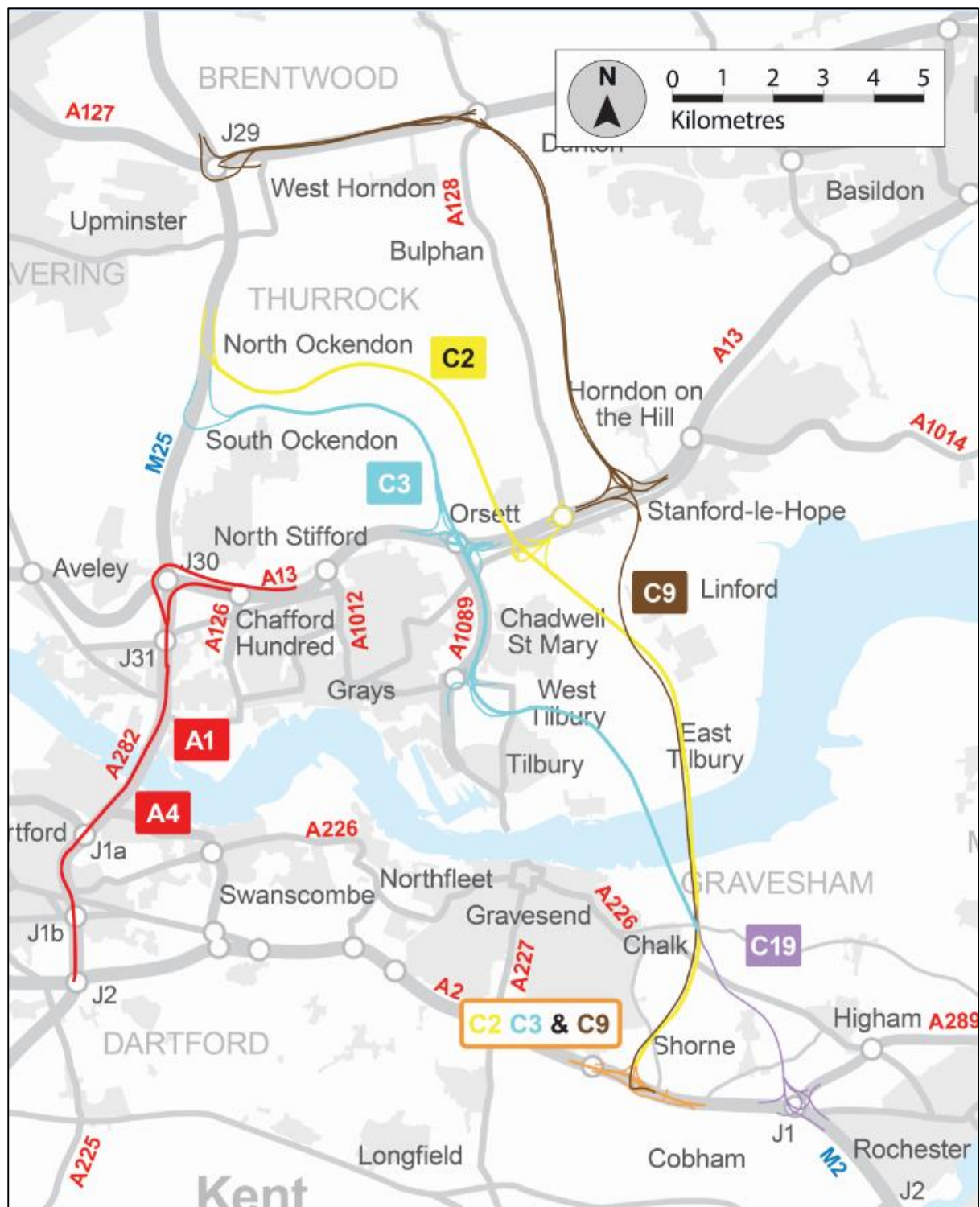


FIGURE 16.1 - RECOMMENDED SHORTLISTED OPTIONS

## 17 Glossary

|                       |                                                                                                                                                                                             |
|-----------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| AECOM                 | AECOM Technology Corporation                                                                                                                                                                |
| Alluvium              | Unconsolidated (not cemented together into a solid rock) soil or sediments, which has been eroded, reshaped by water in some form, and re-deposited in a non-marine setting.                |
| ALM                   | Ambient Light Monitor, sensor on signals control brightness                                                                                                                                 |
| ALR                   | all lane running                                                                                                                                                                            |
| AM                    | 07:00 to 10:00                                                                                                                                                                              |
| AMCB                  | Annualised Monetary Costs and Benefits                                                                                                                                                      |
| AMI                   | Advanced Motorway Indicator, with optical feedback for enforcement                                                                                                                          |
| ANPR                  | Automatic Number Plate Recognition                                                                                                                                                          |
| AOD                   | Above ordnance datum, vertical datum used by an ordnance survey as the basis for delivering altitudes on maps.                                                                              |
| AOI                   | Area of interest                                                                                                                                                                            |
| AONB                  | Area of Outstanding Natural Beauty                                                                                                                                                          |
| APTR                  | All-purpose trunk road                                                                                                                                                                      |
| AQMA                  | Air Quality Management Area                                                                                                                                                                 |
| ASC                   | Asset Support Contract                                                                                                                                                                      |
| ATSS                  | Automatic Traffic Surveillance System                                                                                                                                                       |
| AURN                  | Defra Automatic Rural and Urban Network                                                                                                                                                     |
| BC                    | Borough Council                                                                                                                                                                             |
| BCR                   | Benefit Cost Ratio                                                                                                                                                                          |
| BGS                   | British Geological Survey                                                                                                                                                                   |
| BTO                   | British Trust for Ornithology                                                                                                                                                               |
| CC                    | County Council                                                                                                                                                                              |
| CCTV                  | Closed circuit television                                                                                                                                                                   |
| CEC                   | Combined equipment cabinet                                                                                                                                                                  |
| chart datum           | A chart datum is the level of water from which charted depths displayed on a nautical chart are measured.                                                                                   |
| CHARM                 | Common Highways Agency Rijkswaterstaat Model.                                                                                                                                               |
| CJV                   | construction joint venture                                                                                                                                                                  |
| CMU                   | Cable marshalling unit                                                                                                                                                                      |
| COBA                  | COst Benefit Analysis computer program: DfT's tool for estimating accident benefits. The COBA program compares the costs of providing road schemes with the benefits derived by road users. |
| COBA-LT               | New 'light touch' version of COBA.                                                                                                                                                          |
| Connect Plus          | Connect Plus (M25) Ltd, management company for the Dartford-Thurrock Crossing.                                                                                                              |
| C.RO                  | C.RO is the brand name for the subsidiaries of C.RO Ports SA that operate ro-ro terminals in the UK, the Netherlands and Belgium.                                                           |
| CTRL                  | Channel Tunnel Rail Link                                                                                                                                                                    |
| D2AP                  | dual two-lane all-purpose                                                                                                                                                                   |
| Dart Charge           | The toll to use the Dartford Crossing (paid in cash or via Dart-TAG).                                                                                                                       |
| Dartford Cable Tunnel | An £11m tunnel upstream of the Dartford Crossing built in 2003-4 to carry and allow for maintenance of 380kV National Grid electrical cable beneath the River Thames.                       |
| Dart-TAG              | In-vehicle electronic tags which allow account holders and local Thurrock and Dartford residents to use the Dartford Crossing at discounted rates.                                          |

|                                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|--------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| DBFO                                       | Design, build, finance, operate                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| DCC                                        | Dartford Control Centre                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| Defra                                      | Department for Environment, Food and Rural Affairs                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| DFFC                                       | Dartford Free-Flow Crossing (toll booths removed)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| DfT                                        | Department for Transport                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| DGV                                        | Dangerous Goods Vehicle                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| DMRB                                       | Design Manual for Roads and Bridges: A comprehensive manual (comprising 15 volumes) which contains requirements, advice and other published documents relating to works on motorway and all-purpose trunk roads for which one of the Overseeing Organisations (Highways England, Transport Scotland, The Welsh Government or the Department for Regional Development (Northern Ireland)) is highway authority. The DMRB has been developed as a series of documents published by the Overseeing Organisations of England, Scotland, Wales and Northern Ireland. For the Lower Thames Crossing the Overseeing Organisation is Highways England. |
