

A303 Amesbury to Berwick Down

TR010025

7.5 Combined Modelling and Appraisal Report

Appendix D: Economic Appraisal Package

APFP Regulation 5(2)(q)

Planning Act 2008

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

October 2018

Infrastructure Planning

Planning Act 2008

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

A303 Amesbury to Berwick Down
Development Consent Order 20[xx]

COMBINED MODELLING AND APPRAISAL REPORT
Appendix D: Economic Appraisal Package

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Foreword

The A303 Amesbury to Berwick Down scheme (“the Scheme”) forms part of a programme of improvements for upgrading the A303/A358 corridor, improving this vital connection between the South West and London and the South East and including the upgrade of remaining single carriageway sections on the route to dual carriageway. This investment is stated as a priority project in the National Infrastructure Plan and Government’s commitment is confirmed in the Road Investment Strategy (2015-2020). Subject to achieving an approved Development Consent Order (DCO), preliminary works are planned to start in 2020 with the main construction works following in 2021, and the Scheme is due to open to traffic in 2026.

Objectives for the Scheme have been formulated both to address identified problems and to take advantage of the opportunities that new infrastructure would provide. The objectives are defined by the Department for Transport (DfT):

- a. **Transport:** To create a high quality reliable route between the South East and the South West that meets the future needs of traffic;
- b. **Economic Growth:** To enable growth in jobs and housing by providing a free flowing and reliable connection between the South East and the South West.
- c. **Cultural Heritage:** To help conserve and enhance the World Heritage Site and to make it easier to reach and explore; and
- d. **Environment and Community:** To improve biodiversity and provide a positive legacy for nearby communities.

The objectives would be achieved by providing a high quality, two-lane dual carriageway on the A303 trunk road between Amesbury and Berwick Down in Wiltshire. The Scheme would resolve traffic problems and, at the same time, protect and enhance the Stonehenge, Avebury and Associated Sites World Heritage Site (“WHS”). The Scheme would be approximately 8 miles (13km) long and comprise the following key components:

- a. a northern bypass of Winterbourne Stoke with a viaduct over the River Till valley;
- b. a new junction between the A303 and A360 to the west of and outside the WHS, replacing the existing Longbarrow roundabout;
- c. a tunnel approximately 2 miles (3.3km) in length past Stonehenge; and
- d. a new junction between the A303 and A345 at the existing Countess roundabout.

The Economic Appraisal Package explains key assumptions that have been made in the transport economic appraisal; summarising the outputs of the standard transport economic appraisal process; and summarising the processes, assumptions and results of any non-standard aspects of the appraisal. The Economic Appraisal Package is one element of the Combined Modelling and Appraisal (ComMA) Report (Application Document 7.5) which documents the transport modelling and economic assessment process for transport schemes.

Executive summary

The A303 Amesbury to Berwick Down scheme involves the dualling of the first single-carriageway section of A303 encountered after the M3, including the construction of a tunnel approximately 2 miles (3.3km) long as the road passes Stonehenge, the construction of a northern bypass of Winterbourne Stoke and the construction of a flyover at Countess roundabout. The Scheme is one of three A303 / A358 corridor schemes that have been prioritised within the first Road Investment Strategy (RIS) period. Delivery of the RIS is the responsibility of Highways England.

A transport model of the A303 and local roads in the vicinity of the Scheme has been developed, refining the previous stage model through the update of local demand following a comprehensive data collection exercise, refined network detail and improved local area calibration and validation to WebTAG criteria and acceptability guidelines for link and turning flows and travel times. Traffic forecasts have been produced.

The refined forecasts provide the best view of the scheme impacts on the A303, surrounding local road network and on the parallel SRN. Forecast traffic volumes are being used to inform the scheme design, buildability, environmental impacts, traffic-related economics and to inform the procurement route.

This Economic Appraisal Package sets out the benefits arising from changes in travel times; vehicle operating costs (VOCs); changes in indirect taxes; delays during construction and changes in accidents. Traffic-related environmental impacts are summarised from the Environmental Statement (ES), including greenhouse gas emissions, air quality and noise. Outputs from each of the four forecast years (2026, 2031, 2041 and 2051) have informed this assessment.

Costs have been assessed for both public sector delivery of the Scheme and for procurement via private finance mechanisms (PF2) through a Design, Build, Finance and Maintain (DBFM) contract. The Economic Appraisal Package presents costs and benefits from the perspective of the public sector. Public sector funding would incur all construction costs prior to scheme opening whilst private finance investment would spread costs for the public sector (through a unitary charge) over 25 years post scheme opening to 2051. Operating and maintenance expenditure is applicable throughout the 60 year appraisal period regardless of the funding strategy, although some operating and maintenance activity and costs would be incurred by the operator and included in the unitary charge .

The costs of the Scheme through public sector funded delivery have been assessed at approximately £1.2 billion in 2010 prices and values. This includes the approximately £970 million cost of constructing the Scheme with the remainder of the expenditure attributable to operations and maintenance. The costs of the Scheme if it were part-funded through private investment have been assessed at approximately £1.1 billion in 2010 prices and values. Of this, £109 million are retained operating and maintenance costs that Highways England would have to pay during the lifetime of any PF2 contract and after its expiration. The remainder is the investment cost of the Scheme, spread over the duration of any PF2 contract as the unitary charge.

The estimation of travel time benefits and VOCs has been undertaken using the DfT's Transport User Benefits Appraisal (TUBA) software, interpolating between modelled years and extrapolating beyond 2051 for the remainder of the appraisal period to 2085. Economic parameters have been based on interim advice provided by DfT in advance of

the formal WebTAG May 2018 release. Impacts of construction on travel times and VOCs have been modelled using the traffic model and appraised using TUBA.

Accident benefits have been assessed using the DfT's Cost and Benefits to Accidents – Light Touch (COBA-LT) software. Accident impacts have been assessed across the scheme links and all local roads in the Area of Detailed Modelling (AoDM), capturing the impacts on the local area. The regional impacts of the Scheme on accidents – as a result of re-routeing, have also been captured through the assessment of: all A303 links within the modelled Region of Focus; across the A358 between the A303 and M5; A30 between the A303 and M5; M4 between Junctions 13 and 20; and the M5 between Junctions 15 and 28.

The environmental impacts of the Scheme have been assessed using methodologies aligned with WebTAG. Benefits and disbenefits arising from greenhouse gas, air quality and noise impacts of the Scheme are detailed. Details of the appraisal are presented in the Environmental Statement, including Chapter 9 (Noise and Vibration), Chapter 5 (Air Quality and Greenhouse Gases).

User benefits pertaining to improved reliability of the road and wider economic impacts have also been assessed. Reliability has considered the variability of travel times on the single carriageway section of the A303 to be improved against an existing dual carriageway section, using Trafficmaster data. Wider Economic Impacts have been appraised using DfT's Wider Impacts in Transport Appraisal (WITA) software. The WITA assessment has considered the scheme impacts on agglomeration, increased output in imperfectly competitive markets and labour market impacts.

Sensitivity testing has been undertaken to assess the robustness of the scheme appraisal under uncertainty. Four demand-based sensitivity tests have been undertaken: high and low growth (as per guidance in WebTAG Unit M4); alternative local demand arising from potential high employment at the proposed Boscombe Down development; and examining the impacts of the latest DfT Road Traffic Forecasts 2018 on regional LGV and HGV growth. Further to this, sensitivity around costs has been assessed. Estimates of lower bound (P10) and upper bound (P90) costs, representing variations around the central case cost estimate, were appraised.

The culmination of the appraisal is monetised benefits for the transport-related impacts. Table ES-1 provides a summary of the transport-related benefits over the 60-year appraisal period for the core scenario, along with the cultural heritage benefits that additionally form the adjusted BCR.

Table ES-1: Transport-related benefits summary (£m)

Benefit component		Publicly Funded	Privately Financed
Initial PVB	TEE benefits (including construction), of which:	252	252
	(... <i>Commuting user benefits:</i>)	(... 12)	(... 12)
	(... <i>Other user benefits:</i>)	(... 61)	(... 61)
	(... <i>Business user benefits:</i>)	(... 179)	(... 179)
	Indirect tax revenues	87	87
	Corporation Tax revenues	0	6
	Accident benefits	4	4
	Air quality	0	0
	Noise	0	0
	Greenhouse gas emissions	-86	-86
	Initial PVB	257	262
Adjusted PVB	Travel time reliability	61	61
	Wider Impacts	35	35
	Cultural heritage impacts	955	955
	Adjusted PVB	1,308	1,313

2010 prices and values, discounted to 2010, rounded to nearest million.

1 Introduction

1.1 Background

- 1.1.1 This report details the economic assessment undertaken as part of the A303 Amesbury to Berwick Down scheme.
- 1.1.2 The report presents the monetised costs and transport benefits of the Scheme and describes the methodologies used to derive the economic impacts. The economic impacts are used to inform the overall value for money (VfM) assessment for the Scheme.

1.2 Report structure and purpose

Project Control Framework Product

- 1.2.1 Highways England's Transport Planning Group (TPG) revised its list of expected PCF products in 2017. A formal Economic Appraisal Report (EAR) is no longer specified as part of the 'Economic Appraisal Package' which must be prepared, with TPG guidance instead noting that the majority of reporting be encapsulated in an 'end of stage' Combined Modelling and Appraisal (ComMA) report.
- 1.2.2 The guidance states that the 'Economic Appraisal Package' must provide sufficient evidence to the TPG Business Partner to:
 - a. demonstrate the key assumptions that have been made while undertaking the transport economic appraisal;
 - b. summarise the output of the standard transport economic appraisal process; and
 - c. where wider economy impacts have been assessed, summarise the processes, assumptions and results.
- 1.2.3 It has been agreed with the TPG Business Partner for A303 Amesbury to Berwick Down that, whilst no longer a formal PCF product, a formal EAR will be produced that provides the necessary evidence as detailed in the guidance for the 'Economic Appraisal Package'. This document therefore is the 'Economic Appraisal Package', an appendix to the ComMA.

Introduction to the Economic Appraisal Package

- 1.2.4 The Economic Appraisal Package sets out information, detail and evidence pertaining to the economic assessment of transport related impacts of the Scheme.
- 1.2.5 The primary focus of the Economic Appraisal Package is to explain the transport-related economic impacts of the Scheme and the methodologies adopted to derive these from the relevant transport inputs. The report should provide the TPG Business Partner with enough evidence to approve the analytic work. The Economic Appraisal Package should be produced in accordance with relevant guidance (such as WebTAG) and be proportionate to the requirements of PCF Stage 3.

Report structure

- 1.2.6 The structure of this Economic Appraisal Package follows the guidance given in Highways England's requirements as set out in Interim Advice Note (IAN) 106/08. No formal guidance on structure is given in WebTAG. Table 1-1 presents the structure from IAN 106/08 and provides cross-references to the relevant sections of this report.
- 1.2.7 The content required by the relevant sections (predominantly Chapters 12 and 13) of the standard Highways England ComMA report structure are appropriately captured in this document.

Table 1-1: Interim Advice Note 106/08 contents guide for EAR

Content	Report Section	Comment
Study overview		
Statement of scheme objectives.	§2.1, §2.3	
Description of the purposes of the economic assessment process.	§2.4, §3	
Explanation of how the traffic model has been used in assessing the scheme(s).	§2.5	
Description of scheme being assessed, with reference to the 'Forecasting Report'	§2.1	
Plan showing schemes being assessed.	§2	Figure 2-1 and Figure 2-2 provide an overview of the scheme alignment
Economic Assessment Approach		
Description of the economic assessment process - Reference which components of benefits are estimated using TUBA/COBA, QUADRO and INCA.	§3	
Description of methods used to represent variable demand responses including details of initial assessment using elasticity based calculation and reason for using full VADMA or simple elasticity approach.	§3.3	§3.3 provides a summary, with greater detail on variable demand modelling covered in the Transport Model Package, Appendix B to the Combined Modelling and Appraisal Report, and Transport Forecasting Package, Appendix C to the Combined Modelling and Appraisal Report (Application Document 7.5)
Estimation of Costs		
Statement of DS costs (and DM costs) and their source.	§4.2	
Implication for tax revenues, grants and subsidies.	§4.3	
Details of risk and optimism bias.	§4.4	
Calculation of maintenance costs.	§4.5	
Estimation of Benefits		

Content	Report Section	Comment
Explanation of the use of TUBA and/or COBA and with reference to why the software was chosen.	§5.2, §5.3	§5.2 provides a brief summary of the software used.
Explanation of travel time savings calculation giving assumptions on vehicle-purpose splits used and factoring process etc.	§5.3	
Detailed explanation of the derivation of vehicle operating cost savings and identification of where these are occurring.	§5.3	
Detailed explanation of the derivation of accident cost savings including description of source and extent of existing accident data, methodology for calculation of local accident rates and location of accident benefits.	§5.4	
Detailed explanation of the incident savings	§5.7	
Detailed explanation of the derivation of construction and maintenance benefits.	§5.5	
Economic Assessment Results		
Definition of price base and year to which costs and benefits are discounted.	§6.2	
Profile of benefits over the 60 years, to highlight whether the benefits occur earlier in the schemes life.	§6.4	
Profiles of benefits split by time period to highlight whether the benefits are from the peaks or inter-peak periods.	§6.5	
Presentation of travel time and vehicle operating results.	§6.6	
Presentation of accident results including numbers, severity and cost in worksheet.	§6.8	
Presentation of delay due to construction and maintenance results.	§6.9	
Presentation of incident results.	§6.14	
Presentation of results in a Transport Economic Efficiency (TEE) Table.	§6.11	
Presentation of results in Public Accounts (PA) Table.	§6.12	
Presentation of cost/benefit results in Analysis of Monetised Costs and Benefits Table (AMCB). Including the inclusion of environmental benefits (if calculated).	§6.13	
Summary		
Summary of economic assessment process and discussion of results.	§8.1, §8.2	

Content	Report Section	Comment
Where alternatives are being considered provide a recommendation on which alternative provides best economic justification, considering the study/scheme objectives.	N/A	This is a PCF Stage 3 report considering the Preferred Route to be submitted to DCO. Options previously appraised at PCF Stage 2.

1.2.8 Following this introductory chapter, the remainder of this Economic Appraisal Package is structured as follows:

- a. Chapter 2 - Study overview
- b. Chapter 3 - Economic assessment approach
- c. Chapter 4 - Estimation of costs
- d. Chapter 5 - Estimation of benefits
- e. Chapter 6 - Economic assessment results
- f. Chapter 7 - Sensitivity testing
- g. Chapter 8 - Summary

1.2.9 A list of abbreviations and glossary of terminology can be found at the end of this document. This consolidates key acronyms noted and previously expanded in the main text of this report.

1.2.10 This report concludes with a number of appendices, as follows:

- a. Appendix A – Sectors used for TUBA
- b. Appendix B – Sectorised TUBA outputs
- c. Appendix C – TUBA Economic Parameter File
- d. Appendix D – COBA-LT Economic Parameter File
- e. Appendix E – Sectorised WITA outputs
- f. Appendix F – TUBA sensitivity test distributional benefit plots
- g. Appendix G – Environment summary tables
- h. Appendix H – Valuing Heritage Impacts report
- i. Appendix I – Willingness to Pay study and quality assurance
- j. Appendix J – Derivation of costs

1.3 Complementary reports

1.3.1 Whilst this report can be read in isolation, it is recommended that this report be read in conjunction with the Combined Modelling and Appraisal Report (Application Document 7.5) and its Appendices. This will provide the full scope of the traffic modelling and economic appraisal work undertaken.

1.3.2 This Economic Appraisal Package is one of a number of Appendices to the Combined Modelling and Appraisal Report (Application Document 7.5) as follows:

- a. Transport Data Package, Appendix A to the Combined Modelling and Appraisal Report;
- b. Transport Model Package, Appendix B to the Combined Modelling and Appraisal Report;
- c. Transport Forecasting Package, Appendix C to the Combined Modelling and Appraisal Report; and
- d. Economic Appraisal Package, Appendix D to the Combined Modelling and Appraisal Report.

Western section

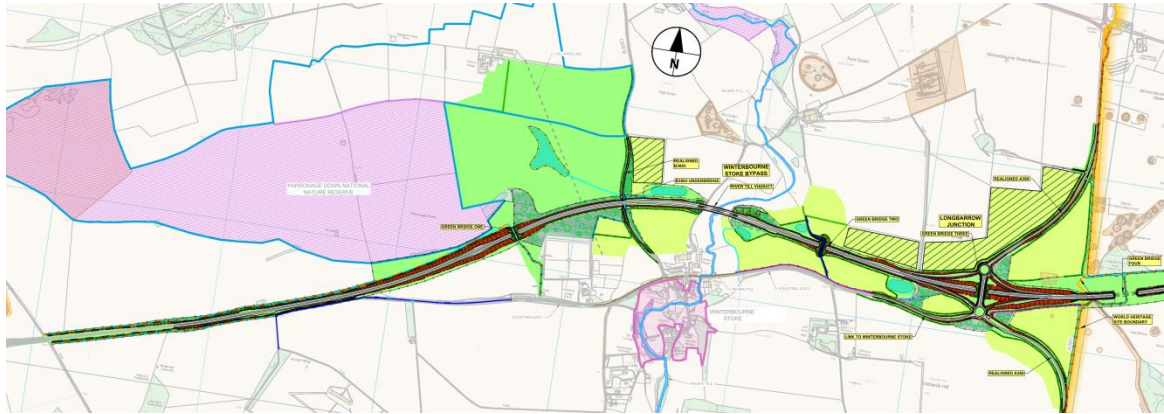


Figure 2-2: Western section

- 2.1.3 The Scheme would commence on the existing A303 approximately at Yarnbury Castle and would closely follow the existing A303 alignment, south of Parsonage Down NNR. It would then continue in a north easterly direction providing a bypass to the north of the village of Winterbourne Stoke.
- 2.1.4 A 'green bridge' would be constructed over the new A303 north-west of Scotland Lodge Farm near the south-east corner of Parsonage Down. This bridge would provide ecological and landscape connectivity across the Scheme and would form part of a non-motorised user (NMU) route and agricultural access route which would run from adjacent to a layby on the existing A303 to Parsonage Down and Yarnbury Castle. An area east of Parsonage Down would be used to create chalk grassland habitat using excavated chalk material arising from construction.
- 2.1.5 Local access from Winterbourne Stoke, northwards towards Shrewton, would be provided by the B3083. This access would be maintained by the provision of a single span bridge to carry the new A303 over the B3083. The proposed new bridge would be located approximately 50m to the west of the existing B3083. This location would necessitate the realignment of some 400m of the B3083 but would enable the B3083 to be kept open to traffic throughout the construction period other than for discrete periods to allow short duration specific activities to be undertaken (e.g. construction of tie-ins etc.). The clear span of the bridge would accommodate both the re-aligned B3083 and a segregated verge on the east side to allow cattle movements and equestrian use across the new alignment. The minimum headroom would be 5.35m.
- 2.1.6 The Scheme would continue in an easterly direction, crossing the River Till valley on a new twin deck viaduct. The River Till viaduct would carry the proposed A303 over the River Till SAC and SSSI and its floodplain. The viaduct would be designed to minimise impacts on the river below while balancing other environmental considerations, such as landscape and visual impacts. It would be a twin deck structure, with each deck approximately 14m wide and 210m long, and with a gap of approximately 7m between the decks. The road level on the bridge would be approximately 10m above the River Till where it crosses the river channel. The location of the piers would not be within the SAC or SSSI and would allow the existing bridleway (WST04) from Winterbourne Stoke to remain at its current location. An environmental screen, approximately 1.5m in height, would be installed on the southern parapet to help screen vehicle movements from locations to the south.

- 2.1.7 A second green bridge at the Winterbourne Stoke Public Right of Way (PRoW) WST06B would maintain the existing PRoW over the new A303 alignment and as with other green bridges would provide for ecological and landscape connectivity across the Scheme.
- 2.1.8 Continuing to the east, the Scheme would cross the line of the existing A303 approximately 700m west of the existing A360 Longbarrow roundabout. A new grade separated junction with the A360 is proposed to the west of the WHS boundary. This junction, known as the Longbarrow junction, would accommodate free-flowing traffic movements between the A360 and the A303. The junction would consist of two roundabouts connected by a short length of dual carriageway, carried over the A303 on a new green bridge with earth bunds on each side, to help mitigate visual impact and to provide ecological connectivity. The structure would be a single span bridge, with headroom of at least 5.35m. The roundabouts would be set below existing ground level.
- 2.1.9 Traffic lights would be required at the Longbarrow junction. The traffic lights could be used during both day and night. A link to the de-trunked A303 to the west, accessing Winterbourne Stoke, would also be provided from the new Longbarrow junction.

Central section



Figure 2-3: Central section

- 2.1.10 As the Scheme crosses the line of the existing A360, it would enter into the WHS where it then follows closely the line of the existing A303.
- 2.1.11 The proposed alignment over the first c.1.0km of this section would generally be in a cutting varying in depth between approximately 7m and 10m. Approximately 2.5m to the top of the cutting would have a 1 in 2 grassed slope. The bottom of the cutting would comprise vertical retaining walls.
- 2.1.12 However, shortly after entering the WHS there would be a further green bridge (also known as a 'land bridge') that would be approximately 150m in length and would start approximately 150m from the western boundary of the WHS. In addition to an NMU route, this bridge would also provide visual and landscape connectivity between barrow groups to the north and south of the Scheme. The existing A303 through the WHS would be converted to a restricted byway.
- 2.1.13 The western tunnel portal would be located within the WHS, north west of Normanton Gorse, approximately 1.0km east of the existing Longbarrow

roundabout and immediately to the south of the existing A303. The tunnel would commence with a fully grassed approximately 200m long over cut and cover tunnel before it becomes a bored tunnel. Tunnel service buildings would be located outside the tunnel portal.

- 2.1.14 The Scheme would then continue in tunnel in an easterly direction following an alignment that is broadly similar to the existing A303 but at a depth of up to approximately 50m.
- 2.1.15 The tunnel would be a twin-bore structure, approximately 1.9 miles (approximately 3 km) in length, and each tunnel bore would have an internal diameter of approximately 11.5m.
- 2.1.16 The two bores would be connected underground by a series of cross passages at regular intervals to allow for the safe evacuation of road users in the event of an incident in one of the bores.
- 2.1.17 The tunnel would contain a number of mechanical and electrical, operational and safety systems. The items of plant required to power and control these systems would predominantly be housed at the tunnel service buildings located outside of the tunnel.
- 2.1.18 The tunnel would emerge at the eastern tunnel portal through a short section of cut and cover tunnel approximately 85m in length extending eastwards from the bored tunnel section. The eastern tunnel portal would be located to the east of the King Barrow Ridge and The Avenue and just to the north of the existing A303. The portal approach would be in deep cutting formed with 1 in 2 grassed slopes.
- 2.1.19 The Scheme would then closely follow the line of the existing A303 to Countess roundabout.

Eastern section

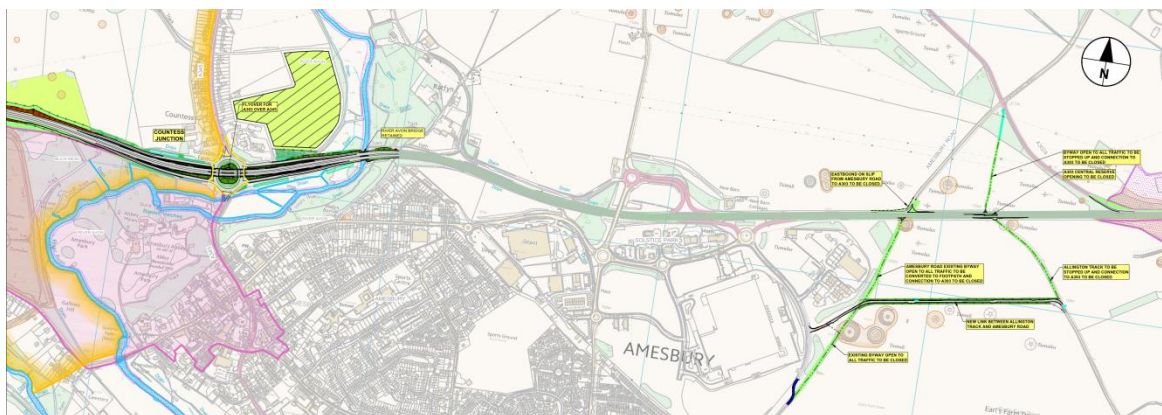


Figure 2-4: Eastern section

- 2.1.20 A new flyover above the existing roundabout would separate traffic going east-west along the A303 from traffic going north-south along the A345 Countess Road, with slip roads accommodating traffic movements between the two roads. The new flyover would include two single span bridges that would accommodate the existing roundabout traffic lanes. The minimum headroom of the bridges would be 5.35m.

- 2.1.21 Retaining walls would be required at this junction to support the A303 between the slip-roads. Noise barriers, approximately 1.8m high, would be installed along both sides of the flyover to help screen vehicles and to help attenuate vehicle noise at nearby houses.
- 2.1.22 There are two existing subways between the proposed eastern tunnel portal and Countess junction, which would be removed. Two new pedestrian crossings would be created around the existing Countess roundabout to provide north-south connectivity along Countess Road under the A303.
- 2.1.23 The Scheme would tie in with the existing A303 close to the existing River Avon Bridge, to the west of Solstice Park junction.
- 2.1.24 To the east of the Solstice Park junction there would be a number of changes to existing rights of way and to points of access to and from the A303.

2.2 Status of the Scheme

- 2.2.1 The A303 Amesbury to Berwick Down scheme is being developed by Highways England (the applicant) as part of its responsibility to deliver the RIS and to operate, maintain and modernise the Strategic Road Network (SRN).
- 2.2.2 The Scheme is currently nearing the end of Stage 3 of Highways England's Project Control Framework process for the delivery of Major Projects. This is also known as the Development phase. The Scheme is one of three schemes being taken forward as part of Highways England's Major Project's Complex Infrastructure Programme (CIP), based on its scale and value. The Scheme has 'Tier 1' status at the Department for Transport (DfT).
- 2.2.3 PCF Stage 3 will culminate with an application to the Planning Inspectorate (PINS) for a Development Consent Order (DCO). This is expected in Autumn 2018.

2.3 Statement of scheme objectives

- 2.3.1 Objectives for the Scheme have been formulated both to address identified problems and to take advantage of the opportunities the new infrastructure would provide. The objectives are defined in the Department for Transport's (DfT's) Client Scheme Requirements (CSRs) which respond directly to the need for change:
 - a. **Transport:** To create a high quality route between the South East and the South West that meets the future needs of traffic;
 - b. **Economic Growth:** To enable growth in jobs and housing by providing a free flowing and reliable connection between the South East and the South West;
 - c. **Cultural Heritage:** To help conserve and enhance the World Heritage Site (WHS) and make it easier to reach and explore; and
 - d. **Environment and Community:** To improve biodiversity and provide a positive legacy for nearby communities.

2.4 Economic assessment purpose

- 2.4.1 An assessment of the transport related economics is required in order to:
- assess the impact of the transport element of the Scheme in terms of benefit to the economy through reduced congestion on the A303 corridor;
 - quantify the wider economic benefits of the Scheme, reflecting the importance of the A303 to regional and national economies; and
 - allow for the presentation of transport related benefits in terms of social factors.

2.5 Traffic modelling

Introduction

- 2.5.1 Traffic modelling has been undertaken in order to assess the impacts of the Scheme on both the local area and wider regional networks. The vast majority of inputs to the economic assessment of the Scheme are derived from the 'A303 Stonehenge SWRTM (DCO)' traffic model.
- 2.5.2 This section provides a summary of the traffic modelling that has been used as a basis for the economic assessment of the Scheme. This section is not intended to provide detailed coverage of the traffic models, as comprehensive information can be found in the relevant Packages.
- 2.5.3 Further detail on the 'A303 Stonehenge SWRTM (DCO)' model can be found in:
- The Transport Model Package, Appendix B to the Combined Modelling and Appraisal Report (Application Document 7.5), which details the development of the Base Year 'A303 Stonehenge SWRTM (DCO)' model including the calibration and validation of the model to observed traffic counts and travel times; and
 - The Transport Forecasting Package, Appendix C to the Combined Modelling and Appraisal Report (Application Document 7.5), which provides information on the derivation of forecast traffic flows in the 'Do Minimum' and the impacts of the Scheme in the core scenario, as well as a discussion on the impacts in alternative growth scenarios.

Key features of the model

- 2.5.4 Pre-existing transport models of the local and regional area existed in the form of Highways England's South West Regional Traffic Model (SWRTM) and the model developed to assess scheme options at PCF Stage 2. Information from these models was augmented, particularly with the introduction of local demand data, local traffic counts and network refinements pertinent to the single scheme being taken forward at PCF Stage 3 (as described above).
- 2.5.5 Given the specific issues on the A303 caused by holiday traffic, a busy day period model was developed to cover the most congested periods during the year. The refined 'A303 Stonehenge SWRTM (DCO)' model therefore covers four main time periods, being: the neutral month AM, IP and PM average hours and the busy day average hour.

- 2.5.6 The model features an Area of Detailed Modelling (AoDM) specific to the single scheme option being appraised. This is the area over which impacts of the Scheme are likely to be significant. The refined AoDM extends north on the Salisbury Plain, north of Larkhill and Bulford, and south to the northern extents of Wilton and Salisbury. The eastern extent of the AoDM extends to the east of the A338, whilst the area extends towards Warminster in the west, incorporating the A36. This area is shown spatially in Figure 2-5.

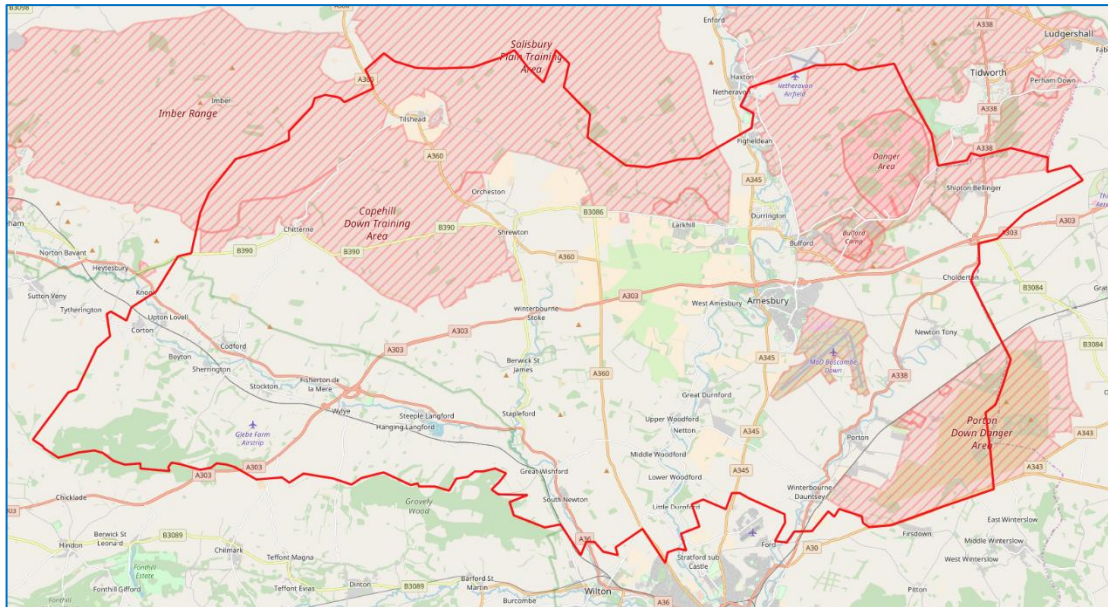


Figure 2-5: 'A303 Stonehenge SWRTM (DCO)' model – Area of Detailed Modelling

- 2.5.7 The base year of the model is 2017 and there are four time periods:
- neutral AM average hour (07:00 – 10:00);
 - neutral Interpeak average hour (10:00 – 16:00);
 - neutral PM average hour (16:00 – 19:00); and
 - 'busy day' average hour (10:00 – 19:00).
- 2.5.8 There are five user-classes in the traffic matrices, comprising three vehicle types:
- car business;
 - car commute;
 - car other;
 - light goods vehicles (LGV); and
 - heavy goods vehicles (HGV).
- 2.5.9 Generalised costs used to determine the routing of traffic in the model were based on the interim May 2018 WebTAG Databook. These interim values were provided by DfT reflecting the A303 Amesbury to Berwick Down scheme's Tier 1 project status and used in advance of the formal issuing of the May 2018 WebTAG Databook.

Base year calibration and validation

- 2.5.10 The validation of the base year trip matrices, following estimation, was demonstrated using the WebTAG screenline acceptability guidelines for the local AoDM. Comparing screenline performance against SWRTM for the wider fully modelled area for the neutral month time periods showed similar results, suggesting local demand refinements made no material change to the Fully Modelled Area.
- 2.5.11 Assignment calibration and validation for the neutral month time periods showed no material change in the Fully Modelled Area for either link flow validation or journey times compared to SWRTM. Against observed data in the AoDM, the refined model meets or exceeds WebTAG acceptability guidelines for individual link flow calibration, independent link and turning count validation and journey time route and segment validation.
- 2.5.12 The strategic models therefore provide a sound base from which to forecast the impacts of traffic growth and the Scheme and from which secondary analysis, such as skims for economic appraisal can be undertaken.

Forecasting

- 2.5.13 Forecast years have been developed for four years: 2026, 2031, 2041 and 2051. 2026 represents the Scheme Opening Year, whilst 2041 is the Design Year – 15 years after opening.
- 2.5.14 Car growth has been forecast through the use of National Trip End Model (NTEM) v7.2 datasets, with local redistribution in the Wiltshire Unitary Authority and Test Valley district undertaken based on housing and employment data provided by the authorities.
- 2.5.15 LGV and HGV growth has been forecast based on the National Transport Model (NTM) Road Traffic Forecasts 2015 (RTF15) Scenario 1 dataset.
- 2.5.16 The proximity of a number of army camps and the ongoing Ministry of Defence (MoD) rebasing programme has meant that additional allowance for trips has been made above-and-beyond that represented in NTEM. This is because barrack accommodation within the camp boundaries is not represented in NTEM.
- 2.5.17 Four sensitivity tests around the core scenario have been undertaken. These comprise:
- a. the standard WebTAG Unit M4 low growth scenario;
 - b. the standard WebTAG Unit M4 high growth scenario;
 - c. a scenario including the proposed Boscombe Down development east of Amesbury, which would provide an additional 7,500 jobs within the AoDM; and
 - d. a sensitivity test examining the impacts of an interim release of the DfT's revised Road Traffic Forecasts 2018 (RTF18), which provide lower freight vehicle forecasts than the 2015 dataset (RTF15) used in the core scenario. Additionally, this test incorporates the final May 2018 WebTAG Databook update.

3 Economic assessment approach

3.1 Introduction

- 3.1.1 Economic assessment is the determination of the benefits of a transport scheme using information on travel demand, traffic flows, journey times and other data derived from a transport model.
- 3.1.2 A Benefit to Cost Ratio (BCR) can be calculated from the economic assessment by comparing the scheme costs against the outturn benefits over a 60 year appraisal period. The value for money of the Scheme will consider these benefits together with other impacts.
- 3.1.3 Considering the nature of the A303 Amesbury to Berwick Down scheme and its potential impacts on the economy, environment, tourism and social well-being, the key transport benefits are likely to be derived from reductions to delays and improved travel times through the corridor.
- 3.1.4 Other transport-related benefits and disbenefits that are likely to be associated with the Scheme will arise from:
 - a. changes in the number of accidents;
 - b. changes in vehicle operating costs (VOCs);
 - c. changes in indirect taxes;
 - d. greenhouse gas emissions;
 - e. air quality and noise benefits;
 - f. social impacts; and
 - g. delays during construction.
- 3.1.5 As noted in the CSRs and the description of the Scheme set out in chapter 2, a key objective is to enhance the outstanding universal value of the Stonehenge and Avebury World Heritage Site. There are significant benefits associated with the Scheme and its enhancement of the heritage features of the site. Whilst the focus of this report is on the direct transport-related economic impacts of the Scheme, heritage related benefits are noted and discussed at a high-level, with supporting information from other reports given in appendices as relevant.
- 3.1.6 Travel time benefits, VOC benefits and changes in indirect tax are all calculated through a conventional transport user benefit appraisal. These benefits have been derived using the DfT's standard 'Transport Users Benefit Appraisal' (TUBA) software.
- 3.1.7 Benefits arising due to changes in the number and type of accidents have been appraised and quantified using the DfT's standard 'Cost and Benefit to Accidents – Light Touch' (COBALT) software.
- 3.1.8 An assessment of the environmental impacts of the Scheme, quantifying and monetising air quality and noise benefits where there are large forecast changes in traffic flows has been undertaken in line with WebTAG Unit A3 'Environmental Impact Appraisal'.

