Lower Thames Crossing

7.7 Combined Modelling and Appraisal Report – Appendix D – Economic Appraisal Package: Economic Appraisal Report

APFP Regulation 5(2)(q)

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

Volume 7

DATE: October 2022

Planning Inspectorate Scheme Ref: TR010032
Application Document Ref: TR010032/APP/7.7

VERSION: 1.0

Lower Thames Crossing

7.7 Combined Modelling and Appraisal Report – Appendix D – Economic Appraisal Package: Economic Appraisal Report

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1 Executive summary

1.1 Introduction

1.1.1 This Economic Appraisal Report (EAR) describes the methodologies used to appraise the economic, environmental, social benefits and costs of the proposed A122 Lower Thames Crossing (the Project) and presents the appraisal results.[1] The appraisal informs the Project's value for money (VfM) assessment.

1.1.2 The appraisal has been undertaken in line with the Department for Transport's (DfT) Transport Analysis Guidance (TAG) (Department for Transport, a). This categorises benefits into three levels, Levels 1, 2 and 3, based on the degree of analytical maturity used to appraise benefits. Therefore, the appraisal includes a mix of monetised values, quantitative information and qualitative assessments of impacts.[2]

1.1.3 The EAR presents the Project's net public accounts costs (costs less user charging revenues) and then reports, in turn, the three levels of benefits. Chapter 11 presents a summary of all monetised values and their sensitivity to different assumptions. However, all impacts, monetised and non-monetised, contribute to the Project's VfM assessment which is summarised in Chapter 12.

1.1.4 The EAR is part of Appendix D - Economic Appraisal Package within the Combined Modelling and Appraisal Report (ComMA) (Application Document 7.7). Appendix D of the ComMA also includes an Appraisal Summary Table Report, a Distributional Impact Appraisal Report and a Level 3 Wider Economic Impacts Report.

1.2 The Project

1.2.1 The route of the Project connects to the A2 and M2 in Kent, east of Gravesend, crossing under the River Thames through two bored tunnels, linking to the A13 and joining the M25 south of junction 29. The route is approximately 23km long, 4.25km of which is in the tunnels. The tunnels are located to the east of the village of Chalk on the south of the Thames and to the west of East Tilbury on the north side.

1.2.2 Junctions are proposed at the following locations:

a. New junction with the A2 to the south-east of Gravesend

b. Modified junction with the A13/A1089 in Thurrock

c. New junction with north-facing slip roads on the M25 between junctions 29 and 30

[1] Benefits, disbenefits (negative benefits) costs and road user charging revenues are also referred to as impacts in this report.
[2] Numbers included in tables in this report do not necessarily all sum exactly due to rounding

1.2.3 The opening year used for the appraisal of capital expenditure (CAPEX) costs is different from the rest of the application assumptions, whereby the costs assume a completion of construction in 2031, while the rest of the application assumes an opening year of 2030.

1.2.4 The application as a whole is based on the opening year of 2030. The project construction schedule supports this opening date, with a reasonable allowance for construction time risk, and National Highways is confident that this can be achieved. Nevertheless, for the purposes of the cost assessment it is appropriate to allow for a reasonable level of time risk for both the duration of the DCO statutory process and for construction. Standard practice is to allow for the cost and schedule that reflect a scenario where it is possible that the project could be delivered faster, or take longer to complete, characterised as the most likely. There will be scenarios where the project is delivered faster and at either higher or lower cost, and also scenarios where the project is delivered slower and at either higher or lower cost.

1.2.5 There is no single scenario that on its own would represent the worst case for each aspect of the application. The current schedule, which demonstrates a reasonable likelihood that the project can open in 2030, is considered an appropriate reasonable worst case for the purposes of the application assessments.

1.2.6 The modelled costs for 2031 include additional costs associated with the prolongation of the programme, constituting less than 1% of the total cost. Therefore, the modelled capital expenditure for the 2031 scenario is higher than the anticipated costs if the project opens in 2030. The BCR for the project based on benefits commencing in 2030 and costs assuming construction completion in 2031 is therefore conservative.

1.2.7 However, there is always a level of uncertainty over the construction programme on large projects and the Project’s programme may well be refined when contractors are appointed, and the detailed design developed. Therefore, the small deviation in opening dates is not considered to have a material impact on the robustness of the Project’s appraisal or VfM assessment.

1.2.8 There would be charges to use the tunnels in line with those at the Dartford Crossing.

1.3 Appraisal methodology

1.3.1 The appraisal is based on the transport modelling outputs from the Lower Thames Area Model (LTAM) and includes the direct impacts of the Project on transport users and service providers as well as impacts on the environment, wider society, and government.

1.3.2 TAG provides methods for quantifying many of the impacts of the Project and giving them a monetary value. Most impacts in the central case appraisal are estimated over a 60-year appraisal period from the Project’s opening date except for construction costs, construction carbon emissions and delays to transport users and providers which arise during construction. All impacts that are expressed in monetary terms are converted into 2010 prices and discounted back to 2010 values, referred to as 2010 prices and values, in order that the benefits and costs can be compared. The DfT has set 2010 as the common base year to be used in transport appraisals. The discount rates used are set by HM Treasury (HM Treasury, 2022) and for the central case appraisal are:

a. 3.5% for the first 30 years from the 2022 appraisal year and 3.0% thereafter for all impacts except human health impacts

b. 1.5% for the first 30 years from the 2022 appraisal year and 1.29% thereafter for human health impacts

1.3.3 The impact of all monetised impacts – benefits and net costs – is summarised using Benefit Cost Ratios (BCRs).

1.3.4 The appraisal results are all based on road users paying the same charges to use the Project's tunnels as those at the Dartford Crossing and assume no increase in real terms over time.

1.3.5 The three levels used to appraise benefits comprise:

a. Level 1 – This includes impacts for which there are established methods to estimate monetary values, including those on transport users and providers and other economic, environmental, and social impacts. These impacts are based on traffic forecasts from LTAM which assume fixed land uses in the study area. Level 1 impacts, including their sensitivity to different traffic growth levels and net costs, are reported using Initial BCRs.

b. Level 2 – This includes two types of impacts, journey time reliability and wider economic impacts, for which there are less established monetary valuation approaches. These impacts are also estimated on the assumption of fixed land uses. Level 2 impacts are added to the Level 1 impacts to enable Adjusted BCRs to be calculated.

c. Level 3 – This includes a mix of non-monetised quantitative and qualitative appraisals, an indicative monetised value for landscape which is not included in the BCR, a distributional analysis of impacts on vulnerable social groups and other appraisal information such as evidence about additional wider economic impacts based on variable land use that are not included in the Level 2 analysis.

1.3.6 In estimating benefits and user charging revenues, the LTAM model was used to forecast the impact of the Project on the performance of the highway network in terms of changes in traffic flows, travel times, speeds, and levels of congestion. The model assesses how users may change the route they use if the Project was constructed, as well as possible changes to the frequency with which they make their trips, the mode of travel they use, the time of day they travel and the destinations of their trips. LTAM forecasts were produced for the Project's construction period and its 60-year operational phase for three levels of traffic growth – Low, Core and High.

1.3.7 The net costs of the Project to the public accounts include capital expenditure (CAPEX) on the Project's construction and operating, maintenance and renewals expenditure (OMR) less road user charging revenues. CAPEX costs were calculated for three levels of cost confidence using probabilistic Quantified Risk Assessment techniques to produce three cost estimates:

a. P10 – This is the CAPEX cost for which there is a 10% chance that it will not be exceeded

b. Most Likely – This is the expected level of the CAPEX cost

c. P90 – This is the CAPEX cost for which there is a 90% chance that it will not be exceeded

1.3.8 OMR costs were produced based on Low, Central and High estimates.

1.3.9 Level 1 and 2 impacts for the central case scenario, based on Core traffic growth and Most Likely CAPEX costs, are summarised in the Appraisal Summary Table (AST) which is included in the Appraisal Summary Table Report.

1.4 Central case appraisal results

1.4.1 The CAPEX costs of the Project, expressed in outturn prices, range from £6,220.2m (P10) to £11,470.6m (P90) with a Most Likely value of £8,083.4m. These costs were expressed in 2010 prices and values using DfT's TAG data book v1.18 and DfT's Transport User Benefits Appraisal (TUBA) appraisal software and installer v1.9.17 but with the TUBA Economic Parameters file v1.9.18 (May 2022) which is consistent with the TAG data book v1.18. For simplicity, references hereafter will simply be to TUBA v1.9.18. The Most Likely CAPEX value in 2010 prices and values is £3,119.6m.

1.4.2 The OMR costs are estimated using TUBA v1.9.18 to be £327.4m (2010 prices and values).

1.4.3 Revenues from user charges, based on LTAM traffic forecasts, were estimated using TUBA v1.9.18 to be £746.8m (2010 prices and values). These revenues are deducted from the Project's costs to calculate the Present Value of Costs (PVC) of £2,700.2m (2010 prices and values), as shown in

1.4.4 Table 1.1.

Table 1.1 Present Value of Costs, central case (£m, 2010 prices and values)

PVC components	£m
CAPEX	3,119.6
OMR	327.4
Revenues	-746.8
PVC	**2,700.2**

1.4.5 The Level 1 monetised benefits for transport users and providers include journey time savings, changes in vehicle operating costs, user charge disbenefits and delays during construction and planned maintenance periods. These impacts, which measure the Project's impact on the economic efficiency of the transport system and assume fixed land use, are split between commuters, other users and business users, as shown in Table 1.2.

1.4.6 The first three impacts (journey time savings, changes in vehicle operating costs, user charge disbenefits) were valued using TUBA v1.9.18. Delays to road users during planned maintenance periods were estimated using National Highways QUeues And Delays at ROadworks (QUADRO) program. Delays to road users during construction were modelled using LTAM and appraised using TUBA v1.9.18.

1.4.7 The Level 1 appraisal also includes monetised estimates for:

a. Noise based on the outputs of noise modelling and valued using the TAG Noise workbook.

b. Air quality based on the outputs of air quality modelling and valued using the TAG Air Quality workbook.

c. Physical activity impacts using DfT's Active Mode Appraisal Toolkit.

d. Greenhouse gas emissions from road users and the Project's embodied carbon. All emissions have been valued in monetary terms using National Highways Carbon Valuation Toolkit version 1.4.2.

e. Accident impacts which are estimated and valued using DfT's COsts and Benefits Appraisal – Light Touch (COBALT) program.

f. Indirect tax revenues which are valued using TUBA v1.9.18.

1.4.8 The sum of monetised Level 1 benefits is called the Level 1 Present Value of Benefits (PVB) and is £1,295.9m (2010 prices and values) as shown in Table 1.2.

Table 1.2 Level 1 benefits, central case (£m, 2010 prices and values)

Benefit	£m
Noise	3.4
Air quality	-7.8
Physical activity	21.2
Greenhouse gases	-527.8
Accidents	-67.8
Economic efficiency: Consumer (Commuting)	361.6
Economic efficiency: Consumer (Other)	426.7
Economic efficiency: Consumer (Business)	1,042.9

Benefit	**£m**
Indirect tax revenues	43.5
Level 1 PVB	**1,295.9**

1.4.9 Table 1.3 shows that for the central case scenario, the ratio of the Level 1 PVB to the PVC produces an Initial BCR of 0.48.

1.4.10 The Level 2 appraisal includes monetised estimates of journey time reliability (JTR) and wider economic impacts (WEI) both of which assume no changes in land use.

1.4.11 Reliability benefits include those from reductions in incidents, day-to-day variability of travel times and local road diversions and were estimated using National Highways Motorway Reliability Incidents And Delays (MyRIAD) software.

1.4.12 The main Level 2 WEI impact is productivity benefits for businesses from static agglomeration or clustering. This impact, along with increased tax revenues due to increased labour supply, was estimated using DfT's Wider Impacts Transport Appraisal (WITA) v2.2 appraisal software. The third WEI impact of the Project, higher business output due to the presence of imperfectly competitive markets, was valued based on 10% of business transport user and provider benefits and business journey time reliability benefits, in line with guidance in TAG Unit A2.1 (Department for Transport, 2019a).

1.4.13 The addition of these Level 2 impacts to the Level 1 PVB provides a Level 1 and 2 PVB of £3,299.5m (2010 prices and values) and enables an Adjusted BCR to be calculated when the Level 1 and 2 PVB is compared against the PVC. Table 1.3 shows that the Adjusted BCR for the central case appraisal, based on the Core traffic growth scenario and Most Likely CAPEX costs, is 1.22.

Table 1.3 Initial and Adjusted BCRs, central case (£m, 2010 prices and values)

	£m
Level 1 PVB	1,295.9
PVC	2,700.2
Initial BCR	**0.48**
Journey time reliability	487.1
Wider economic impacts	1,516.6
Level 2 PVB	2,003.7
Level 1 and 2 PVB	3,299.5
PVC	2,700.2
Adjusted BCR	**1.22**

1.4.14 The following benefits can be spatially disaggregated – transport user and provider impacts, static agglomeration, labour supply and economic output. These sum to £3,488.5m (2010 prices and values). This exceeds the Project's total benefits of £3,299.5m because there are £189.0 m of net disbenefits

(benefits less disbenefits) that cannot be spatially disaggregated. Of the benefits that can be spatially disaggregated:

a. £1,672.3m are gained by those starting or ending their journeys in the Lower Thames area (Thurrock, Brentwood, Havering, Dartford, Gravesham and Medway).

b. £1,090.5m are gained by those starting or ending their journeys in the South East Local Enterprise Partnership (SELEP) region.

c. £725.7m are gained by those starting or ending their journeys in other local authorities in Great Britain.

1.5 Level 3 appraisal evidence

1.5.1 The Level 3 appraisal includes:

a. Non-monetised quantitative information and qualitatively appraised impacts which are included in the AST

b. An indicative monetary value for landscape which is not included in the BCRs or AST

c. Other appraisal evidence not included in the BCRs or AST

1.5.2 Table 1.4 summarises the qualitative appraisal scores shown in the AST.

Table 1.4 Qualitative appraisal scores included in AST

	Very Large Adverse	Large Adverse	Moderate Adverse	Slight Adverse	Neutral	Slight Positive/ Beneficial	Moderate Positive/ Beneficial	Large Positive/ Beneficial
Environment	Biodiversity	Historic environment	Landscape Townscape	Water environment	–	–	–	–
Social	–	–	–	–	Personal security	Affordability	–	Journey quality Severance
Economic	–	–	–	–	–	–	–	Option and non-use value
Distributional	–	Noise: • Income • Children	Noise: • Adults 70+	–	Accidents: • Children • Adults 70+ • Pedestrians • Cyclists • Motorcyclists • Male 16–25 year olds Severance: • Children • Adults 70+ • People with illness	Severance: • Car ownership	User benefits: • Income	Air quality: • Income • Children Affordability (Gravesham residents)

1.5.3 Table 1.4 shows that:

a. Biodiversity has a Very Large Adverse score.

b. Historic Environment has a Large Adverse score.

c. Landscape and Townscape have Moderate Adverse scores.

d. Water environment has a Slight Adverse score.

e. All of the social impacts have Neutral or Positive scores.

f. There is a Positive score for option and non-use values.

g. There are Neutral or Beneficial distributional appraisal scores for vulnerable social groups except for noise impacts which are Moderate Adverse and Large Adverse.

1.5.4 There is an indicative monetary value of -£93.4m (2010 prices and values) for landscape impacts based on DfT's supplementary guidance on landscape (Department for Transport, 2021a). While this value is not included in the BCRs or AST, it is taken into account in the VfM assessment.

1.5.5 Other Level 3 evidence not included in the BCR or AST, but which is considered in the VfM assessment, comprises:

a. Network resilience benefits – TAG does not provide guidance on how this impact should be appraised and therefore a qualitative appraisal has been developed and undertaken. This indicates that the Project is likely to have a positive impact on the resilience of the road network.

b. International trade impacts – TAG does not provide guidance on how this impact should be appraised and therefore a qualitative appraisal has been developed and undertaken. This indicates that the Project is likely to have a small positive impact on flows of Foreign Direct Investment into the UK.

c. Undervaluation of freight impacts – The Project is forecast to carry a higher percentage of freight users than is typical on the strategic road network (SRN). Current estimates for values of time and journey time reliability are primarily based on drivers' wages and ignore the impacts of late delivery. Therefore, the appraisal does not reflect the full value that freight users place on changes in journey time and journey reliability.

d. Additional wider economic impacts – There is strong evidence about the Project's potential to generate additional productivity benefits for businesses as firms relocate and as labour moves to more or less productive jobs. These benefits, referred to as dynamic clustering benefits, arise through mechanisms that bring markets closer together, facilitate changes in business behaviour, encourage trade and inward investment, strengthen labour markets and enable land use change.

1.6 Sensitivity tests

1.6.1 Sensitivity tests were undertaken to assess the impact on the benefits, costs, revenues and BCRs of:

a. Different traffic growth levels – The Adjusted BCR falls to 1.09 under Low traffic growth and rises to 1.36 under High traffic growth.

b. Different CAPEX costs – The Adjusted BCR rises to 1.79 under P10 costs and falls to 0.80 under P90 costs.

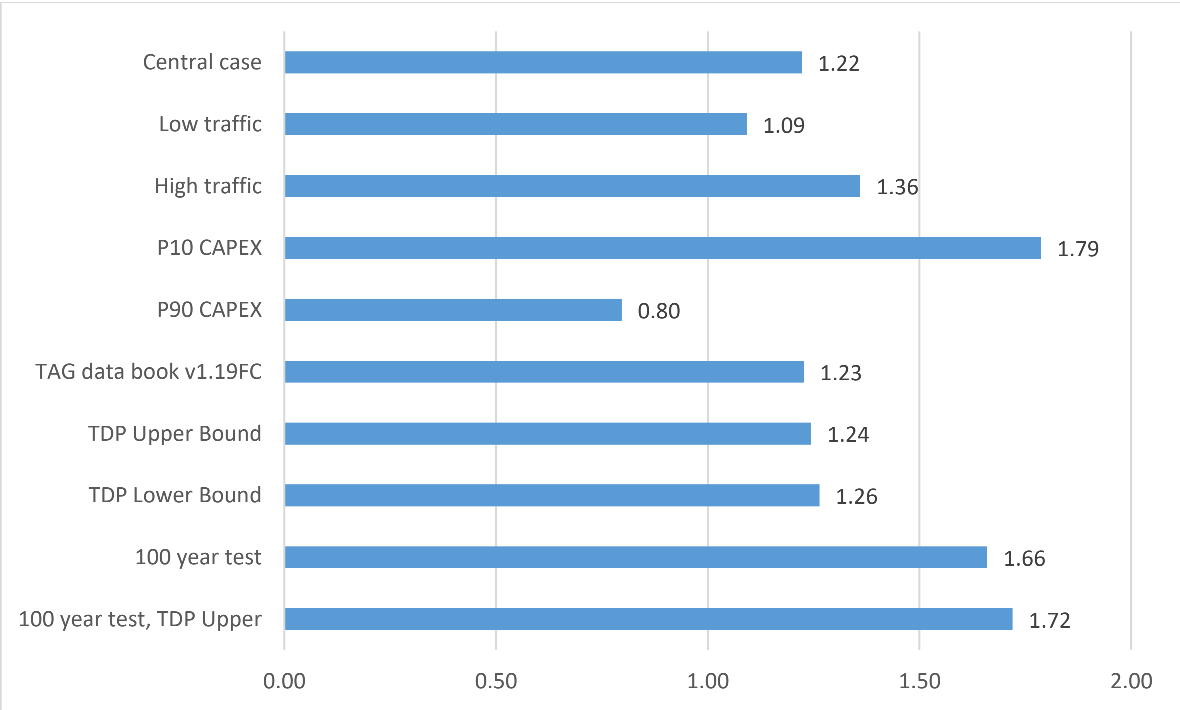
c. Appraisal parameters in the forthcoming TAG data book version 1.19FC – The Adjusted BCR rises to 1.23.

d. The effect of Transport Decarbonisation Plan (TDP) policies on road user carbon has been assessed in two tests. The Adjusted BCR rises to 1.24 in the TDP Upper bound test and 1.26 in the TDP Lower bound TDP test.

e. The use of a 100-year appraisal period – Two scenarios were developed under which the Adjusted BCR increases respectively to 1.66 (Scenario 1) and 1.72 (Scenario 2). Scenario 1 does not take account of TDP policies on road user carbon emissions, while the Upper Bound TDP test is reflected in Scenario 2.

1.6.2 The impact of these sensitivity tests on the Adjusted BCR is shown graphically in Plate 1.1.

Plate 1.1 Impact of sensitivity tests on the Adjusted BCR



1.7 Value for Money

1.7.1 A VfM assessment has taken account of the Project's net costs and its monetised and non-monetised benefits. Based on the categories in DfT's VfM framework, the Project has been assessed as providing Low VfM (Department for Transport, 2015).

2 Introduction

2.1 Purpose of this report

2.1.1 This Economic Appraisal Report (EAR) describes the methodologies used to appraise the economic, environmental, social benefits and costs of the proposed A122 Lower Thames Crossing (the Project) and presents the appraisal results.[3] The appraisal informs the Project's value for money (VfM) assessment.

2.1.2 The appraisal has been undertaken in line with the Department for Transport's (DfT) Transport Analysis Guidance (TAG) (Department for Transport, a). This categorises benefits into three levels, Levels 1, 2 and 3, based on the degree of analytical maturity used to appraise benefits. Therefore, the appraisal includes a mix of monetised values, quantitative information and qualitative assessments of impacts.

2.1.3 The EAR presents the Project's net costs (costs less user charging revenues) to the public accounts and then reports, in turn, the three levels of benefits. Chapter 11 presents a summary of all monetised values and their sensitivity to different assumptions. However, all impacts, monetised and non-monetised, contribute to the Project's VfM assessment which is summarised in Chapter 12.

2.1.4 The EAR is part of Appendix D - Economic Appraisal Package within the Combined Modelling and Appraisal Report (ComMA) (Application Document 7.7). Appendix D of the ComMA also includes an Appraisal Summary Table Report, a Distributional Impact Appraisal Report and a Level 3 Wider Economic Impacts Report.

2.1.5 The ComMA also provides information, within the following appendices, about the transport data, transport model and traffic forecasts which are used as key inputs to the appraisal:

a. Appendix A – Transport Data Package – This includes the transport data collected and used within the traffic modelling and forecasting as part of the evidence base for the Project's appraisal

b. Appendix B – Transport Model Package – This describes the development of the Lower Thames Area Model (LTAM) transport model

c. Appendix C – Transport Forecasting Package – This includes traffic forecasts produced using the LTAM and upon which this appraisal is based

2.1.6 All impacts have been appraised in line with HM Treasury's Green Book (HM Treasury, 2022) and DfT's TAG guidance (Department for Transport, a) and reflect how they have changed between a Without Scheme scenario and a With Scheme scenario. The impacts in the Central Case scenario have been estimated over a 60-year appraisal period from the opening of the Project to traffic, except for the following impacts which occur prior to scheme opening:

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[3] Benefits, disbenefits (negative benefits) costs and road user charging revenues are also referred to as impacts in this report.

a. Capital construction costs (CAPEX)

b. Construction carbon emissions

c. Delays during construction for transport users

2.2 Report structure

2.2.1 The remaining chapters of this report are structured as follows:

a. Chapter 3 summarises the need for the Project, lists the Project's objectives, explains the option identification and selection process and describes the Project's proposed design upon which the appraisal is based.

b. Chapter 4 summarises the appraisal methodologies which are based on DfT's TAG guidance.

c. Chapter 5 explains the key features of the LTAM transport model and the traffic forecasts which provide key inputs into the appraisal.

d. Chapter 6 presents the Project's public accounts impacts.

e. Chapter 7 reports the appraisal of Level 1 transport user and provider impacts.

f. Chapter 8 reports the appraisal of other Level 1 impacts.

g. Chapter 9 reports the appraisal of Level 2 impacts.

h. Chapter 10 reports the appraisal of Level 3 impacts.

i. Chapter 11 presents the Initial and Adjusted Benefit Cost Ratios (BCRs) for the central case scenario and reports the results of various sensitivity tests.

j. Chapter 12 contains conclusions about the Project's appraisal and summarises the VfM assessment.

k. A set of Annexes A to D provide more details about the appraisal results.

3 The Project

3.1 Introduction

3.1.1 This chapter explains the need for the Project and lists its objectives. It briefly describes the options that have been appraised and the proposed Project design which is the subject of the appraisal in this report.

3.2 The need for the Project

3.2.1 For almost 60 years, the Dartford Crossing has provided the only road crossing of the River Thames east of London. It regularly carries over 180,000 vehicles on the busiest days of the year (National Highways, 2019) which is over the intended capacity. Traffic flows this far in excess of the design capacity of the road result in frequent congestion and poor journey time reliability, making the Dartford Crossing one of the least reliable sections of the strategic road network (SRN).

3.2.2 Operational challenges caused by these high traffic flows are further exacerbated when accidents and incidents occur. The poor local network resilience is further undermined by a lack of alternative routes across the river.

3.2.3 The Dartford Crossing is a critical part of the country’s road network. It connects communities and businesses and provides a vital link for the nearby major ports, which play an important role in the distribution of goods across the rest of the UK. Reliable river crossings are essential for the provision of services and goods, enabling local businesses to operate effectively and for residents to access housing, jobs, leisure and retail facilities on both sides of the river.

3.2.4 The current operational challenges have significant negative impacts on users and non-users in terms of economic productivity and trade, social and user experience and environmental impacts.

3.2.5 Congestion and incidents at the crossing cause slow and unreliable journeys for a high number of vehicles for long periods, every day. This has severe economic, safety and environmental impacts – impacting significantly on users and local communities.

3.2.6 A failure to progress the Project could have significant negative impacts on the future growth potential of the national and regional economies and the prosperity of the local population, now and into the future. Without additional road capacity, the transport, economic and environmental problems will continue to worsen over time.

3.2.1 The consequences of not proceeding with a new crossing are as follows:

a. Congestion and delays would likely worsen both at the Dartford Crossing and on the local road network – journey times would increase and journeys would be less reliable.

b. National, regional and local productivity and economic growth would be constrained and the cost of moving freight by road would increase.

c. Growth potential for ports in the Lower Thames area would be limited to frustrate the Government's growth ambitions such as the Thames Freeport.

d. There is expected to be a further deterioration of safety on the roads close to the Dartford Crossing.

e. Increases in road traffic would likely increase congestion, noise and vehicle emissions in an area which already exceeds acceptable levels.

3.2.2 The Project would significantly contribute to resolving these issues and deliver benefits across a wide range of needs and opportunities. This demonstrates a clear and compelling need for the Project.

3.2.3 A more comprehensive explanation as to why the Project is needed is included in the Need for the Project (Application Document 7.1).

3.3 Scheme Objectives

3.3.1 The various issues which give rise to the need for the Project, as set out above, form the basis for the identification of the Scheme Objectives.

3.3.2 These objectives, which comprise three principal categories of Economic, Community and Environment, and Transport, were developed by National Highways and endorsed by the DfT, after the Government commissioned the former Highways England (now National Highways) to identify and assess options for a new road crossing in the Lower Thames area in 2014. These objectives are shown in

3.3.3 Table 3.1.

Table 3.1 Scheme Objectives

Type of objective	Objectives
Economic	• To support sustainable local development and regional economic growth in the medium to long term • To be affordable to government and users • To achieve value for money
Community and environment	• To minimise adverse impacts on health and the environment
Transport	• To relieve the congested Dartford Crossing and approach roads and improve their performance by providing free-flowing north-south capacity • To improve the resilience of the Thames crossings and the major road network • To improve safety

3.4 Option identification and selection

3.4.1 This section summarises the appraisal of options to meet the Scheme Objectives and the outcome of those appraisals which led to the selected design. More detail is provided in the Need for the Project (Application Document 7.1).

3.4.2 A structured process has been followed by the DfT and National Highways to identify and assess potential options for the Project.

3.4.3 DfT carried out a study in 2009 that reviewed six potential crossing locations, identified as A, B, C, D1, D2 and E (Department for Transport, 2009). This study found that the two location D and location E options would not relieve the congested Dartford Crossing, and so they were not selected for further assessment. Further work was carried out by DfT in 2013 to consider three of the potential crossing locations in more detail, A, B and C (Department for Transport, 2013a). Following public consultation in 2013, two crossing locations, A and C, were taken forward for further consideration (Department for Transport, 2013b). Location B was not taken forward due to conflict with the development of Ebbsfleet Garden City and the Swanscombe Peninsula. As a result, no viable solutions could be developed at this location.

3.4.4 A detailed option identification and route selection process was then carried out by the Highways Agency (as it then was) at the two crossing locations taken forward. Several route options were considered at location A and location C. A potential modification was considered to location C, which included changes to the roads connecting the M20 and M2, known as C variant.

3.4.5 Four route options were short-listed for consideration as part of this process: one at location A (route 1) and three at location C. The three route options at location C were identified as routes 2, 3 and 4 north of the Thames, and western southern/eastern southern links south of the Thames. The assessment also considered different options for crossing the river. Assessment of the C variant options determined that they did not help to transfer traffic from the Dartford Crossing on to the new route at location C. It also had substantial impacts on the Kent Downs Area of Outstanding Natural Beauty (AONB). As a result, the C variant options were not considered further.

3.4.6 A non-statutory public consultation on route options was held in 2016 (Highways England, 2016). It explained that location A (route 1) had been assessed as not meeting the Scheme Objectives and therefore proposed a crossing at location C. Of the three potential route options at location C, the consultation included a proposed configuration involving route 3, the eastern southern link and a bored tunnel crossing of the River Thames.

3.4.7 Following the public consultation, further appraisal was undertaken, considering the findings of the consultation, and this resulted in the selection of the preferred route, announced in April 2017.

3.4.8 The preferred route announced by the Secretary of State was route 3 north of the Thames, with a twin-bored tunnel crossing of the River Thames east of Gravesend and Tilbury and a new road south of the Thames which will join the A2 east of Gravesend (the western southern link). The choice of the western southern link therefore represented a change to the proposed scheme as had been presented at the 2016 consultation.

3.4.9 The preferred route was selected based on the information obtained before, during and after the non-statutory public consultation. This route met the Scheme Objectives, while having the lowest impact on several environmentally sensitive areas, particularly on the Thames Estuary and Marshes Special Protection Area (SPA) and Ramsar site, ancient woodlands in the area, and the Kent Downs

AONB, as well as on the communities close to the route. The assessment that resulted in the identification of the preferred route is presented in the Post-Consultation Scheme Assessment Report (Highways England, 2017).

Project development

3.4.10 Following the Secretary of State's announcement of the preferred route in April 2017, National Highways have continued to develop the proposal. Previous options appraisals have been re-assessed and further studies were conducted where necessary. A further review was undertaken in 2020. This reassessment, which took account of changes made to the proposals for the Project following the preferred route announcement, reconfirmed that the preferred route remains the best solution.

3.5 Project description

Project route

3.5.1 The Project would provide a connection between the A2 and M2 in Kent and the M25 south of junction 29, crossing under the River Thames through a tunnel. The Project route is presented in Plate 3.1.

3.5.2 The A122 would be approximately 23km long, 4.25km of which would be in tunnel. On the south side of the River Thames, the Project route would link the tunnel to the A2 and M2. On the north side, it would link to the A13, M25 junction 29 and the M25 south of junction 29. The tunnel entrances would be located to the east of the village of Chalk on the south of the River Thames and to the west of East Tilbury on the north side.

3.5.3 Junctions are proposed at the following locations:

a. New junction with the A2 to the south-east of Gravesend

b. Modified junction with the A13/A1089 in Thurrock

c. New junction with the M25 between junctions 29 and 30

3.5.4 The Project route would be three lanes in both directions, except for:

a. link roads

b. stretches of the carriageway through junctions

c. the southbound carriageway from the M25 to the junction with the A13/A1089, which would be two lanes

3.5.5 In common with most A-roads, the A122 would operate with no hard shoulder but would feature a 1m hard strip on either side of the carriageway. It would also feature technology including stopped vehicle and incident detection, lane control, variable speed limits and electronic signage and signalling. The A122 design outside the tunnel would include emergency areas. The tunnel would include a range of enhanced systems and response measures instead of emergency areas.

3.5.6 The A122 would be classified as an 'all-purpose trunk road' with green signs. For safety reasons, walkers, cyclists, horse riders and slow-moving vehicles would be prohibited from using it.

Junction modifications

3.5.7 Alterations would be required to both the M25 at the northern limits of the route and on the A2 at the southern end. The existing A13/A1089 junction would also require modifications to connect to the Project route.

Vertical alignment

3.5.8 The new A122 would be at varying heights along the route, with approximately 80% in a cutting, false cutting or tunnel. The A2 would remain at its current level, with the junction between the A2 and the A122 requiring some link roads at or below ground level, on embankments and structures such as bridges. As it approaches the southern tunnel entrance, the A122 would be at ground level before descending into a deep cutting. To the north of the River Thames, the A122 would be lowered as much as practicable to reduce its impact on the landscape. Where the road crosses the Tilbury floodplain, railway lines, and the Mardyke floodplain, it would be elevated.

Local roads

3.5.9 The Project would include adjustment to a number of local roads. Most existing local roads affected by the Project route would be reconnected or designed to provide alternative provision. In most locations, the affected local roads would cross over the Project route.

Tunnel

3.5.10 It is currently proposed that two tunnel boring machines (TBMs) would be used to construct the tunnel, one for each bore.

3.5.11 Emergency access and vehicle turn-around facilities would be provided at the tunnel entrances. Cross-passages providing a connection between the two bores would be provided for emergency incident response and tunnel user evacuation. Tunnel portal structures would accommodate service buildings for control operations, mechanical and electrical equipment, drainage and maintenance operations.

Highway crossings

3.5.12 Approximately 50 new highway crossings would be required, comprising road bridges, underpasses, green bridges and footbridges. In addition, widening and other modification of existing highways crossings would be required.

Highway drainage

3.5.13 South of the River Thames, the highway drainage system would discharge into vegetated drainage comprising infiltration basins with lined sediment forebays, ditches and swales. The intention is that these would outfall from the drainage systems to ground.

3.5.14 North of the River Thames, the highway drainage system would discharge into vegetated drainage comprising wetland-type retention ponds with sediment forebays, ditches and swales within an infiltration basin at the A13 junction. Existing dry retention ponds located along the M25 would be upgraded to wetland-type retention ponds with sediment forebays. The outfall from these ponds would discharge into watercourses and ditches.

Safety and security

3.5.15 The A122 would include the following:

a. Modern safety measures and design standards with technology to manage traffic and provide better information to drivers

b. Variable Message Signs to display variable speed limits, travel information, hazard warnings and both advisory and mandatory signage to drivers

c. CCTV cameras and detection equipment to monitor and manage network usage, for alerting and investigating incidents (e.g. stopped vehicles), for maintenance and asset protection, and for detection of crime

d. Above-ground traffic detection to control automatic traffic management systems (e.g. variable speed limits) and to collect data on traffic flows

e. Free-flow road user charging infrastructure

f. Equipment within the tunnel to monitor and control the tunnel environment during normal and emergency operations

Road User charging

3.5.16 In December 2014, the Government stated in the National Policy Statement for National Networks (NPSNN) (Department for Transport, 2014) that the '*Government will consider tolling as a means of funding new road capacity on the SRN. River and estuarial crossings will normally be funded by tolls or road user charges*'.

3.5.17 To align with NPSNN policy and to help the Project meet the Scheme Objectives, it is proposed that road user charges would be levied in line with the Dartford Crossing. Vehicles would be charged for using the new tunnel.

Walkers, cyclists and horse riders

3.5.18 Where the Project affects existing Public Rights of Way, these would be reinstated with provision of under- or overbridges, or a suitable alternative provision would be made. The Project proposes a number of new, diverted, upgraded and reinstated routes for walkers, cyclists and horse riders.

Environmental design

3.5.19 The Project has been developed to avoid or minimise significant effects on the environment, and during the design process further measures have been incorporated to mitigate adverse impacts that would arise and that cannot be avoided. Some of the measures adopted include landscaping, noise mitigation measures, and the provision of green infrastructure along the Project route, including a number of green bridges. The Project would create a number of new areas of ecological habitat, providing mitigation or compensation for the impacts on existing areas. Two new parks would be created including Tilbury Fields to the west of the northern tunnel entrance, and Chalk Park, to the south of the River Thames.

Construction compounds and Utility Logistics Hubs

3.5.20 While the Project is being built, construction compounds would be located along the Project route. Larger compounds would be required at the northern and southern tunnel entrances to allow for tunnelling operations and materials management. Utility Logistics Hubs would be needed for specific utility works.

Haulage routes and construction traffic management

3.5.21 Where there is no direct access from the SRN, suitable local roads would initially be used to access the site. Following this, temporary haul routes would be constructed off the SRN early in the programme where possible to access the site and further reduce usage of the local road network. In some instances, the temporary haul roads may need to connect to the existing local road network. Traffic management measures would be used to control the impacts of construction on the local and SRN .

Services and utility installations and diversions

3.5.22 To accommodate the construction and operation of the Project, it would be necessary to install and divert multiple utilities including overhead electricity powerlines, high-pressure gas mains and other utility networks and their associated infrastructure including cabinets, substations and maintenance compounds. New utility connections would be installed to the compounds and to the tunnels.

Land required

3.5.23 The Project would require land on a permanent basis for the road and tunnel, along with other operational infrastructure, and environmental mitigation and compensation.

3.5.24 On a temporary basis, land would be required for construction compounds, logistics areas and other construction activities. The utility installations and diversions, some environmental works and flood compensation requirements would require land to be taken on a temporary basis, and for permanent rights to be acquired for the operation and maintenance of any utility infrastructure, and to secure environmental works and flood compensation.

3.5.25 The full land requirement for the Project is shown on the Land Plans (Application Document 2.2) and set out in the Statement of Reasons (Application Document 4.1).

3.5.26 The Project would also require both permanent acquisition and temporary use of areas of special category land, which includes common land and public open space. Replacement land would be provided for some of this special category land. In other cases, in accordance with the Planning Act 2008, replacement land has not been included, for example, because it is only proposed to install and divert utilities through the land and the land would not be permanently impacted. This means that its previous use can continue once the works are finished.

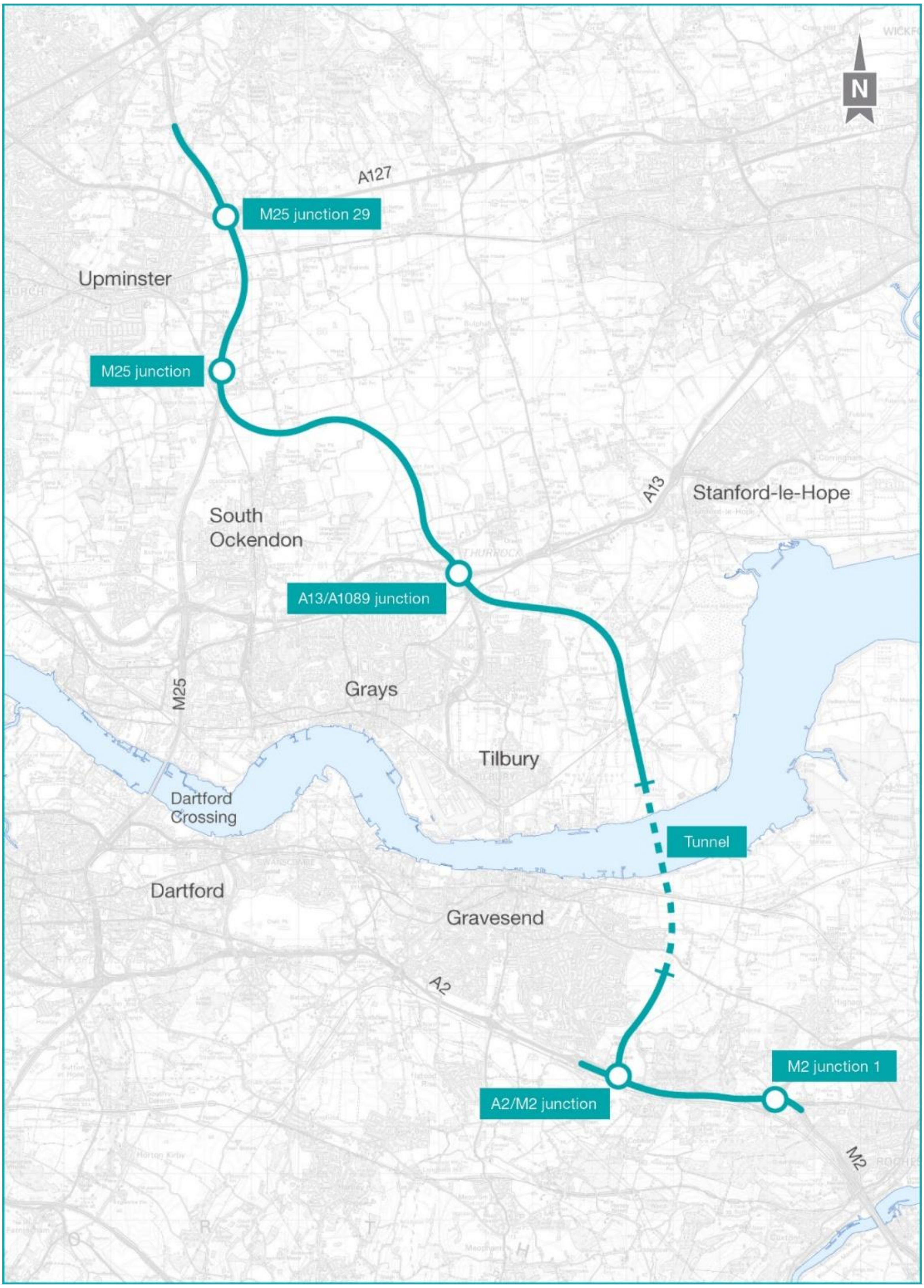
3.5.27 Consultation with relevant landowners, occupiers and agents remains an ongoing focus through the development of the Project. Compensation for affected parties follows the statutory Compensation Code.

Operations and maintenance

3.5.28 Following completion, the A122 would be part of the SRN.

3.5.29 To carry out inspection, certain specified maintenance activities in the tunnel and periodic emergency exercises, a periodic full closure of the relevant bore(s) would be required. These would be planned to minimise disruption, and where feasible lane closures would be used instead.

Plate 3.1 A122 Lower Thames Crossing route alignment



4 Appraisal methodology

4.1 Introduction

4.1.1 This chapter summarises the overall appraisal approach, assumptions and the methods used to appraise the Level 1, Level 2 and Level 3 benefits.

4.2 Appraisal approach and assumptions

4.2.1 HM Treasury's Green Book appraisal and evaluation guidance (HM Treasury, 2022) recommends that the appraisal of public sector projects and programmes should be based on a social cost benefit analysis. Therefore, based on TAG guidance, the appraisal of the Project includes information about a wide range of monetised and non-monetised impacts. These include the direct impacts on transport users and providers as well as impacts on the environment, wider society and government. These impacts are determined by forecast changes in traffic flows, travel times, delays, speeds, and the distribution of traffic and mode choice between the Without Scheme and With Scheme scenarios produced by the LTAM transport model. Some impacts are welfare impacts which have important effects on society and the quality of life although they are not included within Gross Domestic Product (GDP), while other impacts affect measured economic growth and are included within GDP.

4.2.2 TAG Unit A1.1 explains that when expressed in discounted present values (Department for Transport, 2021b):

a. the sum of monetised benefits is known as the Present Value of Benefits (PVB)

b. a project's costs less its revenues from road user charges are known as the Present Value of Costs (PVC)

c. the ratio of the PVB to the PVC produces a Benefit Cost Ratio (BCR) which is a measure of a project's net impacts

4.2.3 It should be noted that the appraisal of some impacts presented in this report uses different methodologies to those upon which the Environmental Statement (Application Documents 6.1, 6.2 and 6.3) is based. Therefore, the appraisal of some impacts presented in this report and the Appraisal Summary Table Report will differ compared to their assessments in the Environmental Statement.

4.2.4 The appraisal of benefits is split into three levels, 1, 2 and 3, that reflect differences in the maturity of the analytical techniques available for quantifying impacts as set out in TAG Unit A2.1 (Department for Transport, 2021a):

a. Level 1 – This includes monetised benefits and disbenefits for transport users and providers and other economic, environmental and social impacts that are all estimated using established traffic modelling and appraisal methods. These impacts are based on the key assumption that land uses remain fixed between the Without Scheme and With Scheme scenarios. The sum of the monetised Level 1 benefits is called the Level 1 PVB. The ratio of the Level 1 PVB to the PVC provides the Initial BCR for a project.

b. Level 2 – This includes monetised journey time reliability benefits and wider economic impacts, both of which assume no changes in land use. These are estimated using less established modelling and appraisal methods. These impacts are added to the Level 1 PVB to produce a Level 1 and 2 PVB. When this is compared to the PVC, it enables an Adjusted BCR to be calculated.

c. Level 3 – Additional Level 3 appraisal evidence has been produced and is presented in this report. This evidence is not used to further amend the BCR, but it does inform the Value for Money assessment. Level 3 evidence includes:

   i. Quantitative information and qualitatively appraised economic, environmental and social impacts

   ii. A distributional appraisal of impacts on vulnerable social groups

   iii. An indicative monetary valuation for landscape which is not included in the BCR

   iv. Other wider economic impacts such as those resulting from a relaxation of the assumption of fixed land use

4.2.5 All monetised impacts are discounted using HM Treasury public sector discount rates and are expressed in 2010 prices and values in order that benefits and costs that arise at different points in time can be directly compared using the BCRs (see Table 4.1).

Table 4.1 Calculation method for BCRs

Appraisal level	BCR calculation	BCR name	Included in Value for Money assessment
Level 1 impacts	Level 1 PVB / PVC	Initial BCR	Yes
Level 2 impacts	Level 1 and 2 PVB / PVC	Adjusted BCR	Yes
Level 3 impacts	Not included	n/a	Yes

4.2.6 TAG provides methods for quantifying many of the impacts of the Project and giving them a monetary value. The values for most impacts are estimated over a 60-year appraisal period from Project opening except for construction costs, construction carbon emissions and delays to transport users and providers which arise during the construction period. All values are converted into 2010 prices and discounted back to 2010 values, referred to as 2010 prices and values. The DfT set 2010 as the common base year to be used in transport appraisals.

4.2.7 The discount rates used are set by HM Treasury at:

a. 3.50% for the first 30 years from the appraisal year, 3.00% for years 31 to 75 and 2.50% for years 76 to 125 for all impacts except human health impacts;

b. 1.50% for the first 30 years from the appraisal year, 1.29% for years 31 to 75 and 1.07% for years 76 to 125 for human health impacts which are included in the appraisal of noise, air quality, accidents and physical activity impacts.

4.2.8 The Project’s appraisal is based on the following assumptions:

a. a 2022 appraisal year.

b. the start of construction in 2024.

c. the opening year used for the appraisal of capital expenditure (CAPEX) costs is different from the rest of the application assumptions, whereby the costs assume a completion of construction in 2031, while the rest of the application assumes an opening year of 2030.

The application as a whole is based on the opening year of 2030. The project construction schedule supports this opening date, with a reasonable allowance for construction time risk, and National Highways is confident that this can be achieved. Nevertheless, for the purposes of the cost assessment it is appropriate to allow for a reasonable level of time risk for both the duration of the DCO statutory process and for construction. Standard practice is to allow for a cost and schedule that reflects a range of scenarios where it is possible that the project could be delivered faster or take longer to complete. This is characterised as the ‘most likely’ cost and schedule. There will be scenarios where the project is delivered faster and at either higher or lower cost, and also scenarios where the project is delivered slower and at either higher or lower cost.

There is no single scenario that on its own would represent the worst case for each aspect of the application. The current schedule, which demonstrates a reasonable likelihood that the project can open in 2030, is considered an appropriate reasonable worst case for the purposes of the application assessments.

The modelled costs for 2031 include additional costs associated with the prolongation of the programme, constituting less than 1% of the total cost. Therefore, the modelled capital expenditure for the 2031 scenario is higher than the anticipated costs if the project opens in 2030. The BCR for the project based on benefits commencing in 2030 and costs assuming construction completion in 2031 is therefore conservative.

However, there is always a level of uncertainty over the construction programme on large projects and the Project’s programme may well be refined when contractors are appointed and the detailed design developed. Therefore, the small deviation in opening dates is not considered to have a material impact on the robustness of the Project’s appraisal or value for money.

d. monetised benefits and revenues are calculated based on the difference in journey times and costs between the Without Scheme and With Scheme LTAM transport model runs.

e. for the central case appraisal (which is based on Core traffic growth and Most Likely CAPEX costs) different Without Scheme and With Scheme LTAM model runs were used for the environmental impacts compared to all other traffic-related impacts, as shown in Table 4.2. The differences reflect a very minor change to the Project design and the effects for all three environmental impacts have been assessed as being negligible.

Table 4.2 LTAM transport model runs for Central Case appraisal

Impact	Without Scheme LTAM run numbers	With Scheme LTAM run numbers
Noise	LR_CM45	LR_CS67
Air quality	LR_CM45	LR_CS67
Road user greenhouse gas emissions	LR_CM45	LR_CS67
All other traffic-related impacts	LR_CM49	LR_CS72

f. over the Project's 60-year operational period, the modelling of daily traffic flows, travel times, delays, speeds, the distribution of traffic and mode choice is based on 10 time periods and a fixed land use assumption. The same approach is used for modelling traffic during the construction period, but this is based on five time periods.

g. the same charges for users of the Lower Thames Crossing are assumed as those using the Dartford Crossing, both of which are assumed to increase in line with the Retail Price Index (RPI).

h. the costs of the Project are based on an assumption that it is fully funded by the Government as stated in Budget 2020 (HM Treasury, 2020).

4.2.9 The central case appraisal results and BCRs for the Project are presented in Chapter 11. Sensitivity tests are reported in Chapter 11 which show how the BCRs vary as a result of:

a. Different traffic growth scenarios

b. A range of cost confidence levels

c. The use of appraisal parameters in the forthcoming TAG data book v1.19FC

d. The implementation of Transport Decarbonisation Plan policies

e. The use of a 100-year appraisal period which reflects the long asset life of the tunnel

4.2.10 A summary of all Level 1 and 2 benefits, costs and user charge revenues for the central case scenario and most qualitatively appraised impacts is presented in an Appraisal Summary Table (AST) contained in the Appraisal Summary Table Report.

4.3 Level 1 impacts

Transport users and providers

4.3.1 The impacts of the Project on transport users and providers measure its effects on the economic efficiency of the transport system. These impacts comprise:

a. Journey times savings

b. Vehicle operating costs changes

c. User charge impacts that reflect the disbenefit of paying user charges

d. Traffic delays and impacts during the Project's construction period

e. Traffic delays and impacts during planned maintenance periods.

4.3.2 The first three of these impacts are estimated for three types of transport users and providers (business users, commuters and other users) under three traffic growth scenarios (Low, Core and High). Impacts are valued using DfT's TUBA appraisal software and installer v1.9.17 but with the TUBA Economic Parameters file v1.9.18 (May 2022) which is consistent with the TAG data book v1.18 (Department for Transport, a). For simplicity, references hereafter will simply be to TUBA v1.9.18.

4.3.3 Delays during construction were modelled using LTAM and valued using TUBA v1.9.18. The impacts of these delays include user benefits, which are split between the three transport user types (commuters, business users and others), indirect tax revenues and road user charging revenues. These impacts are only estimated for the Core traffic growth scenario and the same values are used for the Low and High growth scenarios.

4.3.4 The impacts of delays during planned maintenance periods were appraised using National Highways QUADRO appraisal software. The impacts of these delays include user benefits for the three transport user types, indirect tax revenues, accident impacts and road user greenhouse gas emissions. These impacts are only estimated for the Core traffic growth scenario and the same values are used for the Low and High growth scenarios.

4.3.5 The estimates of these five benefits, for each traffic growth scenario, are presented in Transport Economic Efficiency (TEE) tables. Impacts on business users are reported as economic impacts in the AST and impacts on commuters and other users are reported as social impacts in the AST.

4.3.6 The impact of national uncertainty in traffic forecasts on the economic appraisal of the Project has been assessed following guidance in TAG Unit M4 (Department for Transport, 2019b).

4.3.7 The High traffic growth scenario was derived by adding an additional percentage of trips to the core travel demand. This was calculated as 2.5% multiplied by the square root of the number of years since the LTAM model's base year. For example, as the LTAM base year is 2016, then for 2030, which is 14 years later, the percentage of additional trips is 2.5% x 3.74 (square root of 14) which equals 9.35%.

4.3.8 For the Low growth scenario, the same approach was used, but in this case the trips were subtracted from the Core growth scenario trip matrices.

Environmental impacts

4.3.9 The Level 1 appraisal includes traffic-based environmental impacts which are quantified and monetised over 60 years from scheme opening. It also includes the Project's embodied carbon impacts during its construction and operational phases.

Traffic-based impacts

4.3.10 The Level 1 traffic-based environmental impacts are based on LTAM traffic forecasts and comprise:

a. Noise – Changes in noise levels on sensitive receptors (e.g. residential properties)

b. Air quality – Changes in the exposure of people to air pollutants

c. Greenhouse gas emissions – Changes in traded and non-traded road user tailpipe carbon emissions[4]

4.3.11 Environmental modelling of the Project's impacts on noise and air quality has been undertaken, as set out in Chapters 5 and 12 of the Environmental Statement (Application Document 6.1). Monetary values for noise and air quality impacts are calculated using the relevant TAG guidance, unit values and workbooks and are included in the central case appraisal (Department for Transport, 2022a). The same monetary values for these impacts are included in the Low and High traffic growth scenarios.

4.3.12 Road user tailpipe greenhouse gas emissions reflect the change in emissions as a result of the Project's With Scheme Core growth traffic forecasts compared to the Without Scheme forecasts and also take account of forecast emission rates contained in the Department for Environment, Food and Rural Affairs (Defra) Emissions Factor Toolkit (EFT) v11 (Defra, 2021).

4.3.13 The EFT Toolkit includes forecasts of emission rates up to 2050 based on projections by the National Atmospheric Emissions Inventory of:

a. The vehicle fleet composition (i.e. the future fleet mix of petrol, diesel and electric vehicles based on data about the current fleet composition for different road types in the UK and European euro emission standards)

[4] Traded greenhouse gas emissions arise from materials that are included in the UK and European Emissions Trading Schemes, such as the production of steel and concrete. Non-traded greenhouse gas emissions refer to all other emissions.

b. Fuel quality and retrofitting

c. Technology conversions in the national fleet, such as improvements in engine efficiency

4.3.14 The EFTv11 emission rates were applied to speed banded LTAM traffic flows for each modelled time period, with and without the Project, using National Highways Speed Banding Tool v4.3, with an adjustment made for the vehicle fleet in London. The composition of the vehicle fleet in London into euro classes is based on bespoke vehicle fleet information and projections for London provided by Transport for London in early 2018.

4.3.15 In order to generate 60-year forecasts of emissions with and without the Project, emissions for non-modelled years were interpolated.

4.3.16 Monetary values for these non-traded and traded road user tailpipe emissions have been calculated using National Highways Carbon Valuation Toolkit v1.4.2 based on the monetary values for carbon per tonne in TAG data book v1.18. The appraisal produces the additional tonnes of non-traded and traded road user tailpipe CO_2 equivalent (CO_2e) emissions generated by the Project over 60 years from scheme opening in 2030 (the With Scheme scenario) compared to the Without Scheme scenario.

4.3.17 The same monetary value for road user greenhouse gas emissions was included in the Low, Core and High traffic growth scenarios.

Other environmental impacts

4.3.18 The Level 1 appraisal also includes four embodied carbon impacts arising from the Project's construction and its operations, maintenance and renewals programmes over 60 years from scheme opening:

a. Construction emissions – The Project is based on a low carbon construction design and estimates of traded and non-traded construction emissions, in tonnes, have been modelled to reflect the Project's construction programme and use of the low carbon materials and construction processes.

b. Operational emissions – The Project has been designed to generate zero non-traded and traded carbon emissions during its 60-year operational phase from scheme opening in 2030.

c. Maintenance and renewals emissions – The Project's maintenance and renewals programmes will be designed to generate zero non-traded and traded emissions from 2040. Estimates of these emissions for the period from scheme opening in 2030 to 2039 have been developed as follows:

   i. An estimate of the Project's annual maintenance emissions in tonnes has been produced based on its maintenance programme. These emissions have been assumed to be constant for each year between 2030 and 2039. It has been assumed that there is a 95% / 5% split of these emissions between non-traded and traded emissions.

ii. An estimate of the Project's average annual renewals emissions, in tonnes, has been produced by profiling emissions over the period 2030 to 2039 in line with the Project's profile of renewals expenditure in this period. Based on the relative percentages of traded and non-traded construction emissions, in each year 59% of renewals emissions are assumed to be traded emissions and 41% of renewals emissions are assumed to be non-traded emissions.

4.3.19 The estimates of traded and non-traded embodied carbon impacts have been valued using National Highways Carbon Valuation Toolkit v1.4.2 and the monetary values for carbon per tonne in TAG data book v1.18 less a National Highways forecast of carbon emissions permit costs, which internalises some, but not all, of the disbenefit of these emissions. This permit forecast is based on the average cost of a carbon emission permit since the UK Emissions Trading Scheme started in 2021 and inflated using a National Highways generic construction cost inflation profile.

4.3.20 The same monetary value for the Project's embodied carbon emissions is included in the Low, Core and High traffic growth scenarios.

4.3.21 More details about the Project's embodied carbon emissions are set out in the Project's Carbon and Energy Management Plan (Application Document 7.19).

Social impacts

4.3.22 Two social impacts of the Project, on accidents and physical activity, have been estimated and expressed in monetary terms:

a. The impact on accidents has been appraised using DfT's COBALT software.

b. The impact on Physical Activity has been appraised using DfT's Active Mode Appraisal Toolkit.

4.3.23 The same monetary values for accidents and physical activity are used in the calculation of BCRs for the Low, Core and High traffic growth scenarios.

Public Accounts impacts

4.3.24 The TAG appraisal framework also includes Public Accounts impacts that arise from transport projects. This refers to the financial costs incurred, and the revenues received, by central or local government bodies including public sector agencies. Public Accounts impacts comprise:

a. Costs to the broad transport budget – These include CAPEX costs incurred during the Project's planning and construction period and OMR costs. Road user charging revenues, which affect the funding available for transport, are deducted from the costs:

i. CAPEX costs include the costs of preparation, supervision, works and lands. The costs were built up from a base cost with the addition of risk and uncertainty allowances. The inclusion of risk and uncertainty means that Optimism Bias is not included in the appraisal. The base CAPEX costs were prepared in real terms and allow for variations in the rates of inflation for highway construction compared to the general rate of inflation for the economy as given in HM Treasury's GDP deflators included in the TAG data book (Department for Transport, a). The CAPEX costs have been estimated for three levels of cost confidence: Low (P10), Most Likely (P41) and High (P90).[5]

ii. OMR costs comprise operating, maintenance and renewals costs associated with the roads, tunnels, road user charging system and other operational expenditure. Operating costs include expenditure on routine and non-traffic related maintenance costs such as drainage, street lighting and grass cutting. Maintenance costs are for traffic related maintenance. Renewal costs include reconstruction, resurfacing and surface dressing. The base OMR costs were prepared in real terms and allow for variations in the rates of inflation for highways OMR activities compared to the general rate of inflation for the economy as given in HM Treasury's GDP deflators included in the TAG data book (Department for Transport, a). Low, Central and High estimates of OMR costs have been developed.

iii. User charge revenues. These include all user charge receipts collected at the Project, as well as the change in receipts at the Dartford Crossing and within the London Congestion Charge area and those collected at the Silvertown and Blackwall Tunnels. There is also a small change in user charge revenues due to construction delays which arise during the Project's construction period. Given that the Project's costs reflect the available transport budget, these revenues are deducted from the CAPEX and OMR costs to enable the PVC to be calculated.

b. Indirect tax revenues – This is the impact of the Project on central government receipts from fuel taxes and VAT. This affects central government's total budget. These arise during the Project's construction period, normal operation and planned maintenance periods and are treated as benefits that are included in the Level 1 PVB.

4.3.25 The ratio of Level 1 PVB and the PVC enables an Initial BCR to be calculated.

[5] P10 means that there is a 10% probability that this level of costs will not be exceeded. Most Likely reflects costs based on P41 and means there is a 41% probability that this level of costs will not be exceeded. P90 means that there is a 90% probability that this level of costs will not be exceeded.

4.4 Level 2 impacts

4.4.1 There are two types of Level 2 impacts which are expressed in monetary terms:

a. Journey time reliability benefits for business and non-business users. These include changes in incident delays, diversions on to the local road network and day to day variability of journey times.

b. Wider economic impacts. These include productivity benefits for firms from static agglomeration or clustering, increased business output in imperfectly competitive markets and additional income tax for the Government due to increased labour supply.

4.4.2 These Level 2 impacts are added to the Level 1 PVB to derive a Level 1 and 2 PVB which, when compared to the PVC, allows an Adjusted BCR to be calculated.

4.4.3 Table 4.3 and Table 4.4 summarise the key assumptions for benefits and costs for the Level 1 and 2 monetised impacts in the central case appraisal.

Table 4.3 Summary of appraisal assumptions: benefits and user charge revenues

Assumption	Value
TAG data book version	1.18
TUBA software and installer version	1.9.17
TUBA Economics file	1.9.18
WITA	WITA 2.2
Open for traffic	2030
Greenhouse gases	EFTv11 with London adjustment and Speed Banding Toolkit v4.3
Carbon monetary values	Department for Business, Energy and Industrial Strategy (BEIS) 2021 values
Embodied carbon	Included
Carbon Valuation Toolkit	v1.4.2

Table 4.4 Summary of appraisal assumptions: CAPEX and OMR costs

Assumption	Value
TAG data book version	1.18
TUBA software and installer version	1.9.17
TUBA Economics file	1.9.18
Open for traffic	2031[1]
CAPEX outturn	£8,083m
CAPEX inflation indices	Bespoke Building Cost Information Service (BCIS) Tender Price Index (TPI)

Assumption	Value
Base date of CAPEX and OMR estimates	2019 Q1
Historic CAPEX costs excluded to the end of:	November 2021
CAPEX Most Likely P value	P41
OMR costs	Central

1. CAPEX and OMR costs are based on a 10 March 2031 Open for Traffic date that reflects the construction programme included in the assured CAPEX estimate of 11 February 2022.

4.5 Level 3 impacts

4.5.1 The following Level 3 appraisals are included in the EAR:

a. Qualitative appraisals of environmental impacts. These comprise:

   i. Landscape

   ii. Townscape

   iii. Historic environment

   iv. Biodiversity

   v. Water environment

b. Qualitative appraisals of social impacts. These comprise:

   i. Journey quality: these comprise travellers' care, views, and stress.

   ii. Personal security: this includes impacts on crime, or the fear of crime, within the transport context.

   iii. Affordability: changes in people's transport costs beyond those captured in user and provider benefits. This is a distributional impact that reflects impacts for vulnerable groups such as households with low incomes.

   iv. Severance: the extent to which the Project separates residents from the facilities and services they use within their community caused by substantial changes in transport infrastructure or by changes in traffic flows.

   v. Option and non-use values: these are benefits that reflect the option for people to use the Lower Thames and land made available by the Project.

c. A distributional appraisal of the Project's impacts on vulnerable social groups.

d. The monetisation of landscape impacts – this is not included in the BCR.

e. A qualitative appraisal of network resilience.

f. A qualitative appraisal of international trade impacts.

g. Discussion about the values of time and reliability used for freight users.

h. Evidence about the potential for further wider economic impacts based on variable land uses that could have major impacts on the Lower Thames economy.

5 Traffic modelling

5.1 Introduction

5.1.1 This chapter explains the traffic modelling approaches that were developed for the Project's construction period and 60-year operational period based on a 2030 opening year. It also summarises the Without Scheme and With Scheme forecast traffic flows on the Dartford Crossing and Lower Thames Crossing.

5.2 Construction modelling approach

5.2.1 There will be some disruption and delays to the journey times and possibly the journey distances of some road users during the Project's construction period. The Project's construction programme is complex and involves works associated with both the construction of the new highways and tunnel, as well as the provision of new, and diversion of existing, utility connections.

5.2.2 These construction works will result in new, temporary, vehicle movements, as well as changes to existing traffic flows through the introduction of temporary traffic management across the road network. This will result in slow running through roadworks and/or additional time and distance taken to travel via an alternative route. The latter is most likely to occur during any road closures when the new road is joined to the road network.

5.2.3 As with all large projects, assumptions about the construction programme have been made, which will be refined as contractors are appointed and as the detailed design is developed.

5.2.4 The LTAM was used to provide an extensive quantitative assessment of the impacts of construction works on the road network and includes:

a. Heavy Goods Vehicle (HGV) movements associated with the construction of the Project

b. Vehicle movements associated with staff attending the construction sites

c. Temporary traffic management measures associated with construction activities

5.2.5 As the number of additional construction vehicles on the network vary over time and the traffic management measures occur at different times, a series of representative construction phases were modelled using LTAM.

5.2.6 For each of the 11 phases, the HGV movements associated with the construction of the Project and staff travel vehicles were added to the forecast background number and pattern of vehicle movements in LTAM. The number of construction-related vehicle movements was averaged over each phase, so that the LTAM forecasts the average conditions within each phase.

5.2.7 The construction of the Project would require the use of traffic management measures, such as narrow lanes and traffic lights to control traffic through contraflows. Some of these measures relate to enabling works where, for example, measures are required to enable compound accesses to be built or for utilities diversions.

5.2.8 The enabling works traffic management tends to be relatively short term. Other traffic management relates to the main works where, for example, measures are required to enable the construction of the new junctions required for the Project. The main works traffic management measures tend to be in place for longer periods.

5.2.9 The indicative start and end dates of each of the 11 construction phases are shown in Table 5.1.

Table 5.1 Construction modelling phases

Phase	Start date	End date	Duration (months)
1	01/01/2025	31/08/2025	8
2	01/09/2025	28/02/2026	6
3	01/03/2026	31/05/2026	3
4	01/06/2026	31/10/2026	5
5	01/11/2026	31/03/2027	5
6	01/04/2027	31/08/2028	5
7	01/09/2027	31/03/2028	7
8	01/04/2028	30/11/2028	8
9	01/12/2028	31/03/2029	4
10	01/04/2029	31/07/2029	4
11	01/08/2029	31/12/2030	17

5.2.10 Full details of the number of HGV movements and staff vehicle movements and the traffic management measures included in the modelling of each phase are provided in Chapter 8 of the Transport Assessment (Application Document 7.9).

5.2.11 DfT’s TUBA v1.9.18 was used to value construction delays in terms of transport user benefits, indirect tax revenues and user charge revenues. Chapter 7 explains the assumptions used by TUBA in valuing these impacts and highlights where these assumptions differ between the Project’s construction and operational phases.

5.2.12 A proportionate appraisal approach has been applied to the impacts of the construction programme, focusing on those that are expected to be the largest – these are user impacts, indirect tax revenues and user charge revenues. The appraisal of those impacts reflect transport modelling outputs based on weighted averages of traffic flows and speeds produced from the 11 construction phases.

5.3 Operational modelling approach

5.3.1 The LTAM transport model was used to forecast the impact of the Project on the performance of the highway network. LTAM forecasts the changes as a result of the Project on traffic flows, travel times, speeds and levels of congestion on the road network. The model considers how users may change the route they use if the new crossing was available, as well as possible changes to the frequency with which they make their trips, the mode of travel they use, the time of day they travel and the destinations of their trips.

5.3.2 The model covers the whole of Great Britain so that the journey time and distance of the complete journey for trips that travel to, from or through the Lower Thames fully modelled area is known. Annex A shows that the fully modelled area includes:

a. The entirety of the M25 to ensure consistency in the modelling of journey times in both directions around the M25

b. The east of London up to, and around, the Silvertown Crossing as this will be the next crossing upstream from Dartford towards the west

5.3.3 Information on the current travel patterns used in LTAM came from the following sources:

a. Anonymised National Highways data on the movement of mobile phones in England in 2015 collected for use in developing the car trip matrices in the regional transport models

b. Light Goods Vehicle (LGV) data from the DfT-owned Teletrac (formerly TrafficMaster) data set

c. HGV data from DfT's Great Britain Freight Matrices

5.3.4 This data was scaled to match information from over 1,000 traffic count sites on the number of car, light and heavy goods vehicle movements recorded at each count site over a two-week period in March 2016.

5.3.5 The base year model reflects travel patterns and conditions on the road network in an average weekday in March 2016. The modelled hours are:

a. AM peak hour (07:00–08:00)

b. Average inter-peak hour (09:00–15:00)

c. PM peak hour (17:00–18:00)

5.3.6 The growth in the number of trips made by vans and HGVs is taken from DfT's Road Traffic Forecasts 2018 (Department for Transport, 2018). The overall level of growth in car trips is taken from the DfT National Trip End Model version 7.2 forecasts (Department for Transport, 2017). Local adjustments were also made to reflect the proposed location of new housing and other developments (such as employment, retail and leisure sites) and planned transport projects which are classified as being 'near certain' or 'more than likely' in line with Table A2 in TAG Unit M4 (Department for Transport, 2019b). All of these developments are independent of the Project. The main developments included in LTAM in 2030 and 2045 are shown in Plate 5.1 and Plate 5.2 respectively and more information is provided in Appendix C: Transport Forecasting Package.

5.3.7 Given that the Project would provide a new river crossing that will deliver travel time and distance savings for many trips, it is anticipated that benefits will be experienced in all hours of the day and night. Therefore, a method was adopted to provide trip matrices for non-modelled hours and realistic corresponding matrices of the time, distance and charges incurred for journeys, both with and without the new crossing. An examination of the variation in traffic counts and journey times in the study area led to the development of 10 time periods to cover an entire week, i.e. an average weekday divided into seven time periods and an average weekend day divided into three time periods. Annualisation factors were applied to generate the annual matrices that are used to estimate benefits in monetary terms.

5.3.8 The modelling of how people respond to changes in travel times and costs in the network was undertaken using version 6.3.4 of DfT's DIADEM (Dynamic Integrated Assignment and DEmand Model) software. The DIADEM software uses information on the levels of travel demand, times and costs over the whole 24 hours of an average weekday.

5.3.9 The model allows for people to switch to and from rail in the future. The rail journey times and costs were taken from the National Highways rail model developed for its regional transport models which uses PTV VISUM version 17 software.

5.3.10 LTAM uses Simulation and Assignment of Traffic to Urban Road Networks (SATURN) software version 11.4.07H to determine the route that vehicles take, journey times and traffic conditions on the network.

Plate 5.1 Main future developments included in LTAM in 2030

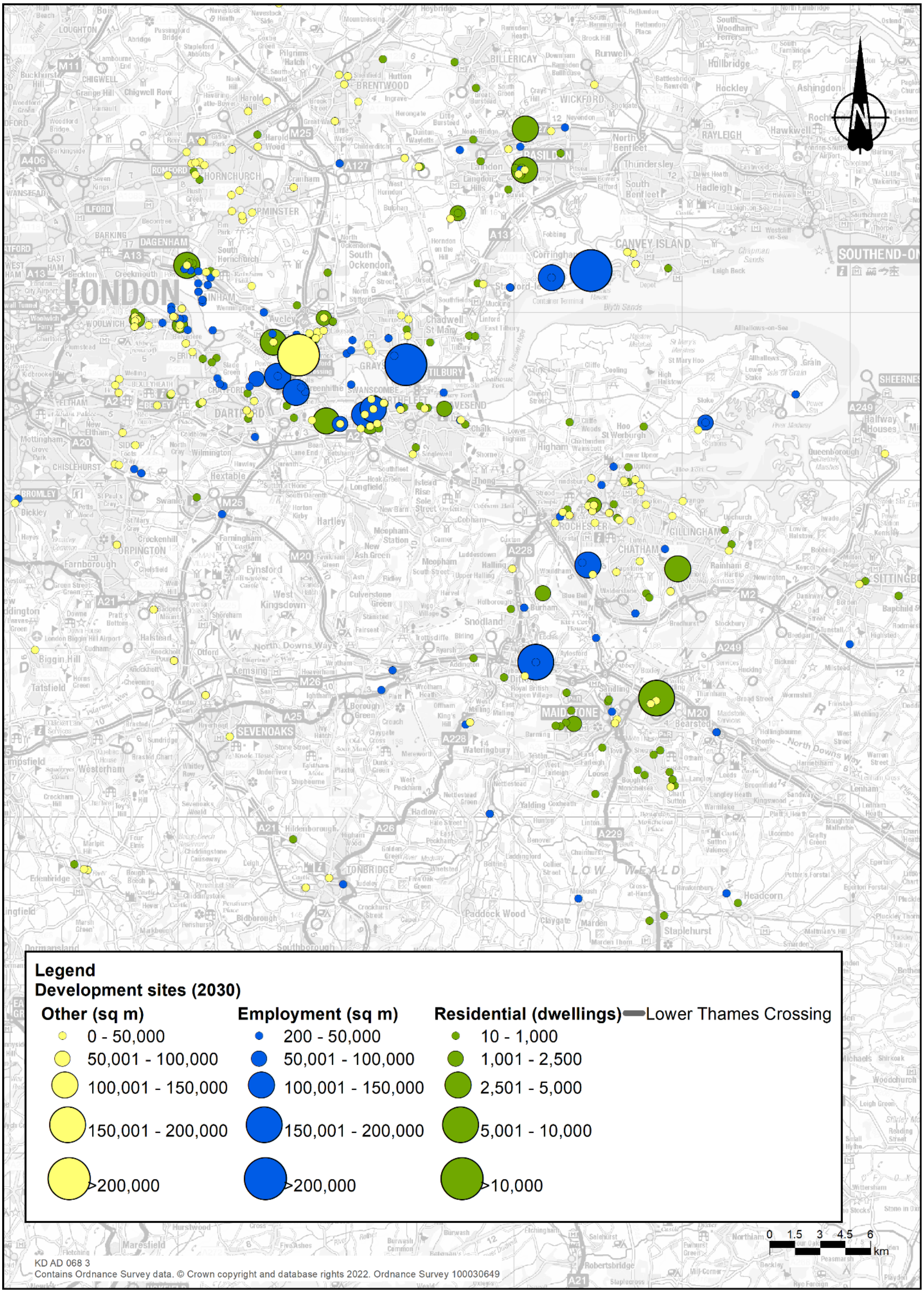
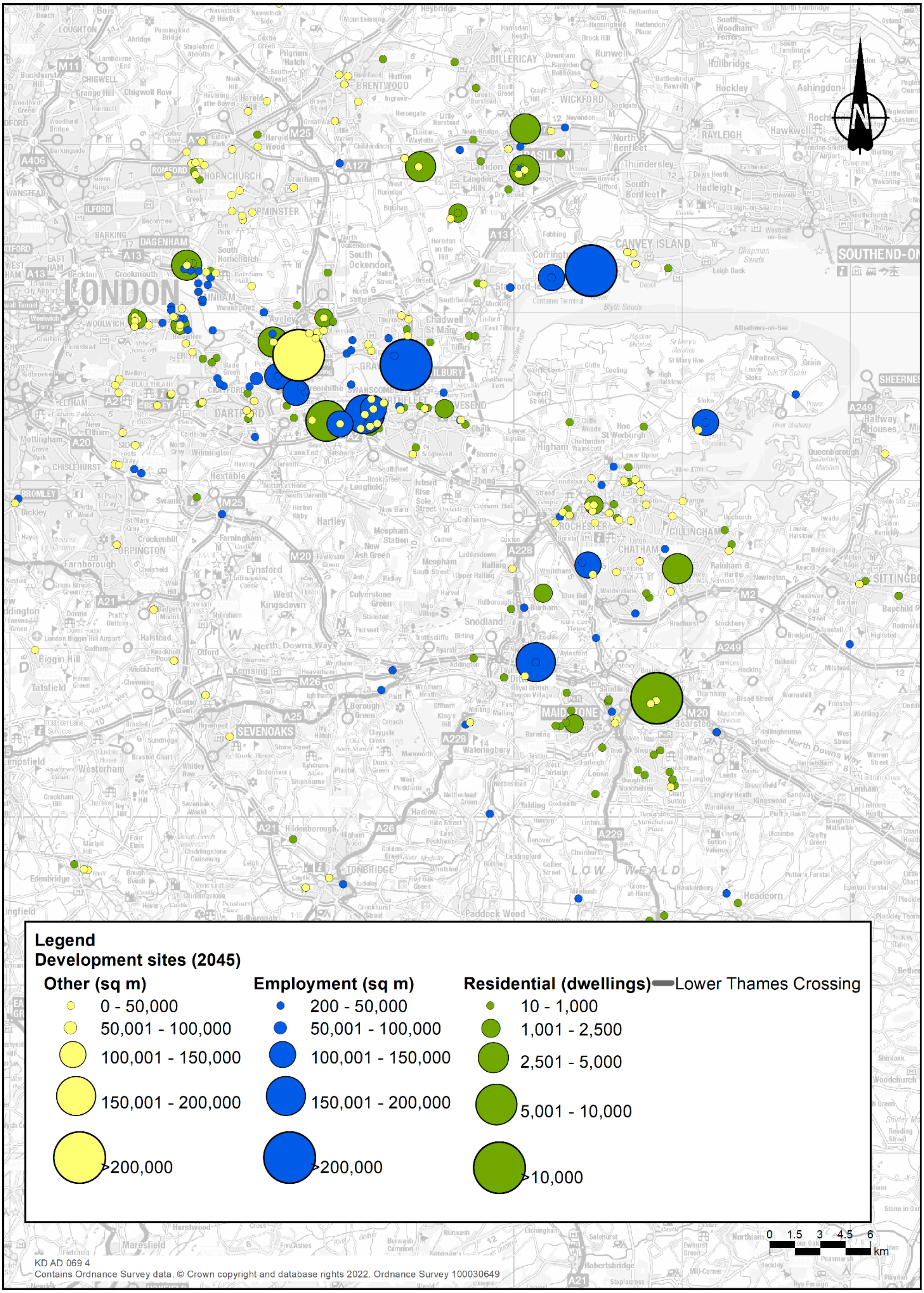


Plate 5.2 Main future developments included in LTAM in 2045



5.4 Operational traffic forecasts

5.4.1 LTAM's forecasts of traffic flows, travel times, delays, speeds, the distribution of traffic and mode choice determine the nature and scale of the impacts from the Project. Traffic forecasts were produced for:

a. 2016 – these are validated against actual traffic flows

b. The Project's opening year of 2030

c. Other forecast years of 2037, 2045 and 2051

5.4.2 For 2030 and the other forecast years, traffic forecasts were produced without the Project and with the Project for the Low, Core and High traffic growth scenarios. The impacts of these scenarios on the Project's BCRs are presented in Chapter 11.

5.4.3

5.4.4 Table 5.2 shows the names of the LTAM model runs used in this appraisal for the different traffic growth scenarios for all impacts except noise, air quality and road user greenhouse gas emissions.

Table 5.2 LTAM runs for traffic growth scenarios

	Low growth	Core growth	High growth
Without Scheme	LR_LM49	LR_CM49	LR_HM49
With Scheme	LR_LS72	LR_CS72	LR_HS72

5.4.5 The appraisals of noise, air quality and road user greenhouse gas emissions are based on LTAM model runs LR_CM45 (Without Scheme) and LR_CS67 (With Scheme). However, the difference in impacts between these and the LR_CM49 (Without Scheme) and LR_CS72 (With Scheme) model runs used for the economic and social impacts has been assessed as negligible.

5.4.6 The ComMA Appendix C: Transport Forecasting Package provides a detailed presentation of the traffic forecasts across the LTAM road network. This includes, for example, roads used for north–south movements across the River Thames and east–west movements on key routes such as the A2, M25 and A13.Table 5.3 Table 5.3 shows the forecast changes in modelled peak and inter-peak two-way hourly traffic flows across the River Thames as a result of the Project. Specifically, it presents the change in two-way, hourly traffic flows, expressed in terms of passenger car units (PCUs), using the Dartford Crossing and Lower Thames Crossing. The table shows:

a. Actual hourly flows for the AM peak hour, inter-peak (IP) hour and PM peak hour over the Dartford Crossing in 2016 and those forecast in 2030 and 2045 without the Project

b. Forecast traffic flows (for the same hourly periods in 2030 and 2045) for the Dartford Crossing and Lower Thames Crossing, assuming the new crossing opens for traffic in 2030

5.4.7 Table 5.3 shows that traffic using the Dartford Crossing in 2045 with the Project in place falls by 9% (AM), 18% (IP) and 17% (PM) compared to a 2045 scenario without the Project. However total traffic across the river in 2045 using the Dartford Crossing and the Project increases by 46% (AM), 30% (IP) and 37% (PM).

Table 5.3 Forecast flows at Dartford Crossing and Lower Thames Crossing

Period	Year	Without Scheme	With Scheme				
		Dartford Crossing*	Dartford Crossing*	% change	Lower Thames Crossing	Total flows	% change
AM peak hour	2016	14,430					
	2030	16,020	13,280	-17%	8,040	21,320	+33%
	2045	16,260	14,870	-9%	8,940	23,810	+46%
Inter-peak hour	2016	11,790					
	2030	14,410	10,780	-25%	6,510	17,290	+20%
	2045	15,660	12,770	-18%	7,590	20,360	+30%
PM peak hour	2016	12,830					
	2030	15,310	12,020	-21%	7,990	20,010	+31%
	2045	16,280	13,540	-17%	8,830	22,370	+37%

The table shows the change in two-way, hourly traffic peak and inter-peak flows, expressed in terms of PCUs.

** Flows at the Dartford Crossing (northbound only) are approaching the Traffic Management Cell.*

All flows rounded to the nearest 10.

Source: Lower Thames Area Model (LR_108 (Run 1), LR_CM49, LR_CS72)

6 Costs

6.1 Introduction

6.1.1 This chapter describes how the Project's costs and revenues have been estimated.

6.1.2 The costs of the Project comprise expenditure incurred during its planning and construction phase, referred to as CAPEX, and expenditure incurred once the Project is in use, comprising its OMR costs. The costs have been estimated on the basis that the Government publicly funds the Project.

6.1.3 The revenues include user charge receipts collected at the Project as well as the change in receipts at the Dartford Crossing, for the London Congestion Charge and those forecast to be collected at the Silvertown and Blackwall Tunnels.

6.1.4 This chapter presents:

a. The Most Likely estimate of CAPEX costs

b. The Central estimate of OMR costs

c. User charge revenues based on Core traffic growth forecasts produced by LTAM

6.1.5 The costs were estimated at 2019 Q1 prices in line with National Highways guidance. They are then inflated to outturn prices, using appropriate inflation indices, which represent the financial resources needed to construct, operate, maintain and renew the Project at the point at which those financial resources are required.

6.1.6 For the economic appraisal, both the costs and revenues have been expressed in 2010 prices and values using TUBA v1.9.18. The CAPEX and OMR costs assume a 2031 opening date based on the latest construction programme, while the road user charging revenues assume a 2030 opening date. Given that the scheme costs reflect the available transport budget, the costs less the user charge revenues constitute the PVC, which is the denominator of the BCR.

6.1.7 Chapter 11 includes sensitivity tests based on different cost confidence levels for the CAPEX costs and Low and High traffic growth scenarios which change the user charge revenues.

6.2 CAPEX costs

6.2.1 The CAPEX costs were estimated and profiled over the Project's planning and construction period and are based on a 2031 opening date for the reasons explained in section 4.2.8 above though the application as a whole is based on the opening year of 2030. This assumes consent is granted and work commences in 2024. Construction may take up to six years, but as with all large projects there is a level of uncertainty over the Project's construction programme, which would be refined when contractors are appointed and as the detailed design is developed.

6.2.2 The estimate of CAPEX costs was prepared by the Project team in accordance with National Highways' capital cost estimating process for Major Projects (Highways England, 2018a).

6.2.3 The CAPEX estimate has been assured by National Highways' Commercial Service Division (CSD) team.

6.2.4 The CAPEX costs are split into:

a. A Base Cost, which represents the costs of work to build the Project, expressed in 2019 Q1 real terms prices

b. Additional costs for Project Risk, Uncertainty, non-recoverable Value Added Tax (NR VAT), Inflation and Portfolio Risk

6.2.5 The base cost estimate was converted to a probability distribution, expressed in outturn costs, by running a Monte Carlo simulation on both the forecast schedule and cost outcomes. The Most Likely costs, which reflect the statistical mode of the range of costs, represent a 41% cost confidence level. A range of costs have been produced and the impacts of costs at P10 and P90 confidence levels on the BCRs are reported in Chapter 11.

6.2.6 Table 6.1 and Plate 6.1 show the inflation rates used to inflate the CAPEX costs from 2019 Q1 prices to outturn prices. This series was specifically developed by the BCIS to reflect the Project's construction programme and use of materials.

Table 6.1 CAPEX inflation rates

2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
2.92%	-0.10%	1.11%	3.30%	2.10%	2.61%	-2.38%	2.04%	5.93%	4.10%	4.18%
2024	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**
3.46%	4.34%	2.08%	2.22%	2.26%	2.29%	2.35%	2.35%	2.38%	2.42%	2.51%

Plate 6.1 CAPEX inflation rates

6.2.7

6.2.8 Table 6.2 shows that the Most Likely CAPEX cost, expressed in outturn prices, is £8,083.4m. An annual profile of these costs during the Project's planning and construction period is included in Annex D.

Table 6.2 CAPEX costs central case (£m, outturn, Most Likely)

Cost category	£m
Preparation	960.0
Supervision	385.0
Lands	440.5
Construction and other costs	6,298.0
Total	8,083.4

Note: Other costs includes items such as inflation and non-recoverable VAT

6.2.9 The CAPEX costs, excluding historic sunk costs (i.e., all costs incurred to the end of November 2021) and NR VAT, were expressed in 2010 prices and values using TUBA v1.9.18 and are estimated to be £3,119.6m. This value is included in the PVC for the Central Case appraisal.

6.3 OMR costs

6.3.1 A Central estimate of the OMR costs was estimated and profiled over a 60-year operational period from 2031 to 2090.

6.3.2 The estimate of OMR costs was prepared by the project team in accordance with National Highways' OMR cost estimating process for Major Projects (Highways England, 2018b).

6.3.3 The estimate has been assured by National Highways' CSD and Operations Directorate.

6.3.4 The OMR costs include four components:

a. Highways

b. Tunnels

c. Other costs

d. Road user charging (RUC) system costs.

6.3.5 Highways OMR costs include expenditure on routine operation, maintenance and renewals of highways assets, structures, and technology, as well as expenditure dealing with severe weather events and non-operational costs.

6.3.6 Tunnels OMR costs include maintenance expenditure on tunnel structures, electrical and mechanical systems, and operational costs.

6.3.7 Other OMR costs include those incurred from renewing highway technology assets, responding to incidents, dealing with severe weather events, the management of maintenance and renewals contractors, National Highways management and systems, risk, and uncertainty.

6.3.8 The RUC system costs include the charging system's fixed, variable and renewals costs. The estimates of these costs are based on evidence that the additional traffic volumes and operation of the RUC system for the Project can be incorporated at a comparatively low marginal cost above that incurred at the Dartford Crossing.

6.3.9 Highways, tunnels, and other costs were inflated to outturn costs using rates within National Highways O&M cost model, as shown in Table 6.3Table 6.3 Inflation rates for OMR highways, tunnels, and other costs. Costs from 2029 to 2090 were increased by 2.20% per annum.

Table 6.3 Inflation rates for OMR highways, tunnels, and other costs

	Year	Inflation Rate	Index (2015=100)
HEMCI	2015	-	100
	2016	-1.90%	98.1
	2017	6.42%	104.4
	2018	3.16%	107.7
Bridge	2019	3.04%	111.0
	2020	2.92%	114.2
RIS 2 Inflation	2021	2.80%	117.4
	2022	2.80%	120.7
	2023	2.80%	124.1
	2024	2.80%	127.6
	2025	2.80%	131.1
Bridge - GDP Deflator	2026	2.65%	134.6
	2027	2.50%	138.0
	2028	2.35%	141.2
	2029+	2.20%	-

6.3.10 RUC system costs were inflated to outturn costs using Consumer Price Inflation (CPI) rates, which is the basis for inflating road user charging system costs within the current contract for operating the Dartford Crossing road user charging system. Table 6.4 shows the CPI rates to 2027 and that for subsequent years to 2090 they are increased by 2.00% per annum.

