highways england

A27 Chichester Bypass

Economic Assessment Report

(updated 27 July 2016)

July 2016

Economic Appraisal Report – List of Amendments

The following changes have been made since the version issued on 14 July 2016.

Corrections

Version	Page	Para/Table/Figure	Comment
14 July 2016	26-28	Para 4.9.3.-4.4.15.2	(duplication of text) These sections were duplicates of section 4.7 – 4.9 and have been removed.
	37	Table 5-4	Erroneously referred to Options 1, 2, 2A. This has been revised to Option 1, 1A, 2.

Formatting Issues

Version	Page	Para/Table/Figure	Comment
14 July 2016	11	Figure 1-2	Was split over two pages – now corrected
	20	Table 3-2	Was split over two pages – now corrected
	24	Table 4-2	Was split over two pages – now corrected
	38	Figure 5-3	Was split over two pages – now corrected
	44	Para 5.8.1 - 2	Paragraph was split into several small sections – now corrected
	46	Para 5.9.1	Paragraph was split into several small sections – now corrected
	54	5th bullet point	Paragraph was split into two small sections – now corrected
	62	Table A-7	Was split over two pages – now corrected
	64	Table A-9	Was split over two pages – now corrected

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GLOSSARY OF TERMS

AADT	Annual Average Daily Traffic
AF	Annualisation Factor
AMCB	Analysis of Monetised Costs and Benefits
AST	Appraisal Summary Table
ATC	Automatic Traffic Count
BCR	Benefit to Cost Ratio
CATM	Chichester Area Transport Model
CDC	Chichester District Council
COBA	COst Benefit Analysis
CSR	Comprehensive Spending Review
DfT	Department for Transport
DIADEM	Dynamic Integrated Assignment and DEmand Modelling
DN	Do Nothing scenario
DM	Do Minimum scenario
DMRB	Design Manual for Roads and Bridges
DS	Do Something scenario
ECI	Early Contractor Involvement
GIS	Geographical Information System
HAM	Highway Assignment Model
HATRIS	Highway Agency Traffic Information System
HE	Highways England
HGV	Heavy Goods Vehicle
IAN	Interim Advice Notice
IP	Inter Peak
LGV	Light Goods Vehicle
LMVR	Local Model Validation Report
LRN	Local Road Network
PA	Public Accounts
PCF	Project Control Framework
PCU	Passenger Car Unit
PI	Public Inquiry
PIA	Personal Injury Accident
PVC	Present Value of Costs
QUADRO	QUeues And Delays at ROad works
RBS	Road Based Study
RTF	Regional Traffic Forecasts
SATURN	Simulation and Assignment of Traffic to Urban Road Networks
SoCoMMS	South Coast Multi Modal Study
SoS	Secretary of State
TAG	Transport Analysis Guidance
TAME	Traffic Appraisal Modelling and Economics
TEE	Economic Efficiency of the Transport System
TFR	Traffic Forecasting Report
TM	Traffic Management
TRADS	TRAffic Database System
TUBA	Transport User Benefit Appraisal
VDM	Variable Demand Modelling
VfM	Value for Money
VOT	Values of Time
VOC	Vehicle Operating Cost
WebTAG	Web Based Transport Analysis Guidance
WSCC	West Sussex County Council

1 Introduction

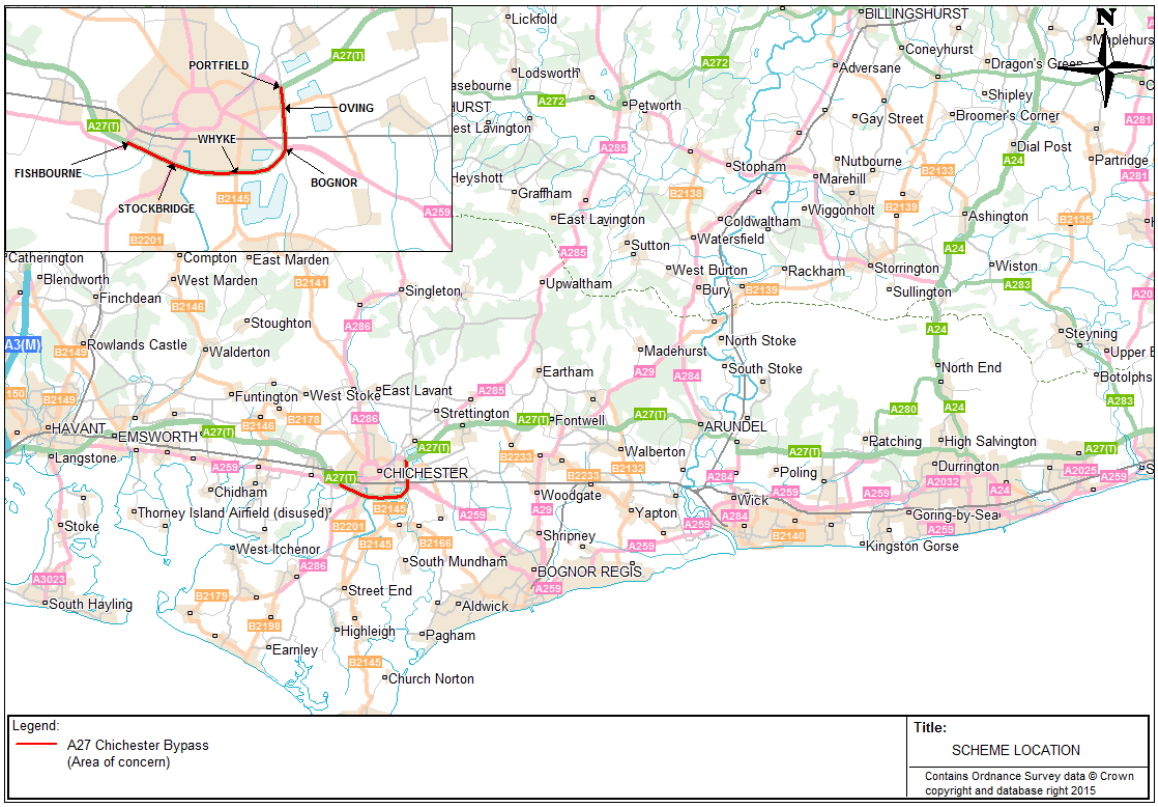
1.1 Project background

1.1.1 Highways England[1] has commissioned Jacobs to develop a traffic model which can be used to assess different options proposed for the A27 Chichester Bypass Improvements scheme intended to release congestion.

1.1.2 The A27 is the only strategic east-west road along the south coast, directly linking Eastbourne in East Sussex to Portsmouth in Hampshire via Brighton, Worthing, Arundel, Chichester and Havant, and onto Southampton and beyond using the M27. In Chichester the A27 loops around the south of the city, forming the Chichester Bypass. The 5km length of the bypass is a dual carriageway and comprises five at-grade roundabouts (Fishbourne, Stockbridge, Whyke, Bognor Road and Portfield), and one signalised junction (Oving). Figure 1-1 shows the location of these key junctions. These junctions are where the radial routes between the south coast (Manhood Peninsula and Bognor Regis) and the city centre cross the bypass, and junction spacing varies from 0.5km to 1.3km

1.1.3 Although a strategic route, the majority of traffic using the bypass is local traffic entering and leaving Chichester itself. It is the combination of the close proximity of the junctions and the conflict between the impeding north-south and east-west traffic flows that generates significant congestion and extensive queuing at most of the junctions at peak times, disrupting the mainline flow of the road and compromising its operation as a strategic route.

Figure 1-1: Scheme Location - A27 Chichester bypass



[1] Previously known as the Highways Agency.

1.1.4 In 2000, the South Coast Multi Modal Study (SoCoMMS) recommended that these issues be resolved using high level local strategies including grade separation of four of the junctions along the A27. These options were rejected in 2003 by the Secretary of State (SoS) on environmental grounds. By March 2005, Highways England during public consultation presented new options which were developed with an aim to accommodate the views of all key stakeholders, minimise damage to the environment, support local issues and public transport solutions. Lower cost variations of the options were assessed and developed by Highways England, culminating in a shortlist of four options being promoted at the end of Project Control Framework (PCF) Stage 1 in 2010.

1.1.5 Since 2010, two further studies into the A27 around Chichester have been undertaken independently from Highways England. One was instigated by Chichester District Council (CDC) in 2012, the other by West Sussex County Council (WSCC) in 2013. The outcome of the studies proposed improvements to the bypass junctions which were designed in conjunction with housing developers or partly funded by local developers. None of the junction improvements identified in the CDC or WSCC reports have been implemented.

1.2 Scheme history

1.2.1 The previous Highways England study identified four options for improvements to the A27 Chichester Bypass. These considered different scenarios at each of the six junctions, including grade separation, full or restricted movement signalised junctions, signalisation of the existing roundabout, or to do nothing. These four options were:

- i. Option 11 - a mid-range option, including grade-separation of Fishbourne Junction and full signalisation of Bognor Road Junction (preferred option).
- ii. Option 13 – based on the original Option 1 presented for Public Consultation in 2004/2005 but without any improvements to the existing Portfield Junction. This option included grade separation at Fishbourne and Bognor Road Junctions with restricted movements at the intermediate junctions.
- iii. Option 15 – based on the original Option 2 presented for Public Consultation in 2004/2005 but without any improvements to the existing Portfield Junction. This option included grade separation at Fishbourne and Bognor Road Junctions with restricted movements at the intermediate junctions. It also included the SLR (Stockbridge Link Road).
- iv. Option 19 – a least cost option, including grade-separation of Fishbourne Junction but with limited improvements at other junctions

1.2.2 Subsequent to the suspension of the Highways England scheme in 2010, two further, low-cost, schemes were identified in studies commissioned by Local Authorities:

- v. Options identified by West Sussex County Council
- vi. Options identified by Chichester District Council

1.2.3 These options recommended junction improvements to all six junctions on the bypass and were envisaged as measures in order to ensure local developments did not cause the levels of congestion and queuing on the bypass to deteriorate beyond those forecasted in 2031 without any developments (but not reducing congestion levels to those experienced in 2009). In addition two other options have been reviewed:

- vii. a northern bypass
- viii. a southern bypass

1.3 Scheme Assessment

1.3.1 In 2015 a new study was commissioned was by Highways England to assess options to improvements to the Chichester Bypass.

1.3.2 During PCF Stage 1 a filtering process has been undertaken to determine the appropriate options to take forward into Stage 2 option selection. Six options plus one sub option were originally shortlisted for the option selection at Stage 2 and were assessed as part of the EAR submitted in January 2016. Since then two further online options (alternative sub-options to Option 1 and Option 3) were developed. Table 1-1, Table 1-2, and Figure 1-2, give a brief description of each option. Details for each option are available in the latest Forecasting Report[2].

1.3.3 The A27 Chichester Bypass Improvement Scheme is currently at PCF Stage 2.

Table 1-1: A27 Do Something Options

Option	Type	Route	Note	Stockbridge Link Road*
1	Online option	Upgrade of existing A27 route	Reduced connectivity with radial routes on existing online route.	No
*1A***	*Online option*	*Upgrade of existing A27 route*		*No*
2	Hybrid option	Upgrade of existing A27 route	Reduced connectivity with radial routes on existing online route. Additional of Stockbridge link road to compensate	Yes
2A	Hybrid option	Upgrade of existing A27 route	Reduced connectivity with radial routes on existing online route. Additional link road to compensate parallel to the A27. (alternative to Option 2 above)	Yes, Link Road realigned to run parallel to A27 bypass route
3	Online option	Upgrade of existing A27 route	Low Cost At Grade Upgrade Option. Reduced connectivity with radial routes on existing online route.	No
*3A***	*Online option*	*Upgrade of existing A27 route*	Increase to 3 lanes on mainline. Reduced connectivity with radial routes on existing online route.	*No*
4	Offline option	2 lane DC Northern Route – No intermediate junctions. Only one intermediate junction near Lavant.	High Speed Interchange West of Fishbourne Roundabout to high speed interchange prior Boxgrove Roundabout, with grade separate junction at Lavant. Assumes closure of Boxgrove rbt, access to A27 from Tangmere Rd.	No
5	Offline option	2 lane DC Northern Route– No intermediate junctions. Only one intermediate junction near Lavant	As option 4 with alternate alignment west of Chichester where the new A27 diverts to the new alignment.	No
6	Hybrid option	Upgrade of existing A27 route, diverting away from existing Oving and Portfield junctions	New A27 diverges away from existing A27 and crosses over the A259 and railway. Dumbbell arrangement created by using the existing Bognor Roundabout and creating a	Yes

* Provision of new link road (60 mph speed limit) to run from Fishbourne roundabout around Stockbridge to east of B3126 to compensate for loss of connectivity at the Stockbridge and Whyke junctions. ** *Two new options are developed.* Note: Highlighted options are part of the current economic assessment whilst other options formed part of the previous economic assessment carried out in January 2016.

[2] A27 Chichester Bypass Improvement Scheme, Forecasting Report, May 2016

Table 1-2: A27 Scheme Options – Upgrades to A27 Chichester Bypass Junctions

Option	Fishbourne	Stockbridge	Whyke	Bognor	Oving	Portfield
1	Grade Separation	Signals & banned right turns and radial straight on		Grade Separation	No Signal & closure of Oving Rd East	As Do Min‡
1A	Grade Separation	As Do Min		Grade Separation	No Signal & closure of Oving Rd East	As Do Min‡
2	Grade Separation	Mainline elevated. No connection to radial route		Grade Separation	No Signal & closure of Oving Rd East	As Do Min‡
2A*	Grade Separation	Mainline elevated. No connection to radial route		Grade Separation	No Signal & closure of Oving Rd East	As Do Min‡
3	Signalised 'Hamburger'	Signals & banned right turns		Signalised Roundabout	Signalised with banned right turns & Oving Rd East closed except for buses	Segregated left turn lane for A27 SB.
3A†	Signalised 'Hamburger'	Signals & banned right turns		Grade Separation	Signalised with banned right turns & Oving Rd East closed except for buses	As Do Min‡‡
4**	As Do Min	As Do Min	As Do Min	As Do Min	As Do Min	As Do Min
5**	As Do Min	As Do Min	As Do Min	As Do Min	As Do Min	As Do Min
6	Grade Separation	Mainline elevated. No connection to radial route		Dumbbell arrangement with new roundabout on A259	As Do Min	As Do Min

** Option 2A is the same as Option2 along the existing Chichester Bypass Junctions*

*** Assumes closure of Boxgrove Rbt and access to A27 from Tangmere Rd, with compensating access road from Tangmere to A285/A27 junction*

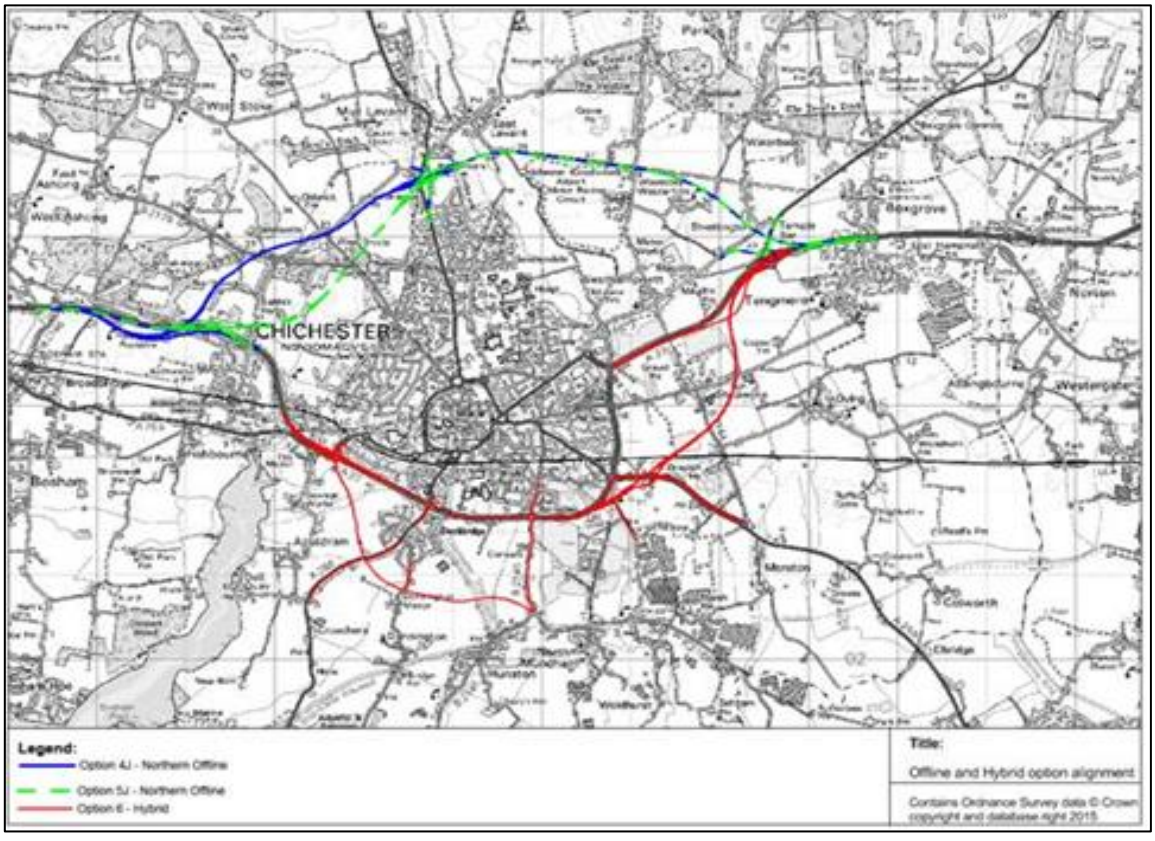
*** Both Options 4 & 5 have no improvements to the existing Chichester Bypass Options*

†Includes widening of main line A27 carriageway from dual to 3 lane (D3AP) in each direction from Fishbourne Rbt to Bognor Rbt

‡As per Do Minimum 2035/2041

‡‡As per Do Minimum 2020

Figure 1-2: Offline Options Alignment



1.3.4 In February 2016, Highways England decided to exclude the northern and southern bypass options (Options 4, 5 and 6) as they were found to exceed the Road Investment Strategy £100m to £250m budget range. At this time Option 2A was also discounted as the economic and environmental assessment found that Option 2 performed better. It is understood that the Highways England will consult on schemes that will meet their objectives to improve traffic flow and safety, that sit at the lower end of the £100m to £250m range. These improvements will be to four junctions on the A27 Chichester Bypass, as stated in the Government's 2014 Roads Investment Strategy.

1.3.5 For the purpose of the current economic assessment, the following five options are considered that meet the Highways England objectives to improve traffic flow and safety and also meet their budget range:

- Option 1;
- Option 1A;
- Option 2;
- Option 3; and
- Option 3A.

1.3.6 Key economic findings of the Offline Option 4 and Option 5 and Hybrid Option 2A and Option 6 which were part of the previous EAR[3] are included in the Appendix A of this report.

1.3.7 It should be noted that the current economic assessment is based on excluding dependent development (i.e. a scenario without the new housing development at strategic development sites but with the transport scheme) following TAG Unit A2.3 whilst the previous assessment was based on including dependent development (i.e. a scenario with the new developments and with the transport scheme).

1.4 Scheme objectives

1.4.1 Highways England aims to remove conflict and congestion at the bypass junctions and improve access to Chichester, the Bournes, the Manhood and the wider Bognor Regis area, enabling other local transport improvements to be implemented.

1.4.2 The Scheme 'A27 Chichester Bypass - Upgrading 6 junctions on the existing 5km bypass' was included in the HM Treasury's June 2013 White Paper 'Investing in Britain's Future', as part of a 'Pipeline of HA road schemes which the government is committed to funding as part of this Spending Round, subject to value for money and deliverability.'

1.4.3 The key Transport and Environmental Objectives of the Scheme are summarised below:

- Reduce congestion on the Chichester bypass;
- Improve journey time reliability;
- Improve capacity and support the growth of regional economies;
- Improve accessibility to areas with tourist activity;
- Reduce adverse environmental impacts and eliminate where possible;
- Address existing Air Quality Management Areas (AQMAs) and ensure no further AQMAs are created as a result of selected option; and
- Address existing noise priority areas and ensure no further noise priority areas as a result of selected option.

[3] A27 Chichester Bypass Improvement Scheme, Economic Assessment Report, January 2016

1.5 Model development and traffic forecasting overview

1.5.1 Throughout the appraisal of an improvement scheme, traffic models are developed and refined. In general, traffic models become more detailed as a scheme progresses. The previous version of the traffic model was developed to assess the junction improvement options as described above, and to present the relevant results.

1.5.2 The 2009 Chichester Area Transport Model (CATM) has been revised to bring it up to date and to allow it to provide the traffic forecasts needed for the current stage of option selection. The opportunity is also being taken to use the latest version of the software previously used.

1.5.3 The key objective behind development of CATM 2014 model is to understand the impact of identified options to relieve the congestion on A27 Chichester bypass. The model can be used for:

- Detailed representation of traffic patterns, flows, delays and congestion, and to support both future forecasts, and the Strategic Case for the scheme;
- Understanding the impacts of different potential scheme options, in order to optimise the proposals;
- Demonstrating the impacts that the scheme(s) are likely to have on the local and strategic road network;
- Allow assessment of the benefits of the scheme, and underpin the Value for Money Case for the Scheme;
- Inform the environmental impacts of traffic flow on Noise, Air Quality and other environmental indices;
- Model the impacts of key strategic housing and non-housing developments; and
- Support local public/stakeholder consultation.

1.5.4 The traffic model developed for PCF Stage 2 used the SATURN software package for Highway Assignment and the DIADEM software for Variable Demand modelling. The main purpose of the traffic model at that stage was to provide traffic forecasts that were sufficiently robust to allow for the option selection and enable the scheme to be taken further for the PCF Stage 3 – Preliminary Design.

1.5.5 In order to provide appropriate inputs to the Economic Appraisal process, and as discussed above, traffic forecasts have been prepared for the following scenarios:

- 2020 Opening Year Do Minimum;
- 2020 Opening Year Do Something;
- 2035 Do Minimum;
- 2035 Do Something;
- 2041 Do Minimum; and
- 2041 Do Something.

1.6 Economic assessment

1.6.1 As explained in TAG Unit A1.1, an economic assessment is undertaken to facilitate the quantification and monetisation of scheme costs and benefits. Overall, schemes are assessed against relevant government objectives, which include:

- provide good value for money in relation to impacts on public accounts;
- improve transport economic efficiency for business users and transport providers;
- improve transport economic efficiency for consumer users; and
- improve reliability.

1.6.2 An economic assessment is undertaken over a 60 year period in accordance with the requirement of TAG Unit A1.1. Economic assessment results are presented in the form of Transport Economic Efficiency (TEE), Public Accounts (PA), and Analysis of Monetised Costs and Benefits (AMCB) tables. The results are also input to an Appraisal Summary Table (AST).

1.6.3 The full economic assessments of the each Do Something option as listed and highlighted in Table 1-1 have been undertaken for the Core growth scenario.

1.7 Purpose of this report

1.7.1 This Economic Assessment Report (EAR) describes the methodology used to undertake the economic assessment. It includes a description of the derivation of scheme costs, user benefits for travel time, vehicle operating costs, accidents and journey time reliability. Delays associated with the scheme construction and maintenance are also assessed. It provides the key statistics derived from these economic assessments. The value for money expressed as a Benefit to Cost Ratio (BCR) is a key output and is determined in accordance with the requirements of TAG Unit A1.1.

1.7.2 The content of the report is based upon the requirements set out in 'Interim Advice Note 106/08 – Guidance Note for Traffic Consultants Employed on HA Schemes'.

1.8 Structure of report

1.8.1 The remainder of this report describes the stages involved in the development of the economic assessment, and contains appropriate reporting of the outputs from the process. This report will provide a reliable basis for the development of the forecast models needed to promote the scheme at next stage of the PCF. The structure of the remainder of this report is as follows:

- **Chapter 2 Economic assessment methodology**– explains the economic assessment approach adopted and the derivation of shortlisted scheme options' benefits.
- **Chapter 3 Estimation of costs** – describes the derivation of the scheme costs.
- **Chapter 4 Estimation of benefits**– provides a summary of the economic assessment results.
- **Chapter 5 Appraisal summary**– provides a summary and conclusion to the above.
- **Chapter 6 Summary and conclusions**- discusses overall summary and conclusions.

2 Economic assessment methodology

2.1 Introduction

2.1.1 The economic assessment is based on the outputs of transport models which predict the movement of people and vehicles in the Do Minimum and Do Something scenarios based on a range of standard parameters. It mainly involves the determination of the costs and benefits of the scheme using traffic flows and speeds obtained from the traffic model to derive travel time savings.

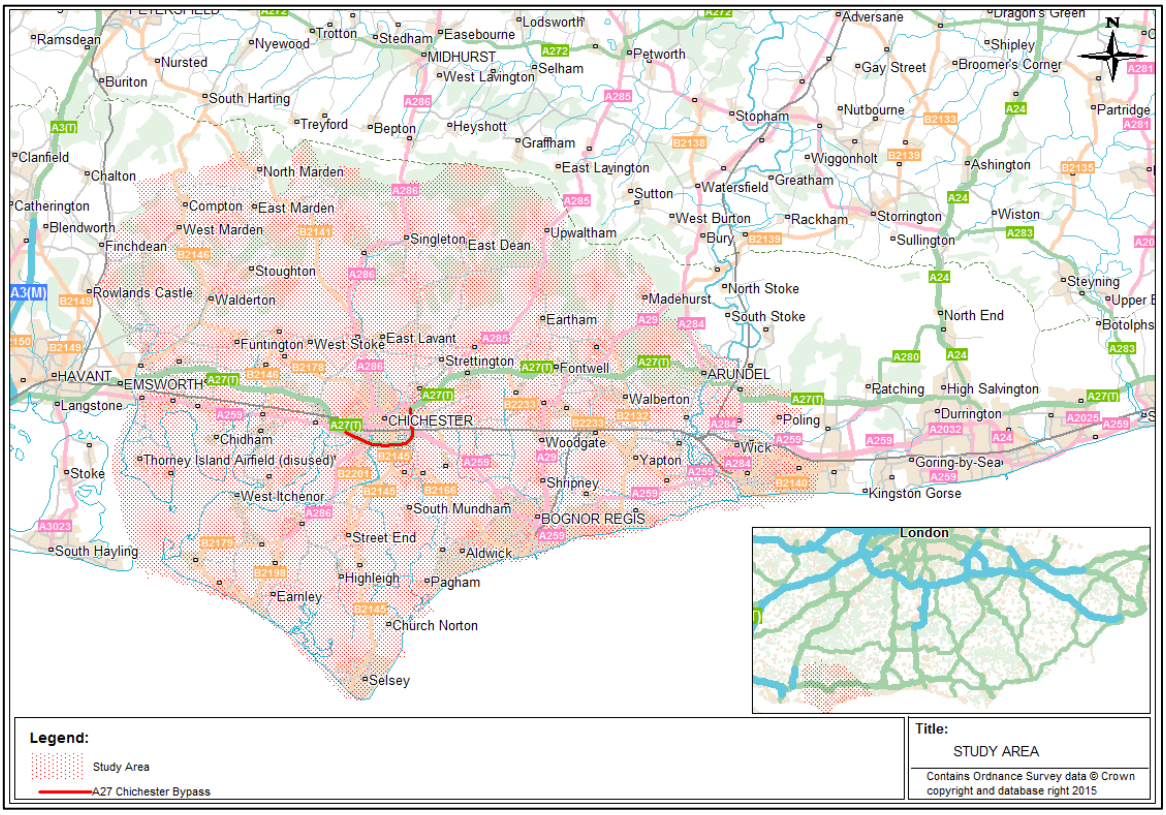
2.2 Study area

2.2.1 The study area for the PCF Stage 2 traffic model was identified in the Local Model Validation Report, which was defined and agreed with Chichester District Council. This was identified to cover the area directly affected by the proposals being tested, with the potential to assess some peripheral impacts on strategic routes in the vicinity of the affected area.

2.2.2 The study area comprised the south of Chichester District (to the northern edge of the South Downs) and that portion of Arun District west of Arundel and the River Arun. This is the same area as covered by the 2009 CATM Study. This wider area allowed detailed representation (through to actual trip ends) of much of the highways traffic in the centre of Chichester and of that using the A27.

2.2.3 The remainder of Sussex and immediately surrounding counties was modelled at medium level of resolution, with more distant areas (e.g. the south west) coded at regional or coarser level of resolution. Figure 2-1 shows the area covered in the model.

Figure 2-1: Study area



2.3 Transport model used

2.3.1 The traffic demand used in the economic assessment of the shortlisted options of A27 Chichester Bypass scheme was derived using DfT's Variable demand model - Dynamic Integrated Assignment and DEmand Modelling (DIADEM). DIADEM uses population and employment figures from TEMPRO (NTEM 6.2) as well as assumptions from the Government on the economic parameters to estimate overall changes in travel demand on the highway network. The DIADEM modelling suite is strategic in nature and is used to identify broad changes in travel patterns across the highway networks as well as the magnitude of this change in the study area. The distribution response (destination choice) is included in the Variable Demand Model, together with a frequency response for optional (other purpose) trips.

2.3.2 The Highway Assignment Model (HAM) developed for the scheme predicts the routes that drivers choose and the associated congestion and delay impacts on roads within the study area.

2.3.3 The HAM traffic model for the A27 Chichester Bypass Scheme was developed for the following time periods:

- Weekday Morning (AM) peak hour (08:00-09:00);
- Weekday Average inter-peak (IP) hour between 10:00-16:00; and
- Weekday Afternoon (PM) peak hour (17:00-18:00).

2.3.4 The traffic model used for forecasting splits the traffic flows into different vehicle categories and different journey purposes. The future year matrices consist of five vehicle type and journey purpose combinations ('User Classes'):

1. User Class 1: Car used for Commuting;
2. User Class 2: Car used for Employer's Business;
3. User Class 3: Car used for Other purposes;
4. User Class 4: Light Goods Vehicles (LGVs); and
5. User Class 5: Heavy Goods Vehicles (HGVs).