- 3.1.9 As detailed in WebTAG Unit A1.3 'User and Provider Impacts', costs to existing transport users due to the construction of a scheme and costs (or benefits) to users arising during future maintenance should be recorded in the economic assessment results where they are likely to be significant.
- 3.1.10 The construction of the Scheme is likely to lead to increased delays and travel times for users due to on-line working and reduced speed limits. The impacts of construction on transport users are assessed using the same transport models and appraisal processes as the conventional transport user benefit appraisal.
- 3.1.11 Whilst the impacts arising from construction have been assessed, the impact of the Scheme on routine maintenance has not been taken forward. Consultation with the solutions workstream noted that maintenance of the existing single lane section of the A303 would generally be undertaken overnight when affected traffic volumes are lower than in the modelled periods. Given the small number of users affected, the net economic consequence of routine maintenance is expected to be negligible. Thus the inclusion of these elements would not materially impact the expected value for money (VfM) of the Scheme.
- 3.1.12 Costs can be broken down into two types: scheme costs; and operation and maintenance costs. Scheme costs represent the total amount of money required to purchase land; plan and design the Scheme; construct the Scheme; and provide supervision during construction. Operation and maintenance costs relate to the cost of people, materials and machinery required to operate and maintain the Scheme after completion.
- 3.1.13 The Scheme could be publicly funded or financed through private finance mechanisms. A publicly funded scheme means that the public sector would assume all costs and risks associated with the Scheme. From the perspective of the public sector, a privately financed scheme would mean that the majority of the Scheme costs and risks would be borne and financed by the private sector and these would be met through a unitary charge for several years after construction.
- 3.1.14 Both costs and benefits are realised at different times during the appraisal period, both before and after scheme opening. Comparison of the total costs of the Scheme against the forecast benefits provides an assessment of the value for money.

3.2 Description of the economic assessment process

- 3.2.1 In accordance with WebTAG Unit A1.1 'Cost-Benefit Analysis' §2.1.1 the economic assessment period should be defined to capture the planned period of scheme development and implementation, ending 60 years after the Scheme Opening Year. The Opening Year for the A303 Amesbury to Berwick Down scheme is assumed to be 2026; therefore the appraisal period extends to the year 2085.
- 3.2.2 It should be noted that regular maintenance and renewal of the A303 Amesbury to Berwick Down scheme will take place, meaning that the lifetime of the asset would – in all likelihood – exceed the 60 year appraisal period. Whilst it is recognised that there is therefore residual value in the Scheme, this has not been assessed in accordance with guidance in WebTAG Unit A1.1.

- 3.2.3 In order to assess the economic benefits arising over the life cycle of the Scheme at least two forecast years should be used to interpolate and extrapolate impacts over the appraisal period as described in WebTAG Unit A1.1 §2.1.1. For the A303 Amesbury to Berwick Down scheme four forecast years have been defined, following TUBA guidance that suggests interpolation should occur for no more than ten years (leading to the modelling of an intermediate forecast year), and modelling a later year for extrapolation. The four forecast years are as follows:
- 2026 (the Scheme Opening Year);
 - 2031 (intermediate Forecast Year);
 - 2041 (the Scheme Design Year – 15 years following opening); and
 - 2051 (TEMPro¹ Horizon Year).
- 3.2.4 The impacts of the Scheme are based on the difference between forecasts of the without-scheme (Do-Minimum) and with-scheme (Do-Something) scenarios. The benefits arising due to these changes are interpolated between each of the forecast years and extrapolated from the final forecast year to cover the whole appraisal period. The extrapolation of the Horizon Year benefits up to the year 2085 assumes zero growth in the magnitude of impacts.
- 3.2.5 Costs and benefits occur in different years throughout the appraisal period. Benefits are realised in the sixty years following the implementation of the Scheme. As noted above, it is assumed that the Scheme could be financed through public sector funding or private finance mechanisms.
- 3.2.6 A publicly funded solution would require up-front investment in preliminary works and construction costs prior to scheme opening with regular operational and maintenance expenditure occurring for the remainder of the appraisal period following scheme opening.
- 3.2.7 A privately financed scheme would mean that the majority of cost to the public sector would be realised throughout the appraisal period. The contracted firm would assume the majority of the up-front costs with unitary charges being paid by Highways England for the remainder of any PF2 contract post opening, and regular public sector operational and maintenance expenditure assumed to continue beyond 2051.
- 3.2.8 There is also significant evidence to suggest that costs and benefits which accrue now are considered to be worth more than those which accrue in the future.
- 3.2.9 In order to compare benefits and costs it is therefore essential that they are converted to a common price base and value, known as a Present Value Year. For the A303 Amesbury to Berwick Down scheme assessment, a Present Value Year of 2010 has been used as advised by WebTAG.
- 3.2.10 Adjusting benefits and costs from a 2010 price base to a 2010 present value, a process called discounting, is done within TUBA. This uses the standard DfT discount rates of 3.5% per year for the first thirty years following 2018 (appraisal date) and then at 3.0% per year for the remainder of the appraisal period.

¹ Trip End Model Programme (TEMPro). Department for Transport.

- 3.2.11 Scheme costs can also be defined in a different price base to the 2010 price base used for this assessment. For this assessment, costs have been input in 2010 prices, in line with WebTAG Unit A1.2 §A4.1.
- 3.2.12 It is also important that the unit of account is consistent between costs and benefits. The two different units of account are market prices and factor costs. Market price unit of account includes indirect taxation and reflects the prices paid for services by consumers. Factor cost unit of account excludes indirect taxation and is usually used for prices paid by the Government and business.
- 3.2.13 As the scheme benefits – calculated by TUBA – are in the market price unit of account, the scheme costs must also be in the market price unit of account. Scheme costs have additionally been converted into the market price unit of account following guidance in WebTAG.
- 3.2.14 Figure 3-1 presents the inputs and outputs into the economic assessment and calculation of the BCR for the A303 Amesbury to Berwick Down scheme. Assumptions surrounding the responsibility of capital and operating costs and risk depend on the financing strategy chosen for the Scheme. The assessment in this Economic Appraisal Package presents the impact of the Scheme against estimated costs for both publicly funded and privately financed solutions.

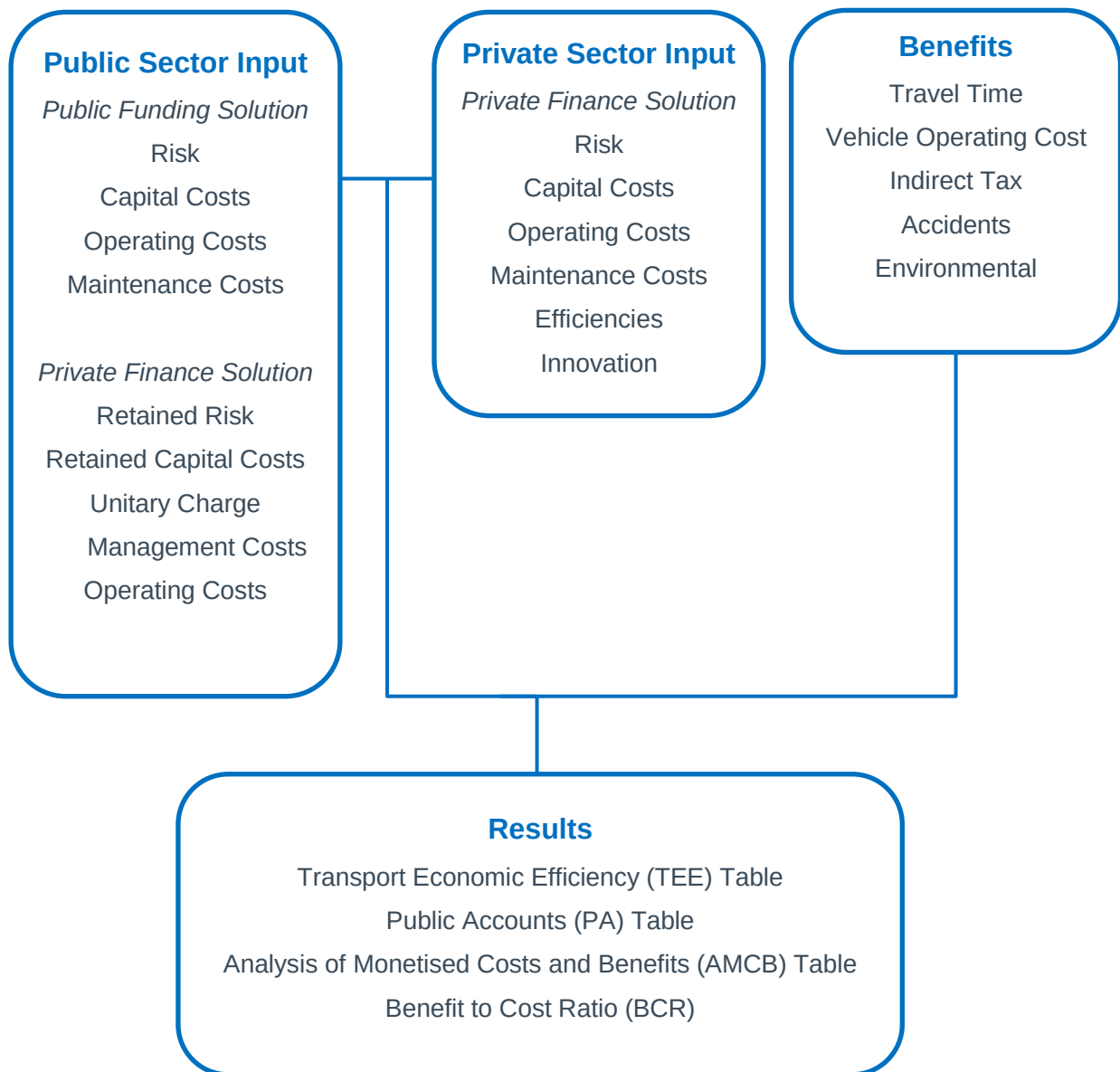


Figure 3-1: Transport-related economic assessment inputs and outputs

3.2.15 The economic assessment has been undertaken in accordance with the following WebTAG Units:

- WebTAG Unit A1.1 'Cost-Benefit Analysis';
- WebTAG Unit A1.2 'Scheme Costs';
- WebTAG Unit A1.3 'User and Provider Impacts';
- WebTAG Unit A2.1 'Wider Impacts';
- WebTAG Unit A3 'Environmental Impact Appraisal'; and
- WebTAG Unit M4 'Forecasting and Uncertainty'.

3.3 Use of variable demand modelling

Introduction

3.3.1 As discussed in WebTAG Unit M1.1 'Principles of Modelling and Forecasting', variable demand modelling (VDM) should be considered in the appraisal of a transport scheme. Any change to transport conditions will, in principle, cause a

change in demand which can be predicted and quantified through the application of a variable demand model.

- 3.3.2 Implementing a transport scheme will result in faster or slower, cheaper or more expensive journeys and this will be reflected in the generalised cost – the sum of time and money costs – of a trip.
- 3.3.3 In the case of the A303 Amesbury to Berwick Down scheme, delays on the A303 are reduced meaning travel time for those travelling by car are reduced. The traffic forecasts represent an equilibrium reflecting the balance of journey time savings delivered by the Scheme and arising from changes in travel demand and the forecast demand responses.
- 3.3.4 Therefore changes in demand can have fundamental implications for the justification of the Scheme in terms of economic, environmental and social impacts. As the section below outlines, the demand responses relating to the Scheme have been appropriately assessed in the design of the base year model and forecasting methodologies.

Variable demand modelling methodology

- 3.3.5 During the development of the Regional Traffic Models (RTMs), the Highways England Integrated DIADEM Interface (HEIDI) was developed incorporating a variable demand modelling element using the DfT's Dynamic Integrated Assignment and Demand Modelling (DIADEM) software.
- 3.3.6 This common VDM approach adheres to WebTAG guidance where appropriate and models the key traveller choices of route, mode, destination and time of day. The development of the RTM VDM approach is detailed in the SWRTM Model Validation Report (document reference REP/MVR/001).
- 3.3.7 Calibration of the VDM was undertaken across all five of the RTMs and the resultant calibration parameter values justified at the total RTM level. The VDM has not therefore been recalibrated as part of the 'A303 Stonehenge SWRTM (DCO)' model refinement to a 2017 base year; instead realism testing has been undertaken to show that there are no material changes from the SWRTM calibrated model. This is detailed in the 'A303 Stonehenge SWRTM (DCO)' Transport Model Package, Appendix B to the Combined Modelling and Appraisal Report (Application Document 7.5).

4 Estimation of costs

4.1 Introduction

- 4.1.1 The estimation of the costs of transport schemes is a crucial part of the scheme appraisal process. As WebTAG Unit A1.2 notes, unrealistic cost estimates will adversely affect the robustness of the assessment of affordability and can result in an inappropriate value for money (VfM) statement.
- 4.1.2 This chapter sets out the key elements of the scheme cost estimate developed for the A303 Amesbury to Berwick Down scheme. This includes the estimate of the base costs and any allowances for risk and optimism bias adjustment. Appendix J presents the cost estimates supplied for the economic appraisal, and the interpretation of these costs, for the A303 Amesbury to Berwick Down scheme.
- 4.1.3 It should be noted that the costs used in scheme appraisal are adjusted to the DfT's standard Present Value Year for appraisal, 2010. This ensures consistency with the assessment of scheme related benefits.

4.2 Statement of costs

- 4.2.1 The Scheme could be taken forward via private finance funding (PF2) mechanisms or could be funded directly by the public sector. Costs associated with both of these scenarios have been assessed from the perspective of the public sector to present the benefit to cost ratio and value for money of the Scheme.
- 4.2.2 A publicly funded solution would require upfront expenditure for preliminary works and to construct the Scheme. Highways England would assume responsibility for all risks associated with the Scheme and be responsible for all operational and maintenance expenditure.
- 4.2.3 A privately financed solution, through PF2 mechanisms, would mean that Highways England would fund the Scheme through the payment of a unitary charge to a Design, Build, Finance and Maintain (DBFM) contractor over a period of about 25 years post scheme opening. It is assumed that Highways England would also retain the cost of preliminary works during construction, a negotiated share of risk, and some operating and maintenance costs. After expiration of the PF2 contract, it is assumed that Highways England would assume responsibility for the full cost of operating and maintaining the Scheme.
- 4.2.4 Highways England's commercial services standard work breakdown structure has been used to estimate the capital cost associated with the Scheme. Surface work costs have been developed through the Highways England standard rate database, which has been built up using actual costs from other projects, in accordance with its established estimating process. As this database does not cover tunnelling works, an estimate for the Scheme was produced using a project specific and detailed work breakdown structure consistent with other tunnelling projects Highways England are currently involved with.
- 4.2.5 All costs have been estimated at Q1 2016 real prices and inflation applied using Highways England's inflation forecast using the standard inflation profile. This

inflation profile is applied to all Major Projects and has been derived in conjunction Highways England Capital Planning with the aim of consistent and realistic capital forecasts. This inflation profile includes defined GDP deflators, which represent the change in the inflation index over time and are used to convert 'nominal' prices to 'real' prices for comparison. As shown in Table 4-1 these deflators do not exactly equate to the deflators presented in the interim WebTAG Databook, used during appraisal of the transport user benefits, or the latest May 2018 WebTAG Databook values, reflecting the time at which information was used and the assessments were undertaken.

Table 4-1: Comparison of GDP deflators

Year	Interim Advice Databook GDP Deflator	Highways England CapEx & OpEx GDP Deflator	% Difference to Interim	May 2018 Databook GDP Deflator	% Difference to Interim
2010	100.00	100.00	0.0%	100.00	0.0%
2016	110.04	108.83	-1.1%	110.01	0.0%
2026	132.45	134.17	1.3%	132.82	0.3%
2031	147.67	150.32	1.8%	148.08	0.3%
2041	183.57	188.71	2.8%	184.08	0.3%
2051	228.20	236.89	3.8%	228.84	0.3%

- 4.2.6 The costs used to determine the benefit to cost ratio and value for money are based on the Scheme promoted through the DCO process. This scheme includes heritage mitigation with an approximately 150m wide green bridge and canopy and vertical retaining walls at the western end of the tunnel.

4.3 Implications of tax revenue, grants and subsidies

- 4.3.1 Should the financing strategy for the Scheme result in the procurement through private finance (PF2) mechanisms, it is assumed that, under this scenario, the Government would receive increased revenue from Corporation Tax. This would be realised during the lifetime of any PF2 contract, as Highways England pays an annual unitary charge to the private DBFM contractor. This increased revenue is captured in the Public Accounts (PA) and Analysis of Monetised Costs and Benefits (AMCB) tables as changes in indirect tax revenue for the privately financed solution.

4.4 Risk and optimism bias

- 4.4.1 As described in WebTAG Unit A1.2 §3.5, optimism bias is the demonstrated systematic tendency for appraisers to be overly optimistic about scheme costs and suggests that uplifts should be applied to the estimates of costs to account for the repeat of historically observed cost overruns.
- 4.4.2 An allowance for risk and optimism bias has been included in the cost estimate. Both portfolio (programme) level risks – risks which affect all projects being developed by Highways England – and project specific risks have been considered and valued in accordance with the Highways England cost manual.

- 4.4.3 Therefore the separate application of an optimism bias uplift factor is not necessary for the value for money assessment for the Scheme.
- 4.4.4 In addition, cost range estimates have been informed using the outputs of the risk assessment. These produce low and high cost forecasts, P10 and P90, which indicate the values at which there is a 10% chance the cost will end up lower or higher respectively.

4.5 Maintenance costs

- 4.5.1 It is assumed that Highways England would have full responsibility for all operational and maintenance costs should the Scheme be publicly funded. These costs would be realised, in varying amounts, throughout the appraisal period following the opening of the Scheme.
- 4.5.2 Under a private financing strategy, it is assumed that the majority of operating and maintenance costs would be borne out by the DBFM contractor during the lifetime of the contract. It is also assumed that Highways England would retain a small annual cost to pay for traffic officers and other related operating costs. Upon the expiration of the PF2 contract, it is assumed that Highways England would assume full responsibility for operating and maintaining the Scheme and therefore would pay the full operating and maintenance costs for the remainder of the appraisal period.
- 4.5.3 It is assumed that there is a cost saving to Highways England arising from the removal of the current A303 carriageway. Some maintenance cost is also assumed to be transferred to the local highway authority for the section of A303 through Winterbourne Stoke, which will be de-trunked upon completion of the Scheme.

4.6 Present Value of Costs

- 4.6.1 The estimated annual cost profile of the Scheme in 2010 market prices discounted to 2010, assuming the total cost of the Scheme is met in full through public sector funding, is shown in Figure 4-1. The publicly funded solution requires investment of approximately £1 billion, in 2010 market prices discounted to 2010 values, prior to scheme opening to finance preliminary works and construction costs. Operational and maintenance (O&M) costs begin from scheme opening in 2026 and are realised for the remainder of the appraisal period.

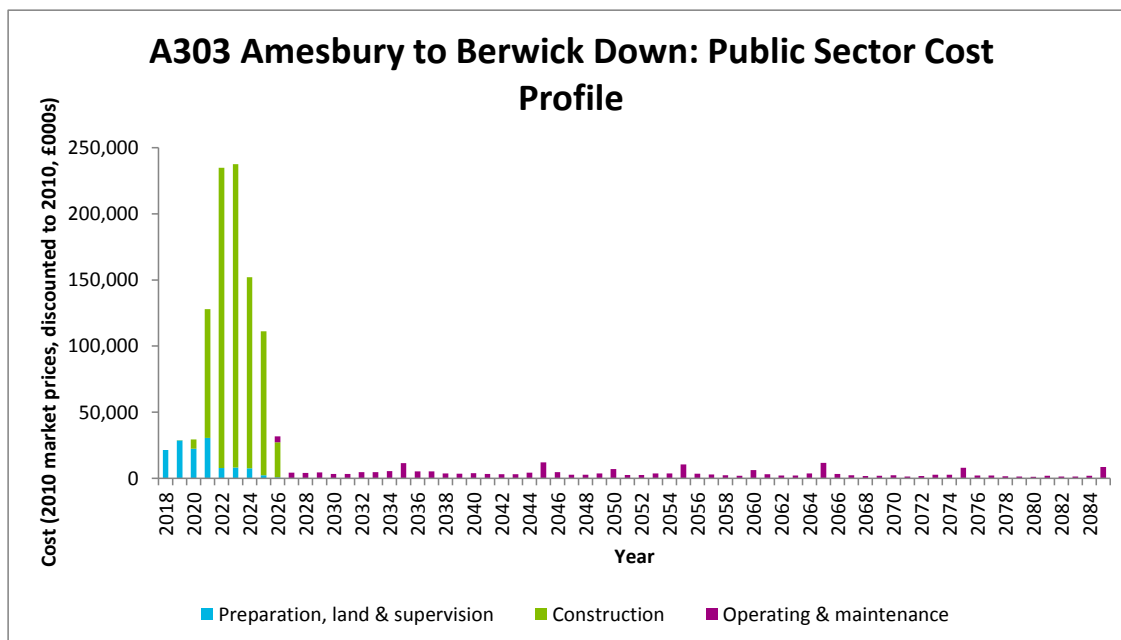


Figure 4-1: Cost profile of publicly funded scheme

4.6.2 Figure 4-2 presents the estimated annual cost profile of the Scheme in 2010 market prices discounted to 2010, should the Scheme be funded through PF2 mechanisms. The unitary charge of approximately £130 million per year (in 2016 factor prices) from 2026 to 2051 can be seen, although decreasing in value in real, discounted terms. Due to the operating and maintenance (O&M) cost savings realised by Highways England throughout any PF2 contract, there are assumed to be some small O&M cost savings during this period.

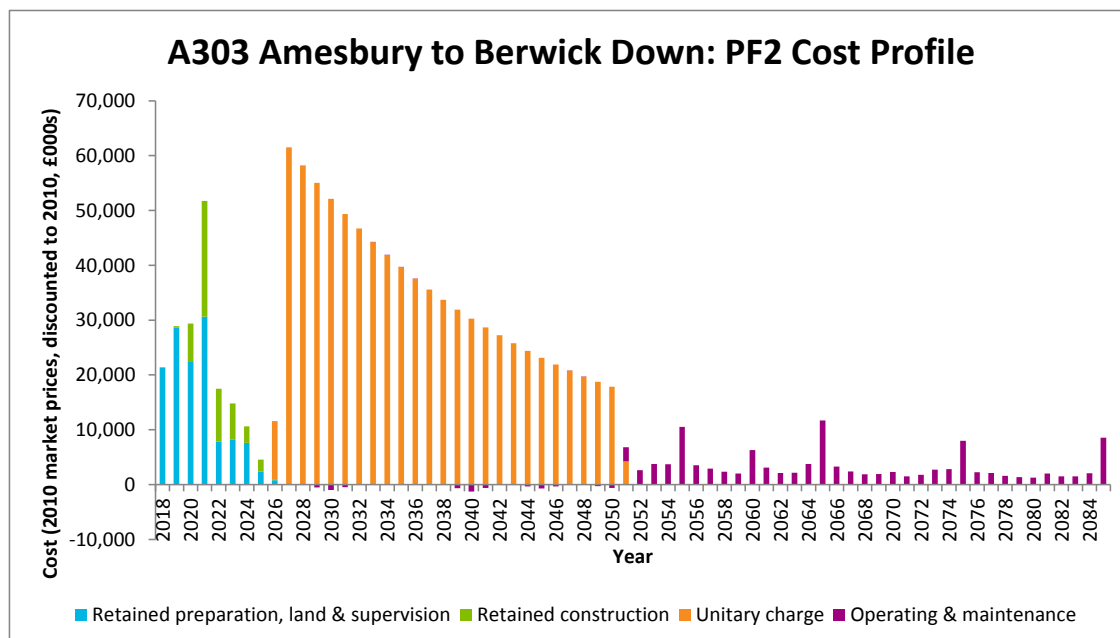


Figure 4-2: Cost profile of privately financed scheme

4.6.3 The Present Value of Costs (PVC) converted to 2010 prices, discounted to 2010 values and converted to the market price unit of account are summarised in Table 4-2 for both the publicly funded and the privately financed solution.

Table 4-2: Scheme Present Value of Costs (£ million)

Cost Element	Public Sector Cost	PF2 Cost
Capital Expenditure	970	0
Retained Capital Expenditure	0	180
Unitary Charge	0	860
Operating Expenditure	235	109
Total	1,206	1,149

Presented in 2010 prices, discounted to 2010. Market price unit of account. Costs are rounded to nearest million.

5 Estimation of benefits

5.1 Introduction

- 5.1.1 This chapter sets out the methodologies and assumptions used for the estimation of the various elements comprising transport user benefits.
- 5.1.2 Key software packages used in the estimation of benefits, parameters used and scenarios modelled are set out. The results from this estimation exercise are given in chapter 6.
- 5.1.3 For each of the different types of benefit detailed, their status within the economic assessment (initial BCR, adjusted BCR or sensitivity test) and whether or not they are monetised is noted.

5.2 Software

- 5.2.1 A number of different software packages have been used in the estimation of economic benefits attributable to the traffic-related elements of the Scheme. Aside from standard Microsoft Office packages used for data and model analysis, key specialist software used is given below:
 - a. SATURN² version 11.3.12W
 - i. An industry standard highway assignment modelling package, used in the development of the RTMs and in many other UK-based highway models. This is the software used for the 'A303 Stonehenge SWRTM (DCO)' model.
 - b. TUBA³ version 1.9.10
 - i. TUBA is the UK industry standard economic appraisal software developed on behalf of the DfT to appraised multi-modal transport studies.
 - ii. Assessment is undertaken in accordance with WebTAG Unit A1.1 'Cost Benefit Analysis' and the relevant WebTAG Databook.
 - iii. An interim version of the May 2018 WebTAG Databook and corresponding interim economics parameter file was used with this version of TUBA to approximate the impacts of the forthcoming TUBA 1.9.11 release. The interim economics parameter file was supplied by the DfT.
 - c. TUBA version 1.9.11
 - i. This updated version of TUBA is consistent with the WebTAG Databook released in May 2018 and for which an associated sensitivity test – outlined in chapter 7 – has been undertaken.
 - d. COBA-LT⁴ version 2013.2
 - i. COBA-LT is a Microsoft Excel based tool developed by the DfT to undertake the analysis of the impact of a road scheme on accidents.

² Simulation and Assignment of Traffic to Urban Road Networks (SATURN), developed by Dirck van Vliet, WS Atkins and ITS Leeds.

³ Transport Users Benefit Appraisal (TUBA), developed for Department for Transport.

⁴ Cost and Benefit to Accidents – Light Touch, developed by Department for Transport.

- ii. COBA-LT assesses the road safety aspects of the Scheme through comparison of accidents by severity in the 'without scheme' and 'with scheme' forecasts.
 - iii. Appraisal is undertaken in accordance with guidance in WebTAG Unit A1.1 'Cost Benefit Analysis' and the relevant WebTAG Databook.
 - e. WITA⁵ version 1.2 Beta (January 2015)
 - i. WITA is software developed on behalf of the DfT for the assessment of wider impacts.
 - ii. Assessment is undertaken in accordance with WebTAG Unit A2.1 'Wider Impacts'.
 - f. ArcGIS versions 10.3 and 10.4
 - i. Used for Geographical Information Systems (GIS) analysis supporting analysis and display of model and economic outputs.
 - g. Microsoft Excel versions 2010, 2013 and 2016
 - i. Used for the processing and factoring of cost information into the required price base and units for use in economic appraisal.
 - ii. Used for the processing of inputs into COBA-LT.
 - iii. Used for the analysis of outputs from TUBA and WITA.
- 5.2.2 Where relevant in the below sections, detailed information is provided on how the software have been used, along with descriptions and explanations of parameters.

5.3 Travel time and vehicle operating cost benefits

Introduction

- 5.3.1 Transport Economic Efficiency (TEE) benefits are derived from forecast travel time, vehicle operating cost and user charge changes during construction and normal operation after the opening of the Scheme.
- 5.3.2 The remainder of this section sets out the assumptions and methodologies employed in order to use data from the 'A303 Stonehenge SWRTM (DCO)' model for the appraisal of travel times and VOC impacts of the Scheme.

Status and monetisation

- 5.3.3 Both travel time and VOC benefits are monetised and included in the initial BCR, the measure of value for money of the Scheme when only transport user benefits are considered. They are recorded in the TEE table.

Forecast years, scenarios and appraisal period

- 5.3.4 As noted in the Transport Forecasting Package, Appendix C to the Combined Modelling and Appraisal Report (Application Document 7.5), four separate forecast years have been modelled:
 - a. 2026 (the Scheme Opening Year);
 - b. 2031 (intermediate Forecast Year);

⁵ Wider Impacts in Transport Appraisal (WITA), developed for Department for Transport.

- c. 2041 (the Scheme Design Year – 15 years following opening); and
- d. 2051 (TEMPro⁶ Horizon Year).

- 5.3.5 The appraisal of benefits has focussed on the core scenario. Detailed information on networks and planning data comprising the core scenario have previously been set out in the Transport Forecasting Package, Appendix C to the Combined Modelling and Appraisal Report (Application Document 7.5), and associated Uncertainty Log.
- 5.3.6 In addition to the core scenario, sensitivity testing has been undertaken to reflect uncertainty in the model inputs. In accordance with guidance given in WebTAG Unit M4 'Forecasting and Uncertainty', both high and low growth sensitivity tests have been undertaken.
- 5.3.7 Additionally, an alternative scenario has been modelled whereby a large proposed development at the Ministry of Defence (MoD) site at Boscombe Down has been included. The development at Boscombe Down – at the time of undertaking the traffic modelling and appraisal – was classified as 'hypothetical' in accordance with definitions of uncertainty given in WebTAG Unit M4. However, given the large size of the proposed site and proximity to the A303, it was felt necessary to undertake an assessment of its potential impacts on the A303 Amesbury to Berwick Down scheme.
- 5.3.8 Details on the assumptions used to define the alternative scenario are given in the Transport Forecasting Package, Appendix C to the Combined Modelling and Appraisal Report (Application Document 7.5). Appraisal of the A303 Amesbury to Berwick Down scheme in both the high and low growth sensitivity tests and the alternative Boscombe Down scenario has been undertaken in TUBA.
- 5.3.9 A further sensitivity test has been undertaken, reflecting the release of new information by DfT following completion of the core forecasts and alternative growth scenarios. In May 2018, the DfT released an updated version of the WebTAG Databook which differed from the interim release provided by DfT earlier in the year. Further to this, the DfT provided the A303 Amesbury to Berwick Down scheme with a draft of the latest 2018 Road Traffic Forecasts (RTF18) from its National Transport Model (NTM) in June 2018, which forecast different growth of goods vehicles from that given in the 2015 Road Traffic Forecasts (RTF15) used in the development of the core scenario. The details of these changes are again set out in the Transport Forecasting Package, Appendix C to the Combined Modelling and Appraisal Report (Application Document 7.5).
- 5.3.10 A standard 60 year appraisal period in-line with guidance in WebTAG Unit A1.1 and Her Majesty's (HM) Treasury's Green Book has been assessed. This starts at the Scheme Opening Year (2026) with a final assessment year of 2085.

Economic parameters

- 5.3.11 As noted in the Transport Model Package, Appendix B to the Combined Modelling and Appraisal Report (Application Document 7.5), both the 'A303 Stonehenge SWRTM (DCO)' model and HEIDI VDM have been calibrated and validated using generalised costs derived from an interim release of the WebTAG Databook.

⁶ Trip End Model Programme (TEMPro). Department for Transport.

Early access to the forthcoming May 2018 WebTAG Databook, in advance of its release, was provided by DfT given the A303 Amesbury to Berwick Down project's 'Tier 1' scheme status.

- 5.3.12 To ensure consistency in appraisal of the forecasts, the economic parameter file used by TUBA for the appraisal of the Scheme has made use of data from the interim May 2018 WebTAG Databook. TUBA 1.9.10 however, is based on the December 2017 WebTAG Databook and so the standard economic parameter file is not consistent with that used in the traffic model forecasts. An interim economic parameter file corresponding with the interim Databook was therefore provided direct by DfT which incorporated the relevant changes.
- 5.3.13 As noted in paragraph 5.3.9, an update to WebTAG was released at the end of May 2018. An associated update of TUBA (v 1.9.11) was released at the end of June 2018. It should be noted that the main assessment work used the information that was current at the time of the work being undertaken. A sensitivity test on the impact of the new Databook and TUBA version is documented in Chapter 7.

User classes

- 5.3.14 The 'A303 Stonehenge SWRTM (DCO)' model comprises five modelled user-classes:
- a. car business;
 - b. car commute;
 - c. car other;
 - d. light goods vehicles (LGV); and
 - e. heavy goods vehicles (HGV).
- 5.3.15 TUBA provides an assessment of benefits by journey purpose, split by vehicle type. The TUBA assessment of the Scheme has therefore been undertaken for seven user-classes, comprising:
- a. car business;
 - b. car commute;
 - c. car other;
 - d. LGV (non-work journey purposes);
 - e. LGV (work journey purposes);
 - f. Ordinary Goods Vehicle (OGV) type 1 (a subset of HGVs – typically Rigid 2 and 3 axle vehicles); and
 - g. OGV type 2 (a subset of HGVs – typically Rigid 4 axle vehicles and all articulated HGVs).
- 5.3.16 The splitting of modelled user-classes into the TUBA assessment user-classes is given below.

Input matrix conversion and units

- 5.3.17 TUBA requires trip, travel time and distance matrices to be defined for each user class, time slice and modelled year. Matrices must be defined for both the Do-Minimum and Do-Something scenarios. These matrices are created by 'skimming' data from the forecast year assignments using SATURN.

- 5.3.18 TUBA also requires matrix data to be input in specific units. However, data skimmed from SATURN does not match these expected units.
- 5.3.19 A process to factor matrix data is therefore required to convert to the correct units prior to input into TUBA. Table 5-1 shows the units and conversion factors applied.

Table 5-1: Matrix data units and conversion

Data	SATURN Units	TUBA Expected Units	Conversion Factor
Trips	PCU* Trips per Hour	Vehicle Trips per Hour	1.0 for Car and LGV classes 0.4 for HGV classes
Travel Time	Seconds	Hours	0.0002778
Travel Distance	Metres	Kilometres	0.001

* PCU – Passenger Car Units

- 5.3.20 Modes are the top level of aggregation in TUBA. Within these modes there are various vehicle types and sub-modes. As specified in Section 5.3.15 the TUBA assessment comprises of seven vehicle types.
- 5.3.21 The 'A303 Stonehenge SWRTM (DCO)' model comprises five user-classes as specified in section 5.3.14. The assignment car user-classes map to the TUBA car vehicle types exactly and no further work is required in this regard. However, conversion is required to correctly appraise LGV and HGV vehicle types.
- 5.3.22 The split between LGVs used for work and non-work purposes has been calculated using the proportions in Table A1.3.4 of the WebTAG Databook (88% of LGV trips are for work purposes whilst 12% of trips are non-work). Therefore the LGV user class trip matrix is factored by 0.12 and 0.88 to convert to the vehicle type trip matrices for TUBA.
- 5.3.23 The split of OGV 1 and OGV 2 within the HGV user class was derived from the Department for Transport (DfT) National Road Traffic Survey 2015 results (Table TRA3105). This showed that 40% of HGV traffic is comprised of OGV 1 type vehicles with the remaining 60% being comprised of OGV 2 type vehicles. Therefore the HGV user class trip matrix, converted from PCUs to vehicles, is split on this basis to convert to the OGV 1 and OGV 2 trip matrices required for TUBA.