Table 6.4 CPI Inflation rates for road user charging system costs

Year	CPI	Index
2019	1.80%	1.00
2020	0.90%	1.02
2021	2.30%	1.03
2022	5.80%	1.05
2023	8.00%	1.11
2024	1.20%	1.20

Year	CPI	Index
2025	1.66%	1.22
2026	2.00%	1.24
2027+	2.00%	1.26

6.3.11 In total the Central estimate of OMR costs, expressed in 2019 Q1 prices is £1,615.4m as shown in Table 6.5. The application of the inflation rates in Table 6.3 and Table 6.4 increases the OMR costs to a total of £4,691.3m in outturn prices.

Table 6.5 OMR costs (£m, Central estimate)

Cost category	2019 Q1 £m	Outturn £m
Highways	583.7	1,731.7
Tunnels	609.6	1,776.9
Other costs	241.8	712.3
Road user charging system costs	180.4	470.3
Total	**1,615.4**	**4,691.3**

6.3.12 An annual profile of these costs over 60 years from Project opening is included in Annex D.

6.3.13 The OMR costs expressed in 2010 prices and values using TUBA v1.9.18 are estimated to be £327.4m. This value is included in the PVC for the Central Case appraisal.

6.4 User charge revenues

6.4.1 The user charge revenues for the Central Case appraisal reflect the change in these revenues, over 60 years from scheme opening, between the Without Scheme scenario and With Scheme scenarios. These include the change in revenue at the Dartford Crossing, revenues from the Lower Thames Crossing, the change in revenue in the London Congestion Charge area and forecast receipts for the Silvertown and Blackwall Tunnels.

6.4.2 For the purposes of economic appraisal, the revenues assume that user charges at the Lower Thames Crossing will be the same as the charges at the Dartford Crossing and that the charges at both crossings rise in line with inflation until 2051 (the last modelled year). The revenues total £748.5m expressed in 2010 prices and values.

6.4.3 There is also a small reduction in user charge revenues of £1.7m (2010 prices and values) due to delays for road users which arise during the construction period.

6.4.4 The total value of user charge revenues of £746.8m (2010 prices and values) is included in the PVC for the Central Case appraisal.

6.5 PVC

6.5.1 The PVC is calculated by adding the CAPEX and OMR costs and deducting the user charge revenues. Table 6.6 shows that the Central Case PVC is £2,700.2m.

Table 6.6 PVC central case (£m, 2010 prices and values)

PVC components	£m
CAPEX	3,119.6
OMR	327.4
Revenues	-746.8
PVC	**2,700.2**

Note: Revenues are based on Core traffic growth model runs: Without Scheme CM49, With Scheme CS72

6.6 Public Accounts tables

6.6.1 Table 6.7, Table 6.8 and Table 6.9 present the Public Accounts tables for the Low, Core and High traffic growth scenarios, all based on Most Likely CAPEX costs and Central OMR costs.

Table 6.7 Public Accounts table, Low growth (£m, 2010 prices and values)

	All modes	Road	Bus and coach	Rail	Other
Local government	–	–	–	–	–
Revenue	–	–	–	–	–
Operating costs	–	–	–	–	–
Investment costs	–	–	–	–	–
Developer subsidy	–	–	–	–	–
Grant/subsidy	–	–	–	–	–
Net impact	–	–	–	–	–
Central Government Funding: Transport	–	–	–	–	–
Revenue	-665.5	-665.5	–	–	–
Operating costs	327.4	327.4	–	–	–
Investment costs	3,119.6	3,119.6	–	–	–
Developer subsidy	–	–	–	–	–
Grant/subsidy	–	–	–	–	–
Net impact	**2,781.5**	**2,781.5**	–	–	–
Central Government Funding: Transport	–	–	–	–	–
Indirect tax revenues	-50.1	-50.1	–	–	–
Totals	–	–	–	–	–
Broad transport budget	**2,781.5**	–	–	–	–
Wider public finances	**-50.1**	–	–	–	–

Notes: Costs appear as positive numbers, while revenues appear as negative numbers. All entries are discounted present values in 2010 prices and values

Table 6.8 Public Accounts table, Core growth (£m, 2010 prices and values)

	All modes	Road	Bus and coach	Rail	Other
Local government	–	–	–	–	–
Revenue	–	–	–	–	–
Operating costs	–	–	–	–	–
Investment costs	–	–	–	–	–
Developer subsidy	–	–	–	–	–
Grant/subsidy	–	–	–	–	–
Net impact	–	–	–	–	–
Central Government Funding: Transport	–	–	–	–	–
Revenue	-746.8	-746.8	–	–	–
Operating costs	327.4	327.4	–	–	–
Investment costs	3,119.6	3,116.6	–	–	–
Developer subsidy	–	–	–	–	–
Grant/subsidy	–	–	–	–	–
Net impact	**2,700.2**	**2,700.2**	–	–	–
Central Government Funding: Transport	–	–	–	–	–
Indirect tax revenues	-43.5	-43.5	–	–	–
Totals	–	–	–	–	–
Broad transport budget	**2,700.2**	–	–	–	–
Wider public finances	**-43.5**	–	–	–	–

Notes: Costs appear as positive numbers, while revenues appear as negative numbers. All entries are discounted present values in 2010 prices and values

Table 6.9 Public Accounts table, High growth (£m, 2010 prices and values)

	All modes	Road	Bus and coach	Rail	Other
Local government	–	–	–	–	–
Revenue	–	–	–	–	–
Operating costs	–	–	–	–	–
Investment costs	–	–	–	–	–
Developer subsidy	–	–	–	–	–
Grant/subsidy	–	–	–	–	–
Net impact	–	–	–	–	–
Central Government Funding: Transport	–	–	–	–	–
Revenue	-820.9	-820.9	–	–	–
Operating costs	327.4	327.4	–	–	–
Investment costs	3,119.6	3,119.6	–	–	–
Developer subsidy	–	–	–	–	–
Grant/subsidy	–	–	–	–	–
Net impact	**2,626.1**	**2,626.1**	–	–	–
Central Government Funding: Transport	–	–	–	–	–
Indirect tax revenues	-34.2	-34.2	–	–	–
Totals	–	–	–	–	–
Broad transport budget	**2,626.1**	–	–	–	–
Wider public finances	**-34.2**	–	–	–	–

Notes: Costs appear as positive numbers, while revenues appear as negative numbers. All entries are discounted present values in 2010 prices and values

7 Level 1: Transport users and providers impacts

7.1 Introduction

7.1.1 This chapter describes the approaches and assumptions used to appraise and value monetised Level 1 impacts on transport users and providers. These impacts, which are all based on LTAM traffic forecasts, are calculated for business users, commuters and other users. They cover:

a. Delays to road users due to the construction of the Project

b. Benefits and disbenefits over the Project's 60-year operational period from scheme opening, which are split into:

   i. Journey time savings

   ii. Changes in vehicle operating costs (VOC)

   iii. Road user charge disbenefits

c. Delays due to planned maintenance works.

7.1.2 Delays during construction were appraised over the Project's construction period using TUBA v1.9.18. The same values for these delays have been included in the appraisal for the Low, Core and High traffic growth scenarios.

7.1.3 User benefits over the Project's 60-year operational period were appraised using TUBA v1.9.18 over 60 years from Project opening in 2030. Different values were calculated for the three traffic growth scenarios.

7.1.4 Maintenance delays were appraised over 60 years using National Highways QUADRO program. The same values for these delays have been included in the appraisal for all three traffic growth scenarios.

7.1.5 Together these impacts provide a measure of the Project's effects on TEE and are included within the Level 1 PVB and Initial BCR. The impacts are reported in TEE tables for each traffic growth scenario.

7.2 TUBA assumptions

7.2.1 DfT's TUBA v1.9.18 was used to value impacts during construction and the 60-year operational phase of the Project. These impacts are based on traffic flow numbers, journey times, distances and user charges produced by the LTAM transport model.

7.2.2 Impacts that are valued during construction comprise transport user and provider delays and changes in indirect tax revenue and road user charging revenue.

7.2.3 For the Project's 60-year operational phase the valuation of transport user and provider impacts are split into changes in journey times, vehicle operating costs and user charge impacts. Changes in indirect tax revenue and road user charging revenue are also valued.

7.2.4 TUBA's economics file v1.9.18 contains the current TAG data book v1.18 recommended national values of time, vehicle operating cost data, tax rates, economic growth rates and other economic parameters for use in the appraisal of a transport project. TUBA uses these parameters to calculate the monetary value of benefits and expresses them in 2010 prices and values.

7.2.5 The main assumptions used in TUBA about user classes (i.e. journey purposes and vehicle types) and values of time are the same when calculating delays during construction and user benefits and disbenefits over 60 years from scheme opening. However, other assumptions, such as the appraisal period, time periods and annualisation factors, differ between the construction delays appraisal and the 60-year operational appraisal. Where these assumptions are different, those assumptions for the 60-year appraisal are explained first in the sections below followed by the assumptions for the construction delays appraisal.

Appraisal period

60-year operational phase

7.2.6 Benefits and disbenefits were appraised over a 60-year period from scheme opening. Within this appraisal period, the modelled years which provide inputs to the 60-year appraisal were:

a. Project opening year – 2030

b. Additional modelled years – 2037, 2045 and 2051

7.2.7 The Horizon Year was set at the end of 2089 to provide a 60-year appraisal period from Project opening, in accordance with TAG Unit A1.1 (Department for Transport, 2021b).

7.2.8 Benefits were calculated in TUBA by straight line interpolation between each modelled year. After 2051, which was the last modelled year, TUBA assumes that traffic flows, journey times and distances remain fixed.

Construction period

7.2.9 Construction delays were appraised for each of the eleven phases of the Project's construction programme which cover the period from 2025 to 2030.

User classes

7.2.10 There are 10 user classes available in LTAM. These are:

a. Car, business trips

b. Car, commuting trips made by low income households

c. Car, commuting trips made by medium income households

d. Car, commuting trips made by high income households

e. Car, other purpose trips made by low income households

f. Car, other purpose trips made by medium income households

g. Car, other purpose trips made by high income households

h. LGV

i. HGV without port access

j. HGV with port access

7.2.11 User classes nine and ten are combined into a single HGV matrix before being inputted to TUBA.

7.2.12 In TUBA the LGV and HGV user classes are further divided into the following sub-classes:

a. LGV personal trips

b. LGV business trips

c. Other Goods Vehicle 1 (OGV1) business trips

d. Other Goods Vehicle 2 (OGV2) business trips

7.2.13 The LGV trip matrices were split into personal and business trips using the standard proportions set out in Table A1.3.4 of TAG data book v1.18 where 88% of LGVs trips are defined as business trips.

7.2.14 The HGV matrix was split into OGV1 and OGV2 matrices using a 40% / 60% split based on proportions on the motorway and SRN seen in the observed count databases used in the development of National Highways' Regional Traffic Models.

Values of time

7.2.15 TAG recommends that income segmentation is used in transport modelling and appraisal when a proposed transport intervention, such as a road project, involves a substantial money charge for users, as would be the case for the Project.

7.2.16 TAG Unit M2.1 recommends that car trips by users for commuting and other purposes are segmented into trips made by low, middle and high income households (Department for Transport, 2020a). DfT provided values of time for the income bands used in LTAM. The TUBA economics file was amended to incorporate the values of time for the three income bands used in the traffic modelling. These values of time are consistent with the national values of time presented in TAG data book v1.18 (Department for Transport, a). More detail about the income banding of trips is provided in Appendix C: Transport Forecasting Package. The values of time used in the appraisal, which increase over time in line with income, are shown in Table 7.1.

Table 7.1 Values of time (£ per hour, 2010 prices and values)

Journey Purpose	Income band	Annual income	2010	2030	2037	2045	2051
Car Commuting	Low	Under £25,000	4.58	5.48	5.91	6.86	7.96
	Medium	£25,000–£50,000	7.7	9.22	9.93	11.53	13.38
	High	Over £50,000	13.42	16.07	17.31	20.09	23.32
Car Other	Low	Under £25,000	2.48	2.97	3.20	3.71	4.31
	Medium	£25,000–£50,000	4.26	5.10	5.50	6.38	7.40
	High	Over £50,000	6.79	8.13	8.76	10.17	11.80
Car Business	All	All	14.86	17.79	19.17	22.25	25.82

Vehicle operating costs

7.2.17 For the 60-year appraisal, fuel and non-fuel vehicle operating costs were calculated using standard TAG methodologies and parameters. Speed and distance data from the LTAM transport model were input into the TUBA software which applies the equations and parameters from TAG Unit A1.3 (Department for Transport, 2022a) and TAG data book v1.18 to estimate changes in vehicle operating costs. The outputs of TUBA are the expected welfare impact of these changes expressed in 2010 prices and values.

Time periods and annualisation factors

60-year operational phase

7.2.18 LTAM produces output data for three modelled hours:

a. AM peak hour (07:00–08:00)

b. The average inter-peak hour (between 09:00–15:00)

c. The PM peak hour (17:00–18:00)

7.2.19 As the Project provides a new river crossing that will deliver travel time and distance savings for many trips, it is anticipated that benefits will be experienced in all hours of the day and night. Therefore, a method was adopted to provide trip matrices for non-modelled hours and realistic corresponding matrices of the time, distance and charges incurred for journeys, both with and without the Project.

7.2.20 An examination of the variation in traffic counts and journey times in the study area led to the development of 10 time periods for use in the appraisal as shown in Table 7.2. An average weekday was divided into seven time periods and an average weekend day was divided into three time periods.

7.2.21 For the non-modelled hours, the trip matrix from the closest modelled hour in terms of the pattern of trips made was factored to represent the level of trips made in the non-modelled hour. This was then assigned to the appropriate network to produce the time, distance and charge matrices for use in TUBA. Annex A1 explains the process used to determine the annualisation and expansion factors used.

Table 7.2 Ten time periods used in 60-year appraisal

Time period	Classification	Hours
AM shoulder	AM	06:00–07:00
AM peak	AM	07:00–09:00
Inter-peak	IP	09:00–15:00
PM shoulder	PM	15:00–16:00 18:00–19:00
PM peak	PM	16:00–18:00
Weekday off-peak charge	OP	19:00–22:00
Weekday off-peak non-charge	OP	22:00–06:00
Weekend peak	WE	09:00–19:00
Weekend off-peak charge	WE	06:00–09:00 19:00–22:00
Weekend off-peak non-charge	WE	22:00–06:00

7.2.22 TAG default purpose splits were applied to the non-modelled hours, with the exception of the PM shoulder peak hours, which use the modelled PM peak hour journey purposes, as they provided a more consistent profile for trip journey purposes.

Construction period

7.2.23 A set of five time periods were used in the construction delays appraisal as shown in

7.2.24 Table 7.3.

Table 7.3 Five time periods used in construction delays appraisal

Time period	Classification	Hours
AM peak	AM	07:00–10:00
Weekday inter-peak	IP	10:00–16:00
PM peak	PM	16:00–19:00
Weekday off-peak	OP	06:00–07:00 19:00–20:00
Weekends/bank holidays	WE	10:00–19:00

TUBA input matrices

60-year operational phase

7.2.25 The number of trips, travel times, travel distances and user charge information were input into TUBA in matrix format. These matrices were prepared as described above for all 10 time periods, 10 user classes and four forecast years (2030, 2037, 2045 and 2051). The data was prepared for both the Without Scheme and With Scheme scenarios.

Construction period

7.2.26 The same approach was used for the construction delay appraisal, but matrices were prepared for five time periods.

Trip matrix factors

7.2.27 TUBA guidance provides three options for disaggregating the matrices produced for the 10 user classes (UCs) in the model:

a. Split the matrix externally outside of TUBA using the matrix manipulation facilities provided in the traffic modelling program being used

b. Edit the TUBA economics file to create a new 'all vehicle' vehicle type, with appropriate values of time (VOT), VOC and other parameters

c. Use the factor option in the 'Input_Matrices' table of the project specific TUBA file

7.2.28 The third of these options is DfT's recommended approach and this was adopted for the appraisal. Table 7.4 below shows that there is a direct correspondence between all car user classes in the LTAM model and the relevant user classes in TUBA. Therefore, the factor used in this appraisal was 100% for all car UCs.

Table 7.4 Trip matrix factors for car user classes

LTAM Model User Class	Car Business	Car Commute Low	Car Commute Middle	Car Commute High	Car Other Low	Car Other Middle	Car Other High
Use/Vehicle type	Business	Commute	Commute	Commute	Other	Other	Other
TUBA User Class	1	2	3	4	5	6	7
Matrix proportion	100%	100%	100%	100%	100%	100%	100%

7.2.29 The light and heavy goods vehicle trip matrices were factored for each TUBA user class using the proportions shown in Table 7.5. The light vehicle split is taken from Table A1.3.4 of TAG data book v1.18 (Department for Transport, a).

7.2.30 The heavy vehicle (OGV1 and OGV2) split is taken as 40% / 60% as calculated in the development of National Highways' Regional Traffic Models. The vehicle matrix for OGV1 has a value of 16% and OGV2 has a value of 24% after converting from PCUs to vehicles. The total proportion for HGVs is 40% because the matrices are output from the model in equivalent PCUs. A heavy goods vehicle is modelled as 2.5 PCUs, hence the PCU value is converted to vehicles by multiplying by 40%.

Table 7.5 Trip matrix conversion factors for goods vehicles (PCUs to vehicles)

Model User Class	LGV personal	LGV freight	OGV1	OGV2
Use/Vehicle type	Other	Business	Business	Business
TUBA User Class	8	9	10	11
Matrix proportion	12%	88%	16%	24%

Distance, time and charge matrix factors

7.2.31 The SATURN traffic assignment software uses metres and seconds as units. However, TAG Unit A1.3 (Department for Transport, 2022a), and therefore TUBA, uses kilometres and hours as units. Therefore, a factor of 0.001 was used to convert the SATURN calculated distances between zones into kilometres and a factor of 0.0002778 to convert travel time between zones into hours.

7.2.32 Within LTAM, charges were specified in pence (p) – this is consistent with the approach used by TUBA resulting in a conversion factor of 1.

TUBA runs

7.2.33 The TUBA process compares the economic performance of the With Scheme scenario to that of the Without Scheme scenario to measure the benefits expected due to the Project. The input files for TUBA consist of the following data provided by the transport model for each origin destination zone pair, user class and time period:

a. Number of trips

b. Travel time

c. Distance

d. Average charge paid per trip

7.2.34 A Project file was created containing details of the user classes to be included and the annualisation factors to be applied. This file also lists all of the matrices to be used in the TUBA run to allow the program to select the relevant data for the analysis. In addition, a standard economics file (DfT default file) has been altered to include the values of time calculated for the income bands shown in Table 7.1, the new journey purposes and time periods and a sectoring file created to identify the sectoring system, as listed in Annex A.2.

Sectoring

7.2.35 The area covered by LTAM is divided into 1,013 zones. Although TUBA has sufficient capacity to read data and process results for this number of zones, it cannot produce geographically disaggregated results at this granular level. Therefore, the zones are grouped into sectors and the spatial information on the results are presented at the sector level.

7.2.36 For the appraisal, a 67-sector system was devised. These sectors include the boroughs and districts around the Project, following commonly used geographical boundaries with sectors becoming coarser with increasing distance from the location of the Project. The TUBA sector system is shown in Annex A.2.

Masking

7.2.37 A mask has been applied to the TUBA input matrices in order to remove Origin-Destination (OD) pairs which will not experience any impact from the introduction of the Project.

7.2.38 The masking system has been constructed using the 67-sector system by determining which zone pairings are unlikely to receive benefits from the Project.

7.2.39 All OD pairings with either an Origin or a Destination in the fully modelled area have been included in the analysis, with all other flows outside this criterion being included/excluded on a sector-by-sector basis using information from TUBA and the LTAM transport model.

7.3 60-year operational phase appraisal results

7.3.1 Values of journey time savings, vehicle operating costs and user charge impacts were estimated for the Low, Core and High traffic growth scenarios. These impacts are presented in TEE Table 7.8, Table 7.9 and Table 7.10. More detail is provided in the following annexes:

a. Annexes A.3 to A.10 include various disaggregations of the transport user and provider impacts.

b. Annex A.11 shows the impact of the mask on user benefits.

c. Annex A.12 includes output from the TUBA Economics parameters file.

d. Annex A.13 TUBA N-1 test reports the results of a test to assess the robustness of the Project's user benefits.

7.4 Construction period appraisal results

7.4.1 A total disbenefit value of £130.8m (2010 prices and values) for construction delays has been calculated using TUBA v1.9.18.

7.4.2 This has been split between commuters, other users and business users in line with proportions of user benefits for these groups in the Core growth scenario of the 60-year user appraisal. These values are shown in Table 7.6. The values of user benefits are calculated in total and split between commuters, other users and business users in line with the proportions for these users over the 60-year operational period of the Project.

Table 7.6 Construction delays impacts on users (£m, 2010 prices and values)

	Commuters	Other users	Business users	All users
User benefits	-25.8	-30.5	-74.5	-130.8

7.4.3 The same total value for construction delays has been included in the appraisal results for the Low, Core and High traffic growth scenarios reported in Table 7.8, Table 7.9 and Table 7.10.

7.5 Maintenance delay appraisal results

7.5.1 There will be some disruption to the journey times and possibly journey distances of some road users during planned maintenance work as a result of lane or full road closures.

7.5.2 The economic impacts of traffic delays during maintenance periods over a 60-year period were appraised using National Highways' QUADRO 2019 software version 4, release 17.0.1. The values for the three types of users are shown in Table 7.7. These sum to a disbenefit of £10.0m (2010 prices and values). Annex A.14 explains the assumptions used for this appraisal.

Table 7.7 Maintenance delays and impacts (£m, 2010 prices and values)

	Commuters	Other users	Business users	All users
User delay	-1.5	-1.8	-3.0	**-6.3**
Fuel VOC	-0.1	-0.2	-1.9	**-2.3**
Non-fuel VOC	-0.2	-0.3	-0.9	**-1.4**
Total	**-1.8**	**-2.3**	**-5.9**	**-10.0**

7.5.3 Delays to business users have the higher disbenefit value compared to commuters and other users as they have the highest values of time. Business users include goods vehicles that incur higher fuel and non-fuel operating costs because of their reassignment along longer diversion routes during road closures.

7.5.4 Disaggregation of the total disbenefits by the type of maintenance shows that:

a. 50.5% of the maintenance disbenefits come from the tunnel refurbishment

b. 39.5% of the disbenefits are due to routine maintenance

c. 10% of the disbenefits are from resurfacing work

7.5.5 The same total value for maintenance delays has been included in the appraisal results for the Low, Core and High traffic growth scenarios reported in the TEE tables shown in the next section.

7.6 Transport Economic Efficiency tables

7.6.1 Table 7.8, Table 7.9 and Table 7.10 present the TEE estimates for the Low, Core and High traffic growth scenarios. These include impacts, appraised across the road network over 60 years, on users in respect of journey times, vehicle operating costs and user charges during normal operation, impacts during construction and impacts during planned maintenance periods.

Table 7.8 Transport Economic Efficiency, Low growth (£m, 2010 prices and values)

Non-business: Commuting User benefits	**All modes**	**Road: Private cars and LGVs**	**Bus and coach passengers**	**Rail passengers**	**Other**
Travel time	388.0	388.0	–	–	–
Vehicle operating costs	-34.8	-34.8	–	–	–
User charges	-5.4	-5.4	–	–	–
During construction and maintenance	-27.6	-27.6	–	–	–
Total	**320.2**	**320.2**	–	–	–

Non-business: Other User benefits	**All modes**	**Road: Private cars and LGVs**	**Bus and coach passengers**	**Rail passengers**	**Other**
Travel time	721.8	721.8	–	–	–
Vehicle operating costs	-271.8	-271.8	–	–	–
User charges	-26.1	-26.1	–	–	–
During construction and maintenance	-32.8	-32.8	–	–	–
Total	**391.1**	**391.1**	–	–	–

Business: User benefits	**All vehicle types**	**Goods vehicles**	**Business cars and LGVs**	**Passengers**	**Freight**
Travel time	761.1	283.0	478.1	–	–
Vehicle operating costs	242.4	189.9	52.4	–	–
User charges	-25.4	-13.6	-11.8	–	–
During construction and maintenance	-80.4	-38.7	-41.7	–	–
Sub-total	**897.7**	**420.7**	**477.0**	–	–

Business: Private sector provider impacts	**All impacts**			**Passengers**	**Freight**
Revenue	–			–	–
Operating costs	–			–	–
Investment costs	–			–	–
Grants/subsidy	–			–	–
Sub-total	–			–	–

Other business impacts	–
Developer contributions	–
Net business impact	**897.7**

Total	–
Efficiency benefits	**1,608.9**

Table 7.9 Transport Economic Efficiency, Core growth (£m, 2010 prices and values)

Non-business: Commuting User benefits	**All modes**	**Road: Private cars and LGVs**	**Bus and coach passengers**	**Rail passengers**	**Other**
Travel time	434.5	434.5	–	–	–
Vehicle operating costs	-39.3	-39.3	–	–	–
User charges	-5.9	-5.9	–	–	–
During construction and maintenance	-27.6	-27.6	–	–	–
Total	**361.6**	**361.6**	–	–	–

Non-business: Other User benefits	**All modes**	**Road: Private cars and LGVs**	**Bus and coach passengers**	**Rail passengers**	**Other**
Travel time	778.6	778.6	–	–	–
Vehicle operating costs	-290.8	-290.8	–	–	–
User charges	-28.4	-28.4	–	–	–
During construction and maintenance	-32.8	-32.8	–	–	–
Total	**426.7**	**426.7**	–	–	–

Business: User benefits	**All vehicle types**	**Goods vehicles**	**Business cars and LGVs**	**Passengers**	**Freight**
Travel time	875.1	337.8	537.3	–	–
Vehicle operating costs	280.4	220.8	59.7	–	–
User charges	-32.3	-18.3	-14.0	–	–
During construction and maintenance	-80.4	-38.7	-41.7	–	–
Sub-total	**1,042.9**	**501.7**	**541.2**	–	–

Business: Private sector provider impacts	**All impacts**	**Passengers**	**Freight**
Revenue	–	–	–
Operating costs	–	–	–
Investment costs	–	–	–
Grants/subsidy	–	–	–
Sub-total	–	–	–

Other business impacts	–
Developer contributions	–
Net business impact	**1,042.9**

Total	–
Efficiency benefits	**1,831.2**

Table 7.10 Transport Economic Efficiency, High growth (£m, 2010 prices and values)

Non-business: Commuting User benefits	All modes	Road: Private cars and LGVs	Bus and coach passengers	Rail passengers	Other
Travel time	490.2	490.2	–	–	–
Vehicle operating costs	-43.6	-43.6	–	–	–
User charges	-6.5	-6.5	–	–	–
During construction and maintenance	-27.6	-27.6	–	–	–
Total	**412.4**	**412.4**	–	–	–

Non-business: Other User benefits	All modes	Road: Private cars and LGVs	Bus and coach passengers	Rail passengers	Other
Travel time	843.0	843.0	–	–	–
Vehicle operating costs	-306.2	-306.2	–	–	–
User charges	-29.9	-29.9	–	–	–
During construction and maintenance	-32.8	-32.8	–	–	–
Total	**474.2**	**474.2**	–	–	–

Business: User benefits	**All vehicle types**	**Goods vehicles**	**Business cars and LGVs**	**Passengers**	**Freight**
Travel time	1,010.4	395.7	614.7	–	–
Vehicle operating costs	325.5	257.3	68.1	–	–
User charges	-42.8	-26.5	-16.3	–	–
During construction and maintenance	-80.4	-38.7	-41.7	–	–
Sub-total	**1,212.7**	**587.9**	**624.8**	–	–

Business: Private sector provider impacts	**All impacts**			**Passengers**	**Freight**
Revenue	–			–	–
Operating costs	–			–	–
Investment costs	–			–	–
Grants/subsidy	–			–	–
Sub-total	–			–	–

Other business impacts	–
Developer contributions	–
Net business impact	**1,212.7**

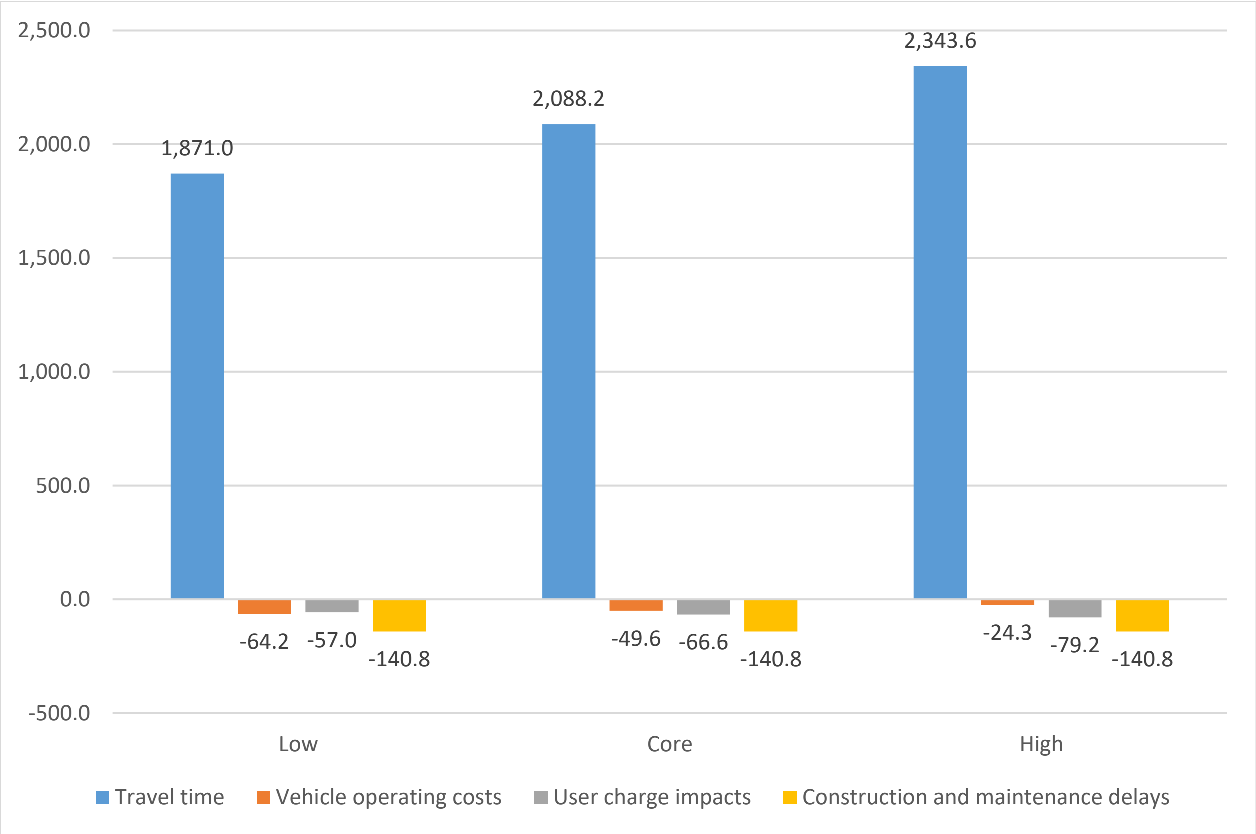
Total	–
Efficiency benefits	**2,099.3**

7.6.2 Table 7.11 and Plate 7.1 summarise the TEE impacts under the three traffic growth scenarios. These range from £1,608.9m (Low) to £2,099.3m (High) with a Core growth value of £1,831.2m. The dominance of travel time savings within TEE impacts is clearly shown.

Table 7.11 TEE impacts: Low, Core and High scenarios (£m, 2010 prices and values)

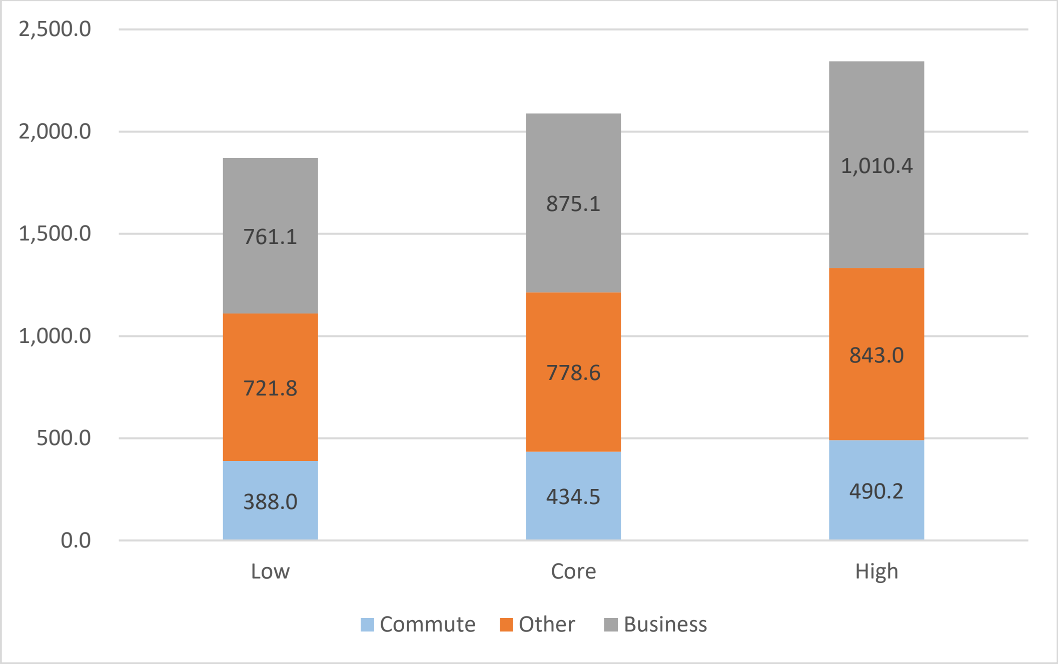
	Low growth £m	**Core growth £m**	**High growth £m**
Travel time	1,871.0	2,088.2	2,343.6
Vehicle operating costs	-64.2	-49.6	-24.3
User charge impacts	-57.0	-66.6	-79.2
Construction and maintenance delays	-140.8	-140.8	-140.8
Total	**1,608.9**	**1,831.2**	**2,099.3**

Plate 7.1 TEE impacts: Low, Core and High scenarios



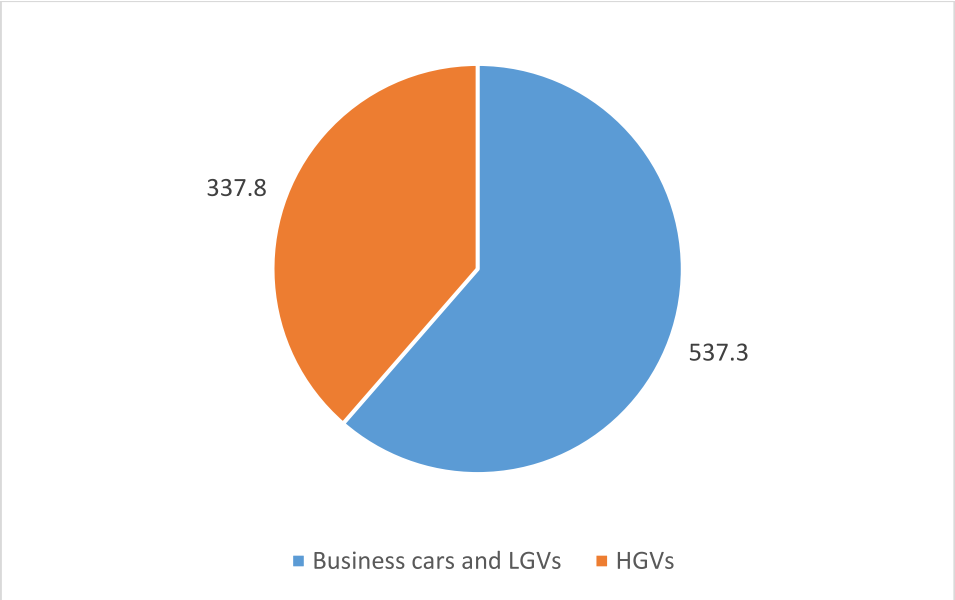
7.6.3 Plate 7.2 disaggregates travel time savings under the three traffic growth scenarios. It shows that business user time savings account for the largest share of savings (between 41% and 43%) under the three growth scenarios.

Plate 7.2 Travel time savings, Core traffic growth (£m, 2010 prices and values)



7.6.4 Plate 7.3 shows that of the £875.1m business user time savings under the Core growth scenario, business cars and LGVs account for £537.3m (61%) and goods vehicles account for £337.8m (39%) of this total.

Plate 7.3 Business travel time savings, Core traffic growth (£m, 2010 prices and values)



8 Level 1: Other impacts

8.1 Introduction

8.1.1 This chapter summarises the approaches used to appraise and calculate other Level 1 impacts of the Project and reports quantitative metrics and monetary values for these impacts.

8.1.2 The other Level 1 impacts comprise:

a. Noise

b. Air quality

c. Physical activity

d. Greenhouse gases

e. Accidents

f. Indirect tax revenues

8.2 Noise impacts

8.2.1 TAG requires that a noise appraisal of a transport intervention is carried out and monetary values calculated for the noise impacts of the Project.

8.2.2 An appraisal of the noise impacts of the Project, based on LTAM core traffic growth forecasts, has been undertaken for the Core traffic growth scenario and using the TAG noise workbook, in line with TAG guidance.

8.2.3 This appraisal is based on LTAM model runs LR_CM45 (Without Scheme) and LR_CS67 (With Scheme). However, the difference in impacts between these slightly earlier LTAM model runs and the LR_CM49 (Without Scheme) and LR_CS72 (With Scheme) model runs used for the economic and social impacts has been assessed as negligible.

8.2.4 The appraisal provides estimates for the forecast year of 2045 of the number of households that experience:

a. Increases in daytime noise

b. Reductions in daytime noise

c. Increases in night-time noise

d. Reductions in night-time noise

8.2.5 The appraisal also estimates the monetary value of noise impacts on amenity and human health.

8.2.6 The key appraisal outputs are presented in the TAG noise workbook and AST in the Appraisal Summary Table Report.Table 8.1 presents the numbers of households experiencing changes in noise for the Core growth scenario.

Table 8.1 Households experiencing changes in noise (2045)

Type of impact	No. of households
Households experiencing increased daytime noise	6,015
Households experiencing reduced daytime noise	5,679
Households experiencing increased night-time noise	5,695
Households experiencing reduced night-time noise	5,002

8.2.7 The monetary value for noise impacts includes the effect on sleep disturbance, amenity, acute myocardial infarction (AMI), stroke and dementia. Table 8.2 reports the monetary values for the different noise impacts and in total for the core traffic growth scenario over the 60-year appraisal period. The total value of these noise impacts is an overall benefit of £3.4m (2010 prices and values).

8.2.8 Due to the low value of these benefits, following the principle of proportionate appraisal, the Core traffic growth value is used in the appraisal of the Low and High traffic growth scenarios.

Table 8.2 Noise monetised values (£m, 2010 prices and values)

Impact	£m
Sleep disturbance	1.2
Amenity	1.3
Acute myocardial infarction	0.4
Stroke	0.2
Dementia	0.2
Total	3.4

8.3 Air quality impacts

8.3.1 TAG requires that an air quality appraisal of a transport intervention is carried out and monetary values calculated for the impacts of changes in the emissions of two air quality pollutants – nitrogen dioxide (NO_2) and particulate matter ($PM_{2.5}$).[6]

8.3.2 An appraisal of the impacts of the Project on the change in NO_2 and $PM_{2.5}$ emitted by traffic, based on LTAM traffic forecasts, has been undertaken for the Core traffic growth scenario and using the TAG air quality workbook, in line with TAG guidance.

8.3.3 This appraisal is based on LTAM model runs LR_CM45 (Without Scheme) and LR_CS67 (With Scheme). However, the difference in impacts between these slightly earlier LTAM model runs and the LR_CM49 (Without Scheme) and LR_CS72 (With Scheme) model runs used for the economic and social impacts has been assessed as negligible.

[6] $PM_{2.5}$ refers to particulate matter with a diameter of less than 2.5 micrometres.

8.3.4 The appraisal uses the Impact Pathway Approach to estimate assessment scores that reflect the change in pollutant concentrations over the population of receptors assessed over the 60-year period from scheme opening.

8.3.5 The appraisal also estimates the monetary values of NO_2 and $PM_{2.5}$ emissions on air quality.

8.3.6 The results are presented in the TAG air quality workbook and AST in the Appraisal Summary Table Report.

8.3.7 Table 8.3 presents the monetary values for air quality impacts in the Core traffic growth scenario over the 60-year appraisal period. The total value of these air quality impacts is a disbenefit of £7.8m.

8.3.8 Following the principle of proportionate appraisal, the Core traffic growth value is used in the appraisal of the Low and High growth scenarios.

Table 8.3 Air quality monetised values (£m, 2010 prices and values)

Impact	£m
NO_2	-4.4
$PM_{2.5}$	-3.4
Total	**-7.8**

8.4 Physical activity

8.4.1 The monetary value of benefits from the Project's provision of new and improved walking and cycling facilities was calculated using the May 2022 version of DfT's Active Mode Appraisal Toolkit (AMAT) (Department for Transport, 2022c). The toolkit implements the guidance set out in TAG Unit A5.1 (Department for Transport, 2020b).

8.4.2 The physical activity benefits of the Project are estimated for the number of new active mode users which comprise walkers and cyclists. These benefits include:

a. Health benefits for people using the new and improved facilities and a decrease in their absenteeism from work

b. Benefits from users' perceptions of the improved quality of the facilities provided

c. Benefits from having fewer vehicles on the road, as some of the users of the new facilities would otherwise have used a car or taxi for their journey

8.4.3 The appraisal does not assess the impacts of the Project on equestrian users.

8.4.4 This section sets outs the appraisal assumptions and appraisal results.

Appraisal assumptions

Provision

8.4.5 The Project's provision for walkers, cyclists and horse riders is set out in the Project Design Report Appendix E (Application Document 7.4). It includes improvements to existing footways, cycle paths and bridleways and new footways, cycle paths and bridleways, dedicated bridges and new signalised crossings as set out below:

a. 27km of improved footpaths, of which 5km are also cycle paths
b. 40km of new footpaths, of which 14km are also cycle paths
c. New bridges such as those over the M25, A127, Mardyke
d. Widened and improved bridges such as at Rectory Road
e. 8 new Pegasus crossings
f. 7 new signalised pedestrian and cycle crossings
g. A new car park, toilet facilities and cycle hire facility to the south of Thong village

Existing usage

8.4.6 Surveys were carried out on a selection of Public Rights of Way (PRoWs) in the Lower Thames area over multiple days during August and September 2019. The survey results are presented in Appendix A of the Transport Assessment (Application Document 7.9).

8.4.7 An average daily number of 492 cyclists and 629 pedestrians were recorded on the selection of routes that were covered by the survey. For some PRoW, the usage levels recorded were very low, less than five trips a day, while for others, such as those on National Cycle Network Route 177, usage levels were much higher at over 100 trips per day.

8.4.8 For this appraisal, in determining existing daily usage levels account has been taken of the length of the current PRoW network in the Lower Thames area, both north and south of the Thames and the presence of National Cycle Network Routes 1 and 177. On this basis it is estimated that there are 600 existing cycling trips per day and 800 existing walking trips per day on the current walking and cycling network.

Increased usage

8.4.9 The AMAT requires estimates of the increase in the number of users of the walking and cycling network as a result of the changes provided by the Project. The changes as a result of the Project include a new car park with cycle hire facilities, improvements to over 27km of existing routes, the provision of over 40km of new routes, new signalised crossings and new bridges.

8.4.10 Case studies of other walking and cycling interventions show that after improvements:

a. There was a 35% increase in usage on the 25km Bristol and Bath Railway Path from 2002 to 2003 (Department for Transport, 2005)
b. There was a 110% annual average increase in usage on the 11km Lincoln to Harby traffic-free path from 2001 to 2003 (Department for Transport, 2005)

8.4.11 For this appraisal, an increase in daily usage of 50% was assumed for both pedestrians and cyclists due to the Project. This is likely to be a conservative assumption given the large amount of new walking and cycling infrastructure that would be provided by the Project.

8.4.12 It is also assumed that the background level of growth in walking and cycling is 0.75% per year, which is the default rate provided in the AMAT. This growth is capped in the appraisal after 30 years from the 2022 scheme appraisal year.

Average trip length

8.4.13 The average length of a cycle trip that uses the network is assumed to be 10km, with 9km of trips using new or improved facilities provided by the Project.

8.4.14 For walk trips the average length of the trip is assumed to be 3km, with 80% of trips using the new or improved footpaths.

Appraisal period

8.4.15 The appraisal period used was 60 years from the Project opening in 2030.

Other assumptions

8.4.16 All other appraisal assumptions are the default values provided in the AMAT.

Appraisal results

Health benefits

8.4.17 The new active mode users will gain health benefits from a decrease in their mortality rate and, on average, the number of deaths among these new users will reduce very slightly in any given year. The monetary value of the reduced risk of premature death is £17.2m (2010 prices and values).

8.4.18 Improved health for these new users from increased walking and cycling activity will also lead to reductions in short-term absences from work. The value of this benefit is £2.92m (2010 prices and values).

8.4.19 These health benefits usually produce the largest monetary values in the appraisal of walking and cycling schemes and this is also the case here.

Journey quality benefits

8.4.20 The improvements to footpaths are predominantly resurfacing and the widening of some sections. Both existing and new users of the network would enjoy these improvements in their journey quality. The value of this benefit is estimated at £0.34m. This is an underestimate of the true value because it excludes the benefits from the provision of new bridges and signalised crossing points.

Mode shift benefits

8.4.21 Modal shift from car to walking and cycling will result in a reduction in the number of car trips and car kilometres driven. As a result, there will be decongestion benefits for other road users from a lower level of traffic on the road network and environmental benefits from reductions in air pollution, noise and road user greenhouse gas emissions.

8.4.22 As more pedestrians and cyclists will be using segregated footpaths and cycleways then the number and severity of accidents will reduce and the value of this is £0.11m.

8.4.23 There will also be a very small reduction in infrastructure maintenance costs.

8.4.24 Central government will receive less indirect tax revenue from the sale of petrol and diesel and this is offset against the benefits from the reduced number of car kilometres driven.

8.4.25 The total value of mode shift benefits resulting from a reduction in the number of car kilometres driven is £0.84m.

Total value of benefits

8.4.26 The total value of the benefits of the scheme, as calculated using the AMAT is £21.2m (2010 prices and values), although this is likely an underestimate of their true economic value. The value of each of the health, journey quality and mode shift benefits in £m (2010 prices and values) are shown in Table 8.4.

8.4.27 The small values for mode shift benefits – local air quality, noise, greenhouse gas emissions, accidents and indirect tax revenues – are not added to the relevant values for these impacts in the main appraisal but are retained within the Physical Activity Appraisal.

Table 8.4 Physical activity benefits (£m, 2010 prices and values)

Type of benefit	Benefits	Central case
Health	Reduced risk of premature death	17.109
	Absenteeism	2.921
Journey quality	Journey ambience	0.338
Mode shift	Decongestion benefit	0.693
	Local air quality	0.014
	Noise	0.007
	Greenhouse gases	0.045
	Accidents	0.110
	Infrastructure maintenance	0.004
	Indirect taxation	-0.032
	Total benefits	**21.208**

Sensitivity tests

8.4.28 Sensitivity tests have been undertaken to assess the impact of different assumed levels of new walking and cycling trips due to the Project. Table 8.5 shows that the benefits range from £10.7m (Low increase) to £31.7m (High increase).

Table 8.5 Physical activity sensitivity tests (£m, 2010 prices and values)

Type of benefit	Benefits	Low	Central case	High
Health	Reduced risk of premature death	8.554	17.109	25.663
	Absenteeism	1.460	2.921	4.381
Journey quality	Journey ambience	0.304	0.338	0.372
Mode shift	Decongestion benefit	0.346	0.693	1.039
	Local air quality	0.007	0.014	0.021
	Noise	0.004	0.007	0.011
	Greenhouse gases	0.023	0.045	0.068
	Accidents	0.055	0.110	0.165
	Infrastructure maintenance	0.002	0.004	0.005
	Indirect taxation	-0.016	-0.032	-0.048
	Total benefits	**10.739**	**21.208**	**31.677**

8.5 Greenhouse gas emissions

8.5.1 TAG requires that an appraisal is undertaken and monetary values calculated for the impacts of a transport intervention on greenhouse gas emissions.

8.5.2 The Project's appraisal includes estimates of road user tailpipe and embodied greenhouse gas (GHG) emissions. More detail about these emissions is set out in the Carbon and Energy Management Plan (Application Document 7.19).

Tailpipe road user emissions

8.5.3 This appraisal is based on LTAM model runs LR_CM45 (Without Scheme) and LR_CS67 (With Scheme). However, the difference in impacts between these slightly earlier LTAM model runs and the LR_CM49 (Without Scheme) and LR_CS72 (With Scheme) model runs used for the economic and social impacts has been assessed as negligible.

8.5.4 Based on the traffic outputs from the LTAM model, estimates of GHG have been generated of the additional tonnes of untraded and traded CO_2 equivalent (CO_2e) emissions that road users will generate over 60 years from Project opening as a result of the Project. An annual profile of these emissions has been produced using the TAG greenhouse gas emissions workbook and the monetary value of these emissions has been generated using National Highways Carbon Valuation Toolkit v1.4.2.

Embodied carbon emissions

8.5.5 The Project is projected to generate four types of embodied carbon emissions:

a. Construction carbon – The Project is based on a low carbon construction design and construction emissions have been modelled to reflect the Project's construction programme and use of the low carbon materials during construction. Over the construction period the Project is projected to generate

1.078 million tonnes of traded and 0.685 million tonnes of non-traded carbon over its construction phase – a total of 1.763 million tonnes.

b. Operational emissions – The Project has been designed to generate zero non-traded and zero traded operational carbon emissions during its 60-year operational phase from scheme opening in 2030, based on National Highways Net zero plan (National Highways, b).

c. Maintenance emissions – The Project's maintenance programme will be designed to generate zero non-traded and traded emissions from 2040 based on National Highways Net zero plan (National Highways, b). Therefore, an estimate of the Project's annual maintenance emissions of 29,763 tonnes has been produced based on its maintenance programme to 2039. These emissions have been assumed to be constant for each year between 2030 and 2039. It has been assumed that there is a 95% / 5% split of these emissions between non-traded (28,274 tonnes) and traded (1,488 tonnes) emissions.

d. Renewals emissions –- The Project's renewals programme will be designed to generate zero non-traded and traded emissions from 2040 based on National Highways Net zero plan (National Highways, b). An estimate of the Project's average annual renewals emissions of 850 tonnes has been produced. These emissions have been profiled over the period 2030 to 2039 in line with the Project's profile of renewals expenditure in this period. Based on the relative percentages of traded and non-traded construction emissions, 60% of renewals emissions are assumed to be traded (520 tonnes) and 40% of renewals emissions are assumed to be non-traded (331 tonnes).

8.5.6 The Project's operational, maintenance and renewals emissions total 28,605 tonnes of non-traded emissions and 2,008 tonnes of traded emissions and sum to a total of 30,613 tonnes.

8.5.7 The total greenhouse gas emissions from the Project are 6.6 million tonnes and reflect the difference between the Without Scheme and With Scheme scenarios.

8.5.8 The estimates of untraded and traded tailpipe and embodied carbon emissions in tonnes, in total and for each five-year Carbon Budget (CB) period, are shown in Table 8.6.

8.5.9 Table 8.7 reports that the monetary values of traded and untraded tailpipe and embodied emissions, based on the latest central prices of carbon in TAG data book v1.18, are £101.3m and £424.7m, which sum to £526.1m.

Table 8.6 Carbon tonnes (tCO_2e)

Source of emissions	Type of emissions	Total	CB3 (2018–22)	CB4 (2023–27)	CB5 (2028–32)	CB6 (2033–37)
Tailpipe emissions	Change in traded carbon over 60 years (tCO_2e)	104,079	0	0	4,266	7,822
	Change in non-traded carbon over 60 years (tCO_2e)	4,699,070	0	0	271,075	439,094
	Total change in carbon over 60 years (tCO_2e)	**4,803,149**	**0**	**0**	**275,341**	**446,916**
Construction emissions	Change in traded carbon over 60 years (tCO_2e)	1,077,533	0	701,858	375,676	0
	Change in non-traded carbon over 60 years (tCO_2e)	685,434	0	446,461	238,972	0
	Total change in carbon over 60 years (tCO_2e)	**1,762,967**	**0**	**1,148,319**	**614,648**	**0**
Operational, renewals and maintenance emissions	Change in traded carbon over 60 years (tCO_2e)	2,008	0	0	557	974
	Change in non-traded carbon over 60 years (tCO_2e)	28,607	0	0	8,554	14,284
	Total change in carbon over 60 years (tCO_2e)	**30,615**	**0**	**0**	**9,111**	**15,258**
Total across all sources	**Total change in carbon over 60 years (tCO_2e)**	**6,596,731**	**0**	**1,148,319**	**899,099**	**462,174**

Note: Excludes tonnes of tailpipe greenhouse gas emissions due to maintenance delays

Table 8.7 Carbon monetised values (£m, 2010 prices and values)

	Tailpipe emissions	Construction and maintenance emissions	Operating, emissions	Total
Present Value of traded carbon over 60 years (£ 2010 prices and values)	5.4	95.9	0	**101.3**
Present Value of non-traded carbon over 60 years (£ 2010 prices and values)	338.4	86.3	0	**424.7**
Present Value of all carbon over 60 years (£ 2010 prices and values)	**343.8**	**182.3**	**0**	**526.1**

Note: Excludes the value of tailpipe greenhouse gas emissions due to maintenance delays which is £1.7m (2010 prices and values).

8.5.10 There is a small additional disbenefit of £1.7m for additional carbon emissions from maintenance delays. This is added to the total in in Table 8.7.

8.5.11 The total disbenefit value for greenhouse gas emissions included within the central case appraisal is £527.8m. This total value is also included in the Low and High traffic growth scenarios.

8.5.12 Sensitivity tests are included in Chapter 11 that show the impact on greenhouse gases of the impact of Transport Decarbonisation Plan policies.

8.6 Accidents

8.6.1 DfT's COBALT software program version 2.3 was used to forecast the total numbers of personal injury accidents (PIAs) and casualties by severity of injury (fatal, serious and slight) over the 60-year period from scheme opening. COBALT v2.3 is based on appraisal parameters in TAG data book v1.18.

8.6.2 The numbers of accidents, casualties and accident rates were calculated for the Without Scheme and With Scheme scenarios and the differences between the scenarios are presented below. The COBALT program also calculates monetary values for the accident costs and the sum of this is included, along with a monetary value for accidents from the QUADRO appraisal of maintenance delays, in the Project's central case appraisal.

8.6.3 While the number of accidents and casualties over the Project's 60-year operational phase rises due to the increased volume of traffic on the road network, resulting in accident disbenefits, the accident rate per vehicle km is forecast to reduce (see Table 8.12).

8.6.4 This section:

a. provides information on the actual number of accidents on key links in the Lower Thames area between 2011 and 2019

b. sets out the approach to determining the accidents appraisal area

c. explains the calculation of accident rates used in the appraisal

d. presents the accidents appraisal results for the Core traffic growth scenario

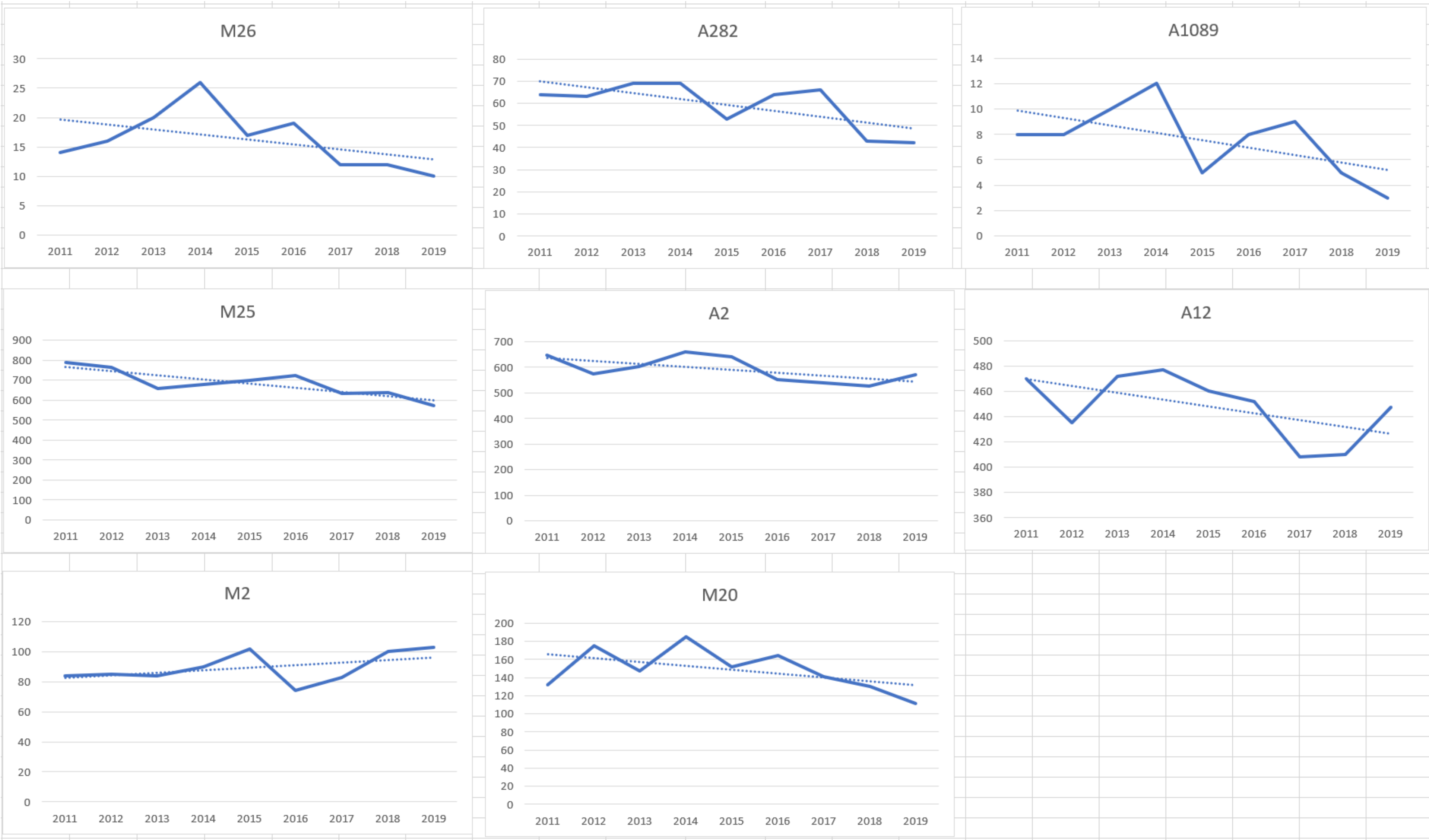
e. includes the result of a sensitivity test

Analysis of accident rates in the Lower Thames area

8.6.5 To inform the accident appraisal, an analysis was undertaken of the numbers of accidents and accident severities between 2011 and 2019 in both directions along the entire lengths of eight key roads within the Lower Thames area – M26, A282, A1089, M25, A2, A12, M2 and M20.

8.6.6 Plate 8.1 shows that the number of accidents has declined, over time, on all of these roads except for the M2. The annual average daily traffic (AADT) along each of these roads has risen and therefore it is expected that the unique calculated local accident rates will reduce over time.

Plate 8.1 Numbers of accidents on key roads, 2011 to 2019



f.

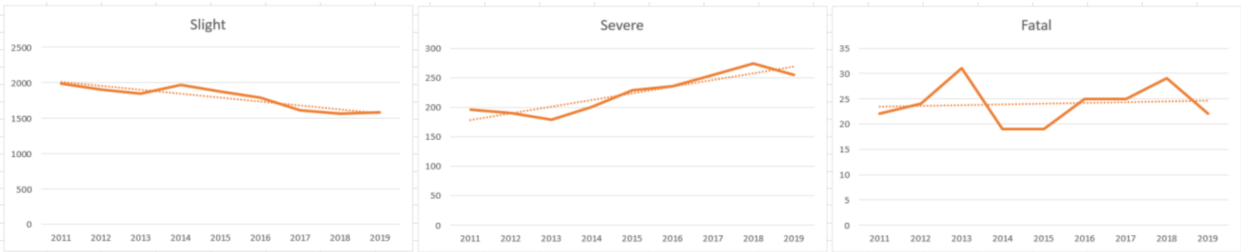
8.6.7 Plate 8.2 shows that across all of the eight roads:

a. The number of slight accidents has declined.

b. The number of severe accidents has increased.

c. The number of fatal accidents has remained constant.

Plate 8.2 Numbers of accidents by severity on key links, 2011 to 2019



8.6.8 Within the period 2011–2019 slight accidents, on average, represent approximately 86% of total accidents across all key links. Therefore, while the number of severe accidents is shown to have increased, this is disproportionate to the number of slight accidents (which are reducing). Most notably, the number of fatal accidents has remained constant and represents 2% of total accidents.

Appraisal area Table 8.8.

8.6.9 Plate 8.3 shows the impacted road links included within the accident appraisal area. Plate 8.4 shows more clearly the impacted road links that are located close to the Project.

8.6.10 The appraisal area was determined by identifying the links with flow changes of 5% or more, and a flow change of above 200 vehicles AADT in 2045, when comparing the With Scheme and Without Scheme scenarios. Additionally, links on the SRN which extend outside the above area were included to fully capture the benefits/disbenefits on key strategic routes in the fully modelled area. Descriptions of the SRN extensions are provided in Table 8.8.

Plate 8.3 Accidents appraisal area

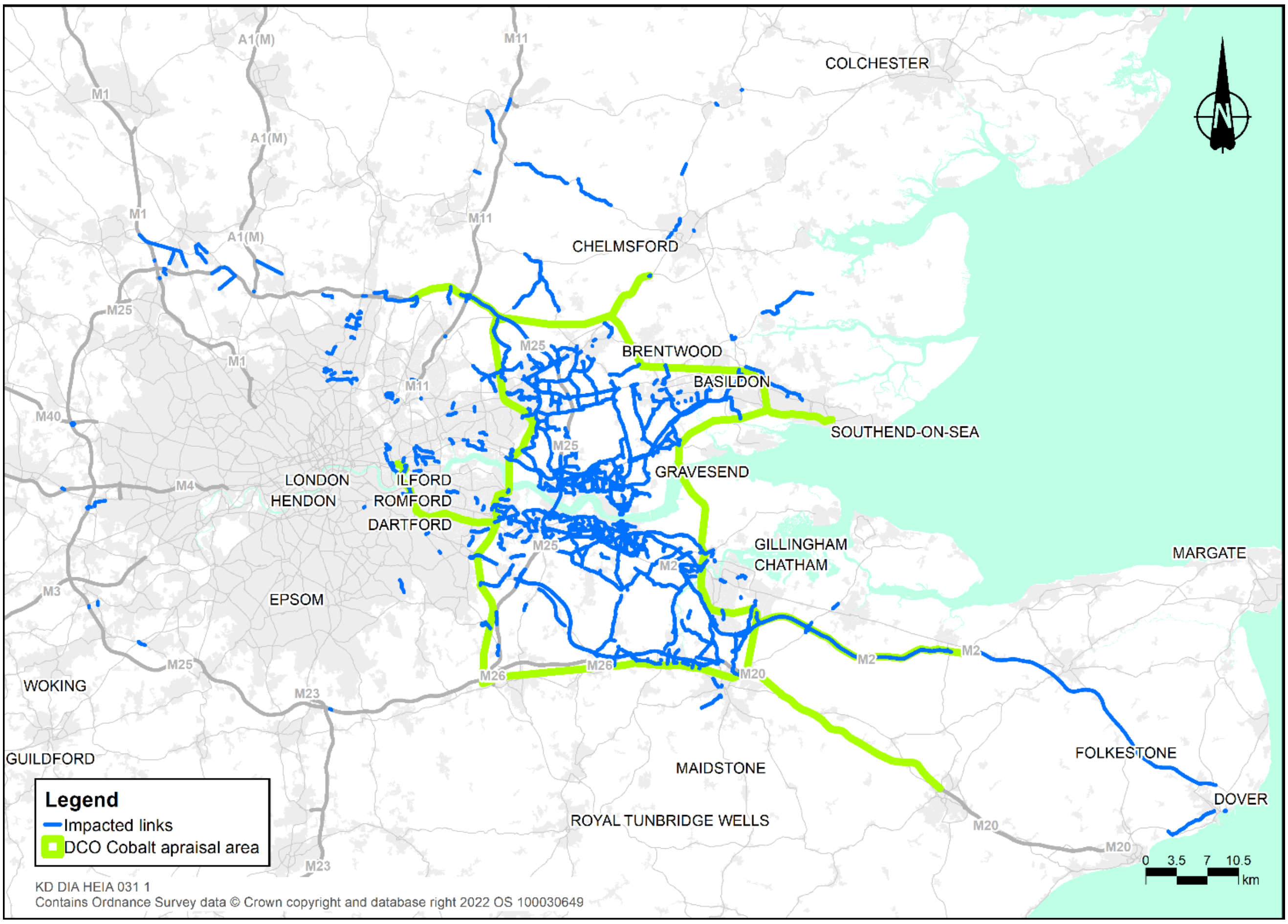


Plate 8.4 Impacted road links in the accidents appraisal close to the Project

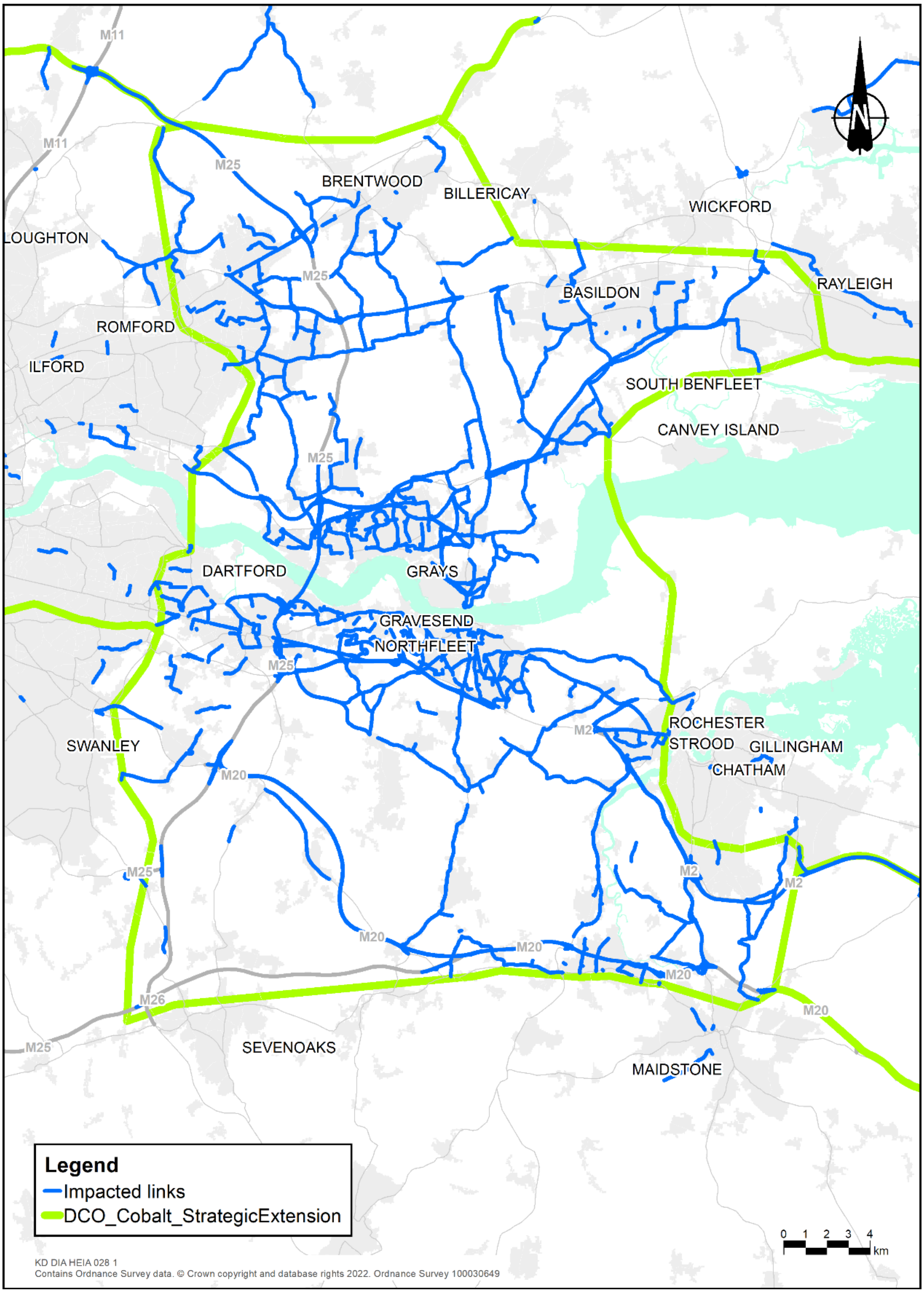


Table 8.8 Accidents appraisal extended SRN links

Road section	Description of extension
M2	Extended up to J7
M20	Extended up to J9
M25 (northern)	Extended up to J26
A12	Extended up to J15
A13 (eastern)	Extended up to Southend-on-Sea
A2 (western)	Extended up to Silvertown Tunnel project

Accident rates

8.6.11 The accident benefits for a road project are derived by applying accident rates to the change in traffic flow on each link to estimate the change in the total number of expected accidents once the project is built.

8.6.12 Accident rates are expressed as PIAs per million vehicle kilometres. TAG provides default accident rates for various types of roads for appraisal. However, it is preferable to use study-area-specific accident rates when such local data for a project’s appraisal area is available. This is because local accident rates provide a more robust estimate of accident benefits compared to the default rates, which are based on national averages.

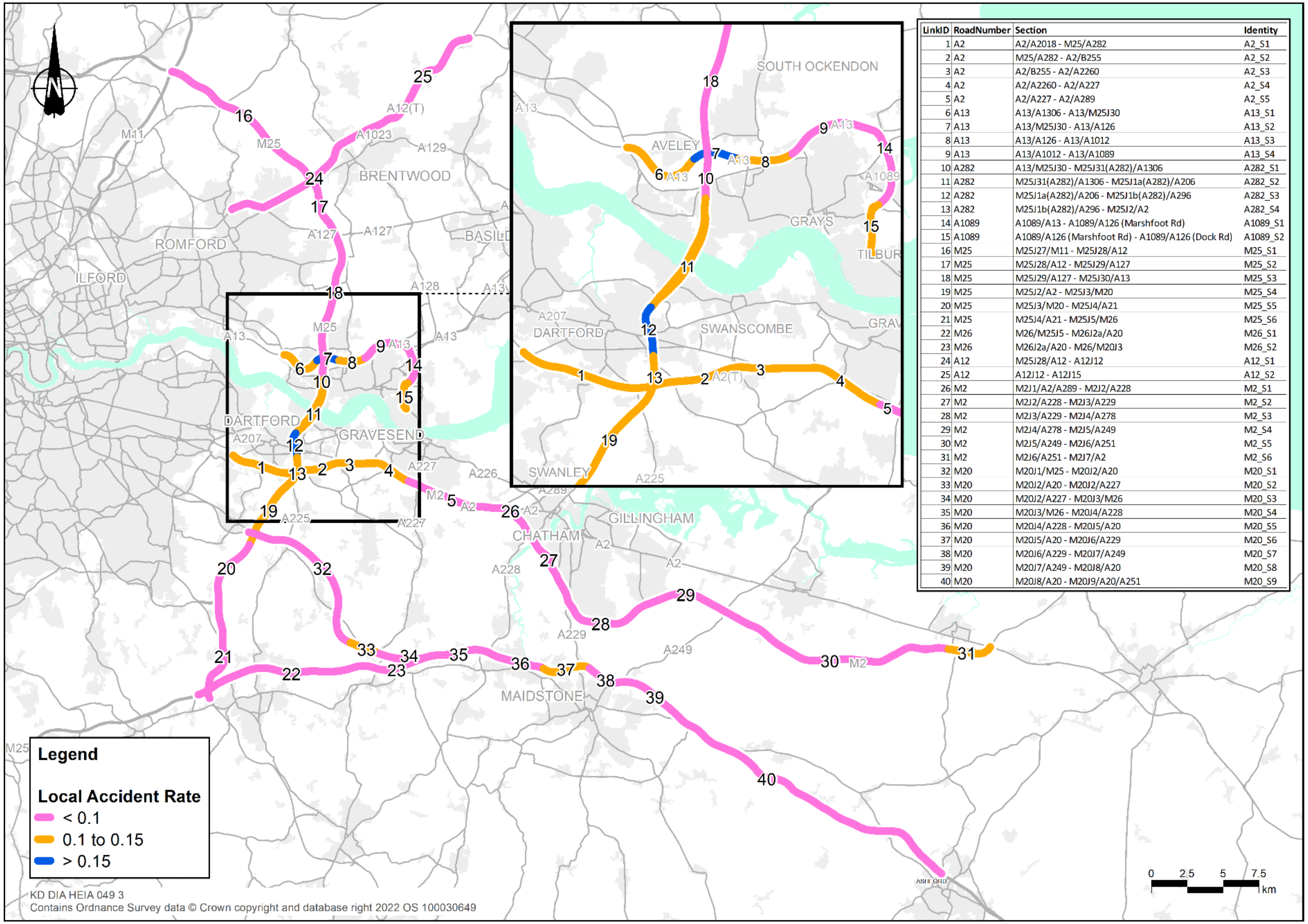
8.6.13 Local accident rates were calculated based on two data sources: STATS19 data (Department for Transport b) and AADT data from National Highways TRIS system of continuous traffic count sites (National Highways a), which are mainly located on the SRN. Local accident rates were calculated based on data for the period from 2015 to 2019. Despite 2020 STATS19 and traffic count data being available, this year was removed from the analysis as the impacts of the COVID-19 pandemic were judged to provide non-representative levels of flows and accidents.

8.6.14 It was not possible to derive local accident rates for each road link within the study area because of the lack of a sufficient quantity of robust data over a consecutive five-year period. Hence, for the appraisal, local accident rates were derived mainly for SRN roads within the appraisal area for which local accident rate information could be derived and national rates were used for the other roads. Insufficient data was available from traffic count sites along the A13 in order to calculate a local accident rate for 2015–2019. Therefore, the local accident rate for A13 links has been calculated using the latest available 5-year period of continuous data collection which is 2011–2015. Plate 8.5shows the roads for which local accident rates were used in the appraisal.

8.6.15 Each road was divided into sections between junctions and local accident rates were calculated for each section. Table 8.9 shows the summary of average accident rates for each road for which a local accident rate has been calculated.

8.6.16 For the central case scenario, the Lower Thames Crossing was classified as a motorway because in terms of accidents it has more motorway characteristics than those of an average all-purpose trunk road, for example 70mph speed limits, segregated junctions, non-motorway traffic prohibited and the distance between junctions.

Plate 8.5 Roads where local accident rates were used in the appraisal



LinkID	RoadNumber	Section	Identity
1	A2	A2/A2018 - M25/A282	A2_S1
2	A2	M25/A282 - A2/B255	A2_S2
3	A2	A2/B255 - A2/A2260	A2_S3
4	A2	A2/A2260 - A2/A227	A2_S4
5	A2	A2/A227 - A2/A289	A2_S5
6	A13	A13/A1306 - A13/M25J30	A13_S1
7	A13	A13/M25J30 - A13/A126	A13_S2
8	A13	A13/A126 - A13/A1012	A13_S3
9	A13	A13/A1012 - A13/A1089	A13_S4
10	A282	A13/M25J30 - M25J31(A282)/A1306	A282_S1
11	A282	M25J31(A282)/A1306 - M25J1a(A282)/A206	A282_S2
12	A282	M25J1a(A282)/A206 - M25J1b(A282)/A296	A282_S3
13	A282	M25J1b(A282)/A296 - M25J2/A2	A282_S4
14	A1089	A1089/A13 - A1089/A126 (Marshfoot Rd)	A1089_S1
15	A1089	A1089/A126 (Marshfoot Rd) - A1089/A126 (Dock Rd)	A1089_S2
16	M25	M25J27/M11 - M25J28/A12	M25_S1
17	M25	M25J28/A12 - M25J29/A127	M25_S2
18	M25	M25J29/A127 - M25J30/A13	M25_S3
19	M25	M25J2/A2 - M25J3/M20	M25_S4
20	M25	M25J3/M20 - M25J4/A21	M25_S5
21	M25	M25J4/A21 - M25J5/M26	M25_S6
22	M26	M26/M25J5 - M26J2a/A20	M26_S1
23	M26	M26J2a/A20 - M26/M20J3	M26_S2
24	A12	M25J28/A12 - A12J12	A12_S1
25	A12	A12J12 - A12J15	A12_S2
26	M2	M2J1/A2/A289 - M2J2/A228	M2_S1
27	M2	M2J2/A228 - M2J3/A229	M2_S2
28	M2	M2J3/A229 - M2J4/A278	M2_S3
29	M2	M2J4/A278 - M2J5/A249	M2_S4
30	M2	M2J5/A249 - M2J6/A251	M2_S5
31	M2	M2J6/A251 - M2J7/A2	M2_S6
32	M20	M20J1/M25 - M20J2/A20	M20_S1
33	M20	M20J2/A20 - M20J2/A227	M20_S2
34	M20	M20J2/A227 - M20J3/M26	M20_S3
35	M20	M20J3/M26 - M20J4/A228	M20_S4
36	M20	M20J4/A228 - M20J5/A20	M20_S5
37	M20	M20J5/A20 - M20J6/A229	M20_S6
38	M20	M20J6/A229 - M20J7/A249	M20_S7
39	M20	M20J7/A249 - M20J8/A20	M20_S8
40	M20	M20J8/A20 - M20J9/A20/A251	M20_S9

Table 8.9 Roads where local accident rates were used in the appraisal

								4 lanes	3 lanes	2 lanes	
Road	**A2**	**A13**	**A282**	**A1089**	**M25**	**M26**	**A12**	**M2 J1-J3**	**M2 J3-J4**	**M2 J4-J7**	**M20 J1-J9**
Between junctions	A2/A2018 to A2/A289	A13/A1306 to A13/A1089	A13/M25 J30 to M25 J2/A2	A1089/A13 to A1089/A126 Dock Road	M25 J27 /M11 and M25 J30/A13 and M25 J2/A2 to M25 J5 /M26	M26/M25 J5 to M26/M20 J3	M25 J28/A12 and A12 J15	M2 J1/A2/A289 to M2 J7/A2			M20 J1/M25 and M20 J9 /A20/A251
Road type	13	13	13	10	3	1	10	3	2	1	2
Road description	Modern D3+ Roads	Modern D3+ Roads	Modern D3+ Roads	Modern D2 Roads	Motorways	Motorways	Modern D2 Roads	Motorways	Motorways	Motorways	Motorways
No. of lanes in each direction	3	3	3	2	4	2	2	4	3	2	3
Speed limit (mph)	>40	>40	>40	>40	50/60/70	50/60/70	>40	50/60/70	50/60/70	50/60/70	50/60/70
Local avg. accident rate	0.119	0.144	0.129	0.101	0.066	0.060	0.064	0.075	0.072	0.087	0.077
TAG accident rate	0.123	0.123	0.123	0.107	0.079	0.080	0.107	0.079	0.067	0.080	0.067
Percentage change	-3.65%	17.07%	5.08%	-5.78%	-16.00%	-25.41%	-39.82%	-4.61%	8.09%	8.90%	14.77%

Accidents appraisal results

8.6.17 Table 8.10 shows for the Without Scheme, With Scheme and the change between these scenarios the number of casualties, by severity type, and the accident rate per km over 60 years from scheme opening for the Core traffic growth scenario.

8.6.18 Table 8.11 presents the annual number of accidents and their economic cost over 60 years from scheme opening for the Core traffic growth scenario without the scheme, with the scheme and the changes. The change in the number of accidents sums to 1,667 and the accident disbenefits sum to £67.5m (2010 prices and values). There are negative accident benefits because there is an increase in vehicle kilometres driven on the road network. However, the accident rate per vehicle km is forecast to reduce.

Table 8.10 Change in the number of casualties

Without Scheme				With Scheme				Change			
Fatal	**Serious**	**Slight**	**Rate/km**	**Fatal**	**Serious**	**Slight**	**Rate/km**	**Fatal**	**Serious**	**Slight**	**Rate/km**
1,441	14,559	146,987	40.65	1,467	14,741	149,451	40.08	26	182	2,464	-0.57

Table 8.11 Annual number of accidents and disbenefits (£, 2010 prices and values)

Year	Without scheme		With scheme		Change	
	Number of accidents	Cost	Number of accidents	Cost	Number of accidents	Cost
2030	1,904	117,303,379	1,919	118,235,590	15	932,211
2031	1,900	115,085,438	1,916	116,072,557	16	987,119
2032	1,896	112,900,706	1,913	113,938,992	17	1,038,286
2033	1,891	110,749,058	1,909	111,834,936	18	1,085,878
2034	1,887	108,630,350	1,906	109,760,407	19	1,130,056
2035	1,882	106,544,421	1,902	107,715,395	20	1,170,974
2036	1,878	104,491,091	1,899	105,699,869	21	1,208,778
2037	1,873	102,470,166	1,895	103,714,055	22	1,243,890
2038	1,863	100,223,985	1,886	101,480,068	23	1,256,082
2039	1,853	98,024,145	1,876	99,290,798	23	1,266,653
2040	1,865	96,969,402	1,888	98,256,170	24	1,286,768
2041	1,876	95,923,068	1,900	97,228,955	25	1,305,886
2042	1,887	94,885,156	1,912	96,209,193	25	1,324,037
2043	1,898	93,855,677	1,924	95,196,923	26	1,341,246
2044	1,909	92,834,637	1,936	94,192,177	27	1,357,540
2045	1,921	91,822,050	1,948	93,194,991	28	1,372,941
2046	1,930	90,705,155	1,958	92,076,357	28	1,371,202
2047	1,938	89,600,436	1,967	90,969,588	28	1,369,152
2048	1,947	88,507,795	1,976	89,874,597	29	1,366,802
2049	1,956	87,427,133	1,985	88,791,297	29	1,364,164

Year	Without scheme		With scheme		Change	
	Number of accidents	Cost	Number of accidents	Cost	Number of accidents	Cost
2050	1,965	86,358,355	1,995	87,719,601	30	1,361,246
2051	1,974	85,301,382	2,004	86,659,422	30	1,358,040
2052	1,974	83,885,592	2,004	85,221,286	30	1,335,694
2053	1,974	82,756,067	2,004	84,073,852	30	1,317,785
2054	1,974	81,641,819	2,004	82,941,937	30	1,300,118
2055	1,974	80,542,640	2,004	81,825,328	30	1,282,688
2056	1,974	79,458,324	2,004	80,723,818	30	1,265,493
2057	1,974	78,388,671	2,004	79,637,201	30	1,248,530
2058	1,974	77,333,481	2,004	78,565,276	30	1,231,795
2059	1,974	76,292,557	2,004	77,507,842	30	1,215,285
2060	1,974	75,265,707	2,004	76,464,704	30	1,198,998
2061	1,974	74,252,738	2,004	75,435,667	30	1,182,929
2062	1,974	73,253,462	2,004	74,420,539	30	1,167,077
2063	1,974	72,267,693	2,004	73,419,132	30	1,151,439
2064	1,974	71,295,248	2,004	72,431,259	30	1,136,010
2065	1,974	70,335,947	2,004	71,456,737	30	1,120,790
2066	1,974	69,389,610	2,004	70,495,384	30	1,105,774
2067	1,974	68,456,061	2,004	69,547,021	30	1,090,960
2068	1,974	67,535,128	2,004	68,611,473	30	1,076,346
2069	1,974	66,626,638	2,004	67,688,566	30	1,061,928
2070	1,974	65,730,423	2,004	66,778,127	30	1,047,704

Year	Without scheme		With scheme		Change	
	Number of accidents	Cost	Number of accidents	Cost	Number of accidents	Cost
2071	1,974	64,846,316	2,004	65,879,988	30	1,033,671
2072	1,974	63,974,153	2,004	64,993,981	30	1,019,828
2073	1,974	63,113,772	2,004	64,119,942	30	1,006,170
2074	1,974	62,265,014	2,004	63,257,710	30	992,696
2075	1,974	61,427,719	2,004	62,407,122	30	979,403
2076	1,974	60,601,733	2,004	61,568,023	30	966,289
2077	1,974	59,786,903	2,004	60,740,255	30	953,352
2078	1,974	58,983,076	2,004	59,923,664	30	940,588
2079	1,974	58,190,105	2,004	59,118,101	30	927,996
2080	1,974	57,407,840	2,004	58,323,414	30	915,573
2081	1,974	56,636,138	2,004	57,539,456	30	903,318
2082	1,974	55,874,856	2,004	56,766,082	30	891,227
2083	1,974	55,123,850	2,004	56,003,149	30	879,298
2084	1,974	54,382,984	2,004	55,250,514	30	867,530
2085	1,974	53,652,118	2,004	54,508,038	30	855,920
2086	1,974	52,931,117	2,004	53,775,583	30	844,466
2087	1,974	52,219,848	2,004	53,053,014	30	833,166
2088	1,974	51,518,178	2,004	52,340,197	30	822,018
2089	1,974	50,825,978	2,004	51,636,998	30	811,020
Total	**116,899**	**4,679,082,489**	**118,566**	**4,746,562,317**	**1,667**	**67,479,828**

8.6.19 The absolute increase in accidents is due to the increased number of kilometres driven. However, Table 8.12 shows that the accident rate per million vehicle km and both the overall number of accidents per km and accident costs per km reduce with the provision of the Project.

8.6.20 Plate 8.6 shows the spatial distribution of accident benefits and disbenefits. The area to the west of the Project mainly sees accident benefits while the area to the east of the Project experiences accident disbenefits.

8.6.21 The maintenance delay appraisal includes a monetary value for accidents of £0.3m. This is added to the monetary value of £67.5m produced by COBALT to produce a total value for accident disbenefits of £67.8m. This value is reported in the Analysis of Monetised Costs and Benefits (AMCB) and AST tables.