2.3.5 Light Goods Vehicles are modelled as a single user class in the traffic model. As personal use represents a small proportion of total LGV trips, and no detailed information on the proportion is available for the study area, all LGV trips are treated as being for employer's business purposes.

2.3.6 TAG provides average journey purpose splits. To split LGV flows into those used for the personal and freight WebTAG guidelines were used, these provide a split of 12% for LGV personal and 88% for LGV freight and used for the economic assessment purpose.

2.3.7 Further detail on the transport models is provided in the Traffic Forecasting Report and Local Model Validation Report[4] prepared for the Scheme.

[4] A27 Chichester Bypass Traffic Forecasting Report, May 2016
A27 Chichester Bypass Local Model Validation Report, May 2016

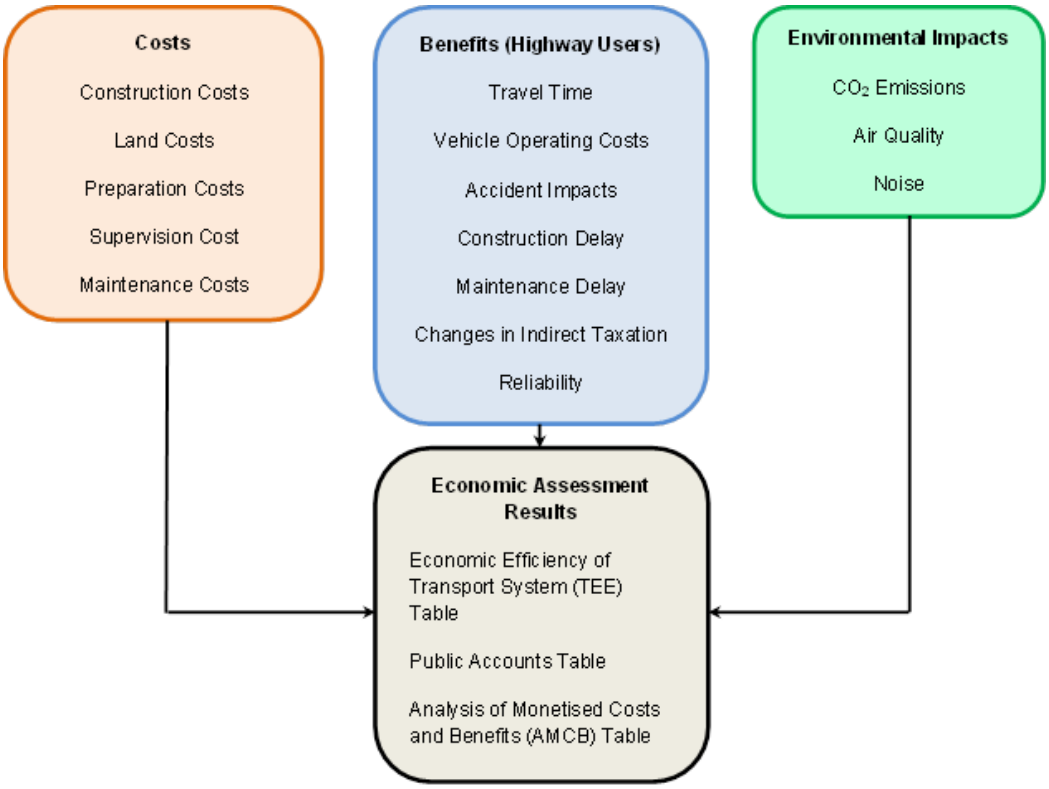
2.4 Appraisal period and future years

2.4.1 In accordance with TAG Unit A1.1, the economic appraisal period extends 60 years after the scheme opening year which is programmed to be complete in 2021 for Options 1 and 2 and 2019/2020 for Options 1A, 3, and 3A as per the provided construction schedule. The model forecast years were 2020 (assumed as the Scheme opening year), 2035 (intermediate/design year) and 2041 (horizon year). The economic appraisal will therefore be carried out up to 2079 with a first appraisal year of 2020 for Options 1A, 3 and 3A whilst the economic appraisal for the Options 1 and 2 will be carried out to 2080 with a first appraisal year of 2021[5].

2.5 Economic appraisal methodology

2.5.1 The Economic Assessment has been carried out using standard procedures and economic parameters as defined by TAG Unit A1. The components that make up the assessment are shown in Figure 2-2.

Figure 2-2: Economic Assessment Components



2.5.2 The following elements of the economic assessment have been considered:

- road user journey time impacts – due to changes in travel time and vehicle operating costs;
- road user safety impacts – due to changes in the future number and/or severity of accidents;
- reliability impacts – due to changes in journey time variability;

[5] While the actual Scheme opening year for the Options 1 and 2 is likely to be 2021, the 2020 model year is the closest year to scheme opening, and advice in TUBA (TUBA FAQ) is that if Scheme opening is only 1 or 2 years after the first modelled year then the modelled year data can be used to represent the Scheme opening year.

- construction and maintenance impacts – impacts on road user travel time and vehicle operating costs during Scheme construction and future maintenance;
- indirect tax revenue – due to changes in the amount of fuel and other direct vehicle operating costs purchased and changes in expenditure on transport offsetting changes in expenditure elsewhere in the economy; and greenhouse gas, noise and air quality impacts.

2.5.3 The results of the assessment are presented in the following tables:

- Transport Economic Efficiency (TEE) Table;
- Public Accounts (PA) Table; and
- Analysis of Monetised Costs and Benefits (AMCB) Table.

3 Estimation of costs

3.1 Overview

3.1.1 As discussed previously, part of the economic analysis process is to derive the costs associated with the scheme, predominantly construction, land, preparation and supervision costs. However, the capital costs of maintenance also need to be considered. The preparation of each shortlisted option costs for the Scheme has been carried out following the principles set out in TAG Unit A1.2 'Scheme Costs'. The costs have been estimated under two broad headings – investment costs and operating and maintenance costs.

3.1.2 Where costs were provided in financial years, these are converted into calendar years for the economic assessment. Unless otherwise stated, all costs have been derived from information provided by the Highways England Commercial Unit team.

3.2 Construction costs

3.2.1 To take into account the uncertainty associated with scheme cost estimation, construction costs are currently produced as a range rather than a single estimate. These costs are known as Range Forecasts and they take into account risks and uncertainty by deriving high, central and low cost estimates. The high forecast takes into account a high likelihood of risk, the central forecast takes into account an average risk and the low forecast a reduced likelihood of risk.

3.2.2 As advised by the Highways England Commercial Unit, optimism bias is not required on Highways England figures. Instead this now takes the form of unscheduled items, project risk, uncertainty and the Minimum (low) and Maximum (high) range.

3.2.3 Outturn costs are the expected costs in the actual years of expenditure. Range Forecasts of outturn costs for construction, land, preparation and supervision for each actual year of expenditure were produced by Highways England and were developed from relevant information (including preliminary design and bills of quantities). Table 3-1 summarises range forecasts for each option. It should be noted that for the economic assessment purpose central estimates are considered as agreed with Highways England.

Table 3-1: Range Forecasts Outturn Costs, £m

Option	Low	Central	High
Option 1	£149.8	**£181.9**	£226.7
Option 1A	£114.4	**£139.4**	£195.5
Option 2	£230.8	**£280.2**	£350.9
Option 3	£38.5	**£47.3**	£59.1
Option 3A	£141.8	**£171.9**	£259.5

3.2.4 The expenditure profiles are based upon cost estimates for each financial year prepared in 2014 Q1 prices and then inflated to outturn costs using Highways England projected construction related inflation. These costs have then been rebased to 2010 calendar year profiles for economic calculations, using the GDP-deflator series as published in the December 2015 TAG Data book. All costs are in factor cost unit of account and exclude VAT, both recoverable and non-recoverable. All spend to date has been removed by Highways England Commercial Unit. Table 3-2 summarises the value of the construction cost with expenditure profile. It also shows total discounted costs in 2010 market price unit of account (Present Value of Costs, 2010 prices, discounted to 2010) for each option. Appendix B represents the capital costs spending profile and calculations of the PVC.

Table 3-2: Summary of the discounted Scheme Costs – Investment, £m

	Option 1	Option 1A	Option 2	Option 3	Option 3A
Preparation	£12.0	£11.3	£16.8	£5.8	£11.8
Supervision	£4.3	£2.2	£5.0	£1.2	£2.6
Works	£103.6	£80.4	£157.9	£24.8	£88.2
Land	£3.6	£3.1	£11.8	£0.5	£17.5
Total, PVC	**£123.4**	**£97.0**	**£191.5**	**£32.3**	**£120.1**

3.3 Operating and maintenance costs

3.3.1 The capital cost of maintenance is the cost of people, machinery, and materials to maintain the highway network and its assets. It also includes any associated traffic management costs for future years. High level capital costs and traffic management costs information for each option was provided by Mott MacDonald. It should be noted that the operating and maintenance costs have been revised down based on the latest maintenance contracts brought forward and therefore costs of these elements are different than these provided in late 2015 and included in the previous economic assessment.

3.3.2 It is understood that Operating and Maintenance (O&M) costs for each option were calculated using Highways England Commercial operating cost model. All costs in the model are presented on a non-discounted basis, in 2015 real prices. These costs were adjusted to a present value year of 2010 and adjusted to market prices. Table 3-3 summarises the discounted Scheme costs for operating and maintenance for each option over a 60- year appraisal period. Appendix C shows the calculations of the PVC with respect to operating/maintenance costs.

Table 3-3 Summary of the discounted Scheme Costs – Operating and Maintenance, £m

Cost Item	Option 1	Option 1A	Option 2	Option 3	Option 3A
Operating & Maintenance, PVC	£13.8	£15.1	£15.8	£12.4	£15.7

3.4 Tax revenues, grants and subsidies

3.4.1 The impact of indirect taxation revenue is calculated within the Transport Users Benefit Appraisal (TUBA) program. As per recent guidance, indirect taxation revenue impacts were assessed as affecting the level of benefits rather than the level of costs. This means that in the Benefit Cost Ratio (BCR) calculation indirect taxation revenue was added to the benefits rather than subtracted from the scheme costs.

3.4.2 No grants or subsidies were included in the economic assessment of the scheme.

4 Estimation of benefits

4.1 Overview

4.1.1 As discussed previously a key part of economic appraisal is to determine the benefits of the Scheme. The costs experienced by road users in the situation without the scheme (known as the Do Minimum) are compared to costs in the situation with the Scheme (known as the Do Something), which should be a net benefit i.e. following the improvement, costs should be lower. Different types of benefit which are being assessed as part of the economic analysis are shown in Figure 4-1.

4.2 Transport user appraisal

4.2.1 The calculation of main economic benefits to road users incorporates use of the DfT's Transport Users Benefit Appraisal (TUBA) program. TUBA compares the economic costs for the Do Something (DS) situation with the costs for the Do Minimum (DM) situation to establish the value of forecast savings in travel time and vehicle operating costs. A BCR is calculated by comparing these values, together with those of other relevant costs and benefits, with the construction and operation costs, over a 60 year period for the scheme.

4.3 Economic parameters

4.3.1 TUBA provides a complete set of default economic parameters in its 'Standard Economics File'. This contains values of time, vehicle operating cost data, tax rates and economic growth rates. TUBA version 1.9.6 reports economic values in 2010 prices, discounted to a present value of 2010.

4.4 Modelled forecast years

4.4.1 As discussed in Section 2.4, traffic forecasts were prepared for the following years:

- Opening year (2020);
- Intermediate/Design year (2035); and
- Horizon year (2041).

4.5 Appraisal period

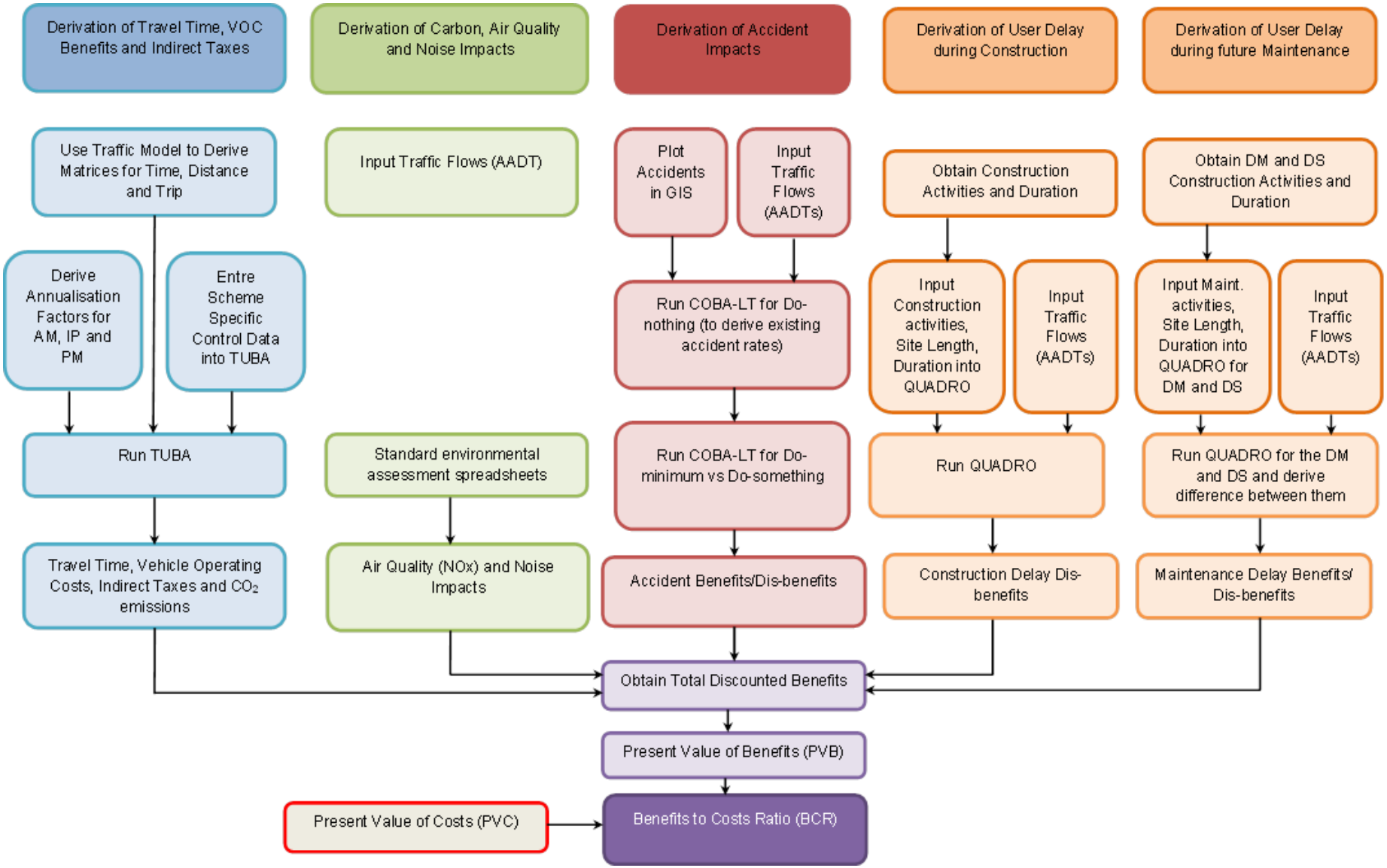
4.5.1 A 60-year appraisal period was used from the Scheme opening year of 2020 therefore providing a final appraisal year of 2079 for Options 1A, 3 and 3A. For Options 1 and 2, a 60-year appraisal period was used from the Scheme opening year of 2021 to final year of 2080 as the Scheme is likely to open in 2021 for these two options. Traffic levels are assumed to remain constant after the Horizon Year of 2041 for the purpose of economic appraisal.

4.6 Time slices and annualisation factors

4.6.1 TUBA works on the basis of five standard-definition time periods as follows:

- AM peak (weekday 07:00 to 10:00);
- PM peak (weekday 16:00 to 19:00);
- Inter-peak (weekday 10:00 to 16:00);
- Off-peak (weekday 19:00 to 07:00); and
- Weekend.

Figure 4-1: Flow Diagram Showing the Process for the Derivation of Benefits



4.6.2 The Highway Assignment Model (HAM) comprises three weekday time periods; an AM peak hour (08:00-09:00), an average inter-peak hour and a PM peak hour (17:00-18:00).

4.6.3 The modelled period benefits calculated by TUBA were converted into an estimate of annual benefits using the following peak hour to peak period factors:

- Weekday AM peak period (7am to 10am, 3 hours) – 2.66 * AM peak hour
- Weekday IP period (10am to 4pm, 6 hours) – 6 * IP peak hour; and
- Weekday PM period (4pm to 7pm, 3 hours) – 2.70 * PM peak hour

4.6.4 The peak hour to peak period factors were calculated using TRADS and WSCC ATC counts collected in the Chichester area. The locations are shown in Figure 2-1 and 2-2 in the Traffic Survey Report. There were calculated using average weekday counts from 2009 to 2014. The applicable factor estimates an annual representation of a particular period based on the peak hour modelling results

4.6.5 The peak periods referred to below are those that have been assumed to be most like each of the model periods, e.g. it is assumed that the 07:00-10:00am period is most like the 08:00-09:00am period from the HAM model and.

4.6.6 The annualisation factor for each TUBA time period also has to incorporate the number of times the period occurs per year, with the year divided up as follows:

- 253 normal weekdays;
- 52 weekends; and
- 8 bank holidays.

4.6.7 The two sets of factors above were combined to create annualisation factors applicable to the standard TUBA time periods. Table 4-1 summarises the TUBA periods and relevant annualisation factors.

Table 4-1: Time Slices and Annualisation Factors

No	Time Slice	Time Period	Duration (mins)	Model	Annualisation Factor
1	07:00-08:00	AM Period	60	AM	673 (253*2.66)
2	10:00-16:00	IP Period	60	IP	1518 (253*6)
3	16:00-19:00	PM Period	60	PM	683 (253*2.70)

4.6.8 As discussed in Section 2.3, the traffic model is developed for five user classes. The five traffic model user classes were split into seven user classes within TUBA to take account of varying values of time for different purposes and vehicle operating costs by vehicle type. The TUBA user classes are shown in Table 4-2 along with proportion of trips for each model user class.

4.6.9 To split LGV flows into those used for personal and freight purposes, WebTAG guidelines were used. These provide a split of 12% for LGV personal and 88% for LGV freight. For the OGV1 and OGV2, splits were derived from long terms Automatic Traffic Counts (ATC) along the A27 route. Table 4-2 summarises the TUBA purpose split.

Table 4-2: Purpose Splits by Time Period

No	Purpose	AM 07:00-10:00	IP 10:00-16:00	PM 16:00-19:00
1	Commute	1.000	1.000	1.000
2	Business	1.000	1.000	1.000
3	Other	1.000	1.000	1.000
4	LGV Personal	0.120	0.120	0.120
5	LGV Freight	0.880	0.880	0.880
6	OGV1	0.580	0.600	0.590
7	OGV2	0.420	0.400	0.410

4.7 Input matrices, representative distance and time skims

4.7.1 Data input to TUBA comprised trip, flow weighted average travel time, and travel distance and charge skim matrices. These matrices were prepared for each Scheme option scenario separately for combinations of three time periods (AM, IP, PM), five user classes and three forecast years (2020, 2035 and 2041) for both Do Minimum (Without Scheme) and Do Something (With Scheme) for each shortlisted option.

4.7.2 The SATURN software, which was used for the HAM model, uses metres and seconds as units. However, TAG unit A1.1 and the TAG Databook (and therefore TUBA) use kilometres and hours as units. Hence a factor of 0.001 was used in the TUBA input file where relevant to convert the SATURN calculated distances between zones into kilometres, and a factor of 0.00028 (=1/3600) was used to convert travel time between zones into hours.

4.7.3 The trip matrices obtained from SATURN are in passenger car units (PCUs). These have been converted into vehicles as TUBA requires matrices in vehicles. A weighted PCU factor of 2.275 has been applied to HGVs, according to the derivation explained in the Traffic Forecasting Report.

4.8 TUBA warnings and logic checking

4.8.1 TUBA undertakes a check on the inputs provided and identifies any large cost or matrix changes between the Do Minimum and Do Something situation. The top 50 warnings of each TUBA type were output and a sample of these was reviewed for each option. Many warnings related to areas well outside the core study area and others were not regarded as material for the assessment. Other ‘sense’ checks were also carried out in terms of matrix level totals and mapping different benefits to sectors level to check the benefits patterns.

4.9 Accident appraisal

4.9.1 One of the key objectives of the Scheme is to improve safety along the A27, hence the need for the appraisal of accident benefits generated by the improvement. TUBA does not calculate the reduction in accident costs as a result of the Scheme. This assessment was undertaken using the DfT’s COst Benefit Analysis – Light Touch (COBA-LT) program, in accordance with WebTAG recommendations.

4.9.2 An ‘accident only ‘COBA-LT’ is considerably easier to set up and run than a ‘full COBA-LT’. However, it was necessary to code a substantial part of the network in order to include the anticipated routing changes between DM and DS.

4.9.3 The appraisal was undertaken using the COBA-LT 2013.2 program which is a spreadsheet based tool and using the latest parameters file. The basic principles of the analysis for each option were as follows:

- a road network of interest was identified (5% or greater change in modelled traffic flows);
- a geocoded database of road accidents for the area (2009-2013) was developed;
- COBA-LT road types and junction types were allocated to all relevant SATURN links;
- SATURN flows by link were based on AADT 24 hour flows for the relevant model year;
- the average number of accidents in the study area by link and junction types was estimated separately;
- Local accidents data provided by police from 2009 to 2013 (with information about accidents and locations of accidents) were used and mapped on GIS tool;
- local accident rates were estimated based on the accidents data by road types and were applied to a separate link and junction COBA-LT analysis; and
- with and without scheme accidents were calculated and converted to monetary values.

4.10 Delays during construction and future maintenance

4.10.1 Part of the cost of the construction, and ongoing maintenance, of the scheme is borne by road users, in terms of traffic delays. It should be noted that at this stage the temporary works design has been considered at a very high level in order to ascertain the land requirements to enable construction of the Scheme for each short-listed option. The details of this will be further developed by the contractor at a later stage. For the purpose of this assessment, information on traffic management in terms of lane widths, speed restriction, traffic management length during construction and maintenance works have been provided by Mott MacDonald and applied for the assessment.

4.10.2 The DfT program QUeues And Delays at ROadwork's (QUADRO) version 4 revision 13.0 (release on 6th February 2015) has been used for assessing and quantifying these delays.

4.10.3 QUADRO calculates the total works and user costs of construction and maintenance tasks. For each task the timing of the works were specified based on the provided construction schedules, along with information on traffic flows, the traffic arrangements at the site, and a representative diversion route around the site. The programme contains an iterative assignment model for allocating traffic to the diversion route if the site becomes overloaded. The effect of the works was evaluated by calculating the time and vehicle operating costs incurred by all traffic on the network, both with and without the works. Output available from the model included information on the speed, queuing, and diversionary behaviour of traffic on an hourly basis, plus cost summaries by type and vehicle category.

4.10.4 The total user costs, for a particular task or profile of tasks over the appraisal period, were then discounted to a base year (2010). This enabled construction and maintenance tasks which occur in different years to be compared on a common basis.

4.10.5 For the purpose of the QUADRO assessment, user delays due to construction were calculated based upon a set of estimated construction phases provided by Mott MacDonald for the short listed options. The overall simplified construction schedule adopted for the assessment is shown in Table 4-3.

4.10.6 There were two periods of construction works to be assessed for each Option as listed below:

- **Daytime works**: Daytime works take place between 06:00 and 20:00 hours, seven days a week. These works involve narrow lanes with occasional contraflow and single lane arrangement with reduced speed limits of 50mph on the A27 and 30/40mph on the minor other roads.
- **Overnight works:** Overnight works takes place between 20:00 and 06:00 hours, seven days a week. The traffic management and speed restriction in place are the same as those applied in the daytime works. However, overnight works involve occasional partial lane to full carriageway closures.

4.10.7 QUADRO was run using the 2014 Base Model AADT flows using the 24-hour flow profile (Monday-Sunday) derived from the long term traffic counts and vehicle class split. QUADRO default information relevant to specific road class was used where local data was not available.

Table 4-3: Construction Schedule

Option 1	Start Date	End Date	Duration
Fishbourne Junction	05/02/2018	22/07/2019	47 weeks in 2018, 29 weeks in 2019
Stockbridge Junction	05/02/2018	05/09/2018	30 weeks in 2018
Whyke Junction	23/07/2019	24/02/2020	23 weeks in 2019, 8 weeks in 2020
Bognor Road Junction	23/07/2019	21/06/2021	23 weeks in 2019, 52 weeks in 2020, 24 weeks in 2021
Oving Junction	23/07/2019	31/10/2019	14 weeks in 2019
Portfield Junction	23/07/2019	25/09/2019	9 weeks in 2019
Option 1A	**Start Date**	**End Date**	**Duration**
Fishbourne Junction	05/02/2018	22/07/2019	47 weeks in 2018, 29 weeks in 2019
Bognor Road Junction	05/02/2018	20/12/2019	47 weeks in 2018, 50 weeks in 2019
Oving Junction	04/10/2019	17/12/2019	40 weeks in 2018, 50 weeks in 2019
Portfield Junction	23/07/2019	21/08/2019	29 weeks in 2018, 33 weeks in 2019
Option 2	**Start Date**	**End Date**	**Duration**
Fishbourne Junction	05/02/2018	22/07/2019	47 weeks in 2018, 29 weeks in 2019
Stockbridge Link Road	05/02/2018	07/12/2018	44 weeks in 2018
Oving Junction	05/02/2018	24/05/2018	15 weeks in 2018
Portfield Road	05/02/2018	17/04/2018	10 weeks in 2018
Stockbridge Junction	23/07/2019	11/05/2020	23 weeks in 2019, 19 weeks in 2020
Whyke Junction	12/05/2020	25/02/2021	33 weeks in 2020, 8 weeks in 2021
Bognor Road Junction	23/07/2019	21/06/2021	23 weeks in 2019, 52 weeks in 2020, 24 weeks in 2021
Option 3	**Start Date**	**End Date**	**Duration**
Stockbridge Junction	05/02/2018	05/09/2018	30 weeks in 2018
Whyke Junction	05/02/2018	05/09/2018	30 weeks in 2018
Oving Junction	05/02/2018	24/05/2018	15 weeks in 2018
Portfield Junction	05/02/2018	17/04/2018	10 weeks in 2018
Fishbourne Junction	06/09/2018	09/05/2019	17 weeks in 2018, 18 weeks in 2019
Bognor Junction	06/09/2018	22/03/2019	17 weeks in 2018, 11 weeks in 2019
Option 3A	**Start Date**	**End Date**	**Duration**
Fishbourne Junction	06/12/2018	09/08/2019	4 weeks in 2018, 31 weeks in 2019
Stockbridge Junction	05/02/2018	05/12/2018	43 weeks in 2018
Whyke Junction	12/08/2019	28/04/2020	20 weeks in 2019, 17 weeks in 2020
Bognor Road Junction	05/02/2018	09/12/2019	47 weeks in 2018, 49 weeks in 2019
Oving Road	10/12/2019	01/04/2020	3 weeks in 2019, 13 weeks in 2020
Portfield	02/04/2020	01/05/2020	4 weeks in 2020
A27 East Tie-in	03/09/2020	11/12/2020	14 weeks in 2020

4.10.8 Diversion routes were not specified for the narrow lanes operations and so a Max-Q-Delay function within QUADRO was used. Diversion routes were specified based on the information provided in the construction schedules by Mott MacDonald where partial lane closure or a complete carriageway closure was proposed. Diversion routes are selected based on their suitability of all vehicles and in majority of the cases they are local 'A' roads around the A27 near Chichester.

4.10.9 To obtain a representative speed/flow curve along each diversion route, a weighted average of the speed/flow on each of the links making up that diversion route was calculated from the model.

4.10.10 Delays due to future maintenance were calculated based upon a set of estimated maintenance schedules provided by Mott MacDonald for each Do Something option and Do Minimum over a 60 year period. Their advice was that realistic maintenance consists of alternating cycles of resurfacing including 50mm inlay and 100mm inlay with structural patching, with durations of 3 days and 5 days respectively per kilometre. These would alternate every 6-8 years and would be applicable for both the Do Minimum and Do Something. Maintenance cycles would get slightly more frequent in the future as traffic flow increase, and for the Do Something particularly for the offline options 4 and 5 there would be an initial "maintenance holiday" where no significant maintenance would be required because the scheme would be new. This information has therefore been used as the basis of the QUADRO assessments for maintenance delays.

4.10.11 Maintenance QUADRO was run on the same basis as those for construction delays described above i.e. using the local hourly profile, using diversion routes where there is complete carriageway closure and using the 2020, 2035 or 2041 Core Scenario AADT flows as appropriate from the Traffic Forecasting Report.

4.10.12 It should be noted that maintenance delays associated with white lining and grass cutting are assumed to be minimal and have therefore been excluded from the above assessments. It has also been assumed that maintenance associated with street lighting, drainage, kerbs and safety barriers would be undertaken at the same time as pavement maintenance.

4.10.13 The results of the two separate QUADRO assessments for the maintenance of pavement and other assets were obtained by subtracting the DM total maintenance value from the DS total maintenance value.

4.11 Greenhouse gases

4.11.1 The Climate Change Act 2008 created a new approach to managing and responding to climate change in the UK. At the heart of the Act is a legally binding target to reduce the UK's greenhouse gas emissions. It is therefore important that the impacts of proposed transport interventions on greenhouse gas emissions - whether they are increased or decreased - are incorporated within the cost benefit analysis in a consistent and transparent way. At this stage the economic assessment of greenhouse gases has not been derived. Detailed assessment will be carried out following relevant TAG at later stage.