| DNO                                        | Distribution Network Operator, owner and operator of the distribution network of towers and cables that bring electricity from our national transmission network to homes and businesses.                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| Do Minimum/<br>Do Nothing/<br>Do Something | <p>Do Minimum option: An option where government takes the minimum amount of action necessary. Used as a benchmark option in some appraisals.</p> <p>Do Nothing option: The status quo option i.e. the option of carrying on with the current arrangements. Does not mean literally doing nothing. Used as a benchmark option in many appraisals.</p> <p>Do Something option: An option that provides enhanced services by comparison to the benchmark 'do nothing' or 'do minimum' baseline option.</p>                                                                                                                                       |
| DP World                                   | Dubai Ports World, London Gateway Port                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| DWT                                        | Deadweight tonnage                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| EA                                         | Environment Agency                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| EI                                         | Electrical Interface, between Highways England and power supplier boundary                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| ELHAM                                      | East London Highways Assignment Model                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| EMS                                        | Enhanced Message Signs, typically mounted on portal gantry, displays information about incidents and hazards                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| English Heritage                           | A registered charity that looks after the National Heritage Collection.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| ERA                                        | Emergency Refuge Area                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| ERT                                        | Emergency Roadside Telephones                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| extrados                                   | The upper or outer curve of an arch.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| facies                                     | A body of rock with specified characteristics; ideally, a facies is a distinctive rock unit that forms under certain conditions of sedimentation, reflecting a particular process or environment.                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| Fastrack                                   | A bus rapid transit scheme operating in the Thames Gateway area of Kent. Operated by Arriva Southern Counties.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| FOSD                                       | full overtaking sight distance                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| FP                                         | footpath                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| FTMS                                       | Fixed text message sign, displays scrollable messages                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| GC                                         | generalised cost                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| GDP                                        | Gross Domestic Product                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| Gina gasket                                | The Gina gasket and Omega seal are used between the sectional elements of immersed tunnels to prevent water ingress due to external water pressure.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| GIS                                        | Geographic information system                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| GLA                                        | Greater London Authority                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| Grade separation                           | The method of aligning a junction of two or more surface transport axes at different heights (grades) so that they will not disrupt the traffic flow on other transit routes when they cross each other.                                                                                                                                                                                                                                                                                                                                                                                                                                       |

|                  |                                                                                                                                                                                                                                                                                                                                                                                                                |
|------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| GVA              | Gross value added, a measure in economics of the value of goods and services produced in an area, industry or sector of an economy.                                                                                                                                                                                                                                                                            |
| ha               | hectares                                                                                                                                                                                                                                                                                                                                                                                                       |
| HA               | Highways Agency (historical, as HA is now Highways England)                                                                                                                                                                                                                                                                                                                                                    |
| HADECS           | Highways England Digital Enforcement Camera System                                                                                                                                                                                                                                                                                                                                                             |
| HATRIS           | Highways England Traffic Information System (journey time database)                                                                                                                                                                                                                                                                                                                                            |
| HGV              | Heavy Goods Vehicles                                                                                                                                                                                                                                                                                                                                                                                           |
| Highways England | Highways England (formerly the Highways Agency) is a government-owned company with responsibility for managing the core road network in England. It operates a variety of information services, liaises with other government agencies as well as providing staff to deal with incidents on their roads. Founded as a government agency in 1994, it was converted to government-owned company on 1 April 2015. |