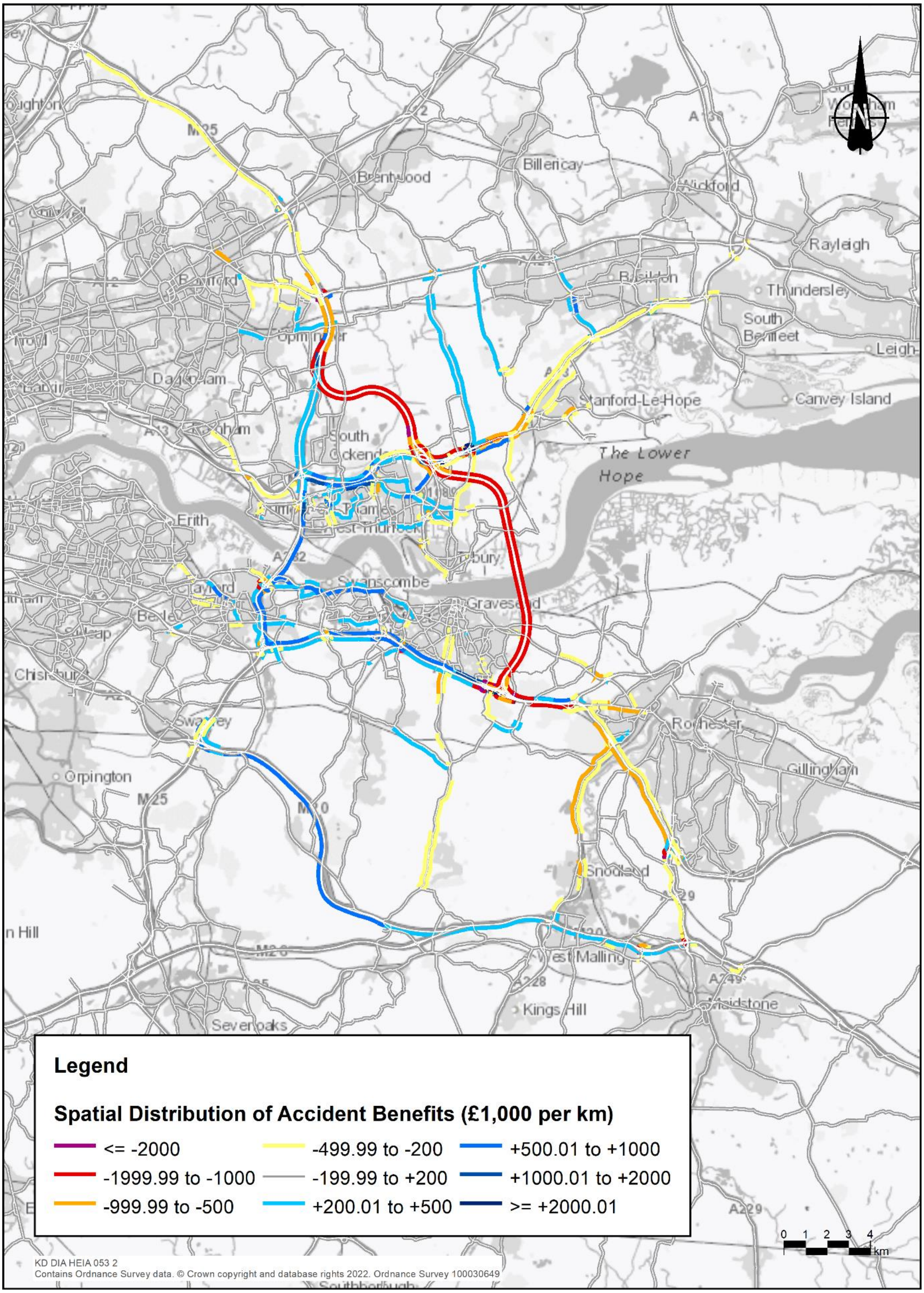
8.6.22 Following the principle of proportionate appraisal, the Core traffic growth value is used in the appraisal of the Low and High growth scenarios.

Table 8.12 Accident cost per vehicle kilometre

	Without Scheme	**With Scheme**	**Change**
Number of accidents over 60-year appraisal period	116,899	118,566	1,667
Accident cost over 60-year appraisal period (£m)*	-4,679.1	-4,746.6	-67.5
Total network length appraised (km)	2,876	2,958	82
Accident rate per million vehicle km in 2030	0.117	0.113	-0.004
Accident rate per million vehicle km in 2045	0.105	0.101	-0.004
Number of accidents per km over 60-year appraisal period	40.65	40.08	-0.57
Accident cost per km over 60-year appraisal period (£m)	1.627	1.605	-0.022

** Excludes -£0.3m from planned maintenance*

Plate 8.6 Spatial distribution of accidents



Sensitivity test

8.6.23 A sensitivity test was undertaken as part of the accidents appraisal to assess the impact of classifying the Lower Thames Crossing as an all-purpose trunk road. The result of the test was that the disbenefit value increased to £98.0m, but there is a reduction in the number of accidents per vehicle km.

8.7 Indirect tax revenues

8.7.1 The appraisal includes three sources of indirect tax revenues which accrue from additional fuel duty and VAT from the change in traffic levels due to the Project. These revenues arise during:

a. The construction period

b. 60-year operational period

c. Planned maintenance periods

8.7.2 The construction delays appraisal includes an estimated value for indirect tax revenue of £4.8m. This value is also included in the Low and High traffic growth scenarios.

8.7.3 The 60-year operational appraisal includes estimates for indirect tax revenue for each of the three traffic growth scenarios. These range from £43.7m (Low) to £27.9m (High) with a Core growth value of £37.1m as shown in Table 8.13.

8.7.4 The maintenance delays appraisal includes an estimated value for indirect tax revenue of £1.6m. This value is also included in the Low and High traffic growth scenarios.

Table 8.13 Estimates of indirect tax revenues (£m, 2010 prices and values)

Benefit	Low growth	Core growth	High growth
Construction delays	4.8	4.8	4.8
60-year operation	43.7	37.1	27.9
Maintenance delays	1.6	1.6	1.6
Total	**50.1**	**43.5**	**34.2**

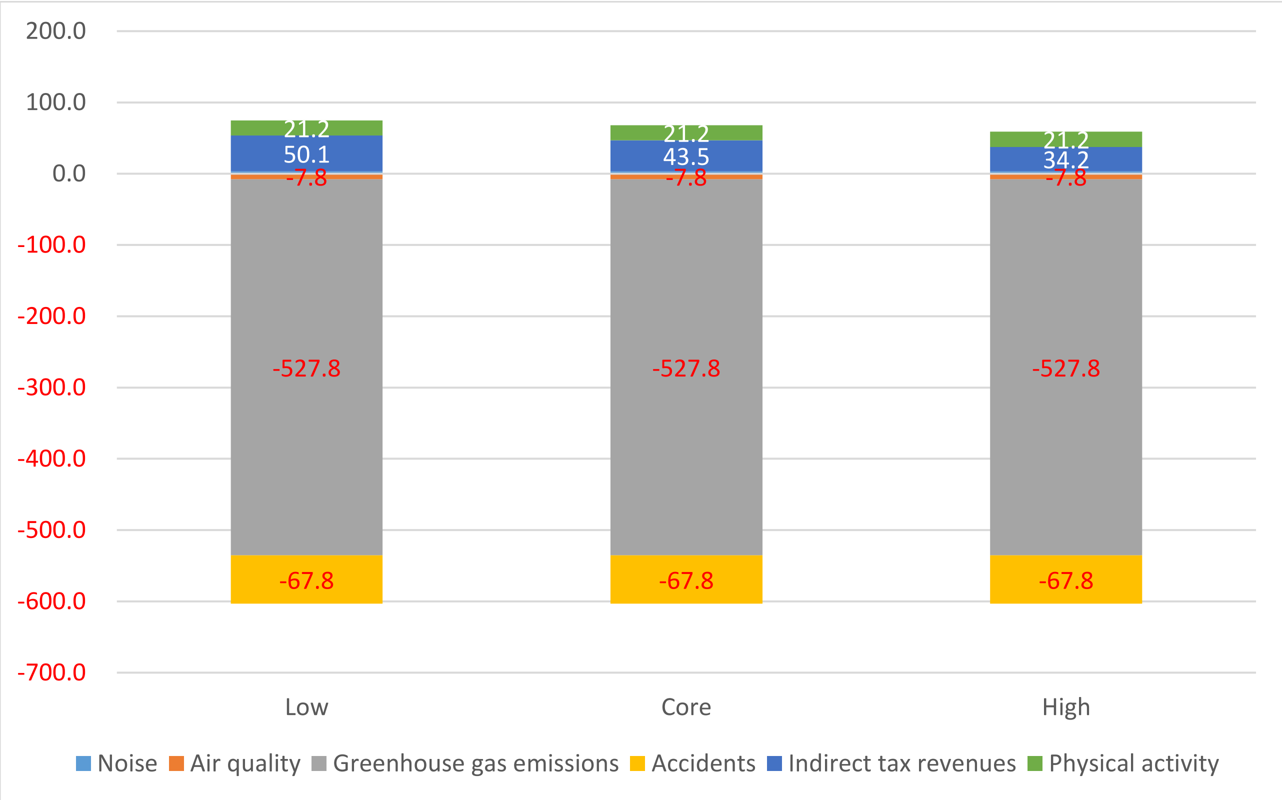
8.8 Summary of other Level 1 benefits

8.8.1 Table 8.14 and Plate 8.5 summarise the other Level 1 benefits for the 60-year appraisal period of the Project (this includes all maintenance delay impacts). Noise, air quality, greenhouse gas emissions and accident disbenefits are unchanged between the three traffic growth scenarios. The impacts range from -£528.7m (Low) to -£544.6m (High) with a Core growth value of -£535.3m.

Table 8.14 Other Level 1 monetised values (£m, 2010 prices and values)

Benefit	Low growth	Core growth	High growth
Noise	3.4	3.4	3.4
Air quality	-7.8	-7.8	-7.8
Physical activity	21.2	21.2	21.2
Greenhouse gases	-527.8	-527.8	-527.8
Accidents	-67.8	-67.8	-67.8
Indirect tax revenues	50.1	43.5	34.2
Total	**-528.7**	**-535.3**	**-544.6**

Plate 8.6 Other Level 1 benefits (£m, 2010 prices and values)



8.9 Level 1 PVB

8.9.1 Table 8.15 presents the Level 1 PVB estimates for Low, Core and High traffic growth. These range from £1,080.2m (Low) to £1,554.7m (High) with a Core growth value of £1,295.9m.

Table 8.15 Level 1 PVB estimates (£m, 2010 prices and values)

Benefit	Low growth	Core growth	High growth
Transport economic efficiency impacts	1,608.9	1,831.2	2,099.3
Other impacts	-528.7	-535.3	-544.6
PVB (Level 1)	**1,080.2**	**1,295.9**	**1,554.7**

8.9.2 Plate 8.7 graphically presents how the various Level 1 impacts sum to total £1,295.9m for the Core traffic growth scenario

8.10 Analysis of Monetised Costs and Benefits tables

8.10.1 Table 8.16, Table 8.17 and Table 8.18 present the TAG AMCB tables for the Low, Core and High traffic growth scenarios, all based on Most Likely CAPEX and Central OMR costs.

Plate 8.7 Level 1 benefits, Core growth (£m, 2010 prices and values)

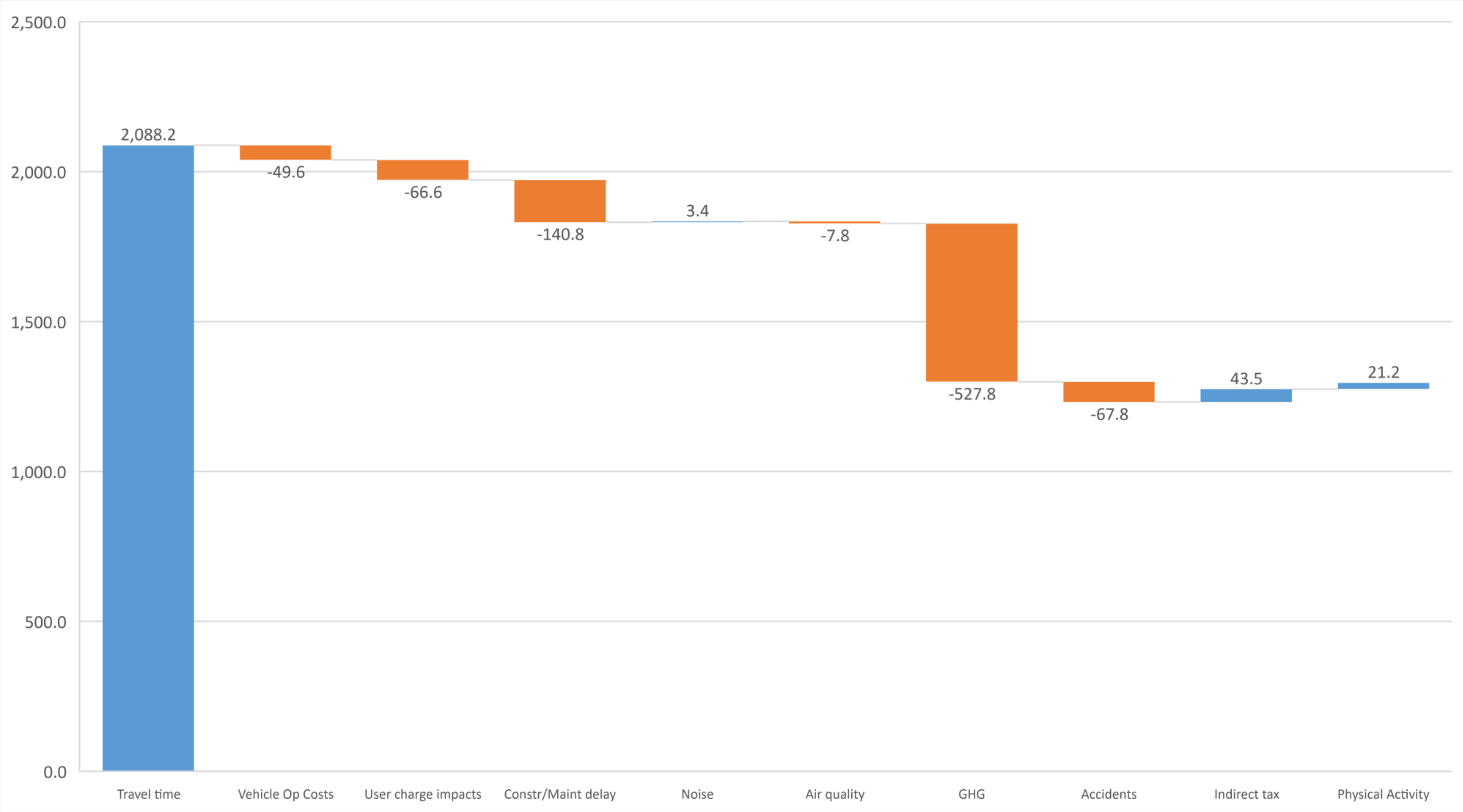


Table 8.16 AMCB table, Low growth (£m, 2010 prices and values)

Noise	3.4	
Local air quality	-7.8	
Greenhouse gases	-527.8	
Journey quality	0	
Physical activity	21.2	
Accidents	-67.8	
Economic efficiency Consumer (Commuting)	320.2	
Economic efficiency Consumer (Other)	391.1	
Economic efficiency Consumer (Business)	897.7	
Wider public finances (indirect tax revenues)	50.1	
Level 1 PVB	**1,080.2**	
Broad transport budget	2,781.5	
PVC	**2,781.5**	
Overall impacts		
NPV	**-1,701.2**	**NPV = PVB – PVC**
Initial BCR	**0.39**	**BCR = PVB / PVC**

Notes:

Construction and maintenance values included in the Economic Efficiency, Greenhouse Gas, Accidents and Indirect Tax Revenue.

The sign of Indirect Tax Revenue has been changed from the Public Accounts table (Table 6.7) because that table represents costs not benefits.

Table 8.17 AMCB table, Core growth (£m, 2010 prices and values)

Noise	3.4	
Local air quality	-7.8	
Greenhouse gases	-527.8	
Journey quality	0	
Physical activity	21.2	
Accidents	-67.8	
Economic efficiency Consumer (Commuting)	361.6	
Economic efficiency Consumer (Other)	426.7	
Economic efficiency Consumer (Business)	1,042.9	
Wider public finances (indirect tax revenues)	43.5	
Level 1 PVB	**1,295.9**	
Broad transport budget	2,700.2	
PVC	**2,700.2**	
Overall impacts		
NPV	**-1,404.3**	**NPV = PVB – PVC**
Initial BCR	**0.48**	**BCR = PVB / PVC**

Notes:

Construction and maintenance values included in the Economic Efficiency, Greenhouse Gas, Accidents and Indirect Tax Revenue.

The sign of Indirect Tax Revenue has been changed from the Public Accounts table (Table 6.8) because that table represents costs not benefits.

Table 8.18 AMCB table, High growth (£m, 2010 prices and values)

Noise	3.4	
Local air quality	-7.8	
Greenhouse gases	-527.8	
Journey quality	0	
Physical activity	21.2	
Accidents	-67.8	
Economic efficiency Consumer (Commuting)	412.4	
Economic efficiency Consumer (Other)	474.2	
Economic efficiency Consumer (Business)	1,212.7	
Wider public finances (indirect tax revenues)	34.2	
Level 1 PVB	**1,554.7**	
Broad transport budget	2,626.1	
PVC	**2,626.1**	
Overall impacts		
NPV	**-1,071.4**	**NPV = PVB – PVC**
Initial BCR	**0.59**	**BCR = PVB / PVC**

Notes:

Construction and maintenance values included in the Economic Efficiency, Greenhouse Gas, Accidents and Indirect Tax Revenue.

The sign of Indirect Tax Revenue has been changed from the Public Accounts table (Table 6.9) because that table represents costs not benefits.

9 Level 2 impacts

9.1 Introduction

9.1.1 This chapter summarises the appraisal of the following Level 2 impacts:

a. Journey time reliability

b. Wider economic impacts

9.2 Journey time reliability impacts

Introduction

9.2.1 Journey time reliability excludes predictable variation relating to varying levels of demand by time of day, day of week and seasonal effects of which travellers are assumed to be aware. Changes in journey time reliability have important impacts on road users.

9.2.2 Given the scale and spatial scope of the transport impacts of the Project, the National Highways MyRIAD 2021 appraisal program has been used to assess the impacts of the Project on journey time reliability (National Highways a). This is an Excel/VBA based tool used to support the reliability appraisal of road investment projects. This analysis focuses specifically on the impacts on the SRN. As such it is likely to underestimate the benefits as it does not consider the impact on local roads. It does however provide a TAG compliant method for assessing the changes in user costs arising from:

a. Direct impacts of incidents on trunk road users (incident delays).

b. Additional impacts of incidents due to some impacted users diverting to other routes (diversion impacts).

c. Changes in travel time variability (TTV) for journeys on the SRN within the study area. TTV integrates the separate contributions of non-incident related variability and variability specifically related to incidents.

9.2.3 The theoretical basis and the technical approaches used to appraise these three impacts are explained in Annex B.

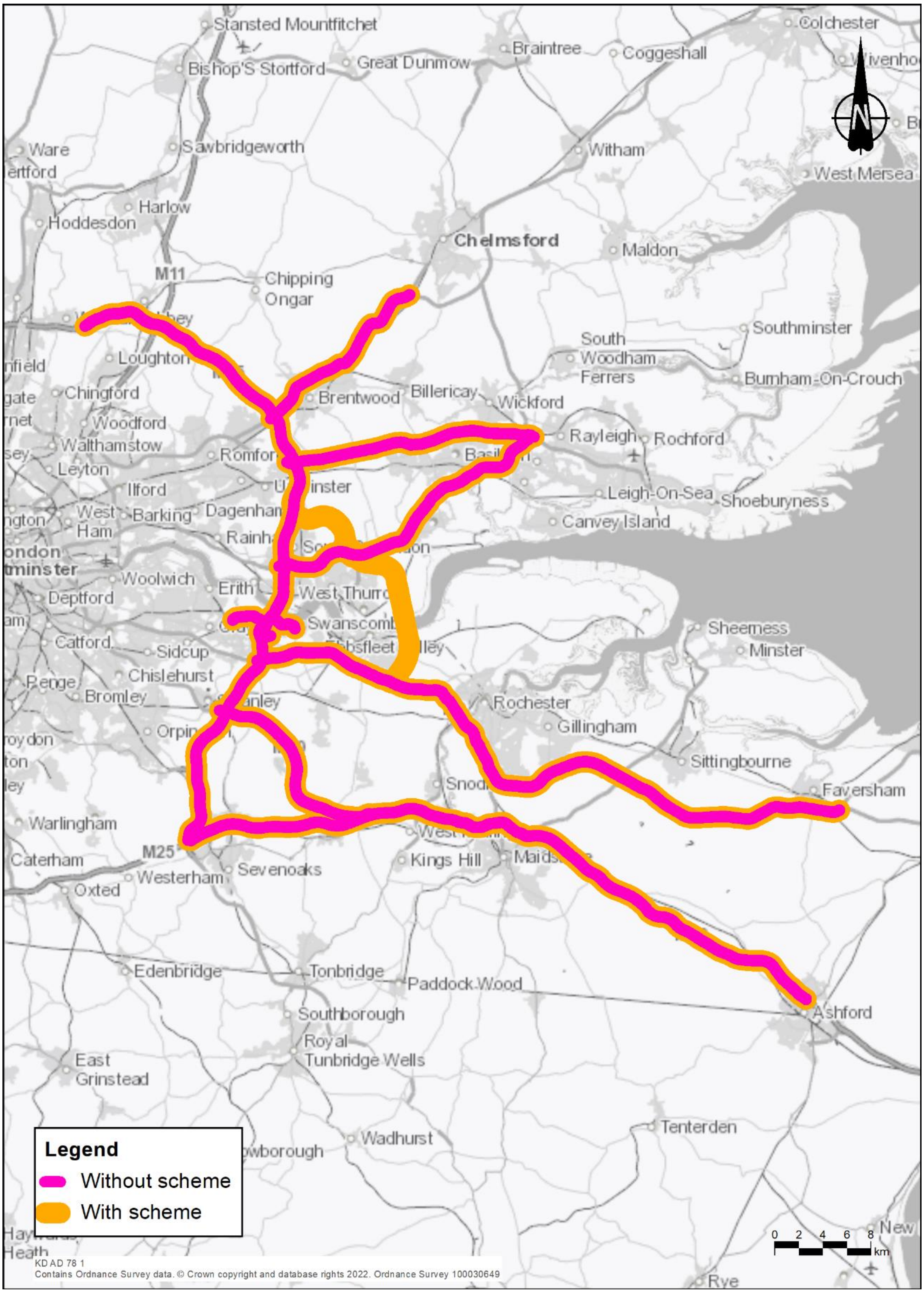
Scenarios and time periods

9.2.4 For the appraisal of the Project, reliability impacts have been assessed for the Without Scheme scenario and the With Scheme scenario. All analysis was undertaken using the 10-time period forecast flows and the four modelled years: 2030; 2037; 2045 and 2051.

Study area network

9.2.5 The journey time reliability study area is shown in Plate 9.1 for the Without Scheme and With Scheme scenarios. It is the SRN within the area used for the accidents analysis.

Plate 9.1 Journey time reliability study area network



Model parameters

9.2.6 The model parameters used in estimating the reliability impacts are set out in Annex B.1.

Incident delay appraisal results

9.2.7 The costs of delays due to incidents is calculated using the MyRIAD software for the Without Scheme and With Scheme scenarios.

9.2.8 These costs were calculated for 10 time periods for the four modelled years. MyRIAD then applies value of time growth and discounts the costs over the 60-year appraisal period used for this Project. The disaggregation between business users, commuters and other users was based on that observed in the Without Scheme scenario.

9.2.9 The results from the incident delay appraisal are shown in Table 9.1. The Project is expected to generate journey time reliability benefits, from reduced incident delays, of £265.4 million.

9.2.10 These benefits accrue primarily in the inter-peak, weekend peak (charged) and AM and PM peak and shoulder peak periods.

Table 9.1 Incident benefits (time period, purpose) (£m, 2010 prices and values)

Time period	Business	Commuters and others	Total
AM peak	13.2	14.3	27.5
Inter-peak	41.8	41.0	82.8
PM peak	15.4	21.9	37.3
Off-peak charged	5.2	7.2	12.4
Off-peak non-charged	2.1	2.0	4.1
AM shoulder	6.8	7.1	13.8
PM shoulder	15.4	20.6	36.1
Weekend peak charged	12.4	31.6	44.0
Weekend off-peak charged	1.9	4.3	6.2
Weekend off-peak non-charged	0.4	0.8	1.2
Total	**114.6**	**150.8**	**265.4**

Diversion impact appraisal results

9.2.11 The total user costs from diversions were assessed for the Without Scheme and With Scheme scenarios.

9.2.12 These were also calculated for each of the 10 time periods and four modelled years. Again, the MyRIAD software was used to apply value of time growth and discount the costs over the 60-year appraisal period used for this Project. The disaggregation between business users, commuters and other users was based on that observed in the split in the Without Scheme scenario.

9.2.13 The results from the diversion impacts appraisal are shown in Table 9.2. The proposed Project is expected to generate journey time reliability benefits from reduced diversion impacts of £68.8 million (2010 prices and values).

9.2.14 These benefits accrue primarily in the inter-peak, AM peak, PM peak and PM shoulder peak periods.

Table 9.2 Diversion benefits (time period, purpose) (£m, 2010 prices and values)

	Business	Commuters and others	Total
AM peak	4.8	5.2	10.0
Inter-peak	12.4	12.1	24.5
PM peak	5.3	7.6	12.9
Off-peak charged	0.1	0.1	0.2
Off-peak non-charged	0.0	0.0	0.0
AM shoulder	1.4	1.4	2.8
PM shoulder	7.0	9.4	16.4
Weekend peak charged	0.5	1.4	1.9
Weekend off-peak charged	0.0	0.0	0.1
Weekend off-peak non-charged	0.0	0.0	0.0
Total	**31.6**	**37.3**	**68.8**

Travel time variability appraisal results

9.2.15 The results from the TTV appraisal are shown in Table 9.3. The Project is expected to generate user benefits from reduced travel time variability of £152.9 million (2010 prices and values).

Table 9.3 TTV benefits (time period, purpose) (£m, 2010 prices and values)

	Business	Commuters and others	Total
AM peak	-0.5	-0.6	-1.1
Inter-peak	23.4	23.0	46.3
PM peak	1.0	1.5	2.5
Off-peak charged	8.4	11.5	19.8
Off-peak non-charged	10.3	10.3	20.6
AM shoulder	3.7	3.9	7.6
PM shoulder	5.0	6.7	11.8
Weekend peak charged	8.4	21.5	30.0
Weekend off-peak charged	3.2	7.2	10.4
Weekend off-peak non-Charged	1.8	3.1	4.9
Total	**64.8**	**88.1**	**152.9**

Total journey time reliability appraisal results

9.2.16 Table 9.4 summarises the total journey time reliability benefits, split between incident delays, local diversion impacts and travel time variability impacts. In total, these benefits are £487.1m (2010 prices and values) for the Core traffic growth scenario.

9.2.17 Annex B.2 provides more information about the appraisal results.

Table 9.4 Total reliability benefits by impact (£m, 2010 prices and values)

Impact type	Business	Commuters and others	Total
Incidents	114.6	150.8	265.4
Local diversions	31.6	37.3	68.8
TTV	64.8	88.1	152.9
Total	**210.9**	**276.2**	**487.1**

9.2.18 Table 9.5 presents total journey time reliability benefits by time period summed across the three impacts – incident delays, local diversions and TTV.

Table 9.5 Total reliability benefits by time period (£m, 2010 prices and values)

Time period	Business	Commuters & Others	Total
AM Peak	17.4	18.9	36.4
Inter Peak	77.5	76.1	153.7
PM Peak	21.8	31.0	52.8
Off-peak Charged	13.7	18.8	32.5
Off-peak Non-charged	12.4	12.3	24.7
AM shoulder	11.9	12.4	24.3
PM shoulder	27.5	36.7	64.2
Weekend Peak Charged	21.3	54.5	75.8
Weekend Off-Peak Charged	5.1	11.5	16.6
Weekend Off-Peak Non-Charged	2.2	3.9	6.1
Total	**210.9**	**276.2**	**487.1**

9.2.19 Reliability impacts for the Low and High traffic growth scenarios have not been reviewed specifically and are assumed to be the same as those for the Core traffic growth scenario.

9.3 Wider economic impacts

9.3.1 Economic theory indicates that under hypothetical conditions of perfect competition, a fully specified appraisal of a transport project would accurately estimate all benefits. In practice, however, most markets are not perfectly competitive and, as a consequence, direct user impacts may be complemented by wider economic impacts. These wider impacts can be large and can therefore be an important part of the overall appraisal of a transport project.

9.3.2 This section summarises the key components of the methodology used to calculate the wider economic impacts which form part of the Level 2 benefits of the Project. DfT's WITA v2.2 appraisal software was used to produce monetary estimates of two wider economic impacts based on the assumption of fixed land use:

a. Productivity benefits due to agglomeration from static clustering

b. Tax revenues arising from changes to labour supply

9.3.3 The value of a further impact – the change in economic output in imperfectly competitive markets – was calculated as 10% of business transport user and provider benefits and journey time reliability benefits for business users in line with TAG guidance.

Agglomeration

9.3.4 Agglomeration is a measure of the effects of the concentration of economic activity in an area. Where a transport project facilitates a reduction in journey times, it will alter the accessibility of firms in an area to other firms and workers. As a result, the concentration of economic activity in an area increases, which results in additional impacts on productivity due to better knowledge and technology synergies from business proximity, and the existence of deeper business and labour markets.

9.3.5 Agglomeration impacts are not directly correlated with journey time benefits and reflect the potential for businesses to interact with one another, rather than the actual pattern of trip making. In particular, where new journey opportunities arise from a new road network, agglomeration may be supported even if trip making between these places is relatively small and this may be particularly important for a river crossing such as the Lower Thames Crossing.

9.3.6 Agglomeration benefits are by far the largest component of Level 2 wider economic impacts.

Change in output in imperfectly competitive markets

9.3.7 A reduction in the costs of transport allows businesses to operate more efficiently and increases their output. This produces additional benefits which can be captured within the appraisal of wider economic impacts. The additional benefit is a result of imperfectly competitive markets where businesses tend to set prices greater than their marginal cost of production.

9.3.8 In line with TAG guidance, this impact is valued at 10% of Level 1 business transport user and provider benefits and journey time reliability benefits for business users.

Tax revenues arising from changes to labour supply

9.3.9 Decisions by workers about whether or not to take a job are assumed to be taken based on both the level of wages to be received and the commuting costs incurred. As the costs of commuting change, then these decisions can change and, as a result, the supply of labour may increase or decrease.

9.3.10 Reductions in commuting journey time or cost are likely to result in a greater labour supply. The benefits to the individual are assumed to be captured in user benefits. However, the changes in tax revenue that result from the labour market impacts are not captured. These tax revenues are therefore included as Level 2 wider economic impact.

Estimates of wider economic impacts

9.3.11 Table 9.6 shows the estimates of wider economic impacts by type of impact in the Low, Core and High traffic growth scenarios.

9.3.12 Annexes C.1 to C.3 present more detailed disaggregations of these impacts, including profiles and spatial distributions of the appraisal results.

Table 9.6 Wider economic impacts (£m, 2010 prices and values)

Type of wider economic impact	Low growth	Core growth	High growth
Agglomeration	1,343.3	1,374.8	1,370.5
Change in output in imperfectly competitive markets	118.9	133.4	150.4
Labour supply impacts	8.0	8.4	8.8
Total	**1,470.2**	**1,516.6**	**1,529.7**
Agglomeration as % of Wider Economic Impacts	91%	91%	90%
Wider Economic Impacts as % of total benefits	48%	46%	43%

9.4 Level 2 PVB

9.4.1 Table 9.7 presents the total value of the Level 2 benefits. These range from £1,957.3m (Low) to £2,016.8m (High) with a Core traffic growth value of £2,003.7m, all expressed in 2010 prices and values.

Table 9.7 Level 2 benefits (£m, 2010 prices and values)

Benefits	Low growth	Core growth	High growth
Journey time reliability	487.1	487.1	487.1
Wider economic impacts	1,470.2	1,516.6	1,529.7
Total	**1,957.3**	**2,003.7**	**2,016.8**

9.5 Level 1 and 2 PVB

9.5.1 Table 9.8 presents the combined Level 1 and Level 2 PVB estimates for the Low, Core and High traffic growth scenarios. These range from £3,037.4m (Low) to £3,571.5m (High) with a Core growth value of £3,299.5m, all expressed in 2010 prices and values.

Table 9.8 Level 1 and 2 benefits (£m, 2010 prices and values)

Benefits	Low growth	Core growth	High growth
Level 1	1,080.2	1,295.9	1,554.7
Level 2	1,957.3	2,003.7	2,016.8
PVB (Level 1 and 2)	**3,037.4**	**3,299.5**	**3,571.5**

9.6 Local and regional benefits

9.6.1 Given the local development and regional economic growth objectives of the Project (see Section 3.3), it is important to understand the spatial distribution of benefits.

9.6.2 The following benefits are spatially distributed across the TUBA sectors and WITA zones (the aggregate totals, expressed in 2010 prices and values, are shown in brackets):

a. Transport user and provider impacts (£1,971.9m)

b. Static agglomeration (£1,374.8m)

c. Labour supply (£8.4m)

d. Economic output (£133.4m)

9.6.3 These benefits sum to £3,488.5m (2010 prices and values). This exceeds the Project’s total benefits of £3,299.5m because there are £189.0m of net disbenefits (benefits less disbenefits) that cannot be spatially disaggregated.

9.6.4 Table 9.9 shows that:

a. Benefits of £1,672.3m are gained by those starting or ending their journeys in the Lower Thames area (Thurrock, Brentwood, Havering, Dartford, Gravesham and Medway).

b. Benefits of £1,090.5m are gained by those starting or ending their journeys in the South East Local Enterprise Partnership (SELEP) region.

c. Benefits of £725.7m are gained by those starting or ending their journeys in other local authorities in Great Britain.

d. £189.0m of net disbenefits cannot be spatially disaggregated.

Table 9.9 Local and regional benefits, Core growth (£m, 2010 prices and values)

Area	Benefits £m
Lower Thames local authorities	1,672.3
Other SELEP local authorities	1,090.5
Lower Thames and SELEP local authorities	**2,762.8**
Other local authorities in Great Britain	725.7
Total	**3,488.5**
Benefits that cannot be disaggregated	-189.0
Total	**3,299.5**

9.6.5 Table 9.10 shows the disaggregation of the £725.7m of benefits that accrue to other local authorities in Great Britain.

Table 9.10 Benefits for other local authorities in GB (£, 2010 prices and values)

	Transport user	Agglomeration	Labour supply	Economic output	Total
Other South East	212,368,750	223,024,664	443,041	14,368,826	**450,205,282**
London	55,570,109	18,226,173	120,265	3,759,862	**77,676,410**
East of England	44,310,059	29,964,188	1,093	2,998,010	**77,273,349**
East Midlands	53,940,411	0	0	3,649,597	**57,590,009**
West Midlands	24,810,591	0	0	1,678,680	**26,489,271**
North West	11,797,041	0	0	798,185	**12,595,226**
Yorkshire & Humber	11,377,854	0	0	769,823	**12,147,678**
North East	1,819,136	0	0	123,082	**1,942,218**
South West	5,431,410	0	0	367,488	**5,798,899**
Scotland	1,441,433	0	0	97,527	**1,538,960**
Wales	2,318,770	0	0	156,887	**2,475,657**
Total	**425,185,564**	**271,215,025**	**564,400**	**28,767,969**	**725,732,957**

9.6.6 Table 9.11 shows how the spatially disaggregated benefits of £3,488.5m are split between SELEP local authorities north and south of the River Thames. It shows that:

a. Benefits of £873.7m accrue to SELEP local authorities south of the river.

b. Benefits of £1,769.6m accrue to SELEP local authorities north of the river.

c. Benefits of £2,643.3m accrue to all SELEP local authorities.

Table 9.11 Benefits for SELEP authorities, Core growth (£m, 2010 prices and values)

	Transport users and providers £m	Agglomeration £m	Labour supply	Economic output	Total benefits £m
North of the River Thames SELEP local authorities	656.5	169.5	3.3	44.4	873.7
South of the River Thames SELEP local authorities	809.9	900.7	4.2	54.8	1,769.6
Total SELEP local authorities	**1,466.4**	**1,070.2**	**7.5**	**99.2**	**2,643.3**
Other local authorities in GB (incl. Havering)	505.5	304.5	1.0	34.2	845.2
Total	**1,971.9**	**1,374.8**	**8.4**	**133.4**	**3,488.5**
Benefits that cannot be disaggregated	n/a	n/a	n/a	n/a	-189.0
Total	**n/a**	**n/a**	**n/a**	**n/a**	**3,299.5**

10 Level 3 impacts

10.1 Introduction

10.1.1 Level 3 analysis provides additional appraisal evidence about the expected impacts of the Project. While this evidence is not included in the BCRs, it is used to inform the VfM assessment.

10.1.2 The following Level 3 impacts are summarised in the AST:

a. Non-monetised environmental impacts

b. Non-monetised social impacts

c. Option and non-use values

d. Distributional impacts

10.1.3 Other Level 3 impacts that are not summarised in the AST comprise:

a. Landscape valuation

b. Network resilience

c. International trade impacts

d. Level 3 wider economic impacts

10.2 Non-monetised environmental impacts

10.2.1 The Appraisal Summary Table Report includes detailed worksheets that provide the analytical basis for the qualitative appraisal of environmental impacts. A summary of these qualitative appraisals and appraisal summary scores are set out in Table 10.1. The AST scores are:

a. Landscape – Moderate Adverse

b. Townscape – Moderate Adverse

c. Historic environment – Large Adverse

d. Biodiversity – Very Large Adverse

e. Water environment – Slight Adverse

Table 10.1 Summary of qualitative environmental appraisals

Impact	Qualitative appraisal summary	Score
Landscape	The widening of the existing M2/A2 corridor, expansion of the existing A13/A1089 junction and modifications to the existing M25 corridor, together with the new A122 Lower Thames Crossing, would adversely affect the landscape character and views within the Area of Outstanding Natural Beauty (AONB), its setting and the local landscape character and views within the Green Belt, including a large adverse effect in the Higham Arable Farmland and Thurrock Reclaimed Fen local landscape character areas, including a large adverse effect in the Higham Arable Farmland and Thurrock Reclaimed Fen local landscape character areas. However, the overall impact of the Project is Moderate Adverse due to the extensive mitigation proposals, including false cuttings, new planting, green bridges and the landscaping of new areas of open space at Chalk Park adjoining the South Portal and Tilbury Fields adjoining the North Portal.	Moderate Adverse
Townscape	The Project route is typically located within Green Belt and along existing trunk roads including widening of the A2 and M25 corridors, and new junctions with the A2, A13, and M25. This new infrastructure would adversely affect a range of defined townscape areas due to their associations with the surrounding rural landscapes. In addition, the historic townscape character of the rural settlements at Thong, south of the River Thames, and West Tilbury, Baker Street and North Ockendon to the north of the River, would be adversely impacted due to their proximity to the Project. These settlements are designated conservation areas where there would be a major change on physical and perceptual qualities and characteristics including their setting.	Moderate Adverse
Historic environment	To the south of the River Thames a Moderate Adverse effect is predicted on archaeological remains and historic buildings. To the north of the River Thames a Large Adverse effect on archaeological remains, historic buildings and historic landscapes is predicted. This results from the total removal of 3 high value listed buildings, which is exceptional in NPSNN terms and the almost total removal of a high value scheduled monument which would be wholly exceptional in NPSNN terms. Overall the effects of the Project are considered to be Large Adverse.	Large Adverse
Biodiversity	A score of Very Large Adverse is predicted as significant residual adverse effects remain from the direct loss and deterioration of irreplaceable habitats and Sites of Special Scientific Interest (SSSI). Although they would not affect the assessment of residual impacts, mitigation and compensation measures are proposed in accordance with the National Policy Statement for National Networks (NPSNN) to offset these adverse effects (Department for Transport, 2014). This includes the creation of over 200ha of new woodland and grassland which would increase the overall area of these habitats and strengthen resilience across the wider network of designated sites and semi-natural habitat within the wider landscape.	Very Large Adverse

Impact	Qualitative appraisal summary	Score
Water environment	The Project has potential to degrade the quality of surface and groundwater bodies and change surface and groundwater levels and flow regimes. These effects may be induced by discharges of construction phase and operational runoff, earthworks, groundwater control and new crossings of watercourses and their floodplains. However, by following construction good practice and by embedding mitigation into the Project's design, effects on the water environment can be successfully avoided or reduced.	Slight Adverse

10.3 Non-monetised social impacts

10.3.1 The Appraisal Summary Table Report also includes worksheets that present the analytical basis for the qualitative appraisal of social impacts. A summary of the qualitative appraisals and appraisal summary scores are set out in Table 10.2. The AST scores are:

a. Personal security – Neutral

b. Journey quality – Large Positive

c. Affordability – Slight Positive

d. Severance – Large Positive

Table 10.2 Summary of qualitative social impact appraisals

Impact	Qualitative appraisal summary	Score
Personal security	The Project is expected to have an overall neutral impact on the personal security of drivers and vehicle occupants in the tunnel, along the route and at crossing points. Personal security of walkers, cyclists and horse riders at crossing points has also been assessed as neutral – while some crossings would be improved through lighting, environment and gradient, others may require underpasses which potentially have an adverse impact on personal security.	Neutral
Journey quality	The change in impact across the journey quality factors of traveller care, views and stress is, on balance, likely to be beneficial and large, affecting more than 10,000 travellers per day. Improvements in traveller stress arise through reductions in congestion at the Dartford Crossing and approach roads, resulting in improved accessibility. The effect on vehicle travellers in relation to views from the road during the operation phase is likely to be positive.	Large Positive
Affordability	Personal affordability would not be affected by the Project because the Without Scheme travel routes and operating costs would still be available. Therefore, the Project has no affordability impact for most users. Journeys by Gravesham residents to and from destinations north of the River Thames would be proportionately cheaper compared to the Without Scheme scenario because their cross-river road user charges would be reduced through a user charge discount. Around 106,900 Gravesham residents would benefit from a reduction in the cost of travel across the River Thames.	Slight Positive

Impact	Qualitative appraisal summary	Score
Severance	All routes severed by the Project would be reinstated using bridges or underpasses except for Hornsby Lane in Thurrock. In net terms 49,020 walking trips per day within the LTAM transport model area are expected to experience a reduction in traffic-related severance.	Large Positive

10.4 Option and non-use impacts

10.4.1 The Project would provide two types of options both of which have a value even if these options are never used. Firstly, road users in the Lower Thames area would have a second option to cross the Thames. Secondly, new areas of land adjacent to the Project route could be developed for housing and employment. The appraisal of these option and non-use values for the Project is based on the principles set out in TAG Unit A4.1 (Department for Transport, 2020b).

Road users

10.4.2 At present road users in the Lower Thames area wanting to cross the Thames are only able to use the Dartford Crossing. When traffic flows at Dartford are disrupted, the only alternative choices to cross the river involve lengthy detours via the Blackwall Tunnel or westbound around the M25. When the Project is built, road users in the Lower Thames area would have two road options for crossing the Thames.

10.4.3 It is not possible to place a monetary value on this option. However, traffic volumes using the Dartford Crossing currently average 50 million trips a year and total volumes across the River Thames (Dartford Crossing and the Project) would increase to 75 million a year with the Project in place. Therefore, this option would be available to a large number of road users. Therefore, the option value for road users has been qualitatively assessed as Large Positive.

Development land

10.4.4 The construction of the Project across areas of land that have not previously been developed opens up the possibility that areas adjacent to the route and close to the Project’s junctions may be developed for housing and employment. There is no certainty that such development would occur because it may potentially require a de-designation of land within the Green Belt (which may be an option open to local planning authorities, and which they may consider suitable in light of the Project). This would depend on local planning policies, the granting of planning permission and the presence of environmental constraints which may constrain such development.

10.4.5 However, the construction of the Project provides decision makers and developers with options about whether to develop land near the route. The major additional capacity in the highway network may assist local authorities in finding suitable land for the new housing in their area.

10.4.6 It is not possible to easily value this potentially developable land because land values depend on whether or not each plot of land would be granted planning permission. However, given the length of the Project’s route, the option value for development land has been assessed as Large Positive.

10.5 Distributional impact appraisal

10.5.1 The methodology and results of the distributional impact appraisal (DIA) of the Project's impacts on vulnerable social groups are described and reported in the Distributional Impact Appraisal Report. Summaries of these appraisals and the AST scores generated by the DIA are shown in Table 10.3.

Table 10.3 Distributional impact appraisal scores

Indicator	Assessment	Scores
User benefits	Overall, there is a net beneficial distributional impact from the Project on user benefits. There are net user benefits across all income quintiles. The distribution of user benefits is within 5% of the population for each income quintile and assessed as even.	Moderate Beneficial for each income quintile
Noise	The distributional appraisal shows a net adverse impact on residential noise levels. The distribution of noise impacts against income quintiles is assessed as uneven with adverse impacts higher than expected in the most deprived (20%) income quintile groups. There is a net increase in properties with increases in noise greater than 1dB in areas with higher than average proportions of children under 16 and people aged 70 and over compared with the regional study area and England and Wales, although the net increases are lower compared with the England and Wales proportions. There is a neutral impact of changes in noise levels on schools and care homes as the majority of schools and care homes would receive no change in noise level.	Income: Large Adverse Children aged under 16: Large Adverse People aged 70 and over: Moderate Adverse
Air quality	The distributional appraisal shows a beneficial air quality impact. The distribution of air quality impacts against income quintiles is assessed as uneven because the two most deprived income quintiles benefit more than the other income quintiles. There is a net decrease in NO_2 in areas with higher than average proportions of children under 16, compared with both the regional study area and with England and Wales. No schools would experience a change in air quality levels..	Income: Large Beneficial for NO_2 Children aged under 16: Large Beneficial for NO_2
Accidents	There is no distributional impact for vulnerable groups analysed which are walkers and cyclists (for A-roads), motorcyclists, under 16 year olds, 16 to 25 year old males, over 70 year olds for any location, compared with regional study area and Great Britain.	Neutral for all vulnerable groups.
Severance	A design aim for the Project is that as far as reasonably practicable all routes severed by the Project during the construction phase would be re-instated by means of bridges or underpasses as appropriate, with no additional impediment. There is therefore likely to be limited direct severance. Hornsby Lane in Thurrock would be permanently closed but there is no increase in distance for the alternative route.	Car ownership: Slight Beneficial Children under 16: Neutral People aged 70 and over: Neutral

Indicator	Assessment	Scores
	Overall, there is likely to be a small net decrease in traffic-related severance in a small number of locations, potentially affecting less than 1% of the population within the regional study area. The distribution of decreased traffic related severance is uneven with respect to car-ownership and there is likely to be a smaller than expected impact of traffic related severance on non-car owning households, compared with the regional study area and England and Wales. The distributions of traffic related severance on children aged under 16, people aged 70 and over and for people with a limiting long-term illness are even as they are similar to the regional study area and England and Wales.	People with a limiting long-term illness: Neutral
Personal affordability	The distribution of personal affordability impacts is uneven across income quintiles as there is a higher proportion of Gravesham residents within the lowest income quintiles compared with the regional study area and England and Wales.	Large Beneficial for Gravesham residents

10.5.2 Table 10.4 presents the qualitative appraisal scores included in the AST.

Table 10.4 Qualitative appraisal scores included in the AST

	Very Large Adverse	Large Adverse	Moderate Adverse	Slight Adverse	Neutral	Slight Positive/ Beneficial	Moderate Positive/ Beneficial	Large Positive/ Beneficial
Environment	Biodiversity	Historic environment	Landscape Townscape	Water environment	–	–	–	–
Social	–	–	–	–	Personal security	Affordability	–	Journey quality Severance
Economic	–	–	–	–	–	–	–	Option and non-use value
Distributional	–	Noise: • Income • Children	Noise: • Adults 70+	–	Accidents: • Children • Adults 70+ • Pedestrians • Cyclists • Motorcyclists • Male 16–25 year olds Severance: • Children • Adults 70+ • People with illness	Severance • Car ownership	User benefits • Income	Air quality: • Income • Children Affordability (Gravesham residents)

10.6 Landscape valuation

10.6.1 A monetary valuation of the impact of the Project on landscape was undertaken. Following TAG guidance, the valuation is not included in the BCR or the AST, but it is taken into account in the value for money assessment of the Project. The valuation is based on the appraisal parameters in TAG data book v1.18.

10.6.2 The appraisal was based on DfT's Value for Money Supplementary Guidance on Landscape (Department for Transport, 2021a). This involves an eight-step process:

a. Undertake the TAG non-monetised valuation

b. Segment the Project

c. Allocate each segment of the scheme to the correct 'land type'

d. Identify the landscape footprint

e. Mitigation

f. Valuation

g. Additional ecosystem services

h. Sensitivity tests

Step 1. TAG valuations

The key landscape and townscape features have been identified from the qualitative landscape and townscape appraisals and were used to inform the landscape valuation.

Step 2. Segmentation

The Project was subdivided into a number of sections based on its anticipated impact on the land. North of the river, 14 sections have been identified. South of the river, six sections have been identified. These are shown on Plate 10.1 and Plate 10.2 below.

Step 3. Allocation

Each segment of the Project was allocated to the correct land type – most of the Project is in areas of Urban Fringe and the Green Belt. Other land is either used for intensive agriculture or forested amenity land (e.g., Thames Chase Community Forest), with some nature conservation designations including pockets of ancient woodland:

a. North of the Thames the land lies within the Green Belt, often close to the urban edge, with smaller areas of Urban Fringe (Forested Land) and nature conservation areas (Natural semi-natural land).

b. South of the Thames, some land falls within the Kent Downs AONB. Elsewhere it is Urban Fringe and falls within the Green Belt.

c. Land within the AONB has various designations including Ancient Woodland and SSSI, Country Park and Registered Historic Park and Gardens. The predominant land type is either Natural, semi-natural land or Urban Fringe (Forested Land).

d. Land outside the AONB but within its setting is mostly used for intensive agriculture. However, towards the A2 and M2 there are large areas of ancient woodland. The land type is Urban Fringe (Green Belt) with some Natural semi-natural land.

Step 4. Landscape footprint

The Project's footprint, defined as 500 metres on either side of the route based on advice in the Value for Money Supplementary Guidance on Landscape, equates to 50 hectares per kilometre. The area of the Project that is currently taken up by the existing road network (M25, A13 and M2/A2) has negligible impact on the footprint but is included in Table 10.5 as Area of Existing Infrastructure discounted from Area Impacted – the area of existing infrastructure is based on the 'blacktop' width of each road including the hard shoulder and central reserve.

Step 5. Mitigation

As mitigation for the impacts of the Project, 327.65 hectares of new woodland planting within the road corridor are proposed as part of the Project and this is taken into account of the landscape valuation. However, the valuation takes no account of new Nitrogen Deposition compensation areas which are located further than 500 metres from either side of the Project. In accordance with the Supplementary Guidance on Landscape, the Project's mitigation approach is made clear in the Value for Money assessment included in Chapter 12.

Step 6. Valuation

The valuation involves multiplying the Project length by the appropriate landscape value for each land type (shown in Table 10.5) and the area of the land type which is impacted upon by the Project. The valuation equation is provided below:

Valuation = Length × Land type value × Land type Area

Step 7. Additional ecosystem services

The Air Quality regulation impacts of the scheme were assessed using the Landscape Monetisation workbook, along with the potential carbon sequestration associated with the gain in woodland. The Workbook calculates that the project will provide:

a. Air Quality regulation by vegetation benefits of £4.39m (PV 100 years, 2010 prices and values).

b. Carbon Sequestration benefits of £5.66m (PV, 2010 prices and values) based on central carbon values.

c. These ecosystem services benefits total £10.05m.

Step 8. Sensitivity tests

No sensitivity testing was undertaken because the landscape character and mitigation within the design envelope were known and incorporated into the appraisal.

10.6.3 Plate 10.1 and Plate 10.2 show the area north and south of the River Thames included in the monetary estimate of landscape impact without mitigation together with the allocation of land types.

10.6.4 Table 10.5 presents the valuation calculations and shows that the valuation of the landscape impacted by the Project, results in a disbenefit of £149.78m. This value takes account of the impact of existing infrastructure as explained above.

Plate 10.1 Landscape valuation study area north of the River Thames

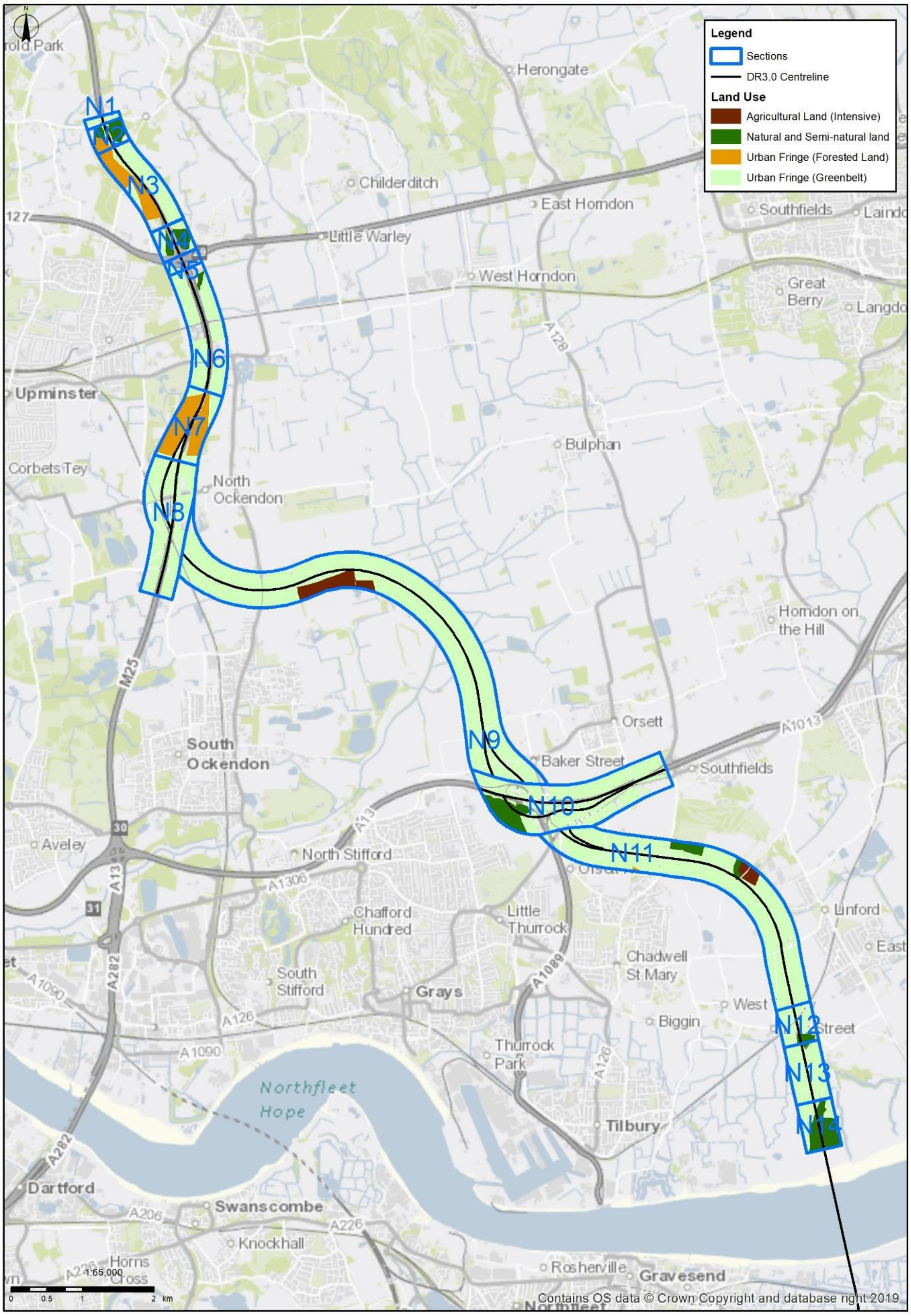


Plate 10.2 Landscape valuation study area south of the River Thames

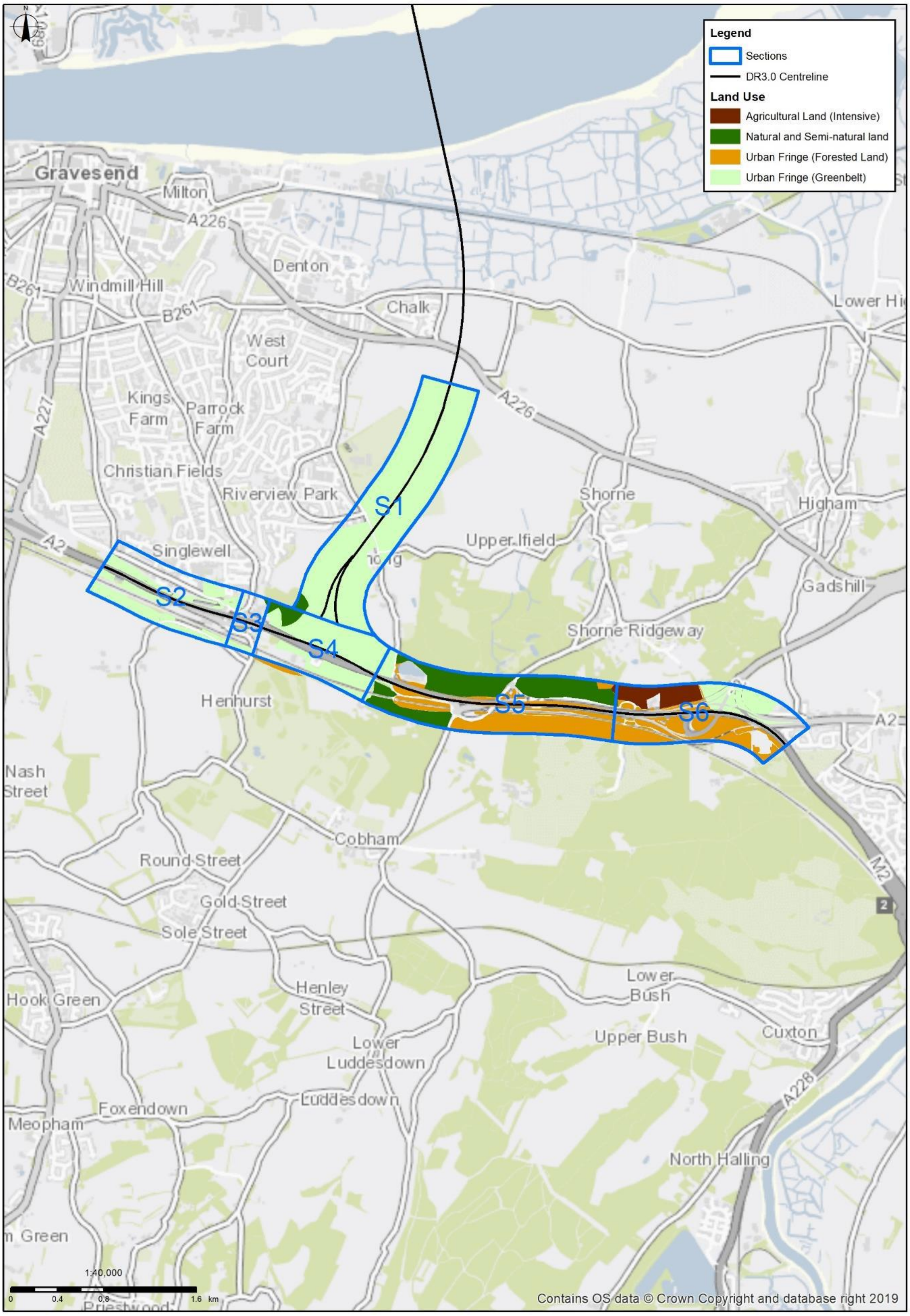


Table 10.5 Landscape valuation before mitigation (£m, 2010 prices and values)

Land type	Net present value (£m/ha) from TAG work book v1.18 (central values)	Length (km)	Area impacted (ha) assumes 50ha/km	Area of existing infrastructure discounted from area impacted (ha)	Final area impacted (ha)	Landscape valuation £m (Present Value × final area)
Urban Core	4.339040	0	0	0	0	0
Urban Fringe (Green Belt)	0.071420	23.98	1199	169.23	1029.77	73.55
Urban Fringe (forested land)	0.216972	3.951	197.55	131.68	65.87	14.29
Rural forested land (amenity)	0.532442	0	0	0	0	0
Agricultural land (extensive)	0.253115	0	0	0	0	0
Agricultural land (intensive)	0.008256	0	0	0	0	0
Natural and semi-natural land	0.531634	3.489	174.45	57.95	116.5	61.94
Total disbenefit before mitigation						**149.78**

10.6.5 Following the valuation, the land types were amended to take account of mitigation as set out in Step 5 above. This results in an increase in the areas of Urban Fringe (forested land) of 327.65 hectares and the same decrease in the area of Urban Fringe (Green Belt). This produces a monetary benefit of £46.38m which reduces the landscape disbenefit to £103.40m.

10.6.6 The additional ecosystem services identified in Step 7 provide benefits of £10.05m which reduce the landscape disbenefits to £93.35m. Table 10.6 sets out this calculation.

Table 10.6 Landscape valuations (£m, 2010 prices and values)

Element	Values
Initial landscape valuation	-£149.78m
Mitigation	+£46.38m
Ecosystem services benefits	+£10.05m
Total landscape disbenefit	-£93.35m

10.6.7 This valuation should be considered alongside the Moderate Adverse appraisal score derived from the qualitative landscape appraisal.

10.7 Resilience

10.7.1 The journey time reliability appraisal presented in Chapter 9 includes the impact of the Project on incidents that last up to six hours in duration.

10.7.2 However, sometimes incidents at the Dartford Crossing last longer than six hours. The ability of the road network to reduce the probability of, and manage and recover from, these long duration impacts is called resilience.

10.7.3 TAG does not provide guidance on how the resilience impacts of transport schemes should be appraised. However, a qualitative appraisal has been developed based on four different types of resilience. These are:

a. Event resilience

b. Weather resilience

c. Asset Management

d. Full closure

Event resilience

10.7.4 Event resilience relates to traffic accidents, breakdowns or non-vehicular encroachments which last more than six hours.

10.7.5 The impact of a transport scheme on event resilience can be divided into three elements:

a. The likelihood of an incident occurring – the Project is expected to cause traffic to redistribute resulting in fewer incidents across the Lower Thames area because:

i. There will be fewer vehicles using the Dartford Crossing and this will provide a greater ability for the Crossing to recover from incidents.

ii. The Project's modern design which will reduce the risk of incidents occurring. Particular features of the Dartford Crossing are its restrictions on vehicle dimensions in the northbound tunnels and on vehicles carrying hazardous loads leading to delays when vehicles do not follow the operational requirements. Many hazardous load vehicles are currently required to be escorted through the northbound tunnels, due to the restrictions. This requires normal traffic to be held approximately every 15 minutes for the escort to take place. This causes traffic to build up on the approach to the northbound crossings. In contrast:

1) The tunnel for the Project has been designed as a Category A tunnel which can be used by vehicles carrying hazardous loads.

2) The tunnel would have dual three-lanes which would enable it to accommodate higher and wider vehicles.

3) The Project has been designed as a free flow addition to the road network and does not have closely spaced junctions.

b. The ability of the SRN to handle an incident while it is ongoing – the Project is not designed as a fully resilient diversion route for Dartford Crossing traffic when an incident occurs at the Dartford Crossing due to the limited available junction and slip road capacity (e.g. M25 junction 2 and eastbound A2/Lower Thames Crossing slip road). Therefore, the Project only has a partial ability to provide an alternative route when an incident occurs at the Dartford Crossing.

c. The ability of the SRN to recover from an incident more quickly – there will be additional network capacity and lower inter-peak demand at the Dartford Crossing. Therefore, the network should be able to recover more quickly from incidents.

10.7.6 Overall, the Project is expected to provide a net increase in event resilience.

Weather resilience

10.7.7 The Project will be more weather resilient than the Dartford Crossing where traffic restrictions are imposed on the QEII Bridge during periods of high winds. The Project will enable high-sided vehicles to be redirected from the Dartford Crossing to the Project during periods of high winds protecting trips for these vehicles and improving resilience for other road users. During weather related bridge closures, trip making across the River Thames would be eased.

Asset management

10.7.8 While the Dartford Crossing infrastructure remains ready for many years of future service, National Highways has in the past had to implement longer term maintenance closures.

10.7.9 The Project will provide increased flexibility for National Highways to optimise the Dartford Crossing's maintenance and minor renewal plans and ensure that effective use is made of the additional capacity and thereby minimise maintenance costs.

10.7.10 The Project would also result in less people being impacted by major renewal work at the Dartford Crossing. While this work would suppress traffic volumes and reduce the benefits of the Project, trip making across the Thames, east of London, would be eased while this essential work is undertaken. The Project's comprehensive modelling of construction delays has helped to inform the planning for this renewals work.

Full closure

10.7.11 A full closure of the Dartford Crossing for a long period of time (months or years), for whatever reason, has never occurred but remains a possibility that would result in major economic, environmental and social disbenefits, locally, regionally and nationally. If such an event occurred, traffic volumes and the expected benefits of the Project would be suppressed, but the provision of the Project would preserve some trip making across the Thames to the east of London in contrast to a scenario without the Project which would involve major traffic diversions.

Overall impact

10.7.12 A qualitative appraisal of the impact of the Project on these different aspects of resilience has been carried out and has taken account of the fact that the resilience of the road network will be higher in early years after the Project has opened at a point of maximum additional capacity.

10.7.13 Overall, the resilience impact has been assessed as positive.

10.8 Freight values of time

10.8.1 The Project is forecast to carry a higher percentage of freight users than is typical on the SRN. Table 7.9 shows that under the Core traffic growth scenario the journey time benefits of the Project in respect of goods vehicles are worth £338m (2010 prices and values).

10.8.2 It is likely that the current estimates for values of time and reliability do not reflect the full value that freight users place on these impacts. This is because current freight values of time are primarily based on the value of the driver's time. As a result, they ignore the impacts of late delivery and therefore they underestimate the journey time impact for freight users.

10.8.3 It is likely that there is a non-linear relationship in which a small amount of unreliability is tolerable and has a relatively low valuation, whereas greater levels of unreliability would have more serious impacts on a business. For example, goods which need to arrive at a fixed time would have a lower tolerance and freight which is destined for a warehouse would have a higher tolerance.

10.8.4 A study from the Netherlands in 2013 sought to identify values of both freight time and freight journey time reliability and found that the value of freight time is greater than would be implied by driver's time and operating cost (Significance *et al.*, 2013). This suggests that the value for time for freight users is undervalued by around 20% in current DfT guidance (Department for Transport, 2022a). Therefore, this level of undervaluation would apply to freight value of time and unreliability benefits in the Project's appraisal.

10.8.5 This potential undervaluation has been taken into consideration in the value for money assessment of the Project.

10.9 International trade impacts

10.9.1 Existing and induced freight trips that benefit from the Project can be either carrying goods for domestic or international trade. The domestic/international shares are unknown, but the transport model forecasts increased trips to ports by freight vehicles.

10.9.2 In supporting the growth of international trade by the provision of more efficient journeys for imports and exports, there is potential for the Project to result in the following international trade impacts:

a. Allocative efficiency

b. Increased competition and specialisation

c. Foreign Direct Investment (FDI)

d. Balance of Payments

Allocative efficiency

10.9.3 As a result of the Project, consumers and businesses would be able to access a wider pool of imports and this would result in an allocative efficiency benefit by improving the matching process between demand and supply. However, this would double count Level 1 transport user and provider benefits which measure the effects of a transport intervention on the economic efficiency of the transport system.

Increased competition and specialisation

10.9.4 As a result of the Project there is likely to be a benefit due to increased competition and specialisation for firms that trade internationally. However, this impact is already monetised within Level 1 business user benefits as a direct economic impact and as additional economic output from the improved operation of imperfectly competitive markets as a Level 2 wider economic impact. Therefore, to avoid double counting, it has not been considered as an international trade impact in the appraisal.

Foreign Direct Investment

10.9.5 A good transport system is important to foreign investors, but there is little evidence that single projects attract FDI. However, the Project is a key part of the Road Investment Strategy 2 and the UK's wider infrastructure programme which are designed to make the UK more attractive to overseas investors (Department for Transport, 2020c).

10.9.6 The benefits of FDI are mixed, although they include technology transfer and know-how, accelerated structural transformation, stimulus to private sector development and employment creation.

10.9.7 Overall, it has been assessed that there are likely to be positive FDI impacts from the Project.

Balance of Payments

10.9.8 Increases in the value of exports improves UK's balance of payment (BoP) position. Conversely, if the value of imports exceeds exports, offset by the use of imports in exports, the BoP deteriorates.

10.9.9 As the UK's trade balance is negative, the Project is likely to have a negative impact on the UK's BoP.

10.9.10 Any change in the number of vehicle trips to other ports, compared to those in the Lower Thames area, due to the Project would be displacement and this would represent a neutral impact.

Overall impact

10.9.11 Overall, it has been assessed that there may be a Slight Positive impact from international trade which is not entirely captured in the freight values of time and journey time reliability impacts. This theoretical framework is not supplemented by quantitative evidence.

10.9.12 Any potential international trade benefits would depend heavily on the capacity of ports to handle additional freight vehicles, distribution centre capacity and technology, customs regulations, a competitive logistics sector, labour supply, training and unmet demand for UK exports.

10.10 Level 3 wider economic impacts

10.10.1 In line with TAG guidance, a range of evidence has been gathered about the potential for the Project to generate two Level 3 wider economic impacts based on the assumption of variable land use:

a. Agglomeration benefits for businesses from dynamic clustering

b. The change in tax revenue as labour moves to more or less productive jobs

10.10.2 The benefits of a transport project are fully captured within transport user benefits, such as journey time savings, if the economy in which the project is located is operating efficiently. Where this is not the case, there are WEI impacts which are additional to transport user benefits. These arise because of market failures in non-transport markets such as labour and land resulting from a divergence of private costs and benefits experienced by individuals, businesses and society. Such WEI impacts should not reflect the displacement of economic activity from other locations. Examples of evidence of market failures in the land and labour markets are: a) when businesses cluster together to gain benefits from greater labour market interactions, knowledge spill-overs and linkages between intermediate and final goods suppliers; and b) the differential between wages received by employees and the costs incurred by an employer due to the distortionary impacts of labour taxes on the labour market. If a transport project is expected to have impacts on secondary markets, such as labour and land, because of market failures then wider economic impacts should be appraised. More detail about the evidence for these impacts is included in the Level 3 Wider Economic Impacts report.

10.10.3 A review of other estuarial road crossings in the UK emphasised the criticality of understanding an area's historical development and current socio-economic characteristics in assessing whether a new crossing's wider economic impacts are likely to be realised.

10.10.4 In the case of the Project, the socio-economic context is important because of its location, close to London and on the main trade route between the UK's industrial heartlands and Europe, which, because of the estuary, is congested at Dartford. That congestion, which is partly due to longer distance movements, is the major factor that limits the development of a single Lower Thames market for goods, services and skills, reducing competition and constraining productivity levels.

10.10.5 An analysis of the current socio-economic conditions of the six Lower Thames local authorities – Dartford, Gravesham and Medway (south of the river) and Thurrock, Havering and Brentwood (north of the river) – found that these areas have similar economic structures but have developed separately. This seems to be primarily due to the barriers imposed by the estuary and the influence of London as a common market for some businesses and the sameness of the hinterland markets, as Kent and Essex are the most similar areas in the UK.

Dynamic agglomeration

10.10.6 There is evidence that the presence of an estuary leads to additional sources of market failure over and above the market failure that arises when firms cluster or agglomerate together.

10.10.7 The analysis using Location Quotients (LQ) has shown that the two local areas have similar economic structures with no clear specialisms with some cross-river duplication of activity in construction, transport and logistics and waste management industries. However, further analysis of how the LQs have changed over time and an estimation of input-output relationships shows that the employment compositions of the manufacturing, utilities and construction sectors have become more diverse over time. Better cross-river accessibility could therefore increase the concentration of professional and managerial functions which would be expected to generate more positive business interactions typically found in clusters. There is also some evidence of a cluster of business support services.

10.10.8 The Project is likely to result in cluster growth and greater diversification of the Local North and Local South economies as businesses relocate from south to north and vice versa across the river and change their land intensity. While further investigation is needed to assess the likely scale of these two-way changes in those industries, the Local North is the larger market and other things being equal, it is likely that a greater level of agglomeration will take place in the larger market, indicating more relocations of firms from the Local South area to the north of the river.

10.10.9 Qualitative evidence, including discussions with organisation in the logistics sector, responses from the Project's 2018 Statutory Consultation (Highways England, 2018c) and other survey and stakeholder evidence confirms most of the quantitative findings on existing and embryonic clusters. The qualitative evidence also pointed to other clusters, not evident in the economic data, in agri-food, the creative industries, robotics and advanced manufacturing. Based on all the evidence gathered, Table 10.7 summarises the business clusters that have been identified in the Lower Thames area.

10.10.10 Many of these are road-using sectors that are likely to benefit from the Project's provision of a step change in cross-river accessibility. Businesses in these clusters will gain opportunities for beneficial relocations and business reorganisations and changes in travel to work patterns. Changes in location and in the intensity of land use are expected to take place to reduce costs, expand output and improve competitiveness, all of which yield productivity and labour supply benefits.

Table 10.7 Business clusters in the Lower Thames area

Cluster type	Cluster name	Area
Key clusters	Transport, logistics and storage	Thurrock and Dartford
	Construction	Lower Thames area
	Business support services	Lower Thames area
	Agri-food	Kent and Essex
Emerging clusters	Creative industries	Thames Estuary
	Maintenance and sale of motor vehicles	Lower Thames area
	Robotics and advanced manufacturing	Lower Thames area
	Ceramics	Lower Thames area
	Financial and insurance services	Brentwood and Havering

Moves to more or less productive jobs

10.10.11 The evidence on dynamic agglomeration points to the potential for an increased intensity of clustering in transport and logistics and in construction, with further potential in business support services. Therefore, a consequence of this dynamic clustering will be that labour will move to more or less productive jobs (M2MLPJ). This M2MLPJ impact reflects a labour market failure in that there is a divergence in wages received by employees from the costs incurred by the employer due to the imposition of labour taxes. These taxes distort incentives for individuals to supply and businesses to demand labour, thereby affecting the competitive labour market equilibrium.

10.10.12 When a transport project is expected to impact on the labour market, as labour moves to more or less productive jobs, the net benefit from these relocations due to the transport project is the change in tax revenue.

10.10.13 Overall the evidence provides context for the Level 2 wider economic impacts and indicates that the Project has potential to generate significant Level 3 wider economic impacts that would be important to the Lower Thames economy, the wider region and nationally.

Robustness of the evidence

10.10.14 The quantitative evidence is based on data drawn from official sources, principally NOMIS labour market statistics and other statistics produced by the Office for National Statistics (ONS). The data has been used to produce outputs using a range of established analytical techniques and models and these have been brought together to produce a balanced and consistent economic analysis which identifies current and embryonic clusters in the Lower Thames area and assesses the potential of the Project to generate wider economic impacts based on land use change.

10.10.15 The quantitative findings have been reinforced by a range of qualitative evidence that includes findings from contact with businesses and from research that examined the impacts at other estuarial road crossings.

11 Benefit cost ratios

11.1 Introduction

11.1.1 This chapter reports the appraisal results and BCRs for the central case scenario and a series of sensitivity tests. The sensitivity tests comprise the impact of:

a. Changes in traffic growth

b. Different levels of CAPEX costs

c. Appraisal parameters in TAG data book v1.19FC which is due to be made definitive by DfT in November 2022

d. The implementation of Transport Decarbonisation Plan policies on road user tailpipe greenhouse gas emissions

e. The use of an extended appraisal period

11.2 Central case

11.2.1 Table 11.1 presents a summary of the central case appraisal results. Table 11.2 provides a fuller breakdown of the results. These are based on:

a. Core traffic growth

b. Most Likely CAPEX costs

11.2.2 The Initial BCR is 0.48 and the Adjusted BCR is 1.22.

Table 11.1 Summary of central case appraisal (£m, 2010 prices and values)

	£m
Level 1 PVB	1,295.9
PVC	-2,700.2
Initial BCR	**0.48**
Journey time reliability	487.1
Wider economic impacts	1,516.6
Level 2 PVB	2,003.7
Level 1 and 2 PVB	3,299.5
PVC	-2,700.2
Adjusted BCR	**1.22**

Table 11.2 Central case appraisal results (£m, 2010 prices and values)

Level 1	Commuting	Journey time savings	434.5
		Vehicle operating cost savings	-39.3
		User charge impacts	-5.9
		Construction and maint. delays	-27.6
		Total	**361.6**
	Other users	Journey time savings	778.6
		Vehicle operating cost savings	-290.8
		User charge impacts	-28.4
		Construction and maint. delays	-32.8
		Total	**426.7**
	Business	Journey time savings	875.1
		Vehicle operating cost savings	280.4
		User charge impacts	-32.3
		Construction and maint. delays	-80.4
		Total	**1,042.9**
	Transport Economic Efficiency	Journey time savings	2,088.2
		Vehicle operating cost savings	-49.6
		User charge impacts	-66.6
		Construction and maint. delays	-140.8
		Total	**1,831.2**
Other Level 1	Noise		3.4
	Local air quality		-7.8
	Greenhouse gases		-527.8
	Physical activity		21.2
	Accidents		-67.8
	Indirect tax revenues		43.5
	Total		**-535.3**
	Level 1 PVB		**1,295.9**
PVC	CAPEX		-3,119.6
	OMR		-327.4
	User charging revenues		746.8
	PVC		**-2,700.2**
	Initial BCR		**0.48**
Level 2	Incidents		265.4
	Local diversions		68.8
	Travel time variability		152.9

	Reliability	**487.1**
	Static agglomeration	1,374.8
	Output change	133.4
	Labour supply	8.4
	Level 2 wider economic impacts	**1,516.6**
	Level 2 PVB	**2,003.7**
	Level 1 and 2 PVB	**3,299.5**
	Adjusted BCR	**1.22**

11.3 Sensitivity tests

Traffic growth

As explained in Chapter 4, sensitivity tests were undertaken to assess the impact of Low and High traffic growth levels on the benefits and revenues and thus the BCRs. The CAPEX and OMR costs were unchanged, but the revenues change in the PVC. The results of these tests are presented in Table 11.3,

11.3.1 Table 11.4 and Plate 11.1.

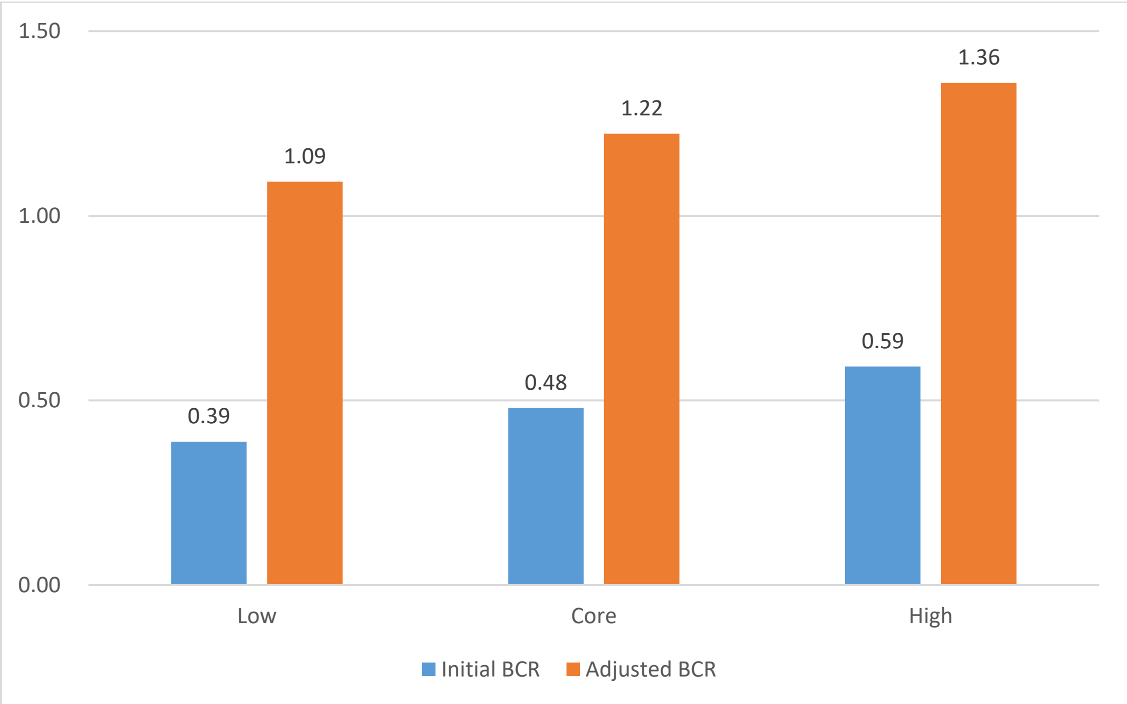
Table 11.3 BCRs for Low, Core and High growth (£m, 2010 prices and values)

	Low growth	Core growth	High growth
Level 1 PVB	1,080.2	1,295.9	1,554.7
PVC	-2,781.5	-2,700.2	-2,626.1
Initial BCR	**0.39**	**0.48**	**0.59**
Journey time reliability	487.1	487.1	487.1
Wider economic impacts	1,470.2	1,516.6	1,529.7
Level 2 PVB	1,957.3	2,003.7	2,016.8
Level 1 and 2 PVB	3,037.4	3,299.5	3,571.5
PVC	-2,781.5	-2,700.2	-2,626.1
Adjusted BCR	**1.09**	**1.22**	**1.36**

Table 11.4 Impact of different traffic growth on the BCR

	Lower benefits ←	Comparable costs and benefits	Higher benefits →
Indicator	**Low**	**Central case** **Core**	**High**
PVB	3,037.4	3,299.5	3,571.5
PVC	2,781.5	2,700.2	2,626.1
Adjusted BCR	1.09	1.22	1.36
Based on Most Likely CAPEX. The PVC changes because the revenues vary with traffic growth.			

Plate 11.1 BCRs for Low, Core and High growth (£m, 2010 prices and values)



CAPEX costs

11.3.2 Sensitivity tests were also undertaken to assess the impact of P10 and P90 CAPEX cost confidence levels on the PVC and BCR. Expressed in outturn prices, the P10 cost is estimated to be £6,220.2m and the P90 cost is estimated to be £11,470.6m. These costs were then expressed in 2010 prices and values using TUBA v1.9.18. The benefits and revenues were unchanged.

11.3.3 The results of these tests are presented in Table 11.5, Table 11.6 and Plate 11.2.

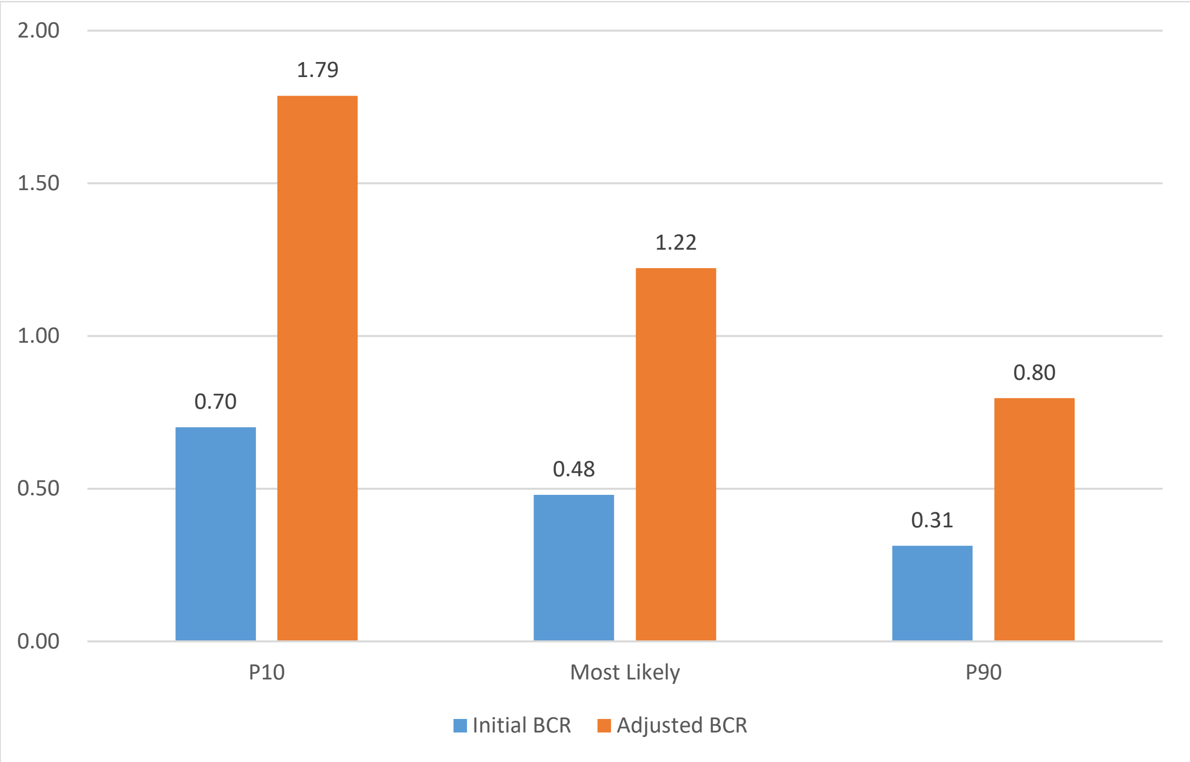
Table 11.5 BCRs for P10, Most Likely and P90 costs (£m, 2010 prices and values)

	P10	Most Likely	P90
Level 1 PVB	1,295.9	1,295.9	1,295.9
PVC	1,846.9	2,700.2	4,140.1
Initial BCR	**0.70**	**0.48**	**0.31**
Journey time reliability	487.1	487.1	487.1
Wider economic impacts	1,516.6	1,516.6	1.516.6
Level 2 PVB	2,003.7	2,003.7	2,003.7
Level 1 and 2 PVB	3,299.5	3,299.5	3,299.5
PVC	1,846.9	2,700.2	4,140.1
Adjusted BCR	**1.79**	**1.22**	**0.80**

Table 11.6 Impact of different CAPEX costs on the BCR

	Lower costs ←	**Comparable costs and benefits**	**Higher costs** →
Indicator		**Central case**	
	Minimum P10	**Most Likely P41**	**Maximum P90**
PVC	1,846.9	2,700.2	4,140.1
Adjusted BCR	1.79	1.22	0.80
Based on the Core growth estimate of PVB of £3,299.5m			

Plate 11.2 BCRs for different CAPEX costs



TAG data book v1.19FC

11.3.4 In May 2022, DfT issued a Forthcoming Change version of the TAG data book v1.19FC that it expects to become definitive in November 2022. An accompanying TUBA Economics file was issued in June enabling these parameters to be used in TUBA.

11.3.5 The new data book and Economics file include the following changes to TAG appraisal parameters:

a. Updated base and forecast fleet proportions including the introduction of values for PSV Electric sub-vehicle/mode type

b. Updated base and forecast fuel consumption and fuel efficiency values.

11.3.6 DfT has published more details about the changes (Department for Transport, 2022d).

11.3.7 A sensitivity test has been run in TUBA on the Core growth scenario to assess the impact of using the new parameters on the valuation of vehicle operating costs. However, most of the changes that result from having a higher proportion of electric vehicles are not captured in this test. Table 11.7 shows the results of this test. The Adjusted BCR increases from 1.22 in the central case to 1.23 with the new TAG data book parameters.

Table 11.7 BCR for TAG data book v1.19FC (£m, 2010 prices and values)

	Central case	Sensitivity test v1.19FC
Level 1 PVB	1,295.9	1,309.2
PVC	2,700.2	2,700.2
Initial BCR	**0.48**	**0.48**
Journey time reliability	487.1	487.1
Wider economic impacts	1,516.6	1,516.6
Level 2 PVB	2,003.7	2,003.7
Level 1 and 2 PVB	3,299.5	3,312.9
PVC	2,700.2	2,700.2
Adjusted BCR	**1.22**	**1.23**

Transport Decarbonisation Plan

11.3.8 The DfT's Transport Decarbonisation Plan (TDP) sets out plans to decarbonise the entire transport system in the UK (Department for Transport, 2021c). This includes measures to:

a. Increase walking and cycling

b. Introduce zero emission buses and coaches

c. Decarbonise railways

d. Mandate the use of zero emission cars, vans, motorcycles and scooters

e. Accelerate maritime and aviation decarbonisation

f. Deliver a zero-emission freight and logistics sector

g. Deliver decarbonisation through places

h. Maximise the benefits of sustainable low carbon fuels

i. Support hydrogen's role in a decarbonised transport system

j. Encourage more choice and increase the efficiency of transport

k. Support UK research and development as a decarbonisation enabler

11.3.9 National Highways has assessed the impact of these TDP policies on road user tailpipe greenhouse gas emissions over 60 years from scheme opening in 2030. Upper bound and lower bound estimates of the impact of these policies have been generated. These estimates are based on the LTAM With Scheme model run CS67 and EFTv11 with the London adjustment.

11.3.10 Table 11.1 reports the Upper bound and Lower bound tailpipe emissions in tonnes, in total and for each Carbon Budget period. It also reports the monetary values of these emissions in 2010 prices and values.