4.11.2 The emissions will be calculated under a 'without scheme' scenario and a 'with scheme' scenario to provide the difference and impact of the scheme. These values will be then converted into a monetary value, calculating a net present value (NPV) over the appraisal period.

4.12 Local air quality

4.12.1 The Air Quality Strategy for England, Scotland, Wales and Northern Ireland (DEFRA 2007) set objectives for eight key air pollutants to protect health with achievement dates between 2003 and 2010. Road transport is a significant source of PM10 and NOx and hence air pollution in the locality near to the road.

4.12.2 The approach to assessing local air quality for a scheme is set out in TAG Unit A3 (Environmental Impact Appraisal) and is based on a quantification of the change in exposure at properties in the opening year.

4.12.3 The next stage in air quality assessment is monetary valuation of the changes in air quality. This makes use of existing economic valuation evidence published by the Inter Departmental Group on Costs and Benefits (Air Quality), to estimate the economic values associated with changes (either worsening or improvement) in air quality. The results of this assessment have been provided by the environmental team for use in the appraisal and the further details are provided in the Environmental Assessment Report[6].

4.13 Noise assessment

4.13.1 The approach for the assessment of traffic-related noise is set out in TAG Unit A3. In common with the assessment of greenhouse gases and air quality, the noise assessment follows a two-stage process. The initial step is the estimation of noise levels at residential property frontages and their subsequent valuation in monetary terms.

4.13.2 The monetary values are national average values per household per year at 2010 prices. These are increased in line with forecasts of GDP per household and discounted over the appraisal period to give a present value of noise. The results of this assessment have been provided by the environmental team for use in the appraisal and the further details are provided in the Environmental Assessment Report.

4.14 Journey time reliability

4.14.1 The A27 improvement Scheme is expected to have reliability consequences that have important implications for the economic case. The reliability elements of the project are just as important as the congestion-relief, for several reasons.

4.14.2 The main cause of unreliability on the A27 Chichester Bypass is due to high levels of congestion during peak hours that compromises the day-to-day journey times. Based on the current layout of the junctions on the A27 Chichester Bypass, during peak hours the day-to-day journey time variability is severe.

4.14.3 Journey time reliability is defined as variation in journey times that drivers are unable to predict, and is assessed as part of the DfT's TAG Unit A1.3 which outlines a method for calculation and valuation of the changes in journey time variability. The guidance in TAG advises the use of traffic models to assess journey time reliability. However, like most traffic models of its type, the model used for this scheme is unable to assess reliability in this way, working as it does with average conditions and flows that do not allow for day-to-day variations that affect reliability.

[6] A27 Chichester Bypass Improvement Scheme, Environmental Impact Assessment Report, January 2016

4.14.4 The guidance also advocates the use of the Motorway Reliability Incident and Delays (MyRIAD), but this requires both the existing and proposed roads to be of motorway standard. However, as the majority of the flows that benefit from the scheme are on the A27 dual carriageway, and as the scheme is primarily a junction improvement, MyRIAD is not an appropriate tool. Thus, in order to provide a more appropriate measure of the journey time reliability, local flow and journey time data was obtained in order to provide a more appropriate measure of the change in the standard deviation of journey times on the A27. This approach was based on guidance given in TAG A1.3 (para 6.3).

4.14.5 Through the use of the observed data, that was restricted to weekdays and term-time days only (excluding bank holidays), a locally calibrated model was set up in order to provide an accurate measure of the journey time reliability for each modelled option and each forecast year. This data was obtained from HATRIS for all roads between each proposed junction improvement. Based on these links, future year journey times and flows were extracted and used for the reliability analysis which provided values of the changes in the standard deviation of journey times. Following this, the reliability benefits were calculated as per TAG guidance. For options where new road layouts were proposed, an alternative approach was taken to ensure benefits were captured.

4.15 High and low growth sensitivity tests

4.15.1 Section 3.5 of the Traffic Forecasting Report explains how the Uncertainty Log, derived following liaison with the relevant Local Authorities and a review of their Core Strategies has been used to develop two sensitivity tests known as the Low and High growth scenarios.

4.15.2 The resultant traffic forecasts have been input into TUBA in the same way as described above and assessment of transport user benefits is carried out for these two scenarios. It should be noted that all other assessments such as COBA-LT, QUADRO, and Reliability have not been carried out for the High and Low Growth scenarios at this stage as agreed with Highways England. For the purpose of preparation of relevant economic assessment tables and to show an indicative BCR for these two scenarios, results of these assessments have been used from the Core Growth assessment as proxy for each option.

5 Appraisal summary

5.1 Overview

5.1.1 The different types of benefits and costs, as well as the methodology for deriving them, have been discussed in Chapters 2, 3 and 4.

5.1.2 This chapter presents the results of these appraisals and how they have been used to derive the overall BCR for each shortlisted option considered for Core growth scenario. It also summaries user benefits of the High and Low growth scenario sensitivity tests carried out for each option.

5.1.3 As mentioned in Chapter 1 that the main content of this report represents an economic assessment of the three previously shortlisted options (Option 1, Option 2 and Option 3) which were part of the EAR submitted in January 2016 and two newly shortlisted options 1A and 3A. The key summary results of the economic assessment of the other options such as Options 2A, 4, 5 and 6 which were part of the previous assessment is included in Appendix A.

5.2 Headline economic appraisal results

5.2.1 Table 5-1 below presents a summary of the BCR for each option for core scenario.

Table 5-1: Headline Benefits Summary - Core Scenario, £m

Scheme Options	Present Value of Benefits (PVB)	Present Value of Costs (PVC)	BCR
Option 1	**£349**	£137	2.55
Option 1A	**£279**	£112	2.49
Option 2	**£551**	£207	2.66
Option 3	**£185**	£45	4.13
Option 3A	**£308**	£136	2.27

Note: All monetary values are discounted to 2010 and in 2010 market price unit of account.

5.2.2 The total benefits, as shown in the PVB column above, including the following items:

- travel time, assessed using TUBA;
- Vehicle Operating Costs (VOC), assessed using TUBA;
- accident, assessed using COBA-LT;
- indirect tax, assessed using TUBA;
- air quality and noise; and
- user delays during construction and future maintenance, assessed using QUADRO.

5.2.3 The Scheme benefits is a combination of different elements listed above and they are dependent on network capacity, average speeds, number of trips, cost of travel, tax, etc. in different options.

5.2.4 Detailed outputs from the economic assessments in terms of TEE, PA and AMCB tables for the Core growth scenario are presented in Appendix D. TUBA outcomes of the Low and High growth scenarios are contained in Appendix E and Appendix F respectively.

5.3 Travel time savings and vehicle operating results

5.3.1 As expected, it is likely that the replacement of at-grade junctions with grade-separated junctions or hamburger type of junction at Fishbourne Roundabout and Bognor Roundabout and signal improvement and banning some of the turning movements at junctions such as Stockbridge, Whyke, Oving, and Portfield Junctions with free-flow links would greatly decrease queues and delays, resulting in significantly decreased journey times along the A27 route and road network in and around Chichester.

5.3.2 It should be noted that each option is different in terms of junction improvements and/or addition of extra links as mentioned in Section 1.2 of this report and therefore travel time and Vehicle Operating Cost (VOC) benefits varies for each of the option.

5.3.3 When road vehicles are used they incur costs such as fuel, maintenance, and wear and tear. These costs are known as Vehicle Operating Costs (VOC). When the scheme is implemented, a variety of changes in speed and distance could occur. For each assessed Option, there is a mixture of increases and decreases in VOC- Fuel and Non-Fuel elements. These occur due to the following reasons:

- Traffic that transfers onto the free-flow links will experience less delay and therefore have quicker journeys. However, some of that traffic travels a slightly longer distance. Such traffic therefore has a mixture of increases and decreases in VOC.
- Other traffic may reroute to take advantage of reduced travel times but this can result in longer distances being travelled (even if they are quicker). Such traffic therefore has a mixture of increases and decreases in VOC.
- Local traffic that would have to re-route away, resulting in longer distances being travelled. Such traffic is therefore likely to have an increase in VOC.
- Other road users in the study area could experience increased journey times due to increases in traffic caused by Variable Demand. Such traffic could increase or decrease VOC depending upon the resultant speeds.

5.3.4 In addition, potential travel time benefits are eroded due to additional traffic caused by Variable Demand (induced traffic) which results in more vehicle-kms in the Do Something than in the Do Minimum, contributing to time and operating costs.

5.3.5 Analysis of the benefits by trip purpose for the Core growth scenario, shown in Table 5-2, indicates that approximately 41%-42% of the benefits are as a result of business trips, approximately 17%-18% are as a result of commuting trips and approximately 40%-42% as a result of other trips. This is because a strategic route like the A27 is likely to have a smaller proportion of commuting trips, and because business trips have a higher value of time; therefore, the benefits are bigger.

Table 5-2: TUBA Benefits (Time+VOC) by Purpose – Core Scenario, £m

User Class	Option 1	Option 1A	Option 2	Option 3	Option 3A
Business	£157.6	£122.6	£235.1	£79.5	£148.7
% Business	41.9%	40.6%	40.9%	42.4%	42.1%
Commuting	£63.8	£51.7	£96.2	£32.7	£60.9
% Commuting	17.0%	17.1%	16.7%	17.5%	17.3%
Other	£154.4	£127.4	£243.2	£75.1	£143.4
% Other	41.1%	42.2%	42.3%	40.1%	40.6%
Total	**£375.8**	**£301.7**	**£574.5**	**£187.3**	**£353.0**

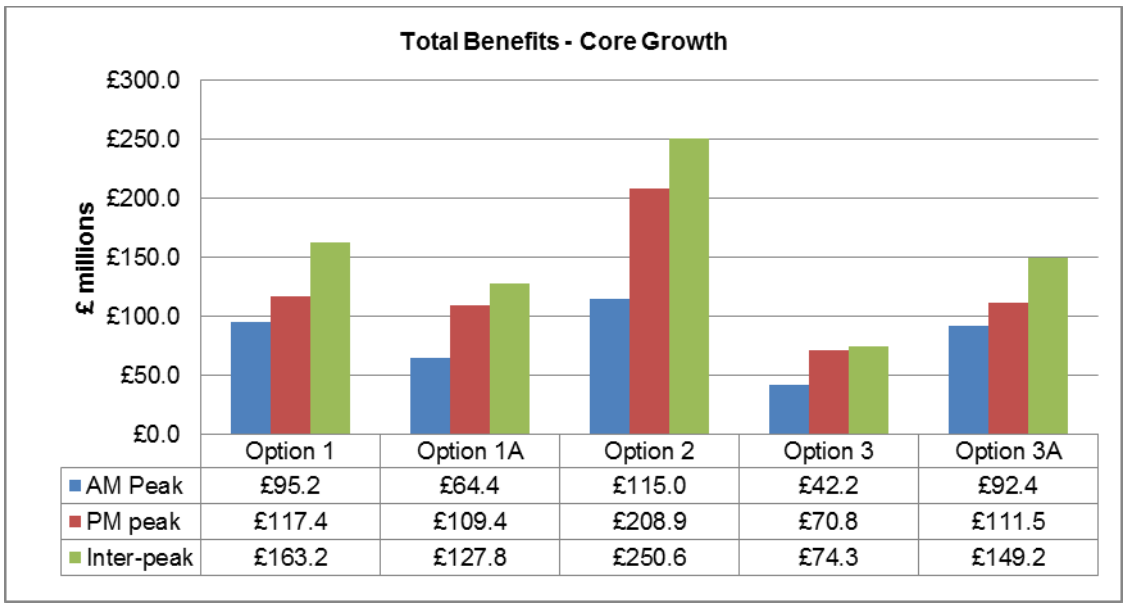
5.3.6 Analysis of benefits grouped by the size of the time saving is shown in Table 5-3 below by user class. The results show that a significant proportion of the scheme's benefits come from large time savings for all of the options.

Table 5-3: TUBA Benefits by Time Savings by Purpose – Core Scenario, £m

Option 1	< 2min	2 to 5min	> 5min	Total
Business	£15.1	£108.7	£25.5	£149.3
Commute	£7.2	£45.0	£14.5	£66.7
Other	£22.1	£117.7	£27.2	£167.0
Option 1A	**< 2min**	**2 to 5min**	**> 5min**	**Total**
Business	£49.0	£51.9	£14.1	£115.0
Commute	£17.1	£24.2	£10.0	£51.3
Other	£59.7	£52.0	£19.3	£131.0
Option 2	**< 2min**	**2 to 5min**	**> 5min**	**Total**
Business	£36.2	£122.8	£62.6	**£221.6**
Commute	£13.7	£55.9	£29.6	**£99.3**
Other	£48.8	£138.1	£68.1	**£255.0**
Option 3	**< 2min**	**2 to 5min**	**> 5min**	**Total**
Business	£19.7	£51.2	£4.8	**£75.7**
Commute	£10.8	£21.2	£3.0	**£35.1**
Other	£25.7	£53.0	£5.3	**£83.9**
Option 3A	**< 2min**	**2 to 5min**	**> 5min**	**Total**
Business	£12.9	£106.8	£21.3	**£141.1**
Commute	£7.4	£43.7	£12.1	**£63.2**
Other	£19.1	£112.4	£23.2	**£154.7**

5.3.7 Analysis of the benefits by time period, in Figure 5-1 shows that approximately 20%-26%, 31%-38% and 40%-44% of the total benefits occurred in each of the three modelled time periods – Weekday AM, PM and IP respectively for majority of the options.

Figure 5-1: TUBA Benefits (Time+VOC) by Time Period – Core Scenario, £m



	Option 1	Option 1A	Option 2	Option 3	Option 3A
AM Peak	£95.2	£64.4	£115.0	£42.2	£92.4
PM peak	£117.4	£109.4	£208.9	£70.8	£111.5
Inter-peak	£163.2	£127.8	£250.6	£74.3	£149.2

5.3.8 Analysis of the user benefits by vehicle type, journey purpose and by time period is shown in Table 5-4 and Table 5-5. It shows that main benefits accrue to car – other (some 39% to 41%). A further approximately 14% to 15% benefits accrue to Car – Business and some 9%-11% benefits accrue to Business Freight (OGVs).

Table 5-4: TUBA Benefits (Time+VOC) by Vehicle Class/Purpose – Core Scenario – Options 1, 1A, and 2, £m

User Class	Option 1			Option 1A			Option 2		
	AM	IP	PM	AM	IP	PM	AM	IP	PM
Car - Business	£13.2	£25.1	£15.8	£8.6	£18.5	£14.1	£16.0	£36.1	£26.7
Car - Commuting	£27.5	£11.5	£24.8	£17.9	£9.2	£24.5	£32.4	£17.6	£46.1
Car - Other	£24.0	£75.1	£50.0	£16.0	£60.8	£46.1	£28.8	£117.6	£88.6
LGV - Freight	£17.8	£29.7	£19.2	£12.8	£24.9	£17.8	£22.2	£48.0	£34.1
LGV - Personal	£1.4	£2.3	£1.5	£1.0	£2.0	£1.4	£1.7	£3.8	£2.7
OGV1	£6.0	£10.6	£3.4	£4.3	£6.8	£3.0	£7.4	£15.1	£5.7
OGV2	£5.2	£8.7	£2.8	£3.7	£5.6	£2.5	£6.4	£12.4	£4.9
Total	**£95.1**	**£163.0**	**£117.5**	**£64.3**	**£127.8**	**£109.4**	**£114.9**	**£250.6**	**£208.8**
Total (AM+IP+PM)	**£375.6**			**£301.5**			**£574.3**		

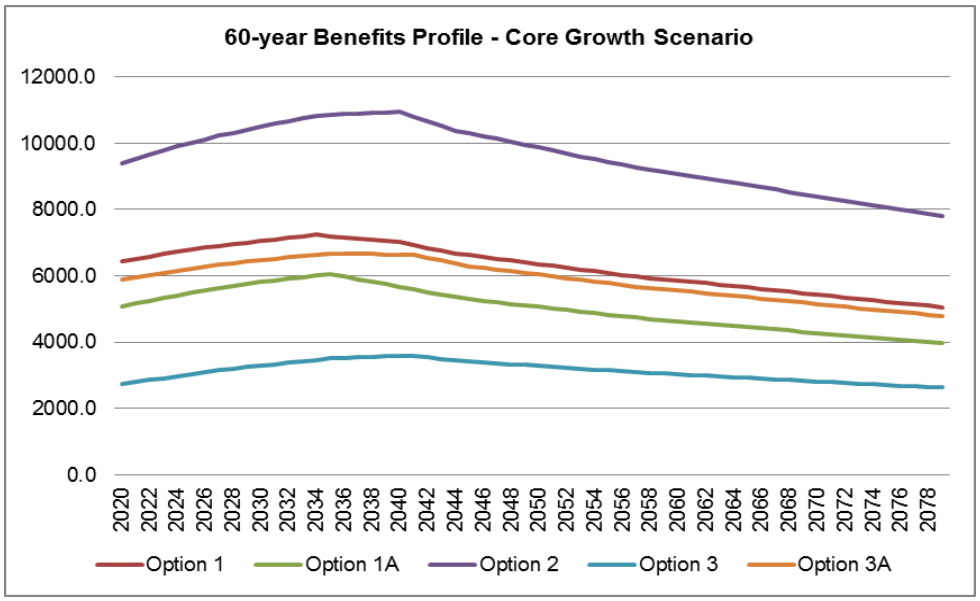
Note: Overall totals may not match exactly with other tables due to rounding issue

Table 5-5: TUBA Benefits (Time+VOC) by Vehicle Class/Purpose – Core Scenario – Options 3 and 3A, £m

User Class	Option 3			Option 3A		
	AM	IP	PM	AM	IP	PM
Car - Business	£6.0	£12.4	£9.5	£12.7	£23.1	£15.0
Car - Commuting	£12.5	£5.2	£15.0	£26.3	£10.5	£24.1
Car - Other	£9.9	£33.4	£29.4	£22.8	£68.3	£47.5
LGV - Freight	£7.5	£12.3	£12.0	£17.6	£26.9	£17.8
LGV - Personal	£0.6	£0.9	£0.9	£1.4	£2.1	£1.4
OGV1	£3.1	£5.5	£2.2	£6.1	£10.1	£3.1
OGV2	£2.6	£4.5	£1.9	£5.3	£8.2	£2.6
Total	**£42.2**	**£74.2**	**£70.9**	**£92.2**	**£149.2**	**£111.5**
Total (AM+IP+PM)	**£187.3**			**£352.9**		

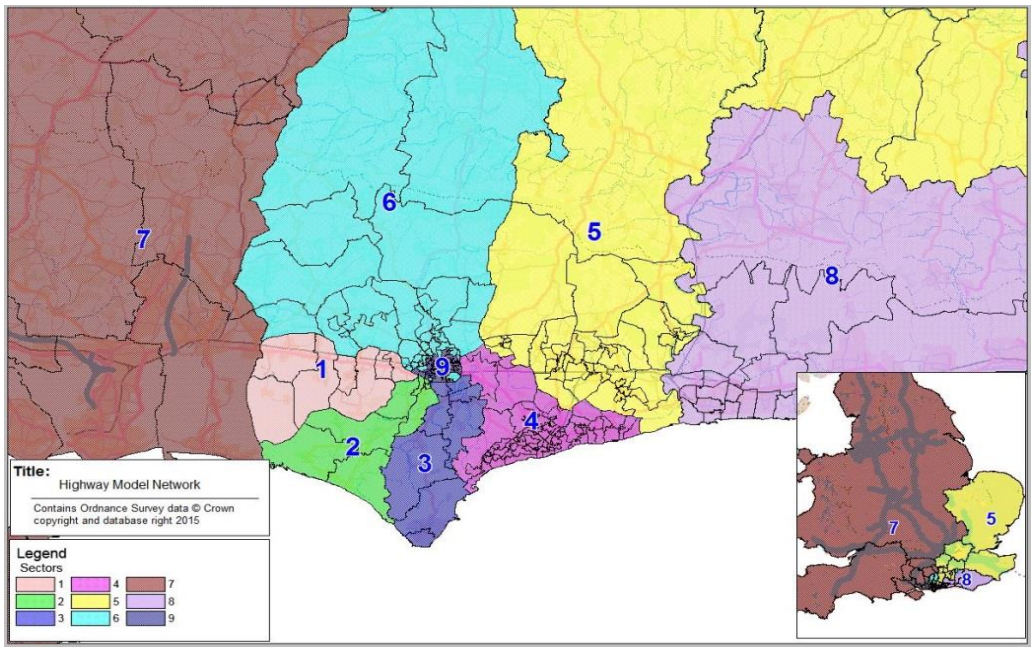
5.3.9 The benefit profile over a scheme's life is required to determine whether the benefits of the scheme occur earlier or later. The benefit profile shown in Figure 5 2 indicates that, as expected, a significant proportion (between 38% - 42%) of the discounted benefits is between the Opening year (2020 for Options 1A, 3 and 3A, 2021 for Options 1and 2) and design year (2041), about 33%-37% are between 2042 and 2061 and 26%-28% of the benefits are between 2062 and 2079/2080. The benefits profiles show that the benefits increase from the opening year to the intermediate year, and then increase again between the intermediate year and the design year for most of the options except Option 1 and Option 1A where there is decreasing trend in benefits from 2035. This is likely to indicate that the network becomes congested by the intermediate year for these two options. The overall benefits then decline steadily after the design year over the remainder of the 60-year assessment period for all options. It should be noted that this is primarily due to the discounting effect, i.e. even though discounted benefits decline over the scheme's life, this does not indicate that the actual undiscounted benefits would be declining over the scheme's life.

Figure 5-2: 60-year Benefits Profile - Core Scenario, £000s



5.3.10 An indicative analysis has been carried out of benefits on a geographical basis - TUBA was run with a sector file, which enables user benefits between each model zone origin-destination pair to be aggregated into larger geographical areas. In TUBA terminology, the larger geographical areas are known as sectors and the relationship between model zones and sectors is defined in the TUBA sector file. There were 9 sectors defined for the appraisal of the A27 Chichester Bypass Improvement Scheme. The sectors are shown in Figure 5-3.

Figure 5-3: TUBA Sectors[7]



[7] 1:Bosham, Nutbourne, Southbourne, Emsworth, 2:Wittering, 3:Seley, 4:Bognor Regis, 5:Chichester to Arun and Routes to NE, 6:South Downs, North of Chichester, 7:Hampshire, West Midlands and North, 8:East of Arun, 9: Centre of Chichester

5.3.11 The distribution of benefits resulting from the Scheme is presented on a sector to sector basis. Table 5-6 to Table 5-10 show the time and VOC benefits for each option.

Table 5-6: Option 1 Sector to Sector Benefits output from TUBA – Core Scenario, £m

Benefits per sector Core Scenario Option 1		Destination									Total
		1	2	3	4	5	6	7	8	9	
Origin	1	0.0	-7.0	-3.1	2.8	1.6	2.4	0.9	3.3	7.5	**8.2**
	2	1.3	-0.1	0.0	-0.9	-0.6	6.5	5.8	-0.6	2.5	**14.0**
	3	1.3	0.2	0.1	0.1	0.3	4.7	4.0	-0.1	2.9	**13.5**
	4	6.1	2.3	0.6	-0.6	5.6	22.4	29.2	4.4	23.8	**93.9**
	5	3.3	7.7	5.4	1.6	0.0	5.5	30.7	-0.2	9.8	**63.9**
	6	1.9	-0.1	1.4	2.4	0.5	2.5	8.5	-0.1	8.1	**25.1**
	7	0.3	-11.7	-6.9	4.5	11.5	4.3	0.2	18.7	5.1	**26.0**
	8	3.7	5.7	2.8	0.9	-2.7	2.1	36.8	0.8	3.2	**53.4**
	9	8.3	3.8	3.5	10.1	10.0	15.2	13.4	2.7	10.7	**77.6**
Total		**26.3**	**0.9**	**3.8**	**20.8**	**26.2**	**65.7**	**129.4**	**29.0**	**73.6**	**375.7**

Table 5-7: Option 1A – Sector to Sector Benefits output from TUBA – Core Scenario, £m

Benefits per sector Core Scenario Option 1A		Destination									Total
		1	2	3	4	5	6	7	8	9	
Origin	1	0.0	-1.0	-0.1	2.0	1.4	3.5	3.0	2.1	11.0	**21.8**
	2	-1.5	0.0	-0.3	-0.9	0.8	0.6	1.3	1.3	-1.8	**-0.4**
	3	-0.7	-0.2	-0.1	-0.3	1.2	0.3	0.7	1.4	-1.3	**1.0**
	4	2.1	1.3	1.7	-0.6	5.4	20.6	12.3	4.8	23.1	**70.8**
	5	1.3	4.7	4.2	1.9	0.2	4.2	17.6	0.6	9.6	**44.3**
	6	1.5	4.0	2.5	3.5	1.4	1.8	9.4	0.4	7.2	**31.7**
	7	0.3	0.2	-0.3	-1.0	4.5	2.4	0.2	7.3	2.7	**16.3**
	8	1.2	3.1	2.2	1.2	-1.3	1.7	21.8	0.5	3.3	**33.6**
	9	7.4	5.9	3.4	12.3	11.9	12.3	16.7	3.4	8.9	**82.3**
Total		**11.6**	**18.2**	**13.1**	**18.1**	**25.6**	**47.4**	**83.0**	**21.8**	**62.7**	**301.4**

Table 5-8: Option 2 - Sector to Sector Benefits output from TUBA – Core Scenario, £m

Benefits per sector Core Scenario Option 2		Destination									Total
		1	2	3	4	5	6	7	8	9	
Origin	1	0.0	-0.1	0.5	1.7	0.5	-0.5	-1.3	1.3	-2.9	**-0.8**
	2	2.7	-0.1	1.0	1.5	4.0	13.0	9.8	2.5	6.3	**40.8**
	3	2.5	0.9	0.4	-0.2	1.5	7.3	6.3	0.7	5.7	**25.2**
	4	8.1	5.0	1.7	-0.8	6.7	25.3	39.4	5.2	26.9	**117.6**
	5	4.2	6.6	3.5	2.3	0.3	6.9	38.0	0.1	11.2	**73.0**
	6	1.9	11.9	6.5	9.7	2.5	2.3	10.4	1.1	7.1	**53.5**
	7	0.2	7.5	5.4	12.1	17.3	3.7	0.6	27.7	0.6	**75.2**
	8	5.0	4.5	1.3	0.8	-2.2	3.2	47.9	0.9	3.9	**65.3**
	9	7.2	21.7	13.6	21.8	15.6	15.4	14.0	4.5	10.9	**124.6**
Total		**31.9**	**57.9**	**34.0**	**49.0**	**46.2**	**76.6**	**165.1**	**44.0**	**69.7**	**574.3**

Table 5-9: Option 3 – Sector to Sector Benefits output from TUBA – Core Scenario, £m

Benefits per sector Core Scenario Option 3		Destination									Total
		1	2	3	4	5	6	7	8	9	
Origin	1	-0.1	-10.5	-5.3	1.0	0.2	0.4	-1.4	0.7	1.2	**-13.8**
	2	1.9	-0.1	-0.1	-1.2	-1.2	4.9	6.1	-1.3	1.2	**10.3**
	3	1.3	0.2	0.1	-0.2	0.1	3.4	4.2	-0.4	2.1	**10.8**
	4	4.8	1.2	-0.3	0.6	2.7	8.8	21.4	1.8	6.0	**47.2**
	5	1.4	2.5	1.4	0.3	0.1	1.6	16.3	-0.2	2.7	**26.0**
	6	1.1	-3.8	-0.2	4.8	1.4	0.9	5.1	0.6	3.8	**13.6**
	7	-0.3	-11.8	-7.5	6.4	9.7	2.9	0.1	16.6	3.1	**19.2**
	8	1.7	2.3	0.9	-0.6	-0.6	1.0	21.0	0.6	0.9	**27.2**
	9	5.1	-1.0	0.6	11.2	8.8	6.7	7.5	2.9	5.0	**46.9**
Total		**17.1**	**-21.1**	**-10.4**	**22.3**	**21.1**	**30.7**	**80.3**	**21.3**	**26.0**	**187.3**

Table 5-10: Option 3A – Sector to Sector Benefits output from TUBA – Core Scenario, £m

Benefits per sector Core Scenario Option 3A		Destination									Total
		1	2	3	4	5	6	7	8	9	
Origin	1	0.0	-9.2	-4.3	1.4	1.0	2.0	0.1	2.4	5.4	**-1.1**
	2	1.4	-0.1	-0.1	-1.2	-1.0	4.8	4.5	-0.8	1.4	**9.2**
	3	1.3	0.3	0.1	0.0	0.3	3.8	3.5	0.0	2.2	**11.5**
	4	6.6	3.0	0.8	-1.0	5.8	20.8	29.8	4.8	21.9	**92.4**
	5	3.2	7.9	5.0	1.1	0.3	3.5	27.8	-0.2	5.7	**54.3**
	6	1.8	1.1	1.9	2.5	0.9	2.6	7.4	-0.1	8.1	**26.2**
	7	0.1	-11.4	-6.7	3.3	12.4	3.7	0.2	20.0	3.4	**25.0**
	8	3.8	5.9	2.7	-0.1	-1.4	1.4	34.6	1.1	1.6	**49.5**
	9	7.3	7.0	4.8	12.0	12.2	16.1	12.3	3.4	10.9	**85.9**
Total		**25.5**	**4.5**	**4.4**	**18.0**	**30.5**	**58.7**	**120.2**	**30.5**	**60.5**	**352.9**

5.3.12 The sector to sector analysis shows that, as expected, the greatest benefits occur between the East-West sectors (East of Arun – Hampshire), North East (Routes to NE) and South-East (Bognor Regis) Sectors and vice versa. Significant benefits also occur from the Centre of Chichester for the majority of the options. The percentage split of these benefits however varies between each option but in summary each option produces significant time savings through the elimination of congestion at the existing junctions on the A27 Chichester Bypass.

5.3.13 Trips originating in some of the sectors particularly sector 1 and sector 2 do not benefit much or even have negative user benefits overall, particularly in the case for Option 3. So for those sectors' trips, the Scheme has very limited to no influence.