| HRA              | Habitats Regulations Assessment                                                                                                                                                                                                                                                                                                                                                                                |
| HS1              | High Speed 1                                                                                                                                                                                                                                                                                                                                                                                                   |
| HSR              | Hard-shoulder running                                                                                                                                                                                                                                                                                                                                                                                          |
| HV               | high voltage                                                                                                                                                                                                                                                                                                                                                                                                   |
| IP               | Inter-peak – 10:00 to 16:00                                                                                                                                                                                                                                                                                                                                                                                    |
| JTMS             | Journey Time Monitoring System                                                                                                                                                                                                                                                                                                                                                                                 |
| JTR              | journey time reliability                                                                                                                                                                                                                                                                                                                                                                                       |
| Lafarge Tarmac   | Lafarge Tarmac Limited is a British building materials company headquartered in Solihull, Birmingham.                                                                                                                                                                                                                                                                                                          |
| LATS             | London Area Travel Survey                                                                                                                                                                                                                                                                                                                                                                                      |
| LDP              | London Distribution Park                                                                                                                                                                                                                                                                                                                                                                                       |
| LTS              | London Transportation Studies.                                                                                                                                                                                                                                                                                                                                                                                 |
| LTP              | London Thamesport, a container seaport on the River Medway, serving the North Sea.                                                                                                                                                                                                                                                                                                                             |
| m                | metres                                                                                                                                                                                                                                                                                                                                                                                                         |
| MAC              | Maintenance Asset Contractor                                                                                                                                                                                                                                                                                                                                                                                   |
| Made Ground      | Manmade deposits such as embankments, re-claimed land, spoil heaps on the natural ground surface                                                                                                                                                                                                                                                                                                               |
| MCZ              | Marine Conservation Zone                                                                                                                                                                                                                                                                                                                                                                                       |
| MD               | MIDAS detector                                                                                                                                                                                                                                                                                                                                                                                                 |
| MI               | Message indicator, typically mounted on portal gantry                                                                                                                                                                                                                                                                                                                                                          |
| MIDAS            | Motorway Incident Detection and Automatic Signalling                                                                                                                                                                                                                                                                                                                                                           |
| MP               | Marker post, indicates location on motorway                                                                                                                                                                                                                                                                                                                                                                    |
| MS1              | Message signs Type 1                                                                                                                                                                                                                                                                                                                                                                                           |