Table 11.1 Transport Decarbonisation Plan sensitivity tests

Scenarios	Tonnes and Present Values	Total	CB3 (2018–2022)	CB4 (2023–2027)	CB5 (2028–2032)	CB6 (2033–2037)
Central case	Net Carbon Impact (tCO2e)	6,596,731	0	1,148,319	899,099	462,174
	PV of Carbon Impacts (£, 2010 prices and values)	526,082,456				
Transport Decarbonisation sensitivity tests	Upper TDP: Net Carbon Impact (tCO2e)	2,937,975	0	1,148,319	869,349	325,236
	Upper TDP: PV of Carbon Impacts (£, £2010 prices and values)	284,433,647				
	Lower TDP: Net Carbon Impact (tCO2e)	2,324,097	0	1,148,319	782,124	178,608
	Lower TDP: PV of Carbon Impacts (£, 2010 prices and values)	231,408,423				

Note: Excludes the value of tailpipe greenhouse gas emissions due to maintenance delays which is £1.7m (2010 prices and values).

11.3.11 Table 11.2 shows the effect of the updated greenhouse gas monetary values due to the TDP tests on the scheme's appraisal results and BCRs.

11.3.12 The BCR rises from 1.22 in the central case appraisal to 1.24 under the Upper bound TDP test and 1.26 under the Lower bound TDP test.

Table 11.2 Impact of TDP tests on the BCRs (£m, 2010 prices and values)

	Central case	Upper bound TDP test	Lower bound TDP test
Level 1 PVB	1,295.9	1,355.3	1,408.3
PVC	2,700.2	2,700.2	2,700.2
Initial BCR	**0.48**	**0.50**	**0.52**
Journey time reliability	487.1	487.1	487.1
Wider economic impacts	1,516.6	1,516.6	1,516.6
Level 2 PVB	2,003.7	2,003.7	2,003.7
Level 1 and 2 PVB	3,299.5	3,359.0	3,412.0
PVC	2,700.2	2,700.2	2,700.2
Adjusted BCR	**1.22**	**1.24**	**1.26**

100-year appraisal period

11.3.13 In December 2020 DfT undertook a public consultation about lengthening the appraisal period used to calculate benefits and costs for project appraisals beyond the standard 60-year period (Department for Transport, 2020d). The consultation was an acknowledgement that some projects are constructed to have a design life far exceeding the standard 60-year appraisal period. Following the consultation, DfT updated TAG Unit A1.1 in May 2021 by including new advice on the use of extended appraisal periods (Department for Transport, 2021b). This states that:

a. Extended appraisals should be undertaken as a sensitivity test and must not form part of a project's central case appraisal.

b. The extended appraisal period should not exceed the longest-lived asset constructed as part of a scheme.

c. In all cases, the extended appraisal period should be no more than 100 years, which is the maximum standard assumed economic asset life.

d. The extended appraisal must include robust cost estimates for all maintenance and renewals required over the period that benefits are claimed.

e. The appraisal should be supported by a strong strategic case rationale for the existence of significant impacts in the very long-term.

f. Scheme promoters are expected to present a range of estimates for post 60-year benefits, not simply a point estimate.

Strategic rationale for long term impacts

11.3.14 The Project includes twin bored tunnels for which the civil engineering work has a 120-year design life. Other aspects of the tunnels, such as the mechanical, electrical, instrumentation, control and automation assets, have shorter design lives. Therefore, two 100-year appraisal period sensitivity tests have been undertaken in line with DfT advice on undertaking these sensitivity tests. The approaches to the scenarios and the appraisal results are reported below.

Appraisal methodologies

11.3.15 The two 100-year appraisal period scenarios differ in respect to the level of road user tailpipe greenhouse gas emissions over the 100-year period from scheme opening as follows:

a. Scenario 1 – The level of road user tailpipe carbon emissions in the central case appraisal was extrapolated over 100 years.

b. Scenario 2 – The level of road user tailpipe carbon emissions in the TDP Upper bound sensitivity test was extrapolated over 100 years.

11.3.16 Those impacts that arise after year 60 from scheme opening are assumed to be the same under both scenarios and are extrapolated from the central case appraisal over the period 61 to 100 years.

11.3.17 The methods for extrapolating the benefits, costs and revenues from 60 years to 100 years are described below.

Benefits

11.3.18 The following impacts were estimated by changing the horizon year in TUBA v1.9.18 from 60 years to 100 years after the open for traffic year of 2030:

a. Journey time savings

b. Vehicle operating costs

c. User charge impacts

d. Indirect tax revenues

11.3.19 Construction delay impacts are unchanged from those in the central case appraisal.

11.3.20 The following impacts produced small monetary values in the central case appraisal. Therefore, 100-year values for these impacts for the period 2030 to 2129 were estimated by dividing the 60-year values by 60 and multiplying by 100:

a. Noise

b. Air Quality

c. Maintenance delays

d. Physical Activity

e. Accidents

11.3.21 The following approaches were applied to the appraisal of embodied carbon emissions:

a. Construction emissions and their monetary value are unchanged from those in the central case appraisal.

b. Operational emissions are assumed to be zero over the 100-year operational phase from scheme opening in 2030.

c. Renewals and maintenance emissions and their monetary values are unchanged from those in the central case appraisal.

11.3.22 Tailpipe road user emissions were appraised over 100 years as described below.

<u>Scenario 1</u>

11.3.23 All emissions and their monetary values for the first 60 years after scheme opening are assumed to be the same as those in the central case appraisal;

11.3.24 For the years 61 to 100:

a. Non-traded tailpipe emissions were held constant at the level in year 60 from scheme opening.

b. Monetary values for non-traded tailpipe emissions were calculated by applying TAG data book monetary values for carbon emissions up to the year 2100. Values from 2101 to 2129 were increased by 1.5% per annum in line with TAG advice.

c. Discount factors that reflect Present Values expressed in 2010 prices and values were applied to the non-traded values in each year to create present values for years 61 to 100 in 2010 prices and values.

d. The Carbon Valuation Toolkit does not show the values applied to traded tailpipe emissions over 60 years. Therefore, as the 60-year traded tailpipe emissions are small in absolute terms, an approximate 100-year estimate was calculated as follows:

i. The 60-year traded total was divided by 60 and multiplied by 100, from which the 60 year total was subtracted to generate a value for years 61 to 100.

ii. This value for years 61 to 100 was then divided by two, as a proxy for the effect of discounting, and then added to the 60-year total to generate an estimate of 100-year traded emissions.

Scenario 2

11.3.25 All emissions and their monetary values for the first 60 years after scheme opening are assumed to be the same as those in the TDP Upper bound sensitivity test.

11.3.26 For years 61 to 100:

e. Non-traded emissions were held constant at the level in year 60

f. Monetary values for non-traded emissions were calculated by applying TAG data book monetary values for carbon emissions up to the year 2100. Values from 2101 to 2129 were increased by 1.5% per annum in line with TAG advice

g. Discount factors that reflect Present Values expressed in 2010 prices and values were applied to the non-traded values in each year to create present values for years 61 to 100 in 2010 prices and values

h. The Carbon Valuation Toolkit does not show the split of traded and non-traded emissions for the TDP tests over 60 years. Therefore, as the value of traded emissions is small in absolute terms, the ratio of Scenario 2 to Scenario 1 non traded emissions was used to generate a value for traded emissions for Scenario 2

i. The same values for embodied carbon and carbon due to delays for road users from planned maintenance works as those in Scenario 1 were used in Scenario 2

11.3.27 The monetary value of journey time reliability and Level 2 wider economic impacts for years 1 to 60 from scheme opening are assumed to be the same as those in the central case appraisal. The values of these impacts for years 61 to 100 were held constant at the values in year 60 and discount factors that reflect Present Values expressed in 2010 prices and values were applied to the values in each year to create present values for years 61 to 100 in 2010 prices and values.

Costs and user charge revenues

11.3.28 CAPEX costs are unchanged from those in the central case appraisal.

11.3.29 OMR costs for years 1 to 60 were the same as those in the central case appraisal. For years 61 to 100 new estimates of highways, tunnels, road user charging system costs and other costs were estimated.

11.3.30 Road user charging revenues were estimated by changing the horizon year in TUBA v1.9.18 to 100 years after the open for traffic year of 2030.

Appraisal results

11.3.31 Table 1.3 presents the appraisal results for the central case appraisal and the two 100-year appraisal period scenarios. All values are expressed in 2010 prices and values. It shows that compared to the central case appraisal:

a. Under both 100-year scenarios:

   i. Time savings rise by £713m from £2,088m to £2,801m

   ii. Disbenefits for other Level 1 impacts, except for greenhouse gas emissions, rise by £21m from -£6m to -£28m

   iii. OMR costs rise by £50m from £327m to £377m

   iv. User charge revenues rise by £126m from £747m to £873m

   v. Level 2 impacts rise by £503m from £2,004m to £2,507m

b. Scenario 1 greenhouse gas emissions disbenefits rise by £103m from £528m to £630m.

c. Scenario 2 greenhouse gas emissions disbenefits fall by £52m from £528m to £475m.

11.3.32 The Initial BCR rises from 0.48 (central case) to 0.71 (Scenario 1) and 0.77 (Scenario 2).

11.3.33 The Adjusted BCR rises from 1.22 (central case) to 1.66 (Scenario 1) and 1.72 (Scenario 2).

Table 1.3 100-year appraisal period results (£m, 2010 prices and values)

	Central case	Scenario 1 100-year	Scenario 2 100-year TDP Upper
Journey time savings	2,088.2	2,801.4	2,801.4
VOC and user charge impacts	-116.3	-126.5	-126.5
Noise and air quality	-4.4	-7.3	-7.3
Greenhouse gas emissions	-527.8	-630.4	-475.4
Accidents	-67.8	-113.0	-113.0
Indirect tax revenues	43.5	43.1	43.1
Construction delay impacts	-130.8	-130.8	-130.8
Maintenance delay impacts	-10.0	-16.3	-16.3
Physical activity	21.2	35.3	35.3
Level 1 PVB	**1,295.9**	**1,855.6**	**2,010.5**
CAPEX	-3,119.6	-3,119.6	-3,119.6
OMR	-327.4	-377.4	-377.4
User charge revenues	746.8	872.6	872.6
PVC	**-2,700.2**	**-2,624.5**	**-2,624.5**
Initial BCR	**0.48**	**0.71**	**0.77**
Journey time reliability	487.1	603.7	603.7

	Central case	Scenario 1 100-year	Scenario 2 100-year TDP Upper
Level 2 wider economic impacts	1,516.6	1,902.8	1,902.8
Level 2 PVB	**2,003.7**	**2,506.5**	**2,506.5**
Level 1 and 2 PVB	**3,299.5**	**4,362.1**	**4,517.1**
PVC	**-2,700.2**	**-2,624.5**	**-2,624.5**
Adjusted BCR	**1.22**	**1.66**	**1.72**

11.3.34 The 100-year appraisal results are summarised in Table 1.4.

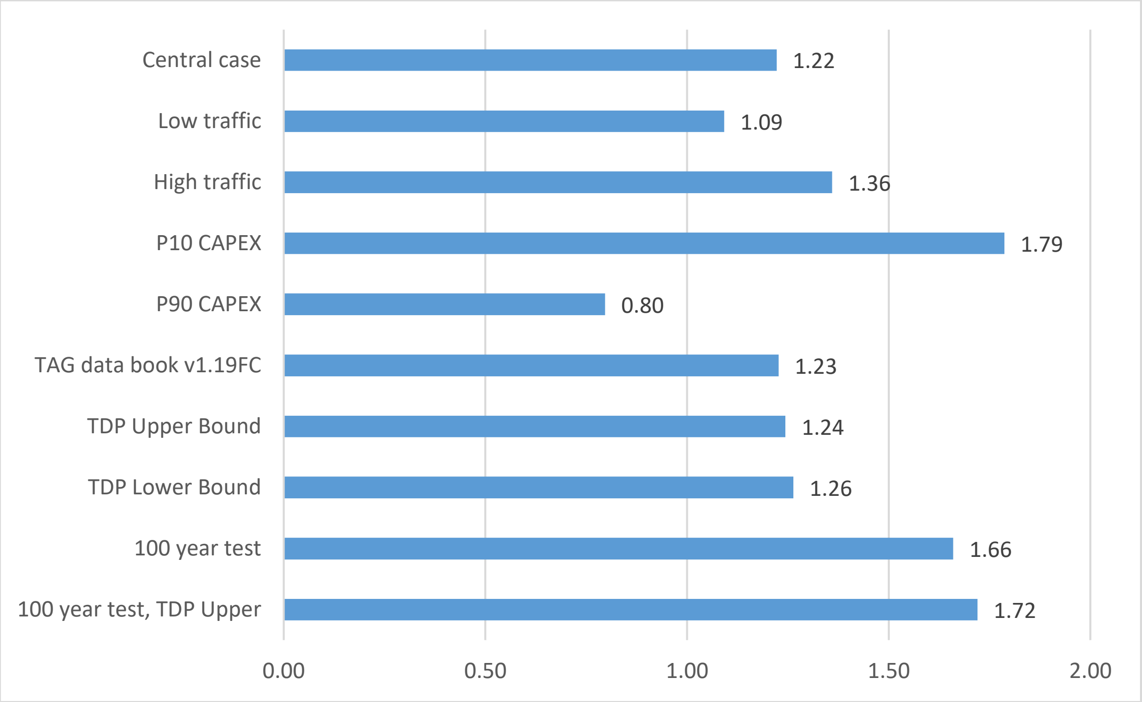
Table 1.4 100-year appraisal period results (£m, 2010 prices and values)

	Central case	Scenario 1 100-year	Scenario 2 100-year TDP Upper
Level 1 PVB	1,295.9	1,855.6	2,010.5
PVC	2,700.2	2,624.5	2,624.5
Initial BCR	**0.48**	**0.71**	**0.77**
Journey time reliability	487.1	603.7	603.7
Wider economic impacts	1,516.6	1,902.8	1,902.8
Level 2 PVB	2,003.7	2,506.5	2,506.5
Level 1 and 2 PVB	3,299.5	4,362.1	4,517.1
PVC	2,700.2	2,624.5	2,624.5
Adjusted BCR	**1.22**	**1.66**	**1.72**

Summary of sensitivity tests

11.3.35 Plate 11.3 summarises the impact of all of these sensitivity tests on the Adjusted BCR. It shows that across the various sensitivity tests, the BCR is most sensitive to the level of CAPEX costs.

Plate 11.3 Impact of sensitivity tests on the Adjusted BCR



12 Conclusions

12.1 Introduction

12.1.1 This chapter sets out the conclusions from the Project's appraisal and reports the Value for Money assessment.

12.2 Appraisal conclusions

12.2.1 The appraisal of the Project, based on DfT's TAG guidance, produces an estimate of Level 1 benefits, or PVB, of £1,295.9m for the Core traffic growth scenario. Journey time savings, which provide the Project's largest benefits, are estimated to be worth £2,088.2m. However, other Level 1 impacts are valued at -£792.3m.

12.2.2 The total costs of the Project, less user charging revenue for the Core traffic growth, or the PVC, is estimated to be £2,700.2m based on Most Likely CAPEX costs. This gives an Initial BCR of 0.48.

12.2.3 The addition of Level 2 benefits increases the PVB to £3,299.5m and results in an Adjusted BCR of 1.22.

12.2.4 There is an inter-relationship between the level of journey time savings and agglomeration benefits. Some users appear to be using some, or all, of their journey time savings from the Project to travel further to secure agglomeration benefits.

12.2.5 Benefits that can be spatially disaggregated sum to £3,488.5m. Of these, £1,672.3m accrue to Lower Thames local authorities and £1,090.5m accrue to other SELEP local authorities.

12.2.6 Sensitivity tests show that:

a. Under the Low traffic growth scenario the Adjusted BCR falls to 1.09 and under the High traffic growth scenario the Adjusted BCR rises to 1.36.

b. Under P10 CAPEX costs the Adjusted BCR rises to 1.79 and under P90 CAPEX costs the Adjusted BCR falls to 0.80.

c. The successful implementation of policies and measures in the Transport Decarbonisation Plan would increase the Project's BCR to 1.24 (Upper bound) or 1.26 (Lower bound).

d. The use of a 100-year appraisal period would result in the Adjusted BCR rising to between 1.66 (based on an extrapolation of central case road user carbon emissions) and 1.72 (based on an extrapolation of TDP upper bound road user carbon emissions).

12.2.7 Additional Level 3 appraisal is taken into account in determining the final VfM assessment. This evidence shows that:

a. Biodiversity has a Very Large Adverse AST score, Historic Environment has a Large Adverse AST score, Landscape and

Townscape have Moderate Adverse scores and Water Environment has a Slight Adverse score.

b. All of the qualitatively appraised social impacts have Neutral or Positive AST scores.

c. There is a Large Positive option and non-use value impact.

d. Most impacts have Neutral or Positive distributional effects for vulnerable social groups except for noise which has Large Adverse and Moderate Adverse impacts on vulnerable groups.

e. There is a moderate indicative monetary disbenefit in respect of landscape based on current guidance.

f. There is a small positive indicative monetary value for active mode impacts.

g. It is expected that the Project will improve the resilience of the road network.

h. Freight benefits that are included in the appraisal are likely to be undervalued.

i. The Project is expected to generate small international trade benefits.

j. There is strong evidence of the potential for the Project to generate Level 3 wider economic impacts that could have major impacts on the Lower Thames economy.

12.3 Value for Money assessment

12.3.1 The Project's VfM assessment is based on the appraisal of its economic, environmental and social benefits, disbenefits, costs and revenues. Some impacts have been estimated and expressed in monetary terms, while others include quantitative information and/or are qualitatively appraised, but all impacts inform the VfM assessment. All monetised impacts are appraised over 60-years from Project opening, except for construction costs and construction period impacts. Monetised impacts are all expressed in 2010 market prices and present values (PV) in order that impacts arising in different years can be directly compared. The VfM assessment takes account of three appraisal levels.

Level 1 appraisal

12.3.2 The Level 1 appraisal includes monetised benefits and disbenefits which are estimated using established modelling and appraisal methods and are based on a fixed land use assumption. Level 1 impacts, such as journey time savings, vehicle operating cost savings, accident impacts and greenhouse gas emissions, sum to provide a Level 1 PVB. The ratio of the Level 1 PVB to the Project's costs less revenues arising from road user charging, referred to as the PVC, produces the Initial BCR, which for the Project's central case appraisal is 0.48.

Level 2 appraisal

12.3.3 The Level 2 appraisal includes benefits which are estimated using less established modelling and appraisal methods and also based on a fixed land use assumption. These comprise wider economic impacts, such as productivity benefits from improved connections between businesses, and improvements in journey time reliability. These benefits are added to the Level 1 PVB to produce a Level 1 and 2 PVB. The ratio of the Level 1 and 2 PVB to the PVC produces the Adjusted BCR which for the central case appraisal is 1.22. The Adjusted BCR provides an indicative measure of VfM, but the Project's final VfM assessment also takes account of Level 3 appraisal evidence and the results of sensitivity tests which change the Project's benefits, costs, revenues and Adjusted BCR.

Level 3 appraisal

12.3.4 The Level 3 appraisal includes a range of other appraisal evidence not included in the Adjusted BCR. It includes:

a. quantitative and qualitative information about impacts that cannot be monetised

b. an assessment of the distribution of some impacts on vulnerable social groups (presented in the Distributional Impact Appraisal Report),

c. a monetary value for Landscape impacts which, based on DfT guidance, cannot be included in the BCR. The valuation takes account of 328 hectares of new woodland planting within the road corridor of the Project, but does not take account of new Nitrogen Deposition compensation areas which are located further than 500 metres from either side of the Project.

d. other appraisal evidence which includes evidence about the Project's potential to generate additional wider economic impacts based on variable land use (presented in the Level 3 Wider Economic Impacts Report).

Sensitivity tests

12.3.5 Sensitivity tests have been undertaken to assess the sensitivity of the Project's monetised benefits, costs and revenues to different traffic growth, costs and other scenarios. The results of these tests are that:

a. The Adjusted BCR falls to 1.09 under the Low traffic growth scenario and rises to 1.36 under the High traffic growth scenario.

b. The Adjusted BCR rises to 1.79 under P10 CAPEX costs and falls to 0.80 under P90 CAPEX costs.

c. The Adjusted BCR rises to 1.23 when the appraisal parameters in the forthcoming TAG data book v1.19FC were applied to the appraisal.

d. The Adjusted BCR rises to 1.24 under the TDP Upper bound test and 1.26 under the TDP Lower bound TDP test.

e. The Adjusted BCR rises to between 1.66 (Scenario 1) and 1.72 (Scenario 2) when the appraisal period is extended to 100 years. Scenario 1 does not take account of TDP policies on road user carbon emissions, while the Upper Bound TDP test is reflected in Scenario 2.

12.3.6 Account has been taken of all of the above appraisal information and evidence in assessing the Project's VfM. Based on the categories in DfT's VfM framework, the Project has been assessed as providing Low VfM (Department for Transport, 2015).

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Glossary

Term	Abbreviation	Explanation
100-year appraisal period	**n/a**	A sensitivity test used to appraise benefits and costs of the Project over a 100-year appraisal period.
2010 prices and values	**n/a**	The price base and present value year used to present and compare monetised costs and benefits of a transport project.
2030 opening year	**n/a**	A modelled year in the Project's LTAM traffic model in which traffic flows and costs are estimated when the Project is opened.
2045 design year	**n/a**	A modelled year in the Project's LTAM traffic model in which traffic flows and costs are estimated on which the Project design is based.
A-weighted decibel	**dB(A)**	An expression of the relative loudness of sounds as perceived by the human ear. A-weighting gives more value to frequencies in the middle of human hearing and less value to frequencies at the edges of human hearing.
A122 Lower Thames Crossing	**Project**	A proposed new crossing of the Thames Estuary linking the county of Kent with the county of Essex, at or east of the existing Dartford Crossing.
AM peak hour	**n/a**	The hour between 07:00–08:00 in in the Project traffic model LTAM.
AM peak period	**n/a**	The period between 06:00–09:00 in in the Project traffic model LTAM.
Acute Myocardial Infarction	**AMI**	Commonly known as a heart attack, this occurs when blood flow decreases or stops to the coronary artery of the heart, causing damage to the heart muscle.
Active Mode Appraisal Toolkit	**AMAT**	A DfT toolkit for appraising the physical activity impacts of transport projects.
Adjusted Benefit Cost Ratio	**Adjusted BCR**	The ratio of the sum of Level 1 and 2 PVBs to PVC
Affected Road Network	**ARN**	In air quality assessment, the network of roads to be considered within the air quality model (selection of the roads within the model depends on a number of criteria such as changes in Heavy Duty Vehicle flows).
Agglomeration	**n/a**	In traffic and economics assessment, benefits which come when firms and/or people locate near one another in geographical clusters
Air quality management area	**AQMA**	An area, declared by a local authority, where air quality monitoring does not meet Defra's national air quality objectives.
Air Quality Strategy Objective	**AQSO**	An objective set by the Air Quality Strategy for England, Scotland, Wales and Northern Ireland to improve air quality in the UK in the medium term. Objectives are focused on the main air pollutants to protect health.
Analysis of Monetised Costs and Benefits	**AMCB**	In transport and economic assessment, the conversion of changes due to a project into an estimated monetary value.
Ancient Semi-Natural Woodland	**ANSW**	A type of ancient woodland, acknowledged as non-statutory designated sites and protected under the National Planning Policy Framework.

Term	Abbreviation	Explanation
Annual Average Daily Traffic	**AADT**	An estimate of the average daily traffic along a defined segment of roadway. This value is calculated from short-term counts taken along the same section, which are then factored to produce the estimate of AADT. Because of this process, the most recent AADT for any given roadway will always be for the previous year.
Annual Average Weekday Traffic	**AAWT**	The average weekly flow of vehicles on a road or section of a road
Appraisal	**n/a**	The process of defining objectives, examining options and weighing up the relevant costs, benefits, risks and uncertainties.
Appraisal period	**n/a**	The period of time over which benefits, costs and revenues are appraised. For a road scheme this includes benefits and costs before scheme opening and all impacts for 60 years from scheme opening.
Appraisal Summary Table	**AST**	A table that appraises the performance of each option against economic, environmental, social and distributional sub-impacts and is used to directly inform the Value for Money assessment for the economic case.
Appraisal year	**n/a**	The year in which an appraisal is undertaken and is used to determine when changes to the discount rate are applied
Area of Outstanding Natural Beauty	**AONB**	Statutory designation intended to conserve and enhance the ecology, natural heritage and landscape value of an area of countryside.
Balance of payments	**BoP**	The difference between all money flowing into a country in a particular period of time (e.g. a quarter or a year) and the outflow of money to the rest of the world.
Base cost	**n/a**	A category of project costs that covers the material and labour inputs.
Benefit	**n/a**	An increase in the welfare of society from a project, programme or policy.
Benefit Cost Ratio	**BCR**	The ratio of a project's benefits to its costs.
Biodiversity Action Plan	**BAP**	National, local and sector-specific plans established under the UK Biodiversity Action Plan, with the intention of securing the conservation and sustainable use of biodiversity.
Black, Asian and Minority Ethnic	**BAME**	A collective term for the minority ethnic population.
Building Cost Information Service	**BCIS**	A provider of cost and price information for the UK construction industry and part of RICS.
CM45	**n/a**	Core traffic growth without scheme scenario used to appraise noise, air quality and greenhouse gases.
CM49	**n/a**	Core traffic growth without scheme scenario used to appraise all impacts except noise, air quality and greenhouse gases.
Capital expenditure	**CAPEX**	The cost of developing or providing non-consumable parts of the product or system.

Term	Abbreviation	Explanation
Carbon Budget	**CB**	Carbon budgets are a simplified way to measure the additional emissions that can enter the atmosphere, whilst limiting global warming to defined levels, such as 1.5°C. Carbon budgets are based on the fact that the amount of warming that will occur can be approximated by total CO2 emissions
Carbon dioxide equivalent	**CO_2e**	A standard unit for measuring carbon footprints that describes, for a given amount of greenhouse gas emissions, the amount of CO2 that would have the same Global Warming Potential (GWP) when measured over a timescale of 100 years.
Central case appraisal	**n/a**	The expected benefits and costs of the Project being submitted for development consent
Closed Circuit Television	**CCTV**	National Highways CCTV cameras are used to monitor traffic flows on the English motorway and trunk road network primarily for the purposes of traffic management.
Combined Modelling and Appraisal Report	**ComMA**	The purpose of the Combined Modelling and Appraisal Report is to inform decision makers and stakeholders on how the evidence underpinning the business case has been developed, from the initial identification of the underlying problem through the collection of data and the production of any supporting traffic models and forecast impacts of the Project on traffic to the eventual economic appraisal.
Compensation of employees	**COE**	A statistical measure of the total gross (pre-tax) wages paid by employers to employees for work done in an accounting period, such as a quarter or a year.
Conservation area	**n/a**	An area of special environmental or historic interest or importance, of which the character or appearance is protected by law against undesirable changes (Section 69 of the Planning (Listed Buildings and Conservation Areas) Act 1990).
Consumer Price Index	**CPI**	A measure that examines the weighted average of prices of a basket of consumer goods and services, such as transportation, food and medical care. It is calculated by taking price changes for each item in the predetermined basket of goods and averaging them.
Consumer Prices Index including owner occupiers' housing costs	**CPIH**	A price index that measures the price of a weighted average market basket of consumer goods and services purchased by households including owner occupiers housing costs.
Core traffic growth	**n/a**	The central traffic growth forecast
COst and Benefit to Accidents – Light Touch	**COBALT**	DfT's software used to appraise the change in accidents due to a transport project.
CS67	**n/a**	Core traffic growth with scheme scenario used to appraise noise, air quality and greenhouse gases
CS72	**n/a**	Core traffic growth with scheme scenario used to appraise all impacts except noise, air quality and greenhouse gase
Day to day variability	**DTDV**	The daily variability in travel times excluding the impact of incidents
Decibel	**dB**	The unit of measurement used for sound pressure levels and noise levels.

Term	Abbreviation	Explanation
Department for Business, Energy and Industrial Strategy	**BEIS**	A department of the UK government, with responsibility for business, industrial strategy, and science and innovation with energy and climate change policy.
Department for Environment, Food and Rural Affairs	**Defra**	The government department responsible for environmental protection, food production and standards, agriculture, fisheries and rural communities in the United Kingdom of Great Britain and Northern Ireland.
Department for Transport	**DfT**	The government department responsible for the English transport network and a limited number of transport matters in Scotland, Wales and Northern Ireland that have not been devolved.
DfT Value for Money Framework	**n/a**	Outlines the Department’s approach to Value for Money assessments and provides guidance on how the outputs of these assessments should be communicated to decision-makers.
Design Manual for Roads and Bridges	**DMRB**	Design Manual for Roads and Bridges: A comprehensive manual 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 (National Highways, Transport Scotland, the Welsh Government or the Department for Regional Development (Northern Ireland)) is the highway authority. For the A122 Lower Thames Crossing, the Overseeing Organisation is National Highways.
Development Consent Order	**DCO**	Means of obtaining permission for developments categorised as Nationally Significant Infrastructure Projects (NSIPs) under the Planning Act 2008.
Disbenefits	**n/a**	Negative benefits.
Discounting	**n/a**	A technique used to compare costs and benefits occurring at different points of time
Displacement	**n/a**	An increase in employment in one firm, locality or region which is offset by reductions elsewhere
Distributional impact	**DI**	The variance of transport intervention impacts across different social groups. The appraisal of DIs is mandatory in the appraisal process and is a constituent of the Appraisal Summary Table (AST)
Distributional Impact Appraisal	**DIA**	An appraisal of Distributional Impacts.
Dynamic clustering		Benefits come when firms and/or people locate near one another in geographical clusters by changing their spatial location
Dynamic Integrated Assignment and DEmand Model	**DIADEM**	DfT software for finding equilibrium between demand and supply in a transport model
Economic Appraisal Report	**EAR**	A report that presents the appraisal methods and results for a transport project
Emissions Factor Toolkit	**EFT**	The Emissions Factors Toolkit (EFT) is published by Defra and the Devolved Administrations to assist local authorities in carrying out review and assessment of local air quality as part of their duties under the Environment Act 1995.

Term	Abbreviation	Explanation
Environment Agency	**EA**	A non-departmental public body of Defra, established under the Environment Act 1995. It is the leading public body for protecting and improving the environment in England and Wales. The organisation is responsible for wide-ranging matters, including the management of all forms of flood risk, water resources, water quality, waste regulation, pollution control, inland fisheries, recreation, conservation and navigation of inland waterways.
Environmental Impact Assessment	**EIA**	A process by which information about environmental effects of a proposed development is collected, assessed and used to inform decision making. For certain projects, EIA is a statutory requirement, reported in an Environmental Statement.
Environmental Quality Standards	**EQS**	The standards set out in the Environmental Quality Standards Directive (2008/105/EC) which concern the presence in surface water of certain pollutants and substances or groups of substances identified as priority or 'priority hazardous', on account of the substantial risk they pose to or via the aquatic environment.
Environmental Statement	**ES**	A document produced to support an application for development consent that is subject to Environmental Impact Assessment (EIA), which sets out the likely impacts on the environment arising from the proposed development.
Essex Red Data List	**ERDL**	Endangered species in Essex included in the Red Data Book which is a public document created to record endangered and rare species of plants, animals, fungi as well as some local subspecies which are present in a particular region.
Foreign Direct Investment	**FDI**	Investment into the UK economy by overseas companies and governments.
GDP deflator	**n/a**	A measure of the level of prices of all new, domestically produced, final goods and services in an economy in a year.
Geographic Information System	**GIS**	An integrated collection of computer software and data used to view and manage information about geographic places, analyse spatial relationships and model spatial processes.
Great Crested Newt	**GCN**	Great crested newts are a European protected species. The animals and their eggs, breeding sites and resting places are protected by law.
Greenhouse gas	**GHG**	Gases able to absorb infrared radiation emitted from Earth's surface and reradiate it back to Earth's surface, thus contributing to the greenhouse effect. Carbon dioxide, methane, and water vapour are the most important greenhouse gases.
Green Belt	**n/a**	A policy and land use zone designation used in land use planning to retain areas of undeveloped land surrounding urban areas.
Green Book	**n/a**	HM Treasury's guidance on how publicly funded projects, programmes and policies should be appraised and evaluated.
Gross Disposable Household Income	**GDHI**	The standard measure of household income

Term	Abbreviation	Explanation
Gross Domestic Product	**GDP**	Total value of all goods and services produced within an economy in one year.
Gross Domestic Product per worker	**n/a**	A measure of productivity.
Gross Value Added	**GVA**	The measure of the value of goods and services produced in an area, industry or sector of an economy.
Groundwater and Groundwater Dependent Terrestrial Ecosystems	**GWDTE**	A wetland that critically depends on groundwater flows and chemistries to support sensitive ecosystems.
Habitat of Principal Importance	**HoPI**	Habitats listed in section 41 of the Natural Environment and Rural Communities (NERC) Act 2006, considered to be the UK's most important habitats for wildlife.
Hectare	**ha**	The hectare is an SI unit of area primarily used in the measurement of land as a metric replacement for the imperial acre. An acre is about 0.405ha and 1ha is about 2.47 acres.
Herfindahl–Hirschman Index	**HH index**	An economic measure of market concentration.
Heavy Goods Vehicle	**HGV**	A large, heavy motor vehicle used for transporting cargo.
High Speed 1	**HS1**	A 109km high-speed railway between London and the UK end of the Channel Tunnel. The line carries international passenger traffic between the UK and continental Europe; it also carries domestic passenger traffic to and from stations in Kent and east London, as well as Berne gauge freight traffic.
Highways England Water Risk Assessment Tool	**HEWRAT**	A water risk assessment tool produced by National Highways
HM49	**n/a**	High traffic growth without scheme scenario
HM Treasury	**HMT**	The government's economic and finance ministry which maintains control over public spending, setting the direction of the UK's economic policy.
HS72	**n/a**	High traffic growth with scheme scenario
Income Domain	**n/a**	One of components of the Index of Multiple Deprivation that measures the proportion of the population in an area experiencing deprivation in terms of low income
Index of Multiple Deprivation	**IMD**	Official measure of relative deprivation for 32,844 small census areas in England. A rank of 1 is the most deprived area.
Indices of deprivation	**IOD**	A measure of the relative levels of deprivation. In England this considers 32,844 small areas or neighbourhoods, called Lower Layer Super Output Areas. The IOD 2019 is based on 39 separate indicators, organised across seven distinct domains of deprivation; these relate to income, employment, education, health, crime, living environment and barriers to housing and services.
Indirect tax revenue	**n/a**	Revenues from indirect taxes, such as fuel duty, paid by road users

Term	Abbreviation	Explanation
Industrial structure	**n/a**	The categorisation of industries with an economy
Inflation	**n/a**	A measure of the increase in prices within the economy
Initial BCR	**n/a**	The BCR that includes Level 1 benefits
Inter-peak	**IP**	An average hour within LTAM to represent an hour within the period 09:00–15:00
International Union for Conservation of Nature	**IUCN**	The International Union for Conservation of Nature is the global authority on the status of the natural world and the measures needed to safeguard it.
International Territorial Level	**ITL**	A geocode standard for referencing the subdivisions of the United Kingdom for statistical purposes, used by the Office for National Statistics (ONS). Within the UK it replaced the EU's NUTS system after Brexit.
Journey time reliability	**JTR**	The variation in journey times that travellers are unable to predict due to incidents and other factors
Krugman Specialisation Index	**KSI**	An economic measure of regional industrial specificalisation
Land Use Transport Interaction model	**LUTI**	An economic model used to estimate the wider economic impacts based on variable land uses
Landscape Character Area	**LCA**	The discrete geographical areas of a particular landscape type. Also referred to as Local Landscape Character Area (LLCA)
Level 1 benefits	**n/a**	Monetised benefits estimated using established methodologies that are included in the Level 1 PVB when calculating the Initial and Adjusted BCRs
Level 2 benefits	**n/a**	Monetised benefits estimated using less established methodologies that are included in the Level 2 PVB when calculating the Adjusted BCR
Level 3 benefits	**n/a**	Either monetised or qualitatively appraised benefits that are not included in BCRs but which are taken into account in assessing a project's Value for Money
Light Goods Vehicle	**LGV**	Vehicles meeting the Department for Transport VEH04 criteria.
LM49	**n/a**	Low traffic growth without scheme scenario
Local authority areas	**LAA**	Several local authorities
Local Nature Reserve	**LNR**	Locally designated nature site protected through the planning system.
Local Planning Authority	**LPA**	A local planning authority is the local authority or council that is empowered by law to exercise statutory town planning functions for a particular area of the UK. May also be referred to as 'local authority'.
Local North	**n/a**	The Lower Thames local authorities of Havering, Thurrock and Brentwood
Local South	**n/a**	The Lower Thames local authorities of Dartford, Gravesham and Medway
Local Wildlife Site	**LWS**	Locally designated nature site protected through the planning system.
Location Quotient	**LQ**	An economic concept used as a relative measure of industry concentration
Lower Layer Super Output Area	**LSOA**	A geographical area defined by the ONS used to produce neighbourhood statistics for small areas with a typical population of around 1,500 people

Term	Abbreviation	Explanation
Lower Thames Area Model	**LTAM**	Transport model designed to forecast impacts of providing additional road based capacity across the River Thames at locations at or east of the existing Dartford Crossing.
LS72	**n/a**	Low traffic growth with scheme scenario
M25 motorway	**n/a**	Orbital motorway that encircles most of Greater London
Marginal external costs	**MEC**	The additional cost imposed on third parties by producing an extra unit of a good or service. In the case of transport projects it includes congestion, air pollution, noise, infrastructure impacts and accidents.
Market failure	**n/a**	A situation where the allocation of goods and services is inefficient resulting from a divergence between the private costs and benefits experienced by individuals, businesses and society.
Monte-Carlo simulation	**n/a**	A computational algorithm based on repeated random sampling to obtain cost estimates.
Most Likely	**n/a**	The expected level of CAPEX costs expressed as a probability (P) level.
Motorway Reliability Incidents And Delays	**MyRIAD**	Motorway Reliability Incidents And Delays appraisal software.
Moves to more or less productive jobs	**M2MLPJ**	A Level 3 wider economic impact that reflects the distortionary effect of taxes on the labour market and is measured by the change in tax revenues to Government due to a transport scheme
National Character Area	**NCA**	NCAs divide England into 159 distinct natural areas. Each NCA is defined by a unique combination of landscape, biodiversity, geodiversity, history, and cultural and economic activity. Their boundaries follow natural lines in the landscape rather than administrative boundaries.
National Highways Carbon Valuation Toolkit v1.4.2	**n/a**	National Highways appraisal tool used to present and value in monetary terms all greenhouse gas emissions of a road project.
National Highways Commercial Services Division	**CSD**	National Highways division responsible for commercial services.
National Planning Policy Framework	**NPPF**	The National Planning Policy Framework was published in March 2012 by the UK's Department of Communities and Local Government, consolidating over two dozen previously issued documents called Planning Policy Statements (PPS) and Planning Practice Guidance Notes (PPG) for use in England. The NPPF was updated in February 2019 and again in July 2021 by the Ministry of Housing, Communities and Local Government.
National Policy Statement for National Networks	**NPSNN**	The NPSNN sets out the need for, and Government's policies to deliver, development of Nationally Significant Infrastructure Projects on the national road and rail networks in England. It provides planning guidance for promoters of Nationally Significant Infrastructure Projects on the road and rail networks, and the basis for the examination by the Examining Authority and decisions by the Secretary of State.

Term	Abbreviation	Explanation
National Trip-End Model	**NTEM**	A DfT model that forecasts the growth in trip origin-destinations (or productions-attractions) up to 2051 for use in transport modelling. The forecasts take into account national projections of population, employment, housing, car ownership and trip rates.
National Vocational Qualifications (NVQ) Level 4	**NVQ4**	National Vocational Qualifications are work-based awards in England, Wales and Northern Ireland that are achieved through assessment and training. NVQ level 4 is equivalent to a degree level education.
Net Present Value	**NPV**	A measure of the total impact of a scheme upon society, in monetary terms, expressed in 2010 prices.
New Economic Geography	**NEG**	A theoretical framework for locational decisions in the context of imperfectly competitive markets.
Nitrogen dioxide	**NO_2**	A reactive gas introduced into the environment by natural causes, including entry from the stratosphere, bacterial respiration, volcanos, and lightning. It is also introduced by the emissions of internal combustion engines burning fossil fuels.
NOMIS	**n/a**	An ONS web site that publishes official census and labour market statistics for the UK
NOMIS Business Register and Employment Survey	**BRES**	An employer survey of the number of jobs held by employees at the location of their workplace broken down by full/part-time and detailed industry classification using five digit SIC codes
Nomenclature of Territorial Units for Statistics	**NUTS**	A standard for referencing the subdivisions of countries for statistical purposes. The standard is developed and regulated by the European Union, and thus only covers the member states of the EU in detail.
Non-Motorised Users	**NMU**	Users of non-motorised vehicles (eg cyclists, horse riders) and pedestrians.
Non-recoverable VAT	**NR VAT**	Value added tax that has been paid but cannot be reclaimed by a business.
Non-traded carbon	**n/a**	Carbon emissions in sectors not included in Emission Trading Systems such as those from road vehicles
O&M model	**n/a**	National Highways model for estimating operating, maintenance and renewals costs of road projects
Office for National Statistics	**ONS**	The executive office of the UK Statistics Authority, a non-ministerial Government department responsible for the collection and publication of statistics related to the economy, population and society of the UK
Off-peak period	**OP period**	The hours between 18:00-06:00 within the Project traffic model (LTAM).
Operating, maintenance and renewals expenditure	**OMR**	Operating, maintenance and renewal expenditure.
Origin-destination	**OD**	Origin-destination data (also known as flow data) includes the travel-to-work and migration patterns of individuals, cross-tabulated by variables of interest (for example occupation).
OSPAR	**n/a**	The mechanism by which 15 governments (including the UK) and the EU cooperate to protect the marine environment of the North-East Atlantic.
Other Goods Vehicle 1	**OGV1**	All rigid vehicles over 3.5 tonnes gross vehicle weight including all large vehicles on a single frame: trucks, tow trucks, campers, motor homes, large ambulances, etc.

Term	Abbreviation	Explanation
Other Goods Vehicle 2	**OGV2**	All articulated vehicles including multi-unit goods-carrying vehicles with a tractor or straight truck power unit, including goods-carrying rigid trucks pulling trailers and rigid vehicles with four or more axles.
P10	**n/a**	Costs for which there is a 10% chance that they will not be exceeded.
P90	**n/a**	Costs for which there is a 90% chance that they will not be exceeded.
PM peak hour	**n/a**	The hour between 17:00–18:00 within LTAM
PM peak period	**n/a**	The hours between 15:00–18:00 within LTAM
Particulate matter	**$PM_{2.5}$**	Particulate matter with a diameter smaller than 2.5 micrometers
Passenger car unit	**PCU**	A metric to allow different vehicle types within traffic flows in a traffic model to be assessed in a consistent manner. PCU factors used within the Project's transport model are: 1 for a car or Light Goods Vehicle; 2 for a bus, 2.5 for a Heavy Goods Vehicle.
Pence per hour	**PPH**	Travel cost per hour
Pence per kilometre	**PPK**	Travel cost per kilometre
Pence per minute	**PPM**	Travel cost per minute
Personal Injury Accident	**PIA**	An accident that involves personal injury occurring on the public highway (including footways) in which at least one road vehicle or a vehicle in collision with a pedestrian in involved and which becomes known to the police within 30 days of its occurrence.
Present Value	**PV**	The result of discounting a stream of benefits or costs
Present Value of Benefits	**PVB**	The sum of discounted benefits
Present Value of Costs	**PVC**	The sum of discounted costs
Public Accounts table	**PA table**	A TAG appraisal table that reports the impacts of the Project on the public finances
Public Rights of Way	**PRoW**	A right possessed by the public, to pass along routes over land at all times. Although the land may be owned by a private individual, the public may still gain access across that land along a specific route. The mode of transport allowed differs according to the type of Public Right of Way which consist of footpaths, bridleways and open and restricted byways
Public Transport	**PT**	A system of vehicles such as buses and trains that operate at regular times on fixed routes and are used by the public
Quantitative Risk Assessment	**QRA**	A formal and systematic risk analysis approach to quantifying the risks associated with the operation of an engineering process.
Quarter 1	**Q1**	The first three month period in a financial year.
Queen Elizabeth II bridge	**QEII bridge**	Queen Elizabeth II Bridge, part of the Dartford-Thurrock crossing.

Term	Abbreviation	Explanation
QUeues And Delays at Roadworks maintenance delays appraisal software	**QUADRO**	A National Highways sponsored computer program to estimate the effects of roadworks in terms of time, vehicle operating and accident costs on the users of the road
Quality Index	**QI**	A measure of the robustness of TRIS traffic data
RAMSAR site	**n/a**	A wetland of international importance, designated under the Ramsar convention
Real terms	**n/a**	A data series for costs and benefits excluding the effect of the general level of price increases
Reliability ratio	**n/a**	A ratio used to calculate Journey Time Reliability benefits
Retail Prices Index	**RPI**	A price index that measures the change in the cost of a representative sample of retail goods and services. No longer classified as a national statistic in the UK
Revenue	**n/a**	Income from road users that are included in the PVC
Risk (costs)	**n/a**	A category of costs associated with events that may arise or may not arise due to a road project
River Basin Management Plan	**RBMP**	A planning document published by the Department for Environment, Food and Rural Affairs and the Environment Agency which sets out how organisations, stakeholders and communities will work together to improve the water environment.
Road user charging	**RUC**	A road user fee for the use of the tunnel.
Roll on – roll off	**Ro-ro**	Freight that can be driven on and off ships using their own wheels or a platform vehicle such as a self-propelled modular transporter
Sensitivity test	**n/a**	A test carried out to investigate the dependency in the model outputs to the values input into the model. Often a single input value is changed in turn and the resulting model outputs examined.
Simulation and Assignment of Traffic to Urban Road Networks, software	**SATURN**	Software used to build transport models
Site of Importance for Nature Conservation	**SINC**	Locally designated nature site protected through the planning system.
Site of Special Scientific Interest	**SSSI**	A conservation designation denoting an area of particular ecological or geological importance
Social cost benefit analysis	**CBA**	A technique used to assess and compare the costs and socio-economic benefits of different options
Social impact appraisal	**n/a**	Social impacts cover the human experience of the transport system and its impact on social factors, not considered as part of economic or environmental impacts
South East Local Enterprise Partnership	**SELEP**	The business-led, public-private body established to drive economic growth across East Sussex, Essex, Kent, Medway, Southend and Thurrock
South East Regional Traffic Model	**SERTM**	National Highways South East Regional Traffic Model

Term	Abbreviation	Explanation
Spatial Computable General Equilibrium model	**SCGE**	A methodology that can be used in the appraisal of the wider economic impacts of a transport intervention.
Special Area of Conservation	**SAC**	A designation under EU Directive 92/43/EEC on the Conservation of Natural Habitats and of Wild Fauna and Flora, also known as the Habitats Directive.
Special Protection Area	**SPA**	A designation under EU Directive 2009/147/EC on the Conservation of Wild Birds.
Standard Industrial Classification	**SIC**	A system used to classify business establishments and other statistical units by the type of economic activity in which they are engaged.
Strategic Road Network	**SRN**	The core road network in England managed by National Highways
Static clustering	**n/a**	Benefits that come when firms and/or people locate near one another in geographical clusters but do not change their spatial location
STATS19	**n/a**	A database of all road traffic accidents that resulted in a personal injury and were reported to the police within 30 days of the accident. The data are collected by the police at the roadside or when the accident is reported to them by a member of the public in a police station.
Teletrac	**n/a**	DfT traffic dataset
Tender Price Index	**TPI**	An index of the prices for which contractor offer to carry out projects
Thames Estuary 2100	**TE2100**	An Environment Agency project (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.
Transport Analysis Guidance	**TAG**	Transport Analysis Guidance published by DfT which provides methods to model and appraise the impacts of transport projects
TAG data book	**n/a**	The data book of appraisal parameters used in transport appraisals for DfT
Transport Decarbonisation Plan	**TDP**	The government’s commitments and actions needed to decarbonise the entire transport system in the UK
Transport Economic Efficiency	**TEE**	An appraisal table used to report the Level 1 benefits that measure the impact of a transport scheme on the efficiency of the transport system
Transport User Benefits Appraisal	**TUBA**	DfT’s transport user benefits appraisal software
TRIS	**n/a**	National Highways Traffic Count Database
Traded carbon	**n/a**	Carbon emissions in the traded sectors covered by Emission Trading Systems such as the power and industrial sectors
Travel time variability	**TTV**	The daily variation in travel times not due to incidents
Tunnel Boring Machine	**TBM**	A large machine used to excavate tunnels with a circular cross-section.
Uncertainty (costs)	**n/a**	A category of project costs that are unpredictable
User class	**UC**	Categorisation of different transport users based on their journey purposes

Term	Abbreviation	Explanation
Value Added Tax	**VAT**	A consumption tax levied in the UK which was introduced in 1973. It is administered and collected by HM Revenue and Customs. VAT is levied on most goods and services provided by registered businesses in the UK and some goods and services imported from outside the European Union. The default VAT rate is the standard rate, 20% since 4 January 2011. Some goods and services are subject to VAT at a reduced rate of 5% (such as domestic fuel) or 0% (such as most food and children’s clothing).
Value for Money	**VfM**	Value for Money, being the optimum combination of whole-life costs and quality to meet the user requirement.
Value of time	**VOT**	The opportunity cost of the time that a traveller spends on their journey and would be the amount that a traveller would be willing to pay in order to save time
Variable demand model	**VDM**	A transport model that represents how people respond to changes in travel times and costs
Vehicle operating costs	**VOC**	Costs that vary with vehicle usage, including fuel, tyres, maintenance, repairs, and mileage-dependent depreciation costs.
VISUM	**n/a**	Strategic car and rail modelling software
Volume over capacity	**V/C**	The ratio of a road’s current or projected traffic volumes to its saturation flow or capacity
Water Framework Directive	**WFD**	Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy. The Directive establishes a framework for the protection of inland surface waters, estuaries, coastal waters and groundwater. The framework for delivering the WFD is through river basin management planning. The UK has been split into several river basin districts. Each river basin district has been characterised into smaller management units known as water bodies. The surface water bodies may be rivers, lakes, estuary or coastal.
Weekend	**WE**	A time period included in the transport model that covers travel on Saturdays and Sundays
Wider Economic Impacts	**WEI**	Land use-related economic consequences of transport interventions, not directly related to impacts on users of the transport network, such as increased productivity. There are two Levels of Wider Economic Impacts, Level 2 and Level 3 benefits, that vary depending on whether land use is assumed to change.
WITA v2.2	**n/a**	DfT Wider Impacts Transport Appraisal Version 2.2 software used to appraise Level 2 wider economic impacts
With Scheme	**n/a**	Appraisal scenario that includes a proposed intervention such as a project, programme or policy. Also referred to as With Project
Without Scheme	**n/a**	Appraisal scenario that excludes a proposed intervention such as a project, programme or policy. Also referred to as Without Project
World War II	**WWII**	World War 2

Annex ATransport Economic Efficiency impacts

A.1 Annualisation and expansion factors

A.1.1 Traffic models produce outputs for defined modelled periods. To calculate the benefits of a transport project, factors are used to convert the modelled periods into annual and average daily and weekday values. Analysis undertaken for the appraisal of the Project has identified the need to assess its economic impacts across all 8,760 hours of the year. This approach stems from the Project providing significant benefits to travellers, even when congestion is very low, such as during the night. The Project provides an alternative route for some movements that lead to substantial reductions in journey distance that would occur at all times of day.

A.1.2 The purpose of this Annex is to describe the approach taken to calculating:

a. the annualisation factors used in the DfT’s TUBA software for the appraisal of the Project

b. the expansion factors used for air quality and noise impact assessments.

A.1.3 The Annex is structured into the following sections which:

a. explain why annualisation and expansion factors are needed

b. discuss how the traffic data used in the annualisation and expansion factor processes was sourced and used

c. explain how the annualisation time periods for the appraisal were determined, the treatment of non-modelled periods and the approach used for purpose splits

d. present the annualisation calculations for each time period

e. explain how the time periods for the expansion factors used for the air quality and noise assessments were identified and presents the expansion factor calculations for the air quality and noise assessments

f. summarises the annualisation and expansion factors

Background

A.1.4 The Lower Thames Area Model (LTAM) traffic model is based on 2015 trip patterns and produces output matrices of vehicle trips for three modelled hours:

a. morning peak hour 07:00 - 08:00

b. interpeak average hour between 09:00 - 15:00

c. evening peak hour 17:00 - 18:00

A.1.5 A series of non-modelled periods were also defined, as described below. Annualisation factors were input into TUBA and used to convert the outputs for the modelled and non-modelled periods to annualised benefits. These benefits are then summed over 60 years.

A.1.6 Expansion factors were used to convert the traffic flows in the modelled hours to average annual daily and weekday traffic flows for air quality and noise impact assessments.

A.1.7 The annualisation factors required for the appraisal needed to:

a. be based on 2016 volumetric data and incorporate the most recent full year data set at the time of modelling

b. reflect the fact that data collected for traffic model calibration and peak hour determination indicated that time periods in the fully modelled area commence one-hour earlier than the default TUBA, air quality and noise time periods

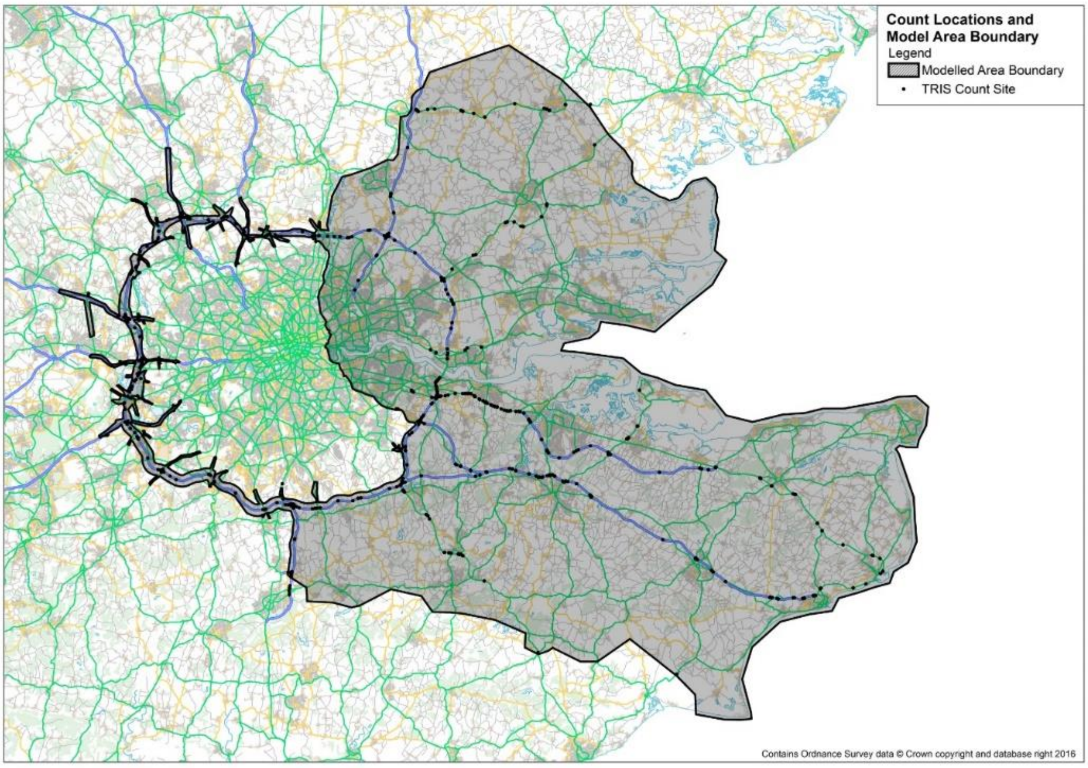
c. take account of modifications to the LTAM modelled journey time, distance and charge skims to more accurately reflect the costs anticipated in non-modelled periods

Traffic data

A.1.8 Traffic flow data is a primary component used for the calculation of annualisation factors. The following section discusses how this data was sourced and processed.

A.1.9 Analysis was undertaken to identify the Project’s potential area of impact. This has led to the development of the fully modelled area shown in Plate A.1.

Plate A.1 Fully modelled area



A.1.10 A range of traffic count data sources were reviewed. National Highways traffic flow data presented in the TRIS database was identified as the primary data source. A review of additional data sources concluded that they were not applicable for annualisation factor calculation because they did not provide 24 hour counts for a full year.

A.1.11 TRIS data within the LTAM fully modelled area was processed to ensure that the count sites used provided high quality data. Two layers of data processing were performed:

a. Data quality index score – a quality index (QI) score is provided with TRIS data. A score of 15 indicates that 15 valid one minute counting records were used to generate a 15 minute interval flow. Flow data with a QI factor of 15 is a National Highways requirement. Only sites where over 95% of data records for the year have a QI score of 15 were used and sites with less than 70% of data records with QI scores of 15 in any particular month were excluded.

b. Spatial analysis – the data sites used were mapped in GIS software to show their spatial dispersion. Trip flow data and the spatial analysis were reviewed in conjunction to ensure that the resultant annualisation factors are not influenced by site clustering.

A.1.12 Applying these criteria resulted in 440 TRIS count sites being used to calculate annualisation factors. Plate A.2 shows the spatial locations of these count sites.

Plate A.2 Spatial location of sifted count sites

TUBA annualisation factors

Time period identification

A.1.13 TUBA has five standard definition time periods:

a. AM peak (weekday 7:00 to 10:00)

b. PM peak (weekday 16:00 to 19:00)

c. Interpeak (weekday 10:00 to 16:00)

d. Off peak (weekday 19:00 to 07:00)

e. Weekend

A.1.14 An assessment of traffic data and the operation of the charging regimes were used to identify the different periods within the year that can be reflected with model outputs. This determined that peak periods in the LTAM fully modelled area differ from those defined in TUBA in that they commence an hour earlier. As a result, the following time periods are used to appraise the Project:

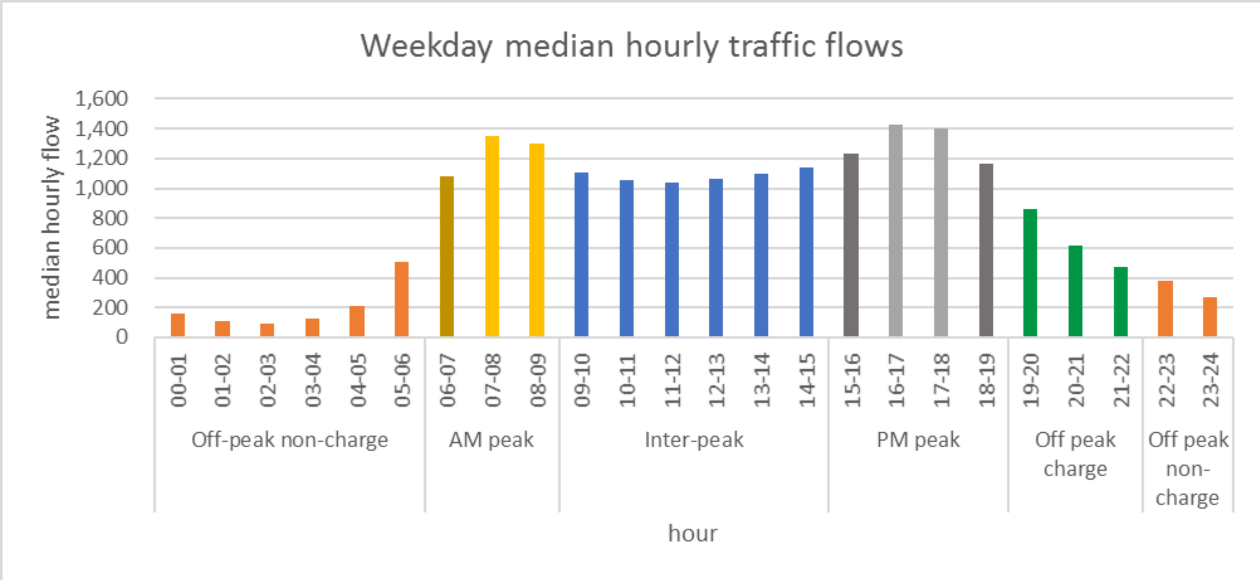
a. AM peak period from 06:00 to 09:00

b. Interpeak (IP) period from 09:00-15:00

c. PM peak period from 15:00-18:00

A.1.15 Plate A.3 shows that the TRIS data selected for the calculation of annualisation factors aligns with the above appraisal time periods.

Plate A.3 TRIS data weekday median hourly traffic flows

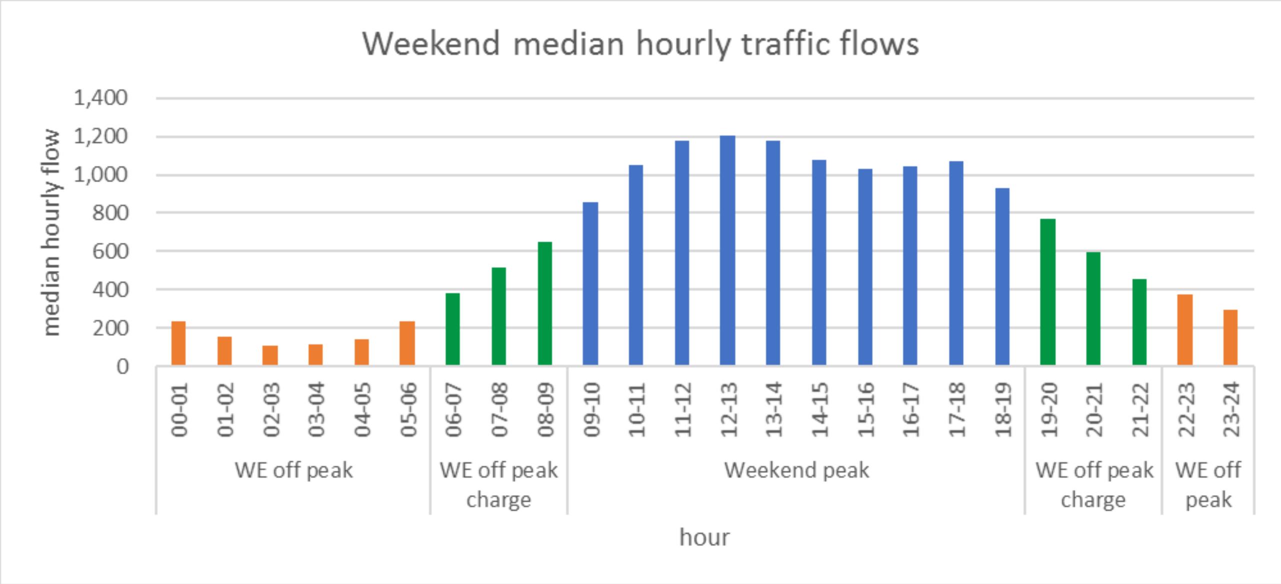


A.1.16 The traffic data in Plate A.3 also shows that the AM peak hour of 06:00 to 07:00 is a lower magnitude than the remaining AM peak hours. The data also shows that the PM peak period has distinct shoulders at 15:00 to 16:00 and 18:00 to 19:00. Treatment of these shoulder peak periods in the appraisal is described below.

A.1.17 The remaining weekday off peak hours of 18:00 to 06:00 have been split into charge and non-charge hours due to the variation in average traffic flows of these periods. The derivation and treatment of these time periods is described below.

A.1.18 Weekend peak and weekend off peak periods have been defined due to the variance in traffic flows during weekend hours. The weekend off peak period has also been split into charge and non-charge hours. The weekend median hourly traffic flows derived from the count database are shown in Plate A.4. The derivation and treatment of the weekend time periods is described below.

Plate A.4 TRIS data weekend median hourly traffic flows



A.1.19 The analysis of traffic data concluded that 10 time periods should be used in the economic appraisal of the Project. These are defined in Table A.1.

Table A.1 Economic Appraisal 10 Time Periods

Day of Week	Time	Time Period Name	Modelled Period using Variable Demand
Weekday	00:00 – 06:00 and 22:00 – 00:00	Weekday Off Peak Non-Charged	No
	06:00 – 07:00	Weekday AM Shoulder	No
	07:00 – 09:00	Weekday AM Peak	Yes
	09:00 – 15:00	Weekday Inter Peak	Yes
	15:00 – 16:00 and 18:00 – 19:00	Weekday PM Shoulder	No
	16:00 – 18:00	Weekday PM Peak	Yes
	19:00 – 22:00	Weekday Off Peak Charged	No
Weekend	00:00 – 06:00 and 22:00 – 00:00	Weekend Off Peak Non-Charged	No
	06:00 – 09:00 and 19:00 – 22:00	Weekend Off Peak Charged	No
	09:00 – 19:00	Weekend Peak Charged	No

Treatment of costs for non-modelled periods

A.1.20 For the non-modelled periods, demand matrices are derived by factoring the matrices from the modelled hours. Table A.2 shows the correspondence between the non-modelled time periods and the modelled time period matrices used.

Table A.2 Non-Modelled Time Period Matrix Source

Non-Modelled Time Period Name	Matrix Source
Weekday Off Peak Non-Charged	12 hour
Weekday AM Shoulder	AM
Weekday PM Shoulder	PM
Weekday Off Peak Charged	12 hour
Weekend Off Peak Non-Charged	12 hour
Weekend Off Peak Charged	12 hour
Weekend Peak Charged	12 hour

A.1.21 The 12 hour matrix is produced by combining the AM, IP and PM matrices and using the peak hour to time period factors derived from analysing the traffic count data.

A.1.22 The factoring process operates by fitting the total demand in the modelled hour to the total demand within the non-modelled hour using relationships derived from analysis of traffic count data. It also modifies the vehicle type and journey purpose proportions to be in line with those expected in the non-modelled hours.

A.1.23 For the non-modelled time periods networks are derived from the model hour networks. Table A.3 shows the correspondence between the non-modelled time periods and the modelled time period networks used.

Table A.3 Non-Modelled Time Period Network Source

Non-Modelled Time Period Name	Network Source
Weekday Off Peak Non-Charged	Inter Peak
Weekday AM Shoulder	AM Peak
Weekday PM Shoulder	PM Peak
Weekday Off Peak Charged	Inter Peak
Weekend Off Peak Non-Charged	Inter Peak
Weekend Off Peak Charged	Inter Peak
Weekend Peak Charged	Inter Peak

A.1.24 Additional modifications are required for the charging elements of the non-modelled time period networks. Charges are modified for each of the non-modelled periods to be in line with the charging regimes of each of the charged components within the model. Assignment model parameters are changed to be in line with the non-modelled hours as required.

A.1.25 Once the non-modelled period demand matrices and networks have been generated for each of the 10 time periods for each forecast year, the matrices are assigned to the networks in the standard way and model outputs can be extracted to support the economic assessment for each of the non-modelled hours.

A.1.26 The 10 time periods were used in the appraisal of transport user and provider benefits in TUBA, journey time reliability using MyRIAD software (see Annex B) and wider economic impacts using WITA software (see Annex C).

Purpose splits

A.1.27 LTAM provides output trip matrices for 10 user classes for each modelled hour. The user classes include disaggregation of the car submode into Low, Middle and High income brackets for commuting and other journey purposes.

A.1.28 As journey purpose splits are different in different time periods, allowance must be made for the journey purpose splits in non-modelled periods that differ from those in modelled hours.

A.1.29 TAG Unit A1.3 provides default journey purpose splits by vehicle type and journey purpose for AM, IP, PM, OP and WE periods. However, these journey purpose splits do not differentiate between Low, Middle and High income user classes.

A.1.30 Accordingly, LTAM modelled hour journey purpose splits are altered to represent the TAG default purpose splits for OP and WE time periods by fitting the trip matrices generated for the OP and WE time periods to the TAG recommended proportions.

A.1.31 This adjustment was only required for the car submode as TAG assumes that journey purposes for LGV and OGV maintain the same purpose splits in all time periods.

A.1.32 Time period specific approaches regarding journey purpose splits were taken for the AM and PM shoulder peak periods.

A.1.33 The purpose splits for the AM shoulder peak hours were set to the TAG AM peak period purpose splits as follows:

a. LTAM AM peak hour purpose splits were built from the South East Regional Traffic Model's (SERTM) AM peak period (07:00 -10:00) purpose split data.

These hours align with the TAG defined AM peak period. However, as explained above, the LTAM uses an AM peak period at the Dartford Crossing and in the wider model area that spans from 06:00 to 09:00

b. To account for the AM peak period commencing at 06:00, the TAG purpose splits for the AM peak period have been used in place of the TAG overnight purpose splits that cover the 06:00 hour. The TAG purpose splits have been used in place of the AM peak modelled hour purpose splits as their lower car business and commuting proportions provide a more conservative assumption and reflect the ramp up of business and commuting traffic anticipated during weekday mornings.

A.1.34 The purpose splits for both hours of the PM shoulder peak period were set to the PM peak modelled hour purpose splits as follows:

a. The LTAM uses a PM peak period at the Dartford Crossing and in the wider model area that spans from 15:00 to 18:00.

b. However, deferring to the TAG PM peak purpose splits for the hour commencing 15:00, as performed for the AM shoulder peak hour, results in a nonsensical shift in the proportion of car business travel. This is due to the TAG AM peak car business travel proportion being half of both the IP and PM peak modelled car business purpose splits (5%, 10% and 9% respectively). Therefore, the PM peak modelled hour purpose split is used for the 15:00 to 16:00 PM shoulder peak hour.

c. LTAM PM peak hour purpose splits are built from the South East Regional Traffic Model's (SERTM) PM peak period (16:00 -19:00) purpose split data. Accordingly, the PM peak modelled hour purpose split is used for the 18:00 to 19:00 PM shoulder peak hour as this hour is encompassed in the SERTM time period from which the LTAM purpose splits were built.

A.1.35 A table showing the purpose splits and how they vary throughout time periods is provided in Table A.4.

A.1.36 In valuing benefits, TUBA uses TAG default person factors. Therefore, in appraising the Project there is not an issue in the non-modelled periods having different person factors than those used for modelled hours.

Table A.4 Purpose splits

Time Period	Hours	Car Business	Car Commuting	Car Other	LGV Work	LGV Other	OGV Work
AM Shoulder	06:00 – 07:00	7%	38%	55%	88%	12%	100%
AM	07:00 – 09:00	10%	45%	45%	88%	12%	100%
IP	09:00 – 15:00	10%	18%	72%	88%	12%	100%

Time Period	Hours	Car Business	Car Commuting	Car Other	LGV Work	LGV Other	OGV Work
PM Shoulder 1	15:00 – 16:00	9%	36%	55%	88%	12%	100%
PM	16:00 – 18:00	9%	36%	55%	88%	12%	100%
PM Shoulder 2	18:00 – 19:00	9%	36%	55%	88%	12%	100%
Weekday Overnight	19:00 – 06:00	4%	29%	67%	88%	12%	100%
Weekend	00:00 – 24:00	2%	8%	90%	88%	12%	100%

TUBA factor calculation

AM peak and shoulder peak periods

A.1.37 The AM peak modelled hour cost skims were applied to the 07:00 - 09:00 hours as the median trip volumes of these hours are of a similar quantum, as shown in Table A.5.

Table A.5 Trip variance from 06:00 to 09:00 in AM peak period

Hour	Variance from modelled hour
06:00 – 07:00	-20%
07:00 – 08:00	-
08:00 – 09:00	-3%

A.1.38 Table A.6 shows the figures used for the annualisation factor calculation. The expansion factor, calculated as the period flow divided by the AM peak modelled hour flow, is multiplied by the number of weekday periods per year to calculate the annualisation factor. The resultant factor is input into the TUBA scheme file to calculate annual trips and benefits for the 07:00 - 09:00 weekday period.

Table A.6 Annualisation factor, 07:00 to 09:00 weekday

Time Period	Hours	AM peak modelled hour flow	Period flow	Expansion factor	Weekday periods per year	Annualisation factor
AM peak	07:00 – 09:00	1,352	2,655	1.96	253	497

A.1.39 As the 06:00 – 07:00 trip volumes vary 20% from the modelled hour, hour specific trip, time, distance and charge skims were created for this AM shoulder peak hour. Table A.7 shows the figures used for the trip matrix and annualisation factor calculation for this shoulder peak hour.

A.1.40 The trip matrix factor, calculated as the period's average hourly flow divided by the AM peak modelled hour flow, is applied to the AM peak modelled hour trip matrix to create a 06:00 – 07:00 trip matrix. This trip matrix is then reassigned to the 07:00 – 08:00 modelled hour network. The resultant trip, time, distance and charge skims are then input into TUBA. An annualisation factor of 253, accounting for the number of weekdays in a year, was input into the TUBA scheme file to calculate annual benefits for the 06:00 – 07:00 weekday period.

A.1.41 Equations for these calculations are included in Table A.7.

Table A.7 Annualisation factor, 06:00 - 07:00 weekday

Time Period	Hours	AM peak modelled hour flow	Period flow	Trip matrix factor	Hours per period	Weekday periods per year	Annualisation factor
AM shoulder	06:00 – 07:00	1,352	1,079	0.80	1	253	253

Interpeak period

A.1.42 As LTAM modelled the average interpeak hour, the modelled hour output was expanded by multiplying it by the number of hours in the interpeak period. Consequently, an expansion factor of 6.0 was applied.

A.1.43 Table A.8 illustrates this process and the resulting annualisation factor. The 6 hours in the IP period were multiplied by the number of periods per year to calculate the annualisation factor. The resulting factor was input into the TUBA scheme file to calculate annual trips and benefits for the 09:00 – 15:00 weekday period.

Table A.8 Annualisation factor, 09:00 to 15:00 weekday

Time Period	Hours	IP average modelled hour flow	Period flow	Hours per period	Weekday periods per year	Annualisation factor
IP	09:00 – 15:00	1,082	6,492	6.0	253	1,518

PM peak and shoulder peak

A.1.44 The PM peak modelled hour cost skims were applied to the 16:00 - 18:00 hours as the median trip volumes in these hours are of a similar quantum, as shown in Table A.9.

Table A.9 Trip variance from 15:00 – 19:00 in PM peak period

Hour	Variance from modelled hour
15:00 – 16:00	-12%
16:00 – 17:00	2%
17:00 – 18:00	-
18:00 – 19:00	-17%

A.1.45 Table A.10 shows the figures used for the calculation of the annualisation factor for the 16:00 – 18:00 weekday period. The expansion factor, calculated as the period flow divided by the PM peak modelled hour flow, was multiplied by the number of periods per year to calculate the annualisation factor. The resulting factor was input into the TUBA scheme file to calculate annual trips and benefits for the 16:00 – 18:00 weekday period.

Table A.10 Annualisation factor, 16:00 to 18:00 weekday

Time Period	Hours	PM peak modelled hour flow	Period flow	Expansion factor	Periods per year	Annualisation factor
PM peak	16:00 – 18:00	1,398	2,824	2.02	253	511

A.1.46 As trip volumes from the hours commencing 15:00 and 18:00 vary by 12% and 17% from the modelled hour, hour specific trip, time, distance and charge skims were created for the PM shoulder peak time periods. The 18:00 to 19:00 hour is considered a PM shoulder peak because while it differs 17% from the PM peak modelled average traffic flow, it differs 36% from the off-peak charge period average traffic flow.

A.1.47 Table A.11 shows the figures used for the trip matrix and annualisation factor calculation for the 15:00 to 16:00 and 18:00 to 19:00 weekday periods. The trip matrix factor, calculated as the period's average hourly flow divided by the PM peak modelled hour flow, was applied to the PM peak modelled hour trip matrix to create a PM shoulder peak trip matrix. This trip matrix was then reassigned to the 17:00 – 18:00 modelled hour network. The resulting trip, time, distance and charge skims were then input into TUBA. An annualisation factor of 506 (hours per period multiplied by periods per year) was input into the TUBA scheme file to calculate annual benefits for these PM shoulder peak weekday periods.

Table A.11 Annualisation factor, 15:00 to 16:00 and 18:00 to 19:00 weekday

Time Period	Hours	PM peak modelled hour flow	Period average hour flow	Trip matrix factor	Hours per period	Periods per year	Annualisation factor
PM shoulder	15:00 – 16:00 18:00 – 19:00	1,398	1,198	0.86	2	253	506

Off-peak charge and non-charge periods

A.1.48 The off-peak period is split into charge and non-charge hours due to the variance of traffic flows experienced during the off-peak period. As the OP period specific trip matrices were reassigned to the IP network, the average hourly flow of these periods was compared with the average IP modelled hour.

Table A.12 shows that the off-peak charge period average hour traffic was 20% less than the IP average hour, while the OP non-charge period was 68% less.

Table A.12 OP charge and non-charge periods variance from IP average hour flow

Time Period	Hours	Variance from average IP modelled hour
Off peak charge	19:00 – 22:00	-20%
Off peak non-charge	22:00 – 06:00	-68%

A.1.49 Table A.13 shows the trip matrix and annualisation factor calculations for the off-peak charge and non-charge periods. The combined 12-hour trip matrix was factored to the trip volume experienced in the average OP charge and non-charge hours. This trip matrix was then reassigned to the IP modelled hour network. The resulting trip, time, distance and charge skims were then input into TUBA. The hours in the OP periods (3 for OP charge and 8 for OP non-charge) were multiplied by the number of periods per year to calculate the annualisation factors. These factors were input into the TUBA scheme file to calculate annual trips and benefits for the 19:00 - 06:00 weekday period.

Table A.13 Annualisation factors, 19:00 to 06:00 OP weekday

Time Period	Hours	12-hour trip matrix flow	Period average hour flow	Trip matrix factor	Hours per period	Weekday periods per year	Annualisation factor
OP charge	19:00 – 22:00	14,278	651	0.05	3	253	759
OP non-charge	22:00 – 06:00	14,278	231	0.02	8	253	2,024

Weekend peak and off-peak periods

A.1.50 The WE peak period is defined as 09:00 to 19:00. This period is defined as peak as the average hourly flow of this period is 98% of the IP average hourly flow.

A.1.51 The WE off-peak period is defined as 19:00 to 09:00 and is split into charge and non-charge periods due to the variance of traffic flows experienced during these periods. Table A.14 shows that the WE charge period experiences an average hourly flow just over half of the IP average hour while the OP no-charge period is 19% of the IP average hour.

Table A.14 Weekend periods variance from average IP modelled hour flow

Time Period	Hours	Variance from average IP modelled hour
Weekend peak	09:00 – 19:00	-2%
Weekend OP charge	06:00 – 09:00 19:00 – 22:00	-48%
Weekend OP non-charge	22:00 – 06:00	-81%

A.1.52 Table A.15 shows the trip matrix factor and the annualisation factor calculations for the weekend periods. The combined 12-hour trip matrix was factored to the trip volume experienced in the average WE peak and off-peak charge and off-peak non-charge hour. The resulting trip matrix was assigned to the IP network. The resulting trip, time, distance and charge skims were then input into TUBA. The hours in the respective periods were multiplied by the number of weekend and bank holiday periods per year to calculate the annualisation factors. These factors were input into the TUBA scheme file to calculate annual benefits for the weekend periods.

Table A.15 Annualisation factors, weekend

Time Period	Hours	12 hour trip matrix flow	Weekend average hour flow	Trip matrix factor	Hours per period	Weekend periods per year	Annualisation factor
WE peak	09:00 – 19:00	14,278	1,063	0.07	10	112	1,120
WE OP charge	06:00 - 09:00 19:00 – 22:00	14,278	561	0.04	6	112	672
WE OP non-charge	22:00 – 06:00	14,278	208	0.01	8	112	896

A.1.53 Table A.16 shows that the 10 annualisation factors for the different time periods sum to 8,756 which equates to 99.95% of the 8,760 hours in a year.

Table A.16 List of annualisation factors

Period	Hour(s)	Annualisation factors
AM shoulder	06:00 – 07:00	253
AM peak	07:00 – 09:00	497
IP (average hour)	09:00 – 15:00	1,518
PM shoulder	15:00 – 16:00	506
PM peak	16:00 – 18:00	511
PM shoulder	18:00 – 19:00	See above PM shoulder

Period	Hour(s)	Annualisation factors
OP charge	19:00 – 22:00	759
OP non-charge	22:00 – 06:00	2,024
WE OP Peak charge	06:00 – 09:00	672
WE Peak	09:00 – 19:00	1,120
WE OP Peak charge	19:00 – 22:00	See above WE OP charge
WE OP non-charge	22:00 – 06:00	896
Total		**8,756**

Environmental expansion factors

Introduction

A.1.54 Outputs from LTAM are used to support the environmental assessment of the scheme. This section of the report provides summary information on those forecasts provided. Current guidance requires that this is provided for the core scenario only, for all forecast years.

A.1.55 Data provided to the environmental teams covers the model periods but is also aggregated to form Annual Average Daily Traffic (AADT) and Annual Average Weekday Traffic (AAWT). It is therefore necessary to initially present the methodologies used in undertaking these aggregations.

AADT and AAWT Calculation Methodology

A.1.56 The LTAM models represent neutral weekday conditions within three distinct peak hours as defined below:

a. AM Peak = 07.00 to 08.00

b. Inter Peak = 09.00 to 15.00 (Average Hour)

c. PM Peak = 17.00 to 18.00

A.1.57 In order to support environmental assessment activities, data from these model time periods needs to be factored to represent broader time periods. These requirements were discussed and agreed with the environmental consultants at a collaborative planning workshop at an early stage of the work. It was agreed that some of the standard environmental time periods would be shifted so as to better match the LTAM model hours and periods. The time periods required in order to support environmental assessment activities are provided in Table A.17.

Table A.17 Environmental Assessment Time Period Definitions

Time Period Name	Description	Hours Included
AADT24	24hr Annual Average All Days	00.00 – 24.00
AADTAM	AM Peak Annual Average All Days	06.00 – 09.00
AADTIP	Inter Peak Annual Average All Days	09.00 – 15.00
AADTPM	PM Peak Annual Average All Days	15.00 – 18.00
AADTOP	Off Peak Annual Average All Days	18.00 – 06.00
AAWT24	24hr Annual Average Weekdays	00.00 – 24.00
AAWTAM	AM Peak Annual Average Weekdays	06.00 – 09.00
AAWTIP	Inter Peak Annual Average Weekdays	09.00 – 15.00
AAWTPM	PM Peak Annual Average Weekdays	15.00 – 18.00
AAWTOP	Off Peak Annual Average Weekdays	18.00 – 06.00
AAWT18	18hr Annual Average Weekdays	06.00 – 24.00
AAWTNighttime	Nighttime Annual Average Weekdays	23.00 – 07.00

A.1.58 In order to derive the factors to enable the transposition, a series of annual traffic counts were analysed. The equations used to generate the time period flow values are presented in Table A.18. The factors derived from analysis of this data are provided in Table A.19. These have been disaggregated by vehicle type.

Table A.18 Environmental Assessment Time Period Equations

Time Period	Equation
AADT24	((LTAM AM x AADTAMFac) + (LTAM IP x AADTIPFac) + (LTAM PM x AADTPMFac)) x AADT24Fac
AADTAM	LTAM AM x AADTAMFac
AADTIP	LTAM IP x AADTIPFac
AADTPM	LTAM PM x AADTPMFac
AADTOP	((LTAM AM x AADTAMFac) + (LTAM IP x AADTIPFac) + (LTAM PM x AADTPMFac)) x AADTOPFac
AAWT24	((LTAM AM x AAWTAMFac) + (LTAM IP x AAWTIPFac) + (LTAM PM x AAWTPMFac)) x AAWT24Fac
AAWTAM	LTAM AM x AAWTAMFac
AAWTIP	LTAM IP x AAWTIPFac
AAWTPM	LTAM PM x AAWTPMFac
AAWTOP	((LTAM AM x AAWTAMFac) + (LTAM IP x AAWTIPFac) + (LTAM PM x AAWTPMFac)) x AAWTOPFac
AAWT18	((LTAM AM x AAWTAMFac) + (LTAM IP x AAWTIPFac) + (LTAM PM x AAWTPMFac)) x AAWT18Fac

Time Period	Equation
AAWTNighttime	((LTAM AM x AAWTAMFac) + (LTAM IP x AAWTIPFac) + (LTAM PM x AAWTPMFac)) x AAWTNighttimeFac

A.1.59 For AADT24, AAWT24, AAWT18 and AAWTNighttime, the total flow through the period is provided. For the other time periods, i.e. AM, IP, PM and OP for both AADT and AAWT, the flow values are divided by the length of the time period in order to obtain the average flow within the time period.

Table A.19 Environmental Assessment Time Period Factors

Time Period	All vehicles factor	Car / LGV factor	HGV factor
AADT24Fac	1.367	1.354	1.368
AADTAMFac	2.338	2.298	2.307
AADTIPFac	6.022	6.216	4.843
AADTPMFac	2.715	2.687	2.928
AADTOPFac	0.367	0.354	0.368
AAWT24Fac	1.348	1.342	1.340
AAWTAMFac	2.762	2.740	2.853
AAWTIPFac	6.000	6.000	6.000
AAWTPMFac	2.898	2.831	3.646
AAWTOPFac	0.348	0.342	0.340
AAWT18Fac	1.264	1.272	1.186
AAWTNightimeFac	0.179	0.159	0.264

A.1.60 In order to support the environmental assessment, it is also necessary to provide average speeds for each of the above time periods. The procedure adopted essentially provides a flow weighted average speed using the relative weights associated with each of the time periods as described above. In line with current guidance, modelled speeds are then further adjusted prior to environmental assessment to adjust for the differences between the base year observed and modelled speeds.

Summary of annualisation and expansion factors

TUBA annualisation summary

A.1.61 Summary tables of the annualisation factors used in TUBA are provided in Table A.20 and Table A.21.

Table A.20 Annualisation factor calculation summary, weekday

Time period		Hour	Modelled hour(s) flow	Period flow	TUBA input source	Trip matrix factor	Expansion factor	Hours per period	Periods per year	Annualisation factor
weekday	AM shoulder	06:00 – 07:00	1,352	1,079	synthesised	0.80	-	1	253	253
	AM peak	07:00 – 08:00	1,352	2,655	LTAM AM peak hour	-	1.96	-	253	497
		08:00 – 09:00								
	IP	09:00 – 10:00	1,082	6,492	LTAM IP average modelled hour	-	6.0	-	253	1,518
		10:00 – 11:00								
		11:00 – 12:00								
		12:00 – 13:00								
		13:00 – 14:00								
		14:00 – 15:00								
	PM shoulder	15:00 – 16:00	1,398	1,198	synthesised	0.86		2	253	506
	PM peak	16:00 – 17:00	1,398	2,824	LTAM PM peak hour	-	2.02	-	253	511
		17:00 – 18:00								
	PM shoulder	18:00 – 19:00	See above PM shoulder							
	OP charge	19:00 – 20:00	14,278	651	synthesised	0.05	-	3	253	759
		20:00 – 21:00								
		21:00 – 22:00								
		22:00 – 23:00	14,278	231	synthesised	0.02		8	253	2,024

Time period		Hour	Modelled hour(s) flow	Period flow	TUBA input source	Trip matrix factor	Expansion factor	Hours per period	Periods per year	Annualisation factor
	OP non-charge	23:00 – 24:00					-			
		00:00 – 01:00								
		01:00 – 02:00								
		02:00 – 03:00								
		03:00 – 04:00								
		04:00 – 05:00								
		05:00 – 06:00								

Table A.21 Annualisation factor calculation summary, weekend

Time period		Hour	Modelled hour(s) flow	Period flow	TUBA input source	Trip matrix factor	Expansion factor	Hours per period	Periods per year	Annualisation factor
weekend	WE OP charge	06:00 – 07:00	14,278	561	synthesised	0.04	-	6	112	672
		07:00 – 08:00								
		08:00 – 09:00								
	WE peak	09:00 – 10:00	14,278	1,063	synthesised	0.07	-	10	112	1,120
		10:00 – 11:00								
		11:00 – 12:00								
		12:00 – 13:00								
		13:00 – 14:00								
		14:00 – 15:00								
		15:00 – 16:00								
		16:00 – 17:00								
		17:00 – 18:00								

Time period		Hour	Modelled hour(s) flow	Period flow	TUBA input source	Trip matrix factor	Expansion factor	Hours per period	Periods per year	Annualisation factor
		18:00 – 19:00								
	WE OP charge	19:00 – 20:00	See above WE OP charge							
		20:00 – 21:00								
		21:00 – 22:00								
	WE OP non-charge	22:00 – 23:00	14,278	208	synthesised	0.01	-	8	112	896
		23:00 – 24:00								
		00:00 – 01:00								
		01:00 – 02:00								
		02:00 – 03:00								
		03:00 – 04:00								
		04:00 – 05:00								
		05:00 – 06:00								

Environmental expansion factor summary

A.1.62 A summary of the expansion factors used for the appraisal of air quality and noise impacts is provided in Table A.22.