5.4 Accident results

5.4.1 As discussed in Chapter 4, an assessment has been made of the number of accidents and their associated costs, for the situations both with and without the Scheme for each option for core growth scenario.

5.4.2 Details of the analysis and overview of methodology adopted for the accidents assessment are provided in Appendix G.

5.4.3 With the scheme in place, the removal of the at-grade junction arrangement at some of the congested junctions such as Fishbourne and Bognor and their replacement with free-flow links designed to modern standards and junction improvements by banning certain movements at some of the junctions such as Whyke and Oving should result in a reduction in accidents and therefore an accident benefit. However, the introduction of the scheme results in an increase in traffic due to Variable Demand (induced traffic) and other traffic transfers, which can increase and decrease flows on existing roads away from the Scheme, which could in turn result in an increased or decreased number of accidents away from the scheme.

5.4.4 The accident results for the wider study area show that there would be an overall decrease in accidents at links and a mixture of increase and decrease of accidents at key junctions for all of the options. When links and junctions are combined together there is an overall reduction of accidents costs for Options 1A, 2 and 3 whilst in Options 1 and 3A, there is a slight increase in accidents costs over 60-year appraisal period. Appendix G explains more details about accident assessment. Table 5-11 shows overall (links and junctions combined) accident benefits/dis-benefits as produced by COBA-LT for each option over 60-year assessment period.

Table 5-11: Overall Predicted Accident Reduction and Benefits – Core Scenario, £m

Options	Reduction in number of Accidents	Casualties Reduction-Fatal	Casualties Reduction-Serious	Casualties Reduction-Slight	Accident Benefits, £m
Option 1	-152	-2	-17	-520	**-£8.5**
Option 1A	47	0	2	-40	**£1.9**
Option 2	88	3	44	64	**£8.4**
Option 3	53	3	28	-194	**£5.8**
Option 3A	-612	-1	-26	-1,116	**-£24.1**

5.5 Construction and maintenance delay results

5.5.1 As discussed in Chapter 4, when schemes are constructed it is inevitable that there are some delays to traffic as it is being built. The majority of the options considered for the Scheme are being constructed on-line (on the same alignment as the existing roads), but delays to existing traffic can be kept to a minimum through the use of effective traffic management. It should be noted that these are regarded as disbenefits due to delays during construction.

5.5.2 Table 5-12 below shows the costs associated with user delays during construction.

Table 5-12: Construction Delays Costs[8] – Core Scenario, £m

Journey Purpose	Option 1	Option 1A	Option 2	Option 3	Option 3A
Business	-£6.4	-£5.9	-£11.5	-£5.0	-£5.5
Commute	-£2.0	-£1.9	-£3.7	-£1.6	-£1.8
Other	-£6.3	-£5.9	-£10.8	-£5.0	-£5.6
Total	**-£14.8**	**-£13.7**	**-£26.0**	**-£11.6**	**-£12.9**

5.5.3 A comparison was made of the future maintenance requirements both with and without the scheme for each option over the 60-year appraisal period as described in Chapter 4. Without the scheme, it is likely that significant maintenance would be required at the start of the appraisal period, which would cause delay to traffic. However, with the scheme in place, no significant maintenance would be required for a number of years after the scheme opens because it is brand new, particularly the case for Options 4 and 5 which are proposed as offline options. However, traffic flows are likely to be higher with the scheme in place due to Variable Demand (induced traffic), thereby resulting in slightly more delays in Do something scenario for most of the options. Table 5-13 below shows the costs associated with user delays during maintenance as produced by QUADRO following the methodology described in Chapter 4. It should be noted that these are regarded as disbenefits due to delays during maintenance.

Table 5-13: Maintenance Delays Costs[8] – Core Scenario, £m

Journey Purpose	Option 1	Option 1A	Option 2	Option 3	Option 3A
Business	-£1.0	-£1.1	-£1.3	-£0.2	-£0.7
Commute	-£0.2	-£0.2	-£0.3	£0.03	-£0.1
Other	-£2.9	-£3.3	-£4.0	-£0.5	-£2.0
Total	**-£4.0**	**-£4.6**	**-£5.6**	**-£0.7**	**-£2.8**

[8] Tables 5-12 and 5-13 shows user delays costs which are generally negative. This does not mean a benefits overall, though.

5.6 Carbon emission, air quality and noise results

5.6.1 As discussed in Chapter 4, Carbon Emissions are not calculated at this stage and detailed assessment will be carried out at later stage following relevant TAG. However, it is envisaged that carbon emissions may increase, which might reduce the overall BCR. Air Quality and Noise benefits are derived by using standard environmental spreadsheets following relevant TAG guidelines. Table 5-14 shows the carbon (greenhouse gases) benefits as calculated using TUBA and air quality (NOx and PM10) and Noise as calculated using the TAG spreadsheet.

Table 5-14: Air Quality and Noise Benefits – Core Scenario, £m

Option	Air Quality	Noise
Option 1	£2.9	-£5.7
Option 1A	£0.6	-£5.3
Option 2	£2.2	-£4.0
Option 3	£2.8	-£3.3
Option 3A	£1.0	-£9.6

5.7 Journey time reliability results

5.7.1 The issues regarding journey time variability are described in Chapter 4 and the details of the analysis are described in Appendix H. Table 5-15 shows the total benefits attributed to reductions in journey times due to improvements in reliability (journey time variability). It should be noted that these values are not included in the calculation of the PVB or BCR but will be included in the Appraisal Summary Table (AST).

Table 5-15: Journey Time Reliability Benefits – Core Scenario, £m

Option	Reliability Benefits
Option 1	£227.7
Option 1A	£85.9
Option 2	£249.8
Option 3	£165.5
Option 3A	£208.2

5.8 Transport economic efficiency (TEE), Public accounts (PA) and Analysis of monetised costs and benefits (AMCB)

5.8.1 The results of the economic appraisal for each option is summarised in Table 5-16. The TEE, PA and AMCB tables for each option are presented in Appendix D for the core scenario.

5.8.2 From the below Table 5-16 it can be seen that out of all the options, Option 2 has the highest PVB of around £551m but this option also has highest PVC of some £207m. The BCR for this option is 2.7 which is second highest among all the options after Option 3. Online Option 1, Option 1A, Option 3 and Option 3A have PVB of some £348m, £280m, £183m and £307m respectively. The PVC of these options is about £137m, £112m, £45m, and £136m respectively and therefore the BCR of these options is 2.5, 2.5, 4.1, and 2.3 respectively.

Table 5-16: Summary of Economic Assessment Results – Core Scenario, £m

			Costs/Benefits				
			Option 1	**Option 1A**	**Option 2**	**Option 3**	**Option 3A**
Benefits	Consumer Commuting User Benefits	Travel Time	£66.7	£51.3	£99.3	£35.1	£63.2
		VOC	-£2.9	£0.4	-£3.1	-£2.4	-£2.3
		Construction Delays	-£2.0	-£1.9	-£3.7	-£1.6	-£1.8
		Maintenance Delays	-£0.2	-£0.2	-£0.3	£0.0	-£0.1
		Net Consumer User Benefits	**£61.6**	**£49.5**	**£92.1**	**£31.0**	**£58.9**
	Consumer Other User Benefits	Travel Time	£167.0	£131.0	£255.0	£83.9	£154.7
		VOC	-£12.6	-£3.6	-£11.8	-£8.8	-£11.3
		Construction Delays	-£6.3	-£5.9	-£10.8	-£5.0	-£5.6
		Maintenance Delays	-£2.9	-£3.3	-£4.0	-£0.5	-£2.0
		Net Consumer User Benefits	**£145.2**	**£118.0**	**£228.4**	**£69.7**	**£135.9**
	Consumer Business User Benefits	Travel Time	£149.3	£115.0	£221.5	£75.7	£141.1
		VOC	£8.3	£7.5	£13.5	£3.8	£7.6
		Construction Delays	-£6.4	-£5.9	-£11.5	-£5.0	-£5.5
		Maintenance Delays	-£1.0	-£1.1	-£1.3	-£0.2	-£0.7
		Net Business User Benefits	**£150.2**	**£115.6**	**£222.2**	**£74.3**	**£142.4**
	Accidents Benefits		-£8.5	£1.9	£8.4	£5.8	-£24.1
	Indirect Tax Revenues		£3.7	-£1.1	£2.0	£4.6	£3.5
	Noise		-£5.7	-£5.3	-£4.0	-£3.3	-£9.6
	Air Quality		£2.9	£0.6	£2.2	£2.8	£1.0
	Total PVB (£m)		**£349.4**	**£279.1**	**£551.3**	**£184.9**	**£308.0**
Costs	Operating and Maintenance Costs		£13.8	£15.1	£15.8	£12.4	£15.7
	Investment Costs		£123.4	£97.0	£191.5	£32.3	£120.1
	Revenue Change		£0.0	£0.0	£0.0	£0.0	£0.0
	Total PVC (£m)		**£137.2**	**£112.2**	**£207.3**	**£44.8**	**£135.9**
Net Present Value (NPV)			**212.2**	**166.9**	**344.0**	**140.1**	**172.2**
Benefits to Cost Ratio (BCR)			**2.55**	**2.49**	**2.66**	**4.13**	**2.27**

Note: All monetary values are discounted to 2010 and in 2010 market price unit of account. Cells highlighted with blue colour are taken from the TUBA assessment. Noise and Air Quality information is provided by Environmental Team within Mott MacDonald. User delays disbenefits during construction and future maintenance are derived from QUADRO.

5.9 Low and high growth scenario sensitivity tests

5.9.1 As discussed in Chapter 4, three traffic forecast scenarios were developed to take into account highest (High), most likely (Core), and lowest (Low) levels of future traffic growth. The economic assessment results described above in this chapter, as summarised in Table 5-16, were calculated using the Core scenario traffic forecast, i.e. most likely level of future growth. However, sensitivity tests have also been undertaken to investigate what effect the Highest Benefits and Lowest Benefits traffic forecasts would have on the BCR. It should be noted that at this stage only TUBA assessments of user benefits were carried out for these two scenarios as agreed with Highways England. For the purpose of producing NPV, PVB and BCR for these two scenarios, other elements such as QUADRO, COBA-LT, Noise, and Air Quality benefits are taken from the Core scenario. Table 5-17 and Table 5-18 summarise the economic assessment results for the Low and High growth scenarios respectively. TUBA outcomes for the Low and High growth scenarios are presented in Appendix E and Appendix F respectively.

Table 5-17: Summary of Economic Assessment Results – Low Growth Scenario, £m

			Costs/Benefits				
			Option 1	**Option 1A**	**Option 2**	**Option 3**	**Option 3A**
Benefits	Consumer Commuting User Benefits	Travel Time	£66.1	£50.9	£98.2	£35.0	£62.4
		VOC	-£2.9	£0.4	-£3.2	-£2.4	-£2.4
		Construction Delays	-£2.0	-£1.9	-£3.7	-£1.6	-£1.8
		Maintenance Delays	-£0.2	-£0.2	-£0.3	£0.0	-£0.1
		Net Consumer User Benefits	**£61.1**	**£49.2**	**£90.9**	**£30.9**	**£58.1**
	Consumer Other User Benefits	Travel Time	£166.1	£131.4	£252.5	£85.1	£153.4
		VOC	-£12.6	-£3.7	-£11.9	-£8.7	-£11.2
		Construction Delays	-£6.3	-£5.9	-£10.8	-£5.0	-£5.6
		Maintenance Delays	-£2.9	-£3.3	-£4.0	-£0.5	-£2.0
		Net Consumer User Benefits	**£144.4**	**£118.4**	**£225.7**	**£70.9**	**£134.6**
	Consumer Business User Benefits	Travel Time	£144.4	£111.9	£213.0	£74.2	£135.8
		VOC	£8.0	£7.2	£13.0	£3.7	£7.3
		Construction Delays	-£6.4	-£5.9	-£11.5	-£5.0	-£5.5
		Maintenance Delays	-£1.0	-£1.1	-£1.3	-£0.2	-£0.7
		Net Business User Benefits	**£145.0**	**£112.1**	**£213.1**	**£72.6**	**£136.9**
	Accidents Benefits		-£8.5	£1.9	£8.4	£5.8	-£24.1
	Indirect Tax Revenues		£3.7	-£1.0	£2.3	£4.6	£3.5
	Noise		-£5.7	-£5.3	-£4.0	-£3.3	-£9.6
	Air Quality		£2.9	£0.6	£2.2	£2.8	£1.0
	Total PVB (£m)		**£342.9**	**£275.8**	**£538.7**	**£184.4**	**£300.4**
Costs	Operating and Maintenance Costs		£13.8	£15.1	£15.8	£12.4	£15.7
	Investment Costs		£123.4	£97.0	£191.5	£32.3	£120.1
	Revenue Change		£0.0	£0.0	£0.0	£0.0	£0.0
	Total PVC (£m)		**£137.2**	**£112.2**	**£207.3**	**£44.8**	**£135.9**
Net Present Value (NPV)			**£205.7**	**£163.6**	**£331.4**	**£139.6**	**£164.5**
Benefits to Cost Ratio (BCR)			**2.50**	**2.46**	**2.60**	**4.12**	**2.21**

Note: All monetary values are discounted to 2010 and in 2010 market price unit of account. Accidents, Noise, Air Quality, User delays during construction and maintenance are taken from the Core growth scenario assessment. Cells highlighted with blue colour are taken from the TUBA assessment. Noise and Air Quality information is provided by Environmental Team within Mott MacDonald. User delays disbenefits during construction and future maintenance are derived from QUADRO.

Table 5-18: Summary of Economic Assessment Results – High Growth Scenario, £m

			Costs/Benefits				
			Option 1	Option 1A	Option 2	Option 3	Option 3A
Benefits	Consumer Commuting User Benefits	Travel Time	£67.4	£52.1	£98.3	£33.2	£63.4
		VOC	-£2.6	£0.6	-£2.9	-£2.3	-£2.3
		Construction Delays	-£2.0	-£1.9	-£3.7	-£1.6	-£1.8
		Maintenance Delays	-£0.2	-£0.2	-£0.3	£0.0	-£0.1
		Net Consumer User Benefits	**£62.6**	**£50.5**	**£91.4**	**£29.3**	**£59.2**
	Consumer Other User Benefits	Travel Time	£168.4	£132.8	£252.8	£81.3	£155.3
		VOC	-£12.3	-£3.5	-£11.4	-£8.9	-£11.0
		Construction Delays	-£6.3	-£5.9	-£10.8	-£5.0	-£5.6
		Maintenance Delays	-£2.9	-£3.3	-£4.0	-£0.5	-£2.0
		Net Consumer User Benefits	**£146.9**	**£120.1**	**£226.5**	**£66.9**	**£136.8**
	Consumer Business User Benefits	Travel Time	£153.2	£118.6	£223.2	£74.4	£143.4
		VOC	£8.2	£7.5	£13.3	£3.5	£7.6
		Construction Delays	-£6.4	-£5.9	-£11.5	-£5.0	-£5.5
		Maintenance Delays	-£1.0	-£1.1	-£1.3	-£0.2	-£0.7
		Net Business User Benefits	**£154.1**	**£119.1**	**£223.6**	**£72.7**	**£144.8**
	Accidents Benefits		-£8.5	£1.9	£8.4	£5.8	-£24.1
	Indirect Tax Revenues		£3.4	-£1.4	-£1.8	£4.6	£3.3
	Noise		-£5.7	-£5.3	-£4.0	-£3.3	-£9.6
	Air Quality		£2.9	£0.6	£2.2	£2.8	£1.0
	Total PVB (£m)		**£355.7**	**£285.5**	**£546.3**	**£178.7**	**£311.3**
Costs	Operating and Maintenance Costs		£13.8	£15.1	£15.8	£12.4	£15.7
	Investment Costs		£123.4	£97.0	£191.5	£32.3	£120.1
	Revenue Change		£0.0	£0.0	£0.0	£0.0	£0.0
	Total PVC (£m)		**£137.2**	**£112.2**	**£207.3**	**£44.8**	**£135.9**
Net Present Value (NPV)			**£218.5**	**£173.3**	**£339.0**	**£133.9**	**£175.4**
Benefits to Cost Ratio (BCR)			**2.59**	**2.55**	**2.64**	**3.99**	**2.29**

Note: All monetary values are discounted to 2010 and in 2010 market price unit of account. Accidents, Noise, Air Quality, User delays during construction and maintenance are taken from the Core growth scenario assessment. Cells highlighted with blue colour are taken from the TUBA assessment. Noise and Air Quality information is provided by Environmental Team within Mott MacDonald. User delays disbenefits during construction and future maintenance are derived from QUADRO.

5.9.2 Table 5-19 below represents PVB, PVC and BCR for the Low, Core and High growth scenarios for each option.

Table 5-19: Summary of PVB, PVC and BCR – Low, Core and High Growth Scenarios

	Low Growth PVB, £m	Core Growth PVB, £m	High Growth PVB, £m	PVC, £m	Low Growth BCR	Core Growth BCR	High Growth BCR
Option 1	£343	**£349**	£356	£137	2.50	2.55	2.59
Option 1A	£276	**£279**	£286	£112	2.46	2.49	2.55
Option 2	£539	**£551**	£546	£207	2.60	2.66	2.64
Option 3	£184	**£185**	£179	£45	4.12	4.13	3.99
Option 3A	£300	**£308**	£311	£136	2.21	2.27	2.29

5.9.3 As expected, the Low growth scenario predicts a moderately lower BCR than the Core growth scenario for most of the options, while the High growth scenario predicts a moderately higher BCR than Core scenario. The BCR for the High and Low growth scenarios in the above table should be treated cautiously as these represent indicative results without the full assessment of the accidents, user delay during construction and maintenance and environmental assessment.

5.10 Sensitivity test - user benefits assessment with Dependent Development

5.10.1 TAG unit A2.3 sets out the approach to be used to estimate the benefits of the dependent development. In summary, this is a two part process which firstly includes estimation of the 'planning gain' arising from the dependent new homes; then secondly subtracting the net external costs caused by the dependent new homes. To assess the transport external costs of the land use development, two transport model runs are required:

1. Without the new housing but with the transport scheme; and
2. With the new housing and with the transport scheme.

5.10.2 The dependant developments are the strategic developments Tangmere, North East Chichester and West of Chichester as described in the latest Forecasting Report[9](Chapter 3). Without the strategic developments housing and without any form of transport scheme the transport network does not provide a reasonable level of service. This is also shown in the forecasting report, where the already congested base year network experiences large increases in delays on the Chichester Bypass in the Do Minimum scenario.

5.10.3 To assess the benefits of the dependent development, two separate TUBA runs were undertaken as mentioned above for all the options for Core scenario using the same network and then compared. Table 5-20 below summarised the user benefits (Time+VOC) for each option – excluding dependent development and including dependent development.

5.10.4 It can be seen from the above table that there is not significant benefits arises with the inclusion of dependent development scenario. In fact the benefits are more or less similar for the including and excluding dependent development. This shows that the A27 Scheme may not play significant role in facilitating new development, but congestion levels are such that new development will not take place until the A27 scheme takes place.

Table 5-20: User benefits comparion – Excluding and Including dependent development by user class

Core Growth	EDD* Op 1	IDD** Op 1	EDD Op 1A	IDD Op 1A	EDD Op 2	IDD Op 2	EDD Op 3	IDD Op 3	EDD Op 3A	IDD Op 3A
Business	£157.6	£159.8	£122.6	£121.1	£235.1	£239.7	£79.5	£80.7	£148.7	£146.6
Commuting	£63.8	£64.5	£51.7	£51.3	£96.2	£98.4	£32.7	£32.4	£60.9	£60.4
Other	£154.4	£158.7	£127.4	£127.3	£243.2	£250.7	£75.1	£77.2	£143.4	£141.4
Total	**£375.8**	**£383.0**	**£301.7**	**£299.7**	**£574.5**	**£588.8**	**£187.3**	**£190.3**	**£353.0**	**£348.4**
Qualitative scores	**Slight Beneficial**		**Slight Adverse**		**Slight Beneficial**		**Slight Beneficial**		**Slight Adverse**	

*Excluding dependent development scenario

**Including dependent development scenario

[9] A27 Chichester Bypass Improvement Scheme, Forecasting Report, June 2016

5.11 Economic Assessment Results – New Value of Time (based on DfT Consultation Document October 2015)

5.11.1 This section describes the initial transport economic efficiency results for all shortlisted options for the A27 Scheme based on the DfT's recent research findings of the Value of Time (VoT) compared with results derived from the current TAG value of time. Note that the model has not been adjusted to reflect the new VoT, and some reassignment or other modelled changes could influence these estimates.

5.11.2 Table 5-21 below summarises the current VoT and the findings of the research carried out by DfT.

Table 5-21: Current WebTAG values of time and DfT Research values (all 2010 market prices)

	Current TAG Values	Research Results	
Non-work travel			
Commute	£6.81		£10.01
Other non-work	£6.04		£4.57
Business Travel		**Distance Band**	
Car (driver/passenger)	£27.06/£20.52	0-50km	£10.08
		50-100km	£16.30
		100km+	£25.12
Rail passenger	£31.96	0-50km	£10.08
		50-100km	£16.30
		100km+	£36.19
Bus Passenger	£16.63	0-50km	£10.08
		50-100km	£16.30
Other public transport	£26.28 (LU passenger)	0-50km	£10.08
		50-100km	£16.30

Source: Understanding and valuing impacts of transport investment - Values of travel time savings, DfT, October 2015

5.11.3 For the purpose of this assessment, a separate 60-year TUBA assessment which applied new values of time was carried out based on the current HAM runs for the forecast years 2020, 2035 and 2041 for all the options for core growth scenario. Table 5-22 below summarises the time benefits for each option which include the business car user time benefits by distance band. Business - car users account about 7%-8% of the time benefits overall. With regard to time benefits by distance band, majority of the time benefits come from trip less than 50km (about 44%-58%) followed by long distance trips (trips more than 100km) which account about 18%-33%. Car – commute and Car – other categories account about 28% and 36% of the overall time benefits respectively whilst goods vehicles account about 7%-9% of the total time benefits.

Table 5-22: User Time Benefits – New Value of Time, £m

Time Benefits	Option 1	Option 1A	Option 2	Option 3	Option 3A
Car - Business (0-50km)	£13.86	£11.27	£20.36	£6.46	£12.90
Car - Business (50-100km)	£5.59	£3.43	£7.93	£3.48	£5.40
Car - Business (100+km)	£7.69	£4.90	£10.65	£4.84	£7.30
Car - Commuting	£98.09	£75.33	£145.93	£51.54	£93.00
Car - Other	£122.10	£95.66	£186.35	£61.48	£113.10
LGV - Personal	£68.09	£54.98	£105.45	£32.79	£63.80
LGV Freight	£5.60	£4.52	£8.68	£2.70	£3.90
OGV1	£16.79	£11.92	£23.46	£9.19	£16.30
OGV2	£11.57	£8.24	£15.98	£6.35	£11.20
Total	**£349.38**	**£270.25**	**£524.79**	**£178.83**	**£326.90**

5.11.4 Table 5-23 below summarises user time benefits for the current VoT and new VoT for each option. It can be seen from the table that with the new values of time, the business car user group time benefits dropped down about 46% - 51% as compared to the current VoT for the same category. The commuting user group's time benefits has increased by 47% whilst the car - other category's time benefits decreased by as much as 24% as compared to the current VoT for the same categories. These changes can be argued due to proposed changes in values of time for the car – business, commute and other categories. Overall time benefits would be about 9% less across all the user class combined with new values of time. It should be noted that there is no change proposed for the LGV – personal and business and OGV – business so these user groups' time benefits will remain same.

Table 5-23: User Time Benefits Comparison – Current vs New Value of Time, £m

User Class	Option 1		Option 1A		Option 2		Option 3		Option 3A	
	Current VoT	New VoT	Current VoT	New VoT	Current VoT	New VoT	Current VoT	New VoT	Current VoT	New VoT
Car - Business	£52.90	£27.10	£39.80	£19.60	£76.60	£38.90	£27.40	£14.80	£76.60	£38.90
Car - Commuting	£66.70	£98.10	£51.20	£75.30	£99.30	£145.90	£35.10	£51.50	£99.30	£145.90
Car - Other	£161.40	£122.10	£126.40	£95.70	£246.30	£186.40	£81.20	£61.50	£246.30	£186.40
LGV - Personal	£68.10	£68.10	£55.00	£55.00	£105.40	£105.40	£32.80	£32.80	£105.40	£105.40
LGV Freight	£5.60	£5.60	£4.50	£4.50	£8.70	£8.70	£2.70	£2.70	£8.70	£8.70
OGV1	£16.80	£16.80	£11.90	£11.90	£23.40	£23.40	£9.20	£9.20	£23.40	£23.40
OGV2	£11.60	£11.60	£8.20	£8.20	£16.00	£16.00	£6.30	£6.30	£16.00	£16.00
Total	**£383.10**	**£349.40**	**£297.00**	**£270.20**	**£575.70**	**£524.70**	**£194.70**	**£178.80**	**£575.70**	**£524.70**

5.11.5 The results of the economic appraisal with new value of time for each option is summarised in Table 5-24. From the below, it can be seen that out of all the options, Option 2 has the highest PVB of around £505m but this option also has highest PVC of some £207m. The BCR for this option is 2.4 which is second highest among all the options. Online Option 1, Option 1A, Option 3 and Option 3A have PVB of some £318m, £256m, £169m and £277m respectively. The PVC of these options is about £137m, £112m, £45m, and £136m respectively and therefore the BCR of these options is 2.3, 2.3, 3.8, and 2.0.

Table 5-24: Summary of Economic Assessment Results – Core Scenario, New Value of Time £m

			Costs/Benefits				
			Option 1	**Option 1A**	**Option 2**	**Option 3**	**Option 3A**
Benefits	Consumer Commuting User Benefits	Travel Time	£98.1	£75.3	£145.9	£51.5	£92.9
		VOC	-£2.9	£0.4	-£3.1	-£2.4	-£2.3
		Construction Delays	-£3.1	-£2.9	-£5.6	-£2.5	-£2.7
		Maintenance Delays	-£0.3	-£0.3	-£0.4	-£0.1	-£0.2
		Net Consumer User Benefits	**£91.8**	**£72.5**	**£136.8**	**£46.6**	**£87.6**
	Consumer Other User Benefits	Travel Time	£127.7	£100.2	£195.1	£64.2	£117.1
		VOC	-£12.6	-£3.6	-£11.8	-£8.8	-£11.3
		Construction Delays	-£5.2	-£4.9	-£8.8	-£4.1	-£4.6
		Maintenance Delays	-£2.4	-£2.7	-£3.3	-£0.4	-£1.6
		Net Consumer User Benefits	**£107.6**	**£89.0**	**£171.2**	**£50.9**	**£99.6**
	Consumer Business User Benefits	Travel Time	£123.6	£94.7	£183.7	£63.1	£116.9
		VOC	£8.3	£7.5	£13.5	£3.8	£7.6
		Construction Delays	-£4.3	-£3.9	-£7.7	-£3.4	-£3.7
		Maintenance Delays	-£0.6	-£0.7	-£0.9	-£0.1	-£0.4
		Net Business User Benefits	**£126.9**	**£97.6**	**£188.6**	**£63.4**	**£120.3**
	Accidents Benefits		-£8.5	£1.9	£8.4	£5.8	-£24.1
	Indirect Tax Revenues		£3.7	-£1.1	£2.0	£4.6	£3.5
	Noise		-£5.7	-£5.3	-£4.0	-£3.3	-£9.6
	Air Quality		£2.9	£0.6	£2.2	£2.8	£1.0
	Total PVB (£m)		**£318.8**	**£255.0**	**£505.2**	**£170.8**	**£278.4**
Costs	Operating and Maintenance Costs		£13.8	£15.1	£15.8	£12.4	£15.7
	Investment Costs		£123.4	£97.0	£191.5	£32.3	£120.1
	Revenue Change		£0.0	£0.0	£0.0	£0.0	£0.0
	Total PVC (£m)		**£137.2**	**£112.2**	**£207.3**	**£44.8**	**£135.9**
Net Present Value (NPV)			**£181.6**	**£142.9**	**£297.8**	**£126.0**	**£142.5**
Benefits to Cost Ratio (BCR)			**2.32**	**2.27**	**2.44**	**3.81**	**2.05**

Note: All monetary values are discounted to 2010 and in 2010 market price unit of account. Accidents, Noise, and Air Quality, are taken from the Core growth scenario assessment. Noise and Air Quality information is provided by Environmental Team within Mott MacDonald. User delays disbenefits during construction and future maintenance are derived from QUADRO by using relevant proposed new value of time for different user class. Travel time, VOC, Indirect tax revenue and Greenhouse gases figures are taken from the TUBA assessment.

6 Summary and conclusions

6.1 Summary and conclusions

6.1.1 The A27 is the only strategic east-west highway along the south coast, directly linking Eastbourne in East Sussex to Portsmouth in Hampshire via Brighton, Worthing, Arundel, Chichester and Havant, and onto Southampton and beyond using the M27. In Chichester the A27 loops around the south of the city, forming the Chichester Bypass. The 5km length of the bypass is dual carriageway and comprises five at-grade roundabouts (Fishbourne, Stockbridge, Whyke, Bognor Road and Portfield), and one signalised junction (Oving). These junctions are where the radial routes between the south coast (Manhood Peninsula and Bognor Regis) and the city centre cross the bypass, and junction spacing varies from 0.5km to 1.3km.

6.1.2 Although a strategic route, the majority of traffic using the bypass is local traffic entering and leaving Chichester itself. It is the combination of the close proximity of the junctions and the conflict between the impeding north-south and east-west traffic flows that generates significant congestion and extensive queuing at most of the junctions at peak times, disrupting the mainline flow of the road and compromising its operation as a strategic route.