| MS3              | Message signs Type 3                                                                                                                                                                                                                                                                                                                                                                                           |
| MS4              | Message signs Type 4                                                                                                                                                                                                                                                                                                                                                                                           |
| MTM              | Medway Traffic Model                                                                                                                                                                                                                                                                                                                                                                                           |
| MX               |                                                                                                                                                                                                                                                                                                                                                                                                                |
| NAOMI            | Traffic modelling software, a larger separate calibrated/ validated version of the SATURN model.                                                                                                                                                                                                                                                                                                               |
| NatCOP           | DfT National Car-ownership Model                                                                                                                                                                                                                                                                                                                                                                               |
| Natural England  | The non-departmental public body of the UK government responsible for ensuring that England's natural environment, including its land, flora and fauna, freshwater and marine environments, geology and soils, are protected and improved.                                                                                                                                                                     |
| NCV              | non-compliant vehicle                                                                                                                                                                                                                                                                                                                                                                                          |
| NDD              | Highways England Network and Development Directorate                                                                                                                                                                                                                                                                                                                                                           |
| NDT              | North Downs Tunnel                                                                                                                                                                                                                                                                                                                                                                                             |



|                                |                                                                                                                                                                                                                                                      |
|--------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| NIA                            | Noise-important area                                                                                                                                                                                                                                 |
| NMU                            | non-motorised user, e.g. pedestrian, cyclist, equestrian                                                                                                                                                                                             |
| NO <sub>2</sub>                | Nitrogen dioxide                                                                                                                                                                                                                                     |
| Noise First Priority Locations | Defra-defined areas identified using environmental noise maps as the most 'important areas' and First Priority Locations for each of Defra's Noise Action Plans                                                                                      |
| NO <sub>x</sub>                | Generic term for mono-nitrogen oxides NO (nitric oxide) and NO <sub>2</sub> (nitrogen dioxide)                                                                                                                                                       |
| NPPF                           | National Planning Policy Framework                                                                                                                                                                                                                   |
| NPS                            | National Policy Statement                                                                                                                                                                                                                            |
| NPSNN                          | National Policy Statement for National Networks                                                                                                                                                                                                      |
| NRTS                           | National Roadside Telecommunications Service                                                                                                                                                                                                         |
| NSIP                           | Nationally significant infrastructure project                                                                                                                                                                                                        |
| NTCC                           | National Traffic Control Centre, based in the West Midlands, a telematics project that provides free, real-time information on England's network of motorways and trunk roads to road users, allowing them to plan routes and avoid congested areas. |
| NTEM                           | DfT National Trip End Model                                                                                                                                                                                                                          |
| NTIS                           | National Traffic Information Service                                                                                                                                                                                                                 |
| OD                             | Ordnance Datum                                                                                                                                                                                                                                       |
| Omega seal                     | The Gina gasket and Omega seal are used between the sectional elements of immersed tunnels to prevent water ingress due to external water pressure.                                                                                                  |
| PA                             | public accounts                                                                                                                                                                                                                                      |