Table A.22 Environmental expansion factory summary table

Time Period	Description	Factor Name	All vehicles factor	Car / LGV factor	HGV factor
AADT24	06:00 – 18:00 Daily to AADT 24	AADT24Fac	1.367	1.354	1.368
AADTAM	07:00 – 08:00 Weekday to 06:00 – 09:00 All day	AADTAMFac	2.338	2.298	2.307
AADTIP	09:00 -15:00 Average Weekday to 09:00 – 15:00 All Day	AADTIPFac	6.022	6.216	4.843
AADTPM	17:00 – 18:00 Weekday to 15:00 – 18:00 All Day	AADTPMFac	2.715	2.687	2.928
AADTOP	06:00 – 18:00 Weekday to 18:00 – 06:00 Allday	AADTOPFac	0.367	0.354	0.368
AAWT24	06:00 – 18:00 Weekday to 00:00 – 24:00 Weekday	AAWT24Fac	1.348	1.342	1.340
AAWTAM	07:00 – 08:00 Weekday to 06:00 – 09:00 Weekday	AAWTAMFac	2.762	2.740	2.853
AAWTIP	09:00 – 15:00 Average Weekday to 09:00 – 15:00 Weekday	AAWTIPFac	6.000	6.000	6.000
AAWTPM	17:00 – 18:00 Weekday to 15:00 – 18:00 Weekday	AAWTPMFac	2.898	2.831	3.646
AAWTOP	06:00 – 18:00 Weekday to 18:00 – 06:00 Weekday	AAWTOPFac	0.348	0.342	0.340
AAWT18	06:00 – 18:00 Weekday to 06:00 – 24:00 Weekday	AAWT18Fac	1.264	1.272	1.186
AAWTNighttime	06:00 – 18:00 Weekday to 23:00 – 07:00 Weekday	AAWTNightimeFac	0.179	0.159	0.264

A.2 TUBA sectors

Plate A.5 TUBA sector plan for the Project (Great Britain)

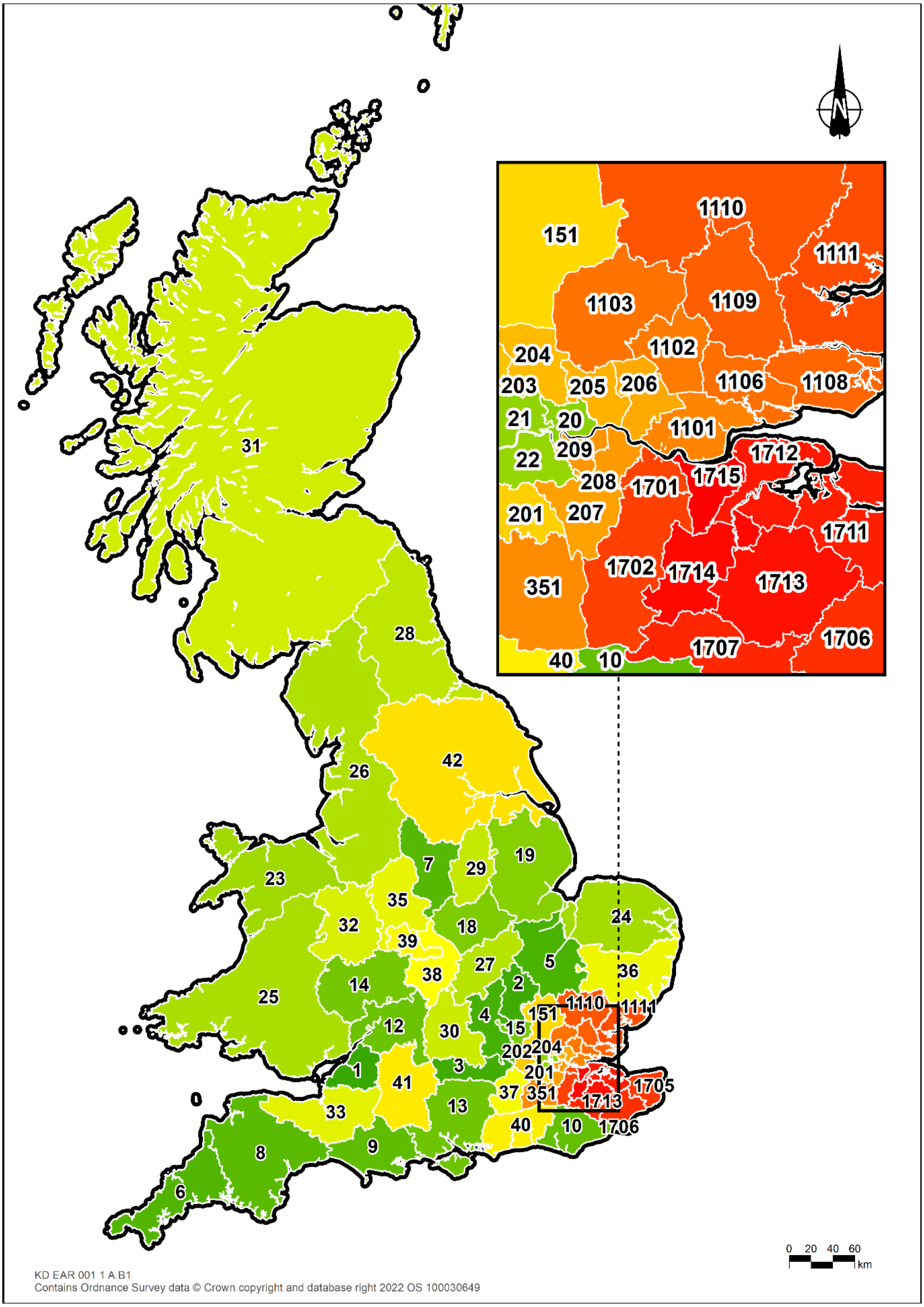


Plate A.6 TUBA sector plan for the Project (London and South East)

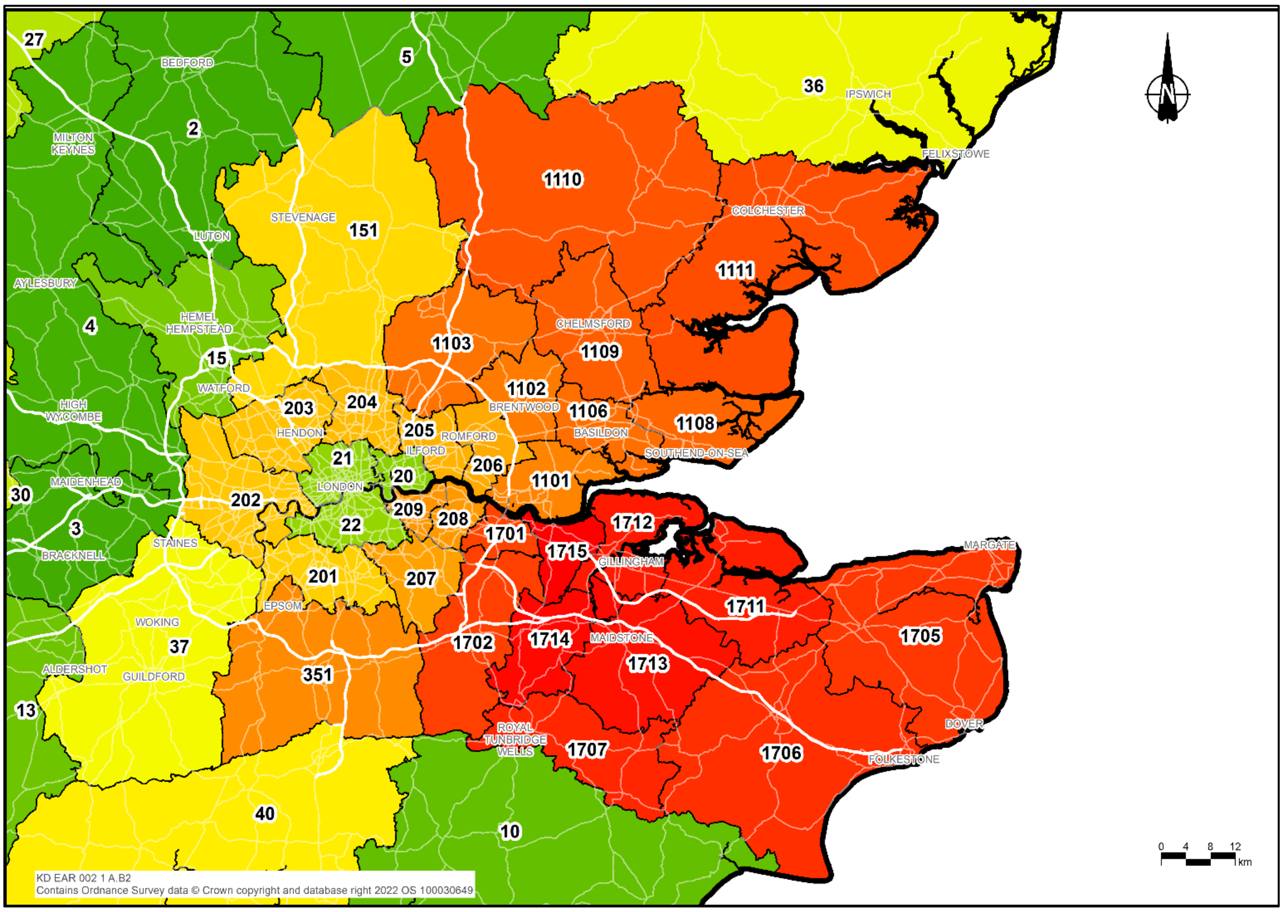


Table A.23 TUBA sector description

Sector No.	Sector Description
1	Avon
2	Bedfordshire
3	Berkshire
4	Buckinghamshire
5	Cambridgeshire
6	Cornwall
7	Derbyshire
8	Devon
9	Dorset
10	East Sussex
12	Gloucestershire
13	Hampshire
14	Hereford & Worcester
15	Hertfordshire (West)
18	Leicestershire
19	Lincolnshire
20	East London
21	North London
22	South London
23	North Wales
24	Norfolk
25	Mid Wales
26	North West Region
27	Northamptonshire
28	Northern Region
29	Nottinghamshire
30	Oxfordshire
31	Scotland
32	Shropshire
33	Somerset
35	Staffordshire
36	Suffolk
37	Surrey (West)
38	Warwickshire

Sector No.	Sector Description
39	West Midlands
40	West Sussex
41	Wiltshire
42	Yorkshire & Humberside
151	Hertfordshire (East)
201	Merton, Kingston, Sutton, Croydon
202	Hillingdon, Ealing, Hounslow & Richmond
203	Barnet, Brent & Harrow
204	Enfield, Haringey & Waltham Forest
205	Barking and Dagenham & Redbridge
206	Havering
207	Bromley
208	Bexley
209	Greenwich
351	Surrey (East)
1101	Thurrock
1102	Brentwood
1103	Epping Forest & Harlow
1106	Basildon & Castle Point
1108	Rochford & Southend-on-Sea
1109	Chelmsford
1110	Uttlesford & Braintree
1111	Maldon, Colchester & Tendring
1701	Dartford
1702	Sevenoaks
1705	Canterbury, Dover & Thanet
1706	Ashford & Shepway
1707	Tunbridge Wells
1711	Swale
1712	Medway
1713	Maidstone
1714	Tonbridge and Malling
1715	Gravesham

A.3 Distribution of TEE benefits by time period

A.3.1 The distribution of TEE benefits across the 10 time periods for the Low, Core and High traffic growth scenarios is shown in Table A.24 and Plate A.7.

A.3.2 The time periods are:

a. AM peak

b. PM peak

c. Inter-peak

d. Off-peak charge weekday (OPCWD)

e. Off-peak non-charge weekday (OPNCWD)

f. AM shoulder

g. PM shoulder

h. Weekend peak (PKWE)

i. Off-peak charge weekend (OPCWE)

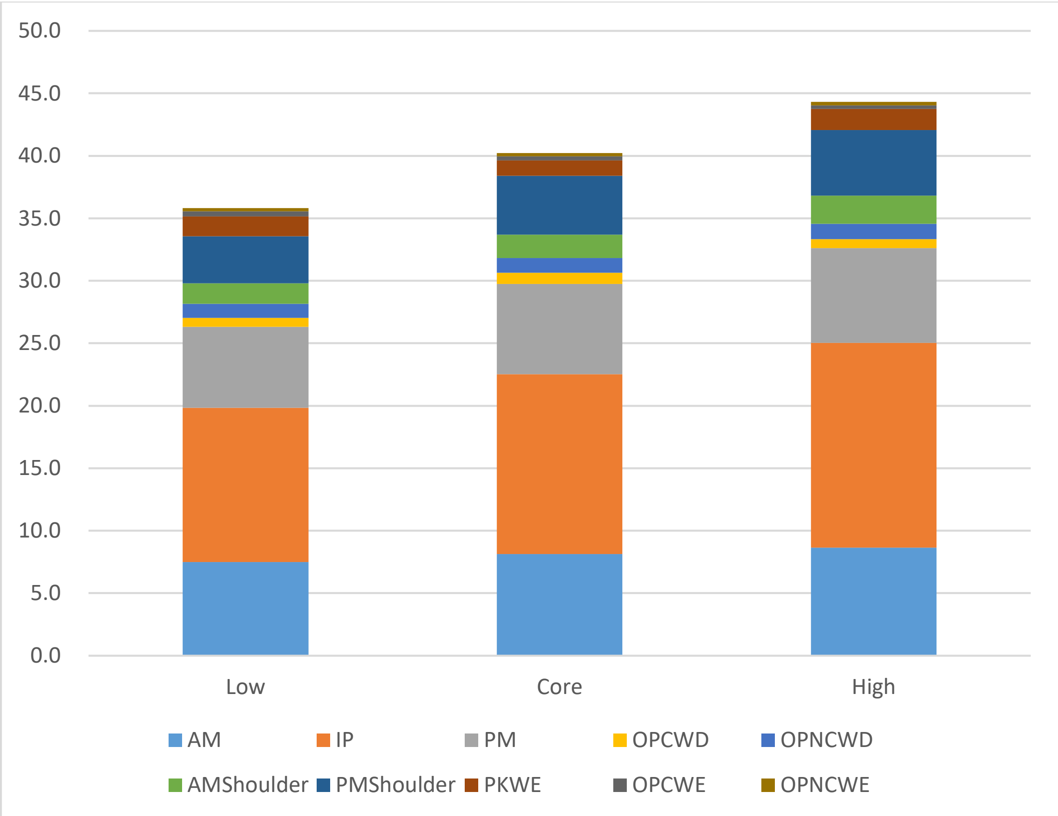
j. Off-peak non-charge weekend (OPNCWE)

Table A.24 Breakdown of TEE benefits by time period - 2030 (£m, 2010 prices and values)

		Low	**Core**	**High**
Benefits	AM	7.5	8.1	8.6
	IP	12.4	14.4	16.4
	PM	6.5	7.2	7.6
	OPCWD	0.7	0.9	0.7
	OPNCWD	1.1	1.2	1.2
	AMShoulder	1.6	1.9	2.2
	PMShoulder	3.8	4.7	5.3
	PKWE	1.6	1.2	1.7
	OPCWE	0.4	0.3	0.3
	OPNCWE	0.3	0.3	0.3
	Total	**35.8**	**40.2**	**44.3**
Share of total %	AM	21	20	19
	IP	34	36	37
	PM	18	18	17

		Low	Core	High
	OPCWD	2	2	2
	OPNCWD	3	3	3
	AMShoulder	5	5	5
	PMShoulder	11	12	12
	PKWE	4	3	4
	OPCWE	1	1	1
	OPNCWE	1	1	1
	Total	**100**	**100**	**100**

Plate A.7 TEE benefits by time period - 2030 £m, 2010 prices and values

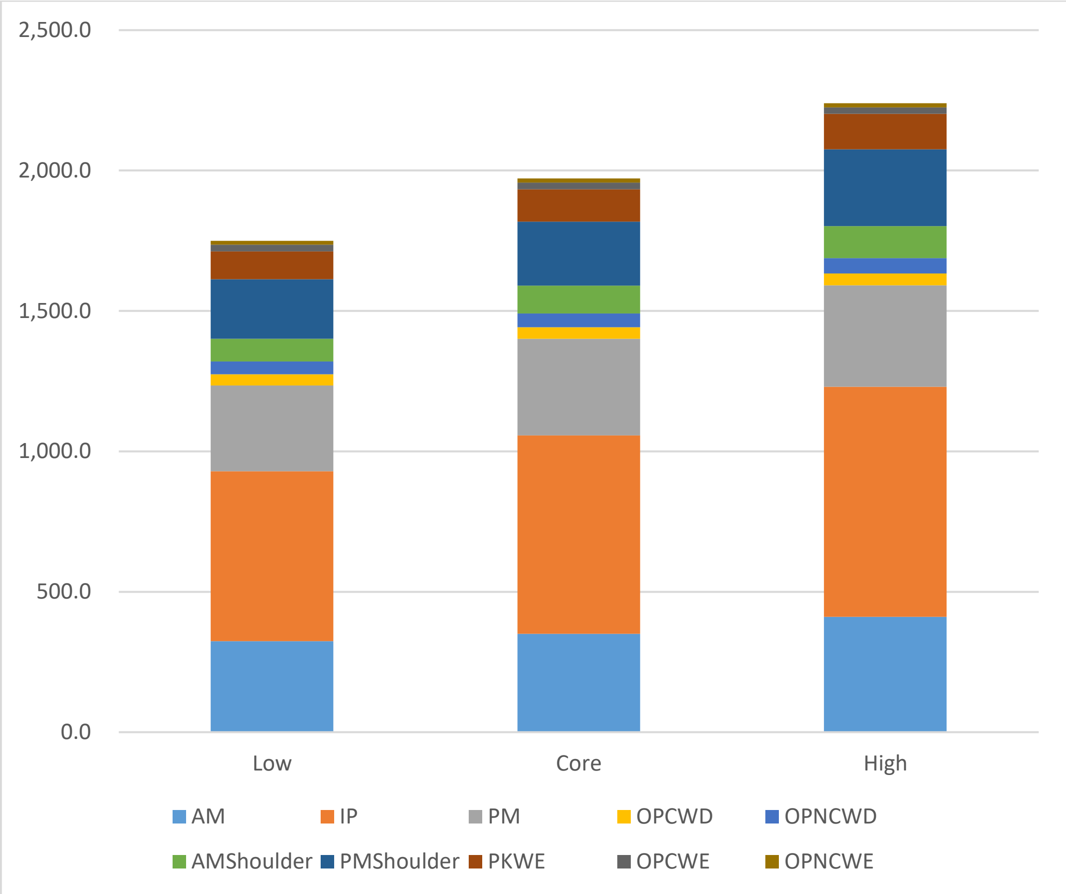


A.3.3 A similar distribution by period over the full 60 years is shown in Table A.25 TEE benefits by time period – 60 years (£m, 2010 prices and values)and Plate A.8.

Table A.25 TEE benefits by time period – 60 years (£m, 2010 prices and values)

		Low	Core	High
Benefits	AM	324.3	350.5	411.1
	IP	605.1	706.0	818.7
	PM	305.5	344.9	361.4
	OPCWD	39.2	40.2	42.3
	OPNCWD	46.0	49.8	54.6
	AMShoulder	81.5	99.2	114.3
	PMShoulder	210.9	227.1	272.8
	PKWE	100.1	115.8	127.4
	OPCWE	23.4	24.0	22.2
	OPNCWE	13.7	14.4	15.3
	Total	**1,749.7**	**1,971.9**	**2,240.1**
Share of total %	AM	19	18	18
	IP	35	36	37
	PM	17	17	16
	OPCWD	2	2	2
	OPNCWD	3	3	2
	AMShoulder	5	5	5
	PMShoulder	12	12	12
	PKWE	6	6	6
	OPCWE	1	1	1
	OPNCWE	1	1	1
	Total	**100**	**100**	**100**

Plate A.8 TEE benefits by time period – 60 years (£m, 2010 prices and values)



A.3.4 Over the 60-year period, Inter-peak TEE benefits typically represent around 36% of total TEE benefits. Benefits for the Inter-Peak appear higher than expected due to annualisation, with the Inter-Peak covering 6 hours of the day with AM and PM only covering 2 hours. Per hour benefits result in a more expected benefits profile as shown in Table A.26.

Table A.26 TEE benefits per hour in AM, IP and PM periods - Core traffic growth (£m, 2010 prices and values)

	Total benefits	No of hours	Benefits per hour
AM	350.5	2	175.3
IP	706.0	6	117.7
PM	344.9	2	172.5

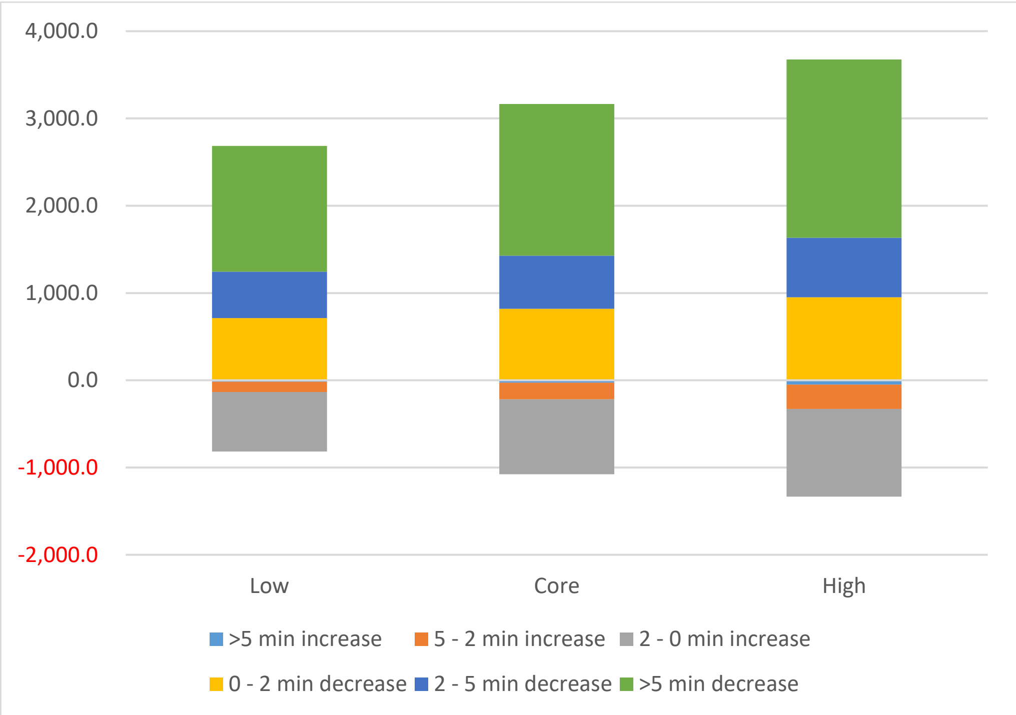
A.4 Journey time benefits by size of time change

A.4.1 Journey time benefits by magnitude of journey time change are shown in Table A.27 and Plate A.9.

Table A.27 Time benefits by magnitude of time change (£m, 2010 prices and values)

	Low	Core	High
>5 min increase	-18.3	-28.2	-51.8
5 - 2 min increase	-116.3	-191.3	-278.2
2 - 0 min increase	-680.2	-857.4	-1,003.0
0 - 2 min decrease	712.4	819.4	952.1
2- 5 min decrease	530.2	607.2	681.9
>5 min decrease	1,443.1	1,738.5	2,042.7
% of TEE benefits from time change of over 5 mins	76	82	85

Plate A.9 Time benefits by magnitude of time change (£m, 2010 prices and values)



A.4.2 Journey time changes of more than 5 minutes account, on average across the three traffic growth scenarios, for 81% of time benefits.

A.5 TEE benefits by vehicle type

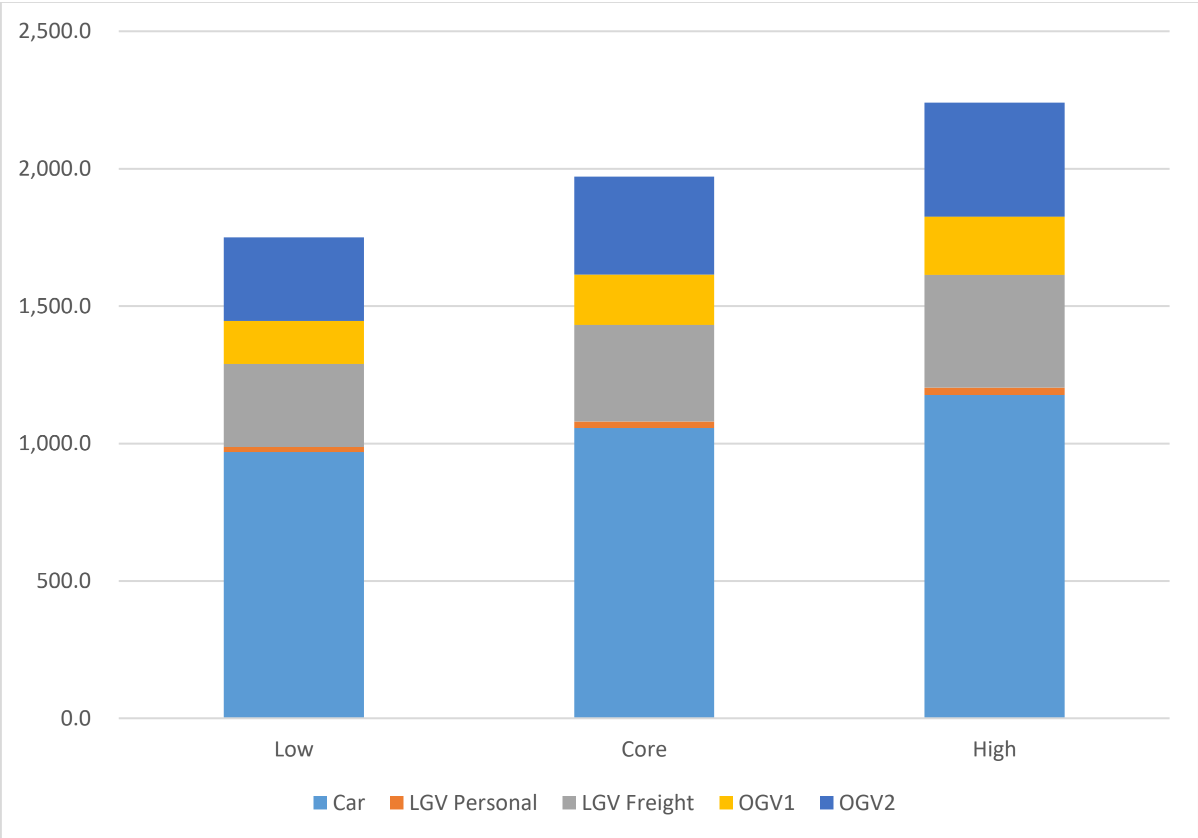
A.5.1 The distribution of TEE benefits by vehicle type (Car, LGV Personal, LGV Freight, OGV1 and OGV2) for the Low, Core and High traffic growth scenarios is shown in Table A.28 and Plate A.10.

A.5.2 It can be seen that car travellers obtain the highest level of benefits with, on average across the three traffic growth scenarios, 54% of total TEE benefits.

Table A.28 TEE benefits by vehicle type (£m, 2010 prices and values)

		Low	Core	High
Benefits	Car	968.0	1,057.0	1,175.5
	LGV Personal	20.3	23.6	27.7
	LGV Freight	302.1	351.0	410.3
	OGV1	155.2	183.0	212.6
	OGV2	304.2	357.3	414.0
	Total	**1,749.7**	**1,971.9**	**2,240.1**
Share of total %	Car	55	54	52
	LGV Personal	1	1	1
	LGV Freight	17	18	18
	OGV1	9	9	9
	OGV2	17	18	18
	Total	**100**	**100**	**100**

Plate A.10 TEE benefits by vehicle type (£m, 2010 prices and values)



A.6 TEE benefit profile over 60 years

A.6.1 The distribution of TEE benefits for the three traffic growth scenarios, over the four modelled years, is shown in Table A.29.

Table A.29 TEE benefits by modelled years (£m, 2010 prices and values)

	Low	Core	High
2030	35.8	40.2	44.3
2037	35.9	41.6	44.4
2045	35.4	39.8	44.5
2051	33.3	37.2	43.4

A.6.2 The profiles of TEE benefits, for the three traffic growth scenarios, over all 60 years is presented in Table A.30 and Plate A.11.

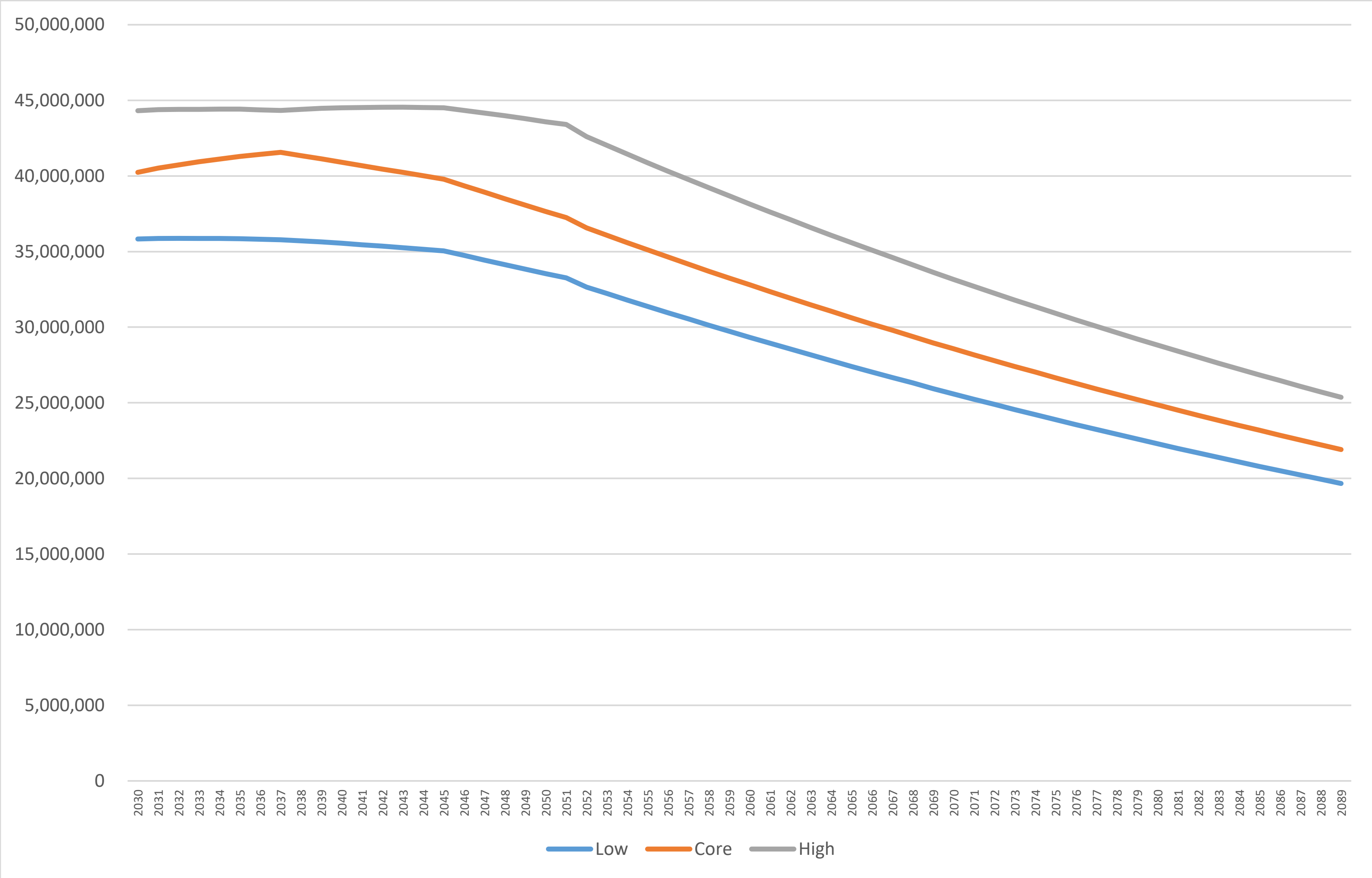
Table A.30 Profile of TEE benefits (£, 2010 prices and values)

Year	Low	Core	High
2030	35,826,576	40,231,733	44,323,305
2031	35,872,566	40,512,300	44,393,202
2032	35,873,077	40,730,743	44,406,491
2033	35,867,760	40,931,267	44,410,900
2034	35,861,439	41,119,592	44,411,904
2035	35,854,962	41,297,785	44,411,556
2036	35,820,491	41,434,348	44,374,779
2037	35,786,332	41,562,031	44,337,061
2038	35,706,037	41,334,912	44,401,763
2039	35,637,774	41,126,812	44,471,439
2040	35,547,202	40,900,464	44,507,502
2041	35,451,117	40,672,928	44,528,092
2042	35,358,431	40,454,214	44,544,931
2043	35,259,688	40,233,578	44,547,031
2044	35,153,962	40,009,766	44,533,593
2045	35,042,221	39,783,638	44,506,063
2046	34,740,732	39,350,220	44,337,551
2047	34,441,358	38,921,610	44,163,502
2048	34,141,360	38,494,528	43,980,125

Year	Low	Core	High
2049	33,840,807	38,069,046	43,787,790
2050	33,539,071	37,644,466	43,586,032
2051	33,255,591	37,242,456	43,399,613
2052	32,657,289	36,565,824	42,601,234
2053	32,224,628	36,074,979	42,019,788
2054	31,796,921	35,589,958	41,445,548
2055	31,374,138	35,110,720	40,878,450
2056	30,956,243	34,637,214	40,318,420
2057	30,543,217	34,169,409	39,765,412
2058	30,135,001	33,707,234	39,219,326
2059	29,731,595	33,250,677	38,680,137
2060	29,332,949	32,799,677	38,147,762
2061	28,939,032	32,354,189	37,622,138
2062	28,549,799	31,914,157	37,103,185
2063	28,165,222	31,479,542	36,590,850
2064	27,785,266	31,050,295	36,085,064
2065	27,409,887	30,626,364	35,585,757
2066	27,039,054	30,207,704	35,092,865
2067	26,672,721	29,794,262	34,606,316
2068	26,310,856	29,385,992	34,126,049
2069	25,938,703	28,966,087	33,632,477
2070	25,586,087	28,568,501	33,165,143
2071	25,237,816	28,175,936	32,703,885
2072	24,893,845	27,788,332	32,248,628
2073	24,554,136	27,405,639	31,799,307
2074	24,218,636	27,027,797	31,355,842
2075	23,887,332	26,654,784	30,918,200
2076	23,560,175	26,286,542	30,486,307
2077	23,237,117	25,923,012	30,060,086
2078	22,918,133	25,564,160	29,639,493
2079	22,603,178	25,209,933	29,224,458
2080	22,292,209	24,860,279	28,814,914
2081	21,985,187	24,515,149	28,410,799
2082	21,682,076	24,174,498	28,012,053
2083	21,382,832	23,838,276	27,618,612

Year	Low	Core	High
2084	21,087,423	23,506,439	27,230,422
2085	20,795,804	23,178,938	26,847,417
2086	20,507,937	22,855,724	26,469,535
2087	20,223,781	22,536,747	26,096,715
2088	19,943,295	22,221,960	25,728,897
2089	19,666,447	21,911,324	25,366,029
Total	**1,749,704,520**	**1,971,946,698**	**2,240,081,743**

Plate A.11 TEE benefits 2030 to 2089 (£m, 2010 prices and values)



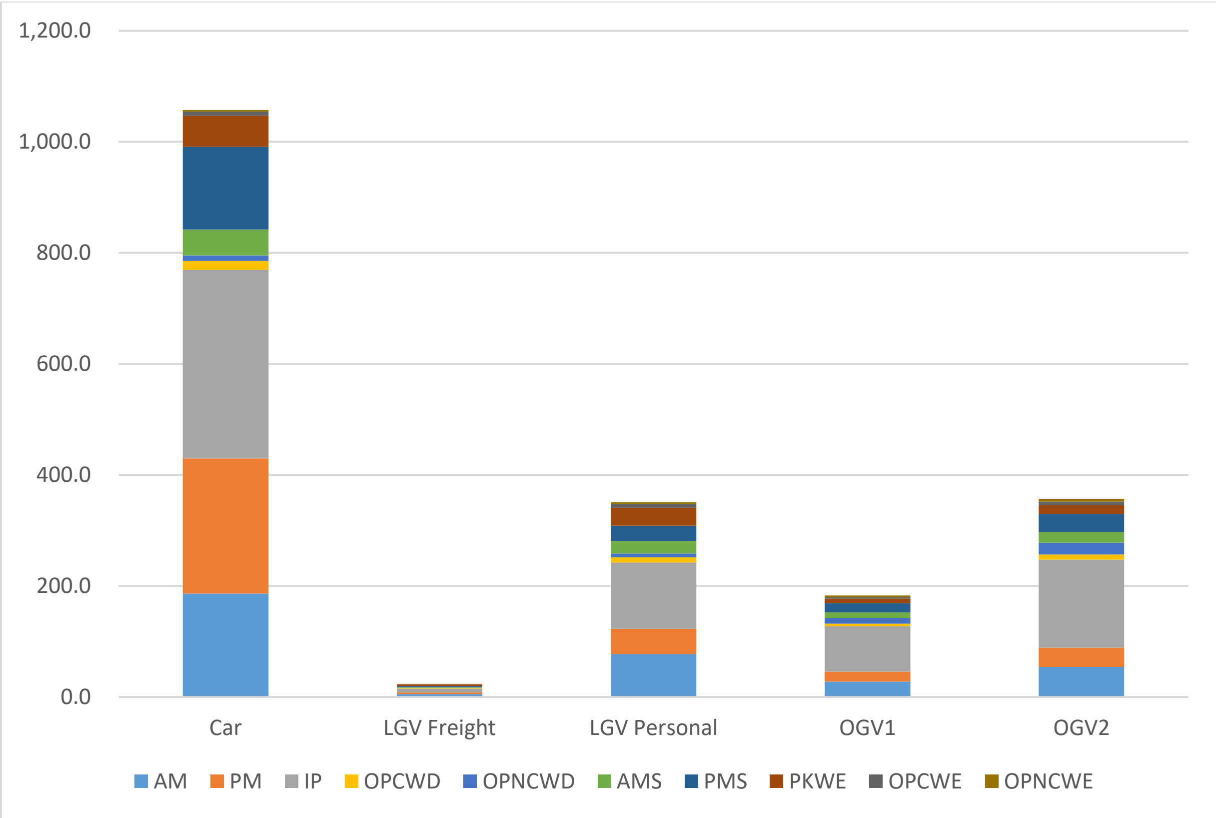
A.7 TEE benefits by time period and vehicle type

A.7.1 TEE benefits disaggregated by time period and vehicle type for the Core traffic growth scenario are shown in Table A.31 and Plate A.12.

Table A.31 TEE benefits by time period and vehicle type (£m, 2010 prices and values)

	AM	PM	IP	OPCWD	OPNCWD	AMS	PMS	PKWE	OPCWE	OPNCWE
Car	186.1	243.6	339.5	16.2	10.1	46.4	148.9	56.2	7.4	2.7
LGV Freight	5.0	2.9	7.4	0.7	0.6	1.4	1.8	2.8	0.6	0.3
LGV Personal	77.4	45.8	119.1	9.2	7.0	22.5	27.7	32.3	6.8	3.2
OGV1	27.9	17.9	81.5	4.7	10.8	9.7	16.4	8.2	3.1	2.8
OGV2	54.2	34.8	158.5	9.4	21.3	19.1	32.2	16.2	6.1	5.5
Total	**350.5**	**344.9**	**706.0**	**40.2**	**49.8**	**99.2**	**227.1**	**115.8**	**24.0**	**14.4**

Plate A.12 TEE benefits by time period and vehicle type (£m, 2010 prices and values)



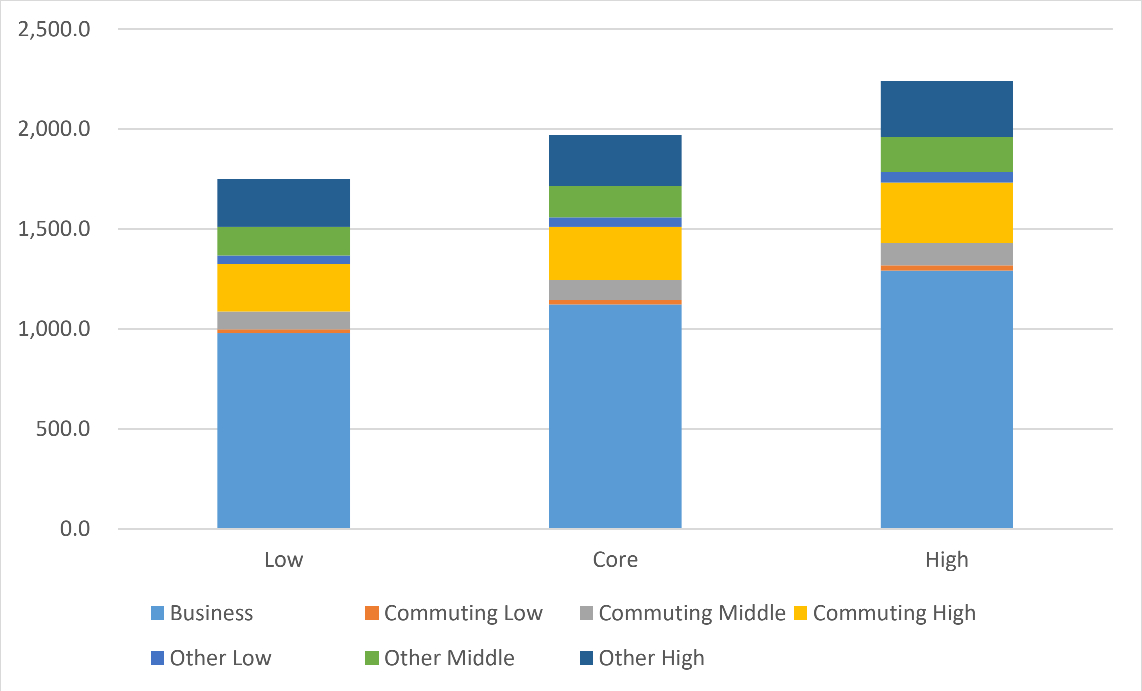
A.8 TEE benefits by journey purpose

A.8.1 TEE benefits disaggregated by journey purpose are shown in Table A.32 and Plate A.13.

Table A.32 TEE benefits by journey purpose (£m, 2010 prices and values)

		Low	Core	High
Benefits by journey purpose over 60 years (£m)	Business	978.1	1,123.3	1,293.1
	Commuting Low	19.4	21.3	24.3
	Commuting Middle	90.0	99.4	113.1
	Commuting High	238.3	268.5	302.6
	Other Low	42.5	45.8	53.0
	Other Middle	143.9	157.4	174.7
	Other High	237.4	256.3	279.3
	Total	**1,749.7**	**1,971.9**	**2,240.1**
Share of total (%)	Business	56	57	58
	Commuting Low	1	1	1
	Commuting Middle	5	5	5
	Commuting High	14	14	14
	Other Low	2	2	2
	Other Middle	8	8	8
	Other High	14	13	12
	Total	**100**	**100**	**100**

Plate A.13 TEE benefits by journey purpose (£m, 2010 prices and values)



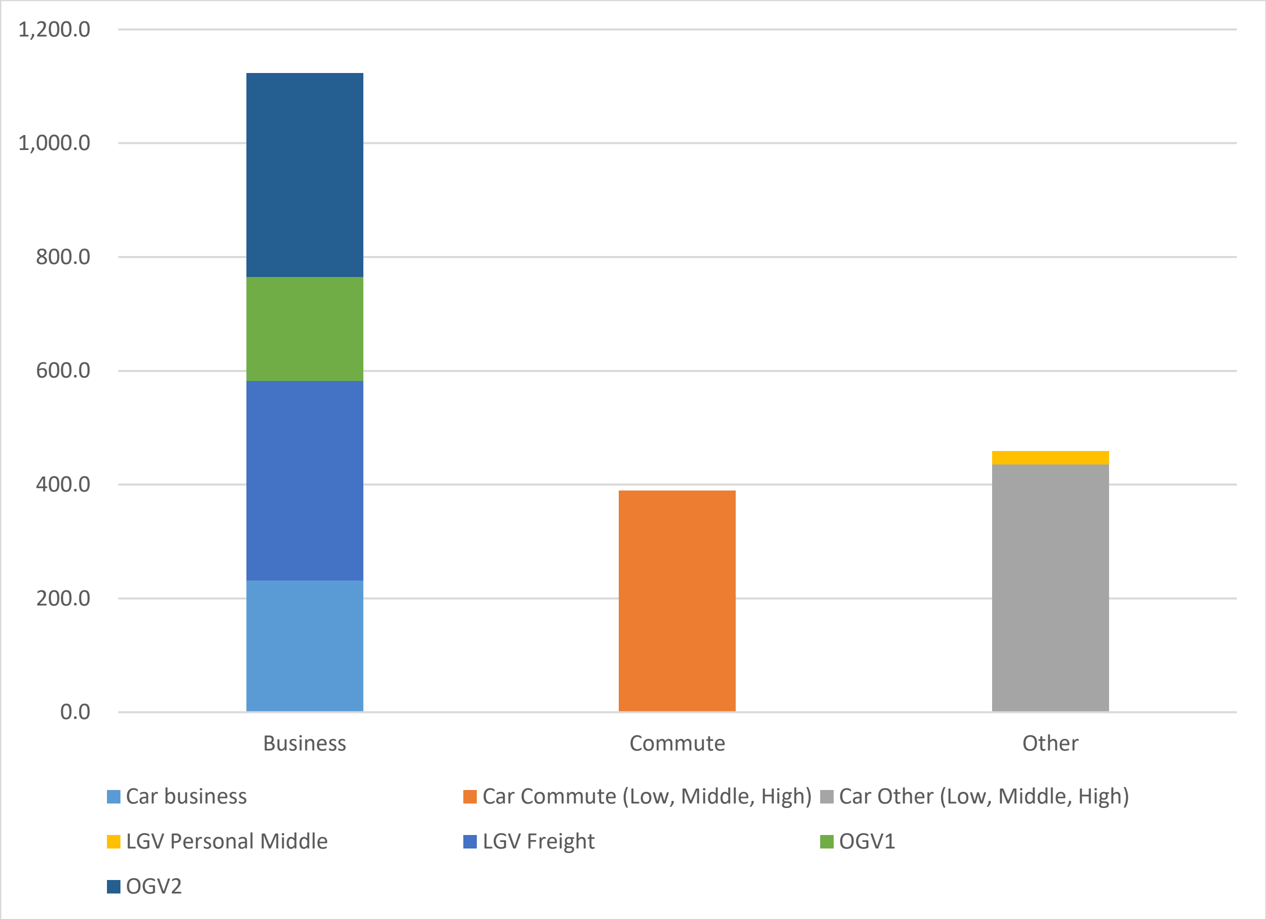
A.9 TEE benefits by vehicle type and journey purpose

A.9.1 Table A.33 and Plate A.14 show TEE benefits disaggregated by vehicle type and journey purpose for the Core traffic growth.

Table A.33 TEE benefits by vehicle type and journey purpose (£m, 2010 prices and values)

	Business	Commute	Other	Total
Car business	232.0	0.0	0.0	232.0
Car Commute (Low, Middle, High)	0.0	389.2	0.0	389.2
Car Other (Low, Middle, High)	0.0	0.0	435.8	435.8
LGV Personal Middle	0.0	0.0	23.6	23.6
LGV Freight	351.0	0.0	0.0	351.0
OGV1	183.0	0.0	0.0	183.0
OGV2	357.3	0.0	0.0	357.3
Total	**1,123.3**	**389.2**	**459.4**	**1,971.9**

Plate A.14 TEE benefits by vehicle type and journey purpose (£m, 2010 prices and values)



A.10 TEE benefits disaggregated by TUBA sector

A.10.1 Table A.34 shows for each TUBA sector:

a. total population

b. TEE benefits by origin

c. TEE benefits by destination

d. average TEE benefits – an average of benefits by origin and destination

e. average TEE benefits as a percentage of total benefits

f. average TEE benefits per head

A.10.2 The sectors are ranked in the table in terms of average TEE benefits.

A.10.3 Plate A.15 show average TEE benefits in graphical form.

A.10.4 Maps are provided as follows:

a. Plate A.16 shows average TEE benefits for Great Britain

b. Plate A.17 shows average TEE benefits for sectors closest to the Project

c. Plate A.18 shows average TEE benefits per head for sectors closest to the Project

Table A.34 TEE benefits by sector – Core traffic growth (£000, 2010 prices and values)

Sector	Sector ID	Sector Population (000's)	Benefits by Origin (£000s)	Benefits by Destination (£000s)	Average Benefits (£000's)	Average user benefits % of total	Average User Benefit Per Head (£)	Rank
Total		64,552	1,971,947	1,971,947	1,971,947	100%	31	
Thurrock	1101	173	361,548	546,564	454,056	23%	2632	1
Gravesham	1715	108	218,452	114,041	166,246	8%	1533	2
Medway	1712	278	232,291	40,569	136,430	7%	491	3
Dartford	1701	103	99,948	139,878	119,913	6%	1167	4
Canterbury, Dover & Thanet	1705	423	139,291	69,736	104,514	5%	247	5
Basildon & Castle Point	1106	276	51,036	118,782	84,909	4%	308	6
Havering	206	258	27,127	133,576	80,352	4%	312	7
Swale	1711	148	101,945	50,294	76,119	4%	513	8
Tonbridge and Malling	1714	122	88,327	43,412	65,869	3%	539	9
Maidstone	1713	178	81,503	24,132	52,817	3%	296	10
Ashford & Shepway	1706	242	73,542	30,213	51,877	3%	214	11
Brentwood	1102	77	24,682	53,704	39,193	2%	512	12
Barking and Dagenham & Redbridge	205	524	15,975	54,079	35,027	2%	67	13
Rochford & Southend-on-Sea	1108	269	21,522	46,111	33,816	2%	125	14
Bexley	208	247	24,864	36,367	30,616	2%	124	15
Sevenoaks	1702	125	24,749	17,729	21,239	1%	170	16
East London	20	568	13,347	27,646	20,497	1%	36	17
Cambridgeshire	5	852	21,884	18,217	20,051	1%	24	18
Bromley	207	331	17,824	18,288	18,056	1%	55	19
Hertfordshire (East)	151	693	9,993	25,465	17,729	1%	26	20
Northamptonshire	27	748	12,140	23,008	17,574	1%	24	21
Greenwich	209	286	10,999	23,089	17,044	1%	60	22
Merton, Kingston, Sutton, Croydon	201	926	21,262	12,279	16,770	1%	18	23
West Sussex	40	859	24,351	9,175	16,763	1%	20	24
Chelmsford	1109	177	13,033	19,475	16,254	1%	92	25
Surrey (West)	37	788	21,759	7,855	14,807	1%	19	26
Maldon, Colchester & Tendring	1111	399	13,030	16,372	14,701	1%	37	27
West Midlands	39	2,916	7,286	20,760	14,023	1%	5	28
South London	22	1,273	9,811	15,089	12,450	1%	10	29
Bedfordshire	2	669	7,276	17,425	12,351	1%	18	30
North West Region	26	7,292	8,416	15,178	11,797	1%	2	31

Sector	Sector ID	Sector Population (000's)	Benefits by Origin (£000s)	Benefits by Destination (£000s)	Average Benefits (£000's)	Average user benefits % of total	Average User Benefit Per Head (£)	Rank
Yorkshire & Humberside	42	5,479	11,095	11,661	11,378	1%	2	32
Leicestershire	18	1,093	7,820	14,084	10,952	1%	10	33
Suffolk	36	759	9,690	11,378	10,534	1%	14	34
North London	21	1,304	11,976	8,895	10,436	1%	8	35
Hertfordshire (West)	15	491	11,179	7,723	9,451	0%	19	36
Buckinghamshire	4	809	9,017	9,871	9,444	0%	12	37
Lincolnshire	19	756	11,032	6,800	8,916	0%	12	38
Surrey (East)	351	448	13,979	3,790	8,884	0%	20	39
Hampshire	13	1,986	8,637	8,853	8,745	0%	4	40
Enfield, Haringey & Waltham Forest	204	872	-637	18,033	8,698	0%	10	41
Nottinghamshire	29	1,154	10,017	7,240	8,629	0%	7	42
Tunbridge Wells	1707	118	10,485	6,573	8,529	0%	72	43
Epping Forest & Harlow	1103	218	2,351	11,913	7,132	0%	33	44
Barnet, Brent & Harrow	203	973	7,411	6,108	6,759	0%	7	45
Uttlesford & Braintree	1110	245	3,306	9,529	6,417	0%	26	46
East Sussex	10	845	11,040	1,714	6,377	0%	8	47
Staffordshire	35	1,131	4,192	7,944	6,068	0%	5	48
Norfolk	24	904	4,435	5,184	4,809	0%	5	49
Derbyshire	7	1,054	2,879	5,990	4,435	0%	4	50
Hillingdon, Ealing, Hounslow & Richmond	202	1,300	6,064	916	3,490	0%	3	51
Warwickshire	38	571	2,109	3,016	2,562	0%	4	52
Oxfordshire	30	688	1,717	2,091	1,904	0%	3	53
Northern Region	28	2,658	1,866	1,773	1,819	0%	1	54
Scotland	31	5,438	1,369	1,514	1,441	0%	0	55
Shropshire	32	498	1,077	1,727	1,402	0%	3	56
North Wales	23	698	919	1,795	1,357	0%	2	57
Devon	8	1,194	1,419	1,227	1,323	0%	1	58
Somerset	33	559	1,327	1,033	1,180	0%	2	59
Mid Wales	25	2,440	810	1,113	962	0%	0	60
Dorset	9	772	758	798	778	0%	1	61
Hereford & Worcester	14	784	515	998	756	0%	1	62
Cornwall	6	566	924	552	738	0%	1	63
Wiltshire	41	498	266	882	574	0%	1	64
Gloucestershire	12	856	449	468	458	0%	1	65

Sector	Sector ID	Sector Population (000's)	Benefits by Origin (£000s)	Benefits by Destination (£000s)	Average Benefits (£000's)	Average user benefits % of total	Average User Benefit Per Head (£)	Rank
Avon	1	1,152	440	320	380	0%	0	66
Berkshire	3	911	802	-67	368	0%	0	67

Plate A.15 Average TEE benefits by TUBA sector (£000, 2010 prices and values)

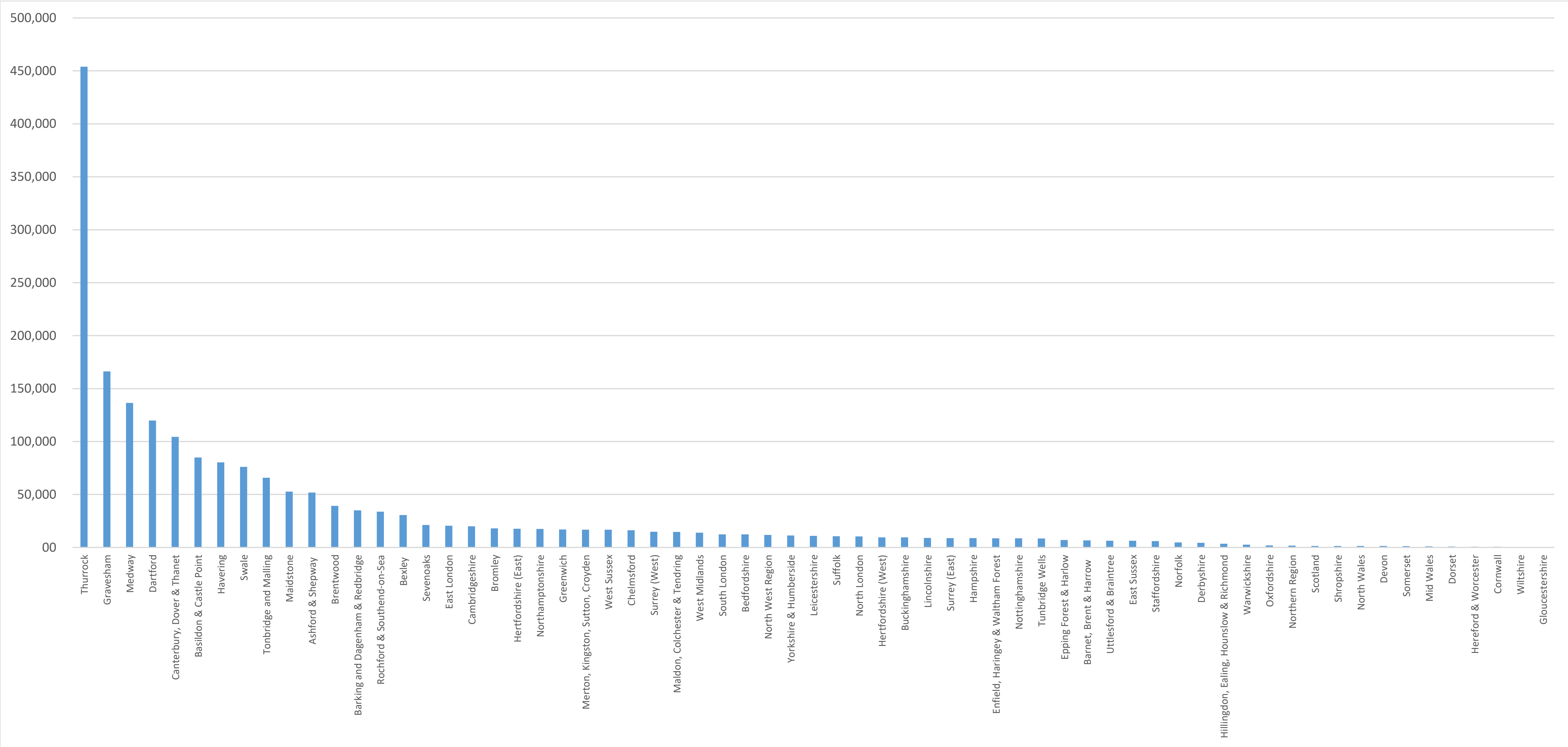


Plate A.16 Average TEE benefits by TUBA sector (Great Britain) (£, 2010 prices and values)

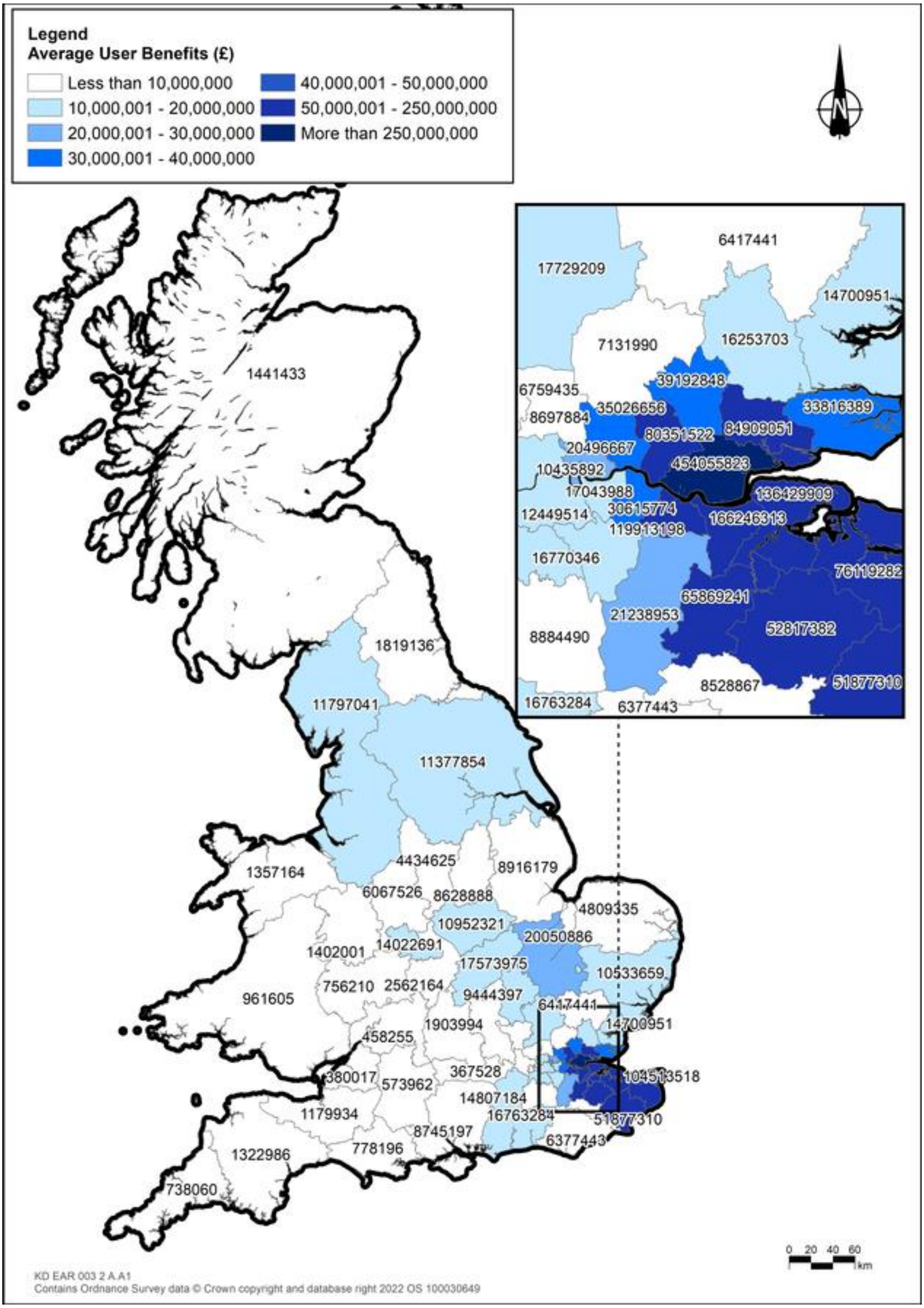


Plate A.17 Average TEE benefits by TUBA sectors close to the Project (£, 2010 prices and values)

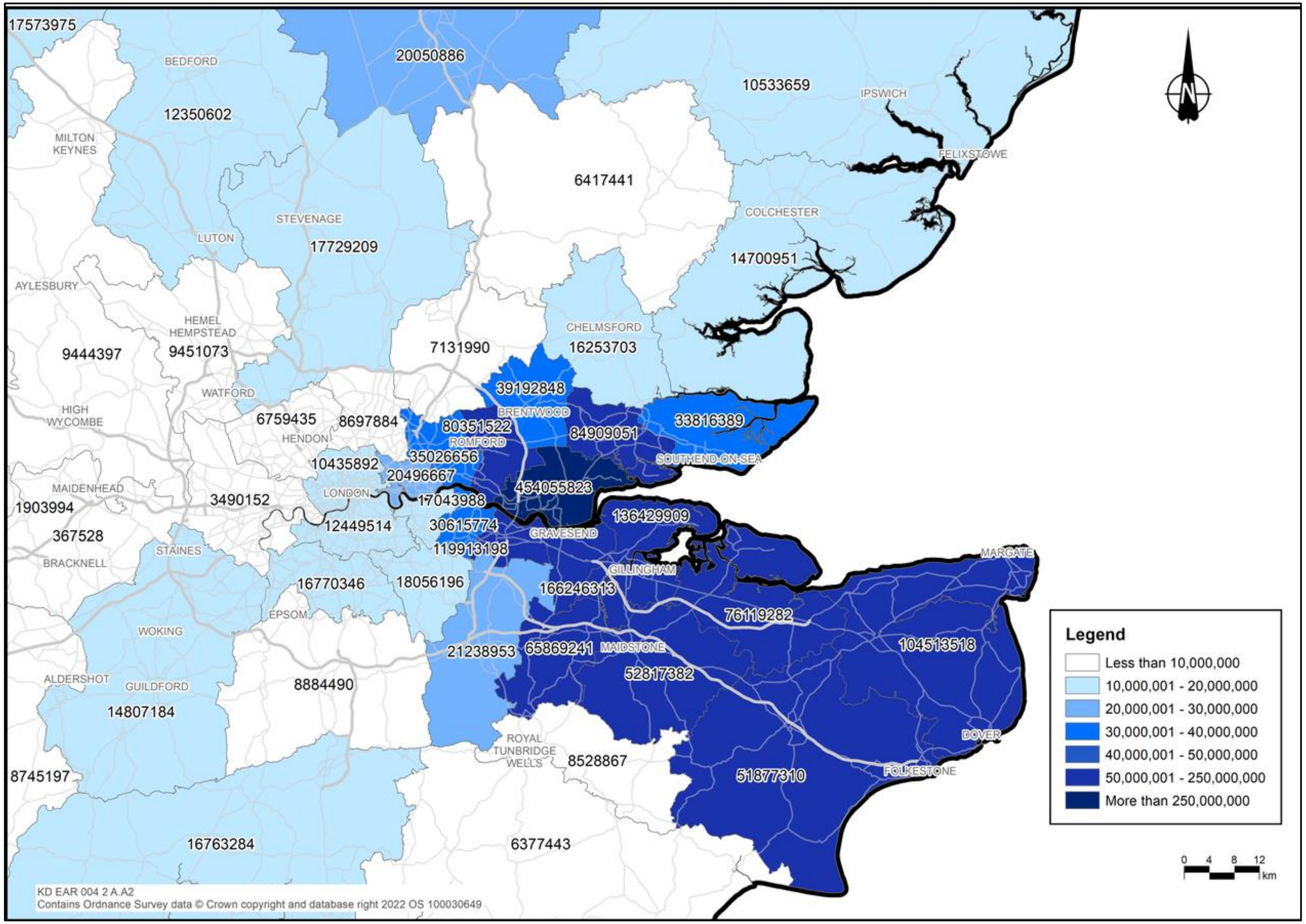
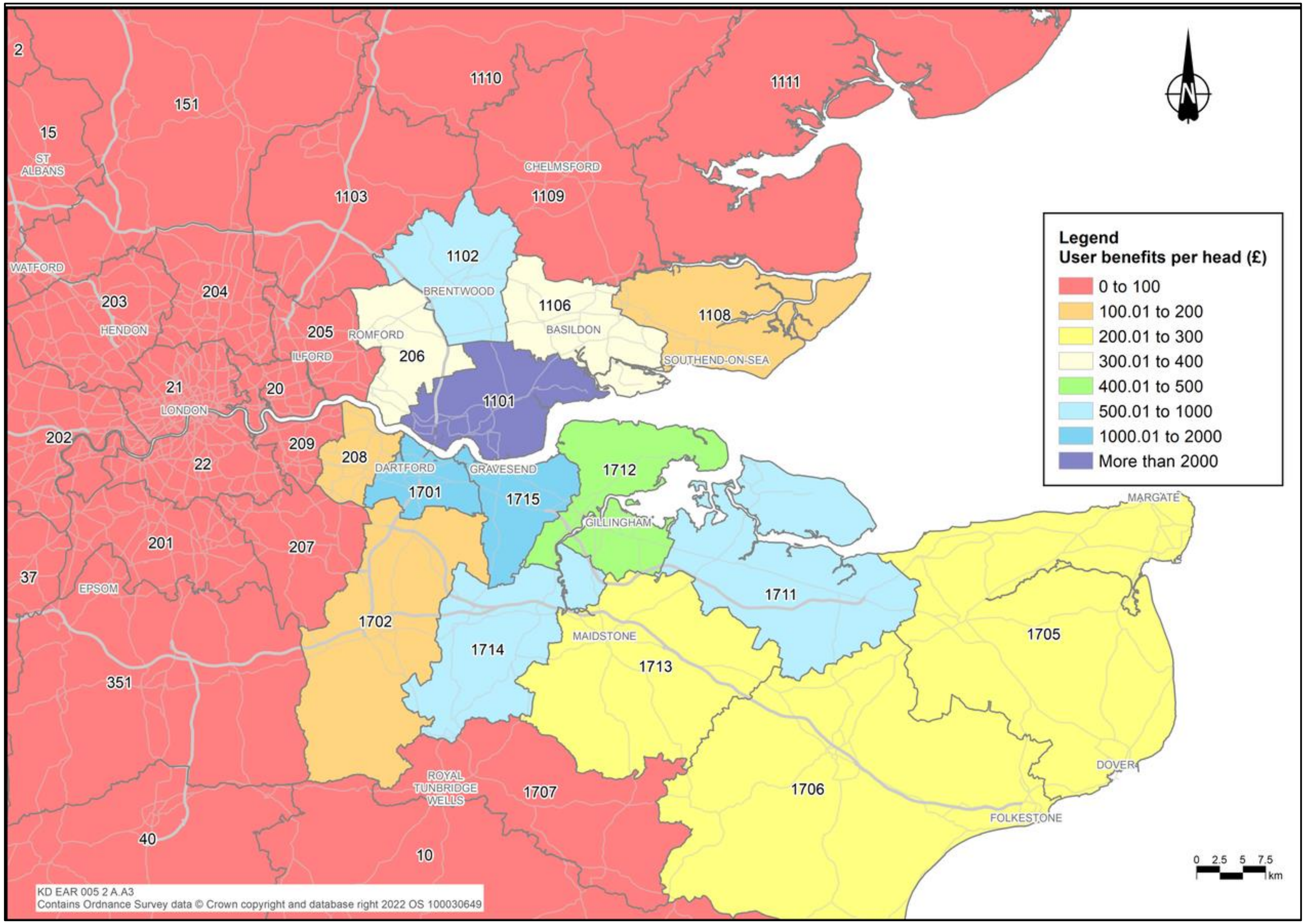


Plate A.18 Average TEE benefits per head by TUBA sectors close to the Project (£, 2010 prices and values)



A.11 Impact of the TUBA mask

A.11.1 Table A.35 shows the difference in TUBA results for the 60-year operational appraisal without the TUBA mask and with the TUBA mask. It shows that the mask has a small impact on TEE benefits, operator revenue and indirect tax revenue. The results exclude the impacts of construction and maintenance delays.

Table A.35 Impact of the TUBA mask (£, 2010 prices and values)

	Total User Benefits	Operator Revenue	Indirect Taxes
Masked benefits	1,971,946,698	748,516,428	37,143,945
Unmasked benefits	1,978,128,203	747,369,610	33,666,430
Difference	**-6,181,505**	**1,146,818**	**3,477,515**

A.11.2 Table A.36 provides a spatial disaggregation of the unmasked and masked user benefits.

Table A.36 Unmasked and masked user benefits (£, 2010 prices and values)

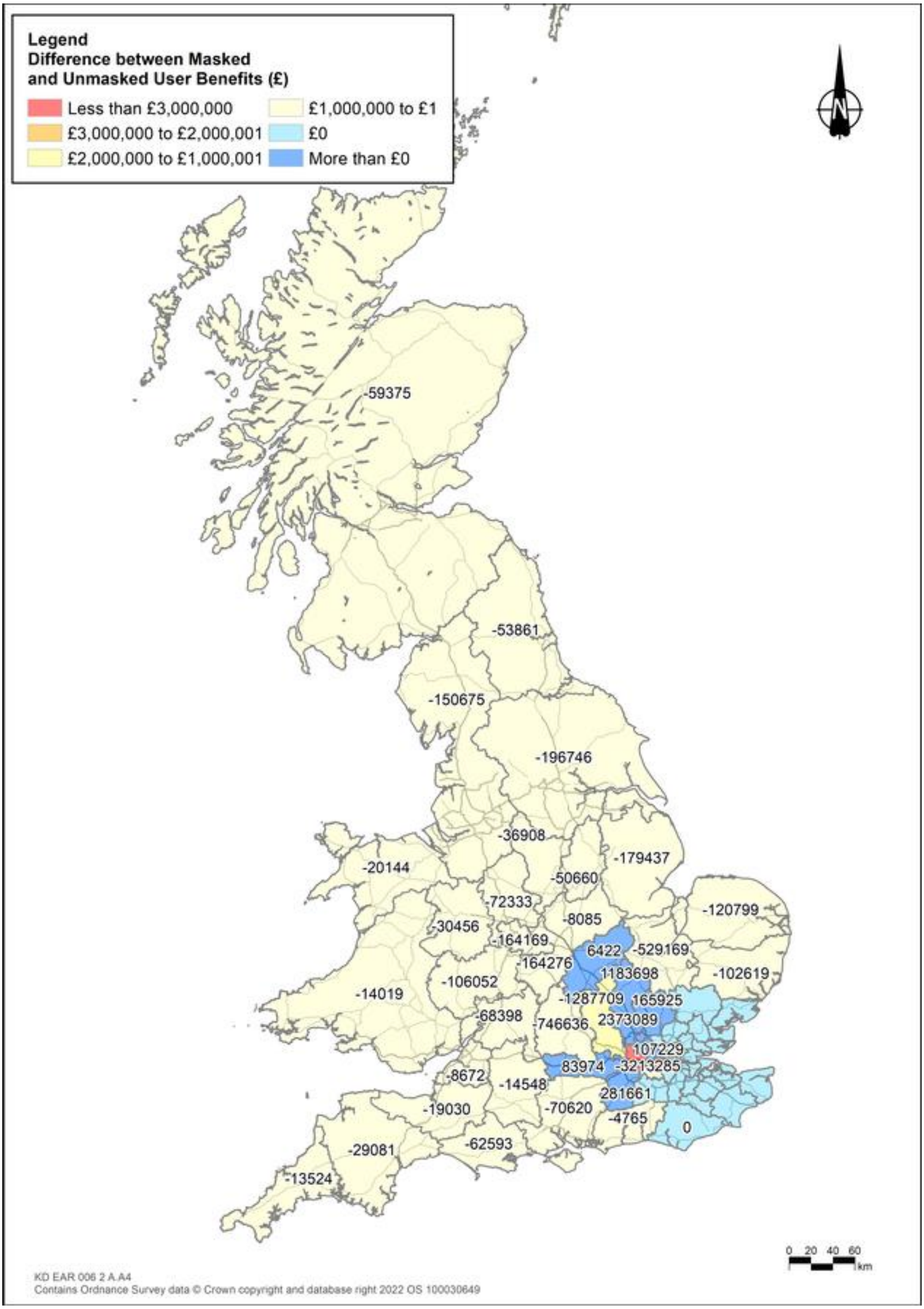
Sector Name	Average User Benefits		
	Unmasked	Masked	Difference
Thurrock	454,055,823	454,055,823	0
Gravesham	166,246,313	166,246,313	0
Medway	136,429,909	136,429,909	0
Dartford	119,913,198	119,913,198	0
Cantebury, Dover & Thanet	104,513,518	104,513,518	0
Basildon & Castle Point	84,909,051	84,909,051	0
Havering	80,351,522	80,351,522	0
Swale	76,119,282	76,119,282	0
Tonbridge and Malling	65,869,241	65,869,241	0
Maidstone	52,817,382	52,817,382	0
Ashford & Shepway	51,877,310	51,877,310	0
Brentwood	39,192,848	39,192,848	0
Barking and Dagenham & Redbridge	35,026,656	35,026,656	0
Rochford & Southend-on-Sea	33,816,389	33,816,389	0
Bexley	30,615,774	30,615,774	0
Sevenoaks	21,238,953	21,238,953	0
Cambridgeshire	20,580,055	20,050,886	-529,169

Sector Name	Average User Benefits		
	Unmasked	Masked	Difference
East London	20,496,667	20,496,667	0
Bromley	18,056,196	18,056,196	0
Northamptonshire	17,567,553	17,573,975	6,422
Hertfordshire (East)	17,563,284	17,729,209	165,925
Merton, Kingston, Sutton, Croydon	17,493,767	16,770,346	-723,422
Greenwich	17,043,988	17,043,988	0
West Sussex	16,768,049	16,763,284	-4,765
Chelmsford	16,253,703	16,253,703	0
South London	15,662,799	12,449,514	-3,213,285
Maldon, Colchester & Tendring	14,700,951	14,700,951	0
Surrey (West)	14,525,523	14,807,184	281,661
West Midlands	14,186,860	14,022,691	-164,169
North West Region	11,947,716	11,797,041	-150,675
Yorkshire & Humberside	11,574,600	11,377,854	-196,746
Bedfordshire	11,166,904	12,350,602	1,183,699
Leicestershire	10,960,406	10,952,321	-8,085
Buckinghamshire	10,732,106	9,444,397	-1,287,709
Suffolk	10,636,278	10,533,659	-102,619
North London	10,328,663	10,435,892	107,229
Lincolnshire	9,095,616	8,916,179	-179,437
Surrey (East)	8,884,490	8,884,490	0
Hampshire	8,815,817	8,745,197	-70,620
Enfield, Haringey & Waltham Forest	8,697,884	8,697,884	0
Nottinghamshire	8,679,548	8,628,888	-50,661
Tunbridge Wells	8,528,867	8,528,867	0
Epping Forest & Harlow	7,131,990	7,131,990	0
Hertfordshire (West)	7,077,984	9,451,073	2,373,089
Hillingdon, Ealing, Hounslow & Richmond	6,835,940	3,490,152	-3,345,788
Uttlesford & Braintree	6,417,441	6,417,441	0
East Sussex	6,377,443	6,377,443	0
Staffordshire	6,139,859	6,067,526	-72,333
Barnet, Brent & Harrow	5,475,086	6,759,435	1,284,349
Norfolk	4,930,134	4,809,335	-120,799
Derbyshire	4,471,533	4,434,625	-36,908

Sector Name	Average User Benefits		
	Unmasked	**Masked**	**Difference**
Warwickshire	2,726,440	2,562,164	-164,276
Oxfordshire	2,650,630	1,903,994	-746,635
Northern Region	1,872,997	1,819,136	-53,861
Scotland	1,500,808	1,441,433	-59,376
Shropshire	1,432,457	1,402,001	-30,456
North Wales	1,377,308	1,357,164	-20,144
Devon	1,352,067	1,322,986	-29,081
Somerset	1,198,964	1,179,934	-19,029
Mid Wales	975,624	961,605	-14,018
Hereford & Worcester	862,262	756,210	-106,052
Dorset	840,789	778,196	-62,593
Cornwall	751,584	738,060	-13,524
Wiltshire	588,510	573,962	-14,548
Gloucestershire	526,653	458,255	-68,398
Avon	388,689	380,017	-8,672
Berkshire	283,554	367,528	83,973
Total	**1,978,128,203**	**1,971,946,698**	**-6,181,505**

A.11.3 Plate A.19 shows the spatial difference between unmasked and masked user benefits.