6.1.3 During PCF Stage 1, a filtering process was undertaken to determine the appropriate improvement options from the previous study to take forward into Stage 2, option selection. In Stage 2, six options plus one sub option were tested and were part of the EAR submitted in January 2016. In February 2016, Highways England decided to exclude the northern and southern bypass options (Options 4, 5 and 6) as they were found to exceed the Road Investment Strategy £100m to £250m budget range. Option 2A also dropped at this stage as the economic and environmental assessment found that Option 2 performed better. Options 1, 2 and 3 were kept with two new sub options - 1A and 3A which are variants of the Option 1 and Option 3 are modelled and taken forward for the latest economic assessment purpose.

6.1.4 The purpose of this report has been to detail how the benefits and costs of these shortlisted options (Option 1, 1A, 2, 3 and 3A) have been derived as part of the economic appraisal process, and to then present the associated results.

6.1.5 Following is a summary of the key outputs from the economic appraisal for the core scenario:

- Travel time savings represent the majority of the benefits associated with the Scheme for all of options.
- The largest portion of the travel time benefits occurs during the IP peak (about 40%-44%) followed by PM (31%-36%) and AM peak (20%-26%) periods for all options.
- Journey distance increases as a result of the Scheme under the majority of the options. Partly as a result of this, across all user classes, time periods and years, overall travel time benefits occur which are generally experienced at the expense of operating cost disbenefits.
- Commuters and Other users experience journey time savings generally at the expense of vehicle operating costs disbenefits. Business users experience substantial overall savings.
- The results output for the AQ taken from the Air Quality spreadsheet for the entire study area predict a slight decrease in PM10 and NOx concentration overall for all of the options.
- The results output from the Noise spreadsheet shows that there is predicted to be disbenefits from changes in noise levels for all of the options.

- The patterns of sector to sector user benefits correlate well with expectations and the following associated considerations:
  - the location of the Scheme, within Sector 9 – Centre of Chichester;
  - the role of the Scheme in significantly reducing journey times for medium and long distance traffic from sectors to the west of the scheme and also North-East and South-East flows and vice versa;
  - at the same time, the Scheme results in some increases in traffic flows on other parts of the road network, with resulting disbenefits to traffic between relevant sectors – such as sectors in south-west for example Bosham, Nutbourne, Southbourne and Emsworth and Wittering.
- The combination of the above patterns results in significant user benefits accruing between the East-West sectors (East of Arun – Hampshire), North East (Routes to NE) and South-East (Bognor Regis) Sectors and vice versa. There are also significant benefits occurring from the Centre of Chichester for all of the options. Percentage splits of these benefits vary between each option but in summary each option produces significant time savings through the elimination of congestion at the existing junctions on the A27 Chichester Bypass.
- Accident assessment shows a decrease of accidents costs overall for Options 1A, 2 and 3 whilst there is a slight increase of accident costs for the Option 1 and Option 3A over a 60-year assessment period.
- One of the major objectives of the Scheme is to improve journey time reliability. That is achieved and demonstrated for each option by the significant benefits associated with reduction in day to day variability under the core scenario.
- From Table 5-16 it can be seen that out of all the options, Option 2 has the highest PVB of around £551m but this option also has highest PVC of some £207m. The BCR for this option is 2.7 (second highest after Option 3). Online Option 1, Option 1A, Option 3 and Option 3A have PVB of some £348m, £280m, £183m and £307m respectively. The PVC of these options is about £137m, £112m, £45m, and £136m respectively and therefore the BCR of these options is 2.5, 2.5, 4.1, and 2.3. In terms of DfT's Value for Money assessment (VfM), Options 1, 1A, 2, and 3A represent *'high value for money'* whilst the Option 3 represents '*very high value for money'.*
- Sensitivity tests were undertaken to understand the economic impact of the Low and High traffic growth scenarios in terms of user benefits using TUBA. As it can be seen from Table 5-19, the Low growth scenario predicts a moderately lower BCR than the Core growth scenario for most of the options, whilst the High growth scenario predicts a moderately higher BCR than Core scenario. It should be noted that these are indicative BCRs as results of the other assessments such as COBA-LT and QUADRO are taken from the Core scenario assessment.
- A test on the depending development shows that the Scheme may not play significant role in facilitating housing development at least for Options 1A and 3A.
- A test with proposed DfT's new value of time for the core scenario using the current HAM results indicates that the time benefits for the business cars could decrease as much as 51%, the car – commute category could see increase in time benefits of about 47% and in Car – other category, time benefits could decrease to 24%.

6.2 Summary of assumptions and caveats affecting the results

6.2.1 Outputs from the transport models are a key input to much of the content in this report. The transport models themselves are also subject to a number of input assumptions which will impact upon the level of travel demand and subsequent economic benefits.

6.2.2 For the purpose of this economic assessment, methodology adopted for traffic forecasting exclude any dependent development (as per the TAG Unit A2.3) whilst the economic assessment carried out in January 2016 was based on inclusion of dependent development. This will have an impact on travel demand and subsequent economic benefits of the shortlisted options.

6.2.3 At the time when transport user benefits analysis was carried out for this Scheme in late December 2015/January 2016 for the seven originally shortlisted options (i.e. Options 1, 2, 2A, 3, 4, 5, and 6), TUBA version 1.9.5 was available and used. More recently DfT has issued a new version of the TUBA 1.9.6 (released on 15th January 2016). The new TUBA version incorporates latest changes made in TAG Data book (released on 23rd December 2015). These changes mainly include latest GDP, population, household, inflation, fuel price and emission factor projections following Autumn Statement in 2015. For the purpose of latest economic assessment for the five shortlisted options (i.e. Options 1, 1A, 2, 3, and 3A) TUBA version 1.9.6 is used therefore transport user benefits of the Options 1, 2 and 3 would be different than those included in the previous EAR.

6.2.4 A test with DfT's new value of time is indicative as it uses current HAM skims where forecasts been made using the current values of time so these results should be treated with caution.

6.2.5 Operating and Maintenance duration and subsequent costs have been changed since last assessment which is based on new type of maintenance contract brought forward and has reduced substantially for all the shortlisted options including Option 1, 2 and 3 which has been brought forward from the previous assessment. This will have an impact on the PVC and user delay disbenefits during future maintenance of these options.

6.2.6 The methodology adopted for calculating reliability benefits is an accepted WebTAG approach.

6.2.7 At this stage, the economic calculations of the greenhouse gases are not undertaken but we expect carbon emissions may increase, which might reduce the BCR.

Appendices

Appendix A. Key Economic Assessment Results of the Option 2A, 4, 5 and 6 (submitted as part of the January 2016 submission)

A.1 Introduction

A.1.1 Document Purpose

A.1.1.1 The main content of the report assessed economic impact of the five shortlisted options (i.e. Options 1, 1A, 2, 3 and 3A) for the A27 improvement Scheme which is currently at PCF Stage 2. In January 2016 Jacobs carried out an economic assessment for the then shortlisted options – 1, 2, 2A, 3, 4, 5, and 6.

A.1.1.2 In February 2016, Highways England decided to exclude the northern and southern bypass options (Options 4, 5 and 6) as they were found to exceed to exceed the Road Investment Strategy £100m to £250m budget range. Option 2A was also discounted as the economic and environmental assessment found that Option 2 performed better. It is understood that the Highways England will consult on schemes that will meet their objectives to improve traffic flow and safety, that sit at the lower end of the £100m to £250m range. This will mean improvements to the four junctions on the A27, as stated in the Government's 2014 Roads Investment Strategy.

A.1.1.3 This document summarises the key economic outputs of the option 2A, 4, 5, and 6. Detailed economic assessment of these options is contained within the EAR submitted in January 2016.

A.1.2 Headline economic appraisal results

A.1.2.1 Table A–1 below presents a summary of the BCR for options 2A, 4, 5, and 6 for the core scenario.

Table A–1: Headline Benefits Summary - Core Scenario, £m

Scheme Options	Present Value of Benefits (PVB)	Present Value of Costs (PVC)	BCR
Option 2A	£361	£207	1.7
Option 4	£693	£259	2.7
Option 5	£687	£240	2.9
Option 6	£688	£448	1.5

Note: All monetary values are discounted to 2010 and in 2010 market price unit of account.

A.1.3 Headline economic appraisal results – Core Scenario

A.1.3.1 Analysis of the benefits by trip purpose for the Core growth scenario, shown in Table A–2, indicates that approximately 41%-44% of the benefits are as a result of business trips, approximately 17%-19% are as a result of commuting trips and approximately 40%-42% as a result of other trips.

Table A–2: TUBA Benefits (Time+VOC) by Purpose – Core Scenario, £m

User Class	Option 2A	Option 4	Option 5	Option 6
Business	£141.2	£268.2	£262.0	£277.9
% Business	40.7%	43.4%	43.6%	41.0%
Commuting	£64.8	£102.4	£98.9	£112.4
% Commuting	18.7%	16.6%	16.5%	16.6%
Other	£140.9	£247.6	£240.2	£287.5
% Other	40.6%	40.1%	40.0%	42.4%
Total	**£346.9**	**£618.2**	**£601.1**	**£677.8**

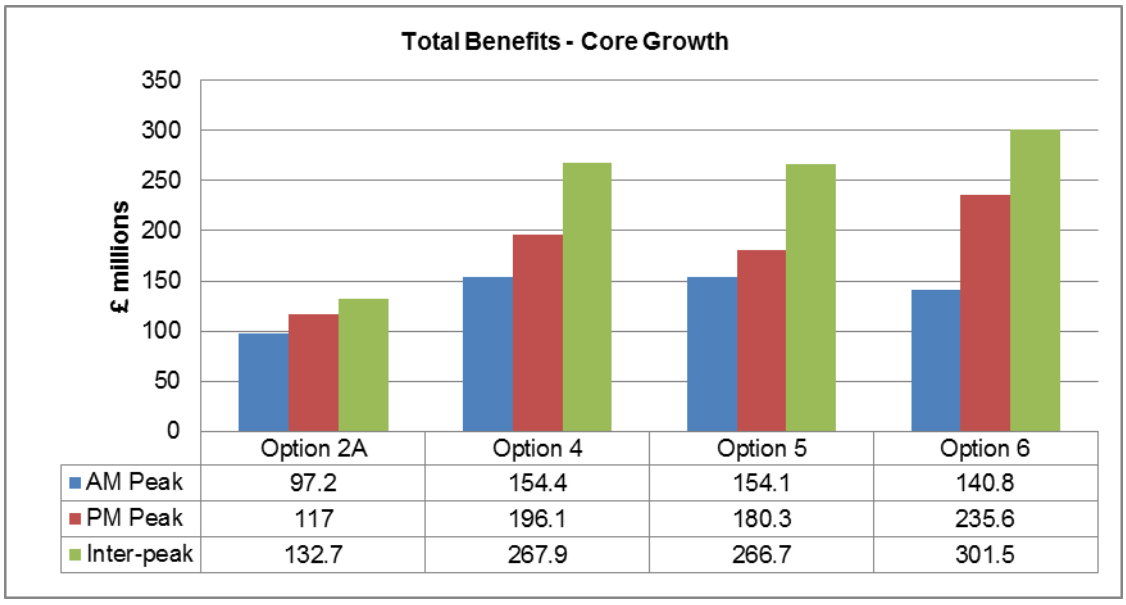
A.1.3.2 Analysis of benefits grouped by the size of the time saving is shown in Table A–3 below by user class. The results show that a significant proportion of the scheme's benefits come from large time savings for all of the options.

Table A–3: TUBA Benefits by Time Savings by Purpose – Core Scenario, £m

Option 2A	< 2min	2 to 5min	> 5min	Total
Business	-£12.6	£84.5	£61.7	£133.6
Commute	-£4.2	£35.5	£28.9	£60.2
Other	-£13.7	£91.9	£64.7	£142.9
Option 4	**< 2min**	**2 to 5min**	**> 5min**	**Total**
Business	£46.4	£72.8	£121.2	£240.5
Commute	£19.9	£33.7	£53.1	£106.7
Other	£58.4	£82.7	£122.5	£263.5
Option 5	**< 2min**	**2 to 5min**	**> 5min**	**Total**
Business	£48.1	£72.6	£113.7	£234.4
Commute	£20.2	£33.1	£48.4	£101.7
Other	£60.2	£80.9	£111.1	£252.2
Option 6	**< 2min**	**2 to 5min**	**> 5min**	**Total**
Business	£34.0	£139.7	£85.1	£258.8
Commute	£12.7	£59.2	£43.2	£115.1
Other	£46.7	£164.3	£85.5	£296.5

A.1.3.3 Analysis of the benefits by time period, in Figure A.1 shows that approximately 21%-28%, 30%-35% and 38%-44% of the total benefits occurred in each of the three modelled time periods – Weekday AM, PM and IP respectively for majority of the options.

Figure A–1: TUBA Benefits (Time+VOC) by Time Period – Core Scenario, £m



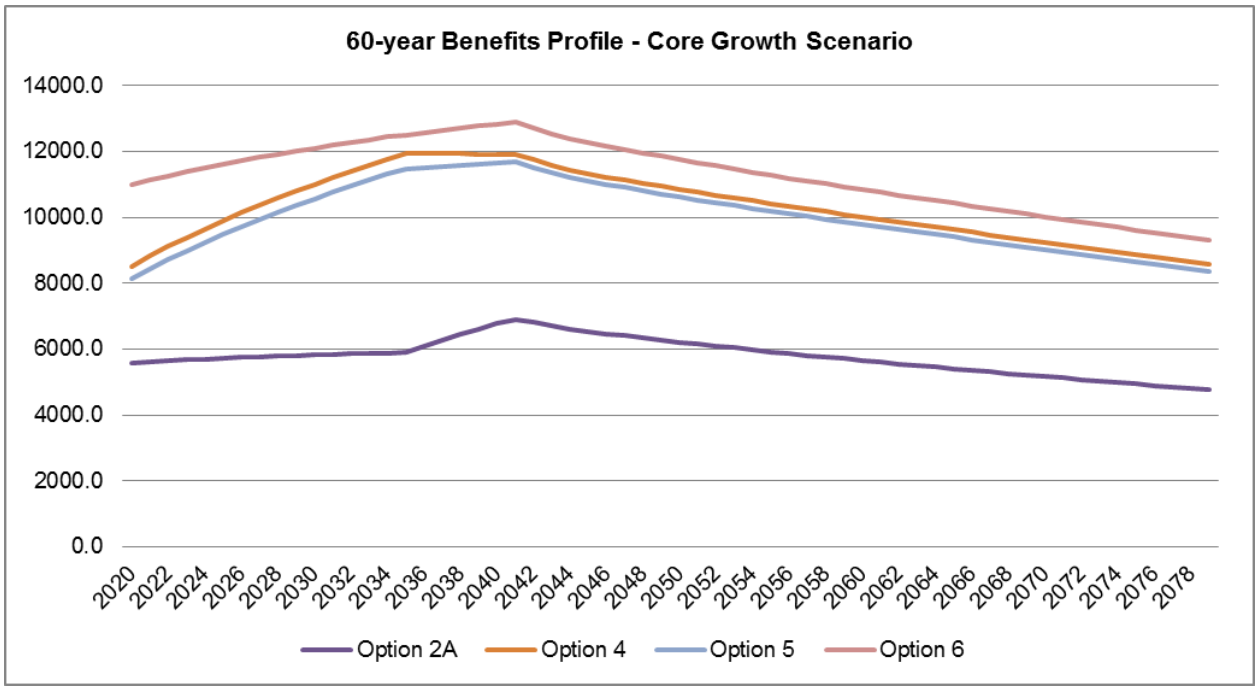
A.1.3.4 Analysis of the user benefits by vehicle type, journey purpose and by time period is shown in Table A–4. It shows that main benefits accrue to car – other (some 39% to 41%). A further approximately 14% benefits accrue to Car – Business and some 9%-12% benefits accrue to Business Freight (OGVs).

Table A–4: TUBA Benefits (Time+VOC) by Vehicle Class/Purpose – Core Scenario, £m

User Class	Option 2A			Option 4			Option 5			Option 6		
	AM	IP	PM	AM	IP	PM	AM	IP	PM	AM	IP	PM
Car - Business	£11.0	£21.6	£16.2	£21.2	£39.9	£27.1	£21.2	£39.6	£24.0	£19.6	£43.1	£30.1
Car - Commuting	£28.5	£9.4	£26.8	£40.0	£18.6	£43.8	£40.0	£18.6	£40.3	£38.7	£21.3	£52.4
Car - Other	£29.9	£58.8	£48.1	£36.2	£120.5	£82.3	£36.2	£120.3	£75.2	£34.9	£142.4	£100.6
LGV - Freight	£14.1	£21.2	£18.2	£30.3	£47.0	£29.6	£30.3	£47.1	£26.9	£27.5	£56.9	£37.3
LGV - Personal	£1.1	£1.6	£1.4	£2.4	£3.8	£2.4	£2.4	£3.8	£2.2	£2.2	£4.5	£3.0
OGV1	£6.7	£10.9	£3.3	£12.6	£20.4	£5.7	£12.4	£20.0	£6.2	£9.4	£18.1	£6.5
OGV2	£6.0	£9.1	£2.9	£11.6	£17.4	£5.1	£11.5	£17.0	£5.5	£8.5	£15.1	£5.6
Total	**£97.3**	**£132.6**	**£116.9**	**£154.3**	**£267.6**	**£196.0**	**£154.0**	**£266.4**	**£180.3**	**£140.8**	**£301.4**	**£235.5**
Total (AM+IP+PM)	**£346.8**			**£617.9**			**£600.7**			**£677.7**		

Note: overall total may not exactly match due to rounding issue

A.1.3.5 The benefit profile over a scheme's life is required to determine whether the benefits of the scheme occur earlier or later. The benefit profile shown in Figure A.2 indicates that, as expected, a significant proportion (between 38% - 42%) of the discounted benefits is between the Opening year (2020) and Horizon year (2041), about 33%-37% are between 2042 and 2061 and 26%-28% of the benefits are between 2062 and 2079. The benefits profiles show that the benefits increase from the opening year to the intermediate year, and then increase again between the intermediate year and the design year for most of the options The overall benefits then decline steadily after the design year over the remainder of the 60-year assessment period for all options. It should be noted that this is primarily due to the discounting effect, i.e. even though discounted benefits decline over the scheme's life, this does not indicate that the actual undiscounted benefits would be declining over the scheme's life.



A.1.3.6 The distribution of benefits resulting from the Scheme is presented on a sector to sector basis**.** Table A–5 to Table A–8 show the percentage split of benefits for each option.

A.1.3.7 The sector to sector analysis shows that, as expected, the greatest benefits occur between the East-West sectors (East of Arun – Hampshire), North East (Routes to NE) and South-East (Bognor Regis) Sectors and vice versa. Significant benefits also occur from the Centre of Chichester for the majority of the options. The percentage split of these benefits however varies between each option but in summary each option produces significant time savings through the elimination of congestion at the existing junctions on the A27 Chichester Bypass.

Table A–5: Option 2A - Sector to Sector Benefits output from TUBA – Core Scenario, £m

Benefits per sector Core scenario Option 2A		Destination									Total
		1	2	3	4	5	6	7	8	9	
Origin	1	0.0	-5.7	-2.5	5.1	3.0	3.6	2.5	4.8	7.3	**18.2**
	2	-9.1	-0.2	-0.8	-3.4	-7.7	-11.7	-16.8	-4.1	-6.8	**-60.6**
	3	-3.6	0.1	0.0	-1.9	-2.5	-3.4	-7.6	-2.0	-3.4	**-24.4**
	4	5.3	3.8	2.6	-3.3	3.9	16.6	30.6	2.0	17.3	**79.0**
	5	4.6	2.2	1.1	1.0	0.8	6.9	43.0	-1.3	10.9	**69.2**
	6	2.4	2.7	2.3	7.4	3.6	2.3	15.1	1.3	6.2	**43.3**
	7	0.3	-8.6	-5.7	12.4	18.6	6.9	0.8	29.9	3.4	**58.0**
	8	5.5	1.4	0.5	0.6	-2.7	3.1	56.3	-0.1	3.6	**68.1**
	9	6.7	14.6	8.4	15.3	13.1	12.0	15.2	3.6	7.0	**95.9**
Total		**12.1**	**10.3**	**5.9**	**33.2**	**30.2**	**36.3**	**139.0**	**34.2**	**45.5**	**346.8**

Table A–6: Option 4 – Sector to Sector Benefits output from TUBA – Core Scenario, £m

Benefits per sector Core Scenario Option 4		Destination									Total
		1	2	3	4	5	6	7	8	9	
Origin	1	0.0	0.6	1.0	3.8	2.7	2.2	3.0	5.0	9.3	**27.6**
	2	0.6	0.1	0.3	0.9	3.6	6.5	5.8	2.5	2.6	**22.8**
	3	1.0	0.3	0.1	0.4	2.3	4.6	3.5	1.9	2.7	**16.8**
	4	4.9	1.7	0.8	3.1	3.7	16.6	24.9	5.5	14.6	**76.0**
	5	3.3	5.4	3.7	0.6	-8.5	6.4	47.5	-5.0	7.3	**60.5**
	6	2.1	9.3	5.8	16.6	7.4	3.0	28.1	6.5	11.8	**90.6**
	7	0.7	0.8	1.0	4.1	24.9	10.5	0.9	61.7	1.8	**106.5**
	8	4.6	3.5	1.8	1.7	-7.6	7.0	95.3	0.9	1.7	**108.9**
	9	8.7	12.9	7.8	23.1	14.0	11.4	19.4	3.7	7.5	**108.4**
Total		**25.9**	**34.6**	**22.3**	**54.3**	**42.5**	**68.2**	**228.3**	**82.8**	**59.3**	**618.1**

Table A–7: Option 5 – Sector to Sector Benefits output from TUBA – Core Scenario, £m

Benefits per sector Core Scenario Option 5		Destination									Total
		1	2	3	4	5	6	7	8	9	
Origin	1	0.0	0.7	1.1	3.8	3.5	2.6	2.6	6.0	9.3	**29.7**
	2	0.6	0.1	0.3	0.9	3.8	6.6	4.7	2.5	2.7	**22.2**
	3	1.0	0.3	0.1	0.4	2.3	4.5	3.2	1.9	2.7	**16.4**
	4	4.8	1.7	0.8	3.1	3.8	16.2	22.5	5.5	14.2	**72.5**
	5	3.3	5.2	3.5	0.6	-8.7	6.0	43.5	-5.7	6.6	**54.3**
	6	2.1	9.3	5.8	17.0	8.2	3.5	26.1	7.2	12.2	**91.4**
	7	0.6	0.8	1.0	4.0	24.1	9.7	0.8	59.5	1.1	**101.5**
	8	4.7	3.3	1.7	1.9	-7.6	6.8	90.3	1.2	1.5	**103.8**
	9	8.6	12.9	7.8	23.5	14.5	12.1	18.1	3.8	7.8	**109.1**
Total		**25.9**	**34.2**	**22.0**	**55.1**	**44.0**	**68.0**	**211.8**	**81.9**	**57.9**	**600.9**

Table A–8: Option 6 – Sector to Sector Benefits output from TUBA – Core Scenario, £m

Benefits per sector Core Scenario Option 6		Destination									Total
		1	2	3	4	5	6	7	8	9	
Origin	1	-0.1	-0.2	0.4	1.9	0.6	-0.9	-1.4	1.5	-4.5	**-2.7**
	2	2.7	-0.1	1.3	3.1	6.3	14.2	11.2	4.2	6.7	**49.6**
	3	2.6	1.0	0.6	1.6	2.2	8.0	7.1	1.7	5.9	**30.6**
	4	7.7	5.3	1.9	-0.8	7.6	26.2	37.8	6.9	26.7	**119.2**
	5	4.8	8.4	4.8	3.5	-1.7	9.0	40.2	-1.1	16.5	**84.4**
	6	1.8	12.5	7.4	20.7	3.9	4.6	11.6	1.3	10.0	**73.8**
	7	0.4	8.4	5.8	14.4	22.5	5.6	0.9	38.7	-0.1	**96.5**
	8	6.0	6.1	2.2	2.7	-4.7	3.7	57.0	0.4	5.2	**78.6**
	9	6.5	22.8	14.0	34.8	19.1	18.3	15.1	5.4	11.6	**147.7**
Total		**32.4**	**64.1**	**38.3**	**81.9**	**55.8**	**88.8**	**179.5**	**59.0**	**78.1**	**677.7**

A.1.4 Transport economic efficiency (TEE), Public accounts (PA) and Analysis of monetised costs and benefits (AMCB)

A.1.4.1 The results of the economic appraisal for each option is summarised in Table A–9. From the below table it can be seen that out of all the options, Option 6 which is a hybrid option, has the highest PVB of around £688m but this option also has highest PVC of some £448m. The BCR therefore for this option is 1.5. Offline Options 4 and 5 have PVB of some £693m and £687m respectively. The PVC of these options is about £259m and £240m respectively and therefore the BCR of these options is 2.7 and 2.9 respectively. Online Option 2A has the NPV of £154m with BCR 1.7.

Table A–9: Summary of Economic Assessment Results – Core Scenario, £m

			Costs/ Benefits			
			Option 2A	**Option 4**	**Option 5**	**Option 6**
Benefits	Consumer Commuting User Benefits	Travel Time	£60.2	£106.7	£101.7	£115.1
		VOC	£4.6	-£4.3	-£2.8	-£2.7
		Construction Delays	-£3.7	-£0.4	-£0.1	-£2.6
		Maintenance Delays	-£0.2	£0.1	£0.1	-£0.4
		Net Consumer User Benefits	**£60.8**	**£102.2**	**£98.9**	**£109.5**
	Consumer Other User Benefits	Travel Time	£142.9	£263.5	£252.2	£296.5
		VOC	-£2.0	-£15.9	-£12.0	-£9.0
		Construction Delays	-£10.8	-£0.1	-£0.4	-£7.5
		Maintenance Delays	-£3.1	£1.1	£1.1	-£5.4
		Net Consumer User Benefits	**£127.0**	**£248.6**	**£240.9**	**£274.6**
	Consumer Business User Benefits	Travel Time	£133.6	£240.5	£234.4	£258.8
		VOC	£7.6	£27.7	£27.6	£19.1
		Construction Delays	-£11.5	-£0.4	-£0.3	-£8.2
		Maintenance Delays	-£1.0	£0.3	£0.3	-£1.8
		Net Business User Benefits	**£128.7**	**£268.0**	**£261.9**	**£267.9**
	Accidents Benefits		£18.3	£61.4	£73.6	£27.2
	Indirect Tax Revenues		£12.3	£8.8	£6.1	£0.3
	Noise		£0.9	£2.9	£3.0	£4.3
	Air Quality		£5.3	£3.2	£3.9	£3.1
	Greenhouse Gases (Carbon)		7.49	-2.25	-1.27	0.61
	Total PVB (£m)		**£360.9**	**£692.9**	**£687.0**	**£687.6**
Costs	Operating and Maintenance Costs		£32.1	£11.8	£11.2	£26.3
	Investment Costs		£175.3	£247.0	£229.2	£421.7
	Revenue Change		£0.0	£0.0	£0.0	£0.0
	Total PVC (£m)		**£207.4**	**£258.8**	**£240.4**	**£448.0**
Net Present Value (NPV)			**£153.5**	**£434.1**	**£446.6**	**£239.5**
Benefits to Cost Ratio (BCR)			**1.7**	**2.7**	**2.9**	**1.5**

Note: All monetary values are discounted to 2010 and in 2010 market price unit of account. Operating & maintenance and investment costs are based the information provided back in Dec 2015/January 2016.

A.1.4.2 As discussed in Chapter 4 of the main report that three traffic forecast scenarios were developed to take into account highest (High), most likely (Core), and lowest (Low) levels of future traffic growth. The key economic assessment results described were calculated using the Core scenario traffic forecast, i.e. most likely level of future growth. However, sensitivity tests have also been undertaken to investigate what effect the Highest Benefits and Lowest Benefits traffic forecasts would have on the BCR. It should be noted that only TUBA assessments of user benefits were carried out. For the purpose of producing NPV, PVB and BCR for these two scenarios, other elements such as QUADRO, COBA-LT, Noise, and Air Quality benefits are taken from the Core scenario. Table A–10 and Table A–11 summarise the economic assessment results for the Low and High growth scenarios respectively.

Table A–10: Summary of Economic Assessment Results – Low Growth Scenario, £m

			Costs/ Benefits			
			Option 2A	**Option 4**	**Option 5**	**Option 6**
Benefits	Consumer Commuting User Benefits	Travel Time	£58.7	£90.6	£84.5	£91.0
		VOC	£3.7	-£5.2	-£3.8	-£4.5
		Construction Delays	-£3.7	-£0.4	-£0.1	-£2.6
		Maintenance Delays	-£0.2	£0.1	£0.1	-£0.4
		Net Consumer User Benefits	**£58.5**	**£85.1**	**£80.7**	**£83.5**
	Consumer Other User Benefits	Travel Time	£132.6	£216.4	£203.6	£232.5
		VOC	-£2.6	-£17.5	-£13.5	-£11.5
		Construction Delays	-£10.8	-£0.1	-£0.4	-£7.5
		Maintenance Delays	-£3.1	£1.1	£1.1	-£5.4
		Net Consumer User Benefits	**£116.1**	**£199.9**	**£190.8**	**£208.0**
	Consumer Business User Benefits	Travel Time	£121.0	£189.3	£182.0	£195.5
		VOC	£6.7	£20.7	£20.6	£12.9
		Construction Delays	-£11.5	-£0.4	-£0.3	-£8.2
		Maintenance Delays	-£1.0	£0.3	£0.3	-£1.8
		Net Business User Benefits	**£115.1**	**£209.9**	**£202.6**	**£198.4**
	Accidents Benefits		£18.3	£61.4	£73.6	£27.2
	Indirect Tax Revenues		£10.2	£12.5	£9.6	£5.0
	Noise		£0.9	£2.9	£3.0	£4.3
	Air Quality		£5.3	£3.2	£3.9	£3.1
	Greenhouse Gases (Carbon)		6.43	-4.09	-3.01	-1.54
	Total PVB (£m)		**£330.9**	**£570.7**	**£561.0**	**£528.0**
Costs	Operating and Maintenance Costs		£32.1	£11.8	£11.2	£26.3
	Investment Costs		£175.3	£247.0	£229.2	£421.7
	Revenue Change		£0.0	£0.0	£0.0	£0.0
	Total PVC (£m)		**£207.4**	**£258.8**	**£240.4**	**£448.0**
Net Present Value (NPV)			**£123.6**	**£311.9**	**£320.7**	**£80.0**
Benefits to Cost Ratio (BCR)			**1.6**	**2.2**	**2.3**	**1.2**

Note: All monetary values are discounted to 2010 and in 2010 market price unit of account. Accidents, Noise, Air Quality, User delays during construction and maintenance are taken from the Core growth scenario assessment. Operating & maintenance and investment costs are based the information provided back in Dec 2015/January 2016.