| PCF                            | Project Control Framework                                                                                                                                                                                                                            |
| PCM                            | Pollution Climate Model<br>Pollution Climate Mapping                                                                                                                                                                                                 |
| pcu                            | passenger car unit                                                                                                                                                                                                                                   |
| Peel Ports                     | Britain's second largest group of ports. Part of the Peel Group.                                                                                                                                                                                     |
| PLA                            | Port of London Authority                                                                                                                                                                                                                             |
| PM                             | 16:00 to 19:00                                                                                                                                                                                                                                       |
| PM <sub>10</sub>               | Particulate matter (in this example, particulates smaller than 10µm that can cause health problems).                                                                                                                                                 |
| Principal Aquifer              | Layers of rock or drift deposits that have high inter-granular and/ or fracture permeability – i.e. they usually provide a high level of water storage. They may support water supply and/ or river base flow on a strategic scale.                  |
| PTZ                            | pan, tilt, zoom                                                                                                                                                                                                                                      |
| PVB                            | Present Value of Benefits                                                                                                                                                                                                                            |
| QEII                           | Queen Elizabeth II                                                                                                                                                                                                                                   |
| Ramsar site                    | A wetland of international importance, designated under the Ramsar convention.                                                                                                                                                                       |
| RCC                            | Regional Control Centre                                                                                                                                                                                                                              |
| RSPB                           | Royal Society for the Protection of Birds                                                                                                                                                                                                            |
| RTMC                           | Regional Technology Maintenance Contractor                                                                                                                                                                                                           |
| RTSR                           | Road Tunnel Safety Regulations, 2007                                                                                                                                                                                                                 |
| RWE                            | RWE npower, a leading integrated UK energy company.                                                                                                                                                                                                  |
| SAC                            | Special Area of Conservation                                                                                                                                                                                                                         |
| SAP                            | Stakeholder Advisory Panel                                                                                                                                                                                                                           |
| SAR                            | Scheme Assessment Report                                                                                                                                                                                                                             |
| SATURN                         | Simulation and Assignment of Traffic to Urban Road Networks, transport model                                                                                                                                                                         |
| SCADA                          | Supervisory control and data acquisition, control system typically used in tunnels.                                                                                                                                                                  |
| SEB                            | Statutory Environmental Body                                                                                                                                                                                                                         |

|                     |                                                                                                                                                                                                                                                                                    |
|---------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| SE LEP              | South East Local Economic Partnership                                                                                                                                                                                                                                              |
| SGAR                | Stage Gateway Review                                                                                                                                                                                                                                                               |
| SI                  | statutory instrument                                                                                                                                                                                                                                                               |
| SM                  | Smart Motorway                                                                                                                                                                                                                                                                     |
| solifluction        | In geomorphology, solifluction is a gradual mass wasting slope process related to freeze-thaw activity, occurring in periglacial environments.                                                                                                                                     |
| SoS                 | Secretary of State                                                                                                                                                                                                                                                                 |
| SPECS               | Average speed camera system                                                                                                                                                                                                                                                        |
| SPA                 | Special Protection Area                                                                                                                                                                                                                                                            |