Plate A.19 Difference between masked and unmasked user benefits (£, 2010 prices and values)



A.12 TUBA Economic Parameters File output

A.12.1 The TUBA Economic parameters file v1.9.18 based on TAG data book v1.18 is shown below.

```
************************************************************************************************************************************************

Economics v1.9.18.0 file details (TAG Data Book v1.18 May 2022)

* Source: https://www.gov.uk/government/publications/tag-data-book

TUBA ECONOMIC PARAMETERS FILE (26/05/2022) consistent with TAG Db v1.18 for the TUBA Version 1.9.17 Software Release

************************************************************************************************************************************************

PARAMETERS
TUBA_version     1.9.17          the current version of TUBA
base_year        2010            defines base year for economic parameters
pres_val_year    2010            present value year for discounting
GDP_base         100.00          value of GDP in base year

** Source: TAG Data Book - Table A 1.3.1
av_ind_tax       19.0            %average final indirect tax rate

** TAG reference: TAG Data Book, Table A 3.4 (for non-traded), hidden worksheet 'GHG' (for traded)
nt_carbdxvalues   83.64 250.92 167.28  base year non-traded carbon dioxide values in £/tonne(low high central)
t_carbdxvalues    83.64 250.92 167.28  base year traded carbon dioxide values in £/tonne(low high central)

************************************************************************************************************************************************


MODES
*No.     Description
  1      Road
  2      Bus
  3      Rail

VEHICLE_TYPE/SUBMODE
*No.     Mode  New_mode  P&R   Type  Description
  1       1      N        N    per   Car
  2       1      N        N    per   LGV Personal
  3       1      N        N    fre   LGV Freight
  4       1      N        N    fre   OGV1
  5       1      N        N    fre   OGV2
  6       2      N        N    per   Bus
  7       3      N        N    per   Light Rail
  8       3      N        N    per   Heavy Rail

PERSON_TYPE
*No.    Type(D/P)   Description
  1       D         Driver
  2       P         Passenger

PURPOSE
*No.    Type(B/C/O) Description
  1       B         Business
  2       C         C_L
  3       C         C_M
```

```
  4       C         C_H
  5       O         O_L
  6       O         O_M
  7       O         O_H

FUEL_TYPE
*No.    Sector    Name     (sector: 1=untraded, sector 2=traded sector)
  1          1    Petrol
  2          1    Diesel
  3          2    Electric

TIME_PERIODS
*No.    Description      Comments
 1      AM              (7-9 weekdays)
 2      PM              (16-18 weekdays)
 3      IP               (9-15 weekdays)
 4      OPCWD            (19-22 weekdays)
 5      OPNCWD          (22-6 weekdays)
 6      AMShoulder      (6-7 weekdays)
 7      PMShoulder      (15-16, 18-19 weekdays)
 8      PKWE            (9-19 weekends)
 9      OPCWE           (6-9, 19,22 weekends)
 10     OPNCWE          (22-6 weekends)

BREAKPOINTS
*Description  Breakpoint1    Breakpoint2    Breakpoint3...
Distance              1.0            5.0           10.0           25.0           50.0         100.0          200.0
TimeSaving           -5.0           -2.0            0.0            2.0            5.0

CHARGES
*No.    Sector           Description
  1     pri              PT fares (private operators)
  2     loc              PT fares (LA operated)
  3     loc              LA tolls
  4     cen              National tolls
  5     pri              Private tolls
  6     loc              LA on-street parking
  7     loc              LA off-street parking
  8     pri              Private parking

DISCOUNT_RATE
** Source: TAG Data Book - Table A 1.1.1
** %change p.a.
*Start_yr     End_yr     Rate
   1             30      3.50
  31             75      3.00
  76            150      2.50

VALUE_OF_TIME_ALLOCATION
** Source: TAG Data Book - Table A 1.3.1
** Default VOT Method to be used: Method 1 for Car & Rail (Business) and Method 3 for All Other Modes-Purpose combinations
*Vtype/submode  Person_type  Purpose_type  VOT_Method
   1            1            1             1
```

```
   1         2         1         1
   8         2         1         1

VALUE_OF_TIME_METHOD1
** Source: TAG Data Book - Table A 1.3.1
** pence per hour (in 2010 base year values and prices)
*Vtype/submode Person_type Purpose_type U   Xmid        k
       1       1       1    2480.37    66.53     67.02
       1       1       2       0.00     0.00      0.00
       1       1       3       0.00     0.00      0.00
       1       2       1    2480.37    66.53     67.02
       1       2       2       0.00     0.00      0.00
       1       2       3       0.00     0.00      0.00
       2       1       1       0.00     0.00      0.00
       2       1       2       0.00     0.00      0.00
       2       1       3       0.00     0.00      0.00
       2       2       1       0.00     0.00      0.00
       2       2       2       0.00     0.00      0.00
       2       2       3       0.00     0.00      0.00
       3       1       1       0.00     0.00      0.00
       3       1       2       0.00     0.00      0.00
       3       1       3       0.00     0.00      0.00
       3       2       1       0.00     0.00      0.00
       3       2       2       0.00     0.00      0.00
       3       2       3       0.00     0.00      0.00
       4       1       1       0.00     0.00      0.00
       4       1       2       0.00     0.00      0.00
       4       1       3       0.00     0.00      0.00
       4       2       1       0.00     0.00      0.00
       4       2       2       0.00     0.00      0.00
       4       2       3       0.00     0.00      0.00
       5       1       1       0.00     0.00      0.00
       5       1       2       0.00     0.00      0.00
       5       1       3       0.00     0.00      0.00
       5       2       1       0.00     0.00      0.00
       5       2       2       0.00     0.00      0.00
       5       2       3       0.00     0.00      0.00
       6       1       1       0.00     0.00      0.00
       6       1       2       0.00     0.00      0.00
       6       1       3       0.00     0.00      0.00
       6       2       1       0.00     0.00      0.00
       6       2       2       0.00     0.00      0.00
       6       2       3       0.00     0.00      0.00
       7       1       1       0.00     0.00      0.00
       7       1       2       0.00     0.00      0.00
       7       1       3       0.00     0.00      0.00
       7       2       1       0.00     0.00      0.00
       7       2       2       0.00     0.00      0.00
       7       2       3       0.00     0.00      0.00
       8       1       1       0.00     0.00      0.00
       8       1       2       0.00     0.00      0.00
       8       1       3       0.00     0.00      0.00
       8       2       1    3646.86   107.04     63.95
```

```
       8       2       2         0.00       0.00       0.00
       8       2       3         0.00       0.00       0.00

VALUE_OF_TIME_METHOD2
** Source: TAG Data Book - Table A 1.3.1
** pence per hour (in 2010 base year values and prices)
** Distance Band 1 (D1) = 0-50 km, Distance Band 2 (D2) = 50-100km, Distance Band 3 (D3) = 100-200km, Distance Band 4 (D4) = +200km
*Vtype/submode Person_type Purpose D1          D2          D3          D4
       1       1       1       842.34    1361.82    1848.85    2376.83
       1       1       2         0.00       0.00       0.00       0.00
       1       1       3         0.00       0.00       0.00       0.00
       1       2       1       842.34    1361.82    1848.85    2376.83
       1       2       2         0.00       0.00       0.00       0.00
       1       2       3         0.00       0.00       0.00       0.00
       2       1       1         0.00       0.00       0.00       0.00
       2       1       2         0.00       0.00       0.00       0.00
       2       1       3         0.00       0.00       0.00       0.00
       2       2       1         0.00       0.00       0.00       0.00
       2       2       2         0.00       0.00       0.00       0.00
       2       2       3         0.00       0.00       0.00       0.00
       3       1       1         0.00       0.00       0.00       0.00
       3       1       2         0.00       0.00       0.00       0.00
       3       1       3         0.00       0.00       0.00       0.00
       3       2       1         0.00       0.00       0.00       0.00
       3       2       2         0.00       0.00       0.00       0.00
       3       2       3         0.00       0.00       0.00       0.00
       4       1       1         0.00       0.00       0.00       0.00
       4       1       2         0.00       0.00       0.00       0.00
       4       1       3         0.00       0.00       0.00       0.00
       4       2       1         0.00       0.00       0.00       0.00
       4       2       2         0.00       0.00       0.00       0.00
       4       2       3         0.00       0.00       0.00       0.00
       5       1       1         0.00       0.00       0.00       0.00
       5       1       2         0.00       0.00       0.00       0.00
       5       1       3         0.00       0.00       0.00       0.00
       5       2       1         0.00       0.00       0.00       0.00
       5       2       2         0.00       0.00       0.00       0.00
       5       2       3         0.00       0.00       0.00       0.00
       6       1       1         0.00       0.00       0.00       0.00
       6       1       2         0.00       0.00       0.00       0.00
       6       1       3         0.00       0.00       0.00       0.00
       6       2       1         0.00       0.00       0.00       0.00
       6       2       2         0.00       0.00       0.00       0.00
       6       2       3         0.00       0.00       0.00       0.00
       7       1       1         0.00       0.00       0.00       0.00
       7       1       2         0.00       0.00       0.00       0.00
       7       1       3         0.00       0.00       0.00       0.00
       7       2       1         0.00       0.00       0.00       0.00
       7       2       2         0.00       0.00       0.00       0.00
       7       2       3         0.00       0.00       0.00       0.00
       8       1       1         0.00       0.00       0.00       0.00
       8       1       2         0.00       0.00       0.00       0.00
       8       1       3         0.00       0.00       0.00       0.00
```

```
      8       2       1       842.34    1361.82    2371.85    3421.63
      8       2       2         0.00       0.00       0.00       0.00
      8       2       3         0.00       0.00       0.00       0.00

VALUE_OF_TIME_METHOD3
** Source TAG Data Book - Table A 1.3.1
** pence per hour (in 2010 base year values and prices)
*Vtype/submode Person_type purpose_type VOT
        1       1       1      1486.44
        1       1       2       458.00
        1       1       3       770.00
        1       1       4      1342.00
        1       1       5       248.00
        1       1       6       426.00
        1       1       7       679.00
        1       2       1      1486.44
        1       2       2       458.00
        1       2       3       770.00
        1       2       4      1342.00
        1       2       5       248.00
        1       2       6       426.00
        1       2       7       679.00
        2       1       1         0.00
        2       1       2         0.00
        2       1       3         0.00
        2       1       4         0.00
        2       1       5         0.00
        2       1       6       454.28
        2       1       7         0.00
        2       2       1         0.00
        2       2       2         0.00
        2       2       3         0.00
        2       2       4         0.00
        2       2       5         0.00
        2       2       6       454.28
        2       2       7         0.00
        3       1       1      1023.53
        3       1       2         0.00
        3       1       3         0.00
        3       1       4         0.00
        3       1       5         0.00
        3       1       6         0.00
        3       1       7         0.00
        3       2       1      1023.53
        3       2       2         0.00
        3       2       3         0.00
        3       2       4         0.00
        3       2       5         0.00
        3       2       6         0.00
        3       2       7         0.00
        4       1       1      1205.96
        4       1       2         0.00
        4       1       3         0.00
```

4	1	4	0.00
4	1	5	0.00
4	1	6	0.00
4	1	7	0.00
4	2	1	1205.96
4	2	2	0.00
4	2	3	0.00
4	2	4	0.00
4	2	5	0.00
4	2	6	0.00
4	2	7	0.00
5	1	1	1205.96
5	1	2	0.00
5	1	3	0.00
5	1	4	0.00
5	1	5	0.00
5	1	6	0.00
5	1	7	0.00
5	2	1	1205.96
5	2	2	0.00
5	2	3	0.00
5	2	4	0.00
5	2	5	0.00
5	2	6	0.00
5	2	7	0.00
6	1	1	1232.02
6	1	2	0.00
6	1	3	0.00
6	1	4	0.00
6	1	5	0.00
6	1	6	0.00
6	1	7	0.00
6	2	1	842.34
6	2	2	995.30
6	2	3	995.30
6	2	4	995.30
6	2	5	454.28
6	2	6	454.28
6	2	7	454.28
7	1	1	0.00
7	1	2	0.00
7	1	3	0.00
7	1	4	0.00
7	1	5	0.00
7	1	6	0.00
7	1	7	0.00
7	2	1	842.34
7	2	2	995.30
7	2	3	995.30
7	2	4	995.30
7	2	5	454.28
7	2	6	454.28
7	2	7	454.28

```
        8       1       1         0.00
        8       1       2         0.00
        8       1       3         0.00
        8       1       4         0.00
        8       1       5         0.00
        8       1       6         0.00
        8       1       7         0.00
        8       2       1      2451.90
        8       2       2       995.30
        8       2       3       995.30
        8       2       4       995.30
        8       2       5       454.28
        8       2       6       454.28
        8       2       7       454.28

GDP_PER_CAPITA_GROWTH
** Source: TAG Data Book - Table A 1.3.2
** %change per annum from 2010 base year
*Start_yr    End_yr    VOT_Gr_purpose1  VOT_Gr_purpose2  VOT_Gr_purpose3   VOT_Gr_purpose4   VOT_Gr_purpose5   VOT_Gr_purpose6   VOT_Gr_purpose7
2011            2011            0.615            0.615            0.615            0.615            0.615            0.615            0.615
2012            2012            0.801            0.801            0.801            0.801            0.801            0.801            0.801
2013            2013            1.253            1.253            1.253            1.253            1.253            1.253            1.253
2014            2014            2.208            2.208            2.208            2.208            2.208            2.208            2.208
2015            2015            1.814            1.814            1.814            1.814            1.814            1.814            1.814
2016            2016            1.425            1.425            1.425            1.425            1.425            1.425            1.425
2017            2017            1.528            1.528            1.528            1.528            1.528            1.528            1.528
2018            2018            1.046            1.046            1.046            1.046            1.046            1.046            1.046
2019            2019            1.122            1.122            1.122            1.122            1.122            1.122            1.122
2020            2020            0.113            0.113            0.113            0.113            0.113            0.113            0.113
2021            2021            0.114            0.114            0.114            0.114            0.114            0.114            0.114
2022            2022            0.113            0.113            0.113            0.113            0.113            0.113            0.113
2023            2023            1.509            1.509            1.509            1.509            1.509            1.509            1.509
2024            2024            1.895            1.895            1.895            1.895            1.895            1.895            1.895
2025            2025            1.577            1.577            1.577            1.577            1.577            1.577            1.577
2026            2026            1.469            1.469            1.469            1.469            1.469            1.469            1.469
2027            2027            1.480            1.480            1.480            1.480            1.480            1.480            1.480
2028            2028            1.480            1.480            1.480            1.480            1.480            1.480            1.480
2029            2029            1.463            1.463            1.463            1.463            1.463            1.463            1.463
2030            2030            1.439            1.439            1.439            1.439            1.439            1.439            1.439
2031            2031            1.413            1.413            1.413            1.413            1.413            1.413            1.413
2032            2032            1.390            1.390            1.390            1.390            1.390            1.390            1.390
2033            2033            1.387            1.387            1.387            1.387            1.387            1.387            1.387
2034            2034            1.371            1.371            1.371            1.371            1.371            1.371            1.371
2035            2035            1.345            1.345            1.345            1.345            1.345            1.345            1.345
2036            2036            1.477            1.477            1.477            1.477            1.477            1.477            1.477
2037            2037            1.476            1.476            1.476            1.476            1.476            1.476            1.476
2038            2038            1.467            1.467            1.467            1.467            1.467            1.467            1.467
2039            2039            1.443            1.443            1.443            1.443            1.443            1.443            1.443
2040            2040            1.416            1.416            1.416            1.416            1.416            1.416            1.416
2041            2041            1.398            1.398            1.398            1.398            1.398            1.398            1.398
2042            2042            1.375            1.375            1.375            1.375            1.375            1.375            1.375
2043            2043            1.351            1.351            1.351            1.351            1.351            1.351            1.351
2044            2044            1.332            1.332            1.332            1.332            1.332            1.332            1.332
```

2045	2045	1.320	1.320	1.320	1.320	1.320	1.320	1.320
2046	2046	1.310	1.310	1.310	1.310	1.310	1.310	1.310
2047	2047	1.291	1.291	1.291	1.291	1.291	1.291	1.291
2048	2048	1.282	1.282	1.282	1.282	1.282	1.282	1.282
2049	2049	1.282	1.282	1.282	1.282	1.282	1.282	1.282
2050	2050	1.291	1.291	1.291	1.291	1.291	1.291	1.291
2051	2051	1.307	1.307	1.307	1.307	1.307	1.307	1.307
2052	2052	1.320	1.320	1.320	1.320	1.320	1.320	1.320
2053	2053	1.332	1.332	1.332	1.332	1.332	1.332	1.332
2054	2054	1.338	1.338	1.338	1.338	1.338	1.338	1.338
2055	2055	1.358	1.358	1.358	1.358	1.358	1.358	1.358
2056	2056	1.370	1.370	1.370	1.370	1.370	1.370	1.370
2057	2057	1.385	1.385	1.385	1.385	1.385	1.385	1.385
2058	2058	1.398	1.398	1.398	1.398	1.398	1.398	1.398
2059	2059	1.406	1.406	1.406	1.406	1.406	1.406	1.406
2060	2060	1.417	1.417	1.417	1.417	1.417	1.417	1.417
2061	2061	1.437	1.437	1.437	1.437	1.437	1.437	1.437
2062	2062	1.444	1.444	1.444	1.444	1.444	1.444	1.444
2063	2063	1.456	1.456	1.456	1.456	1.456	1.456	1.456
2064	2064	1.466	1.466	1.466	1.466	1.466	1.466	1.466
2065	2065	1.482	1.482	1.482	1.482	1.482	1.482	1.482
2066	2066	1.540	1.540	1.540	1.540	1.540	1.540	1.540
2067	2067	1.607	1.607	1.607	1.607	1.607	1.607	1.607
2068	2068	1.531	1.531	1.531	1.531	1.531	1.531	1.531
2069	2069	1.521	1.521	1.521	1.521	1.521	1.521	1.521
2070	2070	1.493	1.493	1.493	1.493	1.493	1.493	1.493
2071	2071	1.518	1.518	1.518	1.518	1.518	1.518	1.518
2072	2072	1.463	1.463	1.463	1.463	1.463	1.463	1.463
2073	2073	1.426	1.426	1.426	1.426	1.426	1.426	1.426
2074	2074	1.355	1.355	1.355	1.355	1.355	1.355	1.355
2075	2075	1.317	1.317	1.317	1.317	1.317	1.317	1.317
2076	2076	1.256	1.256	1.256	1.256	1.256	1.256	1.256
2077	2077	1.271	1.271	1.271	1.271	1.271	1.271	1.271
2078	2078	1.253	1.253	1.253	1.253	1.253	1.253	1.253
2079	2079	1.219	1.219	1.219	1.219	1.219	1.219	1.219
2080	2080	1.193	1.193	1.193	1.193	1.193	1.193	1.193
2081	2081	1.251	1.251	1.251	1.251	1.251	1.251	1.251
2082	2082	1.293	1.293	1.293	1.293	1.293	1.293	1.293
2083	2083	1.309	1.309	1.309	1.309	1.309	1.309	1.309
2084	2084	1.309	1.309	1.309	1.309	1.309	1.309	1.309
2085	2085	1.364	1.364	1.364	1.364	1.364	1.364	1.364
2086	2086	1.422	1.422	1.422	1.422	1.422	1.422	1.422
2087	2087	1.489	1.489	1.489	1.489	1.489	1.489	1.489
2088	2088	1.487	1.487	1.487	1.487	1.487	1.487	1.487
2089	2089	1.498	1.498	1.498	1.498	1.498	1.498	1.498
2090	2090	1.508	1.508	1.508	1.508	1.508	1.508	1.508
2091	2091	1.513	1.513	1.513	1.513	1.513	1.513	1.513
2092	2092	1.511	1.511	1.511	1.511	1.511	1.511	1.511
2093	2093	1.508	1.508	1.508	1.508	1.508	1.508	1.508
2094	2094	1.505	1.505	1.505	1.505	1.505	1.505	1.505
2095	2095	1.501	1.501	1.501	1.501	1.501	1.501	1.501
2096	2096	1.497	1.497	1.497	1.497	1.497	1.497	1.497
2097	2097	1.491	1.491	1.491	1.491	1.491	1.491	1.491

2098	2098	1.484	1.484	1.484	1.484	1.484	1.484	1.484
2099	2099	1.476	1.476	1.476	1.476	1.476	1.476	1.476
2100	2100	1.467	1.467	1.467	1.467	1.467	1.467	1.467
2101	2101	1.467	1.467	1.467	1.467	1.467	1.467	1.467
2102	2102	1.467	1.467	1.467	1.467	1.467	1.467	1.467
2103	2103	1.467	1.467	1.467	1.467	1.467	1.467	1.467
2104	2104	1.467	1.467	1.467	1.467	1.467	1.467	1.467
2105	2105	1.467	1.467	1.467	1.467	1.467	1.467	1.467
2106	2106	1.467	1.467	1.467	1.467	1.467	1.467	1.467
2107	2107	1.467	1.467	1.467	1.467	1.467	1.467	1.467
2108	2108	1.467	1.467	1.467	1.467	1.467	1.467	1.467
2109	2109	1.467	1.467	1.467	1.467	1.467	1.467	1.467
2110	2110	1.467	1.467	1.467	1.467	1.467	1.467	1.467
2111	2111	1.467	1.467	1.467	1.467	1.467	1.467	1.467
2112	2112	1.467	1.467	1.467	1.467	1.467	1.467	1.467
2113	2113	1.467	1.467	1.467	1.467	1.467	1.467	1.467
2114	2114	1.467	1.467	1.467	1.467	1.467	1.467	1.467
2115	2115	1.467	1.467	1.467	1.467	1.467	1.467	1.467
2116	2116	1.467	1.467	1.467	1.467	1.467	1.467	1.467
2117	2117	1.467	1.467	1.467	1.467	1.467	1.467	1.467
2118	2118	1.467	1.467	1.467	1.467	1.467	1.467	1.467
2119	2119	1.467	1.467	1.467	1.467	1.467	1.467	1.467
2120	2120	1.467	1.467	1.467	1.467	1.467	1.467	1.467
2121	2121	1.467	1.467	1.467	1.467	1.467	1.467	1.467
2122	2122	1.467	1.467	1.467	1.467	1.467	1.467	1.467
2123	2123	1.467	1.467	1.467	1.467	1.467	1.467	1.467
2124	2124	1.467	1.467	1.467	1.467	1.467	1.467	1.467
2125	2125	1.467	1.467	1.467	1.467	1.467	1.467	1.467
2126	2126	1.467	1.467	1.467	1.467	1.467	1.467	1.467
2127	2127	1.467	1.467	1.467	1.467	1.467	1.467	1.467
2128	2128	1.467	1.467	1.467	1.467	1.467	1.467	1.467
2129	2129	1.467	1.467	1.467	1.467	1.467	1.467	1.467
2130	2130	1.467	1.467	1.467	1.467	1.467	1.467	1.467
2131	2131	1.467	1.467	1.467	1.467	1.467	1.467	1.467
2132	2132	1.467	1.467	1.467	1.467	1.467	1.467	1.467
2133	2133	1.467	1.467	1.467	1.467	1.467	1.467	1.467
2134	2134	1.467	1.467	1.467	1.467	1.467	1.467	1.467
2135	2135	1.467	1.467	1.467	1.467	1.467	1.467	1.467
2136	2136	1.467	1.467	1.467	1.467	1.467	1.467	1.467
2137	2137	1.467	1.467	1.467	1.467	1.467	1.467	1.467
2138	2138	1.467	1.467	1.467	1.467	1.467	1.467	1.467
2139	2139	1.467	1.467	1.467	1.467	1.467	1.467	1.467
2140	2140	1.467	1.467	1.467	1.467	1.467	1.467	1.467
2141	2141	1.467	1.467	1.467	1.467	1.467	1.467	1.467
2142	2142	1.467	1.467	1.467	1.467	1.467	1.467	1.467
2143	2143	1.467	1.467	1.467	1.467	1.467	1.467	1.467
2144	2144	1.467	1.467	1.467	1.467	1.467	1.467	1.467
2145	2145	1.467	1.467	1.467	1.467	1.467	1.467	1.467
2146	2146	1.467	1.467	1.467	1.467	1.467	1.467	1.467
2147	2147	1.467	1.467	1.467	1.467	1.467	1.467	1.467
2148	2148	1.467	1.467	1.467	1.467	1.467	1.467	1.467
2149	2149	1.467	1.467	1.467	1.467	1.467	1.467	1.467
2150	2150	1.467	1.467	1.467	1.467	1.467	1.467	1.467

2151	2151	1.467	1.467	1.467	1.467	1.467	1.467	1.467

VALUE_OF_TIME_BENEFIT_GROWTH
** Source: TAG Data Book - Annual Parameters (Important Notice) & Table A 1.3.2
** %change per annum from 2010 base year, only applied after scheme current year

*Start_yr	End_yr	VOT_Gr_purpose1	VOT_Gr_purpose2	VOT_Gr_purpose3	VOT_Gr_purpose4	VOT_Gr_purpose5	VOT_Gr_purpose6	VOT_Gr_purpose7
2011	2011	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2012	2012	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2013	2013	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2014	2014	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2015	2015	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2016	2016	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2017	2017	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2018	2018	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2019	2019	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2020	2020	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2021	2021	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2022	2022	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2023	2023	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2024	2024	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2025	2025	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2026	2026	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2027	2027	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2028	2028	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2029	2029	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2030	2030	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2031	2031	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2032	2032	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2033	2033	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2034	2034	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2035	2035	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2036	2036	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2037	2037	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2038	2038	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2039	2039	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2040	2040	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2041	2041	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2042	2042	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2043	2043	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2044	2044	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2045	2045	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2046	2046	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2047	2047	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2048	2048	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2049	2049	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2050	2050	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2051	2051	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2052	2052	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2053	2053	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2054	2054	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2055	2055	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2056	2056	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2057	2057	1.500	1.500	1.500	1.500	1.500	1.500	1.500

2058	2058	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2059	2059	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2060	2060	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2061	2061	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2062	2062	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2063	2063	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2064	2064	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2065	2065	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2066	2066	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2067	2067	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2068	2068	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2069	2069	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2070	2070	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2071	2071	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2072	2072	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2073	2073	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2074	2074	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2075	2075	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2076	2076	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2077	2077	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2078	2078	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2079	2079	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2080	2080	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2081	2081	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2082	2082	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2083	2083	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2084	2084	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2085	2085	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2086	2086	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2087	2087	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2088	2088	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2089	2089	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2090	2090	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2091	2091	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2092	2092	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2093	2093	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2094	2094	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2095	2095	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2096	2096	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2097	2097	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2098	2098	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2099	2099	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2100	2100	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2101	2101	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2102	2102	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2103	2103	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2104	2104	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2105	2105	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2106	2106	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2107	2107	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2108	2108	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2109	2109	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2110	2110	1.500	1.500	1.500	1.500	1.500	1.500	1.500

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2111        2111        1.500       1.500       1.500       1.500       1.500       1.500       1.500
2112        2112        1.500       1.500       1.500       1.500       1.500       1.500       1.500
2113        2113        1.500       1.500       1.500       1.500       1.500       1.500       1.500
2114        2114        1.500       1.500       1.500       1.500       1.500       1.500       1.500
2115        2115        1.500       1.500       1.500       1.500       1.500       1.500       1.500
2116        2116        1.500       1.500       1.500       1.500       1.500       1.500       1.500
2117        2117        1.500       1.500       1.500       1.500       1.500       1.500       1.500
2118        2118        1.500       1.500       1.500       1.500       1.500       1.500       1.500
2119        2119        1.500       1.500       1.500       1.500       1.500       1.500       1.500
2120        2120        1.500       1.500       1.500       1.500       1.500       1.500       1.500
2121        2121        1.500       1.500       1.500       1.500       1.500       1.500       1.500
2122        2122        1.500       1.500       1.500       1.500       1.500       1.500       1.500
2123        2123        1.500       1.500       1.500       1.500       1.500       1.500       1.500
2124        2124        1.500       1.500       1.500       1.500       1.500       1.500       1.500
2125        2125        1.500       1.500       1.500       1.500       1.500       1.500       1.500
2126        2126        1.500       1.500       1.500       1.500       1.500       1.500       1.500
2127        2127        1.500       1.500       1.500       1.500       1.500       1.500       1.500
2128        2128        1.500       1.500       1.500       1.500       1.500       1.500       1.500
2129        2129        1.500       1.500       1.500       1.500       1.500       1.500       1.500
2130        2130        1.500       1.500       1.500       1.500       1.500       1.500       1.500
2131        2131        1.500       1.500       1.500       1.500       1.500       1.500       1.500
2132        2132        1.500       1.500       1.500       1.500       1.500       1.500       1.500
2133        2133        1.500       1.500       1.500       1.500       1.500       1.500       1.500
2134        2134        1.500       1.500       1.500       1.500       1.500       1.500       1.500
2135        2135        1.500       1.500       1.500       1.500       1.500       1.500       1.500
2136        2136        1.500       1.500       1.500       1.500       1.500       1.500       1.500
2137        2137        1.500       1.500       1.500       1.500       1.500       1.500       1.500
2138        2138        1.500       1.500       1.500       1.500       1.500       1.500       1.500
2139        2139        1.500       1.500       1.500       1.500       1.500       1.500       1.500
2140        2140        1.500       1.500       1.500       1.500       1.500       1.500       1.500
2141        2141        1.500       1.500       1.500       1.500       1.500       1.500       1.500
2142        2142        1.500       1.500       1.500       1.500       1.500       1.500       1.500
2143        2143        1.500       1.500       1.500       1.500       1.500       1.500       1.500
2144        2144        1.500       1.500       1.500       1.500       1.500       1.500       1.500
2145        2145        1.500       1.500       1.500       1.500       1.500       1.500       1.500
2146        2146        1.500       1.500       1.500       1.500       1.500       1.500       1.500
2147        2147        1.500       1.500       1.500       1.500       1.500       1.500       1.500
2148        2148        1.500       1.500       1.500       1.500       1.500       1.500       1.500
2149        2149        1.500       1.500       1.500       1.500       1.500       1.500       1.500
2150        2150        1.500       1.500       1.500       1.500       1.500       1.500       1.500
2151        2151        1.500       1.500       1.500       1.500       1.500       1.500       1.500

AV_IND_TAX_CHANGES
** %change per annum from 2010 base year
*Start_yr     End_yr     Growth
2011           2151        0.00

CHARGE_TAX_RATES
** %base year tax rates
*Charge      Final      Intermediate
  1           0.0           0.0
  2           0.0           0.0
  3           0.0           0.0
```

```
  4          0.0          0.0
  5         17.5          0.0
  6          0.0          0.0
  7         17.5          0.0
  8         17.5          0.0

CHARGE_TAX_RATES_CHANGES
** %change per annum from 2010 base year
*Start_yr      End_yr     Charge        Final     Intermediate
2011            2011        1           0.000          0.000
2011            2011        2           0.000          0.000
2011            2011        3           0.000          0.000
2011            2011        4           0.000          0.000
2011            2011        5          14.286          0.000
2011            2011        6           0.000          0.000
2011            2011        7          14.286          0.000
2011            2011        8          14.286          0.000
2012            2151        1           0.000          0.000
2012            2151        2           0.000          0.000
2012            2151        3           0.000          0.000
2012            2151        4           0.000          0.000
2012            2151        5           0.000          0.000
2012            2151        6           0.000          0.000
2012            2151        7           0.000          0.000
2012            2151        8           0.000          0.000

FUEL_COST
** Source: TAG Data Book - Table A 1.3.7
** Source: TAG Data Book - Table A 3.3 (CO2e values)
** (In 2010 base year values and prices)
*Type   Resource(p/unit)  Duty(p/unit)     VAT(%) CO2_grammes/unit (unit=litre for fuel types 1 & 2; unit=KWH for electric)
  1         42.57          57.19          17.50        2230.00
  2         44.31          57.19          17.50        2562.00
  3         11.97           0.00           5.00         389.00

FUEL_COST_CHANGES
** Source: TAG Data Book -Table A 1.3.7 (Derived) & Table A 3.3 CO2 (Derived)
** %change per annum from 2010 base year
*Start_yr      End_yr     Fuel_type    Resource         Duty         VAT    CO2_Den_Change
2011           2011          1          22.226         -0.297      14.286        -0.844
2012           2012          1           2.040         -2.049       0.000        -0.023
2013           2013          1          -3.443         -1.746       0.000        -0.438
2014           2014          1         -11.771         -1.707       0.000        -0.537
2015           2015          1         -28.520         -0.661       0.000         0.000
2016           2016          1          -7.312         -2.068       0.000         0.000
2017           2017          1          19.734         -1.912       0.000        -1.352
2018           2018          1          13.204         -2.203       0.000        -1.370
2019           2019          1         -10.631         -2.442       0.000        -1.389
2020           2020          1         -11.341         -4.832       0.000        -1.409
2021           2021          1           3.590          1.236       0.000         0.000
2022           2022          1           5.005          3.364       0.000         0.000
2023           2023          1           1.744          0.601       0.000         0.000
2024           2024          1           1.726          0.550       0.000         0.000
```

2025	2025	1	1.765	0.745	0.000	0.000
2026	2026	1	2.597	0.658	0.000	0.000
2027	2027	1	1.476	0.681	0.000	0.000
2028	2028	1	1.433	0.674	0.000	0.000
2029	2029	1	1.391	0.663	0.000	0.000
2030	2030	1	1.352	0.653	0.000	0.000
2031	2031	1	2.246	0.653	0.000	0.000
2032	2032	1	1.259	0.650	0.000	0.000
2033	2033	1	1.225	0.644	0.000	0.000
2034	2034	1	1.193	0.637	0.000	0.000
2035	2035	1	1.162	0.645	0.000	0.000
2036	2036	1	0.000	0.640	0.000	0.000
2037	2037	1	0.000	0.635	0.000	0.000
2038	2038	1	0.000	0.630	0.000	0.000
2039	2039	1	0.000	0.649	0.000	0.000
2040	2040	1	0.000	0.681	0.000	0.000
2041	2041	1	0.000	0.629	0.000	0.000
2042	2042	1	0.000	0.592	0.000	0.000
2043	2043	1	0.000	0.587	0.000	0.000
2044	2044	1	0.000	0.587	0.000	0.000
2045	2045	1	0.000	0.586	0.000	0.000
2046	2046	1	0.000	0.587	0.000	0.000
2047	2047	1	0.000	0.587	0.000	0.000
2048	2048	1	0.000	0.587	0.000	0.000
2049	2049	1	0.000	0.586	0.000	0.000
2050	2050	1	0.000	0.587	0.000	0.000
2051	2051	1	0.000	0.587	0.000	0.000
2052	2052	1	0.000	0.587	0.000	0.000
2053	2053	1	0.000	0.587	0.000	0.000
2054	2054	1	0.000	0.587	0.000	0.000
2055	2055	1	0.000	0.587	0.000	0.000
2056	2056	1	0.000	0.587	0.000	0.000
2057	2057	1	0.000	0.587	0.000	0.000
2058	2058	1	0.000	0.586	0.000	0.000
2059	2059	1	0.000	0.587	0.000	0.000
2060	2060	1	0.000	0.587	0.000	0.000
2061	2061	1	0.000	0.587	0.000	0.000
2062	2062	1	0.000	0.587	0.000	0.000
2063	2063	1	0.000	0.587	0.000	0.000
2064	2064	1	0.000	0.587	0.000	0.000
2065	2065	1	0.000	0.587	0.000	0.000
2066	2066	1	0.000	0.587	0.000	0.000
2067	2067	1	0.000	0.587	0.000	0.000
2068	2068	1	0.000	0.587	0.000	0.000
2069	2069	1	-1.686	0.587	0.000	0.000
2070	2070	1	0.000	0.587	0.000	0.000
2071	2071	1	0.000	0.587	0.000	0.000
2072	2072	1	0.000	0.587	0.000	0.000
2073	2073	1	0.000	0.587	0.000	0.000
2074	2074	1	0.000	0.586	0.000	0.000
2075	2075	1	0.000	0.587	0.000	0.000
2076	2076	1	0.000	0.587	0.000	0.000
2077	2077	1	0.000	0.586	0.000	0.000

2078	2078	1	0.000	0.587	0.000	0.000
2079	2079	1	0.000	0.587	0.000	0.000
2080	2080	1	0.000	0.587	0.000	0.000
2081	2081	1	0.000	0.587	0.000	0.000
2082	2082	1	0.000	0.587	0.000	0.000
2083	2083	1	0.000	0.587	0.000	0.000
2084	2084	1	0.000	0.587	0.000	0.000
2085	2085	1	0.000	0.587	0.000	0.000
2086	2086	1	0.000	0.587	0.000	0.000
2087	2087	1	0.000	0.587	0.000	0.000
2088	2088	1	0.000	0.587	0.000	0.000
2089	2089	1	0.000	0.587	0.000	0.000
2090	2090	1	0.000	0.587	0.000	0.000
2091	2091	1	0.000	0.587	0.000	0.000
2092	2092	1	0.000	0.587	0.000	0.000
2093	2093	1	0.000	0.587	0.000	0.000
2094	2094	1	0.000	0.587	0.000	0.000
2095	2095	1	0.000	0.587	0.000	0.000
2096	2096	1	0.000	0.587	0.000	0.000
2097	2097	1	0.000	0.587	0.000	0.000
2098	2098	1	0.000	0.587	0.000	0.000
2099	2099	1	0.000	0.587	0.000	0.000
2100	2100	1	0.000	0.587	0.000	0.000
2101	2101	1	0.000	0.587	0.000	0.000
2102	2102	1	0.000	0.587	0.000	0.000
2103	2103	1	0.000	0.587	0.000	0.000
2104	2104	1	0.000	0.587	0.000	0.000
2105	2105	1	0.000	0.587	0.000	0.000
2106	2106	1	0.000	0.587	0.000	0.000
2107	2107	1	0.000	0.587	0.000	0.000
2108	2108	1	0.000	0.587	0.000	0.000
2109	2109	1	0.000	0.587	0.000	0.000
2110	2110	1	0.000	0.587	0.000	0.000
2111	2111	1	0.000	0.587	0.000	0.000
2112	2112	1	0.000	0.587	0.000	0.000
2113	2113	1	0.000	0.587	0.000	0.000
2114	2114	1	0.000	0.587	0.000	0.000
2115	2115	1	0.000	0.587	0.000	0.000
2116	2116	1	0.000	0.587	0.000	0.000
2117	2117	1	0.000	0.587	0.000	0.000
2118	2118	1	0.000	0.587	0.000	0.000
2119	2119	1	0.000	0.587	0.000	0.000
2120	2120	1	0.000	0.587	0.000	0.000
2121	2121	1	0.000	0.587	0.000	0.000
2122	2122	1	0.000	0.587	0.000	0.000
2123	2123	1	0.000	0.587	0.000	0.000
2124	2124	1	0.000	0.587	0.000	0.000
2125	2125	1	0.000	0.587	0.000	0.000
2126	2126	1	0.000	0.587	0.000	0.000
2127	2127	1	0.000	0.587	0.000	0.000
2128	2128	1	0.000	0.587	0.000	0.000
2129	2129	1	0.000	0.587	0.000	0.000
2130	2130	1	0.000	0.587	0.000	0.000

2131	2131	1	0.000	0.587	0.000	0.000
2132	2132	1	0.000	0.587	0.000	0.000
2133	2133	1	0.000	0.587	0.000	0.000
2134	2134	1	0.000	0.587	0.000	0.000
2135	2135	1	0.000	0.587	0.000	0.000
2136	2136	1	0.000	0.587	0.000	0.000
2137	2137	1	0.000	0.587	0.000	0.000
2138	2138	1	0.000	0.587	0.000	0.000
2139	2139	1	0.000	0.587	0.000	0.000
2140	2140	1	0.000	0.587	0.000	0.000
2141	2141	1	0.000	0.587	0.000	0.000
2142	2142	1	0.000	0.587	0.000	0.000
2143	2143	1	0.000	0.587	0.000	0.000
2144	2144	1	0.000	0.587	0.000	0.000
2145	2145	1	0.000	0.587	0.000	0.000
2146	2146	1	0.000	0.587	0.000	0.000
2147	2147	1	0.000	0.587	0.000	0.000
2148	2148	1	0.000	0.587	0.000	0.000
2149	2149	1	0.000	0.587	0.000	0.000
2150	2150	1	0.000	0.587	0.000	0.000
2151	2151	1	0.000	0.587	0.000	0.000
2011	2011	2	26.919	-0.297	14.286	0.188
2012	2012	2	3.247	-2.049	0.000	1.643
2013	2013	2	-3.680	-1.746	0.000	-0.436
2014	2014	2	-11.343	-1.707	0.000	0.153
2015	2015	2	-29.504	-0.661	0.000	0.004
2016	2016	2	-12.397	-2.068	0.000	0.003
2017	2017	2	22.316	-1.912	0.000	-1.744
2018	2018	2	16.802	-2.203	0.000	-1.775
2019	2019	2	-11.392	-2.442	0.000	-1.807
2020	2020	2	-11.913	-4.832	0.000	-1.841
2021	2021	2	3.816	1.236	0.000	0.000
2022	2022	2	5.133	3.364	0.000	0.000
2023	2023	2	1.862	0.601	0.000	0.000
2024	2024	2	1.853	0.550	0.000	0.000
2025	2025	2	1.886	0.745	0.000	0.000
2026	2026	2	2.790	0.658	0.000	0.000
2027	2027	2	1.583	0.681	0.000	0.000
2028	2028	2	1.535	0.674	0.000	0.000
2029	2029	2	1.489	0.663	0.000	0.000
2030	2030	2	1.445	0.653	0.000	0.000
2031	2031	2	2.399	0.653	0.000	0.000
2032	2032	2	1.343	0.650	0.000	0.000
2033	2033	2	1.306	0.644	0.000	0.000
2034	2034	2	1.270	0.637	0.000	0.000
2035	2035	2	1.236	0.645	0.000	0.000
2036	2036	2	0.000	0.640	0.000	0.000
2037	2037	2	0.000	0.635	0.000	0.000
2038	2038	2	0.000	0.630	0.000	0.000
2039	2039	2	0.000	0.649	0.000	0.000
2040	2040	2	0.000	0.681	0.000	0.000
2041	2041	2	0.000	0.629	0.000	0.000

2042	2042	2	0.000	0.592	0.000	0.000
2043	2043	2	0.000	0.587	0.000	0.000
2044	2044	2	0.000	0.587	0.000	0.000
2045	2045	2	0.000	0.586	0.000	0.000
2046	2046	2	0.000	0.587	0.000	0.000
2047	2047	2	0.000	0.587	0.000	0.000
2048	2048	2	0.000	0.587	0.000	0.000
2049	2049	2	0.000	0.586	0.000	0.000
2050	2050	2	0.000	0.587	0.000	0.000
2051	2051	2	0.000	0.587	0.000	0.000
2052	2052	2	0.000	0.587	0.000	0.000
2053	2053	2	0.000	0.587	0.000	0.000
2054	2054	2	0.000	0.587	0.000	0.000
2055	2055	2	0.000	0.587	0.000	0.000
2056	2056	2	0.000	0.587	0.000	0.000
2057	2057	2	0.000	0.587	0.000	0.000
2058	2058	2	0.000	0.586	0.000	0.000
2059	2059	2	0.000	0.587	0.000	0.000
2060	2060	2	0.000	0.587	0.000	0.000
2061	2061	2	0.000	0.587	0.000	0.000
2062	2062	2	0.000	0.587	0.000	0.000
2063	2063	2	0.000	0.587	0.000	0.000
2064	2064	2	0.000	0.587	0.000	0.000
2065	2065	2	0.000	0.587	0.000	0.000
2066	2066	2	0.000	0.587	0.000	0.000
2067	2067	2	0.000	0.587	0.000	0.000
2068	2068	2	0.000	0.587	0.000	0.000
2069	2069	2	-1.686	0.587	0.000	0.000
2070	2070	2	0.000	0.587	0.000	0.000
2071	2071	2	0.000	0.587	0.000	0.000
2072	2072	2	0.000	0.587	0.000	0.000
2073	2073	2	0.000	0.587	0.000	0.000
2074	2074	2	0.000	0.586	0.000	0.000
2075	2075	2	0.000	0.587	0.000	0.000
2076	2076	2	0.000	0.587	0.000	0.000
2077	2077	2	0.000	0.586	0.000	0.000
2078	2078	2	0.000	0.587	0.000	0.000
2079	2079	2	0.000	0.587	0.000	0.000
2080	2080	2	0.000	0.587	0.000	0.000
2081	2081	2	0.000	0.587	0.000	0.000
2082	2082	2	0.000	0.587	0.000	0.000
2083	2083	2	0.000	0.587	0.000	0.000
2084	2084	2	0.000	0.587	0.000	0.000
2085	2085	2	0.000	0.587	0.000	0.000
2086	2086	2	0.000	0.587	0.000	0.000
2087	2087	2	0.000	0.587	0.000	0.000
2088	2088	2	0.000	0.587	0.000	0.000
2089	2089	2	0.000	0.587	0.000	0.000
2090	2090	2	0.000	0.587	0.000	0.000
2091	2091	2	0.000	0.587	0.000	0.000
2092	2092	2	0.000	0.587	0.000	0.000
2093	2093	2	0.000	0.587	0.000	0.000
2094	2094	2	0.000	0.587	0.000	0.000

2095	2095	2	0.000	0.587	0.000	0.000
2096	2096	2	0.000	0.587	0.000	0.000
2097	2097	2	0.000	0.587	0.000	0.000
2098	2098	2	0.000	0.587	0.000	0.000
2099	2099	2	0.000	0.587	0.000	0.000
2100	2100	2	0.000	0.587	0.000	0.000
2101	2101	2	0.000	0.587	0.000	0.000
2102	2102	2	0.000	0.587	0.000	0.000
2103	2103	2	0.000	0.587	0.000	0.000
2104	2104	2	0.000	0.587	0.000	0.000
2105	2105	2	0.000	0.587	0.000	0.000
2106	2106	2	0.000	0.587	0.000	0.000
2107	2107	2	0.000	0.587	0.000	0.000
2108	2108	2	0.000	0.587	0.000	0.000
2109	2109	2	0.000	0.587	0.000	0.000
2110	2110	2	0.000	0.587	0.000	0.000
2111	2111	2	0.000	0.587	0.000	0.000
2112	2112	2	0.000	0.587	0.000	0.000
2113	2113	2	0.000	0.587	0.000	0.000
2114	2114	2	0.000	0.587	0.000	0.000
2115	2115	2	0.000	0.587	0.000	0.000
2116	2116	2	0.000	0.587	0.000	0.000
2117	2117	2	0.000	0.587	0.000	0.000
2118	2118	2	0.000	0.587	0.000	0.000
2119	2119	2	0.000	0.587	0.000	0.000
2120	2120	2	0.000	0.587	0.000	0.000
2121	2121	2	0.000	0.587	0.000	0.000
2122	2122	2	0.000	0.587	0.000	0.000
2123	2123	2	0.000	0.587	0.000	0.000
2124	2124	2	0.000	0.587	0.000	0.000
2125	2125	2	0.000	0.587	0.000	0.000
2126	2126	2	0.000	0.587	0.000	0.000
2127	2127	2	0.000	0.587	0.000	0.000
2128	2128	2	0.000	0.587	0.000	0.000
2129	2129	2	0.000	0.587	0.000	0.000
2130	2130	2	0.000	0.587	0.000	0.000
2131	2131	2	0.000	0.587	0.000	0.000
2132	2132	2	0.000	0.587	0.000	0.000
2133	2133	2	0.000	0.587	0.000	0.000
2134	2134	2	0.000	0.587	0.000	0.000
2135	2135	2	0.000	0.587	0.000	0.000
2136	2136	2	0.000	0.587	0.000	0.000
2137	2137	2	0.000	0.587	0.000	0.000
2138	2138	2	0.000	0.587	0.000	0.000
2139	2139	2	0.000	0.587	0.000	0.000
2140	2140	2	0.000	0.587	0.000	0.000
2141	2141	2	0.000	0.587	0.000	0.000
2142	2142	2	0.000	0.587	0.000	0.000
2143	2143	2	0.000	0.587	0.000	0.000
2144	2144	2	0.000	0.587	0.000	0.000
2145	2145	2	0.000	0.587	0.000	0.000
2146	2146	2	0.000	0.587	0.000	0.000
2147	2147	2	0.000	0.587	0.000	0.000

2148	2148	2	0.000	0.587	0.000	0.000
2149	2149	2	0.000	0.587	0.000	0.000
2150	2150	2	0.000	0.587	0.000	0.000
2151	2151	2	0.000	0.587	0.000	0.000
2011	2011	3	6.000	0.000	0.000	-1.438
2012	2012	3	3.964	0.000	0.000	-1.878
2013	2013	3	4.453	0.000	0.000	-2.438
2014	2014	3	0.807	0.000	0.000	-1.891
2015	2015	3	-2.124	0.000	0.000	-2.837
2016	2016	3	-1.596	0.000	0.000	-3.035
2017	2017	3	3.662	0.000	0.000	-2.830
2018	2018	3	6.268	0.000	0.000	-3.251
2019	2019	3	4.006	0.000	0.000	-3.618
2020	2020	3	-3.240	0.000	0.000	-3.931
2021	2021	3	9.768	0.000	0.000	-4.324
2022	2022	3	1.799	0.000	0.000	-4.776
2023	2023	3	-0.216	0.000	0.000	-5.300
2024	2024	3	-1.595	0.000	0.000	-5.915
2025	2025	3	1.049	0.000	0.000	-6.643
2026	2026	3	0.894	0.000	0.000	-7.520
2027	2027	3	-1.865	0.000	0.000	-8.594
2028	2028	3	-0.274	0.000	0.000	-9.934
2029	2029	3	-0.789	0.000	0.000	-11.657
2030	2030	3	1.876	0.000	0.000	-13.944
2031	2031	3	-0.287	0.000	0.000	-19.089
2032	2032	3	-2.211	0.000	0.000	-19.090
2033	2033	3	-2.565	0.000	0.000	-19.088
2034	2034	3	-1.399	0.000	0.000	-19.090
2035	2035	3	-1.444	0.000	0.000	-19.089
2036	2036	3	-0.695	0.000	0.000	-19.089
2037	2037	3	-0.258	0.000	0.000	-19.088
2038	2038	3	-0.856	0.000	0.000	-19.090
2039	2039	3	1.451	0.000	0.000	-19.092
2040	2040	3	-1.512	0.000	0.000	-19.088
2041	2041	3	0.000	0.000	0.000	-16.984
2042	2042	3	0.000	0.000	0.000	-5.099
2043	2043	3	0.000	0.000	0.000	-2.043
2044	2044	3	0.000	0.000	0.000	-6.009
2045	2045	3	0.000	0.000	0.000	-15.076
2046	2046	3	0.000	0.000	0.000	-9.204
2047	2047	3	0.000	0.000	0.000	-7.798
2048	2048	3	0.000	0.000	0.000	-5.087
2049	2049	3	0.000	0.000	0.000	-6.945
2050	2050	3	0.000	0.000	0.000	-1.718
2051	2051	3	0.000	0.000	0.000	0.000
2052	2052	3	0.000	0.000	0.000	0.000
2053	2053	3	0.000	0.000	0.000	0.000
2054	2054	3	0.000	0.000	0.000	0.000
2055	2055	3	0.000	0.000	0.000	0.000
2056	2056	3	0.000	0.000	0.000	0.000
2057	2057	3	0.000	0.000	0.000	0.000
2058	2058	3	0.000	0.000	0.000	0.000

2059	2059	3	0.000	0.000	0.000	0.000
2060	2060	3	0.000	0.000	0.000	0.000
2061	2061	3	0.000	0.000	0.000	0.000
2062	2062	3	0.000	0.000	0.000	0.000
2063	2063	3	0.000	0.000	0.000	0.000
2064	2064	3	0.000	0.000	0.000	0.000
2065	2065	3	0.000	0.000	0.000	0.000
2066	2066	3	0.000	0.000	0.000	0.000
2067	2067	3	0.000	0.000	0.000	0.000
2068	2068	3	0.000	0.000	0.000	0.000
2069	2069	3	0.000	0.000	0.000	0.000
2070	2070	3	0.000	0.000	0.000	0.000
2071	2071	3	0.000	0.000	0.000	0.000
2072	2072	3	0.000	0.000	0.000	0.000
2073	2073	3	0.000	0.000	0.000	0.000
2074	2074	3	0.000	0.000	0.000	0.000
2075	2075	3	0.000	0.000	0.000	0.000
2076	2076	3	0.000	0.000	0.000	0.000
2077	2077	3	0.000	0.000	0.000	0.000
2078	2078	3	0.000	0.000	0.000	0.000
2079	2079	3	0.000	0.000	0.000	0.000
2080	2080	3	0.000	0.000	0.000	0.000
2081	2081	3	0.000	0.000	0.000	0.000
2082	2082	3	0.000	0.000	0.000	0.000
2083	2083	3	0.000	0.000	0.000	0.000
2084	2084	3	0.000	0.000	0.000	0.000
2085	2085	3	0.000	0.000	0.000	0.000
2086	2086	3	0.000	0.000	0.000	0.000
2087	2087	3	0.000	0.000	0.000	0.000
2088	2088	3	0.000	0.000	0.000	0.000
2089	2089	3	0.000	0.000	0.000	0.000
2090	2090	3	0.000	0.000	0.000	0.000
2091	2091	3	0.000	0.000	0.000	0.000
2092	2092	3	0.000	0.000	0.000	0.000
2093	2093	3	0.000	0.000	0.000	0.000
2094	2094	3	0.000	0.000	0.000	0.000
2095	2095	3	0.000	0.000	0.000	0.000
2096	2096	3	0.000	0.000	0.000	0.000
2097	2097	3	0.000	0.000	0.000	0.000
2098	2098	3	0.000	0.000	0.000	0.000
2099	2099	3	0.000	0.000	0.000	0.000
2100	2100	3	0.000	0.000	0.000	0.000
2101	2101	3	0.000	0.000	0.000	0.000
2102	2102	3	0.000	0.000	0.000	0.000
2103	2103	3	0.000	0.000	0.000	0.000
2104	2104	3	0.000	0.000	0.000	0.000
2105	2105	3	0.000	0.000	0.000	0.000
2106	2106	3	0.000	0.000	0.000	0.000
2107	2107	3	0.000	0.000	0.000	0.000
2108	2108	3	0.000	0.000	0.000	0.000
2109	2109	3	0.000	0.000	0.000	0.000
2110	2110	3	0.000	0.000	0.000	0.000
2111	2111	3	0.000	0.000	0.000	0.000

2112	2112	3	0.000	0.000	0.000	0.000
2113	2113	3	0.000	0.000	0.000	0.000
2114	2114	3	0.000	0.000	0.000	0.000
2115	2115	3	0.000	0.000	0.000	0.000
2116	2116	3	0.000	0.000	0.000	0.000
2117	2117	3	0.000	0.000	0.000	0.000
2118	2118	3	0.000	0.000	0.000	0.000
2119	2119	3	0.000	0.000	0.000	0.000
2120	2120	3	0.000	0.000	0.000	0.000
2121	2121	3	0.000	0.000	0.000	0.000
2122	2122	3	0.000	0.000	0.000	0.000
2123	2123	3	0.000	0.000	0.000	0.000
2124	2124	3	0.000	0.000	0.000	0.000
2125	2125	3	0.000	0.000	0.000	0.000
2126	2126	3	0.000	0.000	0.000	0.000
2127	2127	3	0.000	0.000	0.000	0.000
2128	2128	3	0.000	0.000	0.000	0.000
2129	2129	3	0.000	0.000	0.000	0.000
2130	2130	3	0.000	0.000	0.000	0.000
2131	2131	3	0.000	0.000	0.000	0.000
2132	2132	3	0.000	0.000	0.000	0.000
2133	2133	3	0.000	0.000	0.000	0.000
2134	2134	3	0.000	0.000	0.000	0.000
2135	2135	3	0.000	0.000	0.000	0.000
2136	2136	3	0.000	0.000	0.000	0.000
2137	2137	3	0.000	0.000	0.000	0.000
2138	2138	3	0.000	0.000	0.000	0.000
2139	2139	3	0.000	0.000	0.000	0.000
2140	2140	3	0.000	0.000	0.000	0.000
2141	2141	3	0.000	0.000	0.000	0.000
2142	2142	3	0.000	0.000	0.000	0.000
2143	2143	3	0.000	0.000	0.000	0.000
2144	2144	3	0.000	0.000	0.000	0.000
2145	2145	3	0.000	0.000	0.000	0.000
2146	2146	3	0.000	0.000	0.000	0.000
2147	2147	3	0.000	0.000	0.000	0.000
2148	2148	3	0.000	0.000	0.000	0.000
2149	2149	3	0.000	0.000	0.000	0.000
2150	2150	3	0.000	0.000	0.000	0.000
2151	2151	3	0.000	0.000	0.000	0.000

CARBDX_VALUE_CHANGES
** Source: TAG Data Book - Table A 3.4 (Non-traded) and hidden worksheet ‘GHG’ (Traded), Derived

*Start_yr	End_yr	Rel(%)_NT_Lw	Abs(t)_NT_Lw	Rel(%)_Tr_Lw	Abs(t)_Tr_Lw	Rel(%)_NT_Hi	Abs(t)_NT_Hi	Rel(%)_Tr_Hi	Abs(t)_Tr_Hi	Rel(%)_NT_Ce	Abs(t)_NT_Ce	Rel(%)_Tr_Ce	Abs(t)_Tr_Ce
2011	2011	1.523	0.000	1.523	0.000	1.523	0.000	1.523	0.000	1.523	0.000	1.523	0.000
2012	2012	1.523	0.000	1.523	0.000	1.523	0.000	1.523	0.000	1.523	0.000	1.523	0.000
2013	2013	1.523	0.000	1.523	0.000	1.523	0.000	1.523	0.000	1.523	0.000	1.523	0.000
2014	2014	1.523	0.000	1.523	0.000	1.523	0.000	1.523	0.000	1.523	0.000	1.523	0.000
2015	2015	1.523	0.000	1.523	0.000	1.523	0.000	1.523	0.000	1.523	0.000	1.523	0.000
2016	2016	1.523	0.000	1.523	0.000	1.523	0.000	1.523	0.000	1.523	0.000	1.523	0.000
2017	2017	1.523	0.000	1.523	0.000	1.523	0.000	1.523	0.000	1.523	0.000	1.523	0.000
2018	2018	1.523	0.000	1.523	0.000	1.523	0.000	1.523	0.000	1.523	0.000	1.523	0.000

2019	2019	1.523	0.000	1.523	0.000	1.523	0.000	1.523	0.000	1.523	0.000	1.523	0.000
2020	2020	1.523	0.000	1.523	0.000	1.523	0.000	1.523	0.000	1.523	0.000	1.523	0.000
2021	2021	1.875	0.000	1.875	0.000	1.875	0.000	1.875	0.000	1.875	0.000	1.875	0.000
2022	2022	1.523	0.000	1.523	0.000	1.523	0.000	1.523	0.000	1.523	0.000	1.523	0.000
2023	2023	1.523	0.000	1.523	0.000	1.523	0.000	1.523	0.000	1.523	0.000	1.523	0.000
2024	2024	1.523	0.000	1.523	0.000	1.523	0.000	1.523	0.000	1.523	0.000	1.523	0.000
2025	2025	1.523	0.000	1.523	0.000	1.523	0.000	1.523	0.000	1.523	0.000	1.523	0.000
2026	2026	1.523	0.000	1.523	0.000	1.523	0.000	1.523	0.000	1.523	0.000	1.523	0.000
2027	2027	1.523	0.000	1.523	0.000	1.523	0.000	1.523	0.000	1.523	0.000	1.523	0.000
2028	2028	1.523	0.000	1.523	0.000	1.523	0.000	1.523	0.000	1.523	0.000	1.523	0.000
2029	2029	1.523	0.000	1.523	0.000	1.523	0.000	1.523	0.000	1.523	0.000	1.523	0.000
2030	2030	1.523	0.000	1.523	0.000	1.523	0.000	1.523	0.000	1.523	0.000	1.523	0.000
2031	2031	1.523	0.000	1.523	0.000	1.523	0.000	1.523	0.000	1.523	0.000	1.523	0.000
2032	2032	1.523	0.000	1.523	0.000	1.523	0.000	1.523	0.000	1.523	0.000	1.523	0.000
2033	2033	1.523	0.000	1.523	0.000	1.523	0.000	1.523	0.000	1.523	0.000	1.523	0.000
2034	2034	1.523	0.000	1.523	0.000	1.523	0.000	1.523	0.000	1.523	0.000	1.523	0.000
2035	2035	1.523	0.000	1.523	0.000	1.523	0.000	1.523	0.000	1.523	0.000	1.523	0.000
2036	2036	1.523	0.000	1.523	0.000	1.523	0.000	1.523	0.000	1.523	0.000	1.523	0.000
2037	2037	1.523	0.000	1.523	0.000	1.523	0.000	1.523	0.000	1.523	0.000	1.523	0.000
2038	2038	1.523	0.000	1.523	0.000	1.523	0.000	1.523	0.000	1.523	0.000	1.523	0.000
2039	2039	1.523	0.000	1.523	0.000	1.523	0.000	1.523	0.000	1.523	0.000	1.523	0.000
2040	2040	1.523	0.000	1.523	0.000	1.523	0.000	1.523	0.000	1.523	0.000	1.523	0.000
2041	2041	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2042	2042	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2043	2043	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2044	2044	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2045	2045	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2046	2046	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2047	2047	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2048	2048	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2049	2049	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2050	2050	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2051	2051	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2052	2052	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2053	2053	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2054	2054	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2055	2055	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2056	2056	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2057	2057	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2058	2058	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2059	2059	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2060	2060	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2061	2061	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2062	2062	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2063	2063	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2064	2064	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2065	2065	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2066	2066	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2067	2067	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2068	2068	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2069	2069	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2070	2070	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2071	2071	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000

2072	2072	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2073	2073	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2074	2074	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2075	2075	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2076	2076	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2077	2077	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2078	2078	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2079	2079	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2080	2080	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2081	2081	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2082	2082	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2083	2083	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2084	2084	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2085	2085	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2086	2086	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2087	2087	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2088	2088	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2089	2089	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2090	2090	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2091	2091	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2092	2092	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2093	2093	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2094	2094	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2095	2095	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2096	2096	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2097	2097	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2098	2098	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2099	2099	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2100	2100	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2101	2101	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2102	2102	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2103	2103	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2104	2104	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2105	2105	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2106	2106	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2107	2107	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2108	2108	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2109	2109	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2110	2110	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2111	2111	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2112	2112	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2113	2113	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2114	2114	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2115	2115	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2116	2116	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2117	2117	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2118	2118	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2119	2119	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2120	2120	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2121	2121	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2122	2122	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2123	2123	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2124	2124	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000

2125	2125	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2126	2126	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2127	2127	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2128	2128	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2129	2129	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2130	2130	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2131	2131	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2132	2132	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2133	2133	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2134	2134	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2135	2135	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2136	2136	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2137	2137	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2138	2138	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2139	2139	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2140	2140	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2141	2141	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2142	2142	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2143	2143	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2144	2144	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2145	2145	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2146	2146	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2147	2147	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2148	2148	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2149	2149	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2150	2150	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000
2151	2151	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000	1.500	0.000

FLEET
** Source: TAG Data Book - Table A 1.3.9
** For 2010 base year proportions

*Veh_type	%Petrol	%Diesel	%Electric
1	59.6299	40.3625	0.0076
2	3.4505	96.4583	0.0912
3	3.4505	96.4583	0.0912
4	0.0000	100.0000	0.0000
5	0.0000	100.0000	0.0000
6	0.0000	100.0000	0.0000
7	0.0000	100.0000	0.0000
8	0.0000	100.0000	0.0000

FLEET_CHANGES
** Source: TAG Data Book - Table A 1.3.9 (derived)
** %change per annum from 2010 base year

*Start_yr	End_yr	Veh_type	%Change_Petrol	%Change_Diesel	%Change_Electric
2011	2011	1	-3.5474	5.2271	72.3684
2012	2012	1	-3.6255	4.8862	75.5725
2013	2013	1	-3.7045	4.5823	52.6087
2014	2014	1	-3.5372	3.9494	137.0370
2015	2015	1	-3.3037	3.3379	101.4423
2016	2016	1	-2.7361	2.5097	63.3652

2017	2017	1	-0.8923	0.5861	47.9912
2018	2018	1	1.1991	-1.4201	38.8203
2019	2019	1	1.7017	-1.9941	33.4222
2020	2020	1	1.8536	-2.2461	27.1952
2021	2021	1	1.6150	-2.5074	42.8975
2022	2022	1	1.4618	-2.7336	40.4296
2023	2023	1	1.3175	-3.0441	37.7636
2024	2024	1	0.9803	-3.5199	40.2425
2025	2025	1	0.2872	-4.2813	45.8903
2026	2026	1	-0.0235	-4.6731	36.0447
2027	2027	1	-0.1975	-4.8289	27.3620
2028	2028	1	-0.3930	-4.9178	21.9646
2029	2029	1	-0.6139	-4.9385	18.2947
2030	2030	1	-0.9186	-4.8594	15.7936
2031	2031	1	-1.1396	-4.5854	13.2690
2032	2032	1	-1.3598	-4.2639	11.3740
2033	2033	1	-1.5543	-3.9092	9.8508
2034	2034	1	-1.7099	-3.6116	8.6724
2035	2035	1	-1.8177	-3.2999	7.6247
2036	2036	1	-1.8688	-3.0327	6.7218
2037	2037	1	-1.8936	-2.8160	5.9844
2038	2038	1	-1.8686	-2.5621	5.2552
2039	2039	1	-1.8261	-2.3161	4.6228
2040	2040	1	-2.0337	-2.4757	4.7437
2041	2041	1	-1.9404	-2.3503	4.2169
2042	2042	1	-1.8614	-2.2344	3.7873
2043	2043	1	-1.7986	-2.0982	3.4172
2044	2044	1	-1.8062	-2.0617	3.2286
2045	2045	1	-1.7138	-1.9060	2.8834
2046	2046	1	-1.6902	-1.8698	2.7094
2047	2047	1	-1.6879	-1.8470	2.5779
2048	2048	1	-1.6589	-1.8011	2.4200
2049	2049	1	-1.6009	-1.7231	2.2342
2050	2050	1	-1.5935	-1.7035	2.1344
2011	2011	2	-9.9551	0.3589	-2.9605
2012	2012	2	-8.0850	0.2503	10.1695
2013	2013	2	-8.1413	0.2417	-2.2564
2014	2014	2	-8.3635	0.2034	22.5603
2015	2015	2	-7.9288	0.1755	16.6952
2016	2016	2	-8.3676	0.1677	15.7007
2017	2017	2	-1.9723	0.0123	17.7552
2018	2018	2	4.0994	-0.1225	20.6247
2019	2019	2	-1.5414	-0.0689	44.2857
2020	2020	2	-1.2465	0.0340	-2.4134
2021	2021	2	-0.1690	-0.0505	16.7089
2022	2022	2	0.1344	-0.0690	17.5767
2023	2023	2	0.9644	-0.1262	23.9603
2024	2024	2	2.0384	-0.2103	30.4753
2025	2025	2	4.5262	-0.4417	47.9714
2026	2026	2	3.4807	-0.4261	32.5352
2027	2027	2	3.9436	-0.5348	31.1116
2028	2028	2	4.5536	-0.6795	30.2961

2029	2029	2	4.8684	-0.7989	27.3836
2030	2030	2	4.9673	-0.9096	24.5096
2031	2031	2	5.0865	-0.9474	20.1742
2032	2032	2	4.8793	-1.0056	17.7808
2033	2033	2	4.6320	-1.0543	15.7803
2034	2034	2	4.3655	-1.0969	14.1249
2035	2035	2	4.0807	-1.1390	12.8123
2036	2036	2	3.8076	-1.1648	11.5496
2037	2037	2	3.5417	-1.1887	10.5057
2038	2038	2	3.2793	-1.2049	9.5762
2039	2039	2	3.0357	-1.2185	8.7799
2040	2040	2	2.8032	-1.2286	8.0825
2041	2041	2	2.5647	-1.2034	7.2582
2042	2042	2	2.4018	-1.2091	6.7416
2043	2043	2	2.2033	-1.2237	6.3558
2044	2044	2	2.0402	-1.2164	5.8890
2045	2045	2	1.8815	-1.2057	5.4663
2046	2046	2	1.6834	-1.1668	4.9758
2047	2047	2	1.5551	-1.1570	4.6635
2048	2048	2	1.4237	-1.1416	4.3618
2049	2049	2	1.2542	-1.1392	4.1548
2050	2050	2	1.1467	-1.1150	3.8719
2011	2011	3	-9.9551	0.3589	-2.9605
2012	2012	3	-8.0850	0.2503	10.1695
2013	2013	3	-8.1413	0.2417	-2.2564
2014	2014	3	-8.3635	0.2034	22.5603
2015	2015	3	-7.9288	0.1755	16.6952
2016	2016	3	-8.3676	0.1677	15.7007
2017	2017	3	-1.9723	0.0123	17.7552
2018	2018	3	4.0994	-0.1225	20.6247
2019	2019	3	-1.5414	-0.0689	44.2857
2020	2020	3	-1.2465	0.0340	-2.4134
2021	2021	3	-0.1690	-0.0505	16.7089
2022	2022	3	0.1344	-0.0690	17.5767
2023	2023	3	0.9644	-0.1262	23.9603
2024	2024	3	2.0384	-0.2103	30.4753
2025	2025	3	4.5262	-0.4417	47.9714
2026	2026	3	3.4807	-0.4261	32.5352
2027	2027	3	3.9436	-0.5348	31.1116
2028	2028	3	4.5536	-0.6795	30.2961
2029	2029	3	4.8684	-0.7989	27.3836
2030	2030	3	4.9673	-0.9096	24.5096
2031	2031	3	5.0865	-0.9474	20.1742
2032	2032	3	4.8793	-1.0056	17.7808
2033	2033	3	4.6320	-1.0543	15.7803
2034	2034	3	4.3655	-1.0969	14.1249
2035	2035	3	4.0807	-1.1390	12.8123
2036	2036	3	3.8076	-1.1648	11.5496
2037	2037	3	3.5417	-1.1887	10.5057
2038	2038	3	3.2793	-1.2049	9.5762
2039	2039	3	3.0357	-1.2185	8.7799
2040	2040	3	2.8032	-1.2286	8.0825

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2041          2041       3            2.5647           -1.2034            7.2582
2042          2042       3            2.4018           -1.2091            6.7416
2043          2043       3            2.2033           -1.2237            6.3558
2044          2044       3            2.0402           -1.2164            5.8890
2045          2045       3            1.8815           -1.2057            5.4663
2046          2046       3            1.6834           -1.1668            4.9758
2047          2047       3            1.5551           -1.1570            4.6635
2048          2048       3            1.4237           -1.1416            4.3618
2049          2049       3            1.2542           -1.1392            4.1548
2050          2050       3            1.1467           -1.1150            3.8719

2051          2151       1            0.0000            0.0000            0.0000
2051          2151       2            0.0000            0.0000            0.0000
2051          2151       3            0.0000            0.0000            0.0000
2011          2151       4            0.0000            0.0000            0.0000
2011          2151       5            0.0000            0.0000            0.0000
2011          2151       6            0.0000            0.0000            0.0000

FUEL_CONSUMPTION
** Source: TAG Data Book - Table A 1.3.8 (Derived)
** For 2010 base year
** Fuel consumption (l/km) = (a_fuel+b_fuel*V+c_fuel*V^2+d_fuel*v^3)/v where v is speed in km/h
*Veh_type Fuel_type a_Fuel             b_Fuel             c_Fuel             d_Fuel       Cut-off_max-speed(km/h)    Cut-off_min-speed(km/h)
1         1         0.470670592        0.100025135        -1.13941E-03       7.54620E-06               130                  10
1         2         0.506917095        0.072679375        -6.99196E-04       5.50970E-06               130                  10
1         3         0.000000000        0.213658961         0.00000E+00       0.00000E+00               120                  10
2         1         0.348674547        0.195516502        -3.06897E-03       1.98195E-05               120                  10
2         2         0.468770124        0.114569329        -1.65287E-03       1.39933E-05               110                  10
2         3         0.000000000        0.232318297         0.00000E+00       0.00000E+00               120                  10
3         1         0.348674547        0.195516502        -3.06897E-03       1.98195E-05               120                  10
3         2         0.468770124        0.114569329        -1.65287E-03       1.39933E-05               110                  10
3         3         0.000000000        0.232318297         0.00000E+00       0.00000E+00               120                  10
4         2         2.611464814        0.138557025        -1.00149E-03       1.09379E-05                85                  12
5         2         5.722097835        0.297158680        -1.96883E-03       1.17351E-05                85                  12
6         2         3.360187016        0.295249387        -3.20910E-03       2.35400E-05                85                  12

FUEL_EFFICIENCY
** Source: TAG Data Book - Table A 1.3.10
** %change per annum from 2010 base year
*Start_yr      End_yr     Veh_type  Fuel_type        Change
2011          2011              1         1          0.604
2011          2011              1         2          0.874
2011          2011              1         3          0.032
2011          2011              2         1         -0.168
2011          2011              2         2          0.177
2011          2011              2         3          0.000
2011          2011              3         1         -0.168
2011          2011              3         2          0.177
2011          2011              3         3          0.000
2011          2011              4         2         -0.113
2011          2011              5         2          0.011
2012          2012              1         1          0.285
2012          2012              1         2          0.975
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2012	2012	1	3	-0.707
2012	2012	2	1	-0.630
2012	2012	2	2	0.468
2012	2012	2	3	0.000
2012	2012	3	1	-0.630
2012	2012	3	2	0.468
2012	2012	3	3	0.000
2012	2012	4	2	-2.932
2012	2012	5	2	0.288
2013	2013	1	1	0.891
2013	2013	1	2	0.920
2013	2013	1	3	0.085
2013	2013	2	1	0.031
2013	2013	2	2	0.107
2013	2013	2	3	0.000
2013	2013	3	1	0.031
2013	2013	3	2	0.107
2013	2013	3	3	0.000
2013	2013	4	2	0.475
2013	2013	5	2	0.068
2014	2014	1	1	0.979
2014	2014	1	2	0.945
2014	2014	1	3	-1.015
2014	2014	2	1	-0.518
2014	2014	2	2	0.057
2014	2014	2	3	-0.042
2014	2014	3	1	-0.518
2014	2014	3	2	0.057
2014	2014	3	3	-0.042
2014	2014	4	2	-1.038
2014	2014	5	2	0.144
2015	2015	1	1	1.281
2015	2015	1	2	1.319
2015	2015	1	3	-0.927
2015	2015	2	1	2.498
2015	2015	2	2	0.323
2015	2015	2	3	-0.454
2015	2015	3	1	2.498
2015	2015	3	2	0.323
2015	2015	3	3	-0.454
2015	2015	4	2	0.361
2015	2015	5	2	0.480
2016	2016	1	1	1.406
2016	2016	1	2	1.207
2016	2016	1	3	1.034
2016	2016	2	1	-0.062
2016	2016	2	2	0.705
2016	2016	2	3	0.340
2016	2016	3	1	-0.062
2016	2016	3	2	0.705
2016	2016	3	3	0.340
2016	2016	4	2	0.747
2016	2016	5	2	0.239

2017	2017	1	1	1.270
2017	2017	1	2	0.783
2017	2017	1	3	1.188
2017	2017	2	1	1.646
2017	2017	2	2	1.249
2017	2017	2	3	0.804
2017	2017	3	1	1.646
2017	2017	3	2	1.249
2017	2017	3	3	0.804
2017	2017	4	2	-0.771
2017	2017	5	2	0.316
2018	2018	1	1	1.029
2018	2018	1	2	0.063
2018	2018	1	3	1.035
2018	2018	2	1	3.029
2018	2018	2	2	0.770
2018	2018	2	3	0.708
2018	2018	3	1	3.029
2018	2018	3	2	0.770
2018	2018	3	3	0.708
2018	2018	4	2	-0.058
2018	2018	5	2	0.407
2019	2019	1	1	0.990
2019	2019	1	2	-0.041
2019	2019	1	3	2.359
2019	2019	2	1	1.141
2019	2019	2	2	0.522
2019	2019	2	3	2.118
2019	2019	3	1	1.141
2019	2019	3	2	0.522
2019	2019	3	3	2.118
2019	2019	4	2	0.247
2019	2019	5	2	0.388
2020	2020	1	1	2.680
2020	2020	1	2	1.323
2020	2020	1	3	2.699
2020	2020	2	1	1.842
2020	2020	2	2	1.432
2020	2020	2	3	-2.324
2020	2020	3	1	1.842
2020	2020	3	2	1.432
2020	2020	3	3	-2.324
2020	2020	4	2	0.341
2020	2020	5	2	0.470
2021	2021	1	1	2.289
2021	2021	1	2	1.469
2021	2021	1	3	5.660
2021	2021	2	1	1.283
2021	2021	2	2	1.165
2021	2021	2	3	-0.804
2021	2021	3	1	1.283
2021	2021	3	2	1.165
2021	2021	3	3	-0.804

2021	2021	4	2	0.484
2021	2021	5	2	0.523
2022	2022	1	1	2.080
2022	2022	1	2	1.497
2022	2022	1	3	3.960
2022	2022	2	1	2.960
2022	2022	2	2	1.102
2022	2022	2	3	-0.880
2022	2022	3	1	2.960
2022	2022	3	2	1.102
2022	2022	3	3	-0.880
2022	2022	4	2	0.491
2022	2022	5	2	0.531
2023	2023	1	1	1.895
2023	2023	1	2	1.393
2023	2023	1	3	2.637
2023	2023	2	1	1.045
2023	2023	2	2	0.925
2023	2023	2	3	-1.450
2023	2023	3	1	1.045
2023	2023	3	2	0.925
2023	2023	3	3	-1.450
2023	2023	4	2	0.500
2023	2023	5	2	0.548
2024	2024	1	1	1.891
2024	2024	1	2	1.258
2024	2024	1	3	2.035
2024	2024	2	1	1.277
2024	2024	2	2	0.822
2024	2024	2	3	-1.389
2024	2024	3	1	1.277
2024	2024	3	2	0.822
2024	2024	3	3	-1.389
2024	2024	4	2	0.490
2024	2024	5	2	0.544
2025	2025	1	1	1.650
2025	2025	1	2	1.164
2025	2025	1	3	1.843
2025	2025	2	1	2.913
2025	2025	2	2	1.999
2025	2025	2	3	-1.541
2025	2025	3	1	2.913
2025	2025	3	2	1.999
2025	2025	3	3	-1.541
2025	2025	4	2	0.918
2025	2025	5	2	1.864
2026	2026	1	1	1.468
2026	2026	1	2	1.107
2026	2026	1	3	1.211
2026	2026	2	1	2.351
2026	2026	2	2	1.780
2026	2026	2	3	-0.553
2026	2026	3	1	2.351

2026	2026	3	2	1.780
2026	2026	3	3	-0.553
2026	2026	4	2	0.900
2026	2026	5	2	1.854
2027	2027	1	1	1.372
2027	2027	1	2	1.130
2027	2027	1	3	0.922
2027	2027	2	1	3.660
2027	2027	2	2	1.600
2027	2027	2	3	-0.253
2027	2027	3	1	3.660
2027	2027	3	2	1.600
2027	2027	3	3	-0.253
2027	2027	4	2	0.874
2027	2027	5	2	1.767
2028	2028	1	1	1.234
2028	2028	1	2	1.148
2028	2028	1	3	0.747
2028	2028	2	1	1.853
2028	2028	2	2	1.433
2028	2028	2	3	0.019
2028	2028	3	1	1.853
2028	2028	3	2	1.433
2028	2028	3	3	0.019
2028	2028	4	2	0.846
2028	2028	5	2	1.644
2029	2029	1	1	1.110
2029	2029	1	2	1.140
2029	2029	1	3	0.694
2029	2029	2	1	1.699
2029	2029	2	2	1.299
2029	2029	2	3	0.258
2029	2029	3	1	1.699
2029	2029	3	2	1.299
2029	2029	3	3	0.258
2029	2029	4	2	0.808
2029	2029	5	2	1.531
2030	2030	1	1	2.306
2030	2030	1	2	2.305
2030	2030	1	3	0.690
2030	2030	2	1	3.530
2030	2030	2	2	2.726
2030	2030	2	3	0.398
2030	2030	3	1	3.530
2030	2030	3	2	2.726
2030	2030	3	3	0.398
2030	2030	4	2	1.394
2030	2030	5	2	3.225
2031	2031	1	1	2.230
2031	2031	1	2	2.375
2031	2031	1	3	0.571
2031	2031	2	1	1.740
2031	2031	2	2	2.564

2031	2031	2	3	0.251
2031	2031	3	1	1.740
2031	2031	3	2	2.564
2031	2031	3	3	0.251
2031	2031	4	2	1.307
2031	2031	5	2	3.126
2032	2032	1	1	2.088
2032	2032	1	2	2.387
2032	2032	1	3	0.492
2032	2032	2	1	2.870
2032	2032	2	2	2.133
2032	2032	2	3	0.170
2032	2032	3	1	2.870
2032	2032	3	2	2.133
2032	2032	3	3	0.170
2032	2032	4	2	1.294
2032	2032	5	2	2.946
2033	2033	1	1	2.021
2033	2033	1	2	2.185
2033	2033	1	3	0.435
2033	2033	2	1	2.820
2033	2033	2	2	2.016
2033	2033	2	3	0.145
2033	2033	3	1	2.820
2033	2033	3	2	2.016
2033	2033	3	3	0.145
2033	2033	4	2	1.240
2033	2033	5	2	2.667
2034	2034	1	1	1.933
2034	2034	1	2	1.998
2034	2034	1	3	0.405
2034	2034	2	1	3.326
2034	2034	2	2	1.646
2034	2034	2	3	0.151
2034	2034	3	1	3.326
2034	2034	3	2	1.646
2034	2034	3	3	0.151
2034	2034	4	2	1.176
2034	2034	5	2	2.450
2035	2035	1	1	1.795
2035	2035	1	2	1.826
2035	2035	1	3	0.374
2035	2035	2	1	-0.177
2035	2035	2	2	1.517
2035	2035	2	3	0.162
2035	2035	3	1	-0.177
2035	2035	3	2	1.517
2035	2035	3	3	0.162
2035	2035	4	2	1.110
2035	2035	5	2	2.072
2036	2036	1	1	1.602
2036	2036	1	2	1.723
2036	2036	1	3	0.362

2036	2036	2	1	1.873
2036	2036	2	2	1.401
2036	2036	2	3	0.192
2036	2036	3	1	1.873
2036	2036	3	2	1.401
2036	2036	3	3	0.192
2036	2036	4	2	1.026
2036	2036	5	2	1.652
2037	2037	1	1	1.499
2037	2037	1	2	1.565
2037	2037	1	3	0.374
2037	2037	2	1	1.484
2037	2037	2	2	1.325
2037	2037	2	3	0.232
2037	2037	3	1	1.484
2037	2037	3	2	1.325
2037	2037	3	3	0.232
2037	2037	4	2	0.935
2037	2037	5	2	1.356
2038	2038	1	1	1.372
2038	2038	1	2	1.357
2038	2038	1	3	0.386
2038	2038	2	1	2.766
2038	2038	2	2	1.280
2038	2038	2	3	0.263
2038	2038	3	1	2.766
2038	2038	3	2	1.280
2038	2038	3	3	0.263
2038	2038	4	2	0.848
2038	2038	5	2	1.046
2039	2039	1	1	1.233
2039	2039	1	2	1.098
2039	2039	1	3	0.402
2039	2039	2	1	0.398
2039	2039	2	2	0.831
2039	2039	2	3	0.296
2039	2039	3	1	0.398
2039	2039	3	2	0.831
2039	2039	3	3	0.296
2039	2039	4	2	0.758
2039	2039	5	2	0.806
2040	2040	1	1	1.198
2040	2040	1	2	1.161
2040	2040	1	3	0.342
2040	2040	2	1	0.753
2040	2040	2	2	0.771
2040	2040	2	3	0.329
2040	2040	3	1	0.753
2040	2040	3	2	0.771
2040	2040	3	3	0.329
2040	2040	4	2	0.660
2040	2040	5	2	0.599
2041	2041	1	1	1.300

2041	2041	1	2	1.581
2041	2041	1	3	0.360
2041	2041	2	1	1.010
2041	2041	2	2	1.026
2041	2041	2	3	0.390
2041	2041	3	1	1.010
2041	2041	3	2	1.026
2041	2041	3	3	0.390
2041	2041	4	2	0.582
2041	2041	5	2	0.436
2042	2042	1	1	0.879
2042	2042	1	2	0.843
2042	2042	1	3	0.374
2042	2042	2	1	0.496
2042	2042	2	2	0.525
2042	2042	2	3	0.477
2042	2042	3	1	0.496
2042	2042	3	2	0.525
2042	2042	3	3	0.477
2042	2042	4	2	0.512
2042	2042	5	2	0.335
2043	2043	1	1	0.765
2043	2043	1	2	0.693
2043	2043	1	3	0.385
2043	2043	2	1	0.415
2043	2043	2	2	0.437
2043	2043	2	3	0.533
2043	2043	3	1	0.415
2043	2043	3	2	0.437
2043	2043	3	3	0.533
2043	2043	4	2	0.451
2043	2043	5	2	0.259
2044	2044	1	1	0.624
2044	2044	1	2	0.557
2044	2044	1	3	0.405
2044	2044	2	1	0.345
2044	2044	2	2	0.357
2044	2044	2	3	0.581
2044	2044	3	1	0.345
2044	2044	3	2	0.357
2044	2044	3	3	0.581
2044	2044	4	2	0.404
2044	2044	5	2	0.202
2045	2045	1	1	0.483
2045	2045	1	2	0.421
2045	2045	1	3	0.407
2045	2045	2	1	0.285
2045	2045	2	2	0.288
2045	2045	2	3	0.623
2045	2045	3	1	0.285
2045	2045	3	2	0.288
2045	2045	3	3	0.623
2045	2045	4	2	0.365

2045	2045	5	2	0.160
2046	2046	1	1	0.320
2046	2046	1	2	0.344
2046	2046	1	3	0.428
2046	2046	2	1	0.652
2046	2046	2	2	0.858
2046	2046	2	3	0.645
2046	2046	3	1	0.652
2046	2046	3	2	0.858
2046	2046	3	3	0.645
2046	2046	4	2	0.374
2046	2046	5	2	0.157
2047	2047	1	1	0.238
2047	2047	1	2	0.257
2047	2047	1	3	0.441
2047	2047	2	1	0.150
2047	2047	2	2	0.136
2047	2047	2	3	0.686
2047	2047	3	1	0.150
2047	2047	3	2	0.136
2047	2047	3	3	0.686
2047	2047	4	2	0.304
2047	2047	5	2	0.087
2048	2048	1	1	0.179
2048	2048	1	2	0.195
2048	2048	1	3	0.452
2048	2048	2	1	0.126
2048	2048	2	2	0.108
2048	2048	2	3	0.717
2048	2048	3	1	0.126
2048	2048	3	2	0.108
2048	2048	3	3	0.717
2048	2048	4	2	0.288
2048	2048	5	2	0.074
2049	2049	1	1	0.135
2049	2049	1	2	0.148
2049	2049	1	3	0.461
2049	2049	2	1	0.106
2049	2049	2	2	0.087
2049	2049	2	3	0.745
2049	2049	3	1	0.106
2049	2049	3	2	0.087
2049	2049	3	3	0.745
2049	2049	4	2	0.275
2049	2049	5	2	0.062
2050	2050	1	1	0.103
2050	2050	1	2	0.114
2050	2050	1	3	0.472
2050	2050	2	1	0.091
2050	2050	2	2	0.072
2050	2050	2	3	0.770
2050	2050	3	1	0.091
2050	2050	3	2	0.072

```
2050          2050          3         3           0.770
2050          2050          4         2           0.266
2050          2050          5         2           0.055
2051          2151          1         1           0.000
2051          2151          1         2           0.000
2051          2151          1         3           0.000
2051          2151          2         1           0.000
2051          2151          2         2           0.000
2051          2151          2         3           0.000
2051          2151          3         1           0.000
2051          2151          3         2           0.000
2051          2151          3         3           0.000
2051          2151          4         2           0.000
2051          2151          5         2           0.000
2011          2151          6         2           0.000

NON_FUEL_VOC
** Source: TAG Data Book - Table A 1.3.14
** For 2010 base year
*Veh_type Fuel_type a_Nonfuel_wrk  b_Nonfuel_wrk  a_Nonfuel_nw   b_Nonfuel_nw
       1       1         4.966        135.946         3.846         0.000
       1       2         4.966        135.946         3.846         0.000
       1       3         1.157        135.946         1.157         0.000
       2       1         7.213         47.113         7.213         0.000
       2       2         7.213         47.113         7.213         0.000
       2       3         2.170         47.113         2.170         0.000
       3       1         7.213         47.113         7.213         0.000
       3       2         7.213         47.113         7.213         0.000
       3       3         2.170         47.113         2.170         0.000
       4       2         6.714        263.817         0.000         0.000
       5       2        13.061        508.525         0.000         0.000
       6       2        30.461        694.547         0.000         0.000

NON_FUEL_VOC_CHANGES
** Source: TAG Unit A1.3 para 5.1.17
** Note: Table A 1.3.15 shows changes by average car (taking into account changes in FLEET mix)
** %change per annum from 2010 base year
*Start_yr      End_yr     Veh_type      Growth
2011           2151         1            0.000
2011           2151         2            0.000
2011           2151         3            0.000
2011           2151         4            0.000
2011           2151         5            0.000
2011           2151         6            0.000
2011           2151         7            0.000
2011           2151         8            0.000

NON_FUEL_TAX_RATES
** For 2010 base year
** percentage
*Submode     Final     Intermediate
  1          17.5           0.0
  2          17.5           0.0
```

```
  3         17.5          0.0
  4         17.5          0.0
  5         17.5          0.0
  6         17.5          0.0
  7          0.0          0.0
  8          0.0          0.0

NON_FUEL_TAX_RATES_CHANGES
** %change per annum from 2010 base year
*Start_yr     End_yr    Submode        Final     Intermediate
2011          2011        1          14.286          0.000
2011          2011        2          14.286          0.000
2011          2011        3          14.286          0.000
2011          2011        4          14.286          0.000
2011          2011        5          14.286          0.000
2011          2011        6          14.286          0.000
2011          2011        7           0.000          0.000
2011          2011        8           0.000          0.000
2012          2151        1           0.000          0.000
2012          2151        2           0.000          0.000
2012          2151        3           0.000          0.000
2012          2151        4           0.000          0.000
2012          2151        5           0.000          0.000
2012          2151        6           0.000          0.000
2012          2151        7           0.000          0.000
2012          2151        8           0.000          0.000

DEFAULT_PURPOSE_SPLIT
** Source: TAG Data Book - Table A 1.3.4
** For 2010 base year
*Vtype/submode   Purpose  Period1  Period2  Period3  Period4  Period5
  1             1       16.5     11.8     16.5     12.9     12.9     16.5     11.8      3.5      3.5      3.5
  1             2       14.7     13.8      3.9     12.8     12.8     14.7     13.8      2.6      2.6      2.6
  1             3       14.7     13.8      4.0     12.9     12.9     14.7     13.8      2.7      2.7      2.7
  1             4       14.7     13.7      3.9     12.8     12.8     14.7     13.7      2.6      2.6      2.6
  1             5       13.1     15.6     23.9     16.2     16.2     13.1     15.6     29.5     29.5     29.5
  1             6       13.2     15.7     23.9     16.2     16.2     13.2     15.7     29.6     29.6     29.6
  1             7       13.1     15.6     23.9     16.2     16.2     13.1     15.6     29.5     29.5     29.5
  2             1        0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
  2             2        0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
  2             3        0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
  2             4        0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
  2             5       33.3     33.3     33.3     33.3     33.3     33.3     33.3     33.3     33.3     33.3
  2             6       33.4     33.4     33.4     33.4     33.4     33.4     33.4     33.4     33.4     33.4
  2             7       33.3     33.3     33.3     33.3     33.3     33.3     33.3     33.3     33.3     33.3
  3             1      100.0    100.0    100.0    100.0    100.0    100.0    100.0    100.0    100.0    100.0
  3             2        0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
  3             3        0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
  3             4        0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
  3             5        0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
  3             6        0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
  3             7        0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
  4             1      100.0    100.0    100.0    100.0    100.0    100.0    100.0    100.0    100.0    100.0
```

4	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	1	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
5	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	1	1.4	2.3	1.7	2.3	2.3	1.4	2.3	0.5	0.5	0.5
6	2	6.1	8.6	2.2	11.8	11.8	6.1	8.6	2.0	2.0	2.0
6	3	6.2	8.7	2.2	11.8	11.8	6.2	8.7	2.1	2.1	2.1
6	4	6.1	8.6	2.1	11.8	11.8	6.1	8.6	2.0	2.0	2.0
6	5	26.7	23.9	30.6	20.8	20.8	26.7	23.9	31.1	31.1	31.1
6	6	26.8	24.0	30.6	20.8	20.8	26.8	24.0	31.2	31.2	31.2
6	7	26.7	23.9	30.6	20.7	20.7	26.7	23.9	31.1	31.1	31.1
7	1	4.5	5.2	3.2	2.5	2.5	4.5	5.2	0.7	0.7	0.7
7	2	16.7	15.3	3.6	18.2	18.2	16.7	15.3	2.5	2.5	2.5
7	3	16.7	15.3	3.6	18.3	18.3	16.7	15.3	2.6	2.6	2.6
7	4	16.7	15.3	3.5	18.2	18.2	16.7	15.3	2.5	2.5	2.5
7	5	15.1	16.3	28.7	14.3	14.3	15.1	16.3	30.6	30.6	30.6
7	6	15.2	16.3	28.7	14.3	14.3	15.2	16.3	30.6	30.6	30.6
7	7	15.1	16.3	28.7	14.2	14.2	15.1	16.3	30.5	30.5	30.5
8	1	17.1	15.7	15.8	17.7	17.7	17.1	15.7	1.8	1.8	1.8
8	2	10.4	12.7	1.8	12.9	12.9	10.4	12.7	0.9	0.9	0.9
8	3	10.4	12.7	1.9	12.9	12.9	10.4	12.7	1	1	1
8	4	10.4	12.7	1.8	12.8	12.8	10.4	12.7	0.9	0.9	0.9
8	5	17.2	15.4	26.2	14.6	14.6	17.2	15.4	31.8	31.8	31.8
8	6	17.3	15.4	26.3	14.6	14.6	17.3	15.4	31.8	31.8	31.8
8	7	17.2	15.4	26.2	14.5	14.5	17.2	15.4	31.8	31.8	31.8

DEFAULT_PERSON_FACTORS
** Source: TAG Data Book - Table A 1.3.3
** For 2010 base year

**			AM - AM	PM - PM	IP - IP	OP - OPCWD	OP - OPNCWD	AM - AMS	PM - PMS	WE - PKWE	WE - OPCWE	WE - OPNCWE
*Vtype/submode	Purpose	Person_type	FactorPer1	FactorPer2	FactorPer3	FactorPer4	FactorPer5					
1	1	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1	1	2	0.13	0.15	0.16	0.17	0.17	0.13	0.15	0.31	0.31	0.31
1	2	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1	2	2	0.13	0.14	0.15	0.15	0.15	0.13	0.14	0.21	0.21	0.21
1	3	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1	3	2	0.13	0.14	0.15	0.15	0.15	0.13	0.14	0.21	0.21	0.21
1	4	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1	4	2	0.13	0.14	0.15	0.15	0.15	0.13	0.14	0.21	0.21	0.21
1	5	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1	5	2	0.71	0.79	0.82	0.79	0.79	0.71	0.79	1.12	1.12	1.12
1	6	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1	6	2	0.71	0.79	0.82	0.79	0.79	0.71	0.79	1.12	1.12	1.12
1	7	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

```
 1        7      2      0.71      0.79      0.82      0.79      0.79      0.71      0.79      1.12      1.12      1.12
 2        5      1      1.00      1.00      1.00      1.00      1.00      1.00      1.00      1.00      1.00      1.00
 2        5      2      0.46      0.46      0.46      0.46      0.46      0.46      0.46      1.03      1.03      1.03
 2        6      1      1.00      1.00      1.00      1.00      1.00      1.00      1.00      1.00      1.00      1.00
 2        6      2      0.46      0.46      0.46      0.46      0.46      0.46      0.46      1.03      1.03      1.03
 2        7      1      1.00      1.00      1.00      1.00      1.00      1.00      1.00      1.00      1.00      1.00
 2        7      2      0.46      0.46      0.46      0.46      0.46      0.46      0.46      1.03      1.03      1.03
 3        1      1      1.00      1.00      1.00      1.00      1.00      1.00      1.00      1.00      1.00      1.00
 3        1      2      0.20      0.20      0.20      0.20      0.20      0.20      0.20      0.26      0.26      0.26
 4        1      1      1.00      1.00      1.00      1.00      1.00      1.00      1.00      1.00      1.00      1.00
 4        1      2      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00
 5        1      1      1.00      1.00      1.00      1.00      1.00      1.00      1.00      1.00      1.00      1.00
 5        1      2      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00
```

```
DEFAULT_PERSON_FACTORS_CHANGE
** Source: TAG Data Book - Table A 1.3.3
** %change per annum from 2010 base year
*Start_yr   End_yr   Submode Purpose Person_type ChangePer1 ChangePer2 ChangePer3 ChangePer4 ChangePer5
2011       2036          1       1        2      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00
2011       2036          1       2        2      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00
2011       2036          1       3        2      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00
2011       2036          1       4        2      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00
2011       2036          1       5        2      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00
2011       2036          1       6        2      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00
2011       2036          1       7        2      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00
2011       2036          2       3        2      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00
2011       2036          3       1        2      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00
2011       2036          4       1        2      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00
2011       2036          5       1        2      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00