Table A–11: Summary of Economic Assessment Results – High Growth Scenario, £m

			Costs/ Benefits			
			Option 2A	Option 4	Option 5	Option 6
Benefits	Consumer Commuting User Benefits	Travel Time	£63.4	£122.4	£118.1	£143.2
		VOC	£4.5	-£4.2	-£3.0	-£1.7
		Construction Delays	-£3.7	-£0.4	-£0.1	-£2.6
		Maintenance Delays	-£0.2	£0.1	£0.1	-£0.4
		Net Consumer User Benefits	**£64.0**	**£117.8**	**£115.1**	**£138.5**
	Consumer Other User Benefits	Travel Time	£148.9	£312.5	£303.5	£369.4
		VOC	-£0.8	-£13.0	-£10.1	-£4.8
		Construction Delays	-£10.8	-£0.1	-£0.4	-£7.5
		Maintenance Delays	-£3.1	£1.1	£1.1	-£5.4
		Net Consumer User Benefits	**£134.2**	**£300.5**	**£294.0**	**£351.6**
	Consumer Business User Benefits	Travel Time	£143.7	£293.9	£287.4	£331.8
		VOC	£8.5	£34.8	£34.7	£26.6
		Construction Delays	-£11.5	-£0.4	-£0.3	-£8.2
		Maintenance Delays	-£1.0	£0.3	£0.3	-£1.8
		Net Business User Benefits	**£139.7**	**£328.5**	**£322.0**	**£348.3**
	Accidents Benefits		£18.3	£61.4	£73.6	£27.2
	Indirect Tax Revenues		£14.7	£4.5	£2.6	-£5.7
	Noise		£0.9	£2.9	£3.0	£4.3
	Air Quality		£5.3	£3.2	£3.9	£3.1
	Greenhouse Gases (Carbon)		£8.8	£0.1	£0.7	£3.6
	Total PVB (£m)		**£385.9**	**£819.0**	**£814.8**	**£871.0**
Costs	Operating and Maintenance Costs		£32.1	£11.8	£11.2	£26.3
	Investment Costs		£175.3	£247.0	£229.2	£421.7
	Revenue Change		£0.0	£0.0	£0.0	£0.0
	Total PVC (£m)		**£207.4**	**£258.8**	**£240.4**	**£448.0**
Net Present Value (NPV)			**£178.5**	**£311.9**	**£574.4**	**£423.0**
Benefits to Cost Ratio (BCR)			**1.9**	**2.2**	**3.4**	**1.9**

Note: All monetary values are discounted to 2010 and in 2010 market price unit of account. Accidents, Noise, Air Quality, User delays during construction and maintenance are taken from the Core growth scenario assessment. Operating & maintenance and investment costs are based the information provided back in Dec 2015/January 2016.

A.1.4.3 Table A–12 below represents PVB, PVC and BCR for the Low, Core and High growth scenarios for options 2A, 4, 5 and 6. As expected, the Low growth scenario predicts a moderately lower BCR than the Core growth scenario for most of the options, while the High growth scenario predicts a moderately higher BCR than Core scenario. The BCR for the High and Low growth scenarios in the above table should be treated cautiously as these represent indicative results without the full assessment of the accidents, user delay during construction and maintenance and environmental assessments for these scenarios.

Table A–12: Summary of Economic Assessment Results, £m

	Low Growth PVB, £m	Core Growth PVB, £m	High Growth PVB, £m	PVC, £m	Low Growth BCR	Core Growth BCR	High Growth BCR
Option 2A	£331	**£361**	£386	£207	1.6	1.7	1.9
Option 4	£571	**£693**	£819	£259	2.2	2.7	3.2
Option 5	£561	**£687**	£815	£240	2.3	2.9	3.4
Option 6	£528	**£688**	£871	£448	1.2	1.5	1.9

Appendix B. Construction costs spending profile and calculation of PVC

Table B–1: Options 1 - 2010 undiscounted and factor costs price

Option 1	2016	2017	2018	2019	2020	2021	2022	2023	Total
Preparation	£1,326,397	£2,122,251	£5,059,052	£4,718,020	£0	£0	£0	£0	£13,225,720
Supervision	£0	£0	£0	£246,689	£1,706,823	£2,274,455	£912,482	£40,457	£5,180,907
Works	£0	£0	£0	£10,001,056	£49,920,149	£45,906,707	£18,611,688	£674,813	£125,114,413
Land	£0	£0	£0	£4,096,897	£0	£0	£0	£0	£4,096,897
Total	£1,326,397	£2,122,251	£5,059,052	£19,062,662	£51,626,972	£48,181,162	£19,524,171	£715,270	£147,617,936

Table B–2: Option 1 - 2010 discounted and market prices

Option 1	2016	2017	2018	2019	2020	2021	2022	2023	Total
Preparation	£1,284,039	£1,985,004	£4,571,864	£4,119,492	£0	£0	£0	£0	£11,960,398
Supervision	£0	£0	£0	£215,394	£1,439,899	£1,853,875	£718,600	£40,536	£4,268,304
Works	£0	£0	£0	£8,732,321	£42,113,306	£37,417,886	£14,657,116	£676,128	£103,596,757
Land	£0	£0	£0	£3,577,164	£0	£0	£0	£0	£3,577,164
Total	£1,284,039	£1,985,004	£4,571,864	£16,644,370	£43,553,205	£39,271,762	£15,375,716	£716,663	£123,402,623

Table B–3: Options 1A - 2010 undiscounted and factor costs price

Option 1A	2016	2017	2018	2019	2020	2021	Total
Preparation	£1,300,294	£1,962,659	£4,773,768	£4,470,935	£0	£0	£12,507,656
Supervision	£0	£0	£0	£222,949	£1,935,408	£506,589	£2,664,945
Works	£0	£0	£0	£12,177,783	£69,185,809	£13,954,700	£95,318,291
Land	£0	£0	£0	£3,565,499	£0	£0	£3,565,499
Total	£1,300,294	£1,962,659	£4,773,768	£20,437,166	£71,121,216	£14,461,288	£114,056,392

Table B–4: Option 1A - 2010 discounted and market prices

Option 1A	2016	2017	2018	2019	2020	2021	Total
Preparation	£1,258,770	£1,835,732	£4,314,053	£3,903,752	£0	£0	£11,312,307
Supervision	£0	£0	£0	£194,665	£1,632,736	£412,913	£2,240,314
Works	£0	£0	£0	£10,632,908	£58,366,074	£11,374,272	£80,373,254
Land	£0	£0	£0	£3,113,179	£0	£0	£3,113,179
Total	£1,258,770	£1,835,732	£4,314,053	£17,844,504	£59,998,810	£11,787,185	£97,039,055

Table B–5: Options 2 - 2010 undiscounted and factor costs price

Option 2	2016	2017	2018	2019	2020	2021	2022	2023	Total
Preparation	£1,576,516	£3,610,472	£7,088,907	£6,308,502	£0	£0	£0	£0	£18,584,397
Supervision	£0	£0	£0	£287,322	£1,987,963	£2,649,092	£1,062,782	£47,121	£6,034,280
Works	£0	£0	£0	£15,003,408	£78,474,861	£68,960,966	£27,209,673	£999,395	£190,648,303
Land	£0	£0	£0	£13,522,479	£0	£0	£0	£0	£13,522,479
Total	£1,576,516	£3,610,472	£7,088,907	£35,121,712	£80,462,823	£71,610,058	£28,272,455	£1,046,515	£228,789,460

Table B–6: Option 2 - 2010 discounted and market prices

Option 2	2016	2017	2018	2019	2020	2021	2022	2023	Total
Preparation	£1,526,171	£3,376,980	£6,406,243	£5,508,205	£0	£0	£0	£0	£16,817,600
Supervision	£0	£0	£0	£250,873	£1,677,072	£2,159,237	£836,964	£47,212	£4,971,358
Works	£0	£0	£0	£13,100,074	£66,202,443	£56,209,076	£21,428,220	£1,001,342	£157,941,155
Land	£0	£0	£0	£11,807,015	£0	£0	£0	£0	£11,807,015
Total	£1,526,171	£3,376,980	£6,406,243	£30,666,167	£67,879,515	£58,368,313	£22,265,184	£1,048,554	£191,537,128

Table B–7: Options 3 - 2010 undiscounted and factor costs price

Option 3	2016	2017	2018	2019	2020	Total
Preparation	£1,123,276	£830,979	£2,285,018	£2,191,605	£0	£6,430,878
Supervision	£0	£0	£0	£228,749	£1,209,453	£1,438,202
Works	£0	£0	£0	£6,522,629	£22,627,251	£29,149,881
Land	£0	£0	£0	£565,157	£0	£565,157
Total	£1,123,276	£830,979	£2,285,018	£9,508,140	£23,836,704	£37,584,117

Table B–8: Option 3 - 2010 discounted and market prices

Option 3	2016	2017	2018	2019	2020	Total
Preparation	£1,087,405	£777,239	£2,064,970	£1,913,578	£0	£5,843,192
Supervision	£0	£0	£0	£199,730	£1,020,310	£1,220,040
Works	£0	£0	£0	£5,695,168	£19,088,652	£24,783,820
Land	£0	£0	£0	£493,461	£0	£493,461
Total	£1,087,405	£777,239	£2,064,970	£8,301,936	£20,108,963	£32,340,513

Table B–9: Options 3A - 2010 undiscounted and factor costs price

Option 3A	2016	2017	2018	2019	2020	2021	Total
Preparation	£1,302,346	£1,984,994	£5,036,295	£4,757,481	£0	£0	£13,081,116
Supervision	£0	£0	£0	£225,440	£1,843,599	£1,056,707	£3,125,746
Works	£0	£0	£0	£11,529,923	£63,225,676	£30,412,060	£105,167,659
Land	£2,955,436	£0	£0	£16,760,552	£0	£0	£19,715,988
Total	£4,257,783	£1,984,994	£5,036,295	£33,273,395	£65,069,275	£31,468,767	£141,090,509

Table B–10: Option 3A - 2010 discounted and market prices

Option 3A	2016	2017	2018	2019	2020	2021	Total
Preparation	£1,260,757	£1,856,623	£4,551,298	£4,153,946	£0	£0	£11,822,624
Supervision	£0	£0	£0	£196,841	£1,555,285	£861,307	£2,613,432
Works	£0	£0	£0	£10,067,235	£53,338,027	£24,788,426	£88,193,688
Land	£2,861,057	£0	£0	£14,634,306	£0	£0	£17,495,362
Total	£4,121,814	£1,856,623	£4,551,298	£29,052,328	£54,893,312	£25,649,733	£120,125,107

Note: The expenditure profiles are based upon cost estimates for each financial year prepared in 2014 Q1 prices and then inflated to outturn costs using HA projected construction related inflation. These costs have then been rebased to 2010 calendar year profiles for economic calculations, using the GDP-deflator series as published in the Web TAG Data book. The 2010 discounted and market price costs are derived by applying indirect tax correction factor of 19% and discount rate of 3.5%.

Appendix C. Maintenance Costs profile and calculation of PVC

Table C–1: Maintenance Costs profile, £m

Year	Option 1		Option 1A		Option 2		Option 3		Option 3A	
	2015 Prices	2010 Discounted	2015 Prices	2010 Discounted	2015 Prices	2010 Discounted	2015 Prices	2010 Discounted	2015 Prices	2010 Discounted
2020			0.06	0.05			0.05	0.04	0.07	0.05
2021	0.05	0.04	0.00	0.00	0.07	0.05	0.00	0.00	0.00	0.00
2022	0.00	0.00	0.06	0.04	0.00	0.00	0.05	0.03	0.07	0.05
2023	0.05	0.04	0.01	0.01	0.07	0.05	0.01	0.00	0.01	0.00
2024	0.01	0.00	1.12	0.75	0.01	0.01	0.39	0.26	0.76	0.51
2025	0.95	0.62	0.07	0.04	0.99	0.65	0.05	0.04	0.07	0.05
2026	0.06	0.04	0.07	0.04	0.08	0.05	0.05	0.03	0.07	0.05
2027	0.06	0.04	0.52	0.32	0.08	0.05	0.28	0.17	0.38	0.23
2028	0.39	0.23	0.35	0.20	0.41	0.24	0.31	0.18	0.41	0.24
2029	0.34	0.19	1.91	1.08	0.64	0.36	1.29	0.73	1.85	1.05
2030	1.82	1.00	0.38	0.21	2.07	1.14	0.38	0.21	0.61	0.34
2031	0.38	0.20	0.43	0.23	0.39	0.21	0.40	0.21	0.63	0.33
2032	0.42	0.22	0.20	0.10	0.46	0.24	0.20	0.10	0.35	0.18
2033	0.20	0.10	0.20	0.10	0.24	0.12	0.20	0.10	0.35	0.17
2034	0.20	0.09	1.50	0.72	0.24	0.12	0.75	0.36	1.32	0.63
2035	1.39	0.64	1.57	0.72	1.41	0.65	1.55	0.72	1.55	0.72
2036	1.43	0.64	0.88	0.39	1.58	0.70	1.14	0.51	1.00	0.45
2037	0.87	0.38	0.83	0.36	1.00	0.43	1.09	0.47	0.95	0.41
2038	0.82	0.34	1.11	0.46	0.94	0.39	1.34	0.56	1.29	0.54
2039	1.10	0.44	2.66	1.07	1.50	0.60	2.33	0.94	2.72	1.10
2040	2.58	1.00	0.35	0.14	2.92	1.14	0.31	0.12	0.41	0.16
2041	0.34	0.13	0.35	0.13	0.36	0.14	0.31	0.12	0.41	0.15
2042	0.34	0.12	0.07	0.02	0.36	0.13	0.05	0.02	0.07	0.03
2043	0.06	0.02	0.52	0.18	0.08	0.03	0.27	0.10	0.37	0.13
2044	0.39	0.13	1.36	0.46	0.40	0.14	0.61	0.21	1.05	0.36
2045	1.20	0.39	0.29	0.09	1.25	0.41	0.30	0.10	0.50	0.16
2046	0.28	0.09	0.15	0.05	0.30	0.09	0.15	0.05	0.29	0.09
2047	0.14	0.05	0.32	0.12	0.18	0.06	0.30	0.11	0.46	0.17
2048	0.31	0.11	0.72	0.25	0.37	0.13	0.60	0.21	0.84	0.30
2049	0.71	0.24	2.73	0.94	1.10	0.38	1.80	0.62	2.58	0.89
2050	2.57	0.86	0.68	0.23	2.86	0.96	0.53	0.18	0.64	0.21
2051	0.67	0.22	0.63	0.21	0.79	0.26	0.51	0.17	0.62	0.20
2052	0.63	0.20	0.19	0.06	0.72	0.23	0.10	0.03	0.12	0.04
2053	0.18	0.06	0.07	0.02	0.25	0.08	0.05	0.02	0.07	0.02
2054	0.06	0.02	1.36	0.41	0.08	0.02	0.61	0.18	1.05	0.31
2055	1.20	0.35	1.50	0.43	1.25	0.36	1.55	0.45	1.68	0.48
2056	1.37	0.38	0.86	0.24	1.48	0.42	1.16	0.33	1.15	0.32
2057	0.85	0.23	0.86	0.24	0.97	0.26	1.17	0.32	1.16	0.31
2058	0.86	0.23	1.14	0.30	0.97	0.26	1.42	0.38	1.49	0.39
2059	1.14	0.29	2.70	0.69	1.53	0.39	2.40	0.62	2.93	0.75
2060	2.66	0.66	0.35	0.09	2.96	0.74	0.31	0.08	0.41	0.10
2061	0.34	0.08	0.85	0.21	0.36	0.09	0.55	0.13	0.73	0.18
2062	0.72	0.17	0.17	0.04	0.75	0.18	0.12	0.03	0.14	0.03
2063	0.16	0.04	0.17	0.04	0.20	0.05	0.12	0.03	0.14	0.03
2064	0.16	0.04	1.46	0.32	0.20	0.05	0.68	0.15	1.12	0.25
2065	1.30	0.28	0.39	0.08	1.37	0.30	0.37	0.08	0.57	0.12
2066	0.39	0.08	0.16	0.03	0.43	0.09	0.18	0.04	0.33	0.07
2067	0.15	0.03	0.56	0.11	0.18	0.04	0.35	0.07	0.58	0.12
2068	0.43	0.08	0.38	0.08	0.44	0.09	0.38	0.08	0.61	0.12
2069	0.38	0.07	1.94	0.37	0.68	0.13	1.36	0.26	2.05	0.39
2070	1.91	0.35	0.35	0.06	2.10	0.39	0.31	0.06	0.41	0.08
2071	0.34	0.06	0.35	0.06	0.36	0.06	0.31	0.06	0.41	0.07
2072	0.34	0.06	0.07	0.01	0.36	0.06	0.05	0.01	0.07	0.01
2073	0.06	0.01	0.52	0.09	0.08	0.01	0.27	0.05	0.37	0.06
2074	0.39	0.06	1.36	0.22	0.40	0.07	0.61	0.10	1.05	0.17
2075	1.20	0.19	1.06	0.17	1.25	0.20	1.34	0.21	1.38	0.22
2076	1.06	0.16	0.91	0.14	1.18	0.18	1.18	0.18	1.17	0.18
2077	0.90	0.14	1.19	0.18	1.03	0.16	1.38	0.21	1.38	0.21
2078	1.19	0.17	1.47	0.22	1.40	0.20	1.63	0.24	1.71	0.25
2079	1.47	0.21	3.49	0.50	1.96	0.28	2.83	0.40	3.45	0.49
2080	3.32	0.46			3.71	0.51				
Total	**45.27**	**13.80**	**47.96**	**15.15**	**51.78**	**15.78**	**40.43**	**12.44**	**50.42**	**15.74**

Note: December 2015 TAG databook GDP deflator is used to get the 2010 prices from 2015 and then prices are converted to market price and discounted using indirect tax correction factor of 19% and discount rate of 3.5% up to 2046 and then 3.0% from 2047 onwards. For Option 1 and Option 2, maintenance costs profile is worked out from 2021-2080 which is in line with TUBA economic assessment.

Appendix D. TEE, PA and AMCB Tables Core Scenario

D.1 Transport Economic Efficiency, Public Accounts and Analysis of Monetised Costs and Benefits – Option 1

D1–1: Transport Economic Efficiency Table

Consumer Benefits (£000's) for Core Scenario Option 1				
	Type	All Modes	Road, Private Cars and LGVs	
Commuting User Benefits	Travel Time	£66,736	£66,736	
	Vehicle Operating Costs	-£2,916	-£2,916	
	User Charges	£0	£0	
	During Construction & Maintenance	-£2,236	-£2,236	
	Net Benefits	**£61,584**	**£61,584**	
Other User Benefits	Travel Time	£166,970	£166,970	
	Vehicle Operating Costs	-£12,618	-£12,618	
	User Charges	£0	£0	
	During Construction & Maintenance	-£9,183	-£9,183	
	Net Benefits	**£145,169**	**£145,169**	
Business	Type	All Modes	Goods Vehicles	Business Cars & LGVs
	Travel Time	£149,323	£28,364	£120,959
	Vehicle Operating Costs	£8,280	£8,446	-£166
	User Charges	£0	£0	£0
	During Construction & Maintenance*	-£7,390	-£972	-£6,418
	Net Benefits	**£150,213**	**£35,838**	**£114,375**
Note: Benefits appear as positive numbers, while costs appear as negative numbers. All entries are discounted present values, 2010 prices and values				

*Split for the Goods Vehicles and Business Cars/LGVs is derived from QUADRO construction user delays (travel time+VOC).

D1–2: Public Accounts Table

Public Accounts (£000's) for Core Scenario, Option 1		
Local Government Funding	All modes	Road
Revenue	£0	£0
Operating Costs	£0	£0
Investment Costs	£0	£0
Developer Contributions	£0	£0
Grant/Subsidy Payments	£0	£0
NET IMPACT	**£0**	**£0**
Central Government Funding - Transport	All modes	Road
Revenue	£0	£0
Operating costs	£13,798	£13,798
Investment costs	£123,403	£123,403
Developer Contributions	£0	£0
Grant/Subsidy Payments	£0	£0
NET IMPACT	**£137,201**	**£137,201**
Central Government Funding- Non Transport		
Indirect Tax Revenues	-£3,745	-£3,745
TOTALS		
Broad Transport Budget	£137,201	£137,201
Wider Public Finances	-£3,745	-£3,745
Note: Costs appear as positive numbers, while revenues and 'Developer and Other Contributions' appear as negative numbers. All entries are discounted present values in 2010 prices and values.		

D1–3: Analysis of Monetised Costs and Benefits Table

Analysis of Monetised Benefits (£000's) for Core Scenario, Option 1	
Noise	-£5,700
Local Air Quality	£2,900
Greenhouse Gases	
Accidents	-£8,466
Economic Efficiency: Consumer Users (Commuting)	£61,584
Economic Efficiency: Consumer Users (Other)	£145,169
Economic Efficiency: Business Users and Providers	£150,212
Wider Public Finances (Indirect Taxation Revenues)	£3,745
Present Value of Benefits (PVB)	**£349,444**
Broad Transport Budget	£137,201
Present Value of Costs (PVC)	**£137,201**
OVERALL IMPACTS	
Net Present Value (NPV)	**£212,243**
Benefit to Cost Ratio (BCR)	**2.55**
Note: This table includes costs and benefits which are regularly or occasionally presented in monetised form in transport appraisals, together with some where monetisation is in prospect. There may also be other significant costs and benefits, some of which cannot be presented in monetised form. Where this is the case, the analysis presented above does NOT provide a good measure of value for money and should not be used as the sole basis for decisions.	

D.2 Transport Economic Efficiency, Public Accounts and Analysis of Monetised Costs and Benefits – Option 1A

D2–1: Transport Economic Efficiency Table

Consumer Benefits (£000's) for Core Scenario Option 1A				
	Type	All Modes	Road, Private Cars and LGVs	
Commuting User Benefits	Travel Time	£51,250	£51,250	
	Vehicle Operating Costs	£364	£364	
	User Charges	£0	£0	
	During Construction & Maintenance	-£2,121	-£2,121	
	Net Benefits	**£49,493**	**£49,493**	
Other User Benefits	Travel Time	£130,952	£130,952	
	Vehicle Operating Costs	-£3,628	-£3,628	
	User Charges	£0	£0	
	During Construction & Maintenance	-£9,276	-£9,276	
	Net Benefits	**£118,048**	**£118,048**	
Business	Type	All Modes	Goods Vehicles	Business Cars & LGVs
	Travel Time	£114,988	£20,158	£94,830
	Vehicle Operating Costs	£7,541	£5,740	£1,802
	User Charges	£0	£0	£0
	During Construction & Maintenance*	-£6,969	-£917	-£6,052
	Net Benefits	**£115,560**	**£24,981**	**£90,580**
Note: Benefits appear as positive numbers, while costs appear as negative numbers. All entries are discounted present values, 2010 prices and values				

* Split for the Goods Vehicles and Business Cars/LGVs is derived from QUADRO construction user delays (travel time+VOC).

D2–2: Public Accounts Table

Public Accounts (£000's) for Core Scenario, Option 1A		
Local Government Funding	All modes	Road
Revenue	£0	£0
Operating Costs	£0	£0
Investment Costs	£0	£0
Developer Contributions	£0	£0
Grant/Subsidy Payments	£0	£0
NET IMPACT	**£0**	**£0**
Central Government Funding - Transport	All modes	Road
Revenue	£0	£0
Operating costs	£15,148	£15,148
Investment costs	£97,039	£97,039
Developer Contributions	£0	£0
Grant/Subsidy Payments	£0	£0
NET IMPACT	**£112,187**	**£112,187**
Central Government Funding- Non Transport		
Indirect Tax Revenues	£1,141	£1,141
TOTALS		
Broad Transport Budget	£112,187	£112,187
Wider Public Finances	£1,141	£1,141
Note: Costs appear as positive numbers, while revenues and 'Developer and Other Contributions' appear as negative numbers. All entries are discounted present values in 2010 prices and values.		

D2–3: Analysis of Monetised Costs and Benefits Table

Analysis of Monetised Benefits (£000's) for Core Scenario, Option 1A	
Noise	-£5,300
Local Air Quality	£600
Greenhouse Gases	
Accidents	£1,860
Economic Efficiency: Consumer Users (Commuting)	£49,493
Economic Efficiency: Consumer Users (Other)	£118,048
Economic Efficiency: Business Users and Providers	£115,560
Wider Public Finances (Indirect Taxation Revenues)	-£1,141
Present Value of Benefits (PVB)	**£279,120**
Broad Transport Budget	£112,187
Present Value of Costs (PVC)	**£112,187**
OVERALL IMPACTS	
Net Present Value (NPV)	**£166,933**
Benefit to Cost Ratio (BCR)	**2.49**
Note: This table includes costs and benefits which are regularly or occasionally presented in monetised form in transport appraisals, together with some where monetisation is in prospect. There may also be other significant costs and benefits, some of which cannot be presented in monetised form. Where this is the case, the analysis presented above does NOT provide a good measure of value for money and should not be used as the sole basis for decisions.	

D.3 Transport Economic Efficiency, Public Accounts and Analysis of Monetised Costs and Benefits – Option 2

D3–1: Transport Economic Efficiency Table

Consumer Benefits (£000's) for Core Scenario Option 2				
	Type	All Modes	Road, Private Cars & LGVs	
Commuting User Benefits	Travel Time	£99,281	£99,281	
	Vehicle Operating Costs	-£3,132	-£3,132	
	User Charges	£0	£0	
	During Construction & Maintenance	-£4,005	-£4,005	
	Net Benefits	**£92,144**	**£92,144**	
Other User Benefits	Travel Time	£254,970	£254,970	
	Vehicle Operating Costs	-£11,793	-£11,793	
	User Charges	£0	£0	
	During Construction & Maintenance*	-£14,814	-£14,814	
	Net Benefits	**£228,363**	**£228,363**	
Business	Type	All Modes	Goods Vehicles	Business Cars & LGVs
	Travel Time	£221,497	£39,435	£182,062
	Vehicle Operating Costs	£13,475	£12,452	£1,023
	User Charges	£0	£0	£0
	During Construction & Maintenance*	-£12,821	-£1,767	-£11,054
	Net Benefits	**£222,151**	**£50,120**	**£172,031**
Note: Benefits appear as positive numbers, while costs appear as negative numbers. All entries are discounted present values, 2010 prices and values				

* Split for the Goods Vehicles and Business Cars/LGVs is derived from QUADRO construction user delays (travel time+VOC).

D3–2: Public Accounts Table

Public Accounts (£000's) for Core Scenario, Option 2		
Local Government Funding	All modes	Road
Revenue	£0	£0
Operating Costs	£0	£0
Investment Costs	£0	£0
Developer Contributions	£0	£0
Grant/Subsidy Payments	£0	£0
NET IMPACT	**£0**	**£0**
Central Government Funding - Transport	All modes	Road
Revenue	£0	£0
Operating costs	£15,784	£15,784
Investment costs	£191,537	£191,537
Developer Contributions	£0	£0
Grant/Subsidy Payments	£0	£0
NET IMPACT	**£207,321**	**£207,321**
Central Government Funding- Non Transport		
Indirect Tax Revenues	-£2,046	-£2,046
TOTALS		
Broad Transport Budget	£207,321	£207,321
Wider Public Finances	-£2,046	-£2,046
Note: Costs appear as positive numbers, while revenues and 'Developer and Other Contributions' appear as negative numbers. All entries are discounted present values in 2010 prices and values.		

D3–3: Analysis of Monetised Costs and Benefits Table

Analysis of Monetised Benefits (£000's) for Core Scenario, Option 2	
Noise	-£4,000
Local Air Quality	£2,200
Greenhouse Gases	
Accidents	£8,401
Economic Efficiency: Consumer Users (Commuting)	£92,144
Economic Efficiency: Consumer Users (Other)	£228,363
Economic Efficiency: Business Users and Providers	£222,151
Wider Public Finances (Indirect Taxation Revenues)	£2,046
Present Value of Benefits (PVB)	**£551,305**
Broad Transport Budget	£207,321
Present Value of Costs (PVC)	**£207,321**
OVERALL IMPACTS	
Net Present Value (NPV)	**£343,984**
Benefit to Cost Ratio (BCR)	**2.66**
Note: This table includes costs and benefits which are regularly or occasionally presented in monetised form in transport appraisals, together with some where monetisation is in prospect. There may also be other significant costs and benefits, some of which cannot be presented in monetised form. Where this is the case, the analysis presented above does NOT provide a good measure of value for money and should not be used as the sole basis for decisions.	