| SPZ                 | Source protection zone. Protected groundwater sources such as wells, boreholes and springs used for public drinking water supply.                                                                                                                                                  |
| SSD                 | stopping signal distance                                                                                                                                                                                                                                                           |
| SSSI                | Site of Special Scientific Interest                                                                                                                                                                                                                                                |
| ST                  | Signal transponder                                                                                                                                                                                                                                                                 |
| SUSTRANS            | sustainable transport                                                                                                                                                                                                                                                              |
| SVD                 | Stopped Vehicle Detection                                                                                                                                                                                                                                                          |
| syncline            | In structural geology, a syncline is a fold with younger layers closer to the centre of the structure.                                                                                                                                                                             |
| TA                  | Technical Advice – Highways England standard                                                                                                                                                                                                                                       |
| TAG                 | Transport Analysis Guidance                                                                                                                                                                                                                                                        |
| TAME                | Traffic Appraisal Modelling and Economics, monitoring equipment                                                                                                                                                                                                                    |
| TAR                 | Technical Appraisal Report                                                                                                                                                                                                                                                         |
| TBM                 | tunnel boring machine                                                                                                                                                                                                                                                              |
| TD                  | Highways England Technical Directorate                                                                                                                                                                                                                                             |
| TDSCG               | Tunnel Design and Safety Consultation Group                                                                                                                                                                                                                                        |
| TE2100              | EA's Thames Estuary 2100 project was formed (November 2012) to develop a comprehensive action plan to manage flood risk for the Tidal Thames from Teddington in West London, through to Sheerness and Shoeburyness in Kent and Essex.                                              |
| TEE                 | Transport Economic Efficiency                                                                                                                                                                                                                                                      |
| TEN-T               | Trans-European Transport Networks (EU)                                                                                                                                                                                                                                             |
| TFL                 | Transport for London                                                                                                                                                                                                                                                               |
| TGSE                | Thames Gateway South Essex                                                                                                                                                                                                                                                         |
| TGSEP               | Thames Gateway South Essex Partnership                                                                                                                                                                                                                                             |
| Thames Cable Tunnel | See Dartford Cable Tunnel.                                                                                                                                                                                                                                                         |
| Thames Gateway      | An area of land stretching 70km east from inner east London on both sides of the River Thames and the Thames Estuary.                                                                                                                                                              |
| Thamesport          | See LTP.                                                                                                                                                                                                                                                                           |
| TIS                 | Traffic Information Services                                                                                                                                                                                                                                                       |
| TM                  | Traffic management                                                                                                                                                                                                                                                                 |
| TMC                 | Traffic Management Cell                                                                                                                                                                                                                                                            |
| TME                 | Traffic measuring equipment                                                                                                                                                                                                                                                        |
| TMU                 | Traffic monitoring unit                                                                                                                                                                                                                                                            |
| TomTom® data        | Journey time data from TomTom database.                                                                                                                                                                                                                                            |
| Townscape           | A cityscape is the urban equivalent of a landscape. <i>Townscape</i> is roughly synonymous with <i>cityscape</i> , though it implies the same difference in urban size and density (and even modernity) implicit in the difference between the words <i>city</i> and <i>town</i> . |