Annualisation

- 5.3.24 The 'A303 Stonehenge SWRTM (DCO)' model represents three average hours in the neutral month, being the average AM hour (07:00 – 10:00), average interpeak hour (10:00 – 16:00) and average PM hour (16:00 – 19:00). In addition, a further time period has been developed to represent the average 'busy day', with calibration and validation data drawn from across 21 Fridays, Saturdays and Sundays in July and August when known problems exist on the A303. The 'busy day' model represents the average 10:00 – 19:00 hour across these three days.

5.3.25 TUBA makes a distinction between time periods and time slices. Time slices are derived from the model (as above), whereas time periods are standard within TUBA and represent the full number of hours across a year for the following:

- a. AM peak (weekday 07:00 – 10:00);
- b. PM peak (weekday 16:00 – 19:00);
- c. Interpeak (weekday 10:00 – 16:00);
- d. Off-peak (weekday 19:00 – 07:00); and
- e. Weekend.

5.3.26 A process of factoring model time slice data is therefore required to convert, or annualise data. This is achieved through the use of annualisation factors.

Data used – Traffic flows

5.3.27 To calculate annualisation factors traffic flows per hour were obtained for both directions on the A303 from WebTRIS for four sites between 01 July 2016 and 30 June 2017. The sites are listed below and shown spatially in Figure 5-1.

- a. west of Winterbourne Stoke TMU site 5588/1 (westbound) and TMU site 5588/2 (eastbound); and
- b. west of Solstice Park TMU site 5593/1 (eastbound) and TMU site 5594/1 (westbound).

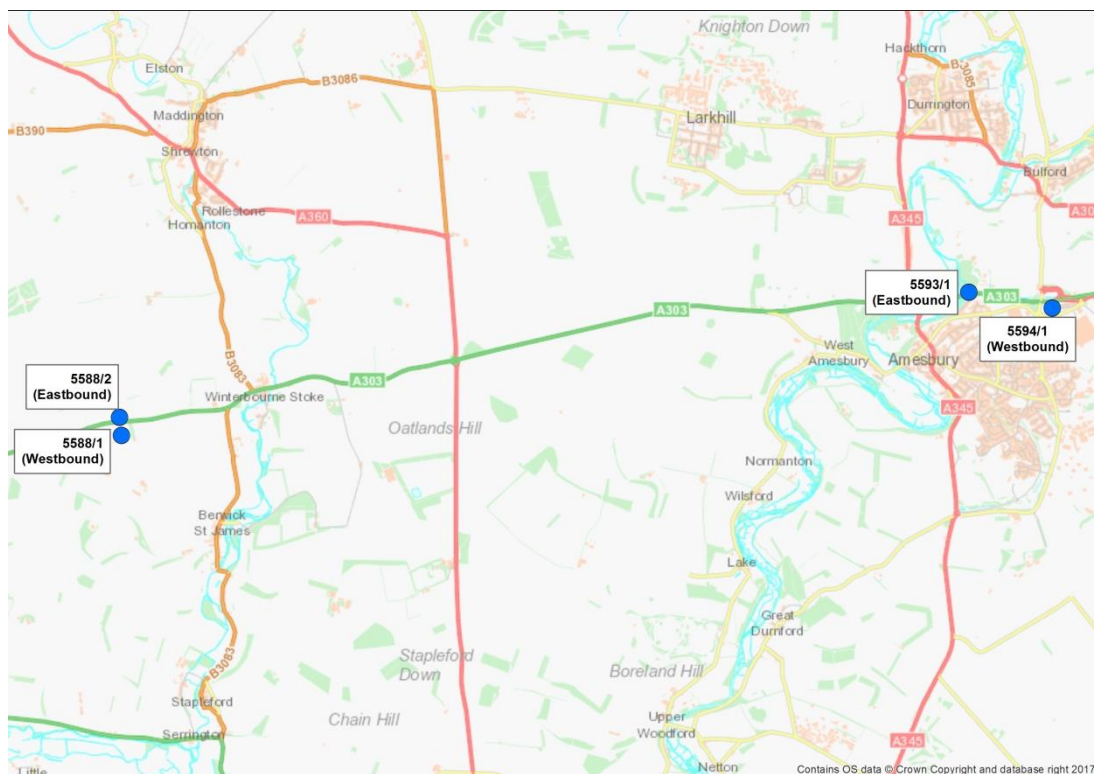


Figure 5-1: Location of WebTRIS sites used for derivation of annualisation factors

5.3.28 Any days that had zero flows at any hour on any of the individual sites were omitted from the calculations, with allowance for these missing periods.

5.3.29 Trafficmaster journey time data on the A303 were used to identify “busy days” (i.e. days that experienced the biggest delays in journey times). Average journey times per day were then calculated by averaging the eastbound and westbound journey times per day between 01/07/16 and 30/06/17 (the latest full annual period for which data were available).

5.3.30 An overall median journey time was then calculated for weekday journey times during October 2016, the median journey time is 16 minutes and 2 seconds.

5.3.31 Delay on a day was calculated as follows:

$$\text{Delay} = \text{Average journey time} - \text{Median October weekday journey time}$$

5.3.32 Any days with delays above 7 minutes and 30 seconds have been identified as busy days. A total of 64 busy days were identified between 07/07/16 and 30/06/17. The threshold of 7m 30s was selected so that the average (flow weighted) delay observed on these 64 busy days was consistent with the average delay observed in the summer period represented in the model (i.e. Friday, Saturday and Sundays over the 7 weeks selected in the July and August school summer holiday period). A review of the 64 days with the longest delays confirmed that these are aligned to school holiday and half term periods.

Busy period annualisation factors

5.3.33 The annualisation factors were obtained by calculating the total flow recorded at the count sites across the year by the observed flow in the modelled period as shown in Table 5-2. The hours of the year were aligned to the four periods represented in the transport model as follows:

- a. Busy day: 10:00 – 19:00 on the 64 days of the year with the largest observed delay;
- b. AM Peak: 07:00 – 10:00 on all working weekdays;
- c. PM Peak: 16:00 – 19:00 on all working weekdays that do not occur on busy days; and
- d. Inter-peak: all other hours of the year.

Table 5-2 Annualisation factors by period

Period	Count (both Sites)	Annual Traffic	Annualisation Factor
AM Peak	3,523	2,741,734	778
PM Peak	3,998	2,519,848	632
Inter Peak	3,886	12,255,928	3,154
Busy day	4,265	2,520,082	591

5.3.34 The 24 hour AADT flow was calculated from the individual modelled hours (AM, IP, PM and Busy) and identified annualisation factors using the below formula:

$$24\text{hour AADT} = \frac{(\text{Busy period} \times 591) + (\text{AM Peak} \times 778) + (\text{PM Peak} \times 632) + (\text{IP} \times 3154)}{365}$$

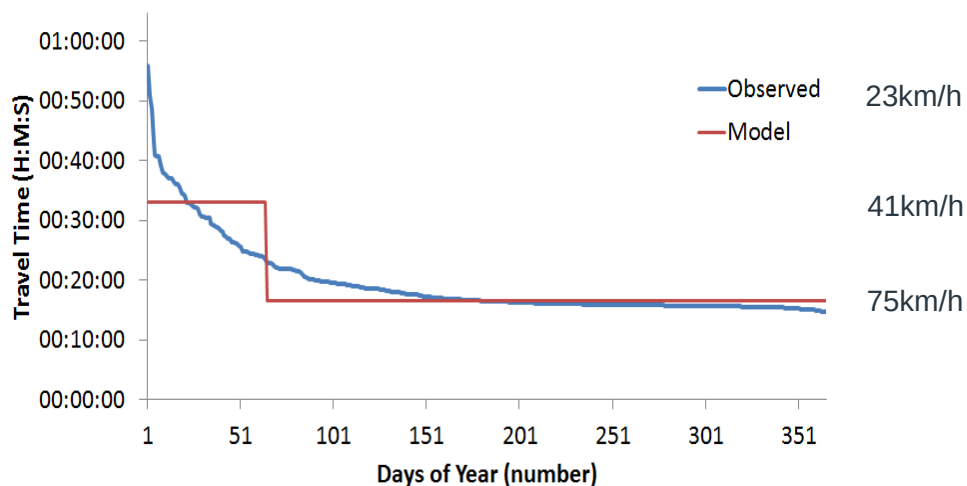
- 5.3.35 The result of applying the factors to the outputs from the model was compared to average observed AADTs past Stonehenge. Table 5-3 below shows a comparison of the two-way AADT past Stonehenge, which shows that whilst the converted model data predicts a slightly lower AADT than observed, it is within the tolerances expected of model validation and reflects the need for assumptions where count data were missing for certain days and hours.

Table 5-3: Comparison of observed and modelled AADT

Observed AADT*	Modelled AADT	Difference	% Difference
27,400	25,500	1,900	- 6.9%

Average AADT for 2017, rounded to nearest 100, WebTRIS sites 30360044 and 30360045 (A303)

- 5.3.36 In addition to verifying that applying the annualisation factors reproduced observed AADT on the A303 past Stonehenge, the annualised average delay calculated from the model was compared with the average delay observed in the Trafficmaster data, to confirm that the average annual delay was reproduced. Figure 5-2 illustrates the observed journey time by day of year (in blue) ordered by length of delay and illustrates how the modelled journey time represents this variation.



Source: 2016-2017 Trafficmaster data: A338-A36, 23km section of A303

Figure 5-2: Annualised average delay

- 5.3.37 In addition to the consideration of traffic volumes and delays, extrapolation from the modelled periods requires consideration of the composition of traffic across the year. The National Travel Survey (NTS) and local roadside interview (RSI) data have been used to understand how the purpose proportions vary at different times of day and between weekdays and the weekend. Table 5-4 shows the proportions of car trip purposes by time period from the NTS and RSI data.

Table 5-4: Car purpose split from NTS and RSI data

Source	Time Period		Employer's Business	Home-based Work	Home-based Other
National Travel Survey	Weekday	Inter peak	5.1%	7.5%	87.4%
	Weekday	Off Peak	3.6%	27.6%	68.8%
	Weekend	All Day	1.5%	5.3%	93.2%
Roadside Interview	Weekday	Inter Peak	14.1%	21.9%	64.0%
National Travel Survey appraisal undertaken on car trips recorded between 2012 and 2015 using all trips with an origin in the South West					
Roadside Interview data collected on the A303 in 2015.					

- 5.3.38 The roadside interview data presents a very different split of purposes compared to the National Travel Survey results for the weekday interpeak period. This reflects the strategic nature of the A303 corridor, carrying longer distance trips whilst the NTS results concern trips of all distances.
- 5.3.39 The NTS data provide an estimate of how the purpose splits change between the interpeak, off-peak and non-busy weekend periods for the whole of the South West. Factors were calculated from the NTS data to represent the change in purpose proportions from the interpeak period to the other two periods. The proportions in the interpeak RSI data were then combined with these factors to produce an estimate of the likely composition of traffic using the A303 during the off peak (7pm – 7am) and non-busy weekend, as shown in Table 5-5.

Table 5-5: Estimated car purpose splits

Time Period		Employer's Business	Home-based Work	Home-based Other
Weekday	OP	10.0%	80.3%	9.7%
Weekend	All Day	4.3%	15.3%	80.4%

- 5.3.40 Trafficmaster data for the busiest days recorded 41 of the 64 busy days as weekdays and 23 as weekend days. Expanded traffic flows by purpose were calculated for the busy weekdays using the interpeak and PM RSI data and average hour traffic flows. Using the weekend purpose splits in Table 5-5, expanded traffic flows by purpose were derived for a non-busy weekend. Analysis of the busy day traffic flows showed that 63% of the busy day traffic occurred between the hours of 10am and 7pm – the time period modelled in the busy day. Applying this factor to the previously derived weekend traffic flows gave estimated flow during the busy weekend period.
- 5.3.41 The calculated flows for the busy weekday and weekend periods were summed, accounting for the number of busy weekdays and weekends identified, to give the average purpose splits for the busy period as shown in Table 5-6.

Table 5-6: Composite car purpose splits (busy day)

Day	Count of Days	Employer's Business	Home-based Work	Home-based Other
Busy Weekday	41	13.7%	27.4%	58.9%
Busy Weekend	23	4.3%	15.3%	80.4%
Busy Day Average	64	10.1%	22.8%	67.1%

- 5.3.42 Reflecting the derivation of the busy day model from the neutral month interpeak model, together with the mix of weekday and weekend days for the period over which the model outputs are extrapolated to annualise benefits, factors have been developed to represent the average composition of demand by purpose. These factors were derived by calculating the change in purpose proportions from the interpeak RSI data (as shown in Table 5-4) to the estimated busy day average purpose proportions (as shown in Table 5-6).
- 5.3.43 Similarly, factors representing the reduced proportion of business travel following extrapolation of the inter-peak across off peak and (non-busy day) weekend days have been derived. These factors were calculated by using the interpeak RSI records and interpeak, off-peak and non-busy weekend average hour traffic counts to expand the flows to each period. The flows were annualised and used to calculate average purpose proportions for the whole period across a year. The derivation of factors was then based on comparing the change in purpose proportions from the interpeak RSI data (as shown in Table 5-4) to the average purpose proportions from the annualised flows.
- 5.3.44 The final factors applied to the extrapolated benefits are shown in Table 5-7.

Table 5-7: Purpose split factors

Purpose Factor	Employer's Business	Home-based Work	Home-based Other
Neutral Interpeak Factors	0.66	1.45	0.92
Busy Day Factors	0.72	1.04	1.05

Masking

- 5.3.45 To ensure that the benefits calculated from the 'A303 Stonehenge SWRTM (DCO)' model are realistic and representative, it is necessary to undertake a 'masking' process to remove any benefits or disbenefits which are calculated but do not come about as a result of the Scheme.
- 5.3.46 The transport model displays model 'noise' in areas located away from the Region of Focus (RoF) where the detailed calibration was undertaken. Because of this, the forecast models show some changes in flow which are not attributable to the Scheme. If left unmasked, these changes could result in benefits being calculated that are not realistic.

Sector system

- 5.3.47 To remove this source of error, a masking process was devised to allow certain origin-destination movements to be excluded from the calculations. This masking process was undertaken at a sector level, where inter-sector trips can be reasonably expected to route similarly. Figure 5-3 shows the sector system used.
- 5.3.48 The sector system is broadly based on Local Authority Districts (LADs). There is greater disaggregation around the study area with sectors becoming more granular in the external areas. The SWRTM RoF is represented in greater detail to allow the trips routeing along either the A303 or the alternative motorway-based routes to be fully represented and masked with sufficient detail.
- 5.3.49 A full list of the sectors and the areas they represent are documented in Appendix A .

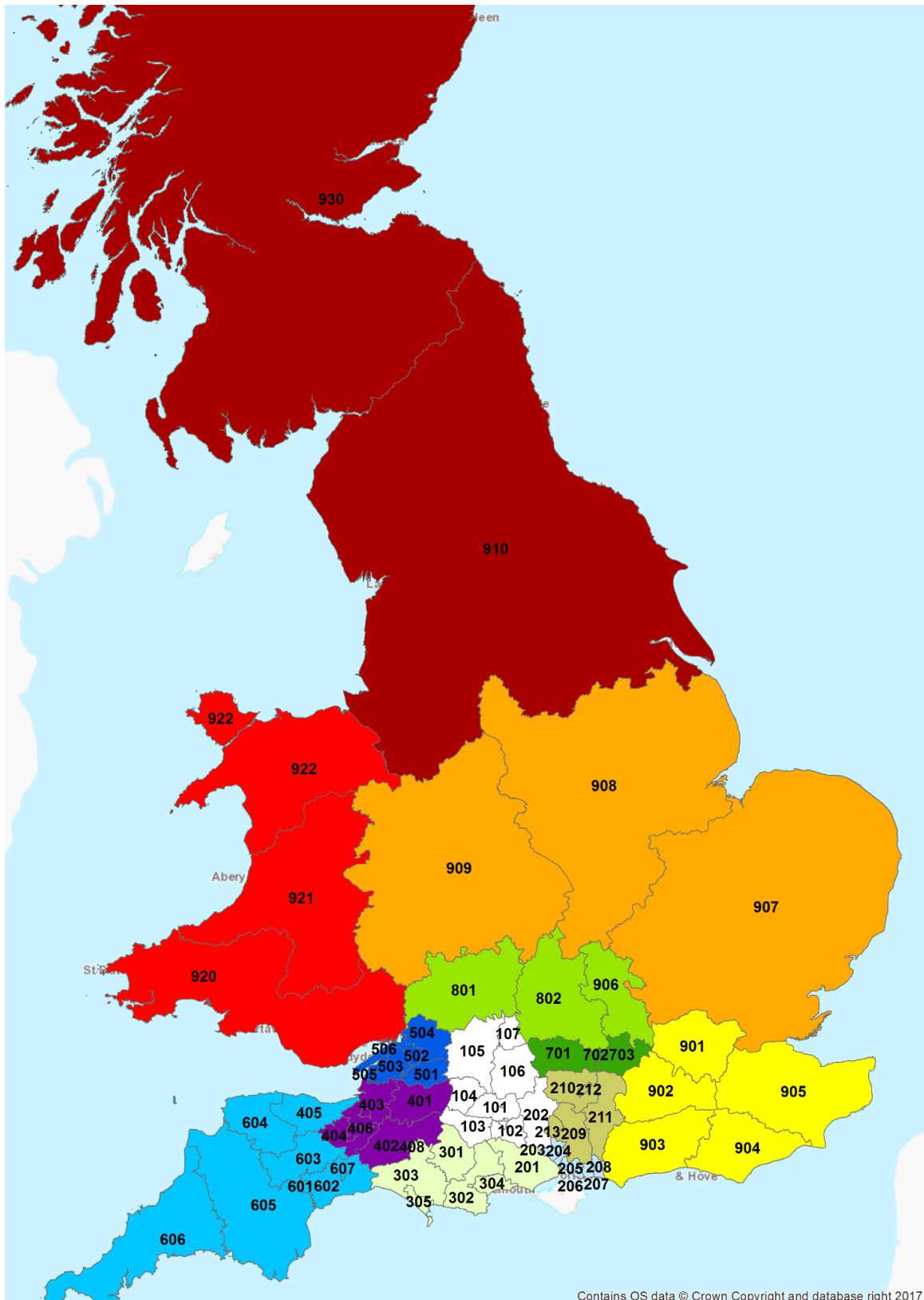


Figure 5-3: Sectoring system used for TUBA masking

- 5.3.50 Urban areas close to the study area have been defined in separate sectors. This has been done to allow intra-urban trips within these areas to be removed from the economic analysis without trips between these urban areas and the nearby LADs having to be masked concurrently.

- 5.3.51 With sector numbers given in brackets, the urban areas with their own sectors are as follows:
- Basingstoke (212);
 - Winchester city (213);
 - Bournemouth and Poole (304);
 - Weymouth (305);
 - Taunton (406);
 - Bridgwater (407);
 - Yeovil (408);
 - Weston-Super-Mare (505);
 - Clevedon (506); and
 - Honiton (607).
- 5.3.52 In addition, Salisbury city centre has also been defined separately but without its intra-sector trips being masked. The full description of masked and unmasked areas is given below.
- 5.3.53 For transparency in reporting, the sectors have been aggregated further into 13 groups which represent broad areas of the country. These are also shown in Figure 5-3, identified by colour. The groups are as follows:

Table 5-8: Groups of TUBA sectors

Group	Sector Name
1	Central area
2	Southampton and Portsmouth
3	East Hampshire
4	Dorset and New Forest
5	Somerset
6	Avon
7	Berkshire
8	South West
9	Gloucestershire, Oxfordshire and Buckinghamshire
10	London and South East
11	Midlands and East of England
12	Wales
13	North and Scotland

Masking identification

- 5.3.54 Movements within sectors were masked from the economic analysis if it was judged that their routing was unlikely to make use of the study area or roads impacted as a result of the Scheme.
- 5.3.55 In most cases masking was able to be applied at a group level. Table 5-9 details which movements between groups have been masked, or partially masked.

Table 5-9: Movements masked out from TUBA analysis

	1	2	3	4	5	6	7	8	9	10	11	12	13
1													
2		1								1			
3			2										
4				1									
5					2								
6						1							
7													
8								1					
9									1	1	1	1	1
10		1							1	1	1		1
11									1	1	1	1	1
12									1		1	1	1
13									1	1	1	1	1
Masking Types:													
1. All trips with region-to-region movement masked													
2. Trips made within urban areas in region-to-region movement masked													

- 5.3.56 The majority of inter-group movements are either fully masked or fully unmasked. The exceptions to these are the intra-urban movements in East Hampshire and Somerset. The urban areas of Winchester, Basingstoke, Yeovil, Bridgwater and Taunton have internal trips masked. The remaining urban areas listed in 5.3.51 are also masked as part of the full-group masking.
- 5.3.57 Salisbury, along with the rest of the central area, is close to the study area and movements to or from this area are expected to be affected by the Scheme.
- 5.3.58 The remaining unmasked movements are all reasonably expected to experience changes to flow and/or travel speeds as a result of the Scheme being implemented. These movements are therefore considered in the economic analysis, and all benefits and/or disbenefits are included.
- 5.3.59 A full list of sector-sector movements that have been masked and removed from the economic assessment are given in Appendix A. The effects of masking are set out in section 6.3, as part of the analysis of the economic assessment results.

Travel times

- 5.3.60 Economic benefits of the Scheme come from savings in travel times and changes in vehicle operating costs to both business and consumer users.
- 5.3.61 Users perceive both money costs and time costs associated with trips they make. The calculation of transport user benefits in TUBA is based on the consumer

surplus theory where consumer surplus is the benefit received by the consumer in excess of these perceived costs.

- 5.3.62 Business users include car and LGV occupants travelling on employer's business along with HGV drivers. Consumer users include any non-business travellers in cars and LGVs including those commuting to and from a place of work.
- 5.3.63 In general, the travel time through the study area will be shorter when the Scheme is implemented. Similarly other routes may see changes in travel times due to rerouting of traffic.
- 5.3.64 TUBA assesses travel time savings across the model, monetising the results using values of time (VoT) to derive the monetary benefits of those time savings.
- 5.3.65 VoT parameters and how they are forecast to change are defined in the economic parameter file, a TUBA input. This file was provided by DfT to align with the interim WebTAG Databook prior to the release of the formal May 2018 Databook.
- 5.3.66 TUBA calculates travel time benefits for each modelled year as specified in WebTAG Unit A1.3. Benefits for non-modelled years are then interpolated and extrapolated as appropriate to cover the whole 60 year appraisal period.

Vehicle operating costs

- 5.3.67 TUBA also calculates vehicle operating cost (VOC) changes. These occur due to changes associated with fuel and non-fuel costs. Non-fuel costs include items such as oil, tyres, vehicle maintenance and depreciation.
- 5.3.68 Factors affecting the VOCs are the speed and distances and how those change when the Scheme is implemented.
- 5.3.69 As with the travel time savings the vehicle operating costs are monetised using standard parameters supplied in the TUBA economic input file and derived from the WebTAG Databook.
- 5.3.70 VOC benefits are similarly interpolated and extrapolated between calculated modelled year values to cover the full 60 year appraisal period.

5.4 Accidents

Introduction

- 5.4.1 The safety impacts of the Scheme have been assessed quantitatively and monetised to be incorporated into the overall economic appraisal for the Scheme. Changes in the number of accidents as a result of the Scheme have been calculated using the DfT's COBA-LT software, using standard accident rates by road type.
- 5.4.2 COBA-LT compares accidents by severity (slight, serious and fatality) across the modelled network in the both the 'Do Minimum' (without scheme) and 'Do Something' (with scheme) scenarios. Link types defined in COBA-LT have been matched to the different links in the 'A303 Stonehenge SWRTM (DCO)' model through a correspondence with modelled capacity indices and a manual review of the network link structure where capacity indices have not been used in the development of the model.

Status and monetisation

- 5.4.3 Accident benefits are monetised and form part of the initial BCR. They are included in the AMCB table.

Forecast years, scenarios, appraisal period and inputs

- 5.4.4 Accident appraisal in COBA-LT has been undertaken over the 60-year appraisal period previously noted. This includes inputs derived from the 'A303 Stonehenge SWRTM (DCO)' model for the 2017 Base Year and the four modelled forecast years as set out above. Data for the non-modelled years were interpolated between modelled years and extrapolated for the remainder of the 60-year appraisal period by the software.
- 5.4.5 The traffic model inputs into COBA-LT are for relevant modelled links for each of the four forecast years in the 'Do Minimum' and 'Do Something'.
- 5.4.6 The inputs comprise Annual Average Daily Traffic (AADT) volumes derived from the model forecasts. The accident appraisal makes use of AADTs derived from a combination of the three modelled neutral time periods and the busy day period. The methodology for the derivation of these factors is set out in the Transport Forecasting Package, Appendix C to the Combined Modelling and Appraisal Report (Application Document 7.5).

Accident rates

- 5.4.7 COBA-LT provides functionality to use observed local accident rates instead of the WebTAG default national averages.
- 5.4.8 WebTAG Unit A4.1 notes that use of average accident costs as defined in the WebTAG Databook and COBA-LT are normally appropriate even where local accident rates differ from the average. The guidance goes on to note that even in cases where the severity split in the local area may differ from the national average, the use of local severity splits is discouraged.
- 5.4.9 Analysis of local accident rates has been undertaken through analysis of DfT STATS19⁷ data for the 2012-2016 period for the section of the A303 between Countess roundabout and Longbarrow roundabout. These data have been compared with national data provided by the DfT⁸⁹. A comparison of the out-turn accident rates for the period 2012-2016 and for 2016 alone is given in Table 5-10.

⁷ STATS19 – Road Safety Data. DfT. <https://data.gov.uk/dataset/cb7ae6f0-4be6-4935-9277-47e5ce24a11f/road-safety-data> [Last accessed: 02 July 2018]

⁸ RAS10002 - Reported accidents and accident rates by road class and severity, Great Britain, 2010 to 2014 average, annual for latest 8 available years. DfT. <https://www.gov.uk/government/statistical-data-sets/ras10-reported-road-accidents#table-ras10002> [Last accessed: 02 July 2018]

⁹ RDL0203 - Road lengths (kilometres) by road type in Great Britain. DfT. <https://www.gov.uk/government/statistical-data-sets/rdl02-road-lengths-kms> [Last accessed: 02 July 2018]

Table 5-10: Comparison of national and local accident rates (2012-2016)

	National – A-roads		A303 (past Stonehenge)	
	2012-2016 avg.	2016	2012-2016 avg.	2016
Accidents (all severities)	65,030	61,455	15.4	16
Length of road (km)	46,774	46,815	11.7	11.7
Accident rate	1.39	1.31	1.32 ▼	1.37 ▲

5.4.10 As the comparison shows, the data past Stonehenge show similar accident rates for national A-roads. In fact, as shown by the 2012-2016 average, the A303 past Stonehenge has a slightly lower accident rate than the average for all national A-roads, albeit the figure for 2016 is slightly higher. The accident rate per km past Stonehenge has a standard deviation of 0.32 for the period 2012-2016; the differences shown in the table are not statistically significant at a 95% confidence level.

5.4.11 Based on the analysis, and coupled with the recommendations in guidance stating a strong preference for the use of national average accident rates, the defaults from the WebTAG Databook and corresponding COBA-LT economics parameter file have been used.

Methodology

5.4.12 The network over which accident appraisal has been undertaken is a subset of that modelled in the 'A303 Stonehenge SWRTM (DCO)' model. The full modelled network contains a large number of links over which there is no impact (i.e. change in traffic volume) as a result of the A303 Amesbury to Berwick Down scheme.

5.4.13 The subset of network used for accident appraisal therefore comprises the links over which impacts of the A303 Amesbury to Berwick Down scheme are shown in the traffic forecasts. This includes:

- a. All links on the A303 forming part of the Scheme;
- b. All links in the modelled Area of Detailed Modelling (AoDM), where the impacts of the Scheme are strong; and
- c. Links where impacts of the Scheme are noted, covering wider diversion to the A303, including:
 - i. all modelled links forming the full length of the A303, between the junction with the M3 and the end of the A303 where it meets the A30 in east Devon;
 - ii. links forming the A358, between the A303 and M5 Junction 25 at Taunton;
 - iii. links forming the A30 between the A303 and M5 Junction 29 at Exeter;
 - iv. links forming the M4 between Junction 13 (Chieveley) and Junction 20 (Almondsbury); and
 - v. links forming the M5 between Junction 15 (Almondsbury) and Junction 29 (Exeter).

5.4.14 It should be noted that appraisal of accidents has not examined changes in traffic on the M3 east of Junction 8 (the A303) or on the M4 east of Junction 13 (Chieveley). This is due to these areas falling outside of the RoF of the model and

thus there is reduced confidence in traffic volumes and responses in these locations.

- 5.4.15 The broad location of the links over which accident benefits have been assessed is given in Figure 5-4 below.

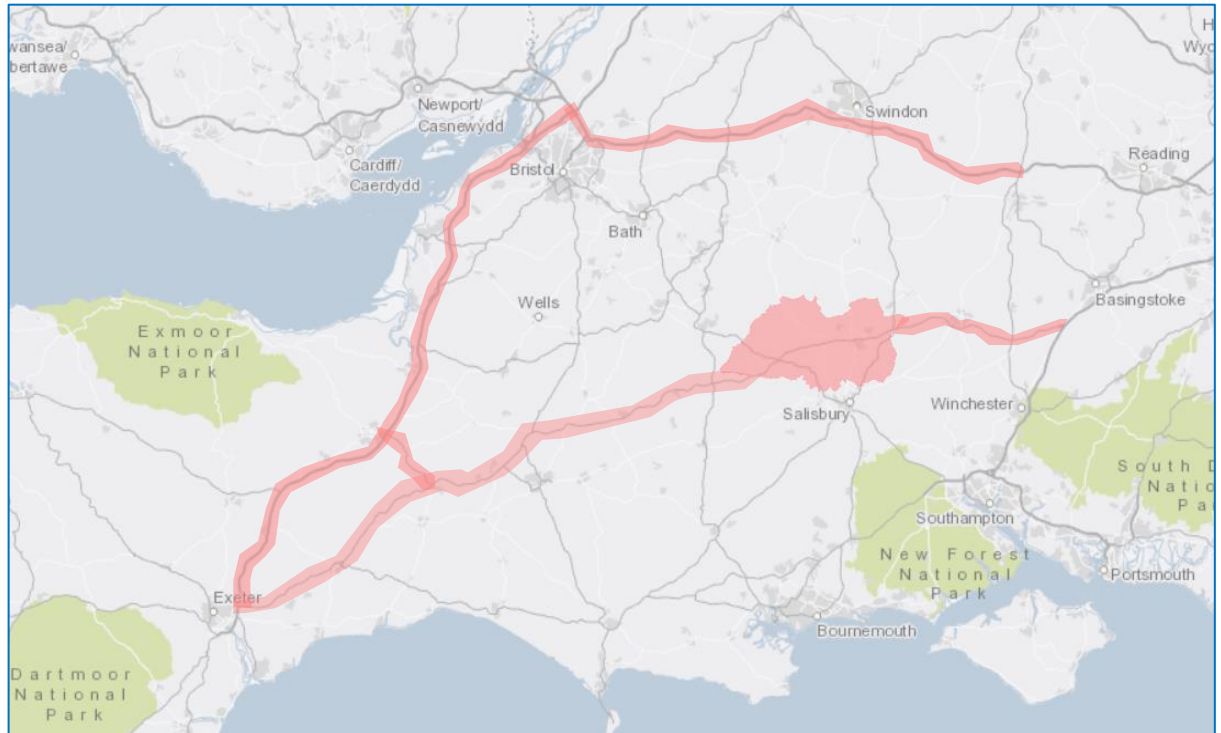


Figure 5-4: Locations of links forming the COBA-LT accident appraisal

Economic parameters

- 5.4.16 As noted in the assessment of user benefits (TUBA) above, the economic parameters used in the appraisal of accidents are based on the interim May 2018 WebTAG Databook. Early access to this Databook, in advance of its release, was provided by DfT given the A303 Amesbury to Berwick Down project's 'Tier 1' scheme status.
- 5.4.17 As with the TUBA assessment, an interim economic parameter file corresponding with the interim Databook was provided direct by DfT.

5.5 Construction

Introduction

- 5.5.1 WebTAG Unit A1.3 §10 notes that the costs to existing transport users due to the construction of a scheme and the costs or benefits to users arising during future maintenance should be recorded in the TEE tables where they are likely to be significant.
- 5.5.2 Impacts during construction may be significant. The current construction programme notes 29 months of reduced speed limits and temporary arrangements during the construction of the Winterbourne Stoke bypass and Countess flyover, and a further 36 months of reduced speed limits and traffic management during the construction of the tunnel.

Status and monetisation

- 5.5.3 Construction and maintenance benefits are monetised and form part of the initial BCR. They are included in the TEE table and as part of the TEE elements in the AMCB table.

Methodology

- 5.5.4 In-line with WebTAG Unit A1.3 §10, the 'A303 Stonehenge SWRTM (DCO)' model has been used to predict the traffic effects of the Scheme under construction, following coding of the construction traffic management, with subsequent economic appraisal undertaken using TUBA, using the same economic parameters and masking as noted above.
- 5.5.5 Traffic management has been coded using the standardised RTM coding manual to ensure consistency with the coding across the rest of the 'A303 Stonehenge SWRTM (DCO)' model. The traffic management layouts have been based on a construction plan as of June 2018.
- 5.5.6 For the purposes of the traffic assessment, two principal phases of the construction programme for the main works have been identified. These correspond to:
- a. Phase 1, when Winterbourne Stoke bypass, Longbarrow junction and Countess roundabout flyover are under construction (likely 2021-2023); and
 - b. Phase 2, when the construction of the tunnel is the primary construction activity (2024 onwards). The Winterbourne Stoke bypass, Longbarrow junction and Countess roundabout flyover constructed in Phase 1 would be operational, albeit with reduced speed limits in places and temporary traffic arrangements.
- 5.5.7 The construction plan will be refined through detailed design of the Scheme with appropriate regard to reducing the overall impacts during construction. For this appraisal, short term variations within these two phases have not been assessed.
- 5.5.8 Rather than develop a separate forecast year model to represent each construction phase, the extant 2026 'Do Minimum' forecast has been used as a proxy. This is considered to be a pragmatic approach, justified by analysis of the traffic volumes and expected growth.
- 5.5.9 Analysis of population growth between 2017 (the base year) and 2026 throughout the AoDM and key neighbouring areas including Tidworth and Ludgershall has shown that 77% is expected to occur between 2017 and 2022. Based on these proportions, AADT growth throughout the construction period is expected to be less than 10% across the area that would be impacted by the Scheme construction. It is therefore sufficient to assess the impacts during construction using the extant 2026 'Do Minimum' models.
- 5.5.10 Further detail on the use and justification of the 2026 'Do Minimum' as a proxy for the construction years is set out in the Traffic Forecasting Package.
- 5.5.11 For the TUBA assessment, a single year appraisal has been undertaken for each of the modelled phases. The inputs have been fed into TUBA to represent 2022 for Phase 1 and 2024 for Phase 2. This is based on the modelling in the 'A303

Stonehenge SWRTM (DCO)' model of a single year for each phase, as noted above. The discounted results from the single year appraisal have subsequently been factored to represent the full duration of the construction phases, being 29 months and 36 months respectively as identified in the construction plan as of June 2018.

5.6 Environmental impacts

Introduction

- 5.6.1 Changes in traffic flows caused by the introduction of the Scheme will result in changes in greenhouse gas emissions from vehicles, depending on changes in flows, speeds and distance travelled. Changes in vehicle type proportions will also impact on air quality and noise.

Status and monetisation

- 5.6.2 Air quality, noise and greenhouse gases are monetised. They form part of the initial BCR and are included in the AMCB table.