D.4 Transport Economic Efficiency, Public Accounts and Analysis of Monetised Costs and Benefits – Option 3

D4–1: Transport Economic Efficiency Table

Consumer Benefits (£000's) for Core Scenario Option 3				
	Type	All Modes	Road, Private Cars & LGVs	
Commuting User Benefits	Travel Time	£35,059	£35,059	
	Vehicle Operating Costs	-£2,382	-£2,382	
	User Charges	£0	£0	
	During Construction & Maintenance	-£1,672	-£1,672	
	Net Benefits	**£31,005**	**£31,005**	
Other User Benefits	Travel Time	£83,944	£83,944	
	Vehicle Operating Costs	-£8,760	-£8,760	
	User Charges	£0	£0	
	During Construction & Maintenance*	-£5,489	-£5,489	
	Net Benefits	**£69,695**	**£69,695**	
Business	Type	All Modes	Goods Vehicles	Business Cars & LGVs
	Travel Time	£75,719	£15,527	£60,193
	Vehicle Operating Costs	£3,758	£4,229	-£471
	User Charges	£0	£0	£0
	During Construction & Maintenance*	-£5,194	-£729	-£4,465
	Net Benefits	**£74,283**	**£19,027**	**£55,257**
Note: Benefits appear as positive numbers, while costs appear as negative numbers. All entries are discounted present values, 2010 prices and values				

* Split for the Goods Vehicles and Business Cars/LGVs is derived from QUADRO construction user delays (travel time+VOC).

D4–2: Public Accounts Table

Public Accounts (£000's) for Core Scenario, Option 3		
Local Government Funding	All modes	Road
Revenue	£0	£0
Operating Costs	£0	£0
Investment Costs	£0	£0
Developer Contributions	£0	£0
Grant/Subsidy Payments	£0	£0
NET IMPACT	**£0**	**£0**
Central Government Funding - Transport	All modes	Road
Revenue	£0	£0
Operating costs	£12,438	£12,438
Investment costs	£32,341	£32,341
Developer Contributions	£0	£0
Grant/Subsidy Payments	£0	£0
NET IMPACT	**£44,779**	**£44,779**
Central Government Funding- Non Transport		
Indirect Tax Revenues	-£4,626	-£4,626
TOTALS		
Broad Transport Budget	£44,779	£44,779
Wider Public Finances	-£4,626	-£4,626
Note: Costs appear as positive numbers, while revenues and 'Developer and Other Contributions' appear as negative numbers. All entries are discounted present values in 2010 prices and values.		

D4–3: Analysis of Monetised Costs and Benefits Table

Analysis of Monetised Benefits (£000's) for Core Scenario, Option 3	
Noise	-£3,300
Local Air Quality	£2,800
Greenhouse Gases	
Accidents	£5,765
Economic Efficiency: Consumer Users (Commuting)	£31,005
Economic Efficiency: Consumer Users (Other)	£69,695
Economic Efficiency: Business Users and Providers	£74,283
Wider Public Finances (Indirect Taxation Revenues)	£4,626
Present Value of Benefits (PVB)	**£184,874**
Broad Transport Budget	£44,779
Present Value of Costs (PVC)	**£44,779**
OVERALL IMPACTS	
Net Present Value (NPV)	**£140,095**
Benefit to Cost Ratio (BCR)	**4.13**
Note: This table includes costs and benefits which are regularly or occasionally presented in monetised form in transport appraisals, together with some where monetisation is in prospect. There may also be other significant costs and benefits, some of which cannot be presented in monetised form. Where this is the case, the analysis presented above does NOT provide a good measure of value for money and should not be used as the sole basis for decisions.	

D.5 Transport Economic Efficiency, Public Accounts and Analysis of Monetised Costs and Benefits – Option 3A

D5–1: Transport Economic Efficiency Table

Consumer Benefits (£000's) for Core Scenario Option 3A				
	Type	All Modes	Road, Private Cars & LGVs	
Commuting User Benefits	Travel Time	£63,225	£63,225	
	Vehicle Operating Costs	-£2,348	-£2,348	
	User Charges	£0	£0	
	During Construction & Maintenance	-£1,957	-£1,957	
	Net Benefits	**£58,920**	**£58,920**	
Other User Benefits	Travel Time	£154,701	£154,701	
	Vehicle Operating Costs	-£11,254	-£11,254	
	User Charges	£0	£0	
	During Construction & Maintenance*	-£7,564	-£7,564	
	Net Benefits	**£135,883**	**£135,883**	
Business	Type	All Modes	Goods Vehicles	Business Cars & LGVs
	Travel Time	£141,051	£27,544	£113,507
	Vehicle Operating Costs	£7,574	£7,995	-£421
	User Charges	£0	£0	£0
	During Construction & Maintenance*	-£6,184	-£868	-£5,316
	Net Benefits	**£142,441**	**£34,671**	**£107,770**
Note: Benefits appear as positive numbers, while costs appear as negative numbers. All entries are discounted present values, 2010 prices and values				

* Split for the Goods Vehicles and Business Cars/LGVs is derived from QUADRO construction user delays (travel time+VOC).

D5–2: Public Accounts Table

Public Accounts (£000's) for Core Scenario, Option 3A		
Local Government Funding	All modes	Road
Revenue	£0	£0
Operating Costs	£0	£0
Investment Costs	£0	£0
Developer Contributions	£0	£0
Grant/Subsidy Payments	£0	£0
NET IMPACT	**£0**	**£0**
Central Government Funding - Transport	All modes	Road
Revenue	£0	£0
Operating costs	£15,745	£15,745
Investment costs	£120,125	£120,125
Developer Contributions	£0	£0
Grant/Subsidy Payments	£0	£0
NET IMPACT	**£135,870**	**£135,870**
Central Government Funding- Non Transport		
Indirect Tax Revenues	-£3,463	-£3,463
TOTALS		
Broad Transport Budget	£135,870	£135,870
Wider Public Finances	-£3,463	-£3,463
Note: Costs appear as positive numbers, while revenues and 'Developer and Other Contributions' appear as negative numbers. All entries are discounted present values in 2010 prices and values.		

D5–3: Analysis of Monetised Costs and Benefits Table

Analysis of Monetised Benefits (£000's) for Core Scenario, Option 3A	
Noise	-£9,600
Local Air Quality	£1,000
Greenhouse Gases	
Accidents	-£24,061
Economic Efficiency: Consumer Users (Commuting)	£58,920
Economic Efficiency: Consumer Users (Other)	£135,883
Economic Efficiency: Business Users and Providers	£142,441
Wider Public Finances (Indirect Taxation Revenues)	£3,463
Present Value of Benefits (PVB)	**£308,046**
Broad Transport Budget	£135,870
Present Value of Costs (PVC)	**£135,870**
OVERALL IMPACTS	
Net Present Value (NPV)	**£172,176**
Benefit to Cost Ratio (BCR)	**2.27**
Note: This table includes costs and benefits which are regularly or occasionally presented in monetised form in transport appraisals, together with some where monetisation is in prospect. There may also be other significant costs and benefits, some of which cannot be presented in monetised form. Where this is the case, the analysis presented above does NOT provide a good measure of value for money and should not be used as the sole basis for decisions.	

Appendix E. Low Growth Scenario – Summary of TUBA Outcomes

Table E-1: User Benefits (Time+VOC) by User Class, £m

Low Growth Scenario	Option 1	Option 1A	Option 2	Option 3	Option 3A
Business	£152.4	£119.1	£226.0	£77.9	£143.1
Commuting	£63.2	£51.3	£95.0	£32.6	£60.0
Other	£153.5	£127.7	£240.6	£76.4	£142.2
Total	**£369.1**	**£298.1**	**£561.6**	**£186.9**	**£345.3**

Table E-2: User Benefits (Time+VOC) by Time Period, £m

Low Growth Scenario	Option 1	Option 1A	Option 2	Option 3	Option 3A
AM Peak	£92.6	£61.7	£111.5	£40.4	£88.9
PM Peak	£116.2	£109.0	£205.0	£71.2	£110.0
Inter-Peak	£160.4	£127.3	£245.0	£75.3	£146.4
Total	**£369.2**	**£298.0**	**£561.5**	**£186.9**	**£345.3**

Table E-3: User Benefits (Time+VOC) by Sub-mode, £m

Low Growth Scenario	Option 1	Option 1A	Option 2	Option 3	Option 3A
Car - Business	£53.9	£41.2	£78.0	£28.4	£50.3
Car - Commute	£63.3	£51.3	£95.0	£32.6	£60.0
Car - Other	£148.6	£123.5	£232.9	£74.1	£137.7
LGV - Freight	£62.8	£52.6	£97.7	£30.2	£58.4
LGV - Personal	£4.9	£4.2	£7.7	£2.4	£4.6
OGV1	£19.4	£13.8	£27.2	£10.5	£18.7
OGV2	£16.2	£11.4	£22.9	£8.6	£15.5
Total	**£369.1**	**£298.0**	**£561.4**	**£186.8**	**£345.2**

Table E-4: Sector to Sector User Benefits (Time+VOC) Outputs – Option 1, £m

Benefits per sector Low scenario Option 1		Destination									
		1	2	3	4	5	6	7	8	9	Total
Origin	1	0.0	-6.5	-2.9	2.8	1.6	2.5	1.1	3.3	7.5	**9.3**
	2	1.4	-0.1	0.0	-0.9	-0.6	6.3	5.7	-0.6	2.3	**13.6**
	3	1.3	0.2	0.1	0.0	0.3	4.5	3.8	-0.1	2.8	**13.0**
	4	5.9	2.2	0.6	-1.0	4.8	21.9	28.6	3.9	23.2	**90.1**
	5	3.3	7.4	5.1	1.5	0.0	5.3	30.0	-0.4	9.5	**61.7**
	6	1.8	0.1	1.4	2.5	0.7	2.6	8.3	0.0	7.8	**25.2**
	7	0.3	-11.3	-6.7	4.5	11.3	4.2	0.2	18.3	4.8	**25.8**
	8	3.7	5.5	2.8	0.7	-2.3	2.1	36.3	-0.1	3.1	**51.8**
	9	8.0	3.9	3.5	10.5	11.0	15.2	13.3	3.0	10.4	**78.7**
Total		**25.7**	**1.5**	**3.9**	**20.6**	**26.8**	**64.6**	**127.2**	**27.2**	**71.5**	**369.1**

Table E-5: Sector to Sector User Benefits (Time+VOC) Outputs – Option 1A, £m

Benefits per sector Low scenario Option 1A	Destination 1	2	3	4	5	6	7	8	9	Total
Origin 1	0.0	-0.8	-0.1	2.0	1.3	3.3	3.0	2.1	11.0	**21.7**
2	-1.3	0.0	-0.3	-0.9	0.8	0.6	1.3	1.3	-1.8	**-0.3**
3	-0.6	-0.1	-0.1	-0.3	1.2	0.2	0.7	1.3	-1.4	**0.8**
4	2.1	1.4	1.7	-1.0	4.7	20.2	12.2	4.4	22.6	**68.5**
5	1.3	4.6	4.1	1.8	0.2	4.1	17.4	0.7	9.5	**43.8**
6	1.5	4.1	2.5	3.6	1.5	1.9	9.4	0.5	7.1	**31.9**
7	0.3	0.4	-0.2	-1.0	4.5	2.4	0.2	7.3	2.5	**16.3**
8	1.2	3.1	2.2	1.0	-1.5	1.6	21.5	0.5	3.2	**32.8**
9	7.3	6.2	3.5	12.2	12.0	12.4	16.7	3.4	8.8	**82.4**
Total	**11.7**	**18.8**	**13.2**	**17.4**	**24.7**	**46.7**	**82.3**	**21.5**	**61.6**	**297.9**

Table E-6: Sector to Sector User Benefits (Time+VOC) Outputs – Option 2, £m

Benefits per sector Low scenario Option 2	Destination 1	2	3	4	5	6	7	8	9	Total
Origin 1	0.0	0.0	0.5	1.7	0.5	-0.5	-1.3	1.3	-2.7	**-0.6**
2	2.7	-0.1	1.0	1.4	4.1	12.6	9.7	2.5	6.1	**40.0**
3	2.5	0.9	0.4	-0.2	1.5	7.1	6.2	0.7	5.5	**24.6**
4	7.9	4.8	1.7	-1.1	5.8	24.7	38.8	4.8	26.1	**113.5**
5	4.2	6.3	3.4	2.2	0.4	6.7	37.3	0.3	11.0	**71.6**
6	1.9	11.6	6.3	9.6	2.5	2.3	10.2	1.1	6.9	**52.3**
7	0.3	7.3	5.2	11.8	16.9	3.9	0.7	27.1	0.8	**73.9**
8	4.9	4.3	1.3	0.7	-2.0	3.1	47.1	0.6	3.8	**63.9**
9	7.0	21.0	13.2	21.3	15.4	15.1	13.9	4.5	10.6	**122.0**
Total	**31.2**	**56.1**	**32.8**	**47.5**	**45.1**	**75.1**	**162.6**	**42.7**	**68.1**	**561.3**

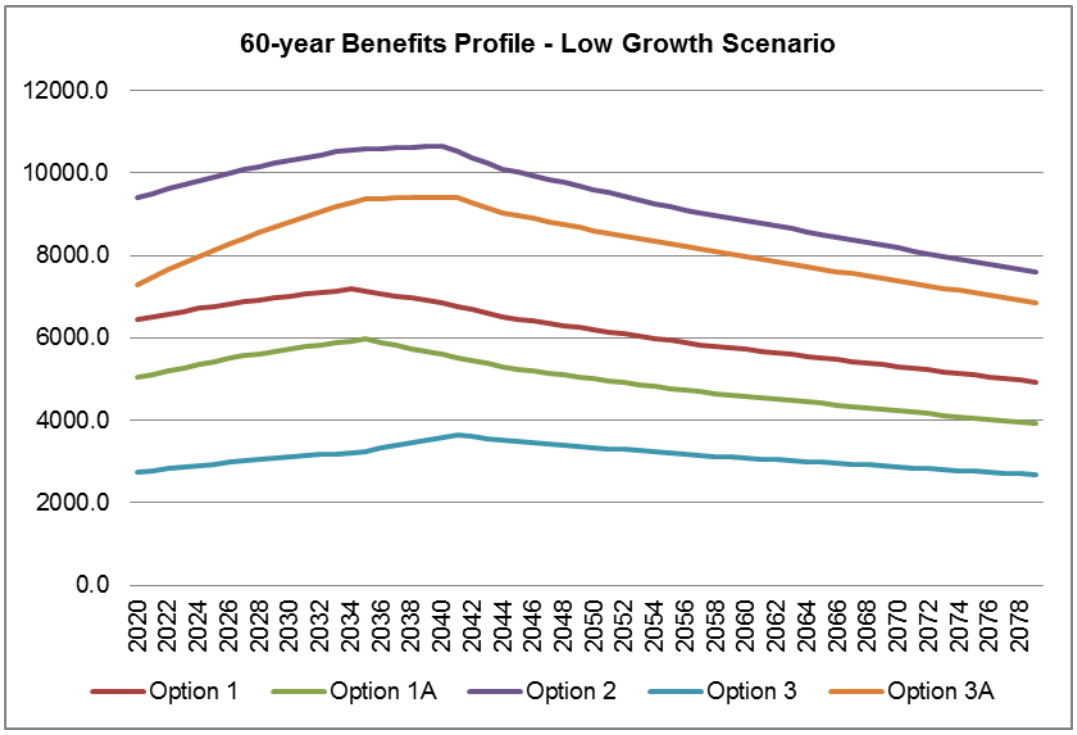
Table E-7: Sector to Sector User Benefits (Time+VOC) Outputs – Option 3, £m

Benefits per sector Low scenario Option 3	Destination 1	2	3	4	5	6	7	8	9	Total
Origin 1	-0.1	-10.2	-5.2	1.0	0.1	0.4	-1.4	0.7	1.3	**-13.3**
2	1.9	-0.1	-0.1	-1.2	-1.1	4.8	6.0	-1.4	1.1	**10.1**
3	1.3	0.2	0.1	-0.2	0.1	3.3	4.1	-0.4	2.0	**10.5**
4	4.7	1.1	-0.3	0.5	2.2	8.6	21.0	1.1	5.6	**44.7**
5	1.4	2.4	1.4	0.2	0.1	1.6	16.0	-0.8	2.8	**25.0**
6	1.2	-3.7	-0.2	5.2	1.5	1.2	5.3	0.7	4.2	**15.3**
7	-0.3	-11.5	-7.3	6.1	9.5	2.8	0.1	16.1	3.0	**18.4**
8	1.7	2.2	0.8	-0.7	-0.6	1.0	20.7	0.3	0.9	**26.3**
9	5.4	-0.9	0.7	11.7	9.2	7.2	8.2	3.0	5.2	**49.8**
Total	**17.3**	**-20.4**	**-10.1**	**22.6**	**21.0**	**30.8**	**80.1**	**19.4**	**26.1**	**186.7**

Table E-8: Sector to Sector User Benefits (Time+VOC) Outputs – Option 3A, £m

Benefits per sector Low scenario Option 3A		Destination									
		1	2	3	4	5	6	7	8	9	Total
Origin	1	0.0	-8.8	-4.2	1.5	1.0	1.8	0.2	2.4	5.2	**-1.0**
	2	1.5	-0.1	-0.1	-1.2	-0.9	4.6	4.5	-0.8	1.4	**9.0**
	3	1.3	0.3	0.1	0.0	0.3	3.6	3.4	0.0	2.1	**11.2**
	4	6.4	2.8	0.8	-1.4	5.0	20.3	29.2	4.2	21.3	**88.7**
	5	3.2	7.6	4.9	1.0	0.3	3.4	27.5	-0.3	5.7	**53.2**
	6	1.7	1.2	1.9	2.4	0.9	2.5	7.2	-0.1	7.7	**25.5**
	7	0.1	-11.0	-6.4	3.6	12.2	3.5	0.2	19.7	3.2	**25.2**
	8	3.8	5.7	2.6	-0.3	-1.3	1.4	34.3	0.6	1.6	**48.3**
	9	7.0	6.9	4.8	12.1	12.2	15.8	12.0	3.4	10.6	**84.8**
Total		**24.9**	**4.7**	**4.5**	**17.7**	**29.8**	**56.9**	**118.6**	**29.1**	**58.8**	**345.1**

Figure E-1: 60-Year User Benefits Profile, £000s



Appendix F. High Growth Scenario – Summary of TUBA Outcomes

Table F-1: User Benefits (Time+VOC) by User Class, £m

High Growth Scenario	Option 1	Option 1A	Option 2	Option 3	Option 3A
Business	£161.4	£126.1	£236.5	£77.9	£151.0
Commuting	£64.8	£52.7	£95.4	£30.9	£61.1
Other	£156.1	£129.3	£241.4	£72.4	£144.3
Total	**£382.3**	**£308.1**	**£573.3**	**£181.2**	**£356.4**

Table F-2: User Benefits (Time+VOC) by Time Period, £m

High Growth Scenario	Option 1	Option 1A	Option 2	Option 3	Option 3A
AM Peak	£96.5	£65.0	£113.0	£42.4	£91.5
PM Peak	£121.5	£114.2	£210.8	£63.1	£114.7
Inter-Peak	£164.5	£129.0	£249.4	£75.8	£150.2
Total	**£382.5**	**£308.2**	**£573.2**	**£181.3**	**£356.4**

Table F-3: User Benefits (Time+VOC) by Sub-mode, £m

High Growth Scenario	Option 1	Option 1A	Option 2	Option 3	Option 3A
Car - Business	£54.6	£41.8	£78.0	£27.1	£50.8
Car - Commute	£64.9	£52.7	£95.4	£30.9	£61.1
Car - Other	£150.7	£124.7	£232.9	£70.0	£139.3
LGV - Freight	£69.4	£57.9	£106.1	£31.2	£64.2
LGV - Personal	£5.4	£4.6	£8.4	£2.4	£5.0
OGV1	£20.4	£14.4	£28.4	£10.6	£19.5
OGV2	£17.0	£12.0	£23.8	£8.8	£16.3
Total	**£382.4**	**£308.1**	**£573.0**	**£181.0**	**£356.2**

Table F-4: Sector to Sector User Benefits (Time+VOC) Outputs – Option 1, £m

Benefits per sector High Scenario Option 1		Destination									Total
		1	2	3	4	5	6	7	8	9	
Origin	1	0.0	-6.7	-3.0	2.8	1.7	2.8	1.2	3.4	7.9	**10.2**
	2	1.4	-0.1	0.0	-0.9	-0.5	6.6	6.0	-0.5	2.4	**14.5**
	3	1.3	0.2	0.1	0.1	0.3	4.6	4.0	-0.1	2.8	**13.2**
	4	6.0	2.2	0.6	-0.7	5.1	22.1	29.1	3.9	23.6	**91.9**
	5	3.3	7.4	5.2	1.4	0.1	5.4	30.4	-0.3	9.6	**62.4**
	6	1.9	0.1	1.4	2.4	0.7	2.6	8.6	0.0	8.1	**25.9**
	7	0.3	-11.6	-6.8	4.3	11.4	4.1	0.2	18.7	4.8	**25.3**
	8	3.8	5.6	2.8	0.8	-2.7	2.1	37.1	0.8	3.1	**53.3**
	9	8.4	4.3	3.8	11.2	12.2	16.1	15.0	3.3	11.3	**85.6**
Total		**26.4**	**1.6**	**4.0**	**21.5**	**28.3**	**66.3**	**131.5**	**29.2**	**73.6**	**382.3**

Table F-5: Sector to Sector User Benefits (Time+VOC) Outputs – Option 1A, £m

Benefits per sector High Scenario Option 1A		Destination									Total
		1	2	3	4	5	6	7	8	9	
Origin	1	0.0	-0.9	-0.1	2.0	1.3	3.3	2.9	2.1	10.8	**21.4**
	2	-1.3	0.0	-0.3	-0.8	1.0	0.9	1.7	1.4	-1.7	**0.9**
	3	-0.6	-0.1	-0.1	-0.3	1.2	0.3	0.9	1.4	-1.3	**1.4**
	4	2.2	1.4	1.8	-0.7	5.0	20.4	12.4	4.4	23.0	**69.8**
	5	1.3	4.7	4.1	1.6	0.2	4.1	17.6	0.6	9.6	**43.9**
	6	1.5	4.2	2.4	3.5	1.4	1.9	9.6	0.5	7.2	**32.1**
	7	0.3	0.4	-0.3	-1.1	4.5	2.3	0.2	7.4	2.6	**16.3**
	8	1.2	3.2	2.2	1.1	-1.9	1.6	22.0	0.6	3.1	**33.0**
	9	7.7	6.8	3.8	13.1	13.1	13.2	18.3	3.7	9.8	**89.3**
Total		**12.2**	**19.7**	**13.6**	**18.4**	**25.8**	**47.8**	**85.6**	**22.0**	**63.0**	**308.0**

Table F-6: Sector to Sector User Benefits (Time+VOC) Outputs – Option 2, £m

Benefits per Sector High Scenario Option 2		Destination									Total
		1	2	3	4	5	6	7	8	9	
Origin	1	0.0	0.0	0.5	1.8	0.5	-0.5	-1.3	1.4	-2.7	**-0.3**
	2	2.7	-0.1	1.0	1.5	4.1	12.8	10.1	2.5	6.3	**40.8**
	3	2.4	0.9	0.4	-0.2	1.5	7.1	6.4	0.7	5.5	**24.6**
	4	8.0	4.9	1.7	-0.8	6.1	24.9	39.5	4.8	26.7	**115.7**
	5	4.2	6.4	3.3	2.0	0.4	6.8	37.6	0.1	11.0	**71.7**
	6	1.9	11.6	6.2	9.7	2.4	2.2	10.4	1.1	7.0	**52.6**
	7	0.2	7.3	5.1	11.8	17.2	3.5	0.6	27.7	0.3	**73.6**
	8	5.0	4.3	1.3	0.7	-2.6	3.0	48.1	1.1	3.8	**64.7**
	9	7.4	21.7	13.5	22.5	16.6	16.0	15.5	4.8	11.6	**129.5**
Total		**31.8**	**57.0**	**32.9**	**49.1**	**46.1**	**75.8**	**166.9**	**44.0**	**69.4**	**573.0**

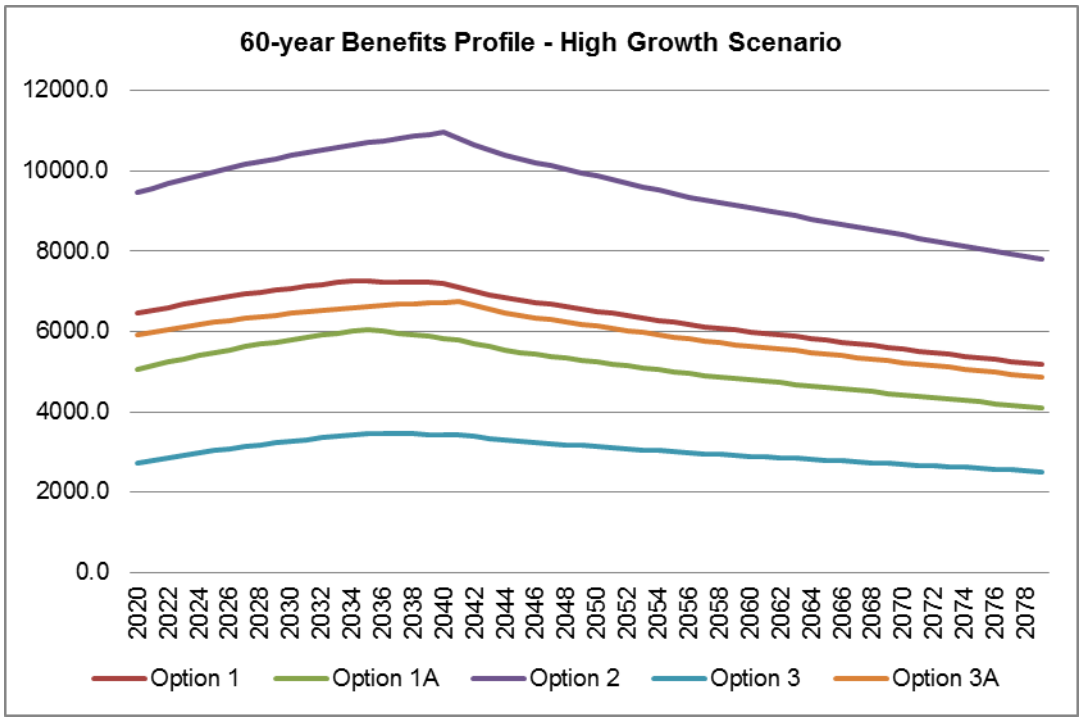
Table F-7: Sector to Sector User Benefits (Time+VOC) Outputs – Option 3, £m

Benefits per Sector High Scenario Option 3		Destination									Total
		1	2	3	4	5	6	7	8	9	
Origin	1	-0.1	-10.3	-5.2	1.1	0.2	0.5	-1.3	0.8	1.5	**-12.9**
	2	2.0	-0.1	0.0	-1.1	-1.1	5.0	6.5	-1.3	1.2	**11.2**
	3	1.3	0.2	0.1	0.0	0.0	3.3	4.3	-0.4	2.0	**10.8**
	4	4.8	1.1	-0.3	0.6	2.1	7.5	21.0	1.4	5.2	**43.5**
	5	1.4	2.1	0.9	0.1	0.0	1.2	15.3	-0.6	2.2	**22.7**
	6	1.1	-3.9	-0.4	4.9	1.5	1.1	5.2	0.7	4.1	**14.3**
	7	-0.3	-12.1	-7.7	5.8	9.5	2.6	0.1	16.3	2.7	**16.9**
	8	1.7	2.0	0.7	-0.7	-1.0	0.8	20.5	0.9	0.7	**25.6**
	9	5.3	-1.3	0.5	11.1	9.5	7.1	8.4	3.2	5.3	**49.0**
Total		**17.1**	**-22.3**	**-11.5**	**21.8**	**20.8**	**29.0**	**80.0**	**21.0**	**25.1**	**181.1**

Table F-8: Sector to Sector User Benefits (Time+VOC) Outputs – Option 3A, £m

Benefits per sector High scenario Option 3A		Destination									Total
		1	2	3	4	5	6	7	8	9	
Origin	1	0.0	-8.9	-4.2	1.5	1.0	1.9	0.2	2.5	5.5	**-0.5**
	2	1.6	-0.1	0.0	-1.1	-0.7	5.0	4.8	-0.7	1.5	**10.1**
	3	1.3	0.3	0.1	0.1	0.3	3.7	3.5	0.0	2.1	**11.5**
	4	6.5	2.9	0.8	-1.1	5.2	20.5	29.6	4.2	21.6	**90.1**
	5	3.2	7.6	4.9	0.9	0.3	3.5	27.8	-0.4	5.7	**53.5**
	6	1.8	1.3	1.9	2.6	1.0	2.5	7.4	0.0	8.0	**26.5**
	7	0.1	-11.3	-6.6	3.1	12.4	3.5	0.2	20.0	3.2	**24.6**
	8	3.8	5.8	2.7	-0.4	-2.0	1.3	35.0	1.0	1.5	**48.7**
	9	7.4	7.4	5.1	12.8	13.5	16.7	13.5	3.8	11.6	**91.8**
Total		**25.6**	**5.0**	**4.6**	**18.4**	**30.9**	**58.6**	**122.0**	**30.2**	**60.8**	**356.3**

Figure F-1: 60-Year User Benefits Profile, £000s



Appendix G. COBA-LT Methodology and Summary of the Results

G.1 Introduction

G.1.1 Document Purpose

G.1.1.1 This document refers to the process of analysing traffic data and the running of the COBA-LT model road network within the defined study area.

G.1.2 Defining the links

G.1.2.1 The study area included all A-Roads, B-Roads and Motorway links within East Lavant to the north, Boxgrove to the east, Stockbridge to the south and Broadbridge to the west. Some minor links with low flows were excluded from the study in order to simplify the study area. 24-hour annual average daily traffic (AADT) counts were used with flows assigned to links from a 2014 SATURN model of the area. Figure G–1 shows the base year (2014) study area with its respective link flows. The figure shows that most traffic flows occur on the A27 and the adjoining links.

Figure G–1: 2014 Base year AADT link flows

G.1.2.2 Table G-1 offers a summary of the key junctions within the study area and the changes proposed for each of the junction.