| TPMS                | Technology Performance Management Service                                                                                                                                                                                                                                          |

|               |                                                                                                                                                                                    |
|---------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| TR            | Telephone responder                                                                                                                                                                |
| TRADS         | Highways England Traffic Data Information System                                                                                                                                   |
| TS            | Transmission station                                                                                                                                                               |
| TTMS          | Travel time monitoring system                                                                                                                                                      |
| TUBA          | Transport Users Benefit Appraisal (DfT economic appraisal software tool)                                                                                                           |
| V/C           | Volume over Capacity (volume/capacity)                                                                                                                                             |
| VMS           | Variable Message Sign, typically mounted on a portal gantry                                                                                                                        |
| VMSL          | Variable Mandatory Speed Limit                                                                                                                                                     |
| Vopak         | Royal Vopak N.V. is a Dutch company that stores and handles various oil and natural gas-related products.                                                                          |
| vpd           | Vehicles per day                                                                                                                                                                   |
| veteran tree  | A veteran tree or legacy tree is a tree which, because of its great age, size or condition, is of exceptional cultural, landscape or nature conservation value.                    |
| WASHMS        | Wind and Structural Health Monitoring System                                                                                                                                       |
| WEB           | wider economic benefit                                                                                                                                                             |
| WebTAG        | DfT's transport analysis guidance website                                                                                                                                          |
| WFD           | Water Framework Directive                                                                                                                                                          |
| WI            | wider impact: land use-related economic consequences of transport interventions, not directly related to impacts on users of the transport network, such as increased productivity |
| Worked Ground | Ares where the ground surface has been significantly modified by human activity, example, quarries, road cuttings                                                                  |
| µg/m3         | micro-gram per cubic metre [ confirm ]                                                                                                                                             |

## 18 References

| Title                                                                                                                                                                                                                                                                                                                                                          | Document number              |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------|
| Technical Appraisal Report - Volume 1: Executive Summary                                                                                                                                                                                                                                                                                                       | HA540039-HHJ-ZZZ-REP-ZZZ-009 |
| Technical Appraisal Report - Volume 3: Appendices                                                                                                                                                                                                                                                                                                              |                              |
| <sup>1</sup> Traffic Flow: Annual periods, 2003 to 2014, April - March; Annual periods, 1963 to 2004, October – September<br><a href="https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/365615/S140375_Traffic_Flow.pdf">https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/365615/S140375_Traffic_Flow.pdf</a> |                              |
| <sup>2</sup> Dartford-Thurrock river crossing: traffic flow data, Annual traffic flow figures for the Dartford Crossing from 2003 to 2014<br><a href="https://www.gov.uk/government/publications/dartford-thurrock-river-crossing-traffic-flow">https://www.gov.uk/government/publications/dartford-thurrock-river-crossing-traffic-flow</a>                   |                              |
| <sup>3</sup> LTC v1 Strategic Traffic Model, NB AM peak hour, SB PM peak hour. Modelled today = 2009                                                                                                                                                                                                                                                           |                              |
| <sup>4</sup> Business Register Employment Survey, NOMIS                                                                                                                                                                                                                                                                                                        |                              |
| <sup>5</sup> Business Register Employment Survey, NOMIS                                                                                                                                                                                                                                                                                                        |                              |
| <sup>6</sup> Dartford Core Strategy. Accessed 28/5/15<br><a href="https://www.dartford.gov.uk/by-category/environment-and-planning2/new-planning-homepage/planning-policy/adopted-local-plan-1995">https://www.dartford.gov.uk/by-category/environment-and-planning2/new-planning-homepage/planning-policy/adopted-local-plan-1995</a>                         | September 2011               |
| <sup>7</sup> Business Register Employment Survey, NOMIS                                                                                                                                                                                                                                                                                                        |                              |

|                                                                                                                                                                                                                                                                                                                    |                              |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------|
| <sup>8</sup> Business Register Employment Survey, NOMIS                                                                                                                                                                                                                                                            |                              |
| <sup>9</sup> Gravesham Local Plan Core Strategy. Accessed 28/5/15<br><a href="http://www.gravesham.gov.uk/services/environment-and-planning/planning/planning-policy/local-plan-core-strategy">http://www.gravesham.gov.uk/services/environment-and-planning/planning/planning-policy/local-plan-core-strategy</a> | September 2014               |