Methodology

- 5.6.3 Assessment of air quality, noise and greenhouse gas benefits has been undertaken in accordance with guidance given in WebTAG Unit A3.
- 5.6.4 A detailed methodology for the appraisal of each of the key environmental benefits captured in the AMCB is given in the Environmental Statement (ES) (Application Document 6.1 chapters 5 and 9). The following chapters of the ES give the methodologies:
- a. Greenhouse gases (ES chapter 5);
 - b. Air quality (ES chapter 5); and
 - c. Noise (ES chapter 9).

5.7 Reliability

Introduction

- 5.7.1 Once improved, users of the A303 will benefit both from lower journey times, but also more reliable and predictable journey times. Journey time reliability relates to the variability of journey times that users are unable to predict.

Status and monetisation

- 5.7.2 Reliability benefits are monetised. They form part of the adjusted BCR and are therefore not included in the AMCB table.

Methodology

- 5.7.3 The basic unit of measurement of variability is the standard deviation of journey times. In the case of single carriageways, there is no single established approach to modelling the effects of increased road capacity on journey time variability: Highways England's Motorway Reliability Incidents And Delays (MyRIAD) tool is only applicable to improvement schemes for motorways and dual carriageways. However, in the case of the A303 Amesbury to Berwick Down scheme, it is possible to infer the likely change in variability by comparing the level of variability on different sections of the existing route.

- 5.7.4 The reliability analysis was previously undertaken at PCF Stage 2 and, as it is based on observed data and not modelled Base Year or forecast traffic flows, has not been updated as part of the PCF Stage 3 refinement.
- 5.7.5 Assessment of reliability has only been undertaken for the core scenario. Once dualled, it is assumed that users of the A303 between Amesbury and Berwick Down will experience the level of reliability currently experienced on the dual carriageway section between Andover and Amesbury. This section is adjacent to the Scheme, and hence experiences broadly similar traffic flows and seasonal variation.
- 5.7.6 For each section, variability in journey time was measured across a sample of journey time observations taken from the vehicle tracking database, Trafficmaster.
- 5.7.7 It is important to distinguish between unpredictable and predictable variation in journey times. To ensure that the analysis only captures unpredictable variation, journey time variability has been measured and compared separately across specific times of the day (AM, Inter-peak and PM periods), days of the week (Monday – Thursday, Friday, and Saturday – Sunday) and months of the year (July-August, and all other months).
- 5.7.8 There were three steps in this process:
- calculation of average journey times for a sample of hours over a 12-month period for each section of the A303 Amesbury to Berwick Down scheme;
 - calculation of the standard deviation of average journey times across this sample for a Do Minimum and Do Something scenario; and
 - application of monetary values and the ‘reliability ratio’ (the ratio of the benefit of a 1 minute change in the standard deviation of journey times and a 1 minute change in travel time) to convert changes in standard deviation into a monetised benefit.

5.8 Wider impacts

Introduction

- 5.8.1 Wider economic impacts are supplementary to the conventional transport user benefits appraisal undertaken in the Department for Transport’s (DfT’s) TUBA software. Wider benefits are not therefore reported as part of the initial BCR. There are four types of wider impact which are appraised:
- Agglomeration impact – As per WebTAG Unit A2.4, this relates to the concentration of economic activity across an area. By improving the accessibility of an area to a greater number of firms and workers, transport schemes can deliver increases in Gross Domestic Product (GDP). The primary influences on determining agglomeration impacts are changes in travel costs, the number and location of workers, and the productivity of those workers.
 - Increased or decreased output in imperfectly competitive markets – As per WebTAG Unit A2.2, this relates to the changes in the output of goods that use transport. Reductions in transport costs to business and/or freight allows for an increase in the production or output of goods or service markets.

- c. Labour market impacts from more/less people working – As per WebTAG Unit 2.3, this is the impact of a transport scheme on labour supply and is based mainly on changes in commuting travel costs.
- d. Labour market impacts from the move to more/less productive jobs – As per WebTAG Unit A2.3, a transport scheme may lead to a change in where people choose to work. Some jobs are more productive than others which can lead to changes in GDP.

5.8.2 The A303 Amesbury to Berwick Down scheme is located close to large regional distribution centres as well as the urban areas of Amesbury, Salisbury and Andover. These provide employment opportunities and therefore by reducing travel costs and increasing accessibility to these areas, the Scheme promotes increased agglomeration and workers moving to more productive jobs.

5.8.3 The A303 also provides the most direct route between the South East and South West. By improving journey times and reliability between these two areas the Scheme will enable easier, and cheaper, travel for long distance business and freight trips providing benefits in the output of goods that use transport.

Status and monetisation

5.8.4 Wider economic impact benefits are monetised. They form part of the adjusted BCR and are therefore not included in the AMCB table.

Methodology

5.8.5 To assess the wider impacts of the Scheme, the DfT's Wider Impacts in Transport Appraisal (WITA) computer program was used.

5.8.6 WITA implements the calculations of wider impacts as described in WebTAG Unit A2.1 'Wider Economic Impacts Appraisal'. In all cases the WITA methodology seeks only to capture the part of the above impacts that is not already captured in conventional transport user benefit calculations.

5.8.7 The appraisal of wider impacts for the Scheme is concerned with the core scenario. As defined in WebTAG Unit A2.1, the core scenario assumes that employment is consistent between the Do-Minimum and Do-Something scenarios and does not include benefits arising from freight trips. A sensitivity test, including freight demand and costs, has also been undertaken to assess its impact.

Forecast years, scenarios and appraisal period

5.8.8 The appraisal of wider impacts focusses on the core scenario and uses data derived from the four forecast year transport models as defined in the appraisal of conventional transport user benefits. Benefits calculated for each of the forecast years are similarly interpolated and extrapolated to cover the whole appraisal period.

5.8.9 It should be noted that the WITA software only allows for an appraisal period extending up to the year 2080. Therefore a standard 60 year appraisal period, in-line with guidance in WebTAG Unit A1.1 and Her Majesty's (HM) Treasury's Green Book, cannot be assessed and the appraisal of wider impacts has a final assessment year of 2080. This means the resulting benefits are an underestimate of the Scheme benefits.

Economic parameters

- 5.8.10 Economic data for each of the Local Authority Districts (LAD) in Great Britain have been derived from version 2.5 of the WebTAG 'Wider Impacts Dataset' published by DfT in 2013¹⁰. These data detail the average wage per worker; index of labour productivity; and GDP per worker across the four industrial sectors as set out in WebTAG Unit A2.4 'Appraisal of Productivity Impacts'.
- 5.8.11 Forecast numbers of workers in each LAD have also been derived from the same dataset for each of the four modelled forecast years.
- 5.8.12 The conventional transport user benefit appraisal used an updated version of the default TUBA economic parameters file incorporating interim revisions of the Office for National Statistics (ONS) estimates and Office for Budget Responsibility (OBR) projections for GDP, average earnings and inflation. The updates in this file have been incorporated into the economic parameters file used in the WITA.

User classes

- 5.8.13 The conventional transport user benefit appraisal, undertaken in TUBA, provides an assessment of benefits by journey purpose, split by vehicle type and has been undertaken for seven user-classes, comprising:
- a. car business;
 - b. car commute;
 - c. car other;
 - d. LGV (non-work journey purposes);
 - e. LGV (work journey purposes);
 - f. Ordinary Goods Vehicle (OGV) type 1 (a subset of HGVs – typically Rigid 2 and 3 axle vehicles); and
 - g. OGV type 2 (a subset of HGVs – typically Rigid 4 axle vehicles and all articulated HGVs).
- 5.8.14 Wider economic impact assessment is only concerned with trips and travel costs made for travel to and from work and during work time. Therefore only the car business and car commute TUBA user classes have been assessed. In the freight sensitivity test, the LGV work and OGV user classes are also included.

Input matrix data and annualisation

- 5.8.15 The same highway matrix data as used in the conventional transport user benefit analysis is input into the appraisal of wider economic impacts. This is detailed in Section 5.3.17 onwards.
- 5.8.16 In the assessment of wider impacts, average generalised travel costs are required for the calculation of effective density and agglomeration benefits. An important element of travel, and therefore average generalised cost, is travel by public transport. In order to represent travel by all modes in the average costs, public transport demand and costs have therefore been derived using SWRTM forecasts used in the VDM.

¹⁰ Wider Impacts Dataset Version 2.5. DfT.

https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/427528/tag-workbook-wider-impacts-dataset.xls [Last Accessed: 10 July 2018]

- 5.8.17 The annualisation of the travel demand uses the same factors as the conventional transport user benefit appraisal as detailed in Section 5.3.24 onwards.

Masking

- 5.8.18 The wider impacts study area should be limited to the area in which the traffic model provides a good estimate of the generalised costs of travel. Agglomeration calculations are based on the idea of 'effective density', which is a measure of how well an area is connected to everywhere else. An incorrect estimation of the base generalised costs would lead to an incorrect base case level of effective density, and hence an incorrect estimation of the impact resulting from any changes in agglomeration caused by the transport intervention.
- 5.8.19 The 'A303 Stonehenge SWRTM (DCO)' model has been derived from the SWRTM and is calibrated and validated within the SWRTM Region of Focus (RoF). Therefore, the wider impacts study area has been limited to this region.
- 5.8.20 In addition to this, due to the known limitations of the Regional Traffic Models (RTMs) in fixed-speed urban areas resulting in instability in the adjacent network, changes in generalised cost for trips wholly within these areas have also been ignored, with no changes in interzonal costs assumed for travel within the masked urban areas (e.g. trips wholly within Bristol). To assess the impacts of inter-zonal changes to/from these urban areas to zones in other sectors, a sensitivity test was undertaken where all generalised costs from the selected urban area zones were assumed to be unchanged. This resulted in a reduction of around only £2 million of benefits (approximately 5%) in the wider assessment, indicating that the sensitivity of the model to longer distance trips to/from the large urban areas is negligible.

Verification of results

- 5.8.21 Using the same GDP and employment inputs, the agglomeration benefit calculations in WITA have been reproduced in a spreadsheet tool to verify the operation of the software.

5.9 Cultural heritage impacts

Introduction

- 5.9.1 Further to the transport-related economic impacts set out above, an assessment of the impacts of the Scheme on cultural heritage was undertaken.
- 5.9.2 One of the key objectives of the Scheme is to protect and enhance the Stonehenge, Avebury and Associated Sites World Heritage Site (WHS). To account for the unique heritage setting of the Scheme a Contingent Valuation study was undertaken during PCF Stage 2. The study determined a financial value that individuals would be willing to pay to remove the A303 from the vicinity of the WHS.
- 5.9.3 Stonehenge is an iconic monument; an international symbol of the UK and its rich prehistoric past. The strategic case details the WHS's national and international significance. A Contingent Valuation study was completed by Simetrica on behalf of Highways England at PCF Stage 2 to understand the value that visitors to the WHS, A303 users and UK residents place on the removal of the A303 from its

current location within the WHS, which would reduce noise, increase tranquillity and reduce landscape severance in the WHS.

Status and monetisation

- 5.9.4 Cultural heritage benefits are monetised. They form part of the adjusted BCR and are therefore not included in the AMCB table.

Methodology

- 5.9.5 Highways England conducted 'Willingness to Pay' surveys to elicit the value individuals place on these benefits. Respondents to the survey were provided with a description of the impact of the existing A303 on the WHS. They were also provided with information on the expected impacts of the Scheme in terms of tranquillity, visual amenity and landscape severance. On the basis of this information, respondents were asked to consider if they were willing to pay something to realise these impacts, or if they would require to be compensated for these impacts. Those willing to pay something were asked how much they would be willing to pay (in the form of an increase in annual taxes over a three-year period). Whilst those requiring compensation were asked what they would be willing to accept in compensation should the Scheme be built. Care was taken to ensure that responses were focused on the impact of removing the road from the landscape, rather than other factors such as transport benefits and considerations of affordability.
- 5.9.6 The survey responses have been used to generate estimates of the aggregate willingness to pay of the UK population as a whole or, put another way, the overall value that society attributes to these benefits.
- 5.9.7 The average willingness to pay/accept values derived from the survey were then aggregated to the relevant population levels within each of the three groups¹¹. Willingness to accept is subtracted from willingness to pay in order to provide a net overall benefit. In accordance with good practice, a range of validity tests were undertaken which demonstrate that the variation in values across different sub-groups of respondents are logical and internally consistent.
- 5.9.8 A more detailed explanation of the survey methodology, bias controls, checks and the benefits aggregation process is described in the Valuing Heritage Impacts report, a copy of which is included in Appendix H.

¹¹ The three survey groups samples were surveyed for were the UK population, A303 road users and visitors to Stonehenge.

6 Economic assessment results

6.1 Introduction

- 6.1.1 The various types of transport benefits and costs arising from the Scheme, along with the methodology for deriving them, have been discussed in chapter 5.
- 6.1.2 This chapter presents the results of the economic assessment. Results of the economic assessment presented in this chapter are derived from a 60 year appraisal period. Unless otherwise stated values presented in this chapter are shown in 2010 market prices, discounted to 2010 in line with WebTAG guidance.
- 6.1.3 TUBA calculates benefits for the four individual modelled years as discussed in chapter 5. Benefits for the intermediate years are then interpolated between the modelled years. The final modelled year of 2051 has its benefits extrapolated for each succeeding year up to the horizon year of 2085. Extrapolated model years are adjusted using the forecast changes to the values of time. These individual years are then discounted over the 60-year full appraisal period.
- 6.1.4 Those benefits that are included in the initial BCR are presented first, culminating in the presentation of the TEE, PA and AMCB tables. Following these tables, benefits included in the adjusted BCR are presented; this includes the journey time reliability and wider impacts.
- 6.1.5 All results in this chapter relate to the core scenario which has been developed in line with guidance given in WebTAG Unit M4. The results for the low and high growth scenarios, along with the alternative scenario testing the impact of the large employment development at the MoD site at Boscombe Down, can be found in chapter 7.

6.2 Definition of price base and year

- 6.2.1 Costs and benefits occur in different years throughout the assessment period. Construction costs occur prior to scheme opening whilst benefits occur throughout the 60 year appraisal period following this.
- 6.2.2 As noted in chapter 3, the A303 Amesbury to Berwick Down assessment has made use of a Present Value Year of 2010 and a price base of 2010.

6.3 Effects of masking

- 6.3.1 Masking has been undertaken as described in section 5.3.45 - 5.3.59.
- 6.3.2 Table 6-1 shows the effects of masking on the total benefits.

Table 6-1: Comparison of masked and unmasked benefits (£000's)

Benefit Type	Unmasked	Masked	Percentage Change
Travel Time	397,000	370,000	-7%
Fuel Vehicle Operating Costs	-17,000	-17,000	-0%
Non-fuel Vehicle Operating Costs	-62,000	-65,000	+5%
Indirect Tax	80,000	82,000	+3%
TOTAL	397,000	370,000	-7%

2010 prices, discounted to 2010. Values rounded to the nearest million pounds.

- 6.3.3 The percentage changes from masking are small, confirming that masking undertaken to address model noise has no material impact on the assessment.

6.4 Benefits profile by year

Undiscounted benefits

- 6.4.1 Benefits are first presented undiscounted. This allows for the comparison of benefits at a 2010 price base but without the adjustment to the Present Value Year; this is to interpret trends across the modelled years (i.e. without adjustment by the discounting). Table 6-2 presents the undiscounted benefits.

Table 6-2: Undiscounted benefits by year split by user type (£000's)

Purpose and mode	2026	2031	2041	2051
Non-Business: Commuting	790	800	2,010	1,780
Non-Business: Other	2,590	3,330	7,720	8,620
Business: Car and LGV	5,170	6,190	12,340	14,680
Business: Goods Vehicles	590	830	1,530	1,980
TOTAL	9,150	11,150	23,600	27,060

2010 prices, undiscounted. Rounded to nearest ten thousand

- 6.4.2 Total benefits increase across the modelled years from 2026 to 2051. Figure 6-1 illustrates this trend. Particular factors affecting this roughly trebling of undiscounted benefits between 2026 and 2051 are the forecast growth in demand, the increased congestion without the Scheme for travel along the A303 and increases in values of time.
- 6.4.3 Commuting benefits do not follow this pattern and decrease in the 2051 forecast year compared to 2041. A sectoral analysis of the benefits showed that these decreases were attributable to increased congestion and delay on the network away from the Scheme which is worsened due to the induced traffic as a result of the implementation of the Scheme.

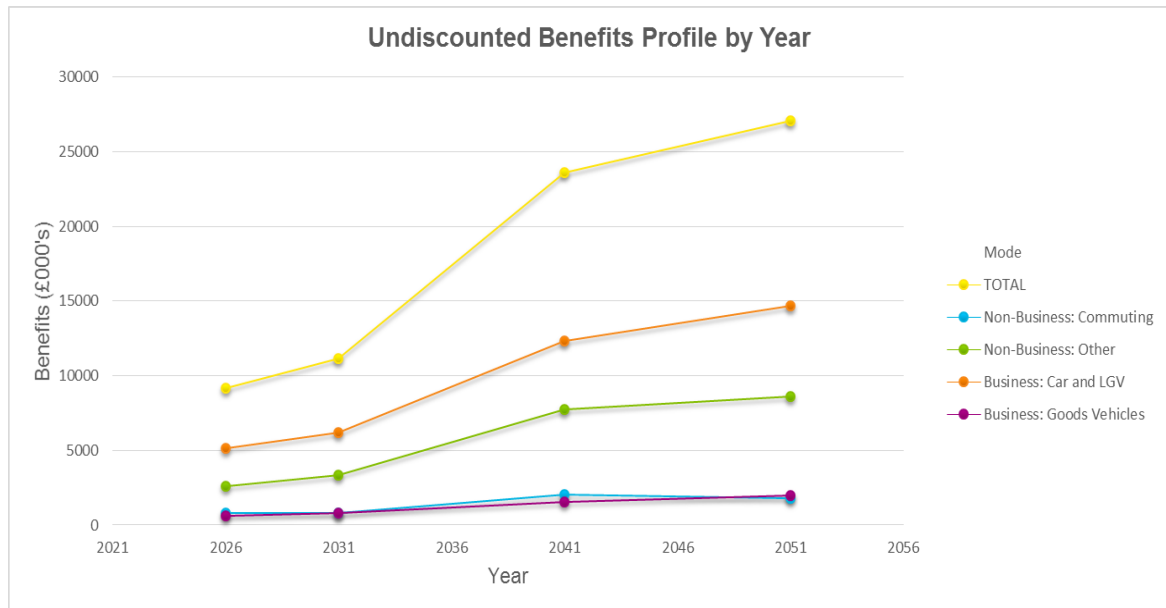


Figure 6-1: Benefits profile by year (£000's)

Discounted benefits

- 6.4.4 The transport user benefits, in 2010 prices discounted to 2010 realised in each year across the 60 year appraisal period, are shown in Figure 6-2. This shows that benefits peak in 2041 before decreasing due to lower magnitudes of benefit caused by congestion elsewhere on the corridor.

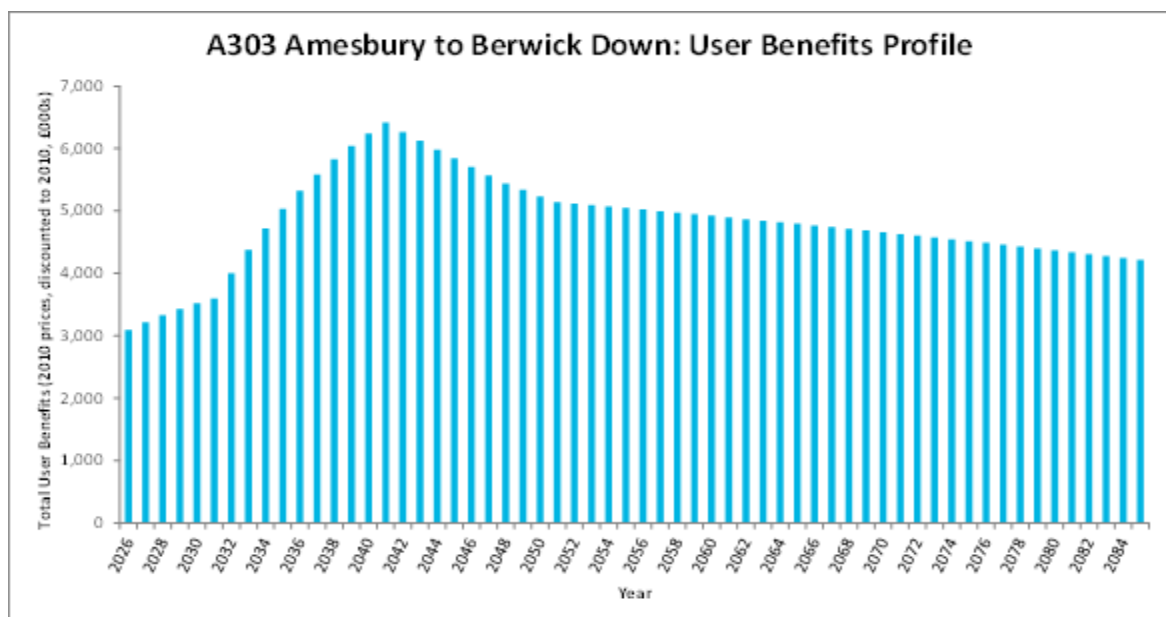


Figure 6-2: Transport user benefits across the appraisal period (£000's)

- 6.4.5 Table 6-3 presents these benefits split by user type. The discounted benefits are forecast to peak between 2031 and 2051. This is due to congestion elsewhere on the corridor reducing the magnitude of benefits realised due to the Scheme in the 2051 forecast year.

Table 6-3 Benefits by year split by user type (£000's)

Purpose and mode	2026	2031	2041	2051	Full Appraisal
Non-Business: Commuting	460	390	690	440	27,000
Non-Business: Other	1,500	1,620	2,660	2,130	120,000
Business: Car and LGV	2,980	3,010	4,250	3,630	197,000
Business: Goods Vehicles	340	400	530	490	26,000
TOTAL	5,270	5,410	8,120	6,700	370,000

2010 prices, discounted to 2010. Rounded yearly to nearest ten thousand; full appraisal to nearest million

6.5 Benefits profile by time period and purpose

6.5.1 Table 6-4 shows the breakdown of benefits by time period and journey purpose.

6.5.2 The time periods covered in the economic assessment are the AM peak period, PM peak period, a combined period covering the interpeak and off-peak periods and the 'busy days' as described in Section 5.3.34.

Table 6-4: Benefits by time period split by user type (£000's)

Purpose and mode	AM	PM	IP & OP	Busy Days	TOTAL
Non-Business: Commuting	6,000	3,000	12,000	7,000	27,000
Non-Business: Other	9,000	3,000	32,000	76,000	120,000
Business: Car and LGV	36,000	18,000	71,000	72,000	197,000
Business: Goods Vehicles	6,000	1,000	15,000	4,000	26,000
TOTAL	57,000	25,000	130,000	158,000	370,000

2010 prices, discounted to 2010. Rounded to nearest million

6.5.3 Business user benefits make up over half of the total benefits across all time periods, including the busy days. The 64 busy days comprise of 41 weekdays, with higher proportions of business and commute trips, and 23 weekend days.

6.5.4 Non-business, other users make up a larger proportion of the benefits in the interpeak, off-peak and busy day periods as journeys to and from work are concentrated in the AM and PM peak periods.

6.6 Benefits profile by type of user benefits

Travel time benefits

6.6.1 It will take less time to traverse the A303 when the Scheme is open. This will result in reductions in end-to-end journey times. Table 6-5 shows the forecast end to end journey times for each modelled year along the A303, between the A34 to the east, and the A3088 near Yeovil to the west.

Table 6-5: Journey times along the A303 by year (neutral month)

		2026	2031	2041	2051
Eastbound	Do Minimum	01:08:11	01:09:11	01:11:00	01:12:44
	Do Something	01:05:06	01:05:53	01:07:14	01:08:36
	Change	00:03:06	00:03:18	00:03:46	00:04:08
	Percentage Change	4.53%	4.76%	5.29%	5.67%
Westbound	Do Minimum	01:09:58	01:11:29	01:14:05	01:16:27
	Do Something	01:07:18	01:08:42	01:11:05	01:13:04
	Change	00:02:39	00:02:48	00:02:59	00:03:23
	Percentage Change	3.80%	3.91%	4.03%	4.42%

- 6.6.2 This shows journey time savings of over three minutes (eastbound) and two minutes (westbound) in each of the modelled years. These time savings have a direct impact on travel time benefits. The results of economic assessment show that there are benefits from travel time savings amounting to £370m over the 60 year appraisal period. Table 6-6 shows a breakdown of the travel time benefits by purpose and mode.

Table 6-6: Travel time benefits by year split by user type (£000's)

Purpose and mode	2026	2031	2041	2051	Full Appraisal
Non-Business: Commuting	580	500	810	530	32,000
Non-Business: Other	1,900	2,060	3,010	2,390	133,000
Business: Car and LGV	2,530	2,580	3,910	3,330	180,000
Business: Goods Vehicles	350	410	500	470	25,000
TOTAL	5,360	5,540	8,240	6,710	370,000

2010 prices, discounted to 2010. Rounded yearly to nearest ten thousand; full appraisal to nearest million

Table 6-7: Travel time benefits by time period split by user type (£000's)

Purpose and mode	AM	PM	IP & OP	BUSY	TOTAL
Non-Business: Commuting	7,000	3,000	15,000	7,000	32,000
Non-Business: Other	11,000	5,000	41,000	76,000	133,000
Business: Car and LGV	33,000	16,000	65,000	66,000	180,000
Business: Goods Vehicles	5,000	1,000	15,000	4,000	25,000
TOTAL	57,000	24,000	136,000	152,000	370,000

2010 prices, discounted to 2010. These are full 60 year appraisal rounded to nearest million

- 6.6.3 Travel time benefits are greatest for (car and LGV) business users, with this purpose and mode contributing 49% of the total travel time benefits. This reflects the higher values of time for these travellers than other purposes and the proportion of travel for business along the A303.

- 6.6.4 Total travel time benefits are greatest during the busy periods, reflecting the substantial congestion delay experienced without the Scheme at these times.
- 6.6.5 For Heavy Goods Vehicles (HGV) the combination of relatively low values of time for the vehicle drivers, lower time savings reflecting 60mph HGV maximum speeds with the Scheme, and comprising less than 10% of traffic using the A303, result in relatively modest monetised benefits.
- 6.6.6 Table 6-8 shows a comparison of car travel time savings compared with HGV travel time savings. This demonstrates the lesser time savings for HGVs resulting in lower benefits.

Table 6-8: Car vs HGV travel time savings (hh:mm:ss)

Time Period	Car Travel Time Saving		HGV Travel Time Saving		HGV Percentage Difference	
	E/b	W/b	E/b	W/b	E/b	W/b
AM	00:04:25	00:03:09	00:04:20	00:02:34	-2%	-19%
IP	00:03:02	00:02:35	00:02:36	00:02:08	-14%	-17%
PM	00:02:41	00:02:52	00:02:18	00:02:34	-14%	-10%
E/b = Eastbound; W/b = Westbound						

VOC benefits

- 6.6.7 Changes in vehicle operating costs (VOCs) arise from the implementation of the Scheme. Some of these are due to the changes in length and speeds along the A303 corridor, increasing distance and speeds travelled, whilst others arise from wider re-routing into the corridor and congestion relief to local roads.
- 6.6.8 The following sections will describe these benefits in terms of fuel VOCs and non-fuel VOCs.

Fuel VOC benefits

- 6.6.9 Table 6-9 and Table 6-10 present the fuel VOC dis-benefits.

Table 6-9: Fuel VOC benefits by year split by user type (£000's)

Purpose and mode	2026	2031	2041	2051	Full Appraisal
Non-Business: Commuting	-30	-30	-50	-40	-2,000
Non-Business: Other	30	-20	-10	20	0
Business: Car and LGV	-210	-150	-220	-150	-8,000
Business: Goods Vehicles	-200	-200	-160	-120	-7,000
TOTAL	-410	-400	-440	-290	-17,000

2010 prices, discounted to 2010. Rounded yearly to nearest ten thousand; full appraisal to nearest million

Table 6-10: Fuel VOC benefits by time period split by user type (£000's)

Purpose and mode	AM	PM	IP & OP	Busy Days	TOTAL
Non-Business: Commuting	-1,000	0	-1,000	0	-2,000
Non-Business: Other	0	0	-2,000	3,000	0
Business: Car and LGV	-2,000	-1,000	-6,000	0	-8,000
Business: Goods Vehicles	-1,000	0	-5,000	0	-7,000
TOTAL	-4,000	-2,000	-15,000	4,000	-17,000

2010 prices, discounted to 2010. These are full 60 year appraisal rounded to nearest million

- 6.6.10 Re-routing changing travel distances and speed changes will contribute to these relatively modest changes, together with the moderate increase in distance due to the bypass around Winterbourne Stoke which lengthens the corridor. This is forecast to result in an increase in fuel use, and higher costs for users, resulting in a disbenefit of approximately £17m.

Non-fuel VOC benefits

- 6.6.11 Table 6-11 and Table 6-12 present the non-fuel benefits. Non-fuel vehicle operating costs are realised in a similar way to the fuel VOCs. Longer trip distances and higher average speeds cause more wear-and-tear on vehicles, increasing costs.

Table 6-11: Non-fuel VOC benefits by year split by user type (£000's)

Purpose and mode	2026	2031	2041	2051	Full Appraisal
Non-Business: Commuting	-350	-270	-260	-210	-11,000
Non-Business: Other	-1,740	-1,510	-1,340	-1,220	-63,000
Business: Car and LGV	140	150	130	80	5,000
Business: Goods Vehicles	80	90	90	70	4,000
TOTAL	-1,860	-1,540	-1,380	-1,280	-65,000

2010 prices, discounted to 2010. Rounded yearly to nearest ten thousand; full appraisal to nearest million.

Table 6-12: Non-fuel VOC benefits by time period split by user type £000's)

Mode	AM	PM	IP & OP	Busy Days	TOTAL
Non-Business: Commuting	-2,000	-1,000	-7,000	-1,000	-11,000
Non-Business: Other	-7,000	-5,000	-33,000	-17,000	-63,000
Business: Car and LGV	1,000	0	1,000	3,000	5,000
Business: Goods Vehicles	1,000	0	2,000	1,000	4,000
TOTAL	-7,000	-6,000	-37,000	-15,000	-65,000

2010 prices, discounted to 2010. These are full 60 year appraisal rounded to nearest million

- 6.6.12 Reflecting research on travel behaviour, it is assumed in the traffic modelling that non business users do not perceive non-fuel costs in planning their journeys.

Nevertheless the additional (unperceived) vehicle operating costs are included in the appraisal.

- 6.6.13 It is noted that there is a non-fuel VOC disbenefit for non-business 'Other' users, whilst there is no material change in fuel VOCs for the same purpose. This is due to the calculation of non-fuel cost for non-work trips, which is a fixed cost per kilometre and does not take account of speed or travel time. Therefore, as a result of the increase in trips as a result of the Scheme (which are not a transfer from other, less direct routes), there is an increase in total cost and hence disbenefit.

Summary

- 6.6.14 Table 6-13 shows the breakdown of discounted benefits by benefit type. This includes indirect tax which is not a benefit to users, but represents the benefits gained by the government due to taxes paid on the increased fuel used by motorists as a result of the Scheme, including the longer journeys induced by the journey times savings delivered by the Scheme.

Table 6-13: Benefits by year split by benefit type (£000's)

Benefit Type	2026	2031	2041	2051	Full Appraisal
Travel Time	5,360	5,540	8,240	6,710	370,000
Fuel Vehicle Operating Costs	-410	-400	-440	-290	-17,000
Non-fuel Vehicle Operating Costs	-1,860	-1,540	-1,380	-1,280	-65,000
Indirect Tax	2,180	1,820	1,710	1,570	82,000
TOTAL	5,270	5,410	8,120	6,700	370,000

2010 prices, discounted to 2010. Rounded yearly to nearest ten thousand; full appraisal to nearest million

6.7 Total benefits by sector

- 6.7.1 Figure 6-3 and Figure 6-4 show the total user benefits by origin and destination respectively. These plots are based on the sectoring system previously described and shown in Figure 5-3.

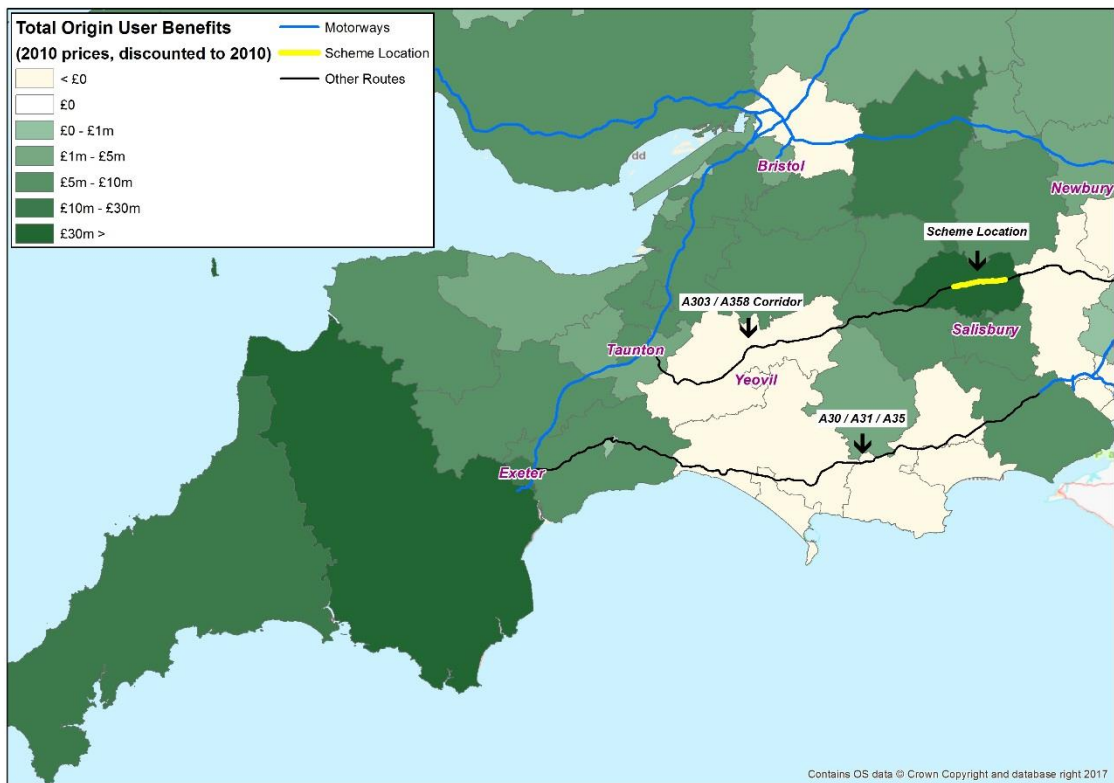


Figure 6-3: Total user benefits by sector (origin)

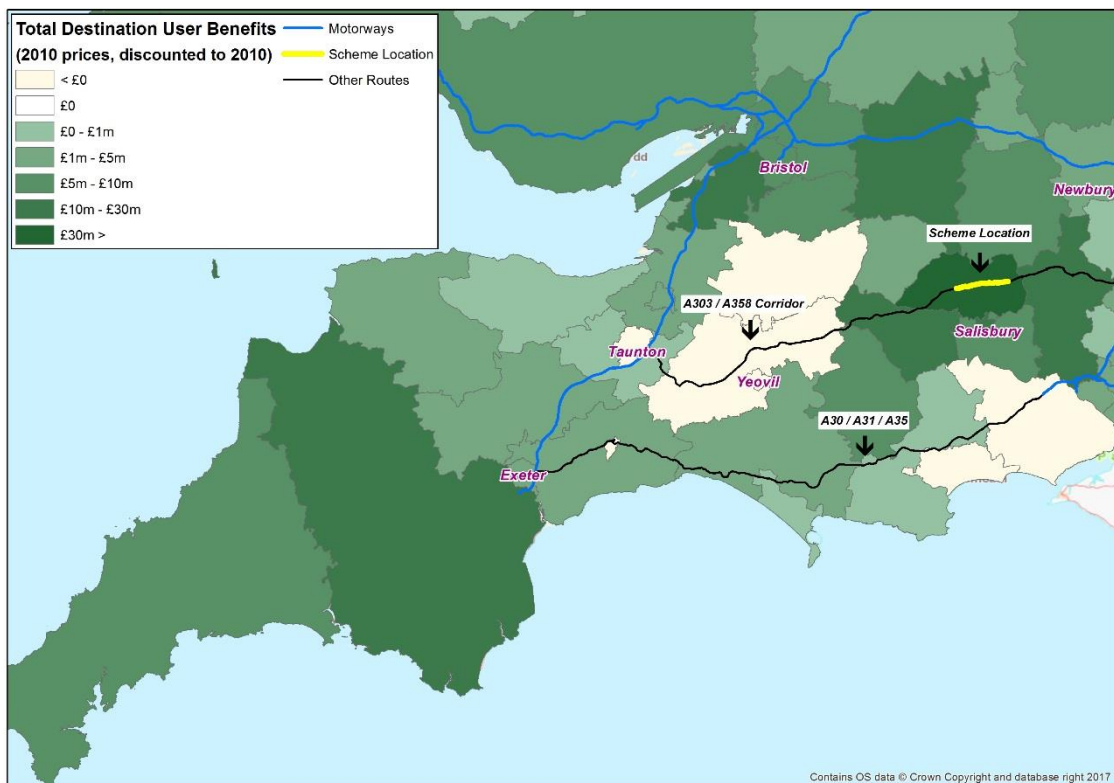


Figure 6-4: Total user benefits by sector (destination)

6.7.2 Figure 6-3 and Figure 6-4 show that the largest transport user benefits occur in the immediate vicinity of the Scheme. This shows that the Scheme has a strong positive impact for local travellers. There are also significant benefits for long

distance travellers shown by the spread of positive impacts across the South West region, particularly in Devon and Cornwall.