Table G–1: Key study area junctions and changes to configuration by each option

	Option				
Junction	**1**	**1A**	**2**	**3**	**3A**
Portfield	No Change	No change	No change	WB A27 slip	No change
Bognor	A27 underpass, roundabout overbridge, + Vinnetrow Road	A27 underpass, roundabout overbridge, + Vinnetrow Road	A27 underpass, roundabout overbridge, + Vinnetrow Road	Signalised Rounabout upgrade	A27 underpass, roundabout overbridge, + Vinnetrow Road
Whyke	Signalled Junction	Unchanged	Overbridge installed with junction removed	Signalled Junction	Signalled Junction
Stockbridge	Signalled Junction	Unchanged	Overbridge installed with junction removed	Signalled Junction	Signalled Junction
Fishbourne	A27 overpass + roundabout junction	A27 overpass + roundabout junction	A27 overpass + roundabout junction + new link road	Signalised Hamburger	Signalised Hamburger

G.1.3 Methodology

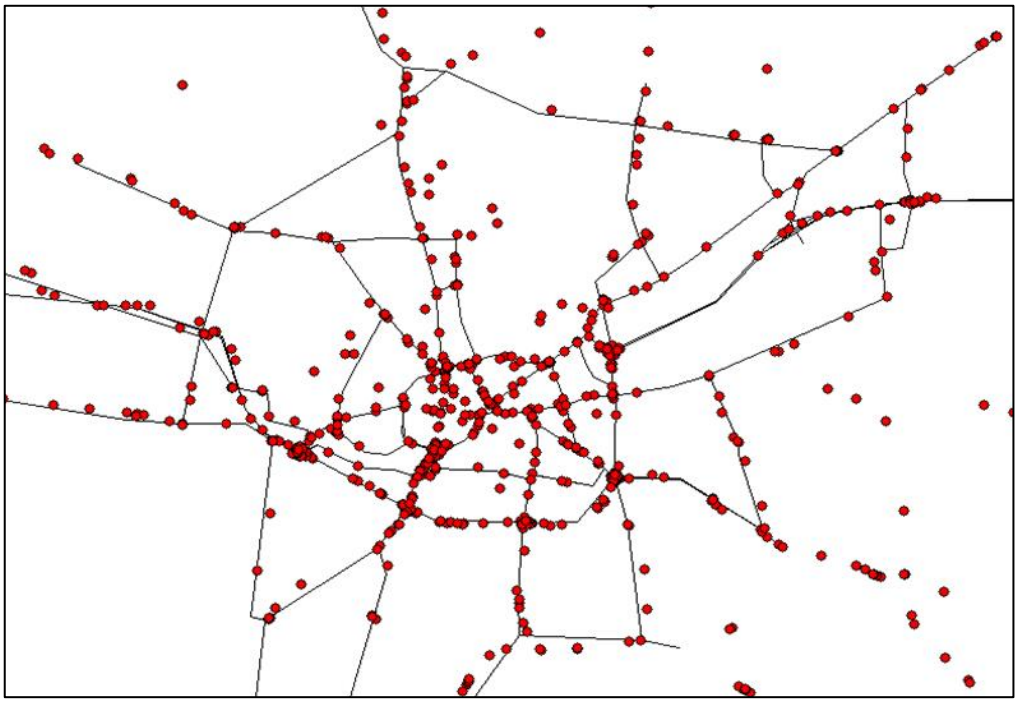
G.1.3.1 The analysis of the economic impact of accidents was undertaken through COBA-LT (COst and Benefit to Accidents – Light Touch). A number of inputs were required to be calculated in order to be run in the COBALT parameters file.

Accident Numbers

G.1.3.2 Local police accident STATS data from 2009 to 2013 were used for the accident analysis. The observed numbers of accidents were entered as a comma-delimited series for each consecutive year for the COBA-LT runs. Accidents within 20 metres of a junction were allocated to junction accident data whilst the remaining accidents along the study links were attributed to link accident data.

G.1.3.3 Figure G–2 shows the location of accidents that occurred in the area from 2009 to 2013. Most accidents occurred in the town centre and on the southern bypass A27, particularly at junctions.

Figure G-2: Accident location data 2009-2014



Speed Limits

G.1.3.4 Google maps, the option drawings, and mapped speed limits provided by the ITO website (http://product.itoworld.com/map/124?lon=1.36778&lat=51.94987&zoom=11) were indicative for our link and junction speed limit inputs.

Road Type

G.1.3.5 We used google maps, map GIS and option drawings to gauge the link and junction types. The types used were referenced against the COBA-LT manual link and junction classifications.

Accident Rates

G.1.3.6 The observed numbers of accidents were entered as a comma-delimited series for each consecutive year for the COBA-LT runs. Accidents within 20 metres of a junction were allocated to junction accident data whilst the remaining accidents along the study links were attributed to link accident data.

G.1.3.7 Using local police accident STATS data facilitates the mapping of the accidents. This procedure however does not specify the direction in which the accidents occurred or whether it was an accident that was caused by oncoming traffic. We hence decided to add opposing link flows together and conducting our link analysis by road section, as opposed to splitting up the analysis by direction.

G.1.3.8 For the junction analysis, the STATS accident numbers were attributed to the relevant junction for a base year run. The accident rates that were calculated from the base year run was then inserted in the future run accident rates subsection.

COBA-LT Limitations/ Caveats

G.1.3.9 COBA-LT requires simplified coding for larger complex junctions such as signalised roundabouts, hamburgers, and larger roundabouts at key A27 junctions. This means that the model can gauge the general effect of introducing such a junction configuration but may not pick up all the costs and benefits associated with each scheme when

taken in isolation. As a result, the accident costs generated should be seen as a guide and be reviewed in conjunction with other data for the effects of individual junction layouts.

G.1.3.10 On links and junctions that are subject to the schemes (Do Something), COBA-LT uses average DfT accident rates. These are estimated from the characteristics that allocated to those links and junctions. This also applies to road sections that had no observed accidents.

G.1.4 Accident Impact Analysis

G.1.4.1 Table G–2, Table G–3 and Table G–4 below summarise the output results for the link, junction and overall combined link and junction respectively. Options 1A, 2 and 3 show overall positive accident benefits due to introduction of the Scheme whilst Options 1 and 3A show overall slight negative benefits due to introduction of the Scheme over a 60-year assessment period. A summary analysis and an analysis of the key junctions in the area have been undertaken for this work. This represented below the tables.

Table G–2: Link accidents summary

		Option 1	Option 1A	Option 2	Option 3	Option 3A
Economic Summary	*Total Without-Scheme Accident Costs, £000s*	*203,991*	*207,920*	*203,992*	*207,920*	*207,884*
	Total With-Scheme Accident Costs, £000s	191,285	195,630	187,424	196,315	198,080
	Total Accident Benefits Saved by Scheme, £000s	**12,707**	**12,290**	**16,567**	**11,605**	**9,804**
Accident Summary	*Total Without-Scheme Accidents*	*3,339*	*3,361*	*3,339*	*3,361*	*3,360*
	Total With-Scheme Accidents	3,123	3,166	3,032	3,172	3,187
	Total Accidents Saved by Scheme	**216**	**195**	**307**	**189**	**173**
Casualty Summary	*Total Without-Scheme Casualties (Fatal)*	*56*	*57*	*56*	*57*	*57*
	Total Without-Scheme Casualties (Serious)	*526*	*529*	*526*	*529*	*529*
	Total Without-Scheme Casualties (Slight)	*3,946*	*3,972*	*3,946*	*3,972*	*3,972*
	Total With-Scheme Casualties (Fatal)	54	54	54	54	55
	Total With-Scheme Casualties (Serious)	487	496	477	498	498
	Total With-Scheme Casualties (Slight)	3,714	3,747	3,613	3,752	3,786
	Total Casualties Saved by Scheme (Fatal)	**2**	**3**	**2**	**3**	**2**
	Total Casualties Saved by Scheme (Serious)	**39**	**34**	**49**	**31**	**31**
	Total Casualties Saved by Scheme (Slight)	**232**	**225**	**333**	**221**	**186**

Table G–3: Junction accidents summary

		Option 1	Option 1A	Option 2	Option 3	Option 3A
Economic Summary	*Total Without-Scheme Accident Costs, £000s*	*245,424*	*247,812*	*245,424*	*247,812*	*247,812*
	Total With-Scheme Accident Costs, £000s	266,597	258,242	253,589	253,652	281,677
	Total Accident Benefits Saved by Scheme, £000s	**-21,173**	**-10,430**	**-8,166**	**-5,840**	**-33,865**
Accident Summary	*Total Without-Scheme Accidents*	*5,666*	*5,659*	*5,720*	*5,659*	*5,659*
	Total With-Scheme Accidents	6,034	5,807	5,939	5,795	6,444
	Total Accidents Saved by Scheme	**-368**	**-148**	**-218**	**-136**	**-785**
Casualty Summary	*Total Without-Scheme Casualties (Fatal)*	*33*	*33*	*33*	*33*	*33*
	Total Without-Scheme Casualties (Serious)	*494*	*494*	*498*	*494*	*494*
	Total Without-Scheme Casualties (Slight)	*7,881*	*7,871*	*7,954*	*7,871*	*7,871*
	Total With-Scheme Casualties (Fatal)	38	37	32	34	37
	Total With-Scheme Casualties (Serious)	550	525	503	496	551
	Total With-Scheme Casualties (Slight)	8,633	8,136	8,223	8,286	9,172
	Total Casualties Saved by Scheme (Fatal)	**-5**	**-3**	**1**	**0**	**-3**
	Total Casualties Saved by Scheme (Serious)	**-56**	**-32**	**-5**	**-3**	**-58**
	Total Casualties Saved by Scheme (Slight)	**-752**	**-265**	**-269**	**-415**	**-1,301**

Table G–4: Combined Link and Junction accidents summary

		Option 1	Option 1A	Option 2	Option 3	Option 3A
Economic Summary	*Total Without-Scheme Accident Costs, £000s*	*449,415*	*455,732*	*449,415*	*455,732*	*455,696*
	Total With-Scheme Accident Costs, £000s	457,882	*453,872*	441,013	449,967	479,757
	Total Accident Benefits Saved by Scheme, £000s	**-8,467**	**1,860**	**8,401**	**5,765**	**-24,061**
Accident Summary	*Total Without-Scheme Accidents*	*9,005*	*9,020*	*9,059*	*9,020*	*9,019*
	Total With-Scheme Accidents	9,157	8,972	8,970	8,967	9,631
	Total Accidents Saved by Scheme	**-152**	**47**	**88**	**53**	**-612**
Casualty Summary	*Total Without-Scheme Casualties (Fatal)*	*90*	*90*	*90*	*90*	*90*
	Total Without-Scheme Casualties (Serious)	*1,020*	*1,023*	*1,023*	*1,023*	*1,023*
	Total Without-Scheme Casualties (Slight)	*11,827*	*11,843*	*11,900*	*11,843*	*11,842*
	Total With-Scheme Casualties (Fatal)	92	90	86	87	91
	Total With-Scheme Casualties (Serious)	1,036	1,021	980	995	1,049
	Total With-Scheme Casualties (Slight)	12,346	11,883	11,836	12,037	12,958
	Total Casualties Saved by Scheme (Fatal)	**-2**	**0**	**3**	**3**	**-1**
	Total Casualties Saved by Scheme (Serious)	**-17**	**2**	**44**	**28**	**-26**
	Total Casualties Saved by Scheme (Slight)	**-520**	**-40**	**64**	**-194**	**-1,116**

G.1.4.2 Overall Options 1A, 2, and 3 see benefits with a reduction in overall accident costs after scheme implementation. Option 3A sees the largest increase in accident costs amongst all the options.

G.1.4.3 For Option 1A, this benefit is principally driven by the improvement road quality along the links, the new junction configuration at Fishbourne. It sees lower accident costs in comparison with Option 1 principally because both Whyke and Stockbridge junctions remain unchanged in configuration.

G.1.4.4 Option 2 sees an overall benefit of £8m due to the road links in key areas being upgraded. Whilst some junction accident costs are reduced, mainly through Whyke and Stockbridge junctions being removed with new overpasses for the roads into Chichester, the benefit generated by this is offset by the additional costs at the new and existing junctions related to the new link road to the south of the A27. These extra links are subject to high flows, ultimately enhancing the total costs.

G.1.4.5 Option 3 has the second highest benefits, reducing accident costs by £6m over a 60 year period. This can mainly be attributed to the improvement in link quality in the study area. In addition, Portfield junction sees accident cost benefits with the introduction of a WB slip road on the A27. The replacement of the existing roundabouts with signals at both Whyke and Stockbridge junctions are the principle drivers in the increase of accident costs at the main junctions.

G.1.4.6 Option 1 sees overall additional costs of £8.5m over a 60 year period. The links see an improvement in the accident costs. The junctions see additional accident costs with

biggest driver of costs for this option being the reconfiguration of Whyke and Stockbridge junctions to signalled cross junction. Furthermore, additional traffic at Portfield generates significant additional junction accident costs giving an overall disbenefits.

G.1.4.7 Option 3A sees an improvement in link accident costs but also the highest increase in accident costs at key junctions. The increase in accident costs of about £24m is driven by additional traffic at Portfield, the new overbridge and additional junction configuration at Bognor, the signalled crossroads layout replacing the roundabout at Whyke and Stockbridge, and the use of a hamburger configuration at Fishbourne junction.

G.1.4.8 Overall the higher flows for each scenario have a significant effect on accident costs and are a significant contributor to an increase in the costs. Options 1 and 3A see a flow increase of over 50% in comparison with the Do-Minimum between the Stockbridge and Fishbourne junctions. In Option 3 increase is 30%, Option 2 increase is 28%, with Option 1A at 17% being the lowest increase.

Analysis of the scheme - key junctions

G.1.4.9 Table G–5 below summarises the accidents costs at key junction for each option.

Table G–5: Analysis of the accident costs at key junctions

Junction	Costs (£000)				
	Option 1	Option 1A	Option 2	Option 3	Option 3A
Total Accident Costs- Portfield	**-£8,021**	**-£3,697**	**-£ 7,358**	**£3,879**	**- £6,533**
Bognor Old	£12,632	£12,573	£14,485	£12,784	£12,784
Bognor New	- £8,547	-£7,123	-£10,886	- £14,320	-£12,324
Bognor extra junction	-£8,776	-£8,281	-£8,250	-	-£9,475
Total Accident Costs - Bognor	**-£4,691**	**-£2,831**	**-£4,650**	**-£1,536**	**-£9,015**
Whyke Old	£8,811	-£2,267	£8,811	£8,910	£8,910
Whyke New	-£16,042	-	-	-£15,142	-£16,532
Total Accident Costs - Whyke	**-£7,231**	**-£2,267**	**£8,811**	**-£6,233**	**-£7,622**
Stockbridge Old	£7,182	-£496	£7,182	£7,264	£7,264
Stockbridge New	-£16,213	-	-	-£15,019	-£16,584
Total Accident Costs - Stockbridge	**-£9,031**	**-£496**	**£7,182**	**-£7,756**	**-£9,320**
Fishbourne Old	£16,905	£17,056	£16,905	£17,089	£17,089
Fishbourne New	-£8,314	-£7,321	-£17,996	-£17,518	-£18,225
Total Accident Costs - Fishbourne	**£8,591**	**£9,735**	**-£1,091**	**-£429**	**-£1,136**

Portfield

G.1.4.10 For this junction, Option 3 has an additional westbound segregated left turn added, allowing traffic joining the Chichester bypass from the A27 to bypass the existing junction at Portfield. All other scenarios see the junction configuration unchanged.

G.1.4.11 All options see an increase in accident costs in comparison with the Do Min. This can be attributed to an overall increase in flow in all modelled scenarios. Option 3 is the only option to see an improvement in accident costs as a result of the new segregated

link bypassing the existing roundabout. Option 1 sees the highest additional accident costs generated as it has the highest overall increase in flow.

Bognor

G.1.4.12 Option 3 sees this junction upgraded from the existing unsignalled roundabout to a signalised roundabout. The remaining options see the A27 grade separated over the junction. This increases the number of slip road junctions in the area. These options also add a junction on Bognor Road where it meets the realigned Vinnetrow Road.

G.1.4.13 From the COBA-LT runs, all options generate additional junction accident costs in relation to the Do Minimum. Option 3 has the smallest increase as its configuration is very similar to the existing, with mainly only additional traffic flow added. The largest cost increase is attributed to Option 3A as a result of the additional flows due to the road capacity increases as part of the scheme.

Whyke

G.1.4.14 Option 1A is the same as the Do Minimum and retains the existing roundabout. In Options 1, 3 & 3A junction is reconfigured with the roundabout removed, signals added, and right turns banned. Option 2 sees the A27 elevated, with no connection to the radial route.

G.1.4.15 Option 2 has a decrease in accident costs at the junction. This is as a result of the junction being removed on the A27 in this option. Option 1A sees a marginal increase in accident costs in relation to Do Minimum. Options 1, 3, and 3A see significant increases in accident costs as a result of the introduction signalised crossroad which COBA-LT treats with a higher accident rate than an unsignalised roundabout.

Stockbridge

G.1.4.16 Similar to Whyke Option 1A is the same as the Do Minimum and retains the existing roundabout. In Options 1, 3 & 3A junction is reconfigured with the roundabout removed, signals added, and right turns banned. Option 2 sees the A27 elevated, with no connection to the radial route.

G.1.4.17 Option 2 sees a large decrease in accident costs at the junction. This is as a result of the junction being removed on the A27 in this option. Option 1A, sees only a slight decrease in accident costs in relation to Do Minimum. This is as a result of a lower flow using the radial link on Stockbridge Road. Options 1, 3, and 3A see significant increases in accident costs as a result of the introduction of a number of additional junctions in the area, mainly as a result of the effects of the additional left slips.

Fishbourne

G.1.4.18 Options 1, 1A, and 2 see a grade separation of the A27 from the existing junction, with the new A27 route passing over the roundabout. In addition, Option 2 also sees a new link road to the south that links the B2145 to Fishbourne. Options 3 and 3A see a hamburger junction installed, with the A27 passing through the middle of a new roundabout configuration with signals.

G.1.4.19 Options 1 and 1A show significant accident cost benefits at the junction as a result of separating out the A27 from the interchange flow. Option 2 though has a similar configuration sees an increase in accident costs as a result of introducing the new Stockbridge link road into the interchange junction that adds to overall traffic flow.

G.1.4.20 Option 3 sees a marginal increase in junction accident costs in comparison to the Do Min. Option 3A sees a larger increase in junction accident costs in comparison with the Do Min. Both options see an increase an increase in costs as a result of the existing roundabout being reconfigured as a signalised hamburger style junction.

Appendix H. Reliability Methodology and Summary of the Results

H.1 Introduction

H.1.1 Document Purpose

H.1.1.1 This document describes the process for estimating the economic benefits on the proposed A27 Chichester Bypass Improvement Scheme related to its role in improving the reliability and resilience of the strategic road network through junction improvements and upgrades. These benefits are separate to average journey time benefits which are covered in the main document of the Economic Assessment Report.

H.1.2 TAG Guidance

H.1.2.1 TAG Unit A1.3 states that the term reliability means the variation in journey times that individuals are unable to predict (Journey Time Variability, or JTV). Such variation could come from recurring congestion at the same period each day that is day-to-day variability, (DTDV) or from non-recurring events including, for example accidents, unplanned roadworks and other similar incidents. Day to day variation excludes predictable variation relating to varying levels of demand by time of day, day of week, and seasonal effects that travellers are assumed to be aware of.

H.1.2.2 TAG A1.3 also states that research (Arup, 2004) has indicated that as long as demand is below capacity, incidents will be the main source of JTV, and DTDV is much less important. However in urban areas many roads are at capacity for long periods, and the two effects are harder to separate.

H.2 The A27 Bypass

H.2.1.1 The main cause of unreliability on the A27 Chichester Bypass is due to DTDV and high levels of peak period congestion that causes a large variation in the day-to-day travel time. Due to the current nature of the junctions (mostly roundabouts) on the A27, during peak hours the day-to-day journey time variability is severe.

H.2.1.2 Traffic flows on the A27 undertaking movements east-west, west-east, north-south and vice-versa are further delayed at each junction as local traffic going into and out of Chichester feeds onto the carriageway.

H.2.1.3 In terms of improving the journey times, the upgrade options generally act to limit the local Chichester traffic movements using the dual carriageway and allow the carriageway to be more free-flowing. Upgrade options include grade-separated roundabouts, banned right turns off the main carriageway and signalising junctions. Most significant changes include entirely new offline dual carriageways to increase the capacity of the network. The studied improvements to the carriageway take place at several junctions along the A27 prior to Fishbourne Roundabout right through to Tangmere/Boxgrove Roundabout and reliability is assessed for each shortlisted option at the PCF Stage 2.

H.2.1.4 As well as improving average journey times these improvements would act to decrease the level of congestion on the network and so decrease the day to day variation in journey times experienced by road users at the section of the A27 Bypass near Chichester.

H.3 Data Source

H.3.1.1 Journey time and flow data for every 15-minute period in year 2014 for journeys taking place from the first junction prior to Fishbourne Roundabout to Arundel Junction was

used. This data enabled a detailed analysis of the flow patterns and the journey time variability on the carriageway. The Highways Agency Traffic Information System (HATRIS) which contains the Journey Time Database (JTDB) was used and provided data that covered this route which was separated by 5 adjacent links:

- A259 (Emsworth Road) to A259 (Fishbourne Roundabout)
- A259 (Fishbourne Roundabout) to A286 (Stockbridge Roundabout)
- A286 (Stockbridge Roundabout) to A259 (Bognor Roundabout)
- A259 (Bognor Roundabout) to A285 (Portfield Roundabout)
- A285 (Portfield Roundabout) to A285 (Arundel Junction)

H.3.1.2 Each 15-minute period was categorised according to the day of the week and whether the period occurred during a bank or school holiday. For the purpose of this assessment, only weekdays, excluding any school holidays and bank holidays, were used.

H.4 Estimating the Benefits

H.4.1.1 Journey time variability benefits are not directly calculated using the standard SATURN modelling tests, and an alternative approach has been conducted to derive these. These aspects can be estimated directly from data and through the use of relatively simple calculations.

H.4.1.2 The methodology uses an adaptation of the TAG A1.3 guidance (para 6.3) for the reliability study to create a locally calibrated model that accurately reflects the situation on the A27.

H.5 Calculating Journey Time Variability Benefits

H.5.1 General improvements in journey time variability

H.5.1.1 For these benefits, following the guidance given in TAG A1.3, the change in standard deviation of journey times was used as a proxy for journey time reliability. This analysis uses term time data only, excluding weekends.

H.5.1.2 TAG A1.3 suggests approximating the change in standard deviation using the following formula:

$$\mathbf{0.0018} * \frac{\boldsymbol{t_1^{2.02} - t_2^{2.02}}}{\boldsymbol{D^{1.41}}}$$

(Where t is the journey time (t_1 before, t_2 after) and D is the journey distance).

H.5.1.3 The approach from TAG suggests that the standard deviation of journey time is related to the reciprocal of the speed of travel.

H.5.1.4 As per TAG guidance a locally calibrated model was derived.

H.5.1.5 As described earlier in this note, detailed journey time data was available for five fixed distanced links between the A259 at Emsworth Road to the A285 at Arundel Junction, both eastbound and westbound on the A27. From this data, it was then possible to

calculate the standard deviation of observed data at different times of day- when the journey time is different.

H.5.1.6 The journey time data extracted from the term-time days, as discussed in section H.3.1.2, were divided up into consecutive 5-hour sections to minimise any bias caused by using the same start time of each consecutive day. For each of these periods, the weighted mean journey times and standard deviation of journey times was calculated for these journeys.

H.5.1.7 Through the use of 5-hour periods[10], the level of detail was considered sufficient to be able to calibrate the model effectively.

H.5.1.8 Given that the observed data was from a total of ten links of known distance, it was concluded that (subject to the ability to calibrate the model to a sufficient degree) there was no need to incorporate the distance component in the revised TAG formula to estimate standard deviation, as the impact of the distance could be incorporated in the initial coefficient of the calibrated equation.

H.5.1.9 Doing this however means that the adjusted formula has only been validated along the calibrated links. By considering journey times and volume/capacity it is possible to approximate the benefits to all of the options considered for the A27.

H.5.1.10 A linear regression analysis was used to compare standard deviation with journey time for different given journey times on each link in each direction. This regression was used to create a new formula to approximate the change in standard deviation for each section of the A27 dual carriageway between modelled and observed data.

H.5.1.11 In the eastbound direction the calibrated formulae for the change on standard deviation between before (scenario 1) and after (scenario 2) are given in Table H–1 and in the westbound direction, the calibrated formulae are given in Table H–2.

Table H–1: Change in standard deviations on links in the eastbound direction on the A27

Link	Change in standard deviation
A259 (Emsworth Road) to A259 (Fishbourne Roundabout)	$0.000000249(t_1^{3.16} - t_2^{3.16})$
A259 (Fishbourne Roundabout) to A286 (Stockbridge Roundabout)	$0.009815230(t_1^{1.79} - t_2^{1.79})$
A286 (Stockbridge Roundabout) to A259 (Bognor Roundabout)	$0.001086473(t_1^{2.07} - t_2^{2.07})$
A259 (Bognor Roundabout) to A285 (Portfield Roundabout)	$0.000151562(t_1^{2.53} - t_2^{2.53})$
A285 (Portfield Roundabout) to A285 (Arundel Junction)	$1.07061e^{-8}(t_1^{4.51} - t_2^{4.51})$

Table H–2: Change in standard deviations on links in the westbound direction on the A27

Link	Change in standard deviation
A259 (Emsworth Road) to A259 (Fishbourne Roundabout)	$1.01247e^{-9}(t_1^{3.99} - t_2^{3.99})$
A259 (Fishbourne Roundabout) to A286 (Stockbridge Roundabout)	$0.000825771(t_1^{2.25} - t_2^{2.25})$
A286 (Stockbridge Roundabout) to A259 (Bognor Roundabout)	$0.002437317(t_1^{1.92} - t_2^{1.92})$
A259 (Bognor Roundabout) to A285 (Portfield Roundabout)	$0.06891009(t_1^{1.35} - t_2^{1.35})$
A285 (Portfield Roundabout) to A285 (Arundel Junction)	$0.000365972(t_1^{2.33} - t_2^{2.33})$

[10] In order to alter the start period of each time-slice, 5-hour periods were the minimum required to allow for an additional hour of each day, therefore differing the start periods of each consecutive day by an hour.

H.5.1.12 The difference in the formulae reflects the difference in flow pattern on each link and in each direction.

H.5.1.13 With the calibrated formulae, no less than 95% of observed points were within two standard deviations of the calculated value for all links including both eastbound and westbound directions. Inspection of the residuals indicated that in both cases they were distributed almost normally around the expected value, with no obvious bias. This indicates a good calibration, and is in line with standard statistical tests.

H.5.1.14 SATURN was used to provide estimates of the future reference case and assessed case journey times and flows on the A27 carriageway in all modelled time periods in the three forecast years: 2020, 2035 and 2041. Journey times and flows were extracted for each option and compared to the do-minimum scenario for all 5 calibrated links in both directions.

H.5.1.15 The calibrated TAG formulae were then used to calculate the change in the standard deviation of journey time between the reference and assessed case in each time period and year. For online options, this was a direct assessment on the A27 carriageway providing estimates of the variability for each link.

H.5.1.16 Using modelled changes in journey time within the network to calculate the change in standard deviation of the dual carriageway user trips assumes that there is no change in the journey (for example due to rerouting or other changes in network conditions) outside of the network. This is an appropriate simplifying assumption, as this analysis is not concerned with the effect of wider network impacts on overall journey time reliability, but on the effect of the junction improvements on the A27 on reliability.

H.5.1.17 The estimated standard deviations derived from the SATURN analysis described above for the assessed case were compared against the current observed standard deviations, and in accordance with TAG A1.3 the change (in minutes) was valued at 80% of the value of an actual minute saved in journey time. These benefits are therefore not 'time savings' but the valuation placed on reductions in journey time variability.

H.5.1.18 The same annualisation factors as used in TUBA by time period were applied to the term-time data and summed per modelled year. A linear interpolation was used to generate a 60-year appraisal, in accordance with TAG. It was assumed that for every year after 2041 the same benefits as in 2041 were experienced, and standard TAG discounting factors were applied. It should therefore be noted that, by assuming that there will be not growth in benefits beyond the last modelled year, the assessments are likely to underestimate the benefits. The TAG reliability benefit formula below was used to estimate benefits.

$$Benefit = -\frac{1}{2}\sum_{ij}\Delta\sigma_{ij} * \left(T_{ij}^{0} + T_{ij}^{1}\right) * VOR$$

H.5.1.19 Where $\boldsymbol{T_{ij}^{0}}$ is the number of trips between zone i and zone j in the reference case, $\boldsymbol{T_{ij}^{1}}$ is the number of trips between zone i and zone j in the assessed case, σ is the approximation to the standard deviation in journey times between the two zones and VOR stands for "Value of Reliability" – the proportion of a person's value of time which is given to reduction in journey time variability. In line with WebTAG guidance a VOR of 0.8 has been used.

H.5.1.20 It must be noted that not all benefits were able to be captured and this includes on alternative link roads that compensate for regions with lost connectivity as well as minor

roads that lead to the A27. Only journey time benefits were calculated for the main A27 carriageway as they could be readily validated using the JTDB data.

H.5.1.21 The total reliability benefit estimates for each given assessed option over a 60-year period in line with the economic assessment are given in Table H–3.

Table H–3: Reliability Benefits (Discounted, in 2010 prices) over 60 years, £m

Assessed Case Option	Total reliability benefits, £m
Option 1	£227.7
Option 1A	£85.9
Option 2	£249.8
Option 3	£165.5
Option 3A	£208.2

H.6 Summary

H.6.1.1 The total benefits attributable to reductions in journey times due to improvement in journey time reliability are shown in Table 3 above. The estimated total benefits range from £86m on Option 1A to £250m on Option 2 in 2010 prices over 60 years. In the cases of new minor alternative link roads, benefits are not considered and these values presented represent the minimum reliability benefits attainable.