2037       2151          1       1        2      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00
2037       2151          1       2        2      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00
2037       2151          1       3        2      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00
2037       2151          1       4        2      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00
2037       2151          1       5        2      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00
2037       2151          1       6        2      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00
2037       2151          1       7        2      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00
2037       2151          2       3        2      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00
2037       2151          3       1        2      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00
2037       2151          4       1        2      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00
2037       2151          5       1        2      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00

PREPARATION&SUPERVISION
** Source: DMRB Volume 13, section 13.1.2.7 The Preparation of Cost Data
** total preparation (by stage & mode) and supervision costs as % of land and construction costs
*Mode   Prep:SI     Prep:PC     Prep:PR     Prep:OP     Prep:WC       Super
  1       12.0        9.0         9.0         6.0         2.0          5.0
  2       12.0        9.0         9.0         6.0         2.0          5.0
  3       12.0        9.0         9.0         6.0         2.0          5.0
```

A.13 TUBA N-1 test

Purpose of this Annex

A.13.1 This Annex explains how the robustness of the Project's user and provider benefits has been assessed and reports the results of methods that were used to inform this assessment.

Overview of transport model uncertainty

A.13.2 All outcomes of a transport model, such as its predicted traffic flows, amounts and locations of delay, and routes, journey times and travel speeds between origins and destinations, are subject to uncertainty. This uncertainty arises from a variety of sources, including the variability of the observed data on which the model is calibrated, the mismatch between theoretical travel demand algorithms and real-world traveller behaviours and the practicalities of reaching an equilibrium point with a variable demand model.

A.13.3 A transport model iterates between updates of supply and demand as it runs, continuing until its demand forecasts satisfy chosen convergence criteria. Paragraph 6.3.1 of TAG Unit M2.1 emphasises that it is crucial that the whole transport model converges to a satisfactory degree, so that there can be confidence that the model's results are as free as possible from noise that arises from an imbalance between demand and supply. Different amounts of noise will be present in a model's outputs depending on the values of convergence statistics at the point at which the scenarios are terminated.

A.13.4 The user benefits derived from a transport intervention are an important component in assessing the VfM of a scheme. Since these benefits are calculated from the transport model's outputs, they are also subject to uncertainty. The greater the amount of noise in a transport model, the greater the uncertainty in the values of user benefits derived from its outputs.

A.13.5 The degree of convergence between demand and supply in a transport model is typically measured using a statistic called the demand/supply relative gap. This is calculated from the changes in demand between successive demand/supply iterations, weighted by network user costs (see paragraph 6.3.4 in TAG Unit M2.1). The lower the value of the relative gap, the less is the noise in the model's results. Paragraph 6.3.8 in TAG Unit M2.1 states that relative gap values of 0.2% or less should be achieved, but that gaps of 0.1% or less are possible in many cases.

A.13.6 TAG does not specify the set of transport model demand and cost data over which the relative gap should be calculated when assessing convergence. The DIADEM v6.3.4 software used to build LTAM's variable demand model allows the calculation of two relative gap values:

a. one calculated over the demands and costs for travel between all model zones - this is referred to as the 'whole model' value;

b. one calculated over the demand and costs for a user-defined subset of model zones - this is referred to as the 'subarea' value.

A.13.7 For LTAM, the subarea is defined as the set of zone-to-zone movements with at least one trip end in the Fully Modelled Area (see Plate A.1 in Annex A).

A.13.8 The values of the convergence criteria used for LTAM are 0.05% for the whole model relative gap and 0.15% for the subarea relative gap. These values were chosen because they are tighter than the targets suggested by TAG while also being readily achievable for all model forecast years.

A.13.9 Recognising the importance of model convergence to the robust calculation of benefits, paragraph 6.3.3 of TAG Unit M2.1 states that:

A.13.10 "improved demand convergence can reduce the convergence errors to less than 10% of the economic benefit derived from the intervention."

A.13.11 Later, paragraph 6.3.10 states that:

A.13.12 *"The required level of convergence needs to be linked to the scale of the benefits of the scheme being appraised, relative to the network size. For instance, the calculation of benefits from small schemes in large networks will be much more sensitive to convergence than large schemes in small networks. On the basis of testing, it has been discovered that the following rule of thumb may be a useful indicator of the suitability of the convergence of the model:* ***ideally the user benefits, as a percentage of network costs, should be at least 10 times the % Gap achieved in the Without-Scheme and With-Scheme scenarios."***

Assessing the robustness of LTC's user benefits

A.13.13 To assist in assessing the robustness of user benefits calculated using TUBA, the TUBA Economics output file contains a table of sensitivity information, which shows the scheme's user benefits as a proportion of network costs across the whole model.

A.13.14 For the Project's Core traffic growth scenario, the scheme's user benefits as percentages of network costs in each modelled year are shown in Table A.37. These range from 0.16% to 0.21%, depending on year.

Table A.37 User benefits as percentages of network costs