- 6.7.3 Some negative impacts can be seen in some sectors, notably in central Somerset. This is due to changes in traffic levels on roads – particularly western sections of the A303 that have not been improved. The additional A303 traffic induced by the Scheme results in some additional congestion and delay on sections of the corridor west of the A36 that, in part, moderate the benefits delivered by the Scheme.

6.8 Accidents

- 6.8.1 As discussed in chapter 5, an assessment has been made of the change in accidents and their associated costs as a result of the Scheme. Standard incident rates by road type are applied to traffic forecasts with and without the Scheme.
- 6.8.2 Accident benefits have been calculated by type (Slight, Serious or Fatal) by COBA-LT, using the standard national average accident rates as set out in the WebTAG Databook.
- 6.8.3 Table 6-14 sets out an assessment of the number of accidents forecast from the traffic flow and accident rates over the 60-year appraisal period for the section of the A303 affected by the Scheme.

Table 6-14: Estimated accidents and casualties for 60-year appraisal period, A303 scheme section only

Accident type	Without Scheme	With Scheme	Difference
Summary of accidents			
No. accidents	1,406	1,374	32
Summary of casualties			
Slight	1,794	1,728	66
Serious	223	186	37
Fatal	32	27	5
Total	2,049	1,941	108

COBA-LT outputs rounded to nearest whole number

- 6.8.4 Table 6-14 demonstrates that the Scheme is forecast to reduce the number of accidents and casualties. This includes five fewer fatalities over the appraisal period and 108 fewer casualties in total. Forecast numbers of killed and seriously injured are expected to reduce from 255 without the Scheme to 213 with the Scheme, a reduction of 16%.
- 6.8.5 The reduction in both accidents and casualties occurs despite the increases in traffic that are forecast through this section of the A303 following implementation of the Scheme (as set out in the Transport Forecasting Package, Appendix C to the Combined Modelling and Appraisal Report (Application Document 7.5)) and despite overall increases in distance of the A303 as a result of the realigned Longbarrow interchange and Winterbourne Stoke bypass. This is due to the reduced incident rates for modern dual 2-lane roads compared to older S2 A-

roads, as defined in COBA-LT, reflecting the safer road design of the Scheme than the existing road.

- 6.8.6 As previously explained in chapter 5, there are wider changes in traffic routing and volumes along the A303, M4 and M5 and on other roads. The accident appraisal has been developed to assess the impacts of re-routing onto the A303 as well as capturing induced demand on the corridor. The result of this is to increase traffic on unimproved sections of the corridor increasing the expected frequency of accidents occurring. Additionally, there is a small element of re-routing away from the M4 and M5, with motorways having lower accident rates than modern dual 2-lane roads in COBA-LT. Conversely to this, however, are the benefits in the AoDM of traffic re-routing onto the A303 from local roads with higher accident rates.
- 6.8.7 Table 6-15 sets out the total number of accidents forecast over the 60-year appraisal period, accounting for the impacts of local and regional re-routing across the wider road network.

Table 6-15: Predicted accidents and casualties for 60-year appraisal period

Accident type	Without Scheme	With Scheme	Difference
Summary of accidents			
No. accidents	33,284	33,279	5
Summary of casualties			
Slight	44,708	44,685	23
Serious	4,201	4,173	28
Fatal	543	542	1
Total	49,452	49,400	52

COBA-LT outputs rounded to nearest whole number

- 6.8.8 Over the 60-year appraisal period, the COBA-LT assessment forecasts five fewer accidents across all of the assessed links. Further to this, 23 fewer slight and 28 fewer serious personal injury accidents (PIAs) are forecast, with one less fatality.
- 6.8.9 The net effects of re-routing and increased traffic along the A303 corridor is to moderate the accident reductions expected on the new route relative to the existing A303 scheme section.
- 6.8.10 The monetary value of the overall change in forecast accidents is a benefit of approximately £4 million.

6.9 Construction and maintenance

- 6.9.1 As explained in section 5.5, construction impacts have been considered in two phases: first construction of new junctions and Winterbourne Stoke Bypass and secondly completion of the tunnel section. The overall impacts during Phase 1 and Phase 2 of the construction programme are set out in Table 6-16.

Table 6-16: Impacts under construction (£000s)

Benefit element	Phase 1	Phase 2	Total
Travel Time	-22,190	-5,550	-27,740
Fuel Vehicle Operating Costs	-1,850	-1,910	-3,760
Non-fuel Vehicle Operating Costs	-2,560	-1,350	-3,910
Indirect Tax	2,470	1,760	4,230
TOTAL	-24,140	-7,050	-31,190

2010 prices, discounted to 2010. Rounded to nearest ten thousand.

- 6.9.2 The results from the construction appraisal show a net disbenefit of around £31 million. This is primarily the result of travel time disbenefits during Phase 1 of the construction plan, although there are also small disbenefits in fuel VOCs and in indirect taxes.

6.10 Environmental impact

- 6.10.1 As discussed in chapter 5, an assessment of the traffic-related environmental impacts of the Scheme has been undertaken in accordance with WebTAG Unit A3. This section sets out the impacts of the Scheme, summarising the results given in the Environmental Statement, with the benefits included in the AMCB table and initial BCR.

Air quality

- 6.10.2 The assessment of the impact of the Scheme on local air quality has shown that there is likely to be a beneficial effect providing approximately £300,000 in benefits as shown in Table 6-17.

Table 6-17: Air quality assessment benefits (£000's)

Benefit Element	Benefit (£000's)
Change in NOx emissions	-510
Change in PM10 concentrations	820
Total value of change in air quality	300

2010 prices, discounted to 2010. Rounded to nearest ten thousand. Values may not sum exactly due to rounding.

Noise

- 6.10.3 The Scheme is expected to lead to significant reductions in traffic noise levels within Winterbourne Stoke and through the tunnelled section in the WHS, including Stonehenge. There are also moderate beneficial impacts in Larkhill, Shrewton and Chitterne due to traffic rerouting on to the corridor. Increases in noise are, however, predicted to be experienced in Amesbury.
- 6.10.4 Overall the Scheme is expected to have a small negative impact on the noise resulting from the corridor in the local area, resulting in a disbenefit of approximately £300,000, as shown in Table 6-18.

Table 6-18: Noise assessment benefits (£000's)

Benefit Element	Benefit (£000's)
Total value of change in noise	-330

2010 prices, discounted to 2010. Rounded to nearest ten thousand.

Greenhouse gases

- 6.10.5 The Scheme is forecast to result in a net increase in carbon emissions of approximately 2,000,000 tonnes across the 60 year appraisal period resulting in a disbenefit of approximately £86 million as shown in Table 6-19.

Table 6-19: Greenhouse gas assessment benefits (£000's)

Benefit Element	Benefit (£000's)
Total value of change in carbon dioxide equivalent emissions	-86,460

2010 prices, discounted to 2010. Rounded to nearest ten thousand.

- 6.10.6 The summary tables from the assessments of the impacts of the Scheme on air quality, noise and greenhouse gas emissions are presented in Appendix G .

6.11 Transport Economic Efficiency (TEE) table

- 6.11.1 The Transport Economic Efficiency (TEE) table summarises the monetised benefits for transport users and private sector providers. All benefits are presented in 2010 prices, discounted to the 2010 Present Value Year. Similarly the benefits are presented in the market price unit of account.
- 6.11.2 Within the TEE table, benefits are presented as positive values whilst dis-benefits (or costs) are presented as negative values.
- 6.11.3 The TEE table presents benefits broken down by those arising due to changes in travel time, vehicle operating costs and user charges. User impacts during construction and maintenance are included; however, monetised reliability impacts are not presented.
- 6.11.4 Impacts on business (user and freight), commuting and other trips are reported separately attributed to their mode and source of change.
- 6.11.5 Table 6-20 shows the summary of monetised benefits for transport users in the core forecast scenario TEE table.

Table 6-20: A303 Amesbury to Berwick Down core forecast scenario TEE table

Non-business: Commuting		ALL MODES	ROAD	BUS and COACH	RAIL	OTHER
<u>User benefits</u>		TOTAL	Private Cars and LGVs	Passengers	Passengers	
Travel time		31,798	31,798	0	0	0
Vehicle operating costs		-13,350	-13,350	0	0	0
User charges		0	0	0	0	0
During Construction & Maintenance		-6,023	-6,023	0	0	0
NET NON-BUSINESS BENEFITS: COMMUTING		12,425	(1a)	0	0	0

Non-business: Other		ALL MODES	ROAD	BUS and COACH	RAIL	OTHER
<u>User benefits</u>		TOTAL	Private Cars and LGVs	Passengers	Passengers	
Travel time		132,958	132,958	0	0	0
Vehicle operating costs		-62,125	-62,125	0	0	0
User charges		0	0	0	0	0
During Construction & Maintenance		-9,803	-9,803	0	0	0
NET NON-BUSINESS BENEFITS: OTHER		61,031	(1b)	0	0	0

Business			Goods Vehicles	Business Cars & LGVs	Passengers	Freight	Passengers
<u>User benefits</u>							
Travel time		205,039	25,140	179,899	0	0	0
Vehicle operating costs		-6,492	-3,204	-3,288	0	0	0
User charges		0	0	0	0	0	0
During Construction & Maintenance		-19,590	-10,661	-8,929	0	0	0
Subtotal		178,957	(2)	11,276	167,682	0	0
Private sector provider impacts					Freight	Passengers	
Revenue		0			0	0	0
Operating costs		0			0	0	0
Investment costs		0			0	0	0
Grant/subsidy		0			0	0	0
Subtotal		0	(3)		0	0	0
Other business impacts							
Developer contributions		0	(4)	0	0	0	0
NET BUSINESS IMPACT		178,957	(5) = (2) + (3) + (4)				

TOTAL		
Present Value of Transport Economic Efficiency Benefits (TEE)	252,413	(6) = (1a) + (1b) + (5)

Notes: Benefits appear as positive numbers, while costs appear as negative numbers.

All entries are discounted present values, in 2010 prices and values

- 6.11.6 The total of the items shown in the TEE table constitutes the Present Value of Transport Economic Efficiency Benefits (TEE PVB). Table 6-20 shows that the TEE PVB of the A303 Amesbury to Berwick Down scheme is approximately £252m across the sixty year appraisal period.

6.12 Public Accounts (PA) table

- 6.12.1 The Public Accounts (PA) table shows the impact on public sector budgets, split between local and central Government.
- 6.12.2 Values shown in the PA table include scheme investment, operating and maintenance costs as well as changes in indirect taxation revenues. Positive values represent expenditure whilst negative values represent increases in revenue.
- 6.12.3 The PA table for the core forecast scenario is shown in Table 6-21 for the publicly funded solution and in Table 6-22 for the privately financed solution. All values are presented in 2010 prices, discounted to a 2010 Present Value Year.

Table 6-21: A303 Amesbury to Berwick Down core forecast scenario PA table, publicly funded

	ALL MODES TOTAL	ROAD INFRASTRUCTURE	BUS and COACH	RAIL	OTHER
<u>Local Government Funding</u>					
Revenue	0	0			0
Operating Costs	3,810	3,810			0
Investment Costs	0	0			0
Developer and Other Contributions	0	0	0	0	0
Grant/Subsidy Payments	0	0	0	0	0
NET IMPACT	0	0	0	0	0
<u>Central Government Funding: Transport</u>					
Revenue	0	0			0
Operating costs	231,443	231,443			0
Investment Costs	970,309	970,309			0
Developer and Other Contributions	0	0	0	0	0
Grant/Subsidy Payments	0	0	0	0	0
NET IMPACT	1,201,752	1,201,752	0	0	0
<u>Central Government Funding: Non-Transport</u>					
Indirect Tax Revenues	-86,501	-86,501	0	0	0
<u>TOTALS</u>					
<u>Broad Transport Budget</u>	1,205,562				
<u>Wider Public Finances</u>	-86,501				
Notes: 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.					

Table 6-22: A303 Amesbury to Berwick Down core forecast scenario PA table, privately financed

	ALL MODES TOTAL	ROAD INFRASTRUCTURE	BUS and COACH	RAIL	OTHER
<u>Local Government Funding</u>					
Revenue	0	0			0
Operating Costs	3,810	3,810			0
Investment Costs	0	0			0
Developer and Other Contributions	0	0	0	0	0
Grant/Subsidy Payments	0	0	0	0	0
NET IMPACT	0	0	0	0	0
<u>Central Government Funding: Transport</u>					
Revenue	0	0			0
Operating costs	105,444	105,444			0
Investment Costs	1,040,085	1,040,085			0
Developer and Other Contributions	0	0	0	0	0
Grant/Subsidy Payments	0	0	0	0	0
NET IMPACT	1,145,529	1,145,529	0	0	0
<u>Central Government Funding: Non-Transport</u>					
Indirect Tax Revenues	-92,081	-92,081	0	0	0
<u>TOTALS</u>					
<u>Broad Transport Budget</u>	1,149,339				
<u>Wider Public Finances</u>	-92,081				
Notes: 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.					

- 6.12.4 The PA tables show that there is an increase in indirect taxation revenue arising from the Scheme regardless of the financing strategy chosen. This includes changes in revenue due to increased fuel and non-fuel operating costs as a result of the Scheme. Table 6-22 shows a larger increase in indirect tax revenues, of approximately £6 million extra, occurs if the Scheme is funded through private finance mechanisms. This is owing to assumed increases in Corporation Tax revenues, which will arise as Highways England would pay an annual unitary charge to a private DBFM contractor during the lifetime of any PF2 contract.
- 6.12.5 For a scheme financed wholly through public sector funding, the cost to the broad transport budget is approximately £1.2 billion in 2010 market prices, discounted to 2010 values. This includes nearly £1 billion in capital investment costs related to scheme construction with operating and maintenance costs totalling approximately £235 million.
- 6.12.6 A privately financed scheme would have a cost of approximately £1.1 billion (2010 market prices, discounted to 2010 values) to the broad transport budget. This incorporates over £1 billion in investment costs including the unitary charge, which would be paid by Highways England to the appointed DBFM contractor, as well as retained costs of preliminary works. Operating and maintenance costs total approximately £109 million across the appraisal period.
- 6.12.7 There is a £3.8 million operating cost invested from local government funding identified regardless of the financing strategy taken forward. This cost represents the maintenance cost passed to the local highway authority for operating and maintaining the de-trunked section of A303 through Winterbourne Stoke, assuming Highways England maintenance cost rates.

6.13 Analysis of Monetised Costs and Benefits (AMCB) table

- 6.13.1 The Analysis of Monetised Costs and Benefits (AMCB) table summarises all of the monetised impacts of a scheme that are considered sufficiently robust for inclusion in the Scheme's Net Present Value (NPV) and initial Benefit to Cost Ratio (BCR).
- 6.13.2 The AMCB table combines information from the TEE and PA tables with monetised estimates of other impacts such as noise, air quality and accidents. Positive values represent benefits whilst negative values represent disbenefits or costs.
- 6.13.3 Table 6-23 and Table 6-24 present the AMCB tables for the core forecast scenario for a scheme financed through public sector funding and private finance investment respectively. All values are shown in 2010 prices, discounted to a 2010 Present Value Year.

Table 6-23: A303 Amesbury to Berwick Down core forecast scenario AMCB table, publicly funded

Noise	-331	
Local Air Quality	302	
Greenhouse Gases	-86,458	
Journey Quality	0	
Physical Activity	0	
Accidents	4,393	
Economic Efficiency: Consumer Users (Commuting)	12,425	
Economic Efficiency: Consumer Users (Other)	61,031	
Economic Efficiency: Business Users and Providers	178,957	
Wider Public Finances (Indirect Taxation Revenues)	86,501	
Present Value of Benefits (see notes) (PVB)	256,821	
Broad Transport Budget	1,205,562	
Present Value of Costs (see notes) (PVC)	1,205,562	
OVERALL IMPACTS		
Net Present Value (NPV)	-948,741	NPV = PVB - PVC
Benefit to Cost Ratio (BCR)	0.21	BCR = PVB / PVC
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.		

Table 6-24: A303 Amesbury to Berwick Down core forecast scenario AMCB table, privately financed

Noise	-331	
Local Air Quality	302	
Greenhouse Gases	-86,458	
Journey Quality	0	
Physical Activity	0	
Accidents	4,393	
Economic Efficiency: Consumer Users (Commuting)	12,425	
Economic Efficiency: Consumer Users (Other)	61,031	
Economic Efficiency: Business Users and Providers	178,957	
Wider Public Finances (Indirect Taxation Revenues)	92,081	
Present Value of Benefits (see notes) (PVB)	262,401	
Broad Transport Budget	1,149,339	
Present Value of Costs (see notes) (PVC)	1,149,339	
OVERALL IMPACTS		
Net Present Value (NPV)	-886,938	NPV = PVB - PVC
Benefit to Cost Ratio (BCR)	0.23	BCR = PVB / PVC

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.

- 6.13.4 The AMCB tables show that the total unadjusted Present Value of Benefits (PVB) to transport users realised by the Scheme are over £262 million over the sixty year appraisal period should the Scheme be partly financed through private investment. As discussed previously, the private financing strategy results in an increase in Corporation Tax revenues of approximately £6 million, which is not realised if the Scheme is wholly publicly funded. Therefore the PVB of a publicly funded scheme is 7% less at approximately £257 million.
- 6.13.5 The PVB of £262 million for a privately financed scheme compares to a Present Value of Costs (PVC) of approximately £1.1 billion. Therefore the initial BCR for the Scheme, when financed with private investment, is 0.23.
- 6.13.6 The publicly funded strategy results in a PVC of approximately £1.2 billion. Comparing to the PVB of approximately £257 million results in an initial BCR for the Scheme of 0.21 when financed from public sector funds.
- 6.13.7 Both financing strategies result in economic benefits realised by transport users of the Scheme which are around 20% of the total scheme cost.

- 6.13.8 Additional benefits attributable to improved reliability, wider economic impacts and cultural heritage impacts are also realised as a result of the Scheme and are discussed in the next sections.

6.14 Reliability

- 6.14.1 The monetary benefits of improved reliability have been calculated by applying WebTAG values of time (as adjusted by the reliability ratio – see below) to the change in the standard deviation of journey times.
- 6.14.2 The reliability ratio is defined as the ratio of the value of a one minute change in journey time variability to the value of a one minute change in journey times. WebTAG Unit A1.3 (May 2018) suggests a reliability ratio of 0.4 (meaning that a one minute improvement in variability is worth 0.4 minutes of travel time savings). The results of the analysis are given in Table 6-25.

Table 6-25: Journey time reliability benefits

Commute	Business	Other	Goods vehicles	Total
10.0	9.1	36.0	5.5	60.5

Benefits in £millions – 2010 prices and values discounted to 2010

6.15 Wider impacts

Introduction

- 6.15.1 The monetary benefits of the wider economic impacts of the Scheme have been calculated using the DfT's Wider Impacts in Transport Appraisal (WITA) computer program.

Appraisal results

- 6.15.2 The appraisal of wider impacts for the Scheme has been undertaken for the core scenario. Given their status and inclusion in the adjusted BCR, the assessment has not been undertaken for any of the alternative growth scenarios.
- 6.15.3 Table 6-26 gives the benefits realised due to wider economic impacts in the core scenario.

Table 6-26: Wider economic impact benefits, core scenario

Wider Impact Measure	Benefit (£000s)
Agglomeration - manufacturing	1,000
Agglomeration – construction	1,000
Agglomeration - consumer services	3,000
Agglomeration - producer services	13,000
Agglomeration – Total	17,000
Labour supply impact	1,000
Increased output in imperfectly competitive market	17,000
The move to more/less productive jobs	0
Total	35,000

2010 prices and values discounted to 2010. Rounded to nearest million

- 6.15.4 Agglomeration benefits arise from improved labour market interactions, knowledge spill-over and linkages between suppliers and consumers. The Scheme reduces travel times and delay for users of the A303 improving the connectivity and accessibility between suppliers and firms. Table 6-26 shows that there are positive agglomeration impacts realised from the Scheme providing around £17 million of benefits across the appraisal period.
- 6.15.5 The largest benefits realised due to increased agglomeration occur in the area immediately surrounding the Scheme as shown in Figure 6-5. This shows that the reduction in travel costs has largest impact in the local area, however, there are benefits realised across the South West, particularly in Devon, Cornwall and western Somerset, indicating the large proportion of strategic, long distance trips which use the A303. It should be noted that the wider impacts assessment was limited to areas wholly within the SWRTM RoF, identified as within the orange boundary on Figure 6-5.

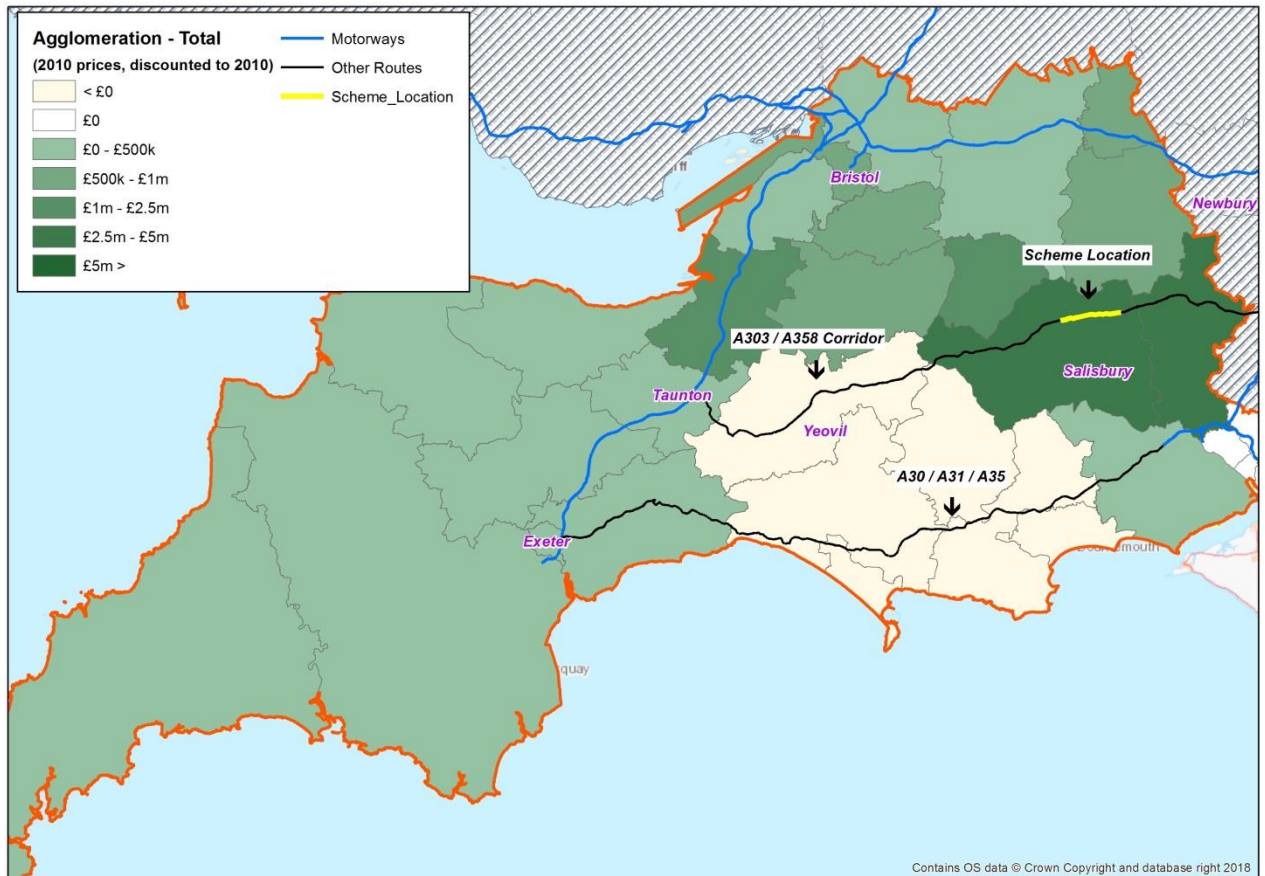


Figure 6-5: Agglomeration impacts, core scenario

- 6.15.6 Transport costs are likely to affect the overall costs and benefits to an individual from working. In deciding whether or not to work, an individual will weigh travel costs against the wage rate of the job travelled to. A change in transport costs is therefore likely to affect the incentives of individuals to work and hence the overall level of labour supplied in the economy. As the Scheme reduces the cost of travel, through improved travel times and reliability, there will be a higher level of labour supplied in the economy as a result of its implementation. There is a positive impact on labour supply as a result of the Scheme, with total benefits in the region of £1 million realised across the appraisal period.
- 6.15.7 Output change in imperfectly competitive markets refers to changes in the level of economic activity as a result of transport investment. Reductions in generalised travel cost induce investment and hence increase output, providing benefits to business users. Because the market is not perfectly competitive, improved transport can increase production beyond the cost of delivering this increase. As a key route between the South West and London, investment in transport infrastructure on the A303 will improve accessibility for business users leading to increased output. Table 6-26 shows that there are positive changes in output realised from the Scheme providing around £17 million of benefits across the appraisal period.
- 6.15.8 Appendix E contains tabular wider impact results by sector.

Freight sensitivity

- 6.15.9 The wider impacts appraised for the Scheme do not include benefits and costs arising due to freight trips in line with WebTAG Unit A2.1.
- 6.15.10 A change in the cost of freight trips will, however, be expected to impact on productivity. To assess the wider economic impact of the Scheme taking freight into account, a sensitivity test was undertaken including freight trips from the 'A303 Stonehenge SWRTM (DCO)' model in the analysis. The results of this appraisal are shown in Table 6-27.

Table 6-27: Wider economic impact benefits, freight sensitivity

Wider Impact Measure	Core Scenario Benefit (£000s)	Freight Sensitivity Benefit (£000s)	% Difference
Agglomeration - manufacturing	1,000	0	-31%
Agglomeration – construction	1,000	1,000	-17%
Agglomeration - consumer services	3,000	3,000	-9%
Agglomeration - producer services	13,000	12,000	-4%
Agglomeration – Total	17,000	16,000	-6%
Labour supply impact	1,000	1,000	0%
Increased output in imperfectly competitive market	17,000	18,000	+7%
The move to more/less productive jobs	0	0	0%
Total	35,000	35,000	0%

2010 prices and values discounted to 2010, rounded to nearest million

- 6.15.11 The benefits realised due to the wider economic impacts of the Scheme are unchanged when freight is additionally considered across the appraisal period. This is consistent with the conventional transport user benefit appraisal which showed that goods vehicles only contribute to around 4% of the TEE PVB.

NTEM 7.2 sensitivity

- 6.15.12 The standard input files included in WITA software are based on the National Trip End Model (NTEM) version 6.2, and the results presented above are based on this. The dataset is outdated, being superseded in July 2016 with the release of NTEM v7.0. Accordingly, a sensitivity test has been undertaken using values from the latest NTEM v7.2 dataset.
- 6.15.13 Table 6-28 presents these results.

Table 6-28: Wider economic impact benefits, NTEM 7.2 sensitivity

Wider Impact Measure	Core Scenario Benefit (£000s)	NTEM Sensitivity Benefit (£000s)	% Difference
Agglomeration - manufacturing	1,000	1,000	+14%
Agglomeration – construction	1,000	1,000	+13%
Agglomeration - consumer services	3,000	4,000	+11%
Agglomeration - producer services	13,000	14,000	+11%
Agglomeration – Total	17,000	19,000	+11%
Labour supply impact	1,000	1,000	+4%
Increased output in imperfectly competitive market	17,000	17,000	0%
The move to more/less productive jobs	0	0	0%
Total	35,000	37,000	+6%

2010 prices and values discounted to 2010, rounded to nearest million

6.15.14 Updating the inputs in line with the latest NTEM values causes a further 6% of wider economic benefits to be forecast. This is approximately a further £2 million.

6.16 Cultural heritage impacts

6.16.1 The aggregate net benefit for the removal of the A303 from its current location within the WHS was £24 million for visitors to Stonehenge¹², while for A303 road users it was £49 million and for the general population it was £1.2bn (in 2016 prices and values). Combining these together represents the overall value that society attributes to the impacts of removing the section of the A303 from this part of the WHS and results in an estimated aggregate NPV of £1.3 billion (2016 prices and values). For comparability with the overall cost benefit analysis this result has been converted to 2010 prices and discounted to 2010 to give a value of £955 million. The results are presented in Table 6-29.

¹² 40% of Stonehenge visitors are from the UK, 60% of visitors are international.

Table 6-29: Aggregate willingness to pay/accept

Group	WTP/WTa variable	% of Study Group	Relevant population	Mean Individual WTP / WTA (£)	Net Individual WTP (£ NPV)	Aggregation to national level (£million)
Visitors	Annual tax	67%	368,292	£23	£68	£24
	Compensation (one off)	1%	2,549	£188	-	
	Neither WTP or WTA	32%	175,863	-	-	
Road Users	Annual tax	67%	822,033	£22	£62	£49
	Compensation (one off)	2%	26,179	£81	-	
	Neither WTP or WTA	31%	371,747	-	-	
General Population	Annual tax	59%	30,445,460	£14	£42	£1,203
	Compensation (one off)	2%	1,182,093	£58	-	
	Neither WTP or WTA	39%	19,806,624	-	-	
Total net present value (2016 prices and values)						£1,277
Total net present value (2010 prices and values discounted to 2010)						£955

- 6.16.2 Upper and lower bound results were derived based on a 95% confidence interval for the willingness to pay values based on the respective sample sizes. The interpretation of this analysis is that the 95% confidence level for the willingness to pay value (net of willingness to accept) is between £1.1 billion and £1.4 billion (2016 prices and values).
- 6.16.3 The assessment demonstrates that the benefits of removing the road from the WHS as perceived by Stonehenge visitors and the general public are substantial.
- 6.16.4 The study methodology, survey design and key results have been externally peer reviewed by DfT and consultants appointed by DfT and Highways England and found to reflect best-practice¹³. A further peer review of the survey has been undertaken by Highways England to show that the results are not impacted by potential survey “scope effects”¹⁴. A more detailed explanation of the survey methodology, bias controls, checks and the benefits aggregation process is described in the Valuing Heritage Impacts report, found in Appendix H.

¹³ Appendix I contains the findings from the peer review work that has been undertaken for the contingent valuation analysis.

¹⁴ Results of contingent valuation studies can be unreliable and misleading because of the difficulty for individuals of identifying the value of the subject of the survey. This effect is called “scope effects”.

7 Sensitivity testing

7.1 Introduction

- 7.1.1 Sensitivity testing has been undertaken to understand the impacts of the Scheme, robustness and tolerances of the appraisal to changes in underlying assumptions.
- 7.1.2 This chapter sets out the sensitivity tests undertaken and the results of the appraisal undertaken on these scenarios. It should be noted that only the TUBA (Transport User Benefits) and COBA-LT (accident) appraisal elements have been assessed for these sensitivity tests.
- 7.1.3 Three separate tests have been undertaken around the core growth assumptions. Aligned with WebTAG Unit M4, both high and low growth sensitivity forecasts have been undertaken. Additionally, reflecting local uncertainty, an alternative growth scenario has been undertaken to assess the potential impacts of development at Boscombe Down, south of the A303 near Amesbury.
- 7.1.4 A separate demand sensitivity test has been undertaken, examining the impacts of the latest NTM RTF18 growth forecasts for LGVs and HGVs in addition to some minor network adjustments and the latest May 2018 WebTAG Databook. This sensitivity also uses the latest version of TUBA (v1.9.11) and COBA-LT parameters files that are consistent with the May 2018 Databook.
- 7.1.5 Cost-based sensitivity analysis is presented in section 7.4. This shows the uncertainty in scheme cost estimates around the central cost estimate (P10 and P90 costs).

7.2 Alternative scenarios

Low and high growth: Methodology

- 7.2.1 The forecasting methodology underpinning the development of the low and high growth forecast scenarios is detailed in the Transport Forecasting Package, Appendix C to the Combined Modelling and Appraisal Report (Application Document 7.5). These assessments have been undertaken in accordance with guidance provided in WebTAG Unit M4 to derive low and high growth demand through the subtraction or addition of a proportion of base year demand. These scenarios illustrate implications of uncertainty in forecast growth in travel demand over time.
- 7.2.2 Appraisal of the low and high growth scenarios follows the same methodology as the core scenario as detailed earlier in this report. The results of this appraisal are presented in the next section.

Low and high growth: Appraisal results

- 7.2.3 Table 7-1 shows the user benefits forecast in the high and low growth scenarios in comparison to the core scenario. Impacts of construction and environmental impacts have not been reassessed for these scenarios and their benefits and disbenefits are not included in the numbers presented in Table 7-1.

Table 7-1: High and low growth scenario transport user benefits

£millions, 2010 Prices and Values	Core	Low Growth	High Growth
Journey Times	370	304	382
Vehicle Operating Costs	-82	-72	-105
Accidents	4	7	1
Indirect Tax Revenues	82	71	101
Present Value of Benefits (PVB)	374	310	379
<i>Percentage change from core</i>	-	-21%	+1%

2010 prices, discounted to 2010. Rounded to nearest million.

7.2.4 The PVB of the low growth scenario is £310 million representing a 21% decrease from the core scenario. This is due to lower traffic flows together with less delay along the A303 in the without-scheme scenario.

7.2.5 There is a 1% increase in benefits in the PVB in the high growth scenario compared to the core scenario (£379 million compared to £374 million). This represents a small increase in magnitude of scheme benefits. Congestion from traffic along the A303 induced by the Scheme is forecast to be larger in this scenario.

Alternative scenario, Boscombe Down development: Methodology

7.2.6 The Boscombe Down scenario reflects the potential implications of an increase in employment to the western end of the Scheme, as detailed in the Traffic Forecasting Package.

Alternative scenario, Boscombe Down development: Appraisal results

7.2.7 Table 7-2 shows the benefits realised in the Boscombe Down scenario compared to the core scenario. Impacts of construction and environmental impacts have not been reassessed for this scenario and their benefits and disbenefits are not included in the numbers presented in Table 7-2.

Table 7-2: Boscombe Down alternative scenario transport user benefits

£millions, 2010 Prices and Values	Core	Boscombe Down
Journey Times	370	421
Vehicle Operating Costs	-82	-82
Accidents	4	5
Indirect Tax Revenues	82	81
Present Value of Benefits (PVB)	374	425
<i>Percentage change from core</i>	-	+13%

2010 prices, discounted to 2010. Rounded to nearest million.