| <sup>10</sup> Business Register Employment Survey, NOMIS                                                                                                                                                                                                                                                           |                              |
| <sup>11</sup> Thurrock Local Development Framework - Core Strategy and Policies for Management of Development. Accessed 28/5/15<br><a href="https://www.thurrock.gov.uk/core-strategy-and-policies/about-core-strategy">https://www.thurrock.gov.uk/core-strategy-and-policies/about-core-strategy</a>             | January 2015                 |
| <sup>12</sup> Business Register Employment Survey, NOMIS                                                                                                                                                                                                                                                           |                              |
| <sup>13</sup> Business Register Employment Survey, NOMIS                                                                                                                                                                                                                                                           |                              |
| <sup>14</sup> Medway Local Development Framework – Submission Draft Core Strategy. Accessed 28/5/15<br><a href="http://www.medway.gov.uk/pdf/Submission%20CS%20amend%209%20feb%202012.pdf">http://www.medway.gov.uk/pdf/Submission%20CS%20amend%209%20feb%202012.pdf</a>                                           | February 2012                |
| <sup>15</sup> Based upon UK Climate Projections for London. The expected sea level rise due to climate change at the two Option Corridors is to be defined.                                                                                                                                                        |                              |
| <sup>16</sup> DfT National Policy Statement for National Networks (NPSNN)                                                                                                                                                                                                                                          | 2015                         |
| <sup>17</sup> ( <a href="https://www.gov.uk/government/publications/thames-estuary-2100-te2100/thames-estuary-2100-te2100">https://www.gov.uk/government/publications/thames-estuary-2100-te2100/thames-estuary-2100-te2100</a> accessed 13th May 2015)                                                            | TE 2100                      |
| <sup>18</sup> C D Warren and N Mortimore - Chalk Engineering Geology-Channel Tunnel Rail Link and North Downs Tunnel. Quarterly Journal of Engineering Geology and Hydrogeology.                                                                                                                                   | 2003                         |
| <sup>191</sup> National Character Areas are prepared by Natural England and are guidance documents that can be used to inform decision-making. They are areas that share similar landscape characteristics and follow natural lines in the landscape rather than administrative boundaries.                        |                              |
| <sup>20</sup> English Heritage, Kent CC and Essex CC, Thames Gateway Historic Environment Characterisation Project                                                                                                                                                                                                 |                              |
| <sup>21</sup> AECOM (2013): Review of Lower Thames Crossing Options: Central Forecasts and Sensitivity Tests Report                                                                                                                                                                                                |                              |
| <sup>22</sup> AECOM: Model Capability Report                                                                                                                                                                                                                                                                       | May 2013                     |
| <sup>23</sup> HHJV (May 2015): LTC V1 Do Minimum Forecasting Assumptions (dr.)                                                                                                                                                                                                                                     | HA540039-HHJ-ZZZ-TNT-TRA-034 |
| <sup>24</sup> AECOM: Review of Lower Thames Crossing Options: Central Forecasts and Sensitivity Tests Report                                                                                                                                                                                                       | April 2013                   |
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| <sup>26</sup> HHJV: LTC V1 Traffic Forecasting Report <i>forthcoming</i> (June 2015)                                                                                                                                                                                                                               | HA540039-HHJ-ZZZ-REP-TRA-005 |
| <sup>27</sup> Hyder: Highways Agency Network Resilience and Adaptation Phase 1 Final Report                                                                                                                                                                                                                        | 2010                         |
| <sup>28</sup> The Review also included Option B – a crossing in the vicinity of the Swanscombe Peninsula - but this was later discarded by the Department for Transport.                                                                                                                                           |                              |
| <sup>29</sup> The terms Wider Economic Benefits (WEBs) and Wider Impacts (WI) are used interchangeably.                                                                                                                                                                                                            |                              |
| <sup>30</sup> DfT WebTAG guidance, Unit A2.1, Wider Impacts                                                                                                                                                                                                                                                        |                              |
| <sup>31</sup> Generalised cost is an aggregated cost that encompasses the monetary and non-monetary costs imposed on travellers for their entire journey. It includes both the monetised time element as well as financial costs associated with the trip such as fares and vehicle operating costs.               |                              |
| <sup>32</sup> The base demand was used to avoid counter-intuitive changes in generalised costs, by keeping the demand matrix fixed. This is consistent with DfT guidance.                                                                                                                                          |                              |

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|--------------------------------------------------------------------------------------------------------------------------------------------|------------------------------|
| <sup>33</sup> The effective density depends on the destination's employment level and generalised costs decayed by the distance parameter. |                              |
| Brentwood BC Corporate Plan                                                                                                                | 2014-2016                    |
| Brentwood BC Replacement Local Plan                                                                                                        | 2005                         |
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| Dartford BC Corporate Plan                                                                                                                 | 2013-2016                    |
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|                                                                                                                       |                                                                           |
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## 19 Appendices

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For the Appendices refer to *Technical Appraisal Report - Volume 3*.