```
SENSITIVITY
Total user benefits as a percentage of total DM user costs
    Modelled Years
Mode   2030 2037 2045 2051
Road   0.16% 0.19% 0.20% 0.21%
```

A.13.15 The smaller the values in Table A.37 are, the greater the potential for model noise to overwhelm the calculated benefits and therefore the tighter the model's convergence needs to be to reduce the likelihood of this.

A.13.16 The fact that a scheme's benefits are a small or large proportion of the total network costs does not in itself allow a conclusion to be reached about their reliability. The benefits could be a small proportion of the total costs in a very well converged model or a large proportion of the total costs in a badly converged model. What counts for robustness is the size of those benefits in comparison to model noise.

A.13.17 To satisfy the rule of thumb given in TAG Unit M2.1, the proportions given in Table A.38 imply a need for model convergence with a whole model relative gap of between 0.016%-0.021%. These are less than the achieved gap values for the Core growth With Scheme and Without Scheme scenarios, which are tabulated in Table A.38.

Table A.38 Whole model and subarea gap values Core growth

Whole Model					Subarea				
	2030	2037	2045	2051		2030	2037	2045	2051
CM49	0.032%	0.046%	0.032%	0.033%	**CM49**	0.081%	0.102%	0.087%	0.097%
CS72	0.031%	0.044%	0.033%	0.034%	**CS72**	0.076%	0.100%	0.111%	0.101%

A.13.18 TAG's rule of thumb is simply a guide to the likely level of convergence that would be necessary. However, a more direct method can be used to determine the actual levels of noise in a transport model's outputs and whether they are of concern.

Methodology

A.13.19 The effect of model noise on scheme user benefits is quantified by taking the model's outputs for the Without- and With-Scheme scenarios from the demand/supply loop immediately prior to the one in which the model was terminated and using these outputs to calculate benefits. The outputs obtained from these calculations are compared to the user benefits obtained using data from the last demand/supply loop and a judgment made as to whether the effect of model noise on benefit calculations is acceptable.

A.13.20 A scenario's final demand/supply loop, which satisfies the convergence criteria, shall be referred to as "loop N", and therefore the penultimate loop is referred to as "loop N-1". It should be noted that the value of N can vary between different forecast years and between the Without-Scheme and With-Scheme scenarios. It is typically the case that N increases as the forecast year increases due to the model needing more time to converge in the presence of increased network congestion.

A.13.21 As explained in Chapter 6, the user benefits of the Lower Thames Crossing are assessed using demands and costs for 10 time periods. The demands and costs data for three of these periods - AM, IP and PM - are taken from the results, using loop N, of the variable demand model scenarios. The demands and costs data for the remaining seven time periods are produced by applying appropriate scaling factors to the final demands from the AM, IP and PM periods and by performing fixed demand assignments with the new data. The cost components were skimmed from the results of these new assignments, as is done for the outputs of loop N.

A.13.22 It is to be noted that TUBA is run using demands and costs data from two scenarios, which the software refers to as the "Do Minimum" and the "Do Something". These names indicate how the two input sets of costs data are used in applying the Rule of a Half approach to user benefit calculation. The costs supplied for TUBA's "Do Minimum" scenario are subtracted from those supplied for TUBA's "Do Something" scenario. The naming used by TUBA indicates only how it uses the input data, and there is no requirement for TUBA's Do Minimum and Do Something to actually represent a Without- or With-Scheme scenario in a specific calculation.

A.13.23 The sensitivity of LTC's user benefits to model noise was examined in the following way:

A.13.24 The demands and costs from loop N-1 and loop N for both the Without- and With-Scheme scenarios were extracted.

A.13.25 Two separate TUBA calculations were run - one using data from the Without-Scheme scenario and one using data from the With-Scheme scenario. In each calculation, the loop N-1 data from the scenario was used as TUBA's "Do Minimum" and the loop N data from the same scenario was used as TUBA's "Do Something".

A.13.26 Additionally, a further separate TUBA calculation was run using the demands and costs from loop N-1 for both the Without- and With-Scheme scenarios as TUBA's Do Minimum and Do Something, respectively.

A.13.27 Step (2) applies the Rule of a Half to the model noise between the final and penultimate loops of a single scenario, leading to what we shall refer to here as the “value of model noise”. If the value of model noise is small compared to the overall benefits of the actual scheme, then this implies that the user benefits from the final loops of the model’s two scenarios are reliable. Conversely, if the user benefit arising from the changes between the last two loops of a scenario is large in comparison to the overall user benefit of the scheme, this would indicate that a small change to the convergence criteria could lead to a large change in the benefits predicted for the scheme.

A.13.28 Step (3) leads to the user benefits for the scheme that would be reported if the traffic model had been run with slightly more relaxed convergence criteria that led to an earlier stop.

Results

A.13.29 The results of the TUBA calculations run using the demands and costs data from loop N-1 and loop N in different combinations are shown in Table A.39. The value given for the case where data for TUBA’s Do Minimum and Do Something input scenarios is taken from loop N corresponds to the sum of the Core scheme benefits excluding the contributions from construction and maintenance delays, as reported in Table 7.11 of Chapter 7.

Table A.39 User benefits for different loops (Core growth, £000, 2010 prices and values)

TUBA DM scenario	TUBA DS scenario	Output quantity	Output value
CM49 loop N	CS72 loop N	Final loop user benefits	1,971,947
CM49 loop N-1	CS72 loop N-1	Penultimate loop user benefits	1,961,268
CM49 loop N-1	CM49 loop N	Without-scheme value of noise	-14,647
CS72 loop N-1	CS72 loop N	With-scheme value of noise	-4,093

A.13.30 The reduction in total user benefits between the calculations using loop N 1 data and those using loop N data is approximately £10.6 million, which is around 0.54% of the user benefits obtained from the outputs of the final, converged model.

A.13.31 The “value of model noise”, obtained by running TUBA with data from loop N-1 and loop N for the Core growth scenarios, is approximately 0.74% in the Without-Scheme scenario (CM49) and approximately 0.21% in with With-Scheme scenario (CS72). These values are both small in comparison to the overall user benefits from the converged model’s outputs. Therefore, it is concluded that the user benefits reported for the scheme are robust.

A.14 Maintenance appraisal assumptions

Introduction

A.14.1 When it is open, the Project will need to be closed periodically for road maintenance, inspection, and repairs. These will occur at night, several times in every year, with an increased number of closures in some post-opening years. During these closures, traffic will need to be diverted away from the Project. QUADRO 2019 v4 R17 software was used to assess the impact of planned maintenance closures of the Project in terms of their impacts on road users' delays, vehicle operating cost, accidents during the diversion, emissions, and the indirect cost revenue.

Traffic management

A.14.2 The traffic management schedule adopted in the QUADRO assessment was based on the following key assumptions that reflect National Highways objectives for traffic management closures.

Maximise Availability:

a. No day time closures

b. Minimise number and timing of night time closures

c. Night time closures to be partial rather than full lane closures wherever possible to allow some traffic flow (and not rely on coordination with the Dartford Crossing)

d. Maximise efficiency of closures across road and tunnel by phasing them together.

Maximise Safety:

a. Lane closures are high safety risk so minimise their number

b. Lane 2 used as a buffer lane. Hence 1 lane and 2 lane roads, full closures only

c. No contraflow in the tunnel.

Optimise Lower Thames Area Network (LTAN) operations:

a. Achieve by maximising the availability of the Lower Thames Crossing

b. No adverse impact upon existing A2, A13 and M25.

A.14.3 Based on these objectives, full night closures were considered and split into three categories:

a. Those carried out in a “normal year” – which provides for routine maintenance. For routine maintenance the whole route will be closed for eight nights per year

b. Those carried out in years 11, 22, 33, 44 and 55 – which provides a level of periodic maintenance for resurfacing works

c. Those carried out in year 20 - 25 – which provides a greater degree of periodic maintenance for mechanical and electrical refurbishment within the tunnel.

A.14.4 The assumptions discussed above are shown in Table A.40.

Table A.40 Projected maintenance schedule

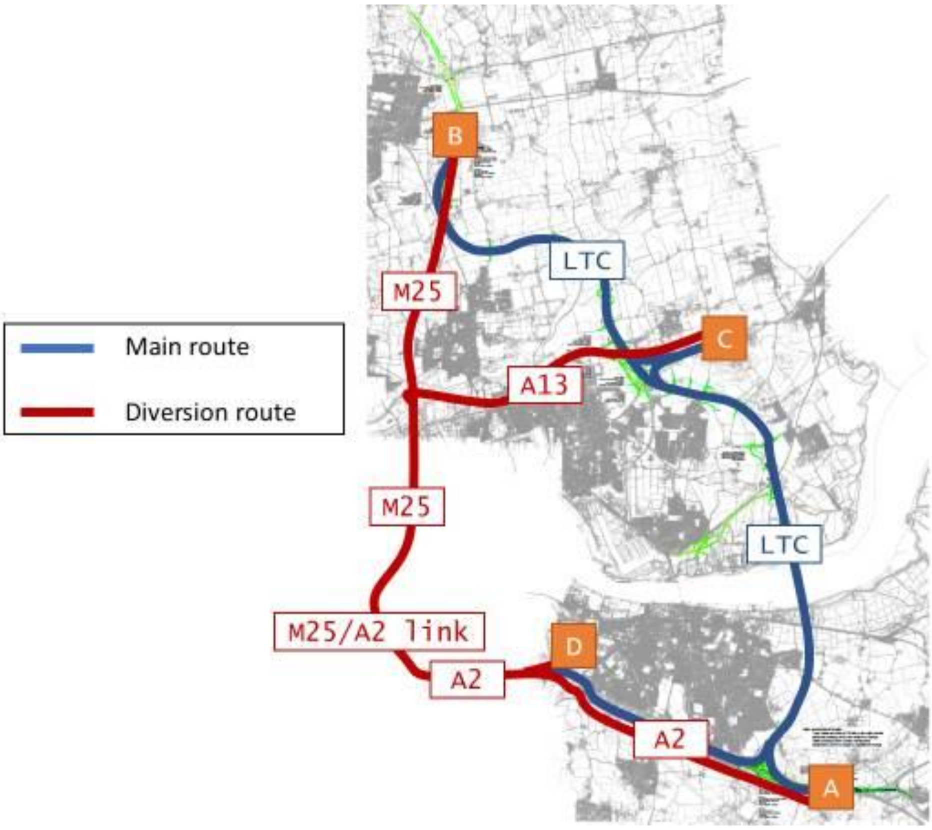
Section	Total Night Closures				
	Normal Years (Routine Maintenance)	Periodic maintenance years 11, 22, 33, 44 and 55		M&E refurbishment Tunnel 20-25 years	
			No. of crews		No of crews
Whole route	8	Detailed below	-	-	-
A2 – Tunnel	8	26	5	-	-
Tunnel	8	15	5	350	Various over 5 year period
Tunnel – A13	8	19	5	-	-
A13 – M25	8	17	5	-	-

QUADRO appraisal

A.14.5 The approach to assess the night closures in the QUADRO model is summarised below.

A.14.6 The sections of the road to be closed included the entire mainline of the Project. As such, the flows were split coarsely by origin-destination into a simple four-by-four matrix, as shown in Plate A.20. All the traffic movements affected by the closure are included in the eight routes (A-B, A-C, C-B, D-C, B-A, C-A, B-C, and C-D). For example, northbound tunnel flow for the Project is the total of A-C, D-C, A-B and route flows.

Plate A.20 Route closure diagram



A.14.7 The QUADRO model was run for each of the eight routes in the opening year 2030, then in 2037, 2045 and 2051, the years for which SATURN model flows were available. Also, model runs were carried out for the horizon year of 2089, assuming 2051 AADT to calculate of the 60 years output profile.

A.14.8 The AADT flow on each of the eight routes in all the model years was calculated from the SATURN model link flows using Select Link Analysis and annualisation factors.

A.14.9 The flows are defined as running on road class 5 “Motorway (urban or rural), dual 3-lane” and accident type 2 “dual 3-lane motorway”. They have a carriageway width of 21.9 metres, corresponding to three lanes in each direction.

A.14.10 The lengths of the main routes were calculated from link lengths in SATURN. The exact location of points A, B, C and D was chosen to be the final divergence point between main and diversionary routes.

A.14.11 QUADRO requires an input of traffic profiles for the main routes affected by the closures to calculate the number of vehicles diverted and the resulting economic impact. Because the traffic forecasts from SATURN are available only for modelled hours - these being weekdays 8-9 am, 9 am-3 pm and 5-6 pm - and QUADRO requires a full picture of traffic profiles over a typical week, the best approximation available of future traffic profiles comes from current

Dartford Crossing routes. As a result, future traffic profiles come from applying current hourly profiles to forecast traffic levels.

A.14.12 The traffic profiles were calculated from count data communicated from LTC. The raw traffic counts were averaged by the hour and day-type to give relative values for traffic flows across a week. The day-types are Monday to Thursday, Friday, Saturday, and Sunday. This operation was performed across four locations to generate a representative chronograph for future flows.

A.14.13 It is then broken down into links to represent road characteristics within the constraints imposed by the programme. These links are reassembled to create a diversionary route for each of the eight routes. A QUADRO programme module named QDIV was used to calculate the speed flow relationship based on parameters for all the diversion routes and the 16-hour AAWT of the QUADRO model years.

A.14.14 Each of the QUADRO runs (8 routes x 5 model years) provided output of a typical week. The outputs were then multiplied by the total number of night closures presented in Table A.40, which was adopted from the maintenance schedule shown in Table A.41.

Table A.41 Number of night closures for each maintenance year

Routes	Routine Maintenance	Periodic Resurfacing plus Route Maintenance*	Tunnel Refurbishment plus Route Maintenance**	Tunnel Refurbishment plus Periodic Maintenance***
	Every year	11 years interval	20-25 years interval	45-50 years interval
A – B	8	34	78	104
B – A	8	34	78	104
A – C	8	34	78	104
C – A	8	34	78	104
B – C	8	25	8	25
C – B	8	25	8	25
C – D	8	34	78	104
D – C	8	34	78	104

** Applied in the years 11, 22, 33, 44 and 55. This is considered a worst case scenario of 26 night closures for resurfacing plus 8 night closures for routine maintenance, which sum to a total of 34 night closures along the routes through the tunnel.*

*** Applied in the years 20 to 25. A total of 350 night closures for tunnel refurbishment, spread over 5 years, involving 70 nights plus 8 nights of routine maintenance work per year.*

**** Applied in the years 45-50 when resurfacing and tunnel refurbishment work were to happen in the same year. Total 350-night closures for tunnel refurbishment to spread along five years, which was 70 nights plus 34 nights of periodic maintenance work per year.*

Annex B Journey Time Reliability Impacts

B.1 Journey time reliability appraisal methodologies

Introduction

B.1.1 This annex describes the appraisal methodologies for the two incident impacts - incident delays and diversions - and travel time variability impacts.

Incident impacts

B.1.2 The journey time reliability appraisal of the Project captures two impacts related to incidents. These are:

a. the direct effect of changes in user costs resulting from changes in the frequency of incidents and their magnitude between the Without Scheme and With Scheme scenarios; and

b. the associated differences in the impacts on other road users from vehicles diverting in response to larger incident related delays.

B.1.3 Plate B.1 illustrates the logical relationship between these two impacts.

Incident delay

B.1.4 An appraisal of the direct impacts of incidents, also known as incident delays, is the core capability of MyRIAD and forms a standard part of many road project appraisals.

B.1.5 To do this, MyRIAD integrates a range of link characteristics and link usage data, from the relevant LTAM Without Scheme and With Scheme scenarios, with MyRIAD datasets which define the incident frequency and a database of reference incidents which define the distribution of incident characteristics (for example the number of lanes closed and duration of the closure).

B.1.6 Where an incident reduces a link’s capacity below the average flow for the time period, a queue of traffic will accumulate. When full capacity is restored, the queue will be at its maximum length and will begin to dissipate.

B.1.7 Average delay per vehicle and the number of vehicles impacted can be calculated on this basis, allowing the expected annual user costs to be assessed for the two scenarios and the impact of changes to be appraised on a ‘Rule of a Half’ basis.

Diversion impacts

B.1.8 Since the release of MyRIAD 2018, the appraisal of a further impact of incidents has also been included, namely diversion impacts.

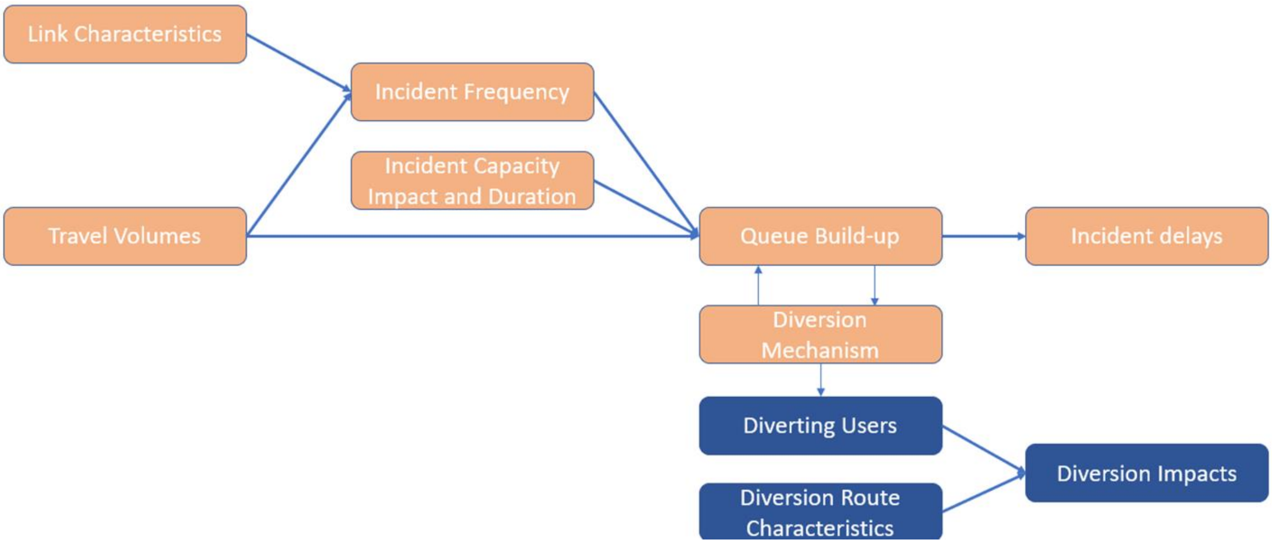
B.1.9 These reflect the additional costs imposed on other users of the road network, from users diverting to avoid queuing associated with an incident.

B.1.10 Research shows that, as an incident related queue grows, road users are increasingly likely to divert to avoid joining the queue (TRL 2004). This response forms part of MyRIAD's core queue accumulation process and it is assumed that diverted traffic experiences the same delay as the traffic that remains on the main carriageway.

B.1.11 The diversion impacts appraisal process builds on this, to integrate the estimated levels of diverted traffic for each incident, with information on the characteristics of the expected diversion route.

B.1.12 This allows the impact of the additional diverting traffic on existing users of the diversion route to be calculated on the basis of the Marginal External Cost (MEC) data provided in TAG Unit A5.4.

Plate B.1 Incident impacts (Incident delays and diversion impacts)



Incident delay appraisal approach

B.1.13 As shown in Plate B.1, incident delays were assessed for an extensive study area. This spatial coverage has been adopted to allow the appraisal to more fully capture the impact of the Project, including potential disbenefits due to increased volumes on roads in the wider area.

B.1.14 Link and flow data for each year, time period and scenario were extracted from the LTAM model covering the following items:

a. Link data:

i. Link length

ii. Link capacity (PCUs)

iii. Number of lanes[7]

b. Flow data:

i. Flows (PCUs) by user class

B.1.15 These were processed to provide inputs to the MyRIAD worksheets in the appropriate format. Link data was converted to a capacity per lane format and flow data was summarised to two variables, vehicle flow and proportion of HGVs. This conversion used LTAM's PCU factor of 2.5 for HGVs and 2 for buses.

B.1.16 One specific issue identified during the model setup was that a number of road sections within the study area do not have an exact match with the road types available within MyRIAD. The approach to the representation of these areas is outlined below.

B.1.17 The alignment between the 10 LTAM time periods and the 5 time periods defined within MyRIAD is also discussed.

Non-standard link coding

B.1.18 Partly as a product of the large scale of the study area, a small proportion of links were identified as not having a direct match to the road types available within MyRIAD.

B.1.19 These include links with the following types:

a. 1 Lane sections of Motorway and 1 Lane sections of All-Purpose Road (generally associated with marge/diverge arrangements at junctions);

b. 2 lane sections of All Lane Running (Dartford Crossing, east and west tunnels);

c. 5 and 6 lane sections of Motorway (M25); and

d. 4 and 5 lane sections of All-Purpose Road (A13, A2).

B.1.20 Analysis of the 2030 AM peak Without Scheme scenario, shows that this affects around 10% of the aggregate link length and around 10% of PCU kilometres in the study area.

B.1.21 To support a fully comprehensive appraisal and allow for the inclusion of these links within the MyRIAD appraisal, they have been coded as the closest match in terms of road type, increasing or reducing the coded lanes available as required. This has required the corresponding lane capacities to be adjusted to

[7] Lane numbers were checked in both Saturn and its SATDB database module to check for any discrepancies due to flares.

maintain alignment with the overall capacity available (i.e. 4 lanes of 2,000 PCU/lane adjusted to 3 lanes of 2,667 PCU/lane).

B.1.22 The most common adjustment being a single lane reduction from a 4 to 3 lane all-purpose road (with lane capacities increased to maintain total capacity). Because incidents impact on varying numbers of lanes, these adjustments to lane numbers and capacities influence the level of forecast incident delays in the affected areas. Analysis of the impact of reducing lane numbers, shows that this can increase incident delay costs on the affected links by 35% to 25% depending on flows, with the differences reducing in higher flow scenarios.

B.1.23 Given the relatively low proportion of flows affected, and the net pattern of positive (on the A13) and negative (on the A2) demand impacts affecting the predominant change implemented, the overall impacts of these adjustments are considered to be limited.

Time period matching

B.1.24 Another issue that had to be addressed was the need to align the 10 time periods used in the LTAM traffic model with the five time periods defined in MyRIAD. The alignment between these categorisations is shown in Table B.1.

B.1.25 The key variables impacted by this are the assumed mix of purpose types (and therefore values of time) for car travel time within the MyRIAD appraisal and the proportions of light vehicles.

B.1.26 The default MyRIAD values for these five MyRIAD time periods have been used in the appraisal. Table B.2 shows the car work time proportions used in MyRIAD while the Light Vehicle proportions are shown in Table B.3.

Table B.1 LTAM and MyRIAD time period alignment

LTAM Time Period ID	LTAM Time Period Name	Annual Hours	MyRIAD Time Period
1	AM Peak	506	AM Peak
2	Inter Peak	1,518	Inter Peak
3	PM Peak	506	PM Peak
5	Off Peak Charged	759	Off Peak
6	Off Peak Non-Charged	2,024	Off Peak
7	AM Shoulder Peak	253	AM Peak
8	PM Shoulder Peak	506	PM Peak
9	Weekend Peak Charged	1,120	Weekend
10	Weekend Off Peak Charged	672	Weekend
11	Weekend Off Peak Non-Charged	896	Weekend

Table B.2 MyRIAD car work time proportions

Time Period Label	Proportion
AM Peak	0.1646
Inter Peak	0.1647
PM Peak	0.1181
Off Peak	0.1288
Weekend	0.3470

Table B.3 MyRIAD light vehicles proportions

Time Period Label	Proportion
Car	0.8777
LGV	0.1223

Diversion impacts appraisal approach

B.1.27 As described in the MyRIAD 2021 User Manual:

B.1.28 Traffic diverting in response to an incident will cause additional congestion on the local road network, which imposes a delay cost on non-diverting traffic.

B.1.29 As shown in Table B.1, the diversion impacts appraisal is an extension of the incident delay analysis, which takes incident driven queuing levels as a key input.

B.1.30 It uses this data, derived from the normal MyRIAD incident delay process, combined with user provided data on the likely diversion routes to apply a MEC process, described more fully below, to calculate the additional costs imposed on other road users by diverting traffic.

B.1.31 These impacts are therefore driven by two factors, changes in the volume and impact of incidents (themselves a product of changing traffic volumes on each link) and changes in the characteristics (length, capacity, base flows) of the diversionary routes available.

B.1.32 As with the incident delay analysis, changes in traffic volumes are extracted directly from the relevant LTAM scenarios.

B.1.33 The characteristics of the diversion routes are however not a direct output of the traffic model. The approach adopted to estimating these is described below.

Marginal external cost process

B.1.34 Application of the MEC process is aligned with TAG guidance, which is the source for the MECs used to calculate the impact of the diverting flows projected by MyRIAD.

B.1.35 For each incident, the process is to:

a. Multiply the number of diverting vehicles by the user-specified increase in local pcu kms per diverting pcu to calculate the additional pcu kms on the diversion route

b. With the user-defined baseline V/C on the diversion route, and the user-defined capacity of the diversion route, calculate how much of the increase in pcu kms occurs in each of the congestion bands defined on the TAG MECs worksheet

c. Interpolate the marginal external costs of congestion on the TAG MECs worksheets to obtain values for the user-defined assessment years, for each congestion band

d. Apply the marginal external costs to the increase in pcu kms for each congestion band

e. Sum over congestion bands

B.1.36 The input MECs used for this are shown in Table B.4, these highlight the significant increases in MECs as congestion on the diversion route increases.

Table B.4 Marginal external cost of congestion (Pence per PCU km, 2010 Prices)

Congestion Band	V/C range	2010	2015	2020	2025	2030	2035	2040	2045	2050
1	0.00 - 0.25	1.1	1.1	1.2	1.2	1.3	1.4	1.5	1.6	1.7
2	0.25 - 0.50	2.9	2.9	3.0	3.1	3.4	3.8	4.1	4.4	4.7
3	0.50 - 0.75	9.7	9.7	9.8	10.5	13.9	12.5	16.2	14.8	18.9
4	0.75 - 1.00	55.4	55.4	57.2	59.3	62.5	63.0	63.0	63.3	63.9
5	>1.00	154.7	154.7	178.9	194.6	213.2	235.1	253.1	269.9	282.8

Route diversion characteristics

B.1.37 As outlined above the MEC process is highly reliant on user defined inputs regarding the characteristics of the diversion route. These characteristics are:

a. Route length

b. Route capacity

c. Baseline (no-incident) diversion route V/C ratio

B.1.38 These have been estimated systematically for all links in the study area using a multi-stage process to identify appropriate average diversion distances for each link and representative capacity and volume measures for these routes.

B.1.39 Given the size of our study area, the first step of the process was to group the links into sections, which would share a common diversion route. This sectioning is shown in Plate B.2 for the Without Scheme network and Plate B.3 for the With Scheme network. As shown the sectioning is reflective of the nodal nature of the SRN, with the sections defined by the junctions and intersections where re-routing would occur.

B.1.40 Each section was then reviewed, using two alternative methods to identify the length of the fastest diversion route. The first approach was to identify the shortest diversion route via the SRN, using the study area network sections as initially defined. This provided an initial estimate of diversion distances for all sections where diversionary routes are available within the study area. This method was however not able to provide estimates for diversion distances in some key locations such as the Dartford Crossing, or for links towards the edge of the study area.

B.1.41 The second approach was use of route planning software to identify potential diversionary routes between section start and finish points. Diversionary routes were identified on a shortest travel time basis.

B.1.42 The outcomes for these two approaches were reviewed for each section in the Without Scheme and With Scheme networks. Based on this review, the shortest plausible diversion route was identified as the expected maximum diversion distance. As explained below, the average diversion distance is assumed to be half this maximum distance.

Plate B.2 Without Scheme network sections and SRN diversions

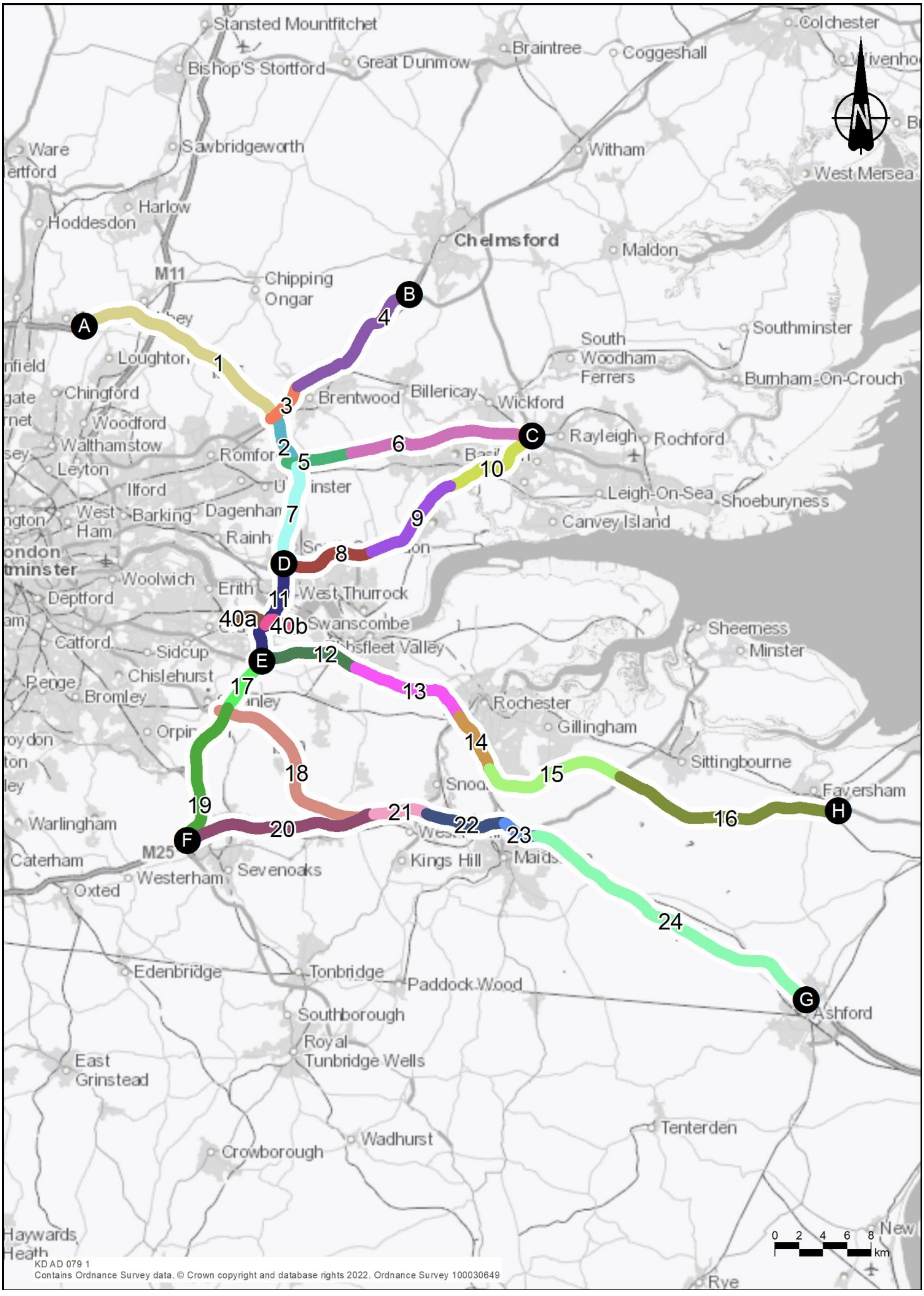
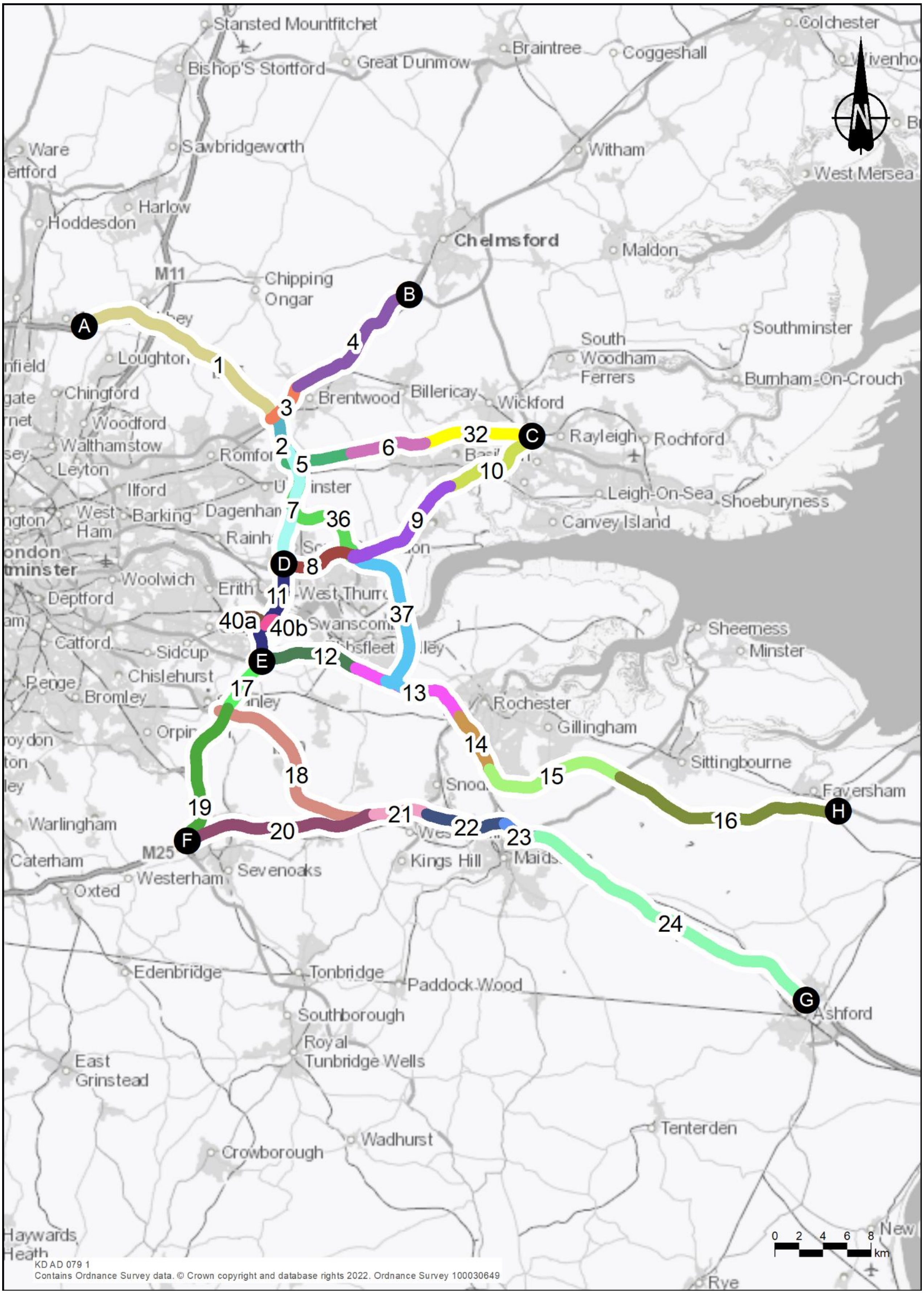


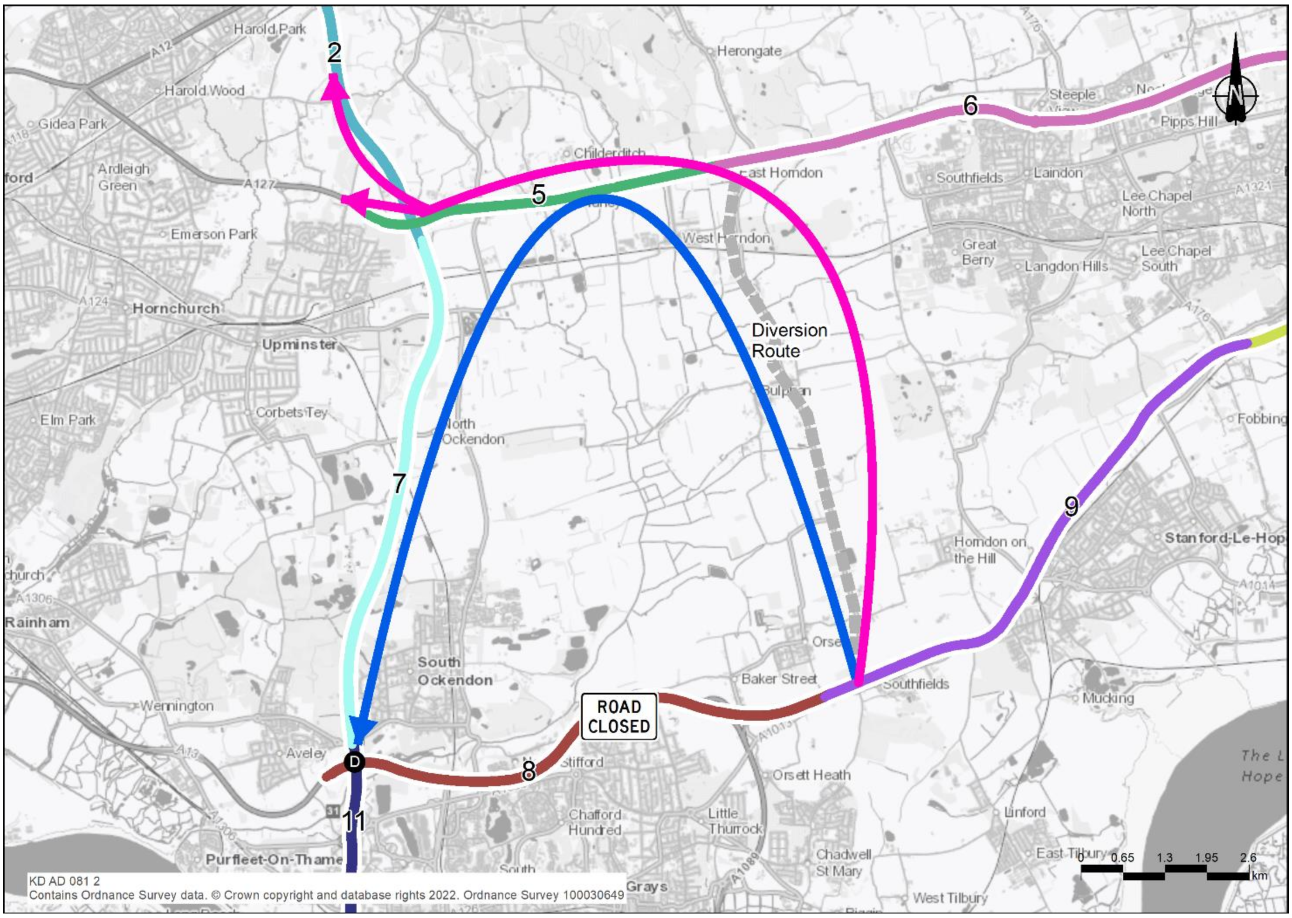
Plate B.3 With Scheme network sections



Maximum average diversion distances

B.1.43 A key issue which the approach to estimating diversion distances has tried to address is the multi-directional nature of travel in the study area and how this will affect average diversion distances. This is illustrated in Plate B.4.

Plate B.4 Diversion route illustration



B.1.44 Assuming an incident which restricts traffic on the highlighted section of the network (section 8), a point to point diversion route is shown via sections 26, 5, and 7.

B.1.45 Various users of section 8 will however be travelling on a route which allows a shorter diversion to be used. For example, trips via both sections 8 and 7, could use the shorter diversion via sections 26 and 5.

B.1.46 In fact, it can be seen that the point-to-point diversion distance reflects the maximum possible diversion length and given a range of onward routes beyond the immediately affected section, many users will have a shorter diversion route available. This could, at the theoretical limit, allow a zero-distance diversion for some users.

B.1.47 Given the complexities of estimating the optimal diversion route for each user of each link, referencing their wider routing, the average diversion distance has been estimated as the midpoint value between these theoretical maximum and minimum distances.

Route capacity and V/C ratio

B.1.48 Estimating a representative capacity and V/C ratio for each diversion route is the second part of the input definition process. As with the route identification process, the key goal is to derive values for this which are appropriate strategic summaries of potentially more complex and varied underlying details.

B.1.49 To do this an approach has therefore been adopted based on a number of strategic assumptions, which allows us to estimate these in a consistent and robust way across the study area.

B.1.50 The estimates of the V/C ratio of the diversion route for each link are based on the assumption that the V/C of the diversion route will be highly correlated with the base route, as both share a common geographic area and link common destinations.

B.1.51 Reflecting this, it has been assumed that, for each link, the V/C of the diversion route will be equal to the average V/C of the section of which that link is a part.

B.1.52 The estimate for the capacity of the diversion route for each link is more approximate and is the average (distance weighted) capacity of the diversion route, based on the proportion of the route made up of 1, 2 and 3+ lane roads. As discussed below, this optimistic view of the diversion capacity has some benefits from an appraisal perspective.

Discussion

B.1.53 Impacts on local road users from diverting traffic during incidents is understood to be an important concern for many local stakeholders.

B.1.54 Although the functionality for this appraisal has only recently been included within MyRIAD, the underlying appraisal logic of both the diversion response to incidents and the MEC process are both well established and provided a clear framework for understanding these issues.

B.1.55 Although the approaches used to develop the inputs for this appraisal involve a degree of abstraction, they are, as set out previously, considered to represent reasonable and proportionate central case approximations of what would be highly variable responses.

B.1.56 In addition, they are considered to incorporate some important factors which allow us to be confident that results from this appraisal are not overstated:

a. Calculation of average diversion distances allows for the potential of users to re-route to reduce overall impact

b. All diverting users are assumed to be able to use the shortest diversion route

c. The approach to the calculation of diversion route capacity is likely to overestimate diversion route capacity.

B.1.57 Together, the first two factors increase confidence that diversion distances are appropriate. The third point also implies a reduced risk that diverting users will trigger flows in the higher MEC congestion bands, and in many ways approximates a wider area response where users of the diversion route may also divert in response to the additional diverting traffic.

B.1.58 As such, the inclusion of this appraisal of diversion impacts within the wider journey time reliability appraisal of the Project is considered an important step and one which allows this previously intangible topic to be included more formally in the discussion of the economic impacts of the Project.

Travel time variability

B.1.59 The appraisal of the Project on travel time variability (TTV) is the third part of the journey time reliability appraisal. This section reviews the impact on road users of changes to the variability of journey time between the Without Scheme and With Scheme scenarios.

B.1.60 As explained in the MyRIAD User Manual, a journey departing at a particular time and day will have a mean journey time (Mott MacDonald / Highways England, 2021). Its variability is then represented by a distribution of times about the mean. As discussed in TAG Unit A1.3, the preferred measure of variability is the standard deviation of travel times around this mean (Department for Transport, 2022).

B.1.61 Changes in the standard deviation of travel time are monetised through the application of a reliability ratio which relates the value of one minute of standard deviation to one minute of average travel time.

B.1.62 For LGV travel the reliability ratio is 0.4, meaning that one minute of standard deviation has the same value as 0.4 minutes of average travel time. A higher ratio of 0.6 is used for goods vehicle reliability.

B.1.63 One important distributional and technical aspect of TTV appraisal is that the impact of any link improvement which reduces journey time variability will be different for link users making different journeys. Whole journey variability will be reduced more for shorter than longer trips. Reliability calculations therefore require a representation of entire journeys.

Travel time variability appraisal approach

B.1.64 Journey time reliability impacts due to changes in travel time variability (TTV) have also been assessed as part of the reliability appraisal. This appraisal has used MyRIAD 2021 to understand how the Project is expected to impact on the travel time variability for trips which use the study area network.

Sources of link TTV

B.1.65 As set out in the MyRIAD User Manual, TTV can be understood as having two components:

a. Incident-related variability on all links

b. Day-to-day variability (DTDV) on all links, i.e., variability not caused by incidents but by fluctuations in demand, weather etc.

B.1.66 In MyRIAD these are forecast separately, the first using the results of the incident delay assessment, the second using a set of DTDV curves which relate speed to DTDV for the various road types.

Translating from link to journey TTV in MyRIAD

B.1.67 Unlike incident delay, TTV is specifically a property of an individual journey. MyRIAD, like most other implementations of TTV appraisal, measures variability as the standard deviation of journey time.

B.1.68 While variability contributions are calculated on a link by link basis, many journeys on links within our study area extend beyond our study area, which influences the extent to which their overall TTV is impacted by link changes.

B.1.69 Reflecting this issue, appraisal of TTV using MyRIAD requires a range of data to estimate the TTV variability of trip elements outside the MyRIAD study area.

B.1.70 The approach followed within MyRIAD is to capture this data using ‘feeder links’ which represent the approximate journey characteristics (length, road type and flow) for the trip elements outside the study area.

Feeder link assumptions

B.1.71 Feeder links are used to represent the characteristics of the proportion of each journey which occurs outside the study area. This allows representation of journeys of differing distances, which will experience differing levels of variability, but are also used to define important assumptions around the road type and congestion levels outside the study area, factors which also play a significant role in determining the level of journey TTV.

B.1.72 Given the number of links within our study area, the level of granularity achievable using a feeder link process is somewhat limited, with distance banding limited to four levels.

B.1.73 A fixed set of distance bands was not used, instead distance thresholds were calibrated separately for each period / year to maintain a consistent proportion of flows in each band, with the target proportions shown in Table B.6.

B.1.74 All feeder links were modelled as 3 lane motorways.

Table B.5 Feeder link distance band proportions and road types

Distance Bands	Target Proportion	Road Type
F1 (Shortest)	10%	3 Lane Motorway
F2	20%	3 Lane Motorway
F3	30%	3 Lane Motorway
F4 (Longest)	40%	3 Lane Motorway

B.1.75 The V/C ratio for each feeder link was assumed to be equivalent to the average V/C ratio experienced within the study area for that year and time period in the Without Scheme scenario. These are summarised in Table B.7. This shows both the substantial variation between the 10 time periods, but also the increasing V/C ratios as growth continues in the future year scenarios.

Table B.6 Feeder link V/C ratios by scenario

Time period	2030	2037	2045	2051
AM Peak	0.72	0.75	0.77	0.78
Interpeak	0.61	0.65	0.68	0.70
PM Peak	0.71	0.74	0.76	0.77
OP charged	0.33	0.37	0.39	0.40
OP Non-charged	0.14	0.16	0.17	0.17
AM Shoulder	0.62	0.65	0.68	0.69
PM shoulder	0.66	0.69	0.71	0.73
WE Peak Charged	0.50	0.55	0.58	0.60
WE OP Charged	0.27	0.30	0.32	0.33
WE OP Non-Charged	0.12	0.13	0.14	0.14

B.1.76 A key issue in undertaking the TTV appraisal is the size and complexity of the study area, which results in a number of analytical and logistical challenges:

a. First, the large number of links in the study area, relative to the number of links which can be accommodated in MyRIAD, limits the degree of detail in which it is possible to define journey characteristics outside the study area; and

b. Secondly, the size of the appraisal area (number of access points) means it is not feasible to fully define a comprehensive set of routes.[8]

B.1.77 To allow for an appraisal to be undertaken, a simplified approach was adopted, which assesses the TTV benefits for flows via each link separately, using the following simplifying assumptions:

a. Low granularity distance banding (four bands); and

b. Shared trip length distribution (TLD) and feeder link distances based on analysis of the whole study area.

c. Appraisal was undertaken separately for three groups of links (Without Scheme only, With Scheme only and shared links) and then summed to calculate the study area total.

B.2 Journey Time Reliability appraisal results

B.2.1 Table B.7 and Plate B.5 show the annual profile of total journey time reliability benefits, across all three reliability impacts, by time period.

B.2.2 Table B.8 and Plate B.6 show the annual profile of total journey time reliability benefits, split between the three impacts.

B.2.3 Table B.9 and Plate B.7 show the annual profile of total journey time reliability benefits by trip purpose.

[8] With circa 30 junctions in the study area, 900 routes are theoretically available – standard use of MyRIAD would define a trip length distribution and feeder link definition for each route. The analytical requirements to support this are not considered achievable within a realistic timescale.

Table B.7 Journey time reliability benefits by time period (£, 2010 prices and values)

Year	AM Peak	Interpeak	PM Peak	OP charged	OP Non-charged	AM Shoulder	PM shoulder	WE Peak Charged	WE OP Charged	WE OP Non-Charged	Grand Total
2030	1,221,722	4,208,621	1,912,494	825,000	569,016	747,994	2,149,664	2,096,096	431,135	147,755	**14,309,497**
2031	1,172,313	4,155,705	1,845,085	816,974	568,592	742,971	2,083,954	2,057,557	426,548	146,442	**14,016,140**
2032	1,124,357	4,103,262	1,779,567	808,949	567,972	737,862	2,019,980	2,019,726	421,978	145,126	**13,728,778**
2033	1,077,818	4,051,294	1,715,892	800,930	567,163	732,674	1,957,701	1,982,588	417,424	143,805	**13,447,288**
2034	1,032,656	3,999,802	1,654,013	792,918	566,174	727,410	1,897,075	1,946,132	412,890	142,481	**13,171,551**
2035	988,838	3,948,787	1,593,885	784,917	565,011	722,076	1,838,061	1,910,344	408,374	141,155	**12,901,448**
2036	946,328	3,898,251	1,535,463	776,929	563,682	716,677	1,780,619	1,875,212	403,879	139,826	**12,636,866**
2037	905,091	3,848,193	1,478,704	768,957	562,193	711,217	1,724,711	1,840,725	399,406	138,497	**12,377,692**
2038	870,731	3,692,511	1,423,262	753,790	554,469	689,221	1,652,576	1,798,423	390,318	136,507	**11,961,809**
2039	837,360	3,541,410	1,369,412	738,923	546,833	667,809	1,582,584	1,757,069	381,433	134,543	**11,557,376**
2040	804,954	3,394,769	1,317,111	724,349	539,285	646,968	1,514,681	1,716,642	372,745	132,603	**11,164,107**
2041	773,488	3,252,473	1,266,320	710,062	531,825	626,682	1,448,811	1,677,121	364,251	130,689	**10,781,721**
2042	742,937	3,114,409	1,217,000	696,057	524,451	606,939	1,384,921	1,638,486	355,946	128,798	**10,409,945**
2043	713,278	2,980,466	1,169,113	682,328	517,164	587,726	1,322,960	1,600,718	347,825	126,932	**10,048,511**
2044	684,488	2,850,537	1,122,623	668,870	509,963	569,028	1,262,875	1,563,798	339,886	125,090	**9,697,158**
2045	656,544	2,724,516	1,077,493	655,677	502,847	550,833	1,204,619	1,527,707	332,124	123,272	**9,355,632**
2046	651,312	2,733,684	1,032,159	642,957	494,600	519,179	1,180,378	1,493,392	326,152	121,247	**9,195,060**
2047	646,036	2,741,481	988,175	630,483	486,484	488,542	1,156,624	1,459,833	320,287	119,254	**9,037,200**
2048	640,722	2,747,955	945,505	618,252	478,497	458,896	1,133,347	1,427,013	314,527	117,293	**8,882,007**
2049	635,371	2,753,156	904,115	606,258	470,638	430,213	1,110,538	1,394,916	308,870	115,363	**8,729,437**
2050	629,988	2,757,129	863,972	594,497	462,903	402,467	1,088,187	1,363,527	303,315	113,464	**8,579,448**
2051	624,576	2,759,921	825,043	582,964	455,291	375,633	1,066,285	1,332,830	297,858	111,595	**8,431,995**
2052	612,507	2,706,589	809,100	571,699	446,493	368,374	1,045,681	1,307,075	292,102	109,438	**8,269,058**
2053	603,587	2,667,173	797,317	563,373	439,991	363,009	1,030,452	1,288,040	287,848	107,845	**8,148,635**
2054	594,797	2,628,330	785,706	555,169	433,583	357,723	1,015,446	1,269,282	283,657	106,274	**8,029,966**
2055	586,135	2,590,054	774,263	547,084	427,269	352,513	1,000,658	1,250,797	279,526	104,726	**7,913,024**
2056	577,599	2,552,334	762,988	539,116	421,046	347,380	986,085	1,232,582	275,455	103,201	**7,797,786**
2057	569,187	2,515,165	751,876	531,265	414,915	342,321	971,724	1,214,632	271,443	101,698	**7,684,226**
2058	560,898	2,478,536	740,926	523,528	408,872	337,336	957,573	1,196,943	267,490	100,217	**7,572,320**
2059	552,730	2,442,441	730,136	515,904	402,918	332,423	943,628	1,179,512	263,595	98,758	**7,462,043**
2060	544,680	2,406,871	719,503	508,391	397,050	327,582	929,886	1,162,334	259,756	97,319	**7,353,373**
2061	536,748	2,371,820	709,025	500,987	391,268	322,811	916,344	1,145,407	255,973	95,902	**7,246,285**
2062	528,931	2,337,279	698,699	493,691	385,570	318,110	902,999	1,128,726	252,245	94,506	**7,140,756**

Year	AM Peak	Interpeak	PM Peak	OP charged	OP Non-charged	AM Shoulder	PM shoulder	WE Peak Charged	WE OP Charged	WE OP Non-Charged	Grand Total
2063	521,228	2,303,241	688,524	486,502	379,955	313,477	889,848	1,112,289	248,572	93,129	**7,036,765**
2064	513,638	2,269,698	678,497	479,417	374,421	308,912	876,890	1,096,090	244,952	91,773	**6,934,288**
2065	506,157	2,236,644	668,616	472,435	368,969	304,413	864,119	1,080,128	241,385	90,437	**6,833,303**
2066	498,786	2,204,072	658,879	465,555	363,595	299,980	851,535	1,064,398	237,869	89,119	**6,733,789**
2067	491,522	2,171,974	649,284	458,775	358,300	295,612	839,134	1,048,897	234,405	87,822	**6,635,724**
2068	484,364	2,140,343	639,828	452,094	353,082	291,307	826,914	1,033,622	230,992	86,543	**6,539,087**
2069	477,310	2,109,173	630,510	445,510	347,940	287,064	814,871	1,018,569	227,628	85,282	**6,443,858**
2070	470,359	2,078,457	621,328	439,022	342,873	282,884	803,004	1,003,735	224,313	84,040	**6,350,015**
2071	463,509	2,048,188	612,280	432,628	337,880	278,764	791,310	989,118	221,046	82,816	**6,257,539**
2072	456,759	2,018,360	603,363	426,328	332,959	274,704	779,786	974,713	217,827	81,610	**6,166,410**
2073	450,107	1,988,967	594,576	420,119	328,110	270,704	768,430	960,518	214,655	80,422	**6,076,608**
2074	443,552	1,960,001	585,917	414,001	323,332	266,761	757,239	946,530	211,529	79,251	**5,988,114**
2075	437,093	1,931,457	577,384	407,972	318,623	262,877	746,211	932,746	208,448	78,097	**5,900,908**
2076	430,727	1,903,329	568,976	402,030	313,983	259,048	735,344	919,162	205,412	76,959	**5,814,973**
2077	424,455	1,875,611	560,690	396,176	309,411	255,276	724,635	905,776	202,421	75,838	**5,730,288**
2078	418,273	1,848,296	552,524	390,406	304,905	251,558	714,082	892,585	199,473	74,734	**5,646,838**
2079	412,182	1,821,379	544,478	384,720	300,464	247,895	703,683	879,587	196,568	73,646	**5,564,602**
2080	406,179	1,794,854	536,549	379,118	296,089	244,285	693,435	866,777	193,706	72,573	**5,483,564**
2081	400,264	1,768,716	528,735	373,597	291,777	240,727	683,337	854,154	190,885	71,516	**5,403,707**
2082	394,435	1,742,958	521,035	368,156	287,527	237,221	673,385	841,715	188,105	70,475	**5,325,012**
2083	388,691	1,717,575	513,447	362,794	283,340	233,767	663,579	829,457	185,365	69,448	**5,247,463**
2084	383,030	1,692,562	505,970	357,511	279,214	230,362	653,915	817,378	182,666	68,437	**5,171,044**
2085	377,452	1,667,913	498,601	352,304	275,148	227,007	644,392	805,474	180,006	67,440	**5,095,737**
2086	371,955	1,643,623	491,340	347,174	271,141	223,702	635,008	793,744	177,384	66,458	**5,021,527**
2087	366,538	1,619,686	484,184	342,118	267,192	220,444	625,760	782,184	174,801	65,490	**4,948,398**
2088	361,201	1,596,099	477,133	337,136	263,301	217,233	616,647	770,793	172,255	64,537	**4,876,334**
2089	355,940	1,572,855	470,185	332,226	259,466	214,070	607,667	759,568	169,747	63,597	**4,805,320**
Grand Total	**36,354,415**	**153,680,953**	**52,778,775**	**32,457,067**	**24,707,027**	**24,268,651**	**64,245,787**	**75,834,894**	**16,648,675**	**6,093,112**	**487,069,355**

Plate B.5 Journey time reliability benefits by time period (£, 2010 prices and values)

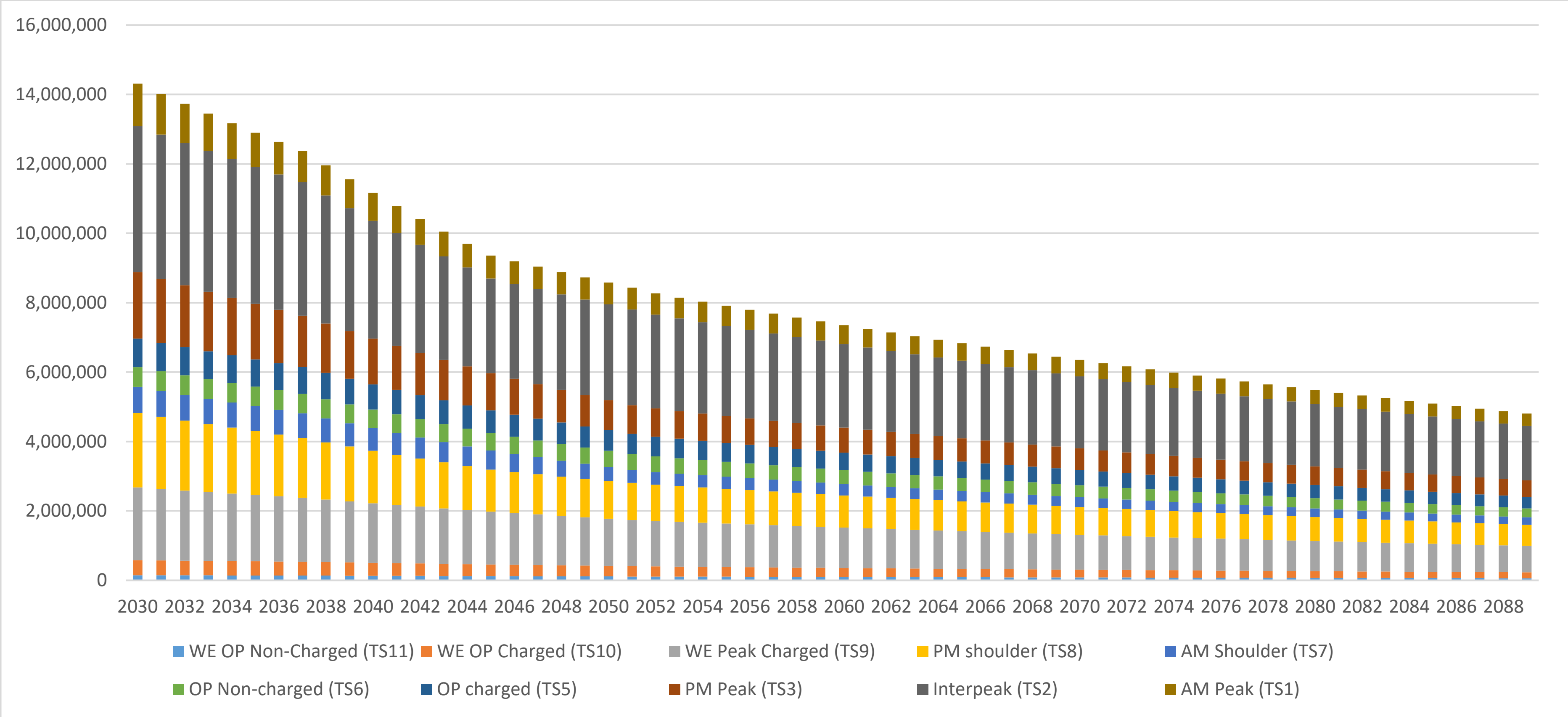


Table B.8 Journey time reliability benefits by impact type (£, 2010 prices and values)

Year	Incident Delays	TTV	Diversion Impacts	Grand Total
2030	6,680,187	6,208,375	1,420,935	**14,309,497**
2031	6,604,740	5,941,417	1,469,983	**14,016,140**
2032	6,529,714	5,682,459	1,516,605	**13,728,778**
2033	6,455,121	5,431,290	1,560,877	**13,447,288**
2034	6,380,973	5,187,706	1,602,871	**13,171,551**
2035	6,307,281	4,951,508	1,642,659	**12,901,448**
2036	6,234,054	4,722,502	1,680,311	**12,636,866**
2037	6,161,301	4,500,497	1,715,894	**12,377,692**
2038	6,048,853	4,283,774	1,629,182	**11,961,809**
2039	5,938,450	4,073,746	1,545,180	**11,557,376**
2040	5,830,056	3,870,236	1,463,816	**11,164,107**
2041	5,723,633	3,673,069	1,385,019	**10,781,721**
2042	5,619,146	3,482,078	1,308,722	**10,409,945**
2043	5,516,560	3,297,096	1,234,855	**10,048,511**
2044	5,415,840	3,117,963	1,163,355	**9,697,158**
2045	5,316,953	2,944,522	1,094,157	**9,355,632**
2046	5,229,563	2,828,628	1,136,869	**9,195,060**
2047	5,143,566	2,716,113	1,177,521	**9,037,200**
2048	5,058,939	2,606,891	1,216,177	**8,882,007**
2049	4,975,662	2,500,875	1,252,900	**8,729,437**
2050	4,893,715	2,397,983	1,287,750	**8,579,448**
2051	4,813,076	2,298,134	1,320,785	**8,431,995**
2052	4,720,070	2,253,726	1,295,262	**8,269,058**
2053	4,651,331	2,220,905	1,276,399	**8,148,635**
2054	4,583,593	2,188,561	1,257,811	**8,029,966**
2055	4,516,842	2,156,689	1,239,493	**7,913,024**
2056	4,451,063	2,125,281	1,221,442	**7,797,786**
2057	4,386,241	2,094,330	1,203,654	**7,684,226**
2058	4,322,364	2,063,830	1,186,125	**7,572,320**
2059	4,259,417	2,033,775	1,168,852	**7,462,043**
2060	4,197,387	2,004,157	1,151,830	**7,353,373**
2061	4,136,260	1,974,970	1,135,055	**7,246,285**
2062	4,076,023	1,946,208	1,118,526	**7,140,756**

Year	Incident Delays	TTV	Diversion Impacts	Grand Total
2063	4,016,663	1,917,865	1,102,236	**7,036,765**
2064	3,958,168	1,889,935	1,086,184	**6,934,288**
2065	3,900,525	1,862,412	1,070,366	**6,833,303**
2066	3,843,721	1,835,289	1,054,778	**6,733,789**
2067	3,787,745	1,808,562	1,039,417	**6,635,724**
2068	3,732,583	1,782,224	1,024,280	**6,539,087**
2069	3,678,225	1,756,269	1,009,364	**6,443,858**
2070	3,624,659	1,730,692	994,664	**6,350,015**
2071	3,571,873	1,705,488	980,179	**6,257,539**
2072	3,519,855	1,680,651	965,904	**6,166,410**
2073	3,468,595	1,656,175	951,838	**6,076,608**
2074	3,418,082	1,632,056	937,976	**5,988,114**
2075	3,368,304	1,608,288	924,316	**5,900,908**
2076	3,319,251	1,584,867	910,855	**5,814,973**
2077	3,270,912	1,561,786	897,590	**5,730,288**
2078	3,223,277	1,539,042	884,519	**5,646,838**
2079	3,176,337	1,516,628	871,637	**5,564,602**
2080	3,130,079	1,494,542	858,944	**5,483,564**
2081	3,084,496	1,472,776	846,435	**5,403,707**
2082	3,039,576	1,451,328	834,108	**5,325,012**
2083	2,995,310	1,430,192	821,961	**5,247,463**
2084	2,951,689	1,409,364	809,990	**5,171,044**
2085	2,908,703	1,388,840	798,194	**5,095,737**
2086	2,866,343	1,368,614	786,570	**5,021,527**
2087	2,824,601	1,348,682	775,115	**4,948,398**
2088	2,783,466	1,329,041	763,827	**4,876,334**
2089	2,742,930	1,309,687	752,704	**4,805,320**
Grand Total	**265,383,938**	**152,850,590**	**68,834,827**	**487,069,355**

Plate B.6 Journey time reliability benefits by impact type (£, 2010 prices and values)

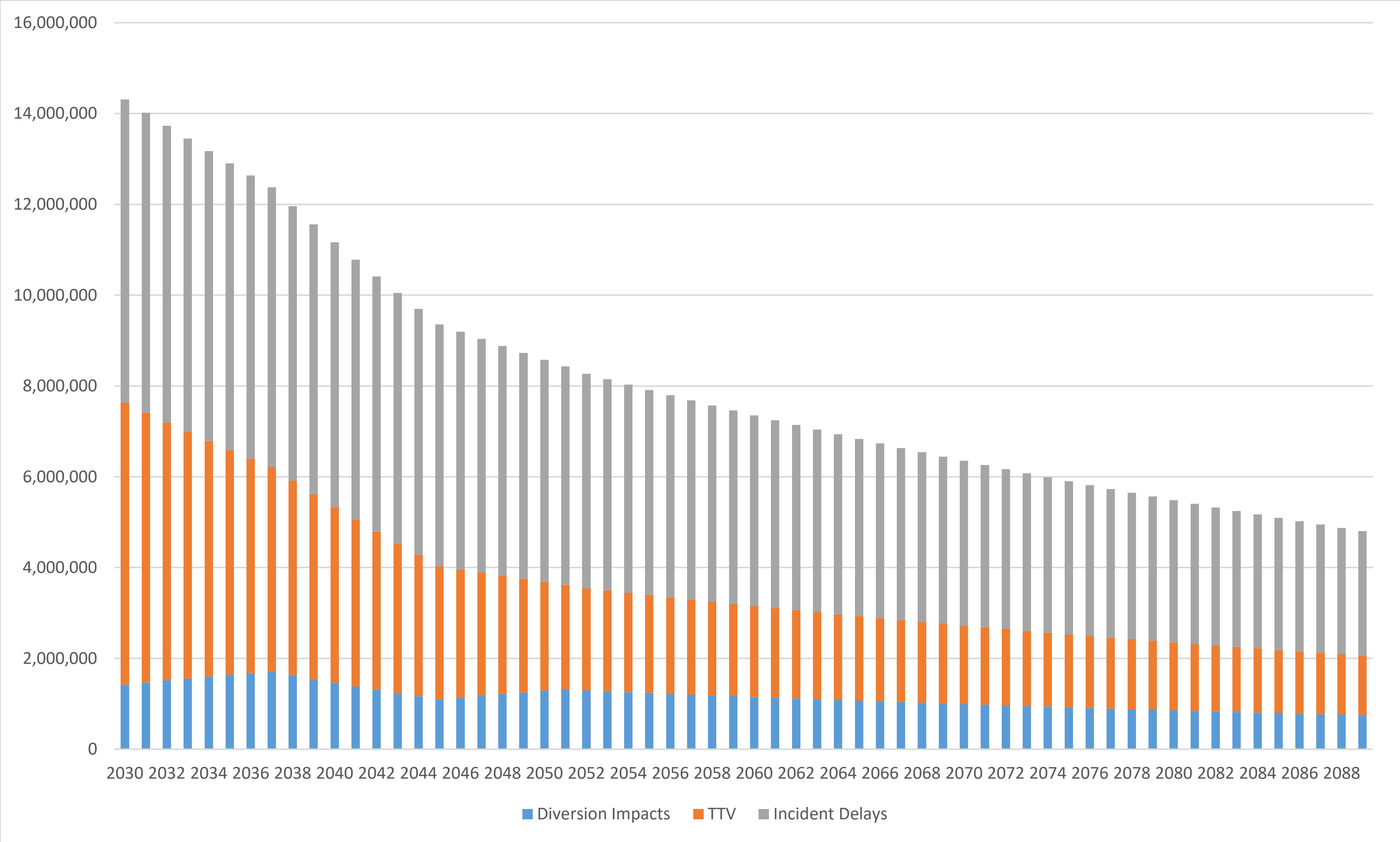
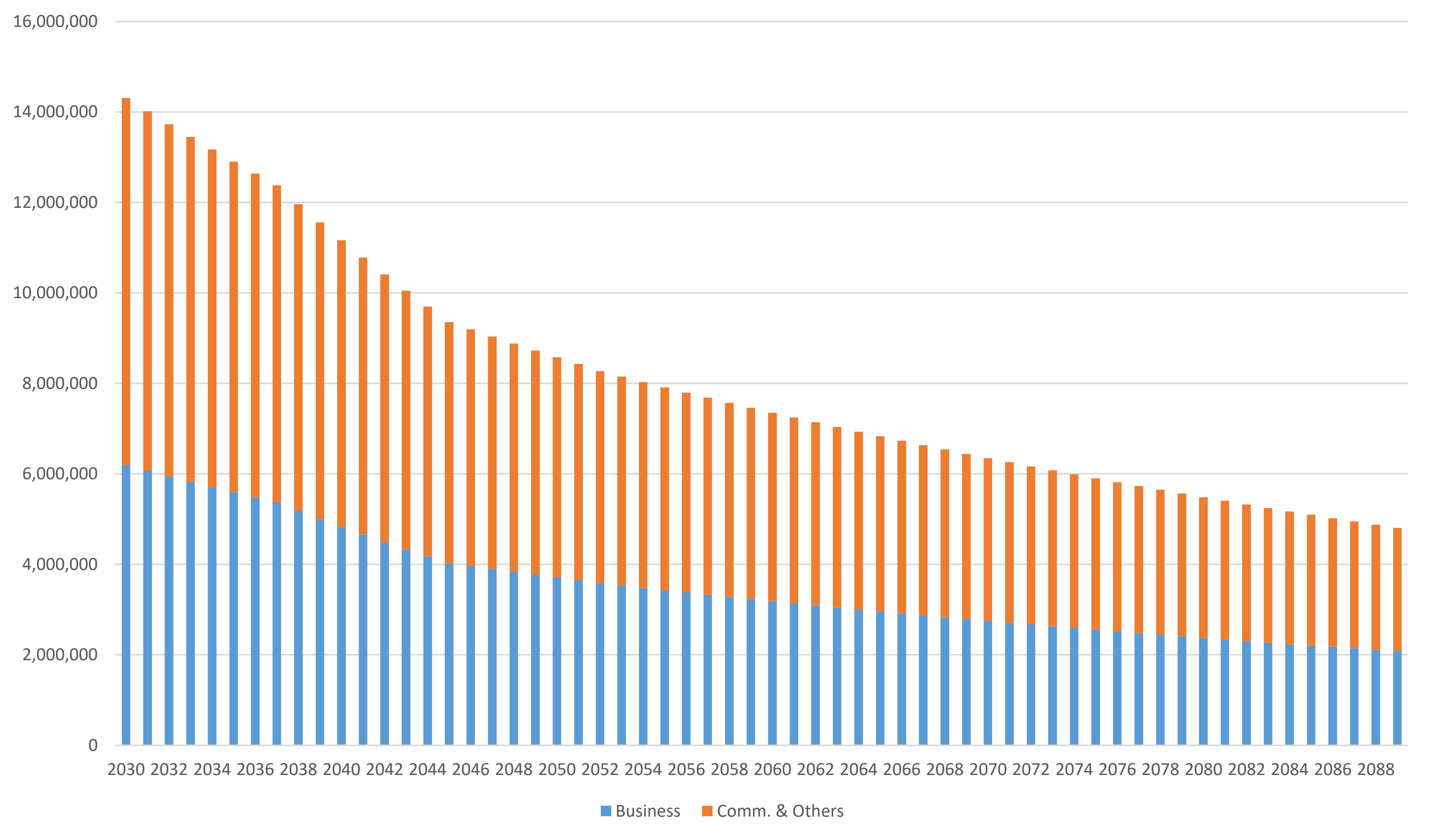


Table B.9 Journey time reliability benefits by trip purpose (£, 2010 prices and values)

Year	Business	Commuters & Others	Grand Total
2030	6,195,398	8,114,099	**14,309,497**
2031	6,070,220	7,945,921	**14,016,140**
2032	5,947,566	7,781,212	**13,728,778**
2033	5,827,386	7,619,902	**13,447,288**
2034	5,709,630	7,461,921	**13,171,551**
2035	5,594,249	7,307,199	**12,901,448**
2036	5,481,195	7,155,671	**12,636,866**
2037	5,370,421	7,007,271	**12,377,692**
2038	5,185,147	6,776,662	**11,961,809**
2039	5,005,027	6,552,349	**11,557,376**
2040	4,829,933	6,334,175	**11,164,107**
2041	4,659,736	6,121,985	**10,781,721**
2042	4,494,314	5,915,631	**10,409,945**
2043	4,333,544	5,714,966	**10,048,511**
2044	4,177,310	5,519,848	**9,697,158**
2045	4,025,496	5,330,136	**9,355,632**
2046	3,961,298	5,233,762	**9,195,060**
2047	3,898,077	5,139,122	**9,037,200**
2048	3,835,821	5,046,186	**8,882,007**
2049	3,774,515	4,954,922	**8,729,437**
2050	3,714,146	4,865,302	**8,579,448**
2051	3,654,701	4,777,294	**8,431,995**
2052	3,584,079	4,684,979	**8,269,058**
2053	3,531,883	4,616,752	**8,148,635**
2054	3,480,448	4,549,517	**8,029,966**
2055	3,429,762	4,483,262	**7,913,024**
2056	3,379,814	4,417,972	**7,797,786**
2057	3,330,593	4,353,633	**7,684,226**
2058	3,282,090	4,290,230	**7,572,320**
2059	3,234,292	4,227,751	**7,462,043**
2060	3,187,191	4,166,182	**7,353,373**
2061	3,140,775	4,105,509	**7,246,285**
2062	3,095,036	4,045,720	**7,140,756**

Year	Business	Commuters & Others	Grand Total
2063	3,049,963	3,986,802	**7,036,765**
2064	3,005,546	3,928,742	**6,934,288**
2065	2,961,776	3,871,527	**6,833,303**
2066	2,918,643	3,815,146	**6,733,789**
2067	2,876,139	3,759,585	**6,635,724**
2068	2,834,253	3,704,834	**6,539,087**
2069	2,792,977	3,650,880	**6,443,858**
2070	2,752,303	3,597,712	**6,350,015**
2071	2,712,221	3,545,318	**6,257,539**
2072	2,672,723	3,493,687	**6,166,410**
2073	2,633,799	3,442,808	**6,076,608**
2074	2,595,443	3,392,670	**5,988,114**
2075	2,557,645	3,343,263	**5,900,908**
2076	2,520,398	3,294,574	**5,814,973**
2077	2,483,693	3,246,595	**5,730,288**
2078	2,447,523	3,199,315	**5,646,838**
2079	2,411,880	3,152,723	**5,564,602**
2080	2,376,755	3,106,809	**5,483,564**
2081	2,342,142	3,061,564	**5,403,707**
2082	2,308,033	3,016,979	**5,325,012**
2083	2,274,421	2,973,042	**5,247,463**
2084	2,241,298	2,929,745	**5,171,044**
2085	2,208,658	2,887,079	**5,095,737**
2086	2,176,493	2,845,034	**5,021,527**
2087	2,144,797	2,803,602	**4,948,398**
2088	2,113,562	2,762,773	**4,876,334**
2089	2,082,782	2,722,538	**4,805,320**
Grand Total	**210,916,960**	**276,152,395**	**487,069,355**

Plate B.7 Journey time reliability benefits by trip purpose (£, 2010 prices and values)



Annex C Level 2 Wider Economic Impacts

C.1 Level 2 wider economic impacts approach

Introduction

C.1.1 This Annex describes the approaches used to estimate the three Level 2 wider economic impacts (WEI) of the Project which are all based on fixed land use:

a. Agglomeration

b. Labour supply impacts

c. Economic output changes due to imperfectly competitive markets

C.1.2 These impacts are defined and their appraisal results are set out in Chapter 9 of the Economic Appraisal Report.

Agglomeration

C.1.3 DfT's WITA v2.2 software was used to calculate the value of agglomeration benefits.

C.1.4 The benefits from agglomeration are estimated to be £1,374.8m (2010 prices and values).

Labour supply

C.1.5 DfT's WITA v2.2 software was used to calculate the value of labour supply impacts.

C.1.6 The benefits from labour supply impacts are estimated to be £8.4m (2010 prices and values).

Change in output in imperfectly competitive markets

C.1.7 The value of the change in output in imperfectly competitive markets is an additional welfare benefit and has been calculated based on a proportion of the business user benefits that were calculated using TUBA and MyRIAD. Guidance set out in paragraph 4.3.1 of TAG Unit A2.2 states that this benefit can be estimated by applying a 10% uplift factor to business transport user and provider benefits and business journey time reliability benefits.

C.1.8 The quantity thus estimated does not need to be separately interpolated between modelled years, extrapolated after the final modelled year or discounted to the appraisal base year (2010), because it is based on a proportion of benefits that have already been interpolated, extrapolated and discounted.

C.1.9 For the Project, business transport user and provider benefits, excluding construction and maintenance delays, are £1,123.3m (2010 prices and values). Business journey time reliability benefits are £210.9m. Together, these sum to £1,334.2m (2010 prices and values).

C.1.10 Therefore, the estimated benefits from the change in output in imperfectly competitive markets have a value of £133.4m (2010 prices and values).

C.1.11 The remainder of this Annex:

a. explains the wider impacts zoning system used to estimate agglomeration and labour supply impacts

b. describes the zonal approach to masking the agglomeration results

c. sets out the various data sources used to inform the estimates of benefits

d. describes the annualisation method for trips in the agglomeration calculations

e. presents the agglomeration impact parameters

Wider impacts zoning system

C.1.12 The data used in the calculation of agglomeration and labour supply impacts is taken from the wider impacts dataset, which is supplied by the DfT and accompanies the TAG wider impacts guidance in Units A2.1 - A2.4.

C.1.13 The employment and GDP values in the dataset are based on information for 380 local authority districts in England, Scotland and Wales.

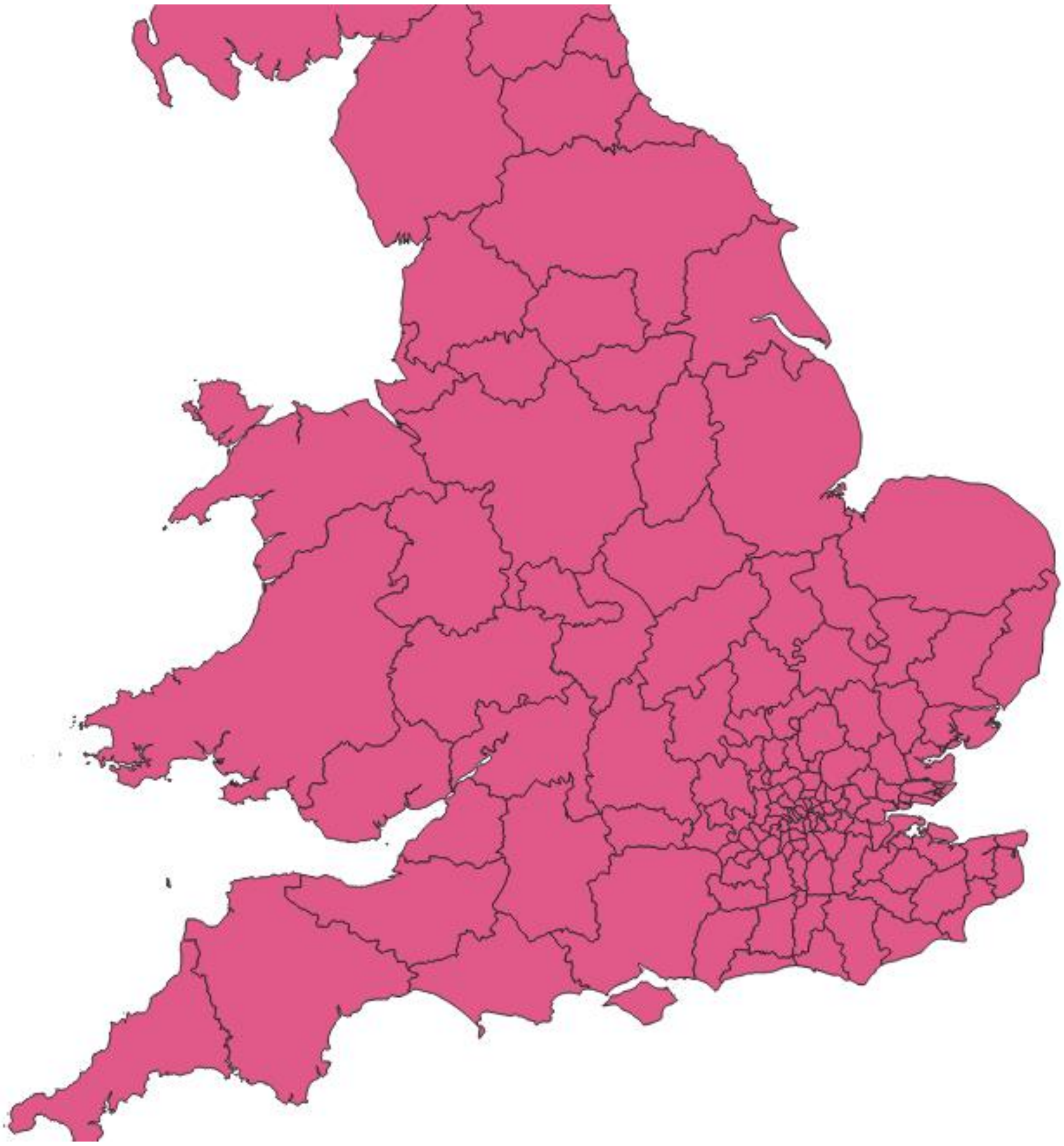
C.1.14 To enable this local data to be used to calculate wider economic impacts in aggregate, different wider economic impacts zoning systems were tested. A final zoning system was devised which includes 136 zones and is defined as follows:

a. Local authority districts were used where transport model zones are smaller than local authority districts, which occurs mostly in the vicinity of the Project; and

b. LTAM transport model zones were used where these are larger than local authority districts, which occurs mostly in the external area.

C.1.15 This zoning system is illustrated in Plate C.1.

Plate C.1 The 136 zone wider impacts zoning system

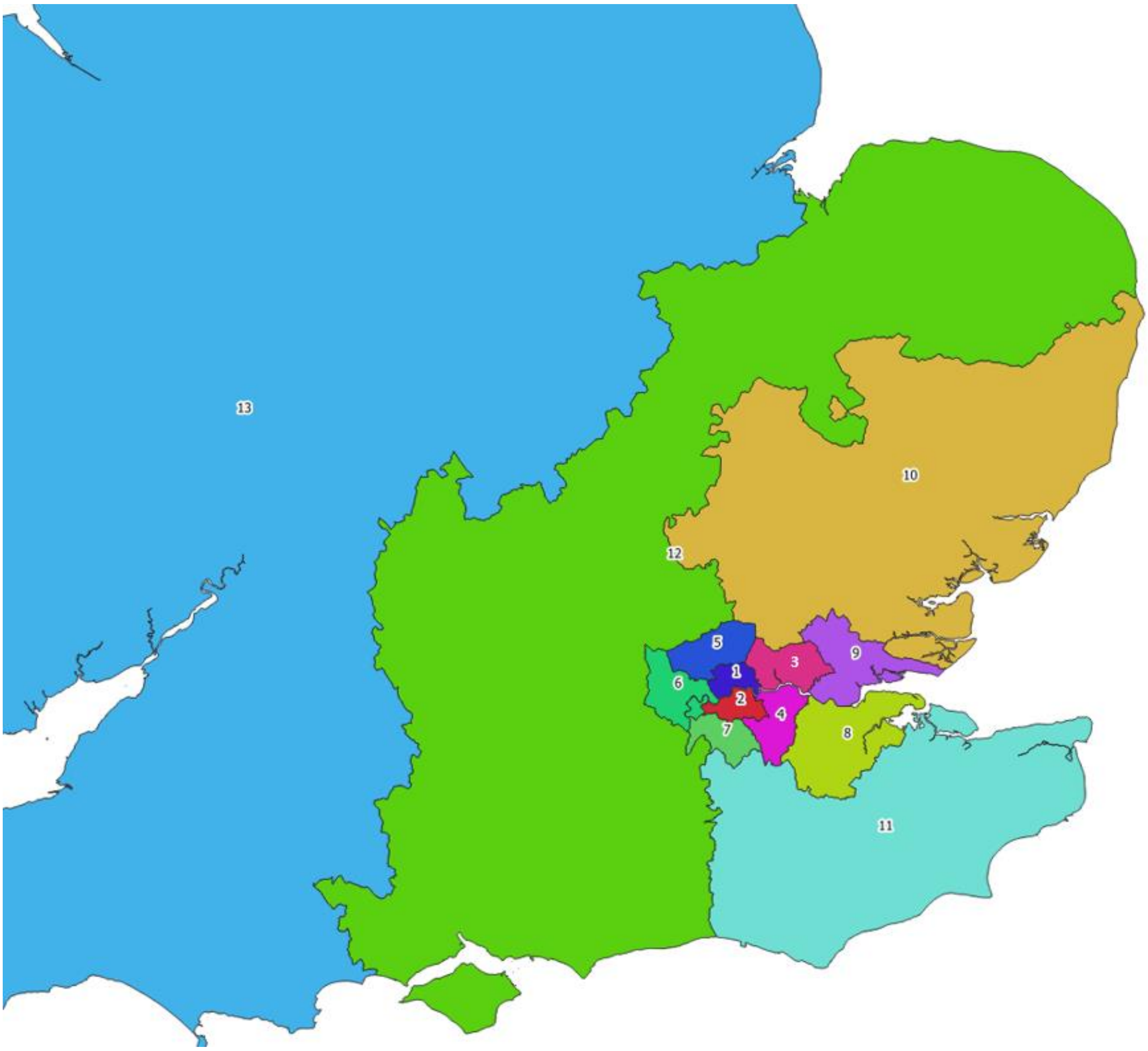


C.1.16 The descriptions of the methods for calculating wider economic impacts that are set out in TAG are based on the expectation that the outputs of the transport model will be combined into local authority districts.

C.1.17 Note that the need to calculate appropriate costs for all movements between the zones in the chosen system is simplified by ensuring that the WEI zones are composed of a whole number of transport model zones.

C.1.18 Sectors formed from aggregations of the WEI zones were also defined within the model for analysis and other uses such as cost freezing and masking – both of which are described below. The sectors are illustrated in Plate C.2.

Plate C.2 Sectors used in the wider impacts model



C.1.19 Many of the data used in the calculation of the wider economic impacts have been taken from the wider impacts dataset, which is supplied by the DfT and accompanies TAG wider economic impacts guidance Units A2.1 to A2.4.

C.1.20 The descriptions of the methods for calculating wider economic impacts that are set out in TAG are based on the expectation that the outputs of the transport model will be combined into local authority districts. With the economic data in the wider impacts dataset also supplied at the level of districts, it was natural to use the 136 zone system for appraising the Project. The zones in this system are illustrated in Plate C.3 and described in Table C.1.

C.1.21 A zone No. 45 has not been included.

Plate C.3 The 136 zone wider impacts zoning system

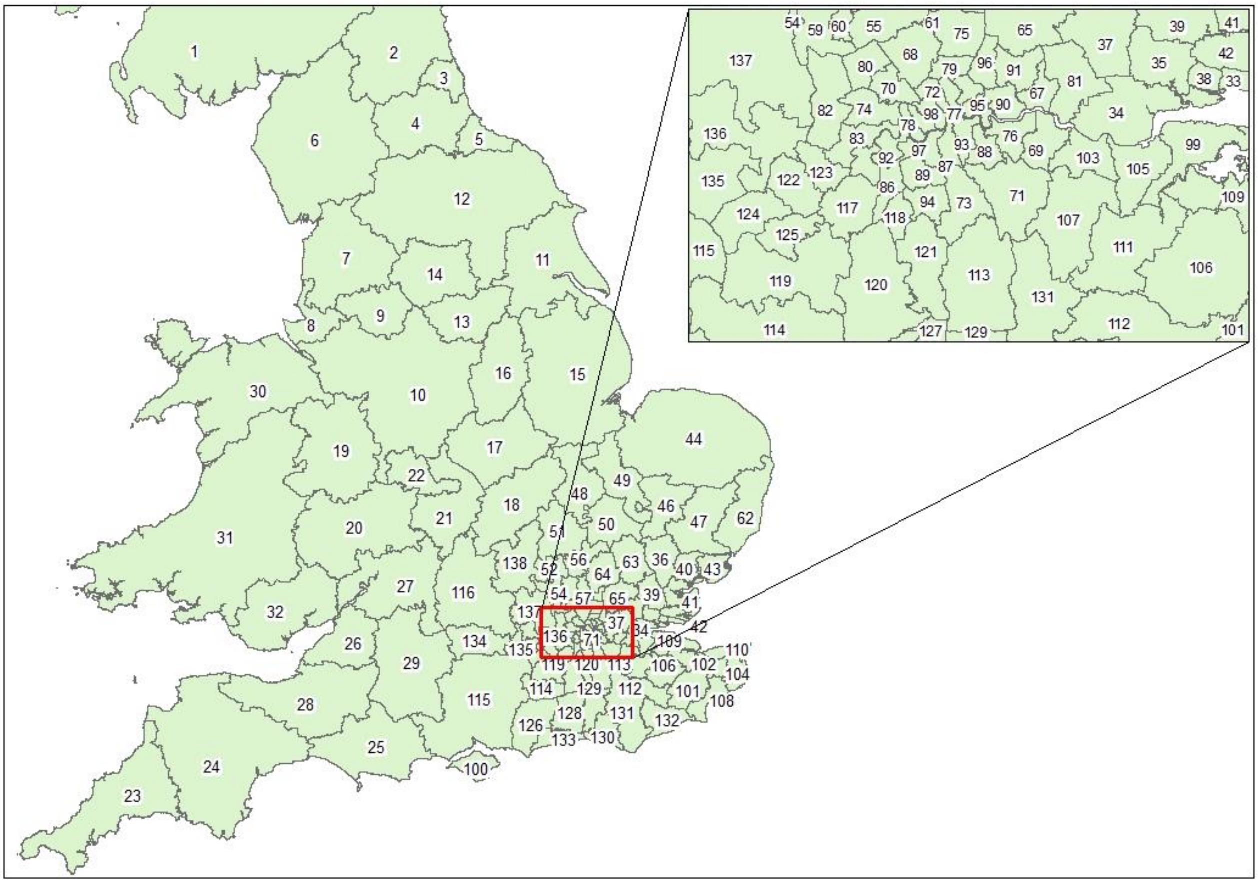


Table C.1 The 136 zone wider impacts zoning system

WITA Zone	Zone Description	WITA Zone	Zone Description
1	Scotland	71	Bromley
2	Northern Region	72	Camden
3	Northern Region	73	Croydon
4	Northern Region	74	Hillingdon, Ealing, Hounslow & Richmond
5	Northern Region	75	Enfield, Haringey & Waltham Forest
6	Cumbria	76	Greenwich
7	Lancashire and Blackburn	77	Hillingdon, Ealing, Hounslow & Richmond
8	Liverpool City Region	78	Hillingdon, Ealing, Hounslow & Richmond
9	Manchester City Region	79	Enfield, Haringey & Waltham Forest
10	Cheshire, Staffordshire and Stoke on Trent	80	Barnet, Brent & Harrow

WITA Zone	Zone Description	WITA Zone	Zone Description
11	Yorkshire & Humberside	81	Hillingdon, Ealing, Hounslow & Richmond
12	Yorkshire & Humberside	82	Hillingdon, Ealing, Hounslow & Richmond
13	Yorkshire & Humberside	83	Islington
14	Yorkshire & Humberside	84	Kensington and Chelsea
15	Lincolnshire	85	Kingston upon Thames
16	Nottinghamshire	86	South London
17	Leicestershire	87	South London
18	Northamptonshire	88	Merton
19	Shropshire	89	Newham
20	Hereford & Worcester	90	Barking and Dagenham & Redbridge
21	Warwickshire	91	Hillingdon, Ealing, Hounslow & Richmond
22	West Midlands	92	South London
23	Cornwall	93	Sutton
24	Devon	94	Tower Hamlets
25	Dorset	95	Enfield, Haringey & Waltham Forest
26	Avon	96	South London
27	Gloucestershire	97	Westminster
28	Somerset	98	Medway
29	Wiltshire	99	Hampshire
30	North Wales	100	Ashford & Shepway
31	Mid Wales	101	Canterbury, Dover & Thanet
32	Mid Wales	102	Dartford
33	Rochford & Southend-on-Sea	103	Canterbury, Dover & Thanet
34	Thurrock	104	Gravesham
35	Basildon & Castle Point	105	Maidstone
36	Braintree	106	Sevenoaks
37	Brentwood	107	Ashford & Shepway
38	Basildon & Castle Point	108	Swale
39	Chelmsford	109	Canterbury, Dover & Thanet
40	Maldon, Colchester & Tendring	110	Tonbridge and Malling
41	Maldon, Colchester & Tendring	111	Tunbridge Wells

WITA Zone	Zone Description	WITA Zone	Zone Description
42	Rochford & Southend-on-Sea	112	Tandridge District
43	Maldon, Colchester & Tendring	113	Surrey (West)
44	Norfolk	114	Hampshire
46	Suffolk	115	Oxfordshire
47	Suffolk	116	Surrey (West)
48	Cambridgeshire	117	Epsom and Ewell
49	Cambridgeshire	118	Surrey (West)
50	Cambridgeshire	119	Mole Valley
51	Bedfordshire	120	Reigate
52	Hertfordshire (East)	121	Surrey (West)
53	Hertfordshire (West)	122	Surrey (West)
54	Hertfordshire (East)	123	Surrey (West)
55	Hertfordshire (East)	124	Surrey (West)
56	Hertfordshire (West)	125	West Sussex
57	Hertfordshire (East)	126	West Sussex
58	Hertfordshire (West)	127	West Sussex
59	Hertfordshire (West)	128	West Sussex
60	Hertfordshire (East)	129	East Sussex
61	Suffolk	130	East Sussex
62	Uttlesford	131	East Sussex
63	Hertfordshire (East)	132	West Sussex
64	Epping Forest & Harlow	133	Berkshire
65	City of London	134	Berkshire
66	Barking and Dagenham & Redbridge	135	Berkshire
67	Barnet, Brent & Harrow	136	Buckinghamshire
68	Bexley	137	Buckinghamshire
69	Barnet, Brent & Harrow		
70	Havering		

C.1.22 Note that the need to calculate appropriate costs for all movements between the zones in the chosen system means that the WEI zones should be composed of a whole number of transport model zones.

Zonal masking of agglomeration results

C.1.23 Due to the sensitivity of agglomeration impacts to small changes in generalised costs, particularly in areas where there are high employment densities and/or large values of GDP per worker, the values obtained for particular WEI zones and forecast years showed large variations in magnitude and (sometimes) sign depending on the choice of zoning system.

C.1.24 To mitigate this variation an approach was devised to remove spuriously large positive or negative agglomeration impacts by masking out benefits or disbenefits from areas which are not expected to be strongly affected by the Project.

C.1.25 Although the masking of particular transport model zones cannot be applied to the input data used to calculate agglomeration impacts – due to the impact on the effective densities – zonal masking was applied to exclude inappropriate benefits or disbenefits. This masking was applied after the final origin-based benefits had been calculated.

C.1.26 Agglomeration impacts are available only for origin zones because effective densities are calculated by summing over all destinations in the WEI zoning system. Therefore, any masking can only be applied to sets of single zones and not pairs of zones that represent OD movements.

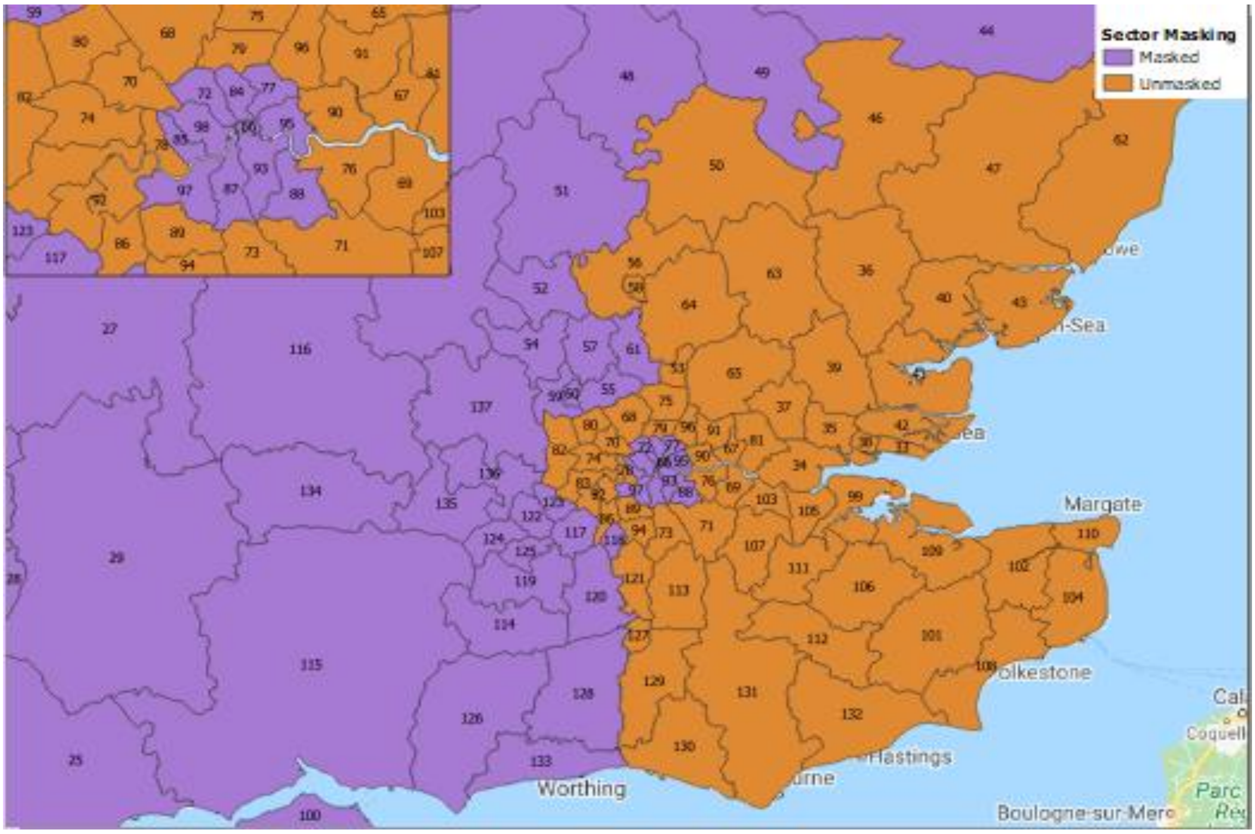
C.1.27 Masking was used to exclude contributions from transport model zones in sectors 1, 2, 12 and 13:

a. Sectors 1 and 2 cover Central and Inner London and are not expected to be affected very much by the Project. However, they have very large employment densities and relatively high values of GDP per worker and so they can generate large positive or negative contributions to the total agglomeration impact from small proportional changes in cost; and

b. Sectors 12 and 13 comprise external areas that are not modelled fully in LTAM and have very large amounts of total employment which are susceptible to very small changes in cost.

C.1.28 In calculating the final agglomeration impacts, it is more appropriate to use zonal masking to exclude spurious contributions to the overall agglomeration impact because this is more similar to the standard method of masking with TUBA-based appraisal, and the effects of cost freezing seem to be worthy of more investigation before being generally applied. Masking has also been applied to the 137-zone system in order to control for large positive and negative agglomeration benefits from Central London and remove benefits from zones outside of the expected area of impact. Table C.4 provides a map of the zones which have been masked, this includes all areas outside of the map's extent.

Plate C.4 Masking applied to the wider impacts model



Summary of data sources and parameters

C.1.29 This section summarises the different data sources that were used and states the values of any parameters that have been drawn from TAG and other sources.

Trips

C.1.30 Highway trips were taken from SATURN matrices in LTAM which contain the trips that were output by the variable demand model (VDM) after demand-supply convergence.

Costs

C.1.31 Highway generalised costs were derived from time, distance and charge data taken from SATURN skims.

Employment data

C.1.32 The following economic data relating to employment was sourced from the TAG wider impacts dataset:

a. Total employment (all industrial sectors) for each forecast year;

b. Total employment by industrial sector for each forecast year; and

c. GDP per worker by industrial sector for each forecast year.

C.1.33 These are provided at the level of local authority districts and were apportioned to transport model zones by applying a zonal conversion derived from postcode densities. For use in calculating agglomeration impacts, these transport zone-level data were aggregated into the different zoning systems using many-to-one correspondences that did not require any transport model zones to be split into portions.

Annualisation of trips in agglomeration calculations

C.1.34 In the calculation of the average generalised costs for the agglomeration impact, the costs of travel in each time period were weighted by factors to take account of the number of peak hours in a year, so that each of the used periods contributes appropriately to the overall average.

C.1.35 The factors used are shown in Table C.2 for calculations that were performed using 10 time periods.

Table C.2 Expansion factors used to weight trips and costs for LTAM 10 time periods

Time Period	Expansion Factor
AM peak	497
Interpeak	1,518
PM peak	511
Offpeak (charged)	759
Offpeak (uncharged)	2,024
AM shoulder	253
PM shoulder	506
Weekend peak	1,120
Weekend offpeak (charged)	672
Weekend offpeak (uncharged)	896

Agglomeration impact parameters

C.1.36 Table C.3 summarises the values of the decay parameters that are used in the calculation of the effective densities used to estimate agglomeration impacts. These parameters are defined for each industrial sector, but they remain constant over time and between modelling scenarios.

Table C.3 Generalised cost decay parameters used in effective densities

Industrial Sector	Description	Value
Manufacturing	Parameter governing exponential decay of effective density with generalised costs for different sectors. Calculated for use with the elasticities reported in Table C.4.	1.097
Construction		1.562
Consumer services		1.818
Producer services		1.746

Source: TAG Unit A2.4, Appendix C

C.1.37 Table C.4 summarises the values of the elasticities of productivity with respect to changes in effective density. These are defined for each industrial sector, but they remain constant over time and between modelling scenarios.

Table C.4 Agglomeration elasticities of productivity used to obtain agglomeration impacts

Industrial Sector	Description	Value
Manufacturing	Agglomeration elasticity of productivity with respect to effective density, by industrial sector. This parameter captures both urbanisation and localisation effects.	0.021
Construction		0.034
Consumer services		0.024
Producer services		0.083

Source: TAG Unit A2.4, Appendix C

C.1.38 Table C.5 summarises the values of the different parameters used when calculating labour supply impacts.

Table C.5 Parameters used in calculating labour supply impacts

Parameter	Description	Value
ϵ_{LS}	Elasticity of labour supply with respect to effective wages	0.1
η	Marginal worker's proportion of average GDP per worker	0.69
Ω	Average annual number of round-trip commuting journeys per worker	300
τ_1	Average tax take required to convert gross earnings to net earnings	0.30
τ_2	Tax wedge on the labour supply impact	0.40

Source: TAG Unit A2.3

C.2 Level 2 wider economic impact results

Introduction

C.2.1 This Annex reports the estimated wider economic impacts for the Core traffic growth scenario.

C.2.2 Table C.6 presents the estimated wider economic impacts for the Core traffic growth scenario over the 60-year appraisal period from 2030 to 2089.

Table C.6 Level 2 wider economic impacts (Core traffic growth)

WEI impacts	£m, 2010 prices and values
Agglomeration	1,374.8
Output change in imperfectly competitive markets	133.4
Labour supply impacts	8.4
Move to more/less productive jobs	Not assessed
Total	**1,516.6**
Agglomeration as % of WEIs	91%
WEIs as % of total direct benefits	46%

LTAM model runs: Without-Scheme = CM49, With-Scheme = CS72

Agglomeration

C.2.3 Table C.7 and Plate C.5 present the profile of agglomeration benefits for the four sectors - manufacturing; construction; consumer services; and producer services - which sum over the 60-year appraisal period to £1,374.8m. These agglomeration benefits decrease gradually over the whole appraisal period.

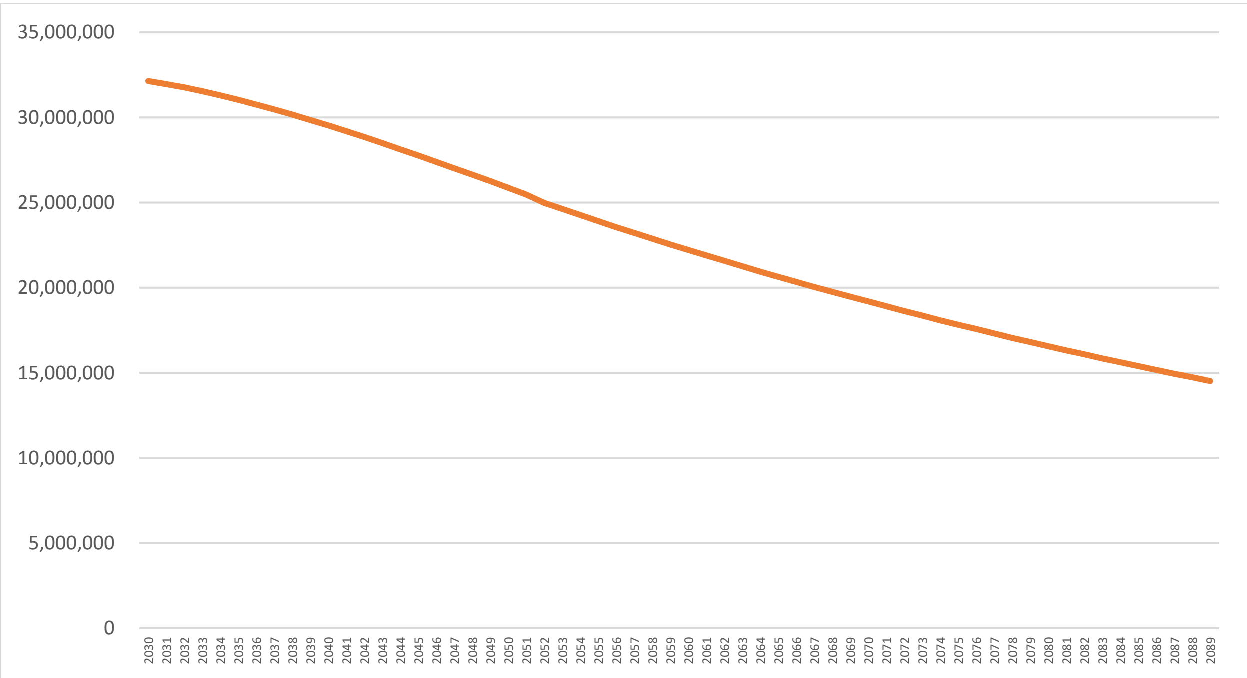
Table C.7 Agglomeration benefits 60-year profile (£, 2010 prices and values)

Year	Agglomeration £
2030	32,137,221
2031	31,963,915
2032	31,765,580
2033	31,544,106
2034	31,301,286
2035	31,038,816
2036	30,758,303
2037	30,461,267
2038	30,166,501
2039	29,856,836
2040	29,533,618

Year	Agglomeration £
2041	29,198,118
2042	28,851,535
2043	28,495,002
2044	28,129,590
2045	27,756,307
2046	27,391,099
2047	27,018,851
2048	26,640,456
2049	26,256,755
2050	25,868,541
2051	25,476,557
2052	24,984,256
2053	24,620,408
2054	24,261,858
2055	23,908,530
2056	23,560,347
2057	23,217,236
2058	22,879,120
2059	22,545,929
2060	22,217,591
2061	21,894,033
2062	21,575,188
2063	21,260,986
2064	20,951,361
2065	20,646,244
2066	20,345,570
2067	20,049,275
2068	19,757,296
2069	19,469,568
2070	19,186,031
2071	18,906,623
2072	18,631,283
2073	18,359,954
2074	18,092,576
2075	17,829,092

Year	Agglomeration £
2076	17,569,445
2077	17,313,579
2078	17,061,440
2079	16,812,972
2080	16,568,123
2081	16,326,840
2082	16,089,070
2083	15,854,763
2084	15,623,869
2085	15,396,337
2086	15,172,118
2087	14,951,165
2088	14,733,430
2089	14,518,865
Total	**1,374,752,628**

Plate C.5 Agglomeration benefits 60-year profile (£, 2010 prices and values)



Labour supply

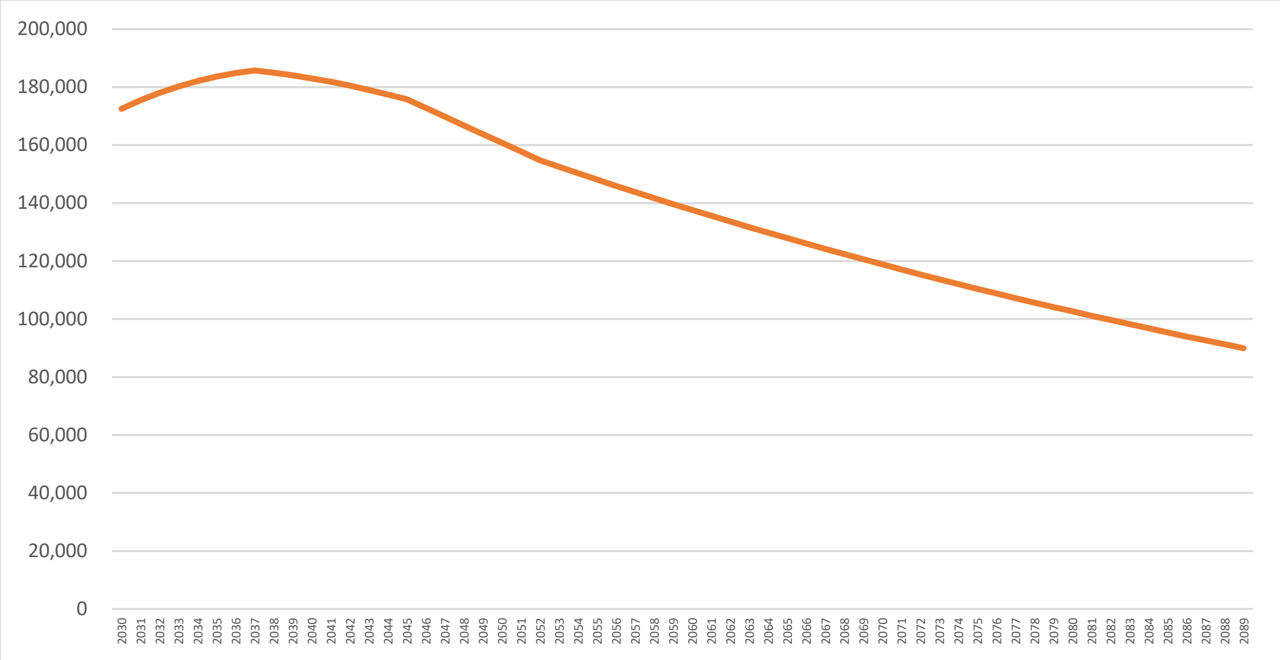
C.2.4 Table C.8 and Plate C.6 present the annual profile of labour supply benefits which sum over the 60-year appraisal period to £8.4m. These increase over the period 2030 to 2037 and then gradually decline over the remaining appraisal period.

Table C.8 Labour supply benefits 60-year profile (£, 2010 prices and values)

Year	Labour Supply £
2030	172,473
2031	175,450
2032	178,028
2033	180,232
2034	182,083
2035	183,603
2036	184,811
2037	185,728
2038	184,982
2039	184,074
2040	183,016
2041	181,819
2042	180,494
2043	179,050
2044	177,498
2045	175,846
2046	172,820
2047	169,799
2048	166,783
2049	163,778
2050	160,785
2051	157,807
2052	154,758
2053	152,504
2054	150,283
2055	148,095
2056	145,938
2057	143,813
2058	141,718
2059	139,654
2060	137,621
2061	135,616
2062	133,641
2063	131,695

Year	Labour Supply £
2064	129,777
2065	127,887
2066	126,025
2067	124,190
2068	122,381
2069	120,599
2070	118,842
2071	117,112
2072	115,406
2073	113,726
2074	112,069
2075	110,437
2076	108,829
2077	107,244
2078	105,682
2079	104,143
2080	102,627
2081	101,132
2082	99,659
2083	98,208
2084	96,778
2085	95,368
2086	93,979
2087	92,611
2088	91,262
2089	89,933
Total	**8,422,204**

Plate C.6 Labour supply benefits 60-year profile (£, 2010 prices and values)



C.3 Level 2 agglomeration benefits by economic sector

Introduction

C.3.1 This Annex provides summaries of the values of the agglomeration impacts by economic sector that have been calculated over the 60-year appraisal period from 2030 to 2089.

C.3.2 The four economic sectors that were measured are:

a. S1: Manufacturing

b. S2: Construction;

c. S3: Consumer services

d. S4: Producer services.

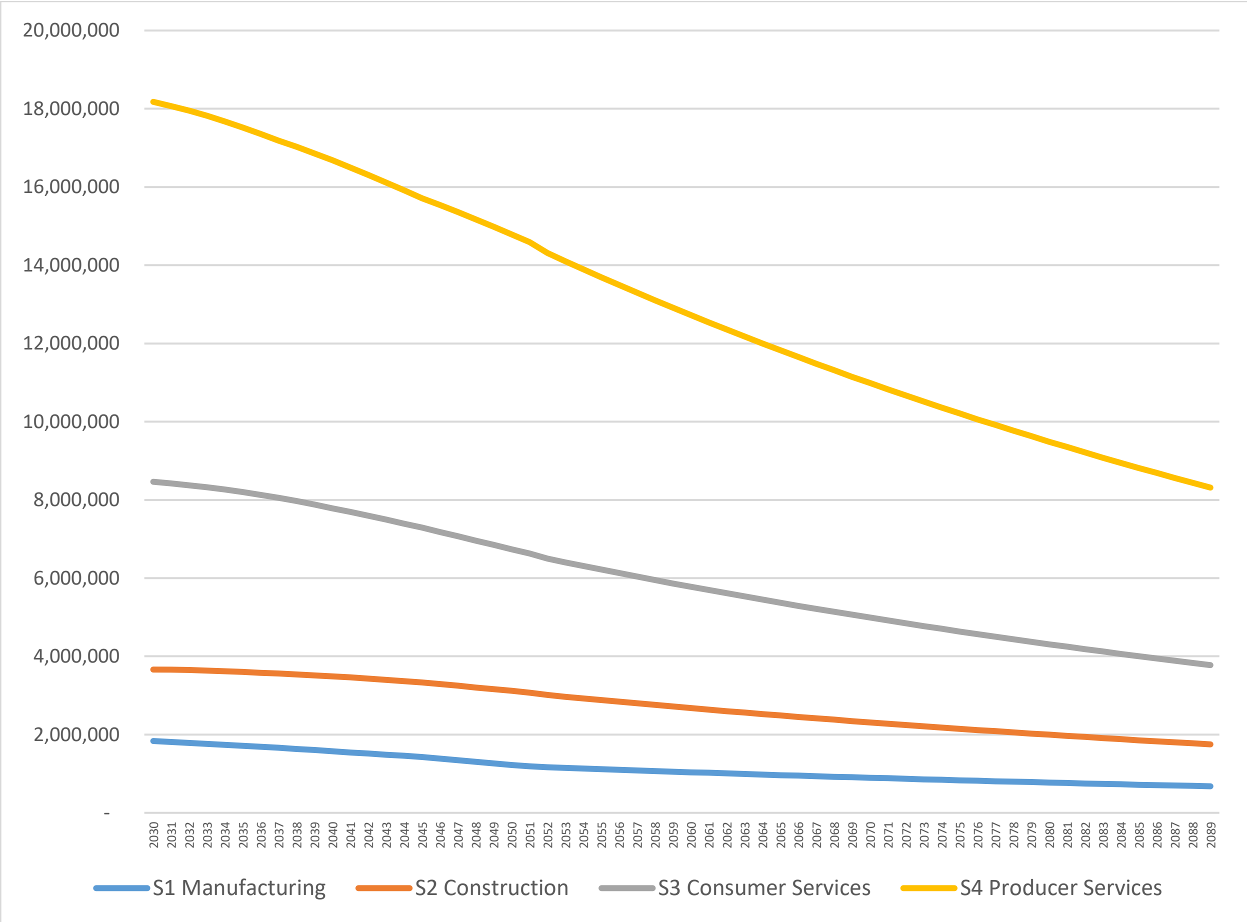
Agglomeration

C.3.3 Table C.9 shows the final values of the discounted total agglomeration benefits by economic sector that have been calculated. This is illustrated in Plate C.7. Of the £1,374.8m of agglomeration benefits, benefits for businesses in the producer services sector account for 57% of these benefits.

Table C.9 Agglomeration benefits by economic sector (£, 2010 prices and values)

Sector ID	Sector	Benefit	% of total
S1	Manufacturing	68,196,361	5
S2	Construction	163,975,406	12
S3	Consumer Services	359,432,678	26
S4	Producer Services	783,148,183	57
	Total	**1,374,752,628**	**100**

Plate C.7 Agglomeration benefits 60-year profile by economic sector (£, 2010 prices and values)



C.4 Level 2 wider economic impacts by year and agglomeration by area

Introduction

C.4.1 This Annex summarises the three wider economic impacts by forecast year and the agglomeration benefits by year and by zone.

Wider economic impacts by forecast year

C.4.2 Table C.10 shows the values of the three WEI benefits that have been calculated. For each impact the table shows:

a. the discounted value of the benefit in each forecast year; and

b. the total discounted benefits over the 60-year appraisal period from 2030 to 2089.

C.4.3 All values in Table C.10 are in 2010 prices and values and units of millions of pounds. Total Level 2 wider economic benefits are valued at £1,516.6m.

Table C.10 Summary of Level 2 wider economic impacts £, 2010 prices and values

WEI Type	Forecast Year Benefit				60-year total
	2030	2037	2045	2051	
Agglomeration	32,137,221	30,461,267	27,756,307	25,476,557	1,374,752,628
Output in imperfectly competitive markets	3,372,874	3,146,525	2,745,371	2,473,660	133,421,512
Labour Supply	172,473	185,728	175,846	157,807	8,422,204
Total	**35,682,568**	**33,793,520**	**30,677,524**	**28,108,024**	**1,516,596,344**

Agglomeration impacts by area

C.4.4 In this section a set of tables and plots are used to summarise the agglomeration impacts by different areas near to the Project. The areas used are Essex, Kent and London. Table C.1 in Annex C presents the zoning system that was used to calculate the final agglomeration impact of £1.375bn, which made use of zonal masking to exclude the impacts to Central and Inner London and the wider external area of LTAM. However, the images and tables in this Annex include the contributions from London that were excluded earlier, so their impact on the final benefits can be assessed in relation to those from other areas.

C.4.5 Plate C.8 to Plate C.11 show the total agglomeration impact (in units of £) in different forecast years for each of the zones from the WEI zoning system that cover Essex, Kent and London. In each case the impacts are displayed in 2010 prices for that year, after discounting to 2010. So that the impacts in different years can be easily compared, the same colour scale is used in each plate.

C.4.6 It can be seen that, as intuitively expected, the largest benefits are obtained closest to the Project and that the magnitude of the benefit decreases with increasing distance from the new crossing. The largest benefits in any forecast year are found in WEI zones adjacent to the Project, which are the Medway, Thurrock, Maidstone, Swale and Gravesham districts.

C.4.7 All the agglomeration impacts in Essex and Kent are positive, but this is not the case for those WEI zones that are inside London. It can be seen from the figures that the impacts in London are generally much smaller in total than for the Essex and Kent zones, which is natural due to London's distance from the new crossing. However, the impacts often change between being positive or negative depending on the forecast year.

C.4.8 The zones towards the centre of London have relatively large variations in impact depending on the forecast year, such as the City of London and Tower Hamlets. Because the agglomeration impact is greater where the number and economic contributions of jobs are the largest, the zones in London – and in particular the Canary Wharf area of Tower Hamlets – can show large positive or negative impacts as a result of small changes to generalised costs that are scaled up by jobs and GDP factors.

Plate C.8 Agglomeration impacts in 2030 in Essex, Kent and London (£, 2010 prices and values)

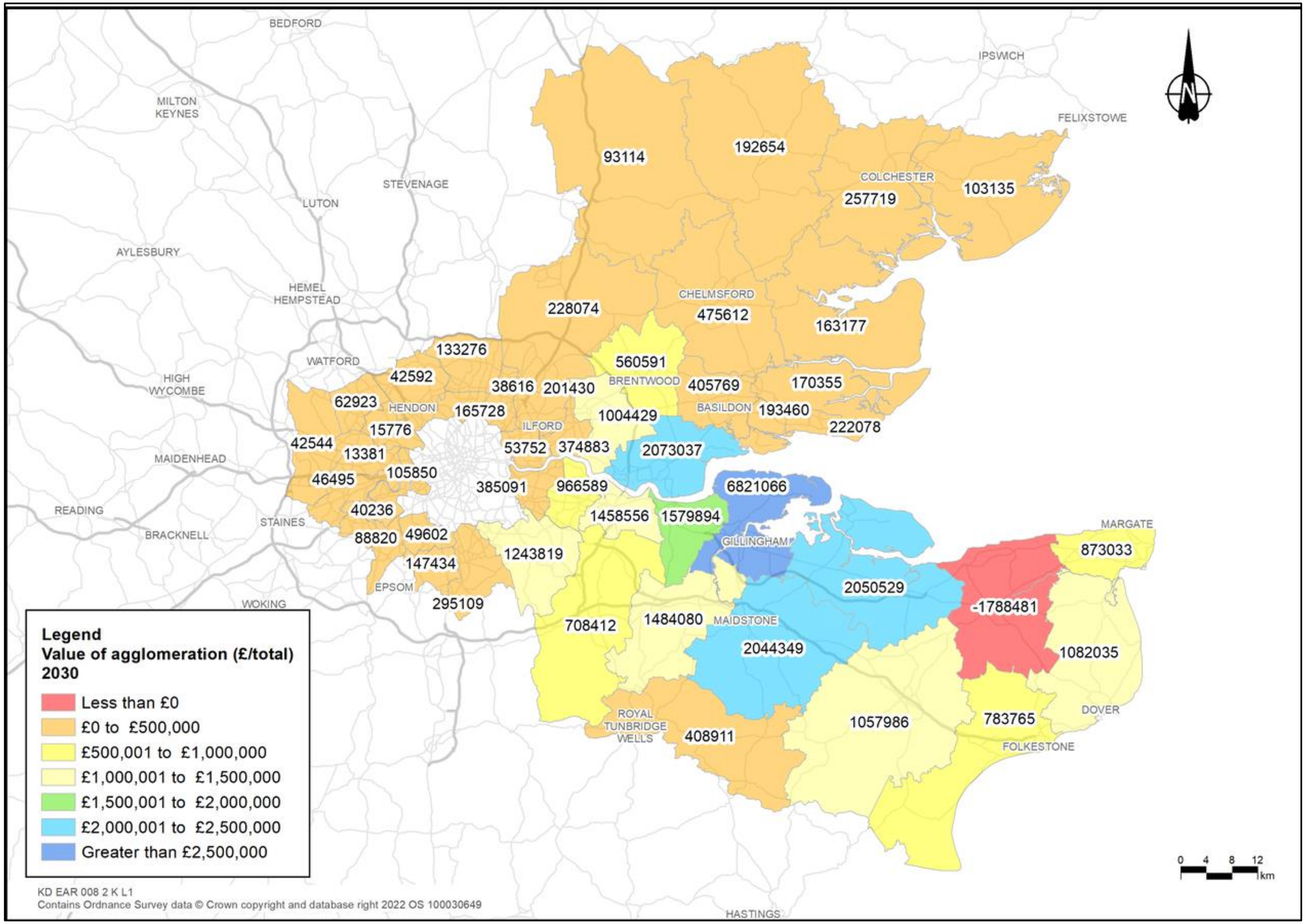


Plate C.9 Agglomeration impacts in 2037 in Essex, Kent and London (£, 2010 prices and values)

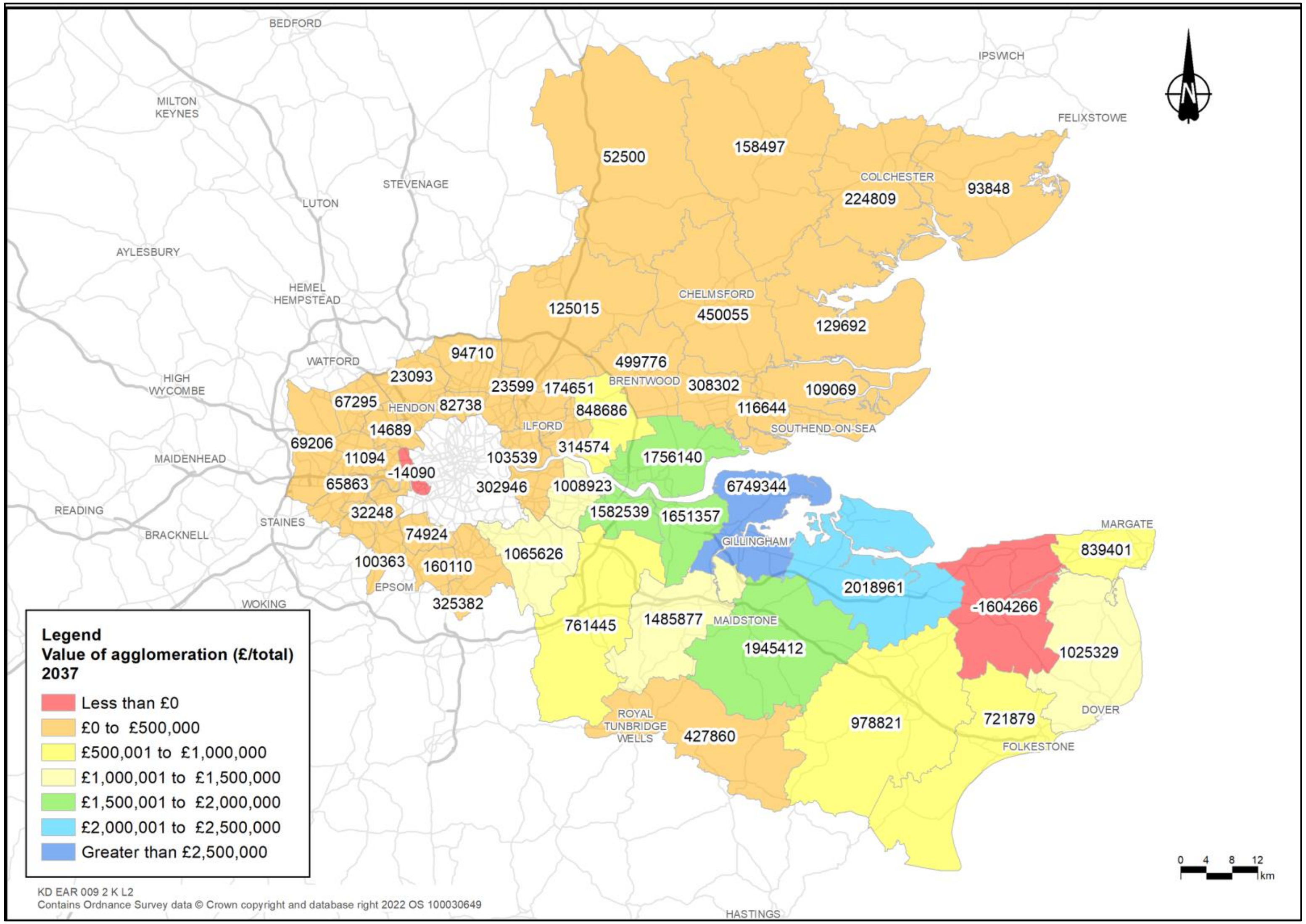


Plate C.10 Agglomeration impacts in 2045 in Essex, Kent and London (£, 2010 prices and values)

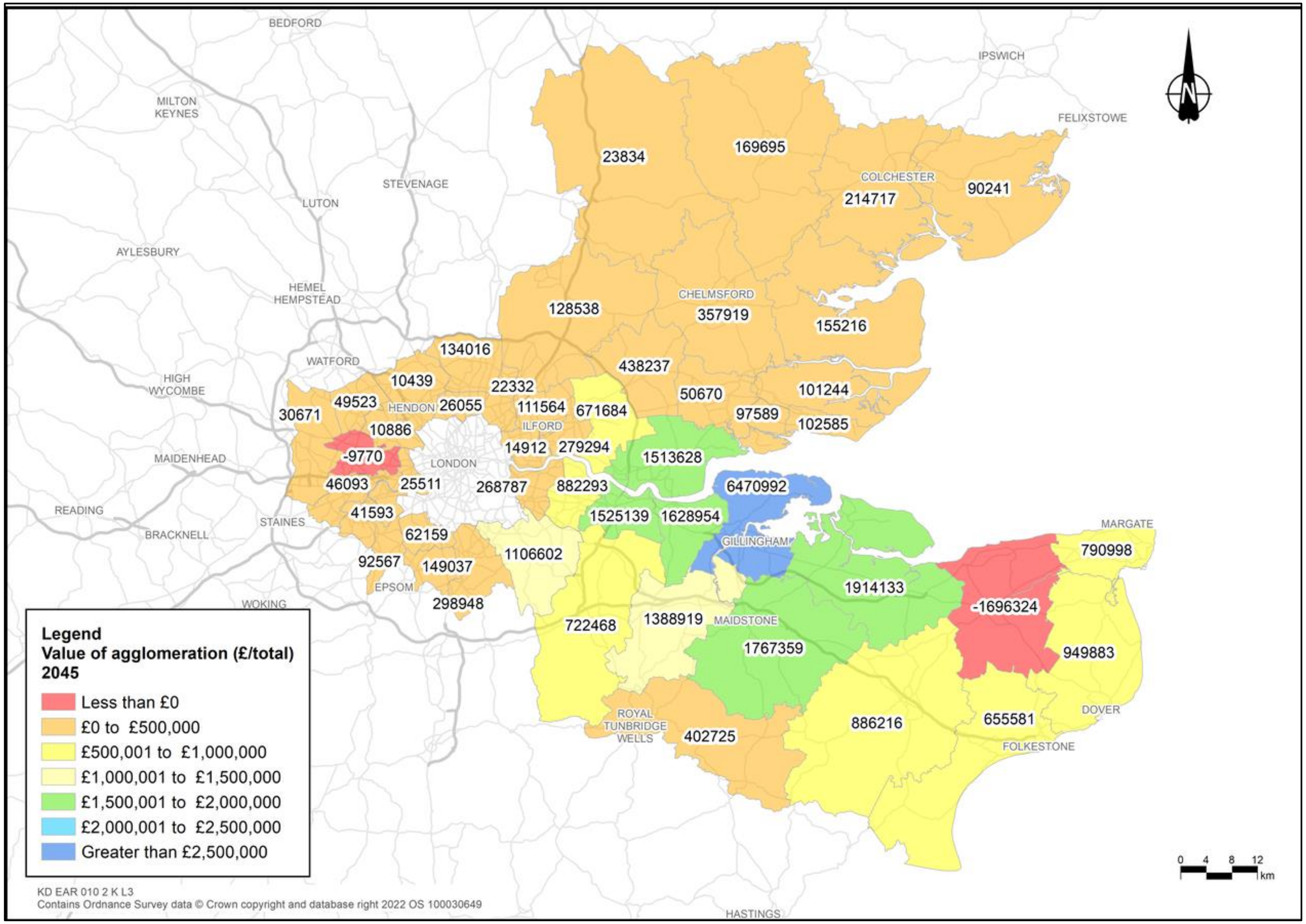
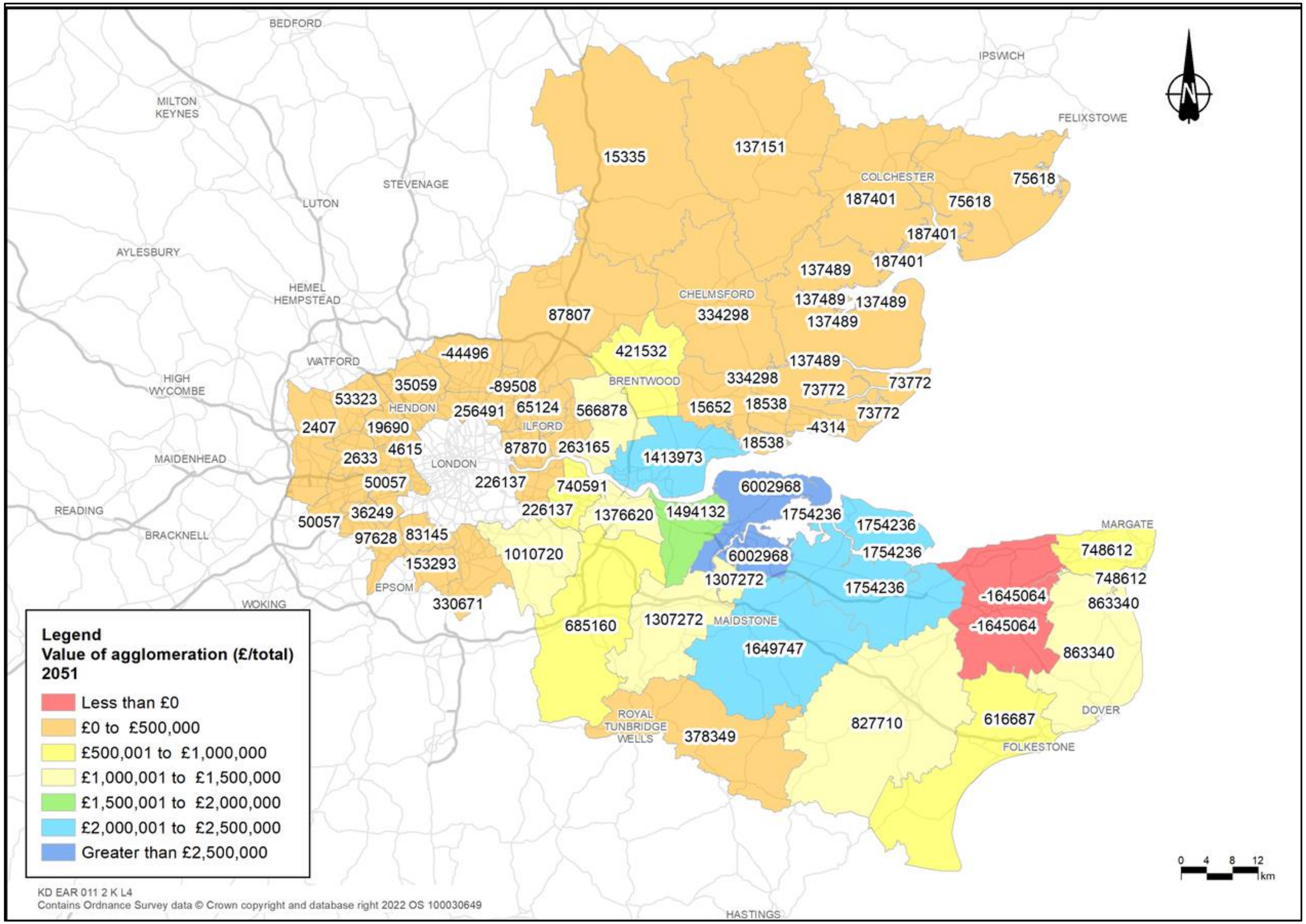


Plate C.11 Agglomeration impacts in 2051 in Essex, Kent and London (£, 2010 prices and values)



C.4.9 Table C.11 shows the total agglomeration benefits over 60 years for each economic sector for each WITA zone.

Table C.11 Agglomeration benefits by economic sector (£, 2010 prices and values)

		Manufacturing	Construction	Consumer Services	Producer Services	Total
1	Scotland	0	0	0	0	0
2	Northern Region	0	0	0	0	0
3	Northern Region	0	0	0	0	0
4	Northern Region	0	0	0	0	0
5	Northern Region	0	0	0	0	0
6	Cumbria	0	0	0	0	0
7	Lancashire and Blackburn	0	0	0	0	0
8	Liverpool City Region	0	0	0	0	0
9	Manchester City Region	0	0	0	0	0
10	Cheshire, Staffordshire and Stoke on Trent	0	0	0	0	0
11	Yorkshire & Humberside	0	0	0	0	0
12	Yorkshire & Humberside	0	0	0	0	0
13	Yorkshire & Humberside	0	0	0	0	0
14	Yorkshire & Humberside	0	0	0	0	0
15	Lincolnshire	0	0	0	0	0
16	Nottinghamshire	0	0	0	0	0
17	Leicestershire	0	0	0	0	0
18	Northamptonshire	0	0	0	0	0
19	Shropshire	0	0	0	0	0
20	Hereford & Worcester	0	0	0	0	0

		Manufacturing	Construction	Consumer Services	Producer Services	Total
21	Warwickshire	0	0	0	0	0
22	West Midlands	0	0	0	0	0
23	Cornwall	0	0	0	0	0
24	Devon	0	0	0	0	0
25	Dorset	0	0	0	0	0
26	Avon	0	0	0	0	0
27	Gloucestershire	0	0	0	0	0
28	Somerset	0	0	0	0	0
29	Wiltshire	0	0	0	0	0
30	North Wales	0	0	0	0	0
31	Mid Wales	0	0	0	0	0
32	Mid Wales	0	0	0	0	0
33	Rochford & Southend-on-Sea	207,926	361,521	449,053	1,243,344	2,261,844
34	Thurrock	2,924,142	9,858,475	32,575,033	32,319,895	77,677,547
35	Basildon & Castle Point	1,281,091	1,657,073	-367,571	2,118,781	4,689,373
36	Braintree	561,644	1,145,179	1,865,337	4,007,170	7,579,330
37	Brentwood	660,147	2,804,635	3,672,159	15,534,681	22,671,622
38	Basildon & Castle Point	362,394	916,831	389,275	1,229,327	2,897,827
39	Chelmsford	643,357	2,320,652	4,796,098	10,810,839	18,570,946
40	Maldon, Colchester & Tendring	498,563	1,158,104	3,126,857	5,490,084	10,273,608
41	Maldon, Colchester & Tendring	467,818	1,394,202	1,940,801	3,358,288	7,161,110
42	Rochford & Southend-on-Sea	308,441	1,008,521	1,068,105	2,190,653	4,575,719

		Manufacturing	Construction	Consumer Services	Producer Services	Total
43	Maldon, Colchester & Tendring	243,915	581,500	1,754,815	1,611,342	4,191,572
44	Norfolk	0	0	0	0	0
46	Suffolk	252,175	133,824	556,749	1,266,412	2,209,159
47	Suffolk	641,276	614,059	1,561,536	3,018,798	5,835,669
48	Cambridgeshire	0	0	0	0	0
49	Cambridgeshire	0	0	0	0	0
50	Cambridgeshire	438,488	271,368	1,438,080	5,309,004	7,456,939
51	Bedfordshire	0	0	0	0	0
52	Hertfordshire (East)	141,596	637,090	1,099,818	2,018,625	3,897,129
53	Hertfordshire (West)	0	0	0	0	0
54	Hertfordshire (East)	0	0	0	0	0
55	Hertfordshire (East)	318,031	331,633	522,823	1,145,935	2,318,422
56	Hertfordshire (West)	0	0	0	0	0
57	Hertfordshire (East)	294,269	165,864	569,110	1,367,036	2,396,279
58	Hertfordshire (West)	0	0	0	0	0
59	Hertfordshire (West)	0	0	0	0	0
60	Hertfordshire (East)	0	0	0	0	0
61	Suffolk	991,333	987,605	4,194,626	8,288,857	14,462,420
62	Uttlesford	94,870	207,391	414,647	692,521	1,409,429
63	Hertfordshire (East)	607,008	490,711	1,201,568	3,007,773	5,307,060
64	Epping Forest & Harlow	320,266	1,084,242	1,213,018	2,945,360	5,562,887
65	City of London	0	0	0	0	0

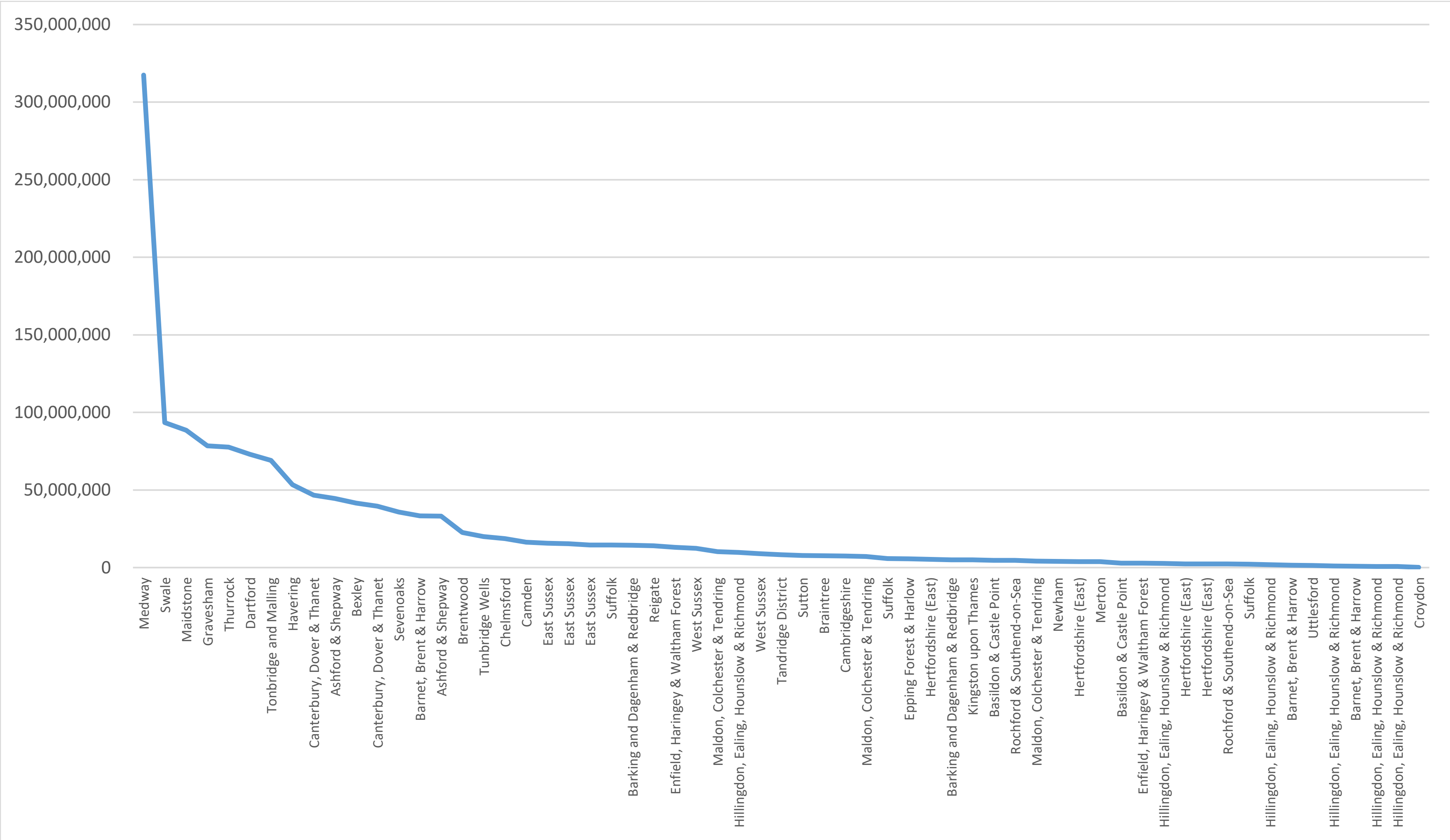
		Manufacturing	Construction	Consumer Services	Producer Services	Total
66	Barking and Dagenham & Redbridge	656,114	1,407,537	4,563,069	7,680,578	14,307,298
67	Barnet, Brent & Harrow	106,026	203,247	290,125	946,225	1,545,623
68	Bexley	1,702,556	4,526,974	10,856,640	24,461,344	41,547,515
69	Barnet, Brent & Harrow	71,006	101,376	259,681	454,499	886,562
70	Havering	1,450,977	5,285,427	9,654,173	37,007,052	53,397,630
71	Bromley	0	0	0	0	0
72	Camden	488,307	1,488,413	3,416,369	11,031,007	16,424,096
73	Croydon	-9,095	7,482	56,851	92,741	147,978
74	Hillingdon, Ealing, Hounslow & Richmond	117,560	168,371	81,508	356,017	723,455
75	Enfield, Haringey & Waltham Forest	346,754	1,118,777	3,895,579	7,619,061	12,980,171
76	Greenwich	0	0	0	0	0
77	Hillingdon, Ealing, Hounslow & Richmond	23,014	17,144	165,547	418,721	624,425
78	Hillingdon, Ealing, Hounslow & Richmond	159,436	613,801	2,975,846	6,008,206	9,757,289
79	Enfield, Haringey & Waltham Forest	104,734	344,397	503,503	1,873,207	2,825,842
80	Barnet, Brent & Harrow	1,025,729	4,128,063	8,934,548	19,246,758	33,335,097
81	Hillingdon, Ealing, Hounslow & Richmond	23,140	52,500	258,971	639,397	974,008
82	Hillingdon, Ealing, Hounslow & Richmond	49,446	117,200	773,086	1,683,204	2,622,935
83	Islington	0	0	0	0	0
84	Kensington and Chelsea	0	0	0	0	0
85	Kingston upon Thames	143,443	304,145	1,078,458	3,392,362	4,918,409
86	South London	0	0	0	0	0
87	South London	0	0	0	0	0

		Manufacturing	Construction	Consumer Services	Producer Services	Total
88	Merton	112,432	308,993	766,585	2,704,706	3,892,716
89	Newham	-97,535	198,781	1,312,391	2,521,410	3,935,048
90	Barking and Dagenham & Redbridge	136,865	657,783	979,658	3,199,849	4,974,154
91	Hillingdon, Ealing, Hounslow & Richmond	88,063	138,378	339,802	1,301,699	1,867,941
92	South London	0	0	0	0	0
93	Sutton	359,325	735,433	1,409,723	5,293,474	7,797,955
94	Tower Hamlets	0	0	0	0	0
95	Enfield, Haringey & Waltham Forest	-120,469	-282,491	-593,986	-1,429,960	-2,426,906
96	South London	0	0	0	0	0
97	Westminster	0	0	0	0	0
98	Medway	15,234,001	35,961,579	85,337,092	180,896,382	317,429,053
99	Hampshire	0	0	0	0	0
100	Ashford & Shepway	3,241,528	4,717,948	13,317,064	23,247,039	44,523,578
101	Canterbury, Dover & Thanet	-990,346	-6,733,999	-34,143,088	-42,436,139	-84,303,572
102	Dartford	1,637,052	12,907,704	21,246,010	37,163,358	72,954,124
103	Canterbury, Dover & Thanet	2,676,335	4,247,415	18,584,062	21,068,205	46,576,016
104	Gravesham	1,973,502	10,980,505	22,281,260	43,250,709	78,485,977
105	Maidstone	3,651,929	9,464,736	22,689,654	52,660,933	88,467,252
106	Sevenoaks	1,054,236	5,212,069	7,165,224	22,354,194	35,785,723
107	Ashford & Shepway	1,629,505	3,123,164	9,305,648	19,008,375	33,066,692
108	Swale	9,758,053	12,894,228	25,637,007	45,200,386	93,489,674
109	Canterbury, Dover & Thanet	2,811,011	6,329,940	11,570,502	18,825,897	39,537,350

		Manufacturing	Construction	Consumer Services	Producer Services	Total
110	Tonbridge and Malling	2,115,718	5,427,838	16,650,293	44,901,785	69,095,635
111	Tunbridge Wells	603,931	1,334,113	4,698,933	13,272,626	19,909,603
112	Tandridge District	196,478	1,248,382	1,721,750	5,135,790	8,302,400
113	Surrey (West)	0	0	0	0	0
114	Hampshire	0	0	0	0	0
115	Oxfordshire	0	0	0	0	0
116	Surrey (West)	0	0	0	0	0
117	Epsom and Ewell	0	0	0	0	0
118	Surrey (West)	0	0	0	0	0
119	Mole Valley	0	0	0	0	0
120	Reigate	272,856	889,896	1,625,976	11,243,189	14,031,917
121	Surrey (West)	0	0	0	0	0
122	Surrey (West)	0	0	0	0	0
123	Surrey (West)	0	0	0	0	0
124	Surrey (West)	0	0	0	0	0
125	West Sussex	0	0	0	0	0
126	West Sussex	976,202	617,151	2,748,876	8,012,946	12,355,175
127	West Sussex	0	0	0	0	0
128	West Sussex	369,840	746,776	2,071,353	5,730,324	8,918,293
129	East Sussex	539,434	1,218,207	3,369,243	10,610,106	15,736,989
130	East Sussex	677,837	2,008,778	3,944,085	8,725,109	15,355,810
131	East Sussex	570,682	1,606,768	3,591,669	8,800,687	14,569,806

		Manufacturing	Construction	Consumer Services	Producer Services	Total
132	West Sussex	0	0	0	0	0
133	Berkshire	0	0	0	0	0
134	Berkshire	0	0	0	0	0
135	Berkshire	0	0	0	0	0
136	Buckinghamshire	0	0	0	0	0
137	Buckinghamshire	0	0	0	0	0
Total		**68,196,361**	**163,975,406**	**359,432,678**	**783,148,183**	**1,374,752,628**

Plate C.12 Distribution of agglomeration benefits (£, 2010 prices and values)



Agglomeration impacts per job

C.4.10 Some of the variation in the distribution of agglomeration impacts is due to the geographic variation in the number of jobs, according to the chosen zoning system. A useful calculation is to view the agglomeration impact in each year as a rate per job in each zone. This calculation is done by dividing the total agglomeration impact in a zone by the total number of jobs across the four industrial sectors that are used. The results of this scaling are shown in Plate C.13 to Plate C.16. The jobs used were the totals for industrial sectors S1 to S4 for each forecast year, as specified in the TAG wider impacts dataset.

C.4.11 The plots showing the impact per job highlight the fact that, with the exception of the centre of London which remains anomalous, the benefits or disbenefits of west London (where the model's network lacks detail) are generally of the order of pence per job. Even for those anomalous London zones, the agglomeration impact is generally of much smaller magnitude than for zones close to the Project.

Plate C.13 Agglomeration impacts per job in 2030 in Essex, Kent and London (£, 2010 prices and values)

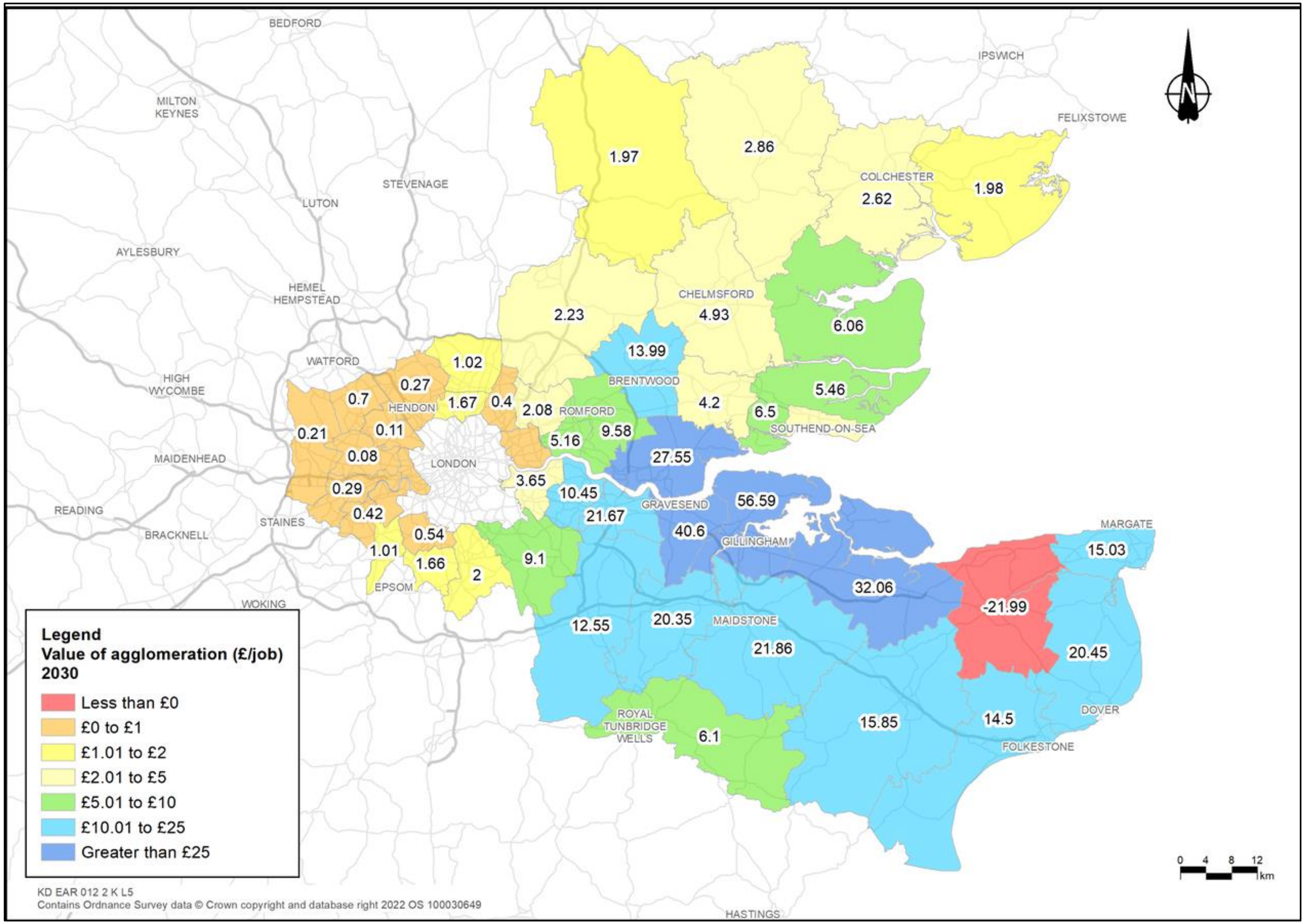


Plate C.14 Agglomeration impacts per job in 2037 in Essex, Kent and London (£, 2010 prices and values)

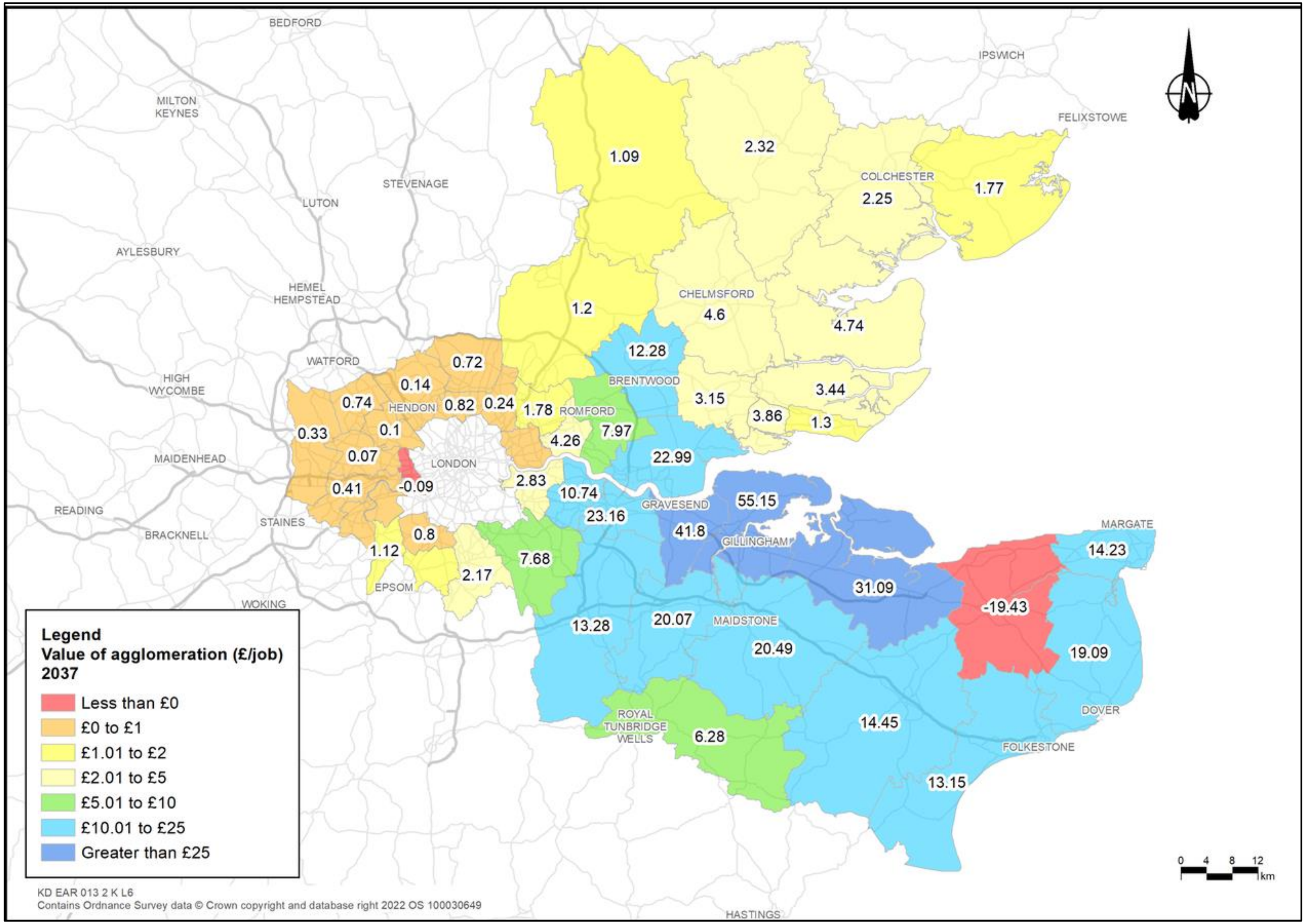


Plate C.15 Agglomeration impacts per job in 2045 in Essex, Kent and London (£, 2010 prices and values)

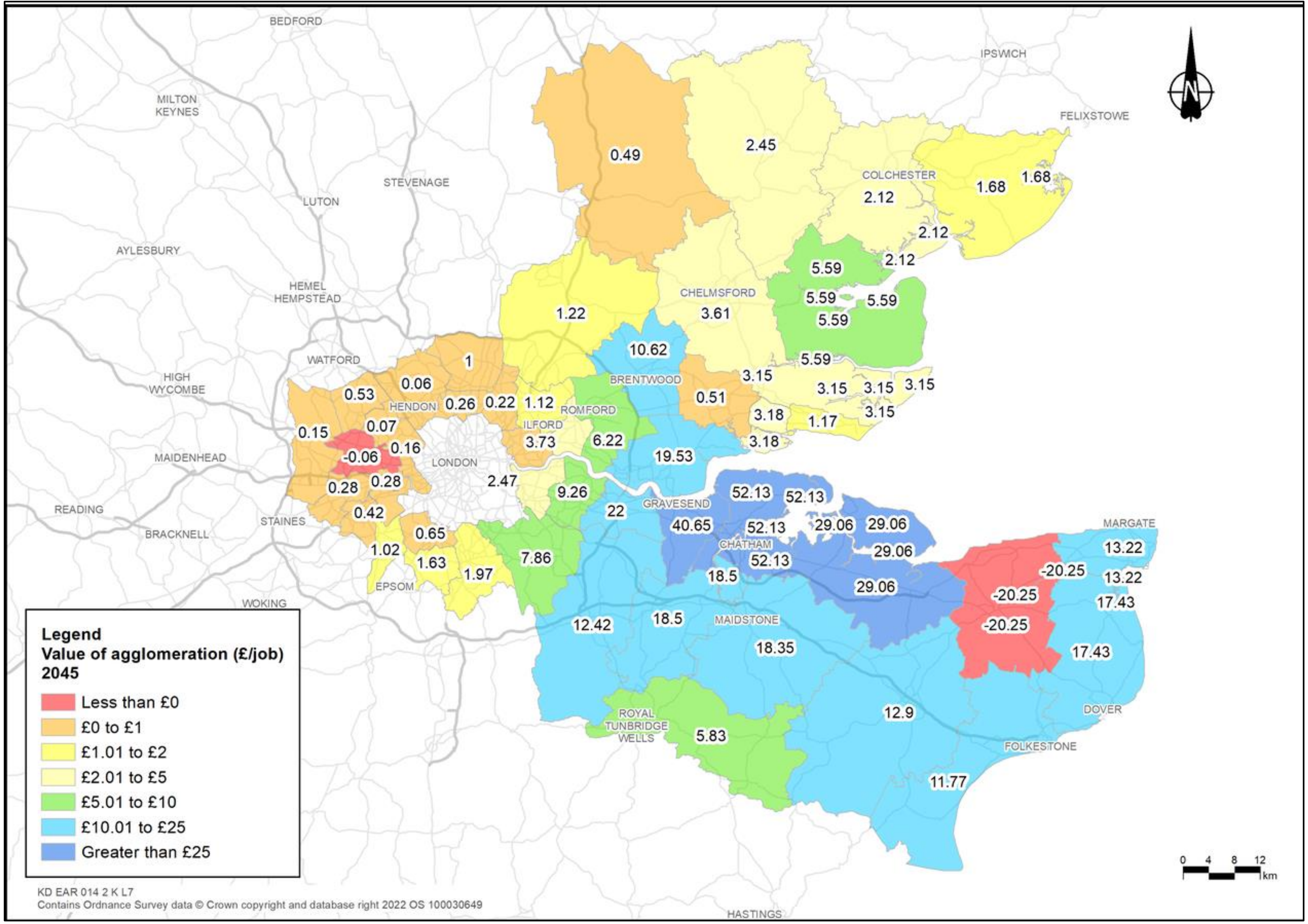
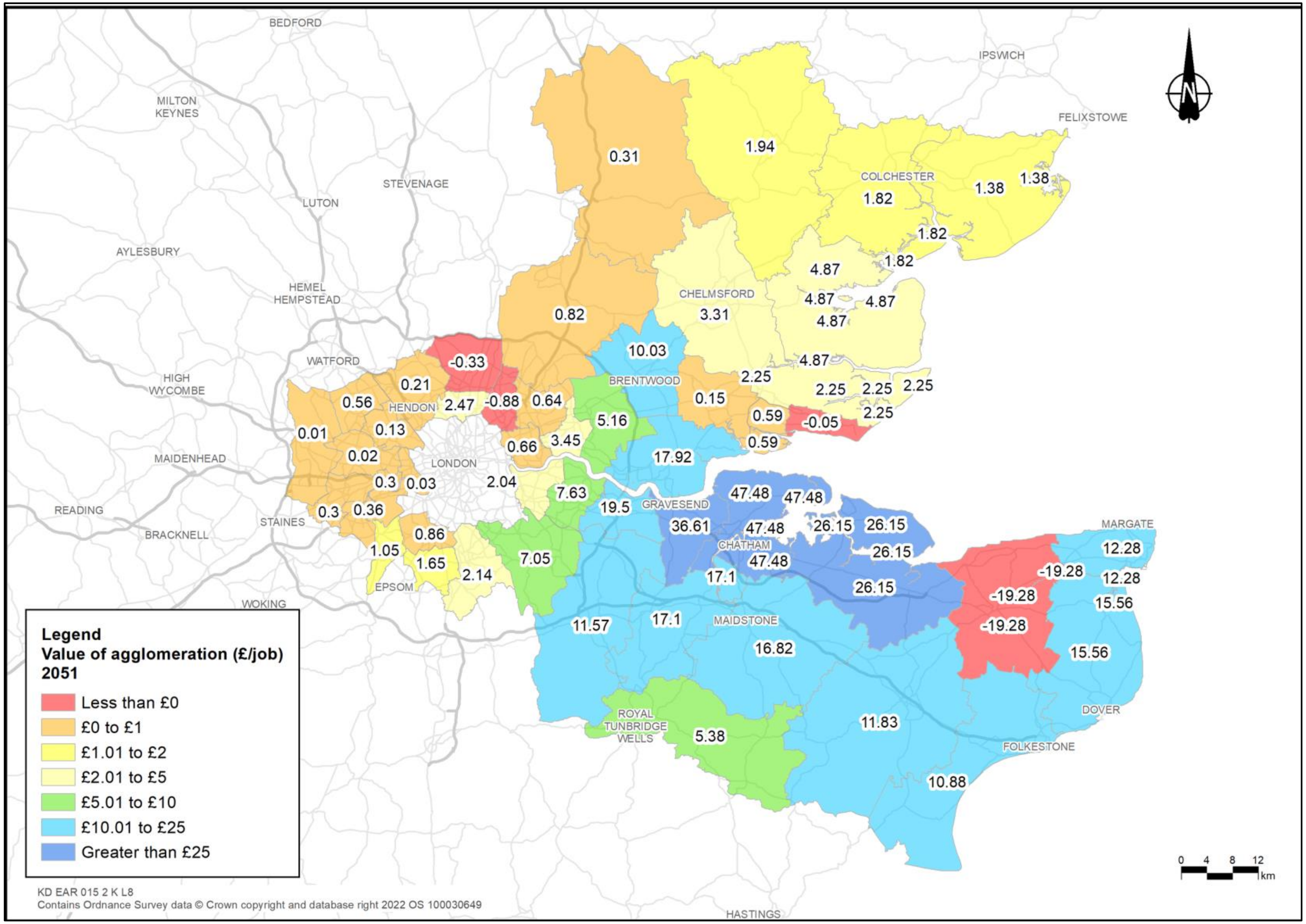


Plate C.16 Agglomeration impacts per job in 2051 in Essex, Kent and London (£, 2010 prices and values)



Annex D Project Costs

This Annex contains tables presenting the annual profiles of outturn CAPEX and OMR costs.

Table D.1 Profile of capital expenditure (CAPEX) costs (£m, outturn, Most Likely)

	Historic	2021/22	2022/23	2023/24	2024/25	2025/26	2026/27	2027/28	2028/29	2029/30	2030/31	2031/32	Total
Preparation	677.2	39.8	87.9	101.6	47.8	3.6	2.1	0.0	0.0	0.0	0.0	0.0	960.0
Supervision	0.0	0.0	0.0	0.0	44.2	57.7	69.0	63.4	67.7	65.5	15.9	1.4	385.0
Lands	0.0	4.5	35.0	15.0	29.3	86.9	94.5	70.9	40.6	35.8	28.0	0.0	440.5
Construction and other costs	0.0	6.6	20.3	58.2	212.4	998.5	1,219.1	1,455.6	1,341.8	804.8	178.8	1.8	6,298.0
Total	**677.2**	**50.8**	**143.3**	**174.8**	**333.8**	**1,146.7**	**1,384.7**	**1,590**	**1,450**	**906.1**	**222.7**	**3.2**	**8,083.4**

Table D.2 Profile of operating, maintenance and renewals (OMR) costs (£m, outturn, Central)

	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2031-42
Highways	6.6	6.1	6.3	6.4	6.5	6.7	6.8	7.0	7.1	8.1	37.1	37.9	**142.6**
Tunnels	9.2	9.4	9.6	9.8	10.6	10.3	13.5	10.7	11.0	31.8	11.5	16.5	**154.0**
Other	2.7	2.6	2.6	2.7	2.9	2.8	2.9	4.8	4.9	4.7	5.6	4.2	**43.3**
RUC	6.9	3.1	3.3	3.4	3.5	3.6	3.7	3.9	4.0	8.9	4.2	4.4	**52.9**
Total	**25.5**	**21.2**	**21.8**	**22.3**	**23.6**	**23.4**	**26.9**	**26.3**	**27.0**	**53.4**	**58.4**	**63.0**	**392.9**

	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2043-54
Highways	7.8	8.0	10.8	11.1	8.5	8.7	8.9	16.6	16.0	75.9	77.6	9.9	**259.6**
Tunnels	13.2	15.7	20.4	12.8	13.1	13.4	13.6	59.2	18.3	14.6	14.9	21.4	**230.5**
Other	11.5	11.7	16.4	18.7	6.3	4.1	3.7	6.1	5.9	6.2	6.3	6.7	**103.7**
RUC	4.5	4.6	4.7	4.9	5.0	5.1	10.9	5.4	5.5	5.6	5.8	5.9	**68.0**
Total	**36.9**	**40.0**	**52.4**	**47.5**	**32.8**	**31.3**	**37.2**	**87.3**	**45.8**	**102.3**	**104.5**	**44.0**	**661.8**

	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2055-66
Highways	10.1	10.3	10.6	10.8	11.0	50.3	50.2	11.8	59.9	61.2	12.6	12.8	**311.4**
Tunnels	50.9	17.5	16.2	21.3	17.0	72.6	17.7	18.1	18.5	18.9	34.7	27.8	**331.2**
Other	7.2	15.2	15.5	4.5	4.6	26.1	26.3	8.0	9.8	7.5	6.3	5.4	**136.6**
RUC	6.0	6.1	6.3	13.2	6.5	6.7	6.8	6.9	7.1	7.2	7.3	7.5	**87.6**
Total	**74.2**	**49.1**	**48.6**	**49.8**	**39.1**	**155.7**	**101.0**	**44.8**	**95.2**	**94.8**	**60.9**	**53.6**	**866.8**

	2067	2068	2069	2070	2071	2072	2073	2074	2075	2076	2077	2078	2067-78
Highways	13.1	13.4	13.7	36.2	35.5	14.6	14.9	122.5	130.4	21.3	16.3	16.7	**448.7**
Tunnels	20.2	20.6	23.2	123.3	22.0	28.9	23.0	23.5	39.1	24.6	25.1	36.1	**409.7**
Other	5.5	5.6	20.2	28.2	13.3	6.1	6.3	9.9	35.2	31.8	6.8	11.4	**180.3**
RUC	15.8	7.8	7.9	8.1	8.3	8.4	8.6	8.8	9.0	18.8	9.3	9.5	**120.3**
Total	**54.6**	**47.5**	**65.0**	**195.8**	**79.1**	**58.1**	**52.8**	**164.7**	**213.6**	**96.5**	**57.6**	**73.7**	**1,158.9**

	2079	2080	2081	2082	2083	2084	2085	2086	2087	2088	2089	2090	2079-90	2031-90
Highways	17.0	19.3	17.8	18.2	18.6	19.0	96.6	98.7	20.3	20.7	21.2	202.1	**569.4**	**1,731.7**
Tunnels	33.7	135.2	27.4	30.8	28.6	29.2	31.6	39.2	31.2	31.9	32.6	200.1	**651.5**	**1,776.9**
Other	11.6	11.3	12.0	27.8	27.4	8.0	11.2	16.1	13.8	8.7	8.9	91.7	**248.5**	**712.3**
RUC	9.7	9.9	10.1	10.3	10.5	10.7	22.5	11.1	11.4	11.6	11.8	12.0	**141.6**	**470.3**
Total	**72.0**	**175.7**	**67.3**	**87.0**	**85.0**	**66.9**	**161.9**	**165.2**	**76.7**	**72.9**	**74.4**	**505.9**	**1,610.9**	**4,691.3**

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Registered office Bridge House, 1 Walnut Tree Close, Guildford GU1 4LZ

National Highways Company Limited registered in England and Wales number 09346363