7.2.8 The transport user benefits realised in the Boscombe Down scenario are 13% higher than the core scenario at £425 million compared to £374 million across the 60 year appraisal period. This increase can be attributed to higher travel time

saving benefits: the reduction in journey times as a result of the Scheme being experienced by more users as well as a slightly larger reduction in delay due to the without-scheme scenario being more congested.

- 7.2.9 Benefits realised due to changes in vehicle operating costs, indirect taxation revenue changes and accidents do not differ materially between the Boscombe Down and core scenarios.

7.3 DfT sensitivity test

Introduction

- 7.3.1 In May 2018, the DfT issued an update to WebTAG. This update of the WebTAG Databook included significant changes from the previous official release (December 2017) with regards to national Gross Domestic Product (GDP) forecasts. The release also differed slightly from the interim WebTAG Databook provided to the A303 Amesbury to Berwick Down team in February 2018 and which formed the basis of the core forecasts.
- 7.3.2 In June 2018, the DfT advised the A303 Amesbury to Berwick Down team, being a Tier 1 scheme, of forthcoming changes to its Road Traffic Forecasts, with large changes forecast for growth in LGVs and HGVs. The changes resulted in broadly halving of LGV growth compared with the previous RTF15 forecasts, and a large reduction in HGVs, including a reduction from 2017 levels in earlier forecast years.
- 7.3.3 Further to this a number of other updates have been made to the forecasting process, including a correction to the directionality associated with army trips to and from bases in the local area.
- 7.3.4 The full details of the updates made in this sensitivity test are set out in the Traffic Forecasting Package.

Economic assessment results

- 7.3.5 Table 7-3 presents the user benefits for this sensitivity test compared with the core scenario. Impacts of construction and environmental impacts have not been reassessed for this scenario and their benefits and disbenefits are not included in the numbers presented in this section.

Table 7-3: DfT sensitivity test transport user benefits

£millions, 2010 Prices and Values	Core	DfT sensitivity test
Journey Times	370	365

Vehicle Operating Costs	-82	-76
Accidents	4	4
Indirect Tax Revenues	82	75
Present Value of Benefits (PVB)	374	368
<i>Percentage change from core</i>	-	-2%

2010 prices, discounted to 2010. Rounded to nearest million.

- 7.3.6 The transport user benefits realised in the DfT sensitivity test are 2% lower than the core scenario at £368 million compared to £374 million across the 60 year appraisal period.
- 7.3.7 Table 7-4 and Table 7-5 present a breakdown of benefits by purpose and mode. Splits are shown by modelled year and modelled time period, respectively. Benefits presented here do not include benefits from the reduction in accidents.

Table 7-4: Benefits by year split by user type (£000's)

Purpose and mode	2026	2031	2041	2051	Full Appraisal
User Benefits					

Non-Business: Commuting	410	320	430	750	35,000
Non-Business: Other	1,640	1,500	2,400	2,310	123,000
Business: Car and LGV	2,850	2,860	3,940	3,410	185,000
Business: Goods Vehicles	280	270	430	420	21,000
TOTAL	5,180	4,950	7,200	6,890	364,000
Percentage change from core					
Non-Business: Commuting	-10%	-17%	-38%	71%	27%
Non-Business: Other	9%	-7%	-10%	8%	3%
Business: Car and LGV	-4%	-5%	-7%	-6%	-6%
Business: Goods Vehicles	-19%	-34%	-18%	-15%	-18%
TOTAL	-2%	-9%	-11%	3%	-2%

2010 prices, discounted to 2010. Rounded yearly to nearest ten thousand; full appraisal to nearest million.

Table 7-5: Benefits by time period split by user type (£000's)

Purpose and mode	AM	PM	IP & OP	Busy Days	TOTAL
User Benefits					
Non-Business: Commuting	9,000	8,000	11,000	7,000	35,000
Non-Business: Other	11,000	6,000	32,000	75,000	123,000
Business: Car and LGV	35,000	20,000	65,000	65,000	185,000
Business: Goods Vehicles	5,000	1,000	12,000	3,000	21,000
TOTAL	60,000	35,000	120,000	150,000	364,000
Percentage change from core					
Non-Business: Commuting	49%	203%	-6%	-2%	27%
Non-Business: Other	15%	84%	1%	-1%	3%
Business: Car and LGV	-3%	9%	-8%	-9%	-6%
Business: Goods Vehicles	-12%	-31%	-17%	-25%	-18%
TOTAL	4%	36%	-7%	-6%	-2%

2010 prices, discounted to 2010. These are full 60 year appraisal rounded to nearest million

- 7.3.8 Across the 60 year appraisal period and compared to the core scenario, total benefits have increased by £8 million for commute and by £3 million for other non-business users. Benefits decrease by £12 million for business car and LGV users, and by £5 million for goods vehicles.
- 7.3.9 The modelled years of 2026, 2031 and 2041 in the DfT sensitivity test show slight reductions across the benefits compared to the core scenario. 2051 benefits are similar to the core, with the full appraisal period showing an overall decrease of £6 million, as previously noted.
- 7.3.10 Benefits increase for the AM and PM modelled periods, with an additional £3 million and £10 million respectively in the DfT sensitivity test scenario compared

to the core scenario. The interpeak/off peak and busy day benefits decrease by £10 million and £8 million respectively.

Explanation of results

- 7.3.11 As stated in paragraph 7.3.2, the update to the RTF resulted in a large decrease in the factors used to growth LGV and HGV demand in the forecasts. As a result of this, the traffic flows for these user classes are lower in the DfT sensitivity test model than in the core scenario. With fewer goods vehicles in the network, average speeds are greater. This is true for both the Do Minimum and the Do Something forecasts.
- 7.3.12 Greater speeds on the Do Minimum network mean that the implementation of the Scheme has less of a decrease in travel times between Do-Minimum and Do-Something. Table 7-6 shows the differences in time saving along journey time route 11, which utilises the A303.

Table 7-6: Difference in time savings along route 11 from implementing scheme under DfT sensitivity test compared with the core scenario

Year	Time Period	Eastbound	Westbound
2026	AM	-00:00:11	-00:00:19
2026	IP	-00:00:06	-00:00:14
2026	PM	-00:00:06	-00:00:02
2031	AM	-00:00:20	-00:00:36
2031	IP	-00:00:06	-00:00:25
2031	PM	-00:00:04	-00:00:28
2041	AM	-00:00:24	-00:00:42
2041	IP	-00:00:15	-00:00:50
2041	PM	00:00:00	-00:00:26
2051	AM	-00:00:20	-00:00:47
2051	IP	-00:00:17	-00:01:02
2051	PM	-00:00:04	-00:00:25

- 7.3.13 The reduction in speed change leads to lower VOC benefits in the DfT sensitivity test scenario.
- 7.3.14 Correspondingly, the reduction in speed gain from implementing the Scheme also reduces the travel time benefits, and reduces indirect tax benefits as less fuel is consumed.
- 7.3.15 This results in an overall reduction in benefits.

7.4 Cost sensitivity

Introduction

- 7.4.1 Tests on the core scenario benefits have been undertaken to understand the sensitivity of the Scheme VfM to different cost estimates. These tests have been undertaken recognising that there is a degree of uncertainty inherent in estimating construction costs.
- 7.4.2 Two separate cost sensitivities have been examined: the P10 cost (representing a lower bound cost estimate) and the P90 cost (representing an upper bound cost estimate). These represent variations in costs around the central case cost estimate, also known as the P50 cost. These tests examine the impact on VfM of inherent uncertainty in construction cost estimates.

P10 and P90 cost estimates

- 7.4.3 Table 7-7 presents the P10 and P90 costs against the median. These costs represent a range estimate for capital costs, based on public sector funding.
- 7.4.4 The P90 cost represents an increase of around 41% above the central P50 cost whilst the estimated P10 cost is around 24% lower.
- 7.4.5 Variations in costs will have obvious impacts on the Scheme VfM – a lower cost will improve the BCR whilst a higher cost will worsen it. The P10 and P90 costs, as assessed, present a potential variation of approximately £783 million. However, the adjusted BCR of the Scheme remains below 1.5 for the lower bound (P10) cost estimate comparing against the total established and evolving monetised impact benefits of around £1.3 billion.

Table 7-7: Comparison of P10, Median and P90 costs

Element		P10 Cost (£ million)	Median Cost (£ million)	P90 Cost (£ million)
Scheme Costs	PVC	920	1,206	1,703

Presented in 2010 prices, discounted to 2010, rounded to nearest million.

8 Summary

8.1 Summary of work

- 8.1.1 The A303 Amesbury to Berwick Down scheme is being developed by Highways England for delivery in the first Road Investment Strategy (RIS) period. The Scheme is currently nearing the end of PCF Stage 3 (the Development phase) which will culminate in the submission of an application by Highways England for a Development Consent Order (DCO) to the Secretary of State.
- 8.1.2 To provide an evidence base for the Scheme at DCO, traffic modelling has been refined at PCF Stage 3. The 'A303 Stonehenge SWRTM (DCO)' model has been developed for a 2017 base year and demonstrates good levels of validation in the vicinity of the Scheme. This work is detailed in the Transport Model Package, Appendix B to the Combined Modelling and Appraisal Report (Application Document 7.5).
- 8.1.3 The traffic impacts of the A303 Amesbury to Berwick Down scheme have been modelled for four forecast years: 2026 (the Opening Year), 2031, 2041 (the Design Year) and 2051. This work is detailed in the Transport Forecasting Package, Appendix C to the Combined Modelling and Appraisal Report (Application Document 7.5).
- 8.1.4 An economic assessment of the Scheme has been undertaken using outputs from the four forecast year models, along with variants assessing the sensitivity of growth at a regional and national level. The appraisal of the Scheme includes consideration of the following impacts, as per guidance given in WebTAG:
- a. Transport Economic Efficiency (TEE) benefits, assessed using TUBA and comprising:
 - i. Travel time and vehicle operating cost (VOC) benefits and disbenefits arising from the Scheme; and
 - ii. Travel time and VOC benefits and disbenefits as a result of construction activities in advance of the Scheme opening year;
 - b. Changes in indirect tax revenues, assessed using TUBA;
 - c. The impact of the Scheme on accidents in both the local area and on regionally affected routes, assessed using COBA-LT;
 - d. The Scheme's impact on travel time reliability, assessed through analysis of current reliability trends on the A303 as shown in Trafficmaster data;
 - e. The wider impacts of the Scheme, assessed using WITA;
 - f. The environmental impacts of the Scheme, including air quality, noise and greenhouse gas impacts, assessed in accordance with WebTAG; and
 - g. The costs of the Scheme, assessed from the perspective of the public sector and for which there are two financing strategy routes which have been appraised:
 - i. Public sector funding comprising:

- i. Investment in capital costs to construct the Scheme prior to opening year; and
 - ii. Operating and maintenance costs beginning post scheme opening for the remainder of the 60 year appraisal period.
- ii. Private Finance (PF2) funding mechanisms comprising:
 - i. Construction costs and risks and maintenance and operating cost changes retained by Highways England;
 - ii. Unitary charge repayments by Highways England post scheme opening for a period of 25 years; and
 - iii. Operation and maintenance costs, both a proportion retained during the PF2 contract and in the period following conclusion of unitary charge payments for the remainder of the 60 year appraisal period.

8.2 Conclusions

- 8.2.1 Table 8-1 provides a summary of the transport-related benefits of the Scheme for the core scenario over the appraisal period, whilst Table 8-2 provides a summary of the scheme costs over the same 60 year period. These benefits and costs are presented for both financing strategies appraised: a wholly publicly funded scheme; and a scheme financed through private sector investment.
- 8.2.2 It should be noted that the assessment documented herein comprises primarily of the transport-related economic impacts.

Table 8-1: Summary of A303 Amesbury to Berwick Down benefits (£ million)

Benefit component		Publicly Funded	Privately Financed
Initial PVB	TEE benefits (including construction), of which:	252	252
	(... <i>Commuting user benefits</i> :)	(... 12)	(... 12)
	(... <i>Other user benefits</i> :)	(... 61)	(... 61)
	(... <i>Business user benefits</i> :)	(... 179)	(... 179)
	Indirect tax revenues	87	87
	Corporation Tax revenues	0	6
	Accident benefits	4	4
	Air quality	0	0
	Noise	0	0
	Greenhouse gas emissions	-86	-86
	Initial PVB	257	262
Adjusted PVB	Travel time reliability	61	61
	Wider Impacts	35	35
	Cultural heritage impacts	955	955
	Adjusted PVB	1,308	1,313

2010 prices and values, discounted to 2010, rounded to nearest million

Table 8-2: Summary of A303 Amesbury to Berwick Down costs (£ million)

Cost Element		Publicly Funded	Privately Financed
PVC	Capital Expenditure	970	0
	Retained Capital Expenditure	0	180
	Unitary Charge	0	860
	Operating Expenditure	235	109
	Total	1,206	1,149

Presented in 2010 prices, discounted to 2010. Market price unit of account. Costs are rounded to nearest million.

- 8.2.3 The A303 Amesbury to Berwick Down scheme provides around £252 million of user benefits, taking into account the impacts of the Scheme on travel times and VOCs, and the disbenefits experienced during a five-year period of construction. A further benefit of approximately £87 million is realised through increased indirect tax revenues.
- 8.2.4 The Scheme has an overall net positive impact on accidents and casualties, with a monetised benefit of around £4 million. The Scheme reduces accidents and casualties across all categories. The benefit in the direct vicinity of the Scheme is higher than the final value of £4 million due to erosion of benefits as a result of increased traffic volumes (through re-routeing and induced traffic) on unimproved sections of the A303 corridor.
- 8.2.5 Environmental impacts of the Scheme have been assessed in accordance with guidance in WebTAG Unit A3. The methodology and results are detailed in the Environmental Statement. The Scheme has little impact on the tonnes of NOx and concentrations of PM10 in the local area but is expected to cause an increase in the total tonnes of greenhouse gas emissions. Overall this leads to a disbenefit of approximately £86 million. The Scheme is expected to significantly reduce traffic noise levels in Winterbourne Stoke and the tunnelled section of the WHS but with increases in noise within Amesbury due to traffic rerouting. Overall there is no material economic impact from the Scheme attributable to noise.
- 8.2.6 A scheme financed wholly through public sector funding has been assessed to have a total cost of approximately £1.2 billion. This includes up-front expenditure for preliminary works and construction of the Scheme prior to the 2026 opening year. Operational and maintenance costs have been assessed throughout the 60 year appraisal period.
- 8.2.7 Delivery of the Scheme through a private finance (PF2) procurement method would result in scheme costs which have been assessed at approximately £1.1 billion. In this scenario the contracted DBFM firm would assume responsibility for the majority of construction related costs with Highways England incurring costs via a unitary charge for 25 years following the Scheme opening, in 2026, as well as retained costs of required preliminary works. Operational and maintenance costs have been assessed throughout the 60 year appraisal period. Should the Scheme be delivered through PF2 mechanisms then this would result in an additional £6 million in increased Corporation Tax revenues.

- 8.2.8 The initial Net Present Value (NPV) of the Scheme, as funded wholly through the public sector, is approximately -£949 million resulting in an initial BCR of 0.21. The assessment of the Scheme as financed through PF2 mechanisms estimates that the initial NPV will be approximately -£886 million resulting in an initial BCR of 0.23.
- 8.2.9 Further to the core transport user benefits, the impact of the Scheme on journey time reliability and wider economic impacts has been appraised. Travel time reliability has been calculated through analysis of observed Trafficmaster journey time data for the single-carriageway section of the A303 past Stonehenge and a comparative dual-carriageway section. Analysis in-line with WebTAG results in a benefit of around £61 million.
- 8.2.10 Wider economic impacts have been assessed using WITA. These take into account the impact of the Scheme on agglomeration, labour supply and increased output in imperfectly competitive markets. The core scenario results in a benefit to the wider economy of around £35 million.
- 8.2.11 A key non-transport related impact of the Scheme is that of the removal of the A303 from the World Heritage Site (WHS), which is captured in the cultural heritage contingent valuation. This was assessed as providing £955 million of benefits. Together, along with the travel time reliability and wider economic impacts, an adjusted BCR is derived.
- 8.2.12 Taking into account the wider economic, journey time reliability and cultural heritage impacts of the Scheme, the adjusted Net Present Value (NPV) is calculated at approximately £102 million for a scheme funded wholly through the public sector. This results in an adjusted BCR of 1.08. Financing the Scheme through PF2 mechanisms provides an adjusted NPV of approximately £164 million resulting in an adjusted BCR of 1.14.

Abbreviations List

AADT	Annual Average Daily Traffic
AMCB	Analysis of Monetised Costs and Benefits
AoDM	Area of Detailed Modelling
BCR	Benefit to Cost Ratio
CIP	Complex Infrastructure Project
COBALT	Cost and Benefits to Accidents – Light Touch
ComMA	Combined Modelling and Appraisal
CSR	Client Scheme Requirements
DBFM	Design, Build, Finance, Maintain
DCO	Development Consent Order
DfT	Department for Transport
DIADEM	Dynamic Integrated Assignment and Demand Modelling
EAR	Economic Appraisal Report
ES	Environmental Statement
GDP	Gross Domestic Product
GIS	Geographic Information Systems
HEIDI	Highways England Integrated DIADEM Interface
HGV	Heavy Goods Vehicle
HM	Her Majesty's
IAN	Interim Advice Note
Km	Kilometre
Km/h	Kilometres per hour
LAD	Local Authority District
LGV	Light Goods Vehicle
MoD	Ministry of Defence
MyRIAD	Motorway Reliability Incidents and Delays
NPV	Net Present Value

NSIP	Nationally Significant Infrastructure Project		
NTEM	National Trip End Model		
NTM	National Transport Model		
NTS	National Travel Survey		
O&M	Operations and Maintenance		
OBR	Office for Budget Responsibility		
OGV	Ordinary Goods Vehicle		
ONS	Office for National Statistics		
PA	Public Accounts	PF2	Private Finance
PIA	Personal Injury Accident		
PINS	Planning Inspectorate		
PVB	Present Value Benefits		
PVC	Present Value Costs		
RIS	Roads Investment Strategy		
RoF	Region of Focus		
RSI	Roadside Interview		
RTM	Regional Traffic Model		
SRN	Strategic Road Network		
SWRTM	South West Regional Traffic Model		
TEE	Transport Economic Efficiency		
TEMPro	Trip End Model Programme		
TEN-T	Trans-European Network - Transport		
TPG	Transport Planning Group		
TUBA	Transport User Benefits Appraisal		
VDM	Variable Demand Model		
VfM	Value for Money		
VOC	Vehicle Operating Cost		
VoT	Value of Time		

WebTAG Web-based Transport Analysis Guidance

WHS World Heritage Site

WITA Wider Impacts in Transport Appraisal

Appendices

Appendix A Sectors for TUBA masking

A.1 Full list of TUBA sectors

Sector Number	Sector Name	Group Name
101	Area of Detailed Modelling	Central Area
102	Salisbury	Central Area
103	Shaftesbury	Central Area
104	West Wiltshire	Central Area
105	North Wiltshire	Central Area
106	Kennet	Central Area
107	Swindon	Central Area
108	Salisbury Centre	Central Area
201	New Forest	Dorset & New Forest
202	Test Valley	Central Area
203	Southampton	Southampton & Portsmouth
204	Eastleigh	Southampton & Portsmouth
205	Fareham	Southampton & Portsmouth
206	Gosport	Southampton & Portsmouth
207	Portsmouth	Southampton & Portsmouth
208	Havant	Southampton & Portsmouth
209	Winchester	East Hampshire
210	Basingstoke and Deane	East Hampshire
211	East Hampshire, Hart and Rushmoor	East Hampshire
212	Basingstoke	East Hampshire
213	Winchester City	East Hampshire
301	North Dorset	Dorset & New Forest
302	West Dorset, Weymouth and Portland	Dorset & New Forest
303	Rest of Dorset	Dorset & New Forest
304	Bournemouth & Poole	Dorset & New Forest
305	Weymouth	Dorset & New Forest
401	Mendip	Somerset
402	South Somerset	Somerset
403	Sedgemoor	Somerset
404	Taunton Deane	Somerset
405	West Somerset	South-West
406	Taunton	Somerset
407	Bridgwater	Somerset
408	Yeovil	Somerset
501	BaNES	Avon
502	Bristol	Avon
503	North Somerset	Avon
504	South Gloucestershire	Avon

Sector Number	Sector Name	Group Name
505	Weston-Super-Mare	Avon
506	Clevedon	Avon
601	Exeter	South-West
602	East Devon	South-West
603	Mid Devon	South-West
604	North Devon	South-West
605	Rest of Devon	South-West
606	Cornwall	South-West
607	Honiton	South-West
701	West Berkshire	Berkshire
702	Reading	Berkshire
703	Rest of Berkshire	Berkshire
801	Gloucestershire	Glos. Oxford. Bucks
802	Oxfordshire	Glos. Oxford. Bucks
901	London	London & South-East
902	Surrey	London & South-East
903	West Sussex	London & South-East
904	East Sussex	London & South-East
905	Kent	London & South-East
906	Buckinghamshire	Glos. Oxford. Bucks
907	East of England	Midlands & East
908	East Midlands	Midlands & East
909	West Midlands	Midlands & East
910	Northern England	North & Scotland
920	South Wales	Wales
921	Mid Wales	Wales
922	North Wales	Wales
930	Scotland	North & Scotland

A.2 Full list of masked movements between sectors

Origin Sector Name	Origin Sector Number	Destination Sector Name	Destination Sector Number
Southampton	203	Southampton	203
Southampton	203	Eastleigh	204
Southampton	203	Fareham	205
Southampton	203	Gosport	206
Southampton	203	Portsmouth	207
Southampton	203	Havant	208
Southampton	203	London	901
Southampton	203	Surrey	902
Southampton	203	West Sussex	903
Southampton	203	East Sussex	904
Southampton	203	Kent	905
Eastleigh	204	Southampton	203
Eastleigh	204	Eastleigh	204
Eastleigh	204	Fareham	205
Eastleigh	204	Gosport	206
Eastleigh	204	Portsmouth	207
Eastleigh	204	Havant	208
Eastleigh	204	London	901
Eastleigh	204	Surrey	902
Eastleigh	204	West Sussex	903
Eastleigh	204	East Sussex	904
Eastleigh	204	Kent	905
Fareham	205	Southampton	203
Fareham	205	Eastleigh	204
Fareham	205	Fareham	205
Fareham	205	Gosport	206
Fareham	205	Portsmouth	207
Fareham	205	Havant	208
Fareham	205	London	901
Fareham	205	Surrey	902
Fareham	205	West Sussex	903
Fareham	205	East Sussex	904
Fareham	205	Kent	905
Gosport	206	Southampton	203
Gosport	206	Eastleigh	204
Gosport	206	Fareham	205
Gosport	206	Gosport	206
Gosport	206	Portsmouth	207
Gosport	206	Havant	208
Gosport	206	London	901

Origin Sector Name	Origin Sector Number	Destination Sector Name	Destination Sector Number
Gosport	206	Surrey	902
Gosport	206	West Sussex	903
Gosport	206	East Sussex	904
Gosport	206	Kent	905
Portsmouth	207	Southampton	203
Portsmouth	207	Eastleigh	204
Portsmouth	207	Fareham	205
Portsmouth	207	Gosport	206
Portsmouth	207	Portsmouth	207
Portsmouth	207	Havant	208
Portsmouth	207	London	901
Portsmouth	207	Surrey	902
Portsmouth	207	West Sussex	903
Portsmouth	207	East Sussex	904
Portsmouth	207	Kent	905
Havant	208	Southampton	203
Havant	208	Eastleigh	204
Havant	208	Fareham	205
Havant	208	Gosport	206
Havant	208	Portsmouth	207
Havant	208	Havant	208
Havant	208	London	901
Havant	208	Surrey	902
Havant	208	West Sussex	903
Havant	208	East Sussex	904
Havant	208	Kent	905
Winchester City	213	Winchester City	213
Basingstoke	212	Basingstoke	212
New Forest	201	New Forest	201
New Forest	201	North Dorset	301
New Forest	201	West Dorset, Weymouth and Portland	302
New Forest	201	Bournemouth and Poole	304
New Forest	201	Weymouth	305
New Forest	201	Rest of Dorset	303
North Dorset	301	New Forest	201
North Dorset	301	North Dorset	301
North Dorset	301	West Dorset, Weymouth and Portland	302
North Dorset	301	Bournemouth and Poole	304
North Dorset	301	Weymouth	305
North Dorset	301	Rest of Dorset	303

Origin Sector Name	Origin Sector Number	Destination Sector Name	Destination Sector Number
West Dorset, Weymouth and Portland	302	New Forest	201
West Dorset, Weymouth and Portland	302	North Dorset	301
West Dorset, Weymouth and Portland	302	West Dorset, Weymouth and Portland	302
West Dorset, Weymouth and Portland	302	Bournemouth and Poole	304
West Dorset, Weymouth and Portland	302	Weymouth	305
West Dorset, Weymouth and Portland	302	Rest of Dorset	303
Bournemouth and Poole	304	New Forest	201
Bournemouth and Poole	304	North Dorset	301
Bournemouth and Poole	304	West Dorset, Weymouth and Portland	302
Bournemouth and Poole	304	Bournemouth and Poole	304
Bournemouth and Poole	304	Weymouth	305
Bournemouth and Poole	304	Rest of Dorset	303
Weymouth	305	New Forest	201
Weymouth	305	North Dorset	301
Weymouth	305	West Dorset, Weymouth and Portland	302
Weymouth	305	Bournemouth and Poole	304
Weymouth	305	Weymouth	305
Weymouth	305	Rest of Dorset	303
Rest of Dorset	303	New Forest	201
Rest of Dorset	303	North Dorset	301
Rest of Dorset	303	West Dorset, Weymouth and Portland	302
Rest of Dorset	303	Bournemouth and Poole	304
Rest of Dorset	303	Weymouth	305
Rest of Dorset	303	Rest of Dorset	303
Yeovil	408	Yeovil	408
Bridgwater	407	Bridgwater	407
Taunton	406	Taunton	406
BaNES	501	BaNES	501
BaNES	501	Bristol	502
BaNES	501	North Somerset	503
BaNES	501	Weston-Super-Mare	505
BaNES	501	Clevedon	506
BaNES	501	South Gloucestershire	504
Bristol	502	BaNES	501
Bristol	502	Bristol	502

Origin Sector Name	Origin Sector Number	Destination Sector Name	Destination Sector Number
Bristol	502	North Somerset	503
Bristol	502	Weston-Super-Mare	505
Bristol	502	Clevedon	506
Bristol	502	South Gloucestershire	504
North Somerset	503	BaNES	501
North Somerset	503	Bristol	502
North Somerset	503	North Somerset	503
North Somerset	503	Weston-Super-Mare	505
North Somerset	503	Clevedon	506
North Somerset	503	South Gloucestershire	504
Weston-Super-Mare	505	BaNES	501
Weston-Super-Mare	505	Bristol	502
Weston-Super-Mare	505	North Somerset	503
Weston-Super-Mare	505	Weston-Super-Mare	505
Weston-Super-Mare	505	Clevedon	506
Weston-Super-Mare	505	South Gloucestershire	504
Clevedon	506	BaNES	501
Clevedon	506	Bristol	502
Clevedon	506	North Somerset	503
Clevedon	506	Weston-Super-Mare	505
Clevedon	506	Clevedon	506
Clevedon	506	South Gloucestershire	504
South Gloucestershire	504	BaNES	501
South Gloucestershire	504	Bristol	502
South Gloucestershire	504	North Somerset	503
South Gloucestershire	504	Weston-Super-Mare	505
South Gloucestershire	504	Clevedon	506
South Gloucestershire	504	South Gloucestershire	504
West Somerset	405	West Somerset	405
West Somerset	405	Exeter	601
West Somerset	405	East Devon	602
West Somerset	405	Honiton	607
West Somerset	405	Mid Devon	603
West Somerset	405	North Devon	604
West Somerset	405	Rest of Devon	605
West Somerset	405	Cornwall	606
Exeter	601	West Somerset	405
Exeter	601	Exeter	601
Exeter	601	East Devon	602
Exeter	601	Honiton	607
Exeter	601	Mid Devon	603

Origin Sector Name	Origin Sector Number	Destination Sector Name	Destination Sector Number
Exeter	601	North Devon	604
Exeter	601	Rest of Devon	605
Exeter	601	Cornwall	606
East Devon	602	West Somerset	405
East Devon	602	Exeter	601
East Devon	602	East Devon	602
East Devon	602	Honiton	607
East Devon	602	Mid Devon	603
East Devon	602	North Devon	604
East Devon	602	Rest of Devon	605
East Devon	602	Cornwall	606
Honiton	607	West Somerset	405
Honiton	607	Exeter	601
Honiton	607	East Devon	602
Honiton	607	Honiton	607
Honiton	607	Mid Devon	603
Honiton	607	North Devon	604
Honiton	607	Rest of Devon	605
Honiton	607	Cornwall	606
Mid Devon	603	West Somerset	405
Mid Devon	603	Exeter	601
Mid Devon	603	East Devon	602
Mid Devon	603	Honiton	607
Mid Devon	603	Mid Devon	603
Mid Devon	603	North Devon	604
Mid Devon	603	Rest of Devon	605
Mid Devon	603	Cornwall	606
North Devon	604	West Somerset	405
North Devon	604	Exeter	601
North Devon	604	East Devon	602
North Devon	604	Honiton	607
North Devon	604	Mid Devon	603
North Devon	604	North Devon	604
North Devon	604	Rest of Devon	605
North Devon	604	Cornwall	606
Rest of Devon	605	West Somerset	405
Rest of Devon	605	Exeter	601
Rest of Devon	605	East Devon	602
Rest of Devon	605	Honiton	607
Rest of Devon	605	Mid Devon	603
Rest of Devon	605	North Devon	604

Origin Sector Name	Origin Sector Number	Destination Sector Name	Destination Sector Number
Rest of Devon	605	Rest of Devon	605
Rest of Devon	605	Cornwall	606
Cornwall	606	West Somerset	405
Cornwall	606	Exeter	601
Cornwall	606	East Devon	602
Cornwall	606	Honiton	607
Cornwall	606	Mid Devon	603
Cornwall	606	North Devon	604
Cornwall	606	Rest of Devon	605
Cornwall	606	Cornwall	606
Gloucestershire	801	Gloucestershire	801
Gloucestershire	801	Oxfordshire	802
Gloucestershire	801	Buckinghamshire	906
Gloucestershire	801	London	901
Gloucestershire	801	Surrey	902
Gloucestershire	801	West Sussex	903
Gloucestershire	801	East Sussex	904
Gloucestershire	801	Kent	905
Gloucestershire	801	East of England	907
Gloucestershire	801	East Midlands	908
Gloucestershire	801	West Midlands	909
Gloucestershire	801	South Wales	920
Gloucestershire	801	Mid Wales	921
Gloucestershire	801	North Wales	922
Gloucestershire	801	Northern England	910
Gloucestershire	801	Scotland	930
Oxfordshire	802	Gloucestershire	801
Oxfordshire	802	Oxfordshire	802
Oxfordshire	802	Buckinghamshire	906
Oxfordshire	802	London	901
Oxfordshire	802	Surrey	902
Oxfordshire	802	West Sussex	903
Oxfordshire	802	East Sussex	904
Oxfordshire	802	Kent	905
Oxfordshire	802	East of England	907
Oxfordshire	802	East Midlands	908
Oxfordshire	802	West Midlands	909
Oxfordshire	802	South Wales	920
Oxfordshire	802	Mid Wales	921
Oxfordshire	802	North Wales	922
Oxfordshire	802	Northern England	910

Origin Sector Name	Origin Sector Number	Destination Sector Name	Destination Sector Number
Oxfordshire	802	Scotland	930
Buckinghamshire	906	Gloucestershire	801
Buckinghamshire	906	Oxfordshire	802
Buckinghamshire	906	Buckinghamshire	906
Buckinghamshire	906	London	901
Buckinghamshire	906	Surrey	902
Buckinghamshire	906	West Sussex	903
Buckinghamshire	906	East Sussex	904
Buckinghamshire	906	Kent	905
Buckinghamshire	906	East of England	907
Buckinghamshire	906	East Midlands	908
Buckinghamshire	906	West Midlands	909
Buckinghamshire	906	South Wales	920
Buckinghamshire	906	Mid Wales	921
Buckinghamshire	906	North Wales	922
Buckinghamshire	906	Northern England	910
Buckinghamshire	906	Scotland	930
London	901	Southampton	203
London	901	Eastleigh	204
London	901	Fareham	205
London	901	Gosport	206
London	901	Portsmouth	207
London	901	Havant	208
London	901	Gloucestershire	801
London	901	Oxfordshire	802
London	901	Buckinghamshire	906
London	901	London	901
London	901	Surrey	902
London	901	West Sussex	903
London	901	East Sussex	904
London	901	Kent	905
London	901	East of England	907
London	901	East Midlands	908
London	901	West Midlands	909
London	901	Northern England	910
London	901	Scotland	930
Surrey	902	Southampton	203
Surrey	902	Eastleigh	204
Surrey	902	Fareham	205
Surrey	902	Gosport	206
Surrey	902	Portsmouth	207

Origin Sector Name	Origin Sector Number	Destination Sector Name	Destination Sector Number
Surrey	902	Havant	208
Surrey	902	Gloucestershire	801
Surrey	902	Oxfordshire	802
Surrey	902	Buckinghamshire	906
Surrey	902	London	901
Surrey	902	Surrey	902
Surrey	902	West Sussex	903
Surrey	902	East Sussex	904
Surrey	902	Kent	905
Surrey	902	East of England	907
Surrey	902	East Midlands	908
Surrey	902	West Midlands	909
Surrey	902	Northern England	910
Surrey	902	Scotland	930
West Sussex	903	Southampton	203
West Sussex	903	Eastleigh	204
West Sussex	903	Fareham	205
West Sussex	903	Gosport	206
West Sussex	903	Portsmouth	207
West Sussex	903	Havant	208
West Sussex	903	Gloucestershire	801
West Sussex	903	Oxfordshire	802
West Sussex	903	Buckinghamshire	906
West Sussex	903	London	901
West Sussex	903	Surrey	902
West Sussex	903	West Sussex	903
West Sussex	903	East Sussex	904
West Sussex	903	Kent	905
West Sussex	903	East of England	907
West Sussex	903	East Midlands	908
West Sussex	903	West Midlands	909
West Sussex	903	Northern England	910
West Sussex	903	Scotland	930
East Sussex	904	Southampton	203
East Sussex	904	Eastleigh	204
East Sussex	904	Fareham	205
East Sussex	904	Gosport	206
East Sussex	904	Portsmouth	207
East Sussex	904	Havant	208
East Sussex	904	Gloucestershire	801
East Sussex	904	Oxfordshire	802

Origin Sector Name	Origin Sector Number	Destination Sector Name	Destination Sector Number
East Sussex	904	Buckinghamshire	906
East Sussex	904	London	901
East Sussex	904	Surrey	902
East Sussex	904	West Sussex	903
East Sussex	904	East Sussex	904
East Sussex	904	Kent	905
East Sussex	904	East of England	907
East Sussex	904	East Midlands	908
East Sussex	904	West Midlands	909
East Sussex	904	Northern England	910
East Sussex	904	Scotland	930
Kent	905	Southampton	203
Kent	905	Eastleigh	204
Kent	905	Fareham	205
Kent	905	Gosport	206
Kent	905	Portsmouth	207
Kent	905	Havant	208
Kent	905	Gloucestershire	801
Kent	905	Oxfordshire	802
Kent	905	Buckinghamshire	906
Kent	905	London	901
Kent	905	Surrey	902
Kent	905	West Sussex	903
Kent	905	East Sussex	904
Kent	905	Kent	905
Kent	905	East of England	907
Kent	905	East Midlands	908
Kent	905	West Midlands	909
Kent	905	Northern England	910
Kent	905	Scotland	930
East of England	907	Gloucestershire	801
East of England	907	Oxfordshire	802
East of England	907	Buckinghamshire	906
East of England	907	London	901
East of England	907	Surrey	902
East of England	907	West Sussex	903
East of England	907	East Sussex	904
East of England	907	Kent	905
East of England	907	East of England	907
East of England	907	East Midlands	908
East of England	907	West Midlands	909

Origin Sector Name	Origin Sector Number	Destination Sector Name	Destination Sector Number
East of England	907	South Wales	920
East of England	907	Mid Wales	921
East of England	907	North Wales	922
East of England	907	Northern England	910
East of England	907	Scotland	930
East Midlands	908	Gloucestershire	801
East Midlands	908	Oxfordshire	802
East Midlands	908	Buckinghamshire	906
East Midlands	908	London	901
East Midlands	908	Surrey	902
East Midlands	908	West Sussex	903
East Midlands	908	East Sussex	904
East Midlands	908	Kent	905
East Midlands	908	East of England	907
East Midlands	908	East Midlands	908
East Midlands	908	West Midlands	909
East Midlands	908	South Wales	920
East Midlands	908	Mid Wales	921
East Midlands	908	North Wales	922
East Midlands	908	Northern England	910
East Midlands	908	Scotland	930
West Midlands	909	Gloucestershire	801
West Midlands	909	Oxfordshire	802
West Midlands	909	Buckinghamshire	906
West Midlands	909	London	901
West Midlands	909	Surrey	902
West Midlands	909	West Sussex	903
West Midlands	909	East Sussex	904
West Midlands	909	Kent	905
West Midlands	909	East of England	907
West Midlands	909	East Midlands	908
West Midlands	909	West Midlands	909
West Midlands	909	South Wales	920
West Midlands	909	Mid Wales	921
West Midlands	909	North Wales	922
West Midlands	909	Northern England	910
West Midlands	909	Scotland	930
South Wales	920	Gloucestershire	801
South Wales	920	Oxfordshire	802
South Wales	920	Buckinghamshire	906
South Wales	920	East of England	907

Origin Sector Name	Origin Sector Number	Destination Sector Name	Destination Sector Number
South Wales	920	East Midlands	908
South Wales	920	West Midlands	909
South Wales	920	South Wales	920
South Wales	920	Mid Wales	921
South Wales	920	North Wales	922
South Wales	920	Northern England	910
South Wales	920	Scotland	930
Mid Wales	921	Gloucestershire	801
Mid Wales	921	Oxfordshire	802
Mid Wales	921	Buckinghamshire	906
Mid Wales	921	East of England	907
Mid Wales	921	East Midlands	908
Mid Wales	921	West Midlands	909
Mid Wales	921	South Wales	920
Mid Wales	921	Mid Wales	921
Mid Wales	921	North Wales	922
Mid Wales	921	Northern England	910
Mid Wales	921	Scotland	930
North Wales	922	Gloucestershire	801
North Wales	922	Oxfordshire	802
North Wales	922	Buckinghamshire	906
North Wales	922	East of England	907
North Wales	922	East Midlands	908
North Wales	922	West Midlands	909
North Wales	922	South Wales	920
North Wales	922	Mid Wales	921
North Wales	922	North Wales	922
North Wales	922	Northern England	910
North Wales	922	Scotland	930
Northern England	910	Gloucestershire	801
Northern England	910	Oxfordshire	802
Northern England	910	Buckinghamshire	906
Northern England	910	London	901
Northern England	910	Surrey	902
Northern England	910	West Sussex	903
Northern England	910	East Sussex	904
Northern England	910	Kent	905
Northern England	910	East of England	907
Northern England	910	East Midlands	908
Northern England	910	West Midlands	909
Northern England	910	South Wales	920

Origin Sector Name	Origin Sector Number	Destination Sector Name	Destination Sector Number
Northern England	910	Mid Wales	921
Northern England	910	North Wales	922
Northern England	910	Northern England	910
Northern England	910	Scotland	930
Scotland	930	Gloucestershire	801
Scotland	930	Oxfordshire	802
Scotland	930	Buckinghamshire	906
Scotland	930	London	901
Scotland	930	Surrey	902
Scotland	930	West Sussex	903
Scotland	930	East Sussex	904
Scotland	930	Kent	905
Scotland	930	East of England	907
Scotland	930	East Midlands	908
Scotland	930	West Midlands	909
Scotland	930	South Wales	920
Scotland	930	Mid Wales	921
Scotland	930	North Wales	922
Scotland	930	Northern England	910
Scotland	930	Scotland	930

Appendix B Sectored TUBA analysis

B.1 Total travel time benefits by group

Table B-1: Travel time user benefits by regional group (£m)

£409.3m	Central Area	So'ton & Po'mouth	East Hampshire	Dorset & New Forest	Somerset	Avon	Berkshire	South-west	Glos. Oxford Bucks	London & South-east	Midlands & East	Wales	North & Scotland
Central Area	88.96	-0.21	0.47	5.26	7.93	5.70	1.85	3.50	1.71	8.03	2.60	1.17	0.11
Southampton & Portsmouth	-0.38	0	0.04	0.72	-0.51	0.48	-0.49	-1.08	-0.86	0	-1.30	0.63	-0.64
East Hampshire	2.34	-0.22	-7.29	1.98	6.78	2.62	-1.46	7.09	-0.54	-3.48	-0.81	0.49	-0.19
Dorset & New Forest	5.81	5.44	1.86	0	-8.21	-0.34	0.60	-3.37	0.36	4.49	0.56	0.35	-0.14
Somerset	10.02	1.22	7.55	-4.58	-24.17	7.40	3.79	-5.75	4.70	19.47	9.41	2.23	1.20
Avon	5.84	1.13	3.35	-0.83	0.01	0	2.12	1.87	1.42	7.69	2.10	-4.38	0.30
Berkshire	2.86	-0.56	-1.21	0.87	3.32	2.49	-1.24	3.55	0.34	-0.17	0.02	2.05	-0.05
South-west	7.00	1.09	10.36	-0.43	-5.78	7.38	3.73	0	5.57	42.45	24.88	4.03	9.02
Glos. Oxford Bucks	1.65	-0.24	-0.33	0.01	2.89	2.78	1.47	3.49	0	0	0	0	0
London & South-east	7.34	0	-1.23	4.68	12.15	7.90	0.32	15.58	0	0	0	5.80	0
Midlands & East	2.97	-0.75	-0.57	0.90	5.02	3.27	0.54	6.07	0	0	0	0	0
Wales	1.36	0.70	0.38	-0.03	0.86	1.57	1.48	1.85	0	3.09	0	0	0
North & Scotland	0.06	-0.26	-0.08	0.01	0.37	0.84	0.07	2.20	0	0	0	0	0

B.2 Total vehicle operating costs by group

Table B-2: Vehicle operating cost user benefits by regional group (£m)

£-79.7m	Central Area	So'ton & Po'mouth	East Hampshire	Dorset & New Forest	Somerset	Avon	Berkshire	South-west	Glos. Oxford Bucks	London & South-east	Midlands & East	Wales	North & Scotland
Central Area	-13.87	0.33	-0.81	-0.86	-2.29	-0.52	-0.52	-1.62	-0.34	-1.69	-0.79	-0.17	-0.10
Southampton & Portsmouth	0.88	0.00	0.36	-0.30	-0.31	-0.10	0.07	-0.16	0.08	0.00	0.22	-0.06	0.07
East Hampshire	-0.76	0.08	0.13	-0.58	-1.58	-0.36	0.19	-3.02	0.09	0.28	0.17	-0.08	0.05
Dorset & New Forest	-0.44	0.11	-0.41	0.00	0.58	0.02	-0.18	0.30	-0.17	-1.22	-0.41	-0.16	0.01
Somerset	-1.59	-0.65	-1.72	0.54	1.24	-0.53	-0.31	0.64	-0.93	-4.07	-1.85	-0.24	-0.17
Avon	-0.36	-0.35	-0.44	0.01	-0.52	0.00	-0.45	-0.67	-0.40	-1.69	-0.49	-0.43	-0.07
Berkshire	-0.85	0.09	0.11	-0.19	-0.64	-0.44	-0.31	0.43	-0.00	-0.01	0.01	-0.38	0.01
South-west	-2.28	-0.46	-3.10	0.21	0.49	-0.98	3.49	0.00	1.99	-7.94	-3.15	-0.48	-0.53
Glos. Oxford Bucks	-0.60	0.05	0.10	0.20	-0.93	-0.40	0.11	-0.51	0.00	0.00	0.00	0.00	0.00
London & South-east	-2.62	0.00	0.01	-1.19	-3.27	-1.82	-0.04	-2.22	0.00	0.00	0.00	-0.98	0.00
Midlands & East	-1.10	0.14	0.20	-0.25	-1.37	-0.54	-0.04	0.29	0.00	0.00	0.00	0.00	0.00
Wales	-0.10	-0.09	-0.06	-0.07	-0.22	-0.08	-0.37	-0.52	0.00	-0.70	0.00	0.00	0.00
North & Scotland	0.02	0.01	0.04	0.01	-0.10	-0.07	-0.01	-0.39	0.00	0.00	0.00	0.00	0.00

B.3 Total user benefits by group

Table B-3 Fuel vehicle operating cost user benefits by regional group (£m)

£329.6m	Central Area	So'ton & Po'mouth	East Hampshire	Dorset & New Forest	Somerset	Avon	Berkshire	South-west	Glos. Oxford Bucks	London & South-east	Midlands & East	Wales	North & Scotland
Central Area	75.09	0.13	-0.34	4.41	5.64	5.19	1.33	1.87	1.37	6.34	1.81	1.00	0.01
Southampton & Portsmouth	0.50	0	0.40	0.43	-0.81	0.38	-0.42	-1.24	-0.79	0	-1.08	0.57	-0.56
East Hampshire	1.58	-0.13	-7.16	1.40	5.20	2.26	-1.27	4.07	-0.45	-3.20	-0.64	0.42	-0.14
Dorset & New Forest	5.37	5.55	1.45	0	-7.63	-0.33	0.42	-3.07	0.19	3.27	0.15	0.20	-0.12
Somerset	8.42	0.57	5.84	-4.04	-22.94	6.86	3.48	-5.11	3.77	15.40	7.56	1.99	1.03
Avon	5.48	0.79	2.92	-0.82	-0.51	0	1.67	1.20	1.02	5.99	1.62	-4.81	0.23
Berkshire	2.00	-0.47	-1.09	0.69	2.68	2.06	-1.55	3.98	0.34	-0.18	0.03	1.67	-0.04
South-west	4.72	0.63	7.26	-0.22	-5.29	6.40	7.21	0	7.56	34.51	21.73	3.55	8.49
Glos. Oxford Bucks	1.04	-0.19	-0.23	0.21	1.96	2.38	1.57	2.98	0	0	0	0	0
London & South-east	4.73	0	-1.22	3.50	8.88	6.08	0.27	13.36	0	0	0	4.82	0
Midlands & East	1.86	-0.61	-0.37	0.65	3.65	2.73	0.50	6.36	0	0	0	0	0
Wales	1.26	0.61	0.32	-0.11	0.63	1.49	1.12	1.33	0	2.39	0	0	0
North & Scotland	0.07	-0.24	-0.05	0.02	0.27	0.77	0.06	1.81	0	0	0	0	0

Table B-4: Travel time user benefits by sector (£m)

[illegible]

Table B-5: Vehicle operating cost user benefits by sector (£m)

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Table B-6: Total user benefits by sector (£m)

[illegible]

Appendix C TUBA economics file

C.1 TUBA economics file

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*****
Economics v1.9.10a file details (WebTAG Data Book v1.9.6 (unpublished))

* Source: DfT

TUBA ECONOMIC PARAMETERS FILE (04/04/2018) Version 1.9.10a Final Release, with adjusted VOT growth parameters
*****

PARAMETERS
TUBA_version      1.9.10      the current version of TUBA
base_year         2010        defines base year for economic parameters
pres_val_year     2010        present value year for discounting
GDP_base          100.00      value of GDP in base year

** Source: TAG Data Book - Table A 1.3.1
av_ind_tax        19.0        %average final indirect tax rate

** TAG reference: TAG Data Book, Table A 3.4 (for non-traded), hidden worksheet 'GHG' (for traded)
nt_carbdrxvalues  26.17  78.50  52.33  base year non-traded carbon dioxide values in £/tonne(low high central)
t_carbdrxvalues   12.30  12.30  12.30  base year traded carbon dioxide values in £/tonne(low high central)
*****

MODES
*No.   Description
1      Road
2      Bus
3      Rail

VEHICLE_TYPE/SUBMODE
*No.   Mode   New_mode   P&R   Type   Description
1      1      N          N     per    Car
2      1      N          N     per    LGV Personal
3      1      N          N     fre    LGV Freight
4      1      N          N     fre    OGV1
5      1      N          N     fre    OGV2
6      2      N          N     per    Bus
7      3      N          N     per    Light Rail
8      3      N          N     per    Heavy rail

PERSON_TYPE
*No.   Type(D/P)   Description
1      D          Driver
2      P          Passenger

PURPOSE
*No.   Type(B/C/O)   Description
1      B          Business
2      C          Commuting
3      O          Other

FUEL_TYPE
*No.   Sector   Name   (sector: 1=untraded, sector 2=traded sector)
1      1       Petrol
2      1       Diesel
3      2       Electric

TIME_PERIODS
*No.   Description   Comments
1      AM peak     (7-10 weekdays)
2      PM peak     (4-7 weekdays)
3      Inter-peak  (10-4 weekdays)
4      Off-peak    (7-7 weekdays)
5      Weekend     (weekend)

BREAKPOINTS
*Description Breakpoint1 Breakpoint2 Breakpoint3...
Distance      1.0         5.0         10.0         25.0         50.0         100.0        200.0
TimeSaving    -5.0         -2.0         0.0         2.0          5.0

CHARGES
*No.   Sector   Description
1      pri     PT fares (private operators)
2      loc     PT fares (LA operated)
3      loc     LA tolls
4      cen     National tolls
5      pri     Private tolls
6      loc     LA on-street parking
7      loc     LA off-street parking
8      pri     Private parking

DISCOUNT_RATE
** Source: TAG Data Book - Table A 1.1.1
** %change p.a.
*Start_yr End_yr Rate
1         30   3.50
31        75   3.00
76        80   2.50

VALUE_OF_TIME_ALLOCATION
** Source: TAG Data Book - Table A 1.3.1
** Default VOT Method to be used: Method 1 for Car & Rail (Business) and Method 3 for All Other Modes-Purpose combinations
*Vtype/submode Person_type Purpose_type VOT_Method
1              1           1           1
1              2           1           1
8              2           1           1
```

VALUE_OF_TIME_METHOD1

** Source: TAG Data Book - Table A 1.3.1

** pence per hour (in 2010 base year values and prices)

*Vtype/submode	Person_type	Purpose_type	U	Xmid	k
1	1	1	2480.37	66.53	67.02
1	1	2	0.00	0.00	0.00
1	1	3	0.00	0.00	0.00
1	2	1	2480.37	66.53	67.02
1	2	2	0.00	0.00	0.00
1	2	3	0.00	0.00	0.00
2	1	1	0.00	0.00	0.00
2	1	2	0.00	0.00	0.00
2	1	3	0.00	0.00	0.00
2	2	1	0.00	0.00	0.00
2	2	2	0.00	0.00	0.00
2	2	3	0.00	0.00	0.00
3	1	1	0.00	0.00	0.00
3	1	2	0.00	0.00	0.00
3	1	3	0.00	0.00	0.00
3	2	1	0.00	0.00	0.00
3	2	2	0.00	0.00	0.00
3	2	3	0.00	0.00	0.00
4	1	1	0.00	0.00	0.00
4	1	2	0.00	0.00	0.00
4	1	3	0.00	0.00	0.00
4	2	1	0.00	0.00	0.00
4	2	2	0.00	0.00	0.00
4	2	3	0.00	0.00	0.00
5	1	1	0.00	0.00	0.00
5	1	2	0.00	0.00	0.00
5	1	3	0.00	0.00	0.00
5	2	1	0.00	0.00	0.00
5	2	2	0.00	0.00	0.00
5	2	3	0.00	0.00	0.00
6	1	1	0.00	0.00	0.00
6	1	2	0.00	0.00	0.00
6	1	3	0.00	0.00	0.00
6	2	1	0.00	0.00	0.00
6	2	2	0.00	0.00	0.00
6	2	3	0.00	0.00	0.00
7	1	1	0.00	0.00	0.00
7	1	2	0.00	0.00	0.00
7	1	3	0.00	0.00	0.00
7	2	1	0.00	0.00	0.00
7	2	2	0.00	0.00	0.00
7	2	3	0.00	0.00	0.00
8	1	1	0.00	0.00	0.00
8	1	2	0.00	0.00	0.00
8	1	3	0.00	0.00	0.00
8	2	1	3646.86	107.04	63.95
8	2	2	0.00	0.00	0.00
8	2	3	0.00	0.00	0.00

VALUE_OF_TIME_METHOD2

** Source: TAG Data Book - Table A 1.3.1

** pence per hour (in 2010 base year values and prices)

** Distance Band 1 (D1) = 0-50 km, Distance Band 2 (D2) = 50-100km, Distance Band 3 (D3) = 100-200km, Distance Band 4 (D4) = +200km

*Vtype/submode	Person_type	Purpose_type	D1	D2	D3	D4
1	1	1	842.34	1361.82	1848.85	2376.83
1	1	2	0.00	0.00	0.00	0.00
1	1	3	0.00	0.00	0.00	0.00
1	2	1	842.34	1361.82	1848.85	2376.83
1	2	2	0.00	0.00	0.00	0.00
1	2	3	0.00	0.00	0.00	0.00
2	1	1	0.00	0.00	0.00	0.00
2	1	2	0.00	0.00	0.00	0.00
2	1	3	0.00	0.00	0.00	0.00
2	2	1	0.00	0.00	0.00	0.00
2	2	2	0.00	0.00	0.00	0.00
2	2	3	0.00	0.00	0.00	0.00
3	1	1	0.00	0.00	0.00	0.00
3	1	2	0.00	0.00	0.00	0.00
3	1	3	0.00	0.00	0.00	0.00
3	2	1	0.00	0.00	0.00	0.00
3	2	2	0.00	0.00	0.00	0.00
3	2	3	0.00	0.00	0.00	0.00
4	1	1	0.00	0.00	0.00	0.00
4	1	2	0.00	0.00	0.00	0.00
4	1	3	0.00	0.00	0.00	0.00
4	2	1	0.00	0.00	0.00	0.00
4	2	2	0.00	0.00	0.00	0.00
4	2	3	0.00	0.00	0.00	0.00
5	1	1	0.00	0.00	0.00	0.00
5	1	2	0.00	0.00	0.00	0.00
5	1	3	0.00	0.00	0.00	0.00
5	2	1	0.00	0.00	0.00	0.00
5	2	2	0.00	0.00	0.00	0.00
5	2	3	0.00	0.00	0.00	0.00
6	1	1	0.00	0.00	0.00	0.00
6	1	2	0.00	0.00	0.00	0.00
6	1	3	0.00	0.00	0.00	0.00
6	2	1	0.00	0.00	0.00	0.00
6	2	2	0.00	0.00	0.00	0.00
6	2	3	0.00	0.00	0.00	0.00
7	1	1	0.00	0.00	0.00	0.00
7	1	2	0.00	0.00	0.00	0.00
7	1	3	0.00	0.00	0.00	0.00
7	2	1	0.00	0.00	0.00	0.00
7	2	2	0.00	0.00	0.00	0.00
7	2	3	0.00	0.00	0.00	0.00
8	1	1	0.00	0.00	0.00	0.00
8	1	2	0.00	0.00	0.00	0.00
8	1	3	0.00	0.00	0.00	0.00
8	2	1	842.34	1361.82	2371.85	3421.63
8	2	2	0.00	0.00	0.00	0.00
8	2	3	0.00	0.00	0.00	0.00

VALUE_OF_TIME_METHOD3

** Source TAG Data Book - Table A 1.3.1

** pence per hour (in 2010 base year values and prices)

*Vtype/submode Person_type purpose_type VOT

1	1	1	1486.44
1	1	2	995.30
1	1	3	454.28
1	2	1	1486.44
1	2	2	995.30
1	2	3	454.28
2	1	1	1023.53
2	1	2	995.30
2	1	3	454.28
2	2	1	1023.53
2	2	2	995.30
2	2	3	454.28
3	1	1	1023.53
3	1	2	0.00
3	1	3	0.00
3	2	1	1023.53
3	2	2	0.00
3	2	3	0.00
4	1	1	1205.96
4	1	2	0.00
4	1	3	0.00
4	2	1	1205.96
4	2	2	0.00
4	2	3	0.00
5	1	1	1205.96
5	1	2	0.00
5	1	3	0.00
5	2	1	1205.96
5	2	2	0.00
5	2	3	0.00
6	1	1	1232.02
6	1	2	0.00
6	1	3	0.00
6	2	1	842.34
6	2	2	995.30
6	2	3	454.28
7	1	1	0.00
7	1	2	0.00
7	1	3	0.00
7	2	1	842.34
7	2	2	995.30
7	2	3	454.28
8	1	1	0.00
8	1	2	0.00
8	1	3	0.00
8	2	1	2451.90
8	2	2	995.30
8	2	3	454.28

VALUE_OF_TIME_GROWTH

** Source: TAG Data Book - Table A 1.3.2

** %change per annum from 2010 base year

*Start_yr	End_yr	VOT_Gr_purpose1	VOT_Gr_purpose2	VOT_Gr_purpose3
2011	2011	0.610	0.610	0.610
2012	2012	0.612	0.612	0.612
2013	2013	1.414	1.414	1.414
2014	2014	2.271	2.271	2.271
2015	2015	1.539	1.539	1.539
2016	2016	1.100	1.100	1.100
2017	2017	1.115	1.115	1.115
2018	2018	0.903	0.903	0.903
2019	2019	0.648	0.648	0.648
2020	2020	0.706	0.706	0.706
2021	2021	0.817	0.817	0.817
2022	2022	0.936	0.936	0.936
2023	2023	1.074	1.074	1.074
2024	2024	1.271	1.271	1.271
2025	2025	1.370	1.370	1.370
2026	2026	1.532	1.532	1.532
2027	2027	1.625	1.625	1.625
2028	2028	1.742	1.742	1.742
2029	2029	1.802	1.802	1.802
2030	2030	1.870	1.870	1.870
2031	2031	1.920	1.920	1.920
2032	2032	1.879	1.879	1.879
2033	2033	1.884	1.884	1.884
2034	2034	1.871	1.871	1.871
2035	2035	1.906	1.906	1.906
2036	2036	1.951	1.951	1.951
2037	2037	1.991	1.991	1.991
2038	2038	1.981	1.981	1.981
2039	2039	1.979	1.979	1.979
2040	2040	1.950	1.950	1.950
2041	2041	1.947	1.947	1.947
2042	2042	1.955	1.955	1.955
2043	2043	1.943	1.943	1.943
2044	2044	1.924	1.924	1.924
2045	2045	1.908	1.908	1.908
2046	2046	1.904	1.904	1.904
2047	2047	1.889	1.889	1.889
2048	2048	1.873	1.873	1.873
2049	2049	1.874	1.874	1.874
2050	2050	1.889	1.889	1.889
2051	2051	1.951	1.951	1.951
2052	2052	2.003	2.003	2.003
2053	2053	1.983	1.983	1.983
2054	2054	1.988	1.988	1.988
2055	2055	1.954	1.954	1.954
2056	2056	1.954	1.954	1.954

2057	2057	1.965	1.965	1.965
2058	2058	1.963	1.963	1.963
2059	2059	1.967	1.967	1.967
2060	2060	1.960	1.960	1.960
2061	2061	1.974	1.974	1.974
2062	2062	1.987	1.987	1.987
2063	2063	1.992	1.992	1.992
2064	2064	2.001	2.001	2.001
2065	2065	2.005	2.005	2.005
2066	2066	2.009	2.009	2.009
2067	2067	2.015	2.015	2.015
2068	2068	2.009	2.009	2.009
2069	2069	2.005	2.005	2.005
2070	2070	2.000	2.000	2.000
2071	2071	1.996	1.996	1.996
2072	2072	1.993	1.993	1.993
2073	2073	1.990	1.990	1.990
2074	2074	1.988	1.988	1.988
2075	2075	1.987	1.987	1.987
2076	2076	1.986	1.986	1.986
2077	2077	1.986	1.986	1.986
2078	2078	1.986	1.986	1.986
2079	2079	1.987	1.987	1.987
2080	2080	1.989	1.989	1.989
2081	2081	1.990	1.990	1.990
2082	2082	1.991	1.991	1.991
2083	2083	1.992	1.992	1.992
2084	2084	1.993	1.993	1.993
2085	2085	1.994	1.994	1.994
2086	2086	1.994	1.994	1.994
2087	2087	1.994	1.994	1.994
2088	2088	1.993	1.993	1.993
2089	2089	1.993	1.993	1.993
2090	2090	1.991	1.991	1.991
2091	2091	1.990	1.990	1.990
2092	2092	1.989	1.989	1.989
2093	2093	1.987	1.987	1.987
2094	2094	1.986	1.986	1.986
2095	2095	1.984	1.984	1.984
2096	2096	1.983	1.983	1.983
2097	2097	1.982	1.982	1.982
2098	2098	1.982	1.982	1.982
2099	2099	1.982	1.982	1.982
2100	2100	1.982	1.982	1.982

AV_IND_TAX_CHANGES
 ** %change per annum from 2010 base year
 *Start_yr End_yr Growth
 2011 2050 0.00

CHARGE_TAX_RATES
 ** %base year tax rates
 *Charge Final Intermediate
 1 0.0 0.0
 2 0.0 0.0
 3 0.0 0.0
 4 0.0 0.0
 5 17.5 0.0
 6 0.0 0.0
 7 17.5 0.0
 8 17.5 0.0

CHARGE_TAX_RATES_CHANGES
 ** %change per annum from 2010 base year
 *Start_yr End_yr Charge Final Intermediate
 2011 2011 1 0.000 0.000
 2011 2011 2 0.000 0.000
 2011 2011 3 0.000 0.000
 2011 2011 4 0.000 0.000
 2011 2011 5 14.286 0.000
 2011 2011 6 0.000 0.000
 2011 2011 7 14.286 0.000
 2011 2011 8 14.286 0.000
 2012 2100 1 0.000 0.000
 2012 2100 2 0.000 0.000
 2012 2100 3 0.000 0.000
 2012 2100 4 0.000 0.000
 2012 2100 5 0.000 0.000
 2012 2100 6 0.000 0.000
 2012 2100 7 0.000 0.000
 2012 2100 8 0.000 0.000

FUEL_COST
 ** Source: TAG Data Book - Table A 1.3.7
 ** Source: TAG Data Book - Table A 3.3 (CO2e values)
 ** (In 2010 base year values and prices)
 *Type Resource(p/unit) Duty(p/unit) VAT(%) CO2_grammes/unit (unit=litre for fuel types 1 & 2; unit=KWH for electric)
 1 41.81 56.18 17.50 2230.00
 2 43.52 56.18 17.50 2562.00
 3 11.85 0.00 5.00 389.00

FUEL_COST_CHANGES

** Source: TAG Data Book -Table A 1.3.7 (Derived) & Table A 3.3 CO2 (Derived)

** %change per annum from 2010 base year

*Start_yr	End_yr	Fuel_type	Resource	Duty	VAT	CO2_Den_Change
2011	2011	1	22.294	-0.241	14.286	-0.844
2012	2012	1	2.134	-1.959	0.000	-0.024
2013	2013	1	-3.564	-1.869	0.000	-0.438
2014	2014	1	-11.754	-1.688	0.000	-0.537
2015	2015	1	-28.374	-0.455	0.000	0.000
2016	2016	1	-7.176	-1.960	0.000	0.000
2017	2017	1	12.255	-1.845	0.000	-1.352
2018	2018	1	-1.934	1.056	0.000	-1.370
2019	2019	1	1.993	2.169	0.000	-1.389
2020	2020	1	1.879	1.641	0.000	-1.408
2021	2021	1	1.675	1.290	0.000	0.000
2022	2022	1	4.308	1.342	0.000	0.000
2023	2023	1	2.819	1.120	0.000	0.000
2024	2024	1	2.631	0.940	0.000	0.000
2025	2025	1	3.605	0.812	0.000	0.000
2026	2026	1	2.238	0.684	0.000	0.000
2027	2027	1	2.189	0.684	0.000	0.000
2028	2028	1	2.142	0.684	0.000	0.000
2029	2029	1	3.146	0.684	0.000	0.000
2030	2030	1	2.033	0.684	0.000	0.000
2031	2031	1	0.000	0.684	0.000	0.000
2032	2032	1	0.000	0.684	0.000	0.000
2033	2033	1	0.000	0.684	0.000	0.000
2034	2034	1	0.000	0.684	0.000	0.000
2035	2035	1	0.000	0.684	0.000	0.000
2036	2036	1	0.000	0.684	0.000	0.000
2037	2037	1	0.000	0.684	0.000	0.000
2038	2038	1	0.000	0.684	0.000	0.000
2039	2039	1	0.000	0.684	0.000	0.000
2040	2040	1	0.000	0.684	0.000	0.000
2041	2041	1	0.000	0.684	0.000	0.000
2042	2042	1	0.000	0.684	0.000	0.000
2043	2043	1	0.000	0.684	0.000	0.000
2044	2044	1	0.000	0.684	0.000	0.000
2045	2045	1	0.000	0.684	0.000	0.000
2046	2046	1	0.000	0.684	0.000	0.000
2047	2047	1	0.000	0.684	0.000	0.000
2048	2048	1	0.000	0.684	0.000	0.000
2049	2049	1	0.000	0.684	0.000	0.000
2050	2050	1	0.000	0.684	0.000	0.000
2051	2051	1	0.000	0.684	0.000	0.000
2052	2052	1	0.000	0.684	0.000	0.000
2053	2053	1	0.000	0.684	0.000	0.000
2054	2054	1	0.000	0.684	0.000	0.000
2055	2055	1	0.000	0.684	0.000	0.000
2056	2056	1	0.000	0.684	0.000	0.000
2057	2057	1	0.000	0.684	0.000	0.000
2058	2058	1	0.000	0.684	0.000	0.000
2059	2059	1	0.000	0.684	0.000	0.000
2060	2060	1	0.000	0.684	0.000	0.000
2061	2061	1	0.000	0.684	0.000	0.000
2062	2062	1	0.000	0.684	0.000	0.000
2063	2063	1	0.000	0.684	0.000	0.000
2064	2064	1	0.000	0.684	0.000	0.000
2065	2065	1	0.000	0.684	0.000	0.000
2066	2066	1	0.000	0.684	0.000	0.000
2067	2067	1	0.000	0.684	0.000	0.000
2068	2068	1	0.000	0.684	0.000	0.000
2069	2069	1	0.000	0.684	0.000	0.000
2070	2070	1	0.000	0.684	0.000	0.000
2071	2071	1	0.000	0.684	0.000	0.000
2072	2072	1	0.000	0.684	0.000	0.000
2073	2073	1	0.000	0.684	0.000	0.000
2074	2074	1	0.000	0.684	0.000	0.000
2075	2075	1	0.000	0.684	0.000	0.000
2076	2076	1	0.000	0.684	0.000	0.000
2077	2077	1	0.000	0.684	0.000	0.000
2078	2078	1	0.000	0.684	0.000	0.000
2079	2079	1	0.000	0.684	0.000	0.000
2080	2080	1	0.000	0.684	0.000	0.000
2081	2081	1	0.000	0.684	0.000	0.000
2082	2082	1	0.000	0.684	0.000	0.000
2083	2083	1	0.000	0.684	0.000	0.000
2084	2084	1	0.000	0.684	0.000	0.000
2085	2085	1	0.000	0.684	0.000	0.000
2086	2086	1	0.000	0.684	0.000	0.000
2087	2087	1	0.000	0.684	0.000	0.000
2088	2088	1	0.000	0.684	0.000	0.000
2089	2089	1	0.000	0.684	0.000	0.000
2090	2090	1	0.000	0.684	0.000	0.000
2091	2091	1	0.000	0.684	0.000	0.000
2092	2092	1	0.000	0.684	0.000	0.000
2093	2093	1	0.000	0.684	0.000	0.000
2094	2094	1	0.000	0.684	0.000	0.000
2095	2095	1	0.000	0.684	0.000	0.000
2096	2096	1	0.000	0.684	0.000	0.000
2097	2097	1	0.000	0.684	0.000	0.000
2098	2098	1	0.000	0.684	0.000	0.000
2099	2099	1	0.000	0.684	0.000	0.000
2100	2100	1	0.000	0.684	0.000	0.000

2011	2011	2	26.989	-0.241	14.286	0.188
2012	2012	2	3.342	-1.959	0.000	1.643
2013	2013	2	-3.801	-1.869	0.000	-0.435
2014	2014	2	-11.326	-1.688	0.000	0.153
2015	2015	2	-29.360	-0.455	0.000	0.004
2016	2016	2	-12.269	-1.960	0.000	0.003
2017	2017	2	18.847	-1.845	0.000	-1.744
2018	2018	2	-2.060	1.056	0.000	-1.775
2019	2019	2	2.105	2.169	0.000	-1.807
2020	2020	2	1.979	1.641	0.000	-1.841
2021	2021	2	1.769	1.290	0.000	0.000
2022	2022	2	4.530	1.342	0.000	0.000
2023	2023	2	2.956	1.120	0.000	0.000
2024	2024	2	2.761	0.940	0.000	0.000
2025	2025	2	3.791	0.812	0.000	0.000
2026	2026	2	2.354	0.684	0.000	0.000
2027	2027	2	2.300	0.684	0.000	0.000
2028	2028	2	2.248	0.684	0.000	0.000
2029	2029	2	3.298	0.684	0.000	0.000
2030	2030	2	2.128	0.684	0.000	0.000
2031	2031	2	0.000	0.684	0.000	0.000
2032	2032	2	0.000	0.684	0.000	0.000
2033	2033	2	0.000	0.684	0.000	0.000
2034	2034	2	0.000	0.684	0.000	0.000
2035	2035	2	0.000	0.684	0.000	0.000
2036	2036	2	0.000	0.684	0.000	0.000
2037	2037	2	0.000	0.684	0.000	0.000
2038	2038	2	0.000	0.684	0.000	0.000
2039	2039	2	0.000	0.684	0.000	0.000
2040	2040	2	0.000	0.684	0.000	0.000
2041	2041	2	0.000	0.684	0.000	0.000
2042	2042	2	0.000	0.684	0.000	0.000
2043	2043	2	0.000	0.684	0.000	0.000
2044	2044	2	0.000	0.684	0.000	0.000
2045	2045	2	0.000	0.684	0.000	0.000
2046	2046	2	0.000	0.684	0.000	0.000
2047	2047	2	0.000	0.684	0.000	0.000
2048	2048	2	0.000	0.684	0.000	0.000
2049	2049	2	0.000	0.684	0.000	0.000
2050	2050	2	0.000	0.684	0.000	0.000
2051	2051	2	0.000	0.684	0.000	0.000
2052	2052	2	0.000	0.684	0.000	0.000
2053	2053	2	0.000	0.684	0.000	0.000
2054	2054	2	0.000	0.684	0.000	0.000
2055	2055	2	0.000	0.684	0.000	0.000
2056	2056	2	0.000	0.684	0.000	0.000
2057	2057	2	0.000	0.684	0.000	0.000
2058	2058	2	0.000	0.684	0.000	0.000
2059	2059	2	0.000	0.684	0.000	0.000
2060	2060	2	0.000	0.684	0.000	0.000
2061	2061	2	0.000	0.684	0.000	0.000
2062	2062	2	0.000	0.684	0.000	0.000
2063	2063	2	0.000	0.684	0.000	0.000
2064	2064	2	0.000	0.684	0.000	0.000
2065	2065	2	0.000	0.684	0.000	0.000
2066	2066	2	0.000	0.684	0.000	0.000
2067	2067	2	0.000	0.684	0.000	0.000
2068	2068	2	0.000	0.684	0.000	0.000
2069	2069	2	0.000	0.684	0.000	0.000
2070	2070	2	0.000	0.684	0.000	0.000
2071	2071	2	0.000	0.684	0.000	0.000
2072	2072	2	0.000	0.684	0.000	0.000
2073	2073	2	0.000	0.684	0.000	0.000
2074	2074	2	0.000	0.684	0.000	0.000
2075	2075	2	0.000	0.684	0.000	0.000
2076	2076	2	0.000	0.684	0.000	0.000
2077	2077	2	0.000	0.684	0.000	0.000
2078	2078	2	0.000	0.684	0.000	0.000
2079	2079	2	0.000	0.684	0.000	0.000
2080	2080	2	0.000	0.684	0.000	0.000
2081	2081	2	0.000	0.684	0.000	0.000
2082	2082	2	0.000	0.684	0.000	0.000
2083	2083	2	0.000	0.684	0.000	0.000
2084	2084	2	0.000	0.684	0.000	0.000
2085	2085	2	0.000	0.684	0.000	0.000
2086	2086	2	0.000	0.684	0.000	0.000
2087	2087	2	0.000	0.684	0.000	0.000
2088	2088	2	0.000	0.684	0.000	0.000
2089	2089	2	0.000	0.684	0.000	0.000
2090	2090	2	0.000	0.684	0.000	0.000
2091	2091	2	0.000	0.684	0.000	0.000
2092	2092	2	0.000	0.684	0.000	0.000
2093	2093	2	0.000	0.684	0.000	0.000
2094	2094	2	0.000	0.684	0.000	0.000
2095	2095	2	0.000	0.684	0.000	0.000
2096	2096	2	0.000	0.684	0.000	0.000
2097	2097	2	0.000	0.684	0.000	0.000
2098	2098	2	0.000	0.684	0.000	0.000
2099	2099	2	0.000	0.684	0.000	0.000
2100	2100	2	0.000	0.684	0.000	0.000

2011	2011	3	6.099	0.000	0.000	-1.438
2012	2012	3	4.038	0.000	0.000	-1.879
2013	2013	3	4.435	0.000	0.000	-2.438
2014	2014	3	0.984	0.000	0.000	-1.892
2015	2015	3	-2.098	0.000	0.000	-2.830
2016	2016	3	-1.225	0.000	0.000	-2.984
2017	2017	3	3.891	0.000	0.000	-3.014
2018	2018	3	9.870	0.000	0.000	-3.283
2019	2019	3	2.673	0.000	0.000	-3.586
2020	2020	3	1.703	0.000	0.000	-3.931
2021	2021	3	1.525	0.000	0.000	-4.322
2022	2022	3	-1.706	0.000	0.000	-4.776
2023	2023	3	0.119	0.000	0.000	-5.302
2024	2024	3	0.855	0.000	0.000	-5.917
2025	2025	3	5.432	0.000	0.000	-6.643
2026	2026	3	1.014	0.000	0.000	-7.518
2027	2027	3	-4.528	0.000	0.000	-8.594
2028	2028	3	1.944	0.000	0.000	-9.935
2029	2029	3	0.145	0.000	0.000	-11.654
2030	2030	3	-2.337	0.000	0.000	-13.949
2031	2031	3	0.000	0.000	0.000	-8.456
2032	2032	3	0.000	0.000	0.000	-8.461
2033	2033	3	0.000	0.000	0.000	-8.460
2034	2034	3	0.000	0.000	0.000	-8.457
2035	2035	3	0.000	0.000	0.000	-8.457
2036	2036	3	0.000	0.000	0.000	-8.457
2037	2037	3	0.000	0.000	0.000	-8.465
2038	2038	3	0.000	0.000	0.000	-8.459
2039	2039	3	0.000	0.000	0.000	-8.457
2040	2040	3	0.000	0.000	0.000	-8.452
2041	2041	3	0.000	0.000	0.000	-4.859
2042	2042	3	0.000	0.000	0.000	-5.087
2043	2043	3	0.000	0.000	0.000	-5.360
2044	2044	3	0.000	0.000	0.000	-5.686
2045	2045	3	0.000	0.000	0.000	-6.005
2046	2046	3	0.000	0.000	0.000	-6.413
2047	2047	3	0.000	0.000	0.000	-6.827
2048	2048	3	0.000	0.000	0.000	-7.355
2049	2049	3	0.000	0.000	0.000	-7.908
2050	2050	3	0.000	0.000	0.000	-8.588
2051	2100	3	0.000	0.000	0.000	0.000

CARBDX_VALUE_CHANGES

Source: TAG Data Book - Table A 3.4 (Non-traded) and hidden worksheet 'GHG' (Traded), Derived

Start_yr	End_yr	Rel(%)_NT_Lw	Abs(t)_NT_Lw	Rel(%)_Tr_Lw	Abs(t)_Tr_Lw	Rel(%)_NT_Hi	Abs(t)_NT_Hi	Rel(%)_Tr_Hi	Abs(t)_Tr_Hi	Rel(%)_NT_Ce	Abs(t)_NT_Ce	Rel(%)_Tr_Ce	Abs(t)_Tr_Ce
2011	2011	1.500	0.000	-10.035	0.000	1.500	-10.035	0.000	1.500	0.000	-10.035	0.000	0.000
2012	2012	1.500	0.000	-47.944	0.000	1.500	0.000	-47.944	0.000	1.500	0.000	-47.944	0.000
2013	2013	1.500	0.000	-37.805	0.000	1.500	0.000	-37.805	0.000	1.500	0.000	-37.805	0.000
2014	2014	1.500	0.000	24.721	0.000	1.500	0.000	24.721	0.000	1.500	0.000	24.721	0.000
2015	2015	1.500	0.000	-99.998	0.000	1.500	0.000	15.301	0.000	1.500	0.000	15.301	0.000
2016	2016	1.500	0.000	0.000	0.000	1.500	0.000	-22.909	0.000	1.500	0.000	-22.909	0.000
2017	2017	1.500	0.000	0.000	0.000	1.500	0.000	7.707	0.000	1.500	0.000	-7.317	0.000
2018	2018	1.500	0.000	0.000	0.000	1.500	0.000	35.758	0.000	1.500	0.000	1.479	0.000
2019	2019	1.500	0.000	0.000	0.000	1.500	0.000	21.686	0.000	1.500	0.000	4.423	0.000
2020	2020	1.500	0.000	0.000	0.000	1.500	0.000	24.137	0.000	1.500	0.000	4.396	0.000
2021	2021	1.667	0.000	3542563.222	0.000	1.667	0.000	111.195	0.000	1.667	0.000	164.056	0.000
2022	2022	1.639	0.000	99.286	0.000	1.639	0.000	52.650	0.000	1.639	0.000	62.037	0.000
2023	2023	1.613	0.000	49.498	0.000	1.613	0.000	34.491	0.000	1.613	0.000	38.235	0.000
2024	2024	1.587	0.000	32.915	0.000	1.587	0.000	25.645	0.000	1.587	0.000	27.626	0.000
2025	2025	1.563	0.000	24.633	0.000	1.563	0.000	20.411	0.000	1.563	0.000	21.622	0.000
2026	2026	1.538	0.000	19.669	0.000	1.538	0.000	16.951	0.000	1.538	0.000	17.761	0.000
2027	2027	1.515	0.000	16.365	0.000	1.515	0.000	14.494	0.000	1.515	0.000	15.068	0.000
2028	2028	1.493	0.000	14.008	0.000	1.493	0.000	12.659	0.000	1.493	0.000	13.085	0.000
2029	2029	1.471	0.000	12.243	0.000	1.471	0.000	11.237	0.000	1.471	0.000	11.563	0.000
2030	2030	1.449	0.000	13.705	0.000	1.449	0.000	10.102	0.000	1.449	0.000	10.898	0.000
2031	2031	9.286	0.000	9.286	0.000	9.286	0.000	9.286	0.000	9.286	0.000	9.286	0.000
2032	2032	8.497	0.000	8.497	0.000	8.497	0.000	8.497	0.000	8.497	0.000	8.497	0.000
2033	2033	7.831	0.000	7.831	0.000	7.831	0.000	7.831	0.000	7.831	0.000	7.831	0.000
2034	2034	7.263	0.000	7.263	0.000	7.263	0.000	7.263	0.000	7.263	0.000	7.263	0.000
2035	2035	6.771	0.000	6.771	0.000	6.771	0.000	6.771	0.000	6.771	0.000	6.771	0.000
2036	2036	6.341	0.000	6.341	0.000	6.341	0.000	6.341	0.000	6.341	0.000	6.341	0.000
2037	2037	5.963	0.000	5.963	0.000	5.963	0.000	5.963	0.000	5.963	0.000	5.963	0.000
2038	2038	5.628	0.000	5.628	0.000	5.628	0.000	5.628	0.000	5.628	0.000	5.628	0.000
2039	2039	5.328	0.000	5.328	0.000	5.328	0.000	5.328	0.000	5.328	0.000	5.328	0.000
2040	2040	5.058	0.000	5.058	0.000	5.058	0.000	5.058	0.000	5.058	0.000	5.058	0.000
2041	2041	4.815	0.000	4.815	0.000	4.815	0.000	4.815	0.000	4.815	0.000	4.815	0.000
2042	2042	4.594	0.000	4.594	0.000	4.594	0.000	4.594	0.000	4.594	0.000	4.594	0.000
2043	2043	4.392	0.000	4.392	0.000	4.392	0.000	4.392	0.000	4.392	0.000	4.392	0.000
2044	2044	4.207	0.000	4.207	0.000	4.207	0.000	4.207	0.000	4.207	0.000	4.207	0.000
2045	2045	4.037	0.000	4.037	0.000	4.037	0.000	4.037	0.000	4.037	0.000	4.037	0.000
2046	2046	3.881	0.000	3.881	0.000	3.881	0.000	3.881	0.000	3.881	0.000	3.881	0.000
2047	2047	3.736	0.000	3.736	0.000	3.736	0.000	3.736	0.000	3.736	0.000	3.736	0.000
2048	2048	3.601	0.000	3.601	0.000	3.601	0.000	3.601	0.000	3.601	0.000	3.601	0.000
2049	2049	3.476	0.000	3.476	0.000	3.476	0.000	3.476	0.000	3.476	0.000	3.476	0.000
2050	2050	3.359	0.000	3.359	0.000	3.359	0.000	3.359	0.000	3.359	0.000	3.359	0.000
2051	2051	2.501	0.000	2.501	0.000	3.882	0.000	3.882	0.000	3.536	0.000	3.536	0.000
2052	2052	2.265	0.000	2.265	0.000	3.652	0.000	3.652	0.000	3.309	0.000	3.309	0.000
2053	2053	2.165	0.000	2.165	0.000	3.560	0.000	3.560	0.000	3.218	0.000	3.218	0.000
2054	2054	2.056	0.000	2.056	0.000	3.460	0.000	3.460	0.000	3.119	0.000	3.119	0.000
2055	2055	1.856	0.000	1.856	0.000	3.267	0.000	2.928	0.000	2.928	0.000	2.928	0.000
2056	2056	1.779	0.000	1.779	0.000	3.199	0.000	2.862	0.000	2.862	0.000	2.862	0.000
2057	2057	1.589	0.000	1.589	0.000	3.017	0.000	2.681	0.000	2.681	0.000	2.681	0.000
2058	2058	1.446	0.000	1.446	0.000	2.883	0.000	2.549	0.000	2.549	0.000	2.549	0.000
2059	2059	1.330	0.000	1.330	0.000	2.777	0.000	2.444	0.000	2.444	0.000	2.444	0.000
2060	2060	1.201	0.000	1.201	0.000	2.657	0.000	2.326	0.000	2.326	0.000	2.326	0.000
2061	2061	0.673	0.000	0.673	0.000	2.132	0.000	1.804	0.000	1.804	0.000	1.804	0.000
2062	2062	0.618	0.000	0.618	0.000	2.088	0.000	1.761	0.000	1.761	0.000	1.761	0.000
2063	2063	0.401	0.000	0.401	0.000	1.881	0.000	1.555	0.000	1.555	0.000	1.555	0.000
2064	2064	0.283	0.000	0.283	0.000	1.774	0.000	1.449	0.000	1.449	0.000	1.449	0.000
2065	2065	0.079	0.000	0.079	0.000	1.579	0.000	1.257	0.000	1.257	0.000	1.257	0.000
2066	2066	0.033	0.000	0.033	0.000	1.545	0.000	1.224	0.000	1.224	0.000	1.224	0.000
2067	2067	-0.193	0.000	-0.193	0.000	1.329	0.000	1.009	0.000	1.009	0.000	1.009	0.000
2068	2068	-0.302	0.000	-0.302	0.000	1.232	0.000	0.914	0.000	0.914	0.000	0.914	0.000
2069	2069	-0.461	0.000	-0.461	0.000	1.085	0.000	0.768	0.000	0.768	0.000	0.768	0.000
2070	2070	-0.585	0.000	-0.585	0.000	0.973	0.000	0.657	0.000	0.657	0.000	0.657	0.000
2071	2071	-0.609	0.000	-0.609	0.000	0.963	0.000	0.649	0.000	0.649	0.000	0.649	0.000
2072	2072	-0.738	0.000	-0.738	0.000	0.847	0.000	0.534	0.000	0.534	0.000	0.534	0.000
2073	2073	-0.837	0.000	-0.837	0.000	0.763	0.000	0.451	0.000	0.451	0.000	0.451	0.000
2074	2074	-1.033	0.000	-1.033	0.000	0.580	0.000	0.580	0.000	0.269	0.000	0.269	0.000
2075	2075	-1.037	0.000	-1.037	0.000	0.592	0.000	0.592	0.000	0.282	0.000	0.282	0.000
2076	2076	-1.310	0.000	-1.310	0.000	0.332	0.000	0.332	0.000	0.024	0.000	0.024	0.000
2077	2077	-1.316	0.000	-1.316	0.000	0.343	0.000	0.343	0.000	0.036	0.000	0.036	0.000
2078	2078	-1.493	0.000	-1.493	0.000	0.181	0.000	0.181	0.000	-0.125	0.000	-0.125	0.000
2079	2079	-1.571	0.000	-1.571	0.000	0.120	0.000	0.120	0.000	-0.185	0.000	-0.185	0.000
2080	2080	-1.769	0.000	-1.769	0.000	0.063	0.000	0.063	0.000	-0.365	0.000	-0.365	0.000
2081	2081	-1.478	0.000	-1.478	0.000	0.252	0.000	0.252	0.000	-0.051	0.000	-0.051	0.000
2082	2082	-1.672	0.000	-1.672	0.000	0.075	0.000	0.075	0.000	-0.226	0.000	-0.226	0.000
2083	2083	-1.769	0.000	-1.769	0.000	-0.002	0.000	-0.002	0.000	-0.303	0.000	-0.303	0.000
2084	2084	-1.854	0.000	-1.854	0.000	-0.068	0.000	-0.068	0.000	-0.387	0.000	-0.387	0.000
2085	2085	-1.834	0.000	-1.834	0.000	-0.026	0.000	-0.026	0.000	-0.324	0.000	-0.324	0.000
2086	2086	-2.050	0.000	-2.050	0.000	-0.222	0.000	-0.222	0.000	-0.519	0.000	-0.519	0.000
2087	2087	-2.154	0.000	-2.154	0.000	-0.305	0.000	-0.305	0.000	-0.601	0.000	-0.601	0.000
2088	2088	-2.198	0.000	-2.198	0.000	-0.326	0.000	-0.326	0.000	-0.621	0.000	-0.621	0.000
2089	2089	-2.321	0.000	-2.321	0.000	-0.426	0.000	-0.426	0.000	-0.720	0.000	-0.720	0.000
2090	2090	-2.359	0.000	-2.359	0.000	-0.439	0.000	-0.439	0.000	-0.732	0.000	-0.732	0.000
2091	2091	-2.279	0.000	-2.279	0.000	-0.331	0.000	-0.331	0.000	-0.623	0.000	-0.623	0.000
2092	2092	-2.328	0.000	-2.328	0.000	-0.353	0.000	-0.353	0.000	-0.644	0.000	-0.644	0.000
2093	2093	-2.521	0.000	-2.521	0.000	-0.520	0.000	-0.520	0.000	-0.810	0.000	-0.810	0.000
2094	2094	-2.577	0.000	-2.577	0.000	-0.548	0.000	-0.548	0.000	-0.837	0.000	-0.837	0.000
2095	2095	-2.649	0.000	-2.649	0.000	-0.591	0.000	-0.591	0.000	-0.879	0.000	-0.879	0.000
2096	2096	-2.712	0.000	-2.712	0.000	-0.623	0.000	-0.623	0.000				

FLEET

** Source: TAG Data Book - Table A 1.3.9

** For 2010 base year proportions

*Veh_type	%Petrol	%Diesel	%Electric
1	59.9925	40.0026	0.0049
2	3.6784	96.3156	0.0060
3	3.6784	96.3156	0.0060
4	0.0000	100.0000	0.0000
5	0.0000	100.0000	0.0000
6	0.0000	100.0000	0.0000
7	0.0000	100.0000	0.0000
8	0.0000	100.0000	0.0000

FLEET_CHANGES

** Source: TAG Data Book - Table A 1.3.9 (derived)

** %change per annum from 2010 base year

*Start_yr	End_yr	Veh_type	%Change_Petrol	%Change_Diesel	%Change_Electric
2011	2011	1	-3.7470	5.6289	0.0000
2012	2012	1	-3.7464	5.0987	177.5510
2013	2013	1	-3.9746	4.9486	85.2941
2014	2014	1	-3.6966	4.1406	170.6349
2015	2015	1	-3.2610	3.2940	113.0499
2016	2016	1	-3.8166	3.3901	136.3386
2017	2017	1	-3.0168	2.5925	28.7420
2018	2018	1	-1.9343	1.4421	29.4730
2019	2019	1	-1.0551	0.5626	30.8176
2020	2020	1	-0.2827	-0.1206	25.7212
2021	2021	1	-0.2099	-0.3483	30.0510
2022	2022	1	-0.2068	-0.5589	32.2143
2023	2023	1	-0.1575	-0.7308	28.5908
2024	2024	1	-0.0740	-1.0150	27.5715
2025	2025	1	-0.1700	-1.4663	31.9952
2026	2026	1	-0.1119	-1.6206	25.4551
2027	2027	1	-0.1050	-1.7119	20.9724
2028	2028	1	-0.1673	-1.7158	17.6091
2029	2029	1	-0.2797	-1.6978	15.3930
2030	2030	1	-0.3868	-1.6102	13.1997
2031	2031	1	-0.4820	-1.5972	11.9371
2032	2032	1	-0.5638	-1.5595	10.7177
2033	2033	1	-0.6500	-1.5213	9.7493
2034	2034	1	-0.7254	-1.5008	8.9813
2035	2035	1	-0.7716	-1.4842	8.2395
2011	2011	2	-11.0966	0.4238	100.0000
2012	2012	2	-9.4086	0.3181	99.1667
2013	2013	2	-12.2827	0.3397	43.5146
2014	2014	2	-9.8699	0.2290	97.6676
2015	2015	2	-7.8086	0.1521	50.8850
2016	2016	2	-11.5125	0.1855	65.7869
2017	2017	2	-10.2523	0.1011	57.1344
2018	2018	2	-9.2892	0.1976	-12.9081
2019	2019	2	-7.9519	0.1382	-5.1702
2020	2020	2	-6.5228	0.0851	4.4071
2021	2021	2	-5.2895	0.0241	20.4526
2022	2022	2	-4.0230	-0.0850	48.6994
2023	2023	2	-3.9040	-0.1944	58.0175
2024	2024	2	-3.0790	-0.3757	62.2386
2025	2025	2	-3.4592	-0.6657	65.4189
2026	2026	2	-3.4461	-0.6389	37.7256
2027	2027	2	-20.0606	-0.5519	30.9817
2028	2028	2	-0.9119	-0.8176	25.1683
2029	2029	2	-1.0518	-0.9329	22.7641
2030	2030	2	-1.3528	-1.0726	21.1429
2031	2031	2	-1.3959	-1.0577	17.0349
2032	2032	2	-1.4529	-1.0780	14.6822
2033	2033	2	-1.5121	-1.0926	12.8368
2034	2034	2	-1.5225	-1.1305	11.6389
2035	2035	2	-1.5071	-1.1423	10.4114
2011	2011	3	-11.0966	0.4238	100.0000
2012	2012	3	-9.4086	0.3181	99.1667
2013	2013	3	-12.2827	0.3397	43.5146
2014	2014	3	-9.8699	0.2290	97.6676
2015	2015	3	-7.8086	0.1521	50.8850
2016	2016	3	-11.5125	0.1855	65.7869
2017	2017	3	-10.2523	0.1011	57.1344
2018	2018	3	-9.2892	0.1976	-12.9081
2019	2019	3	-7.9519	0.1382	-5.1702
2020	2020	3	-6.5228	0.0851	4.4071
2021	2021	3	-5.2895	0.0241	20.4526
2022	2022	3	-4.0230	-0.0850	48.6994
2023	2023	3	-3.9040	-0.1944	58.0175
2024	2024	3	-3.0790	-0.3757	62.2386
2025	2025	3	-3.4592	-0.6657	65.4189
2026	2026	3	-3.4461	-0.6389	37.7256
2027	2027	3	-20.0606	-0.5519	30.9817
2028	2028	3	-0.9119	-0.8176	25.1683
2029	2029	3	-1.0518	-0.9329	22.7641
2030	2030	3	-1.3528	-1.0726	21.1429
2031	2031	3	-1.3959	-1.0577	17.0349
2032	2032	3	-1.4529	-1.0780	14.6822
2033	2033	3	-1.5121	-1.0926	12.8368
2034	2034	3	-1.5225	-1.1305	11.6389
2035	2035	3	-1.5071	-1.1423	10.4114

FUEL_CONSUMPTION

** Source: TAG Data Book - Table A 1.3.8

** For 2010 base year

** Fuel consumption (l/km) = (a_fuel+b_fuel*V+c_fuel*V^2+d_fuel*V^3)/V where V is speed in km/h

*Veh_type	Fuel_type	a_Fuel	b_Fuel	c_Fuel	d_Fuel	Cut-off_speed (km/h)
1	1	1.180114976	0.046394755	-8.58040E-05	2.58210E-06	120
1	2	0.518874946	0.065559191	-6.23082E-04	4.89930E-06	120
1	3	0.000000000	0.150770834	0.000000E+00	0.000000E+00	120
2	1	2.056786303	0.036403260	7.16790E-05	3.91670E-06	120
2	2	1.472750964	0.035295623	-2.42468E-04	8.08990E-06	120
2	3	0.000000000	0.337725402	0.000000E+00	0.000000E+00	120
3	1	2.056786303	0.036403260	7.16790E-05	3.91670E-06	120
3	2	1.472750964	0.035295623	-2.42468E-04	8.08990E-06	120
3	3	0.000000000	0.337725402	0.000000E+00	0.000000E+00	120
4	2	1.911365681	0.344532728	-5.21655E-03	4.48971E-05	90
5	2	3.050431814	0.636257248	-9.10602E-03	6.86386E-05	90
6	2	6.304843405	0.258599871	-3.23145E-03	3.22775E-05	75

FUEL EFFICIENCY

** Source: TAG Data Book - Table A 1.3.10

** %change per annum from 2010 base year

*Start_yr	End_yr	Veh_type	Fuel_type	Change
2011	2011	1	1	0.556
2011	2011	1	2	0.939
2011	2011	1	3	0.000
2011	2011	2	1	-0.230
2011	2011	2	2	0.270
2011	2011	2	3	0.201
2011	2011	3	1	-0.230
2011	2011	3	2	0.270
2011	2011	3	3	0.201
2012	2012	1	1	0.638
2012	2012	1	2	1.054
2012	2012	1	3	1.776
2012	2012	2	1	-0.336
2012	2012	2	2	0.368
2012	2012	2	3	0.203
2012	2012	3	1	-0.336
2012	2012	3	2	0.368
2012	2012	3	3	0.203
2013	2013	1	1	1.034
2013	2013	1	2	1.087
2013	2013	1	3	1.747
2013	2013	2	1	-0.193
2013	2013	2	2	0.123
2013	2013	2	3	0.205
2013	2013	3	1	-0.193
2013	2013	3	2	0.123
2013	2013	3	3	0.205
2014	2014	1	1	1.263
2014	2014	1	2	1.277
2014	2014	1	3	1.720
2014	2014	2	1	-0.205
2014	2014	2	2	0.102
2014	2014	2	3	0.207
2014	2014	3	1	-0.205
2014	2014	3	2	0.102
2014	2014	3	3	0.207
2015	2015	1	1	1.571
2015	2015	1	2	1.686
2015	2015	1	3	1.696
2015	2015	2	1	-0.158
2015	2015	2	2	0.340
2015	2015	2	3	0.207
2015	2015	3	1	-0.158
2015	2015	3	2	0.340
2015	2015	3	3	0.207
2016	2016	1	1	1.886
2016	2016	1	2	1.601
2016	2016	1	3	1.169
2016	2016	2	1	0.157
2016	2016	2	2	0.238
2016	2016	2	3	0.208
2016	2016	3	1	0.157
2016	2016	3	2	0.238
2016	2016	3	3	0.208
2017	2017	1	1	1.715
2017	2017	1	2	1.496
2017	2017	1	3	1.169
2017	2017	2	1	-0.016
2017	2017	2	2	0.084
2017	2017	2	3	0.208
2017	2017	3	1	-0.016
2017	2017	3	2	0.084
2017	2017	3	3	0.208
2018	2018	1	1	1.829
2018	2018	1	2	1.391
2018	2018	1	3	1.169
2018	2018	2	1	0.302
2018	2018	2	2	0.061
2018	2018	2	3	0.208
2018	2018	3	1	0.302
2018	2018	3	2	0.061
2018	2018	3	3	0.208
2019	2019	1	1	2.469
2019	2019	1	2	1.862
2019	2019	1	3	1.171
2019	2019	2	1	0.461
2019	2019	2	2	0.400
2019	2019	2	3	0.207
2019	2019	3	1	0.461
2019	2019	3	2	0.400
2019	2019	3	3	0.207
2020	2020	1	1	2.101
2020	2020	1	2	1.355
2020	2020	1	3	1.177
2020	2020	2	1	0.859
2020	2020	2	2	1.330
2020	2020	2	3	0.206
2020	2020	3	1	0.859
2020	2020	3	2	1.330
2020	2020	3	3	0.206

2021		1	1	2,589
2021	2021	1	2	1,521
2021	2021	1	3	1,136
2021	2021	2	1	1,337
2021	2021	2	2	1,387
2021	2021	2	3	3,053
2021	2021	3	1	1,337
2021	2021	3	2	1,387
2021	2021	3	3	3,053
2022	2022	1	1	2,664
2022	2022	1	2	1,625
2022	2022	1	3	1,097
2022	2022	2	1	1,296
2022	2022	2	2	1,295
2022	2022	2	3	2,808
2022	2022	3	1	1,296
2022	2022	3	2	1,295
2022	2022	3	3	2,808
2023	2023	1	1	2,274
2023	2023	1	2	1,288
2023	2023	1	3	1,073
2023	2023	2	1	1,439
2023	2023	2	2	1,201
2023	2023	2	3	2,595
2023	2023	3	1	1,439
2023	2023	3	2	1,201
2023	2023	3	3	2,595
2024	2024	1	1	2,133
2024	2024	1	2	1,223
2024	2024	1	3	1,056
2024	2024	2	1	1,345
2024	2024	2	2	1,126
2024	2024	2	3	2,407
2024	2024	3	1	1,345
2024	2024	3	2	1,126
2024	2024	3	3	2,407
2025	2025	1	1	2,280
2025	2025	1	2	1,465
2025	2025	1	3	1,043
2025	2025	2	1	1,519
2025	2025	2	2	1,055
2025	2025	2	3	2,240
2025	2025	3	1	1,519
2025	2025	3	2	1,055
2025	2025	3	3	2,240
2026	2026	1	1	1,670
2026	2026	1	2	0,961
2026	2026	1	3	1,283
2026	2026	2	1	1,717
2026	2026	2	2	1,008
2026	2026	2	3	0,000
2026	2026	3	1	1,717
2026	2026	3	2	1,008
2026	2026	3	3	0,000
2027	2027	1	1	1,432
2027	2027	1	2	0,814
2027	2027	1	3	1,264
2027	2027	2	1	1,724
2027	2027	2	2	0,955
2027	2027	2	3	0,000
2027	2027	3	1	1,724
2027	2027	3	2	0,955
2027	2027	3	3	0,000
2028	2028	1	1	1,584
2028	2028	1	2	1,048
2028	2028	1	3	1,251
2028	2028	2	1	1,708
2028	2028	2	2	0,893
2028	2028	2	3	0,000
2028	2028	3	1	1,708
2028	2028	3	2	0,893
2028	2028	3	3	0,000
2029	2029	1	1	1,013
2029	2029	1	2	0,551
2029	2029	1	3	1,242
2029	2029	2	1	1,664
2029	2029	2	2	0,814
2029	2029	2	3	0,000
2029	2029	3	1	1,664
2029	2029	3	2	0,814
2029	2029	3	3	0,000
2030	2030	1	1	0,829
2030	2030	1	2	0,441
2030	2030	1	3	1,235
2030	2030	2	1	1,593
2030	2030	2	2	0,713
2030	2030	2	3	0,000
2030	2030	3	1	1,593
2030	2030	3	2	0,713
2030	2030	3	3	0,000

2031	2031	1	1	1.053
2031	2031	1	2	0.732
2031	2031	1	3	0.000
2031	2031	2	1	1.518
2031	2031	2	2	0.596
2031	2031	2	3	0.000
2031	2031	3	1	1.518
2031	2031	3	2	0.596
2031	2031	3	3	0.000
2032	2032	1	1	0.506
2032	2032	1	2	0.251
2032	2032	1	3	0.000
2032	2032	2	1	1.429
2032	2032	2	2	0.472
2032	2032	2	3	0.000
2032	2032	3	1	1.429
2032	2032	3	2	0.472
2032	2032	3	3	0.000
2033	2033	1	1	0.359
2033	2033	1	2	0.165
2033	2033	1	3	0.000
2033	2033	2	1	1.336
2033	2033	2	2	0.357
2033	2033	2	3	0.000
2033	2033	3	1	1.336
2033	2033	3	2	0.357
2033	2033	3	3	0.000
2034	2034	1	1	0.628
2034	2034	1	2	0.487
2034	2034	1	3	0.000
2034	2034	2	1	1.243
2034	2034	2	2	0.261
2034	2034	2	3	0.000
2034	2034	3	1	1.243
2034	2034	3	2	0.261
2034	2034	3	3	0.000
2035	2035	1	1	0.120
2035	2035	1	2	0.019
2035	2035	1	3	0.000
2035	2035	2	1	1.161
2035	2035	2	2	0.190
2035	2035	2	3	0.000
2035	2035	3	1	1.161
2035	2035	3	2	0.190
2035	2035	3	3	0.000
2036	2100	1	1	0.000
2036	2100	1	2	0.000
2036	2100	1	3	0.000
2036	2100	2	1	0.000
2036	2100	2	2	0.000
2036	2100	2	3	0.000
2036	2100	3	1	0.000
2036	2100	3	2	0.000
2036	2100	3	3	0.000

NON_FUEL_VOC_CHANGES

** Source: TAG Unit A1.3 para 5.1.17

** Note: Table A 1.3.15 shows changes by average car (taking into account changes in FLEET mix)

** %change per annum from 2010 base year

*Start_yr	End_yr	Veh_type	Growth
2011	2100	1	0.000
2011	2100	2	0.000
2011	2100	3	0.000
2011	2100	4	0.000
2011	2100	5	0.000
2011	2100	6	0.000
2011	2100	7	0.000
2011	2100	8	0.000

NON_FUEL_TAX_RATES

** For 2010 base year

** percentage

*Submode	Final	Intermediate
1	17.5	0.0
2	17.5	0.0
3	17.5	0.0
4	17.5	0.0
5	17.5	0.0
6	17.5	0.0
7	0.0	0.0
8	0.0	0.0

NON_FUEL_TAX_RATES_CHANGES

** %change per annum from 2010 base year

*Start_yr	End_yr	Submode	Final	Intermediate
2011	2011	1	14.286	0.000
2011	2011	2	14.286	0.000
2011	2011	3	14.286	0.000
2011	2011	4	14.286	0.000
2011	2011	5	14.286	0.000
2011	2011	6	14.286	0.000
2011	2011	7	0.000	0.000
2011	2011	8	0.000	0.000
2012	2100	1	0.000	0.000
2012	2100	2	0.000	0.000
2012	2100	3	0.000	0.000
2012	2100	4	0.000	0.000
2012	2100	5	0.000	0.000
2012	2100	6	0.000	0.000
2012	2100	7	0.000	0.000
2012	2100	8	0.000	0.000

DEFAULT_PURPOSE_SPLIT

** Source: TAG Data Book - Table A 1.3.4

** For 2010 base year

*Vtype/submode	Purpose	Period1	Period2	Period3	Period4	Period5
1	1	16.5	11.8	16.5	12.9	3.5
1	2	44.1	41.3	11.8	38.5	7.9
1	3	39.4	46.9	71.7	48.6	88.6
2	1	0.0	0.0	0.0	0.0	0.0
2	2	0.0	0.0	0.0	0.0	0.0
2	3	100.0	100.0	100.0	100.0	100.0
3	1	100.0	100.0	100.0	100.0	100.0
3	2	0.0	0.0	0.0	0.0	0.0
3	3	0.0	0.0	0.0	0.0	0.0
4	1	100.0	100.0	100.0	100.0	100.0
4	2	0.0	0.0	0.0	0.0	0.0
4	3	0.0	0.0	0.0	0.0	0.0
5	1	100.0	100.0	100.0	100.0	100.0
5	2	0.0	0.0	0.0	0.0	0.0
5	3	0.0	0.0	0.0	0.0	0.0
6	1	1.4	2.3	1.7	2.3	0.5
6	2	18.4	25.9	6.5	35.4	6.1
6	3	80.2	71.8	91.8	62.3	93.4
7	1	4.5	5.2	3.2	2.5	0.7
7	2	50.1	45.9	10.7	54.7	7.6
7	3	45.4	48.9	86.1	42.8	91.7
8	1	17.1	15.7	15.8	17.7	1.8
8	2	31.2	38.1	5.5	38.6	2.8
8	3	51.7	46.2	78.7	43.7	95.4

DEFAULT_PERSON_FACTORS

** Source: TAG Data Book - Table A 1.3.3

** For 2010 base year

*Vtype/submode	Purpose	Person_type	FactorPer1	FactorPer2	FactorPer3	FactorPer4	FactorPer5
1	1	1	1.00	1.00	1.00	1.00	1.00
1	1	2	0.13	0.15	0.16	0.17	0.31
1	2	1	1.00	1.00	1.00	1.00	1.00
1	2	2	0.13	0.14	0.15	0.15	0.21
1	3	1	1.00	1.00	1.00	1.00	1.00
1	3	2	0.71	0.79	0.82	0.79	1.12
2	2	1	1.00	1.00	1.00	1.00	1.00
2	2	2	0.46	0.46	0.46	0.46	1.03
2	3	1	1.00	1.00	1.00	1.00	1.00
2	3	2	0.46	0.46	0.46	0.46	1.03
3	1	1	1.00	1.00	1.00	1.00	1.00
3	1	2	0.20	0.20	0.20	0.20	0.26
4	1	1	1.00	1.00	1.00	1.00	1.00
5	1	1	1.00	1.00	1.00	1.00	1.00

DEFAULT_PERSON_FACTORS_CHANGE

** Source: TAG Data Book - Table A 1.3.3

** %change per annum from 2010 base year

*Start_yr	End_yr	Submode	Purpose	Person_type	ChangePer1	ChangePer2	ChangePer3	ChangePer4	ChangePer5
2011	2036	1	1	2	0.00	0.00	0.00	0.00	0.00
2011	2036	1	2	2	0.00	0.00	0.00	0.00	0.00
2011	2036	1	3	2	0.00	0.00	0.00	0.00	0.00

PREPARATION&SUPERVISION

** Source: DMRB Volume 13, section 13.1.2.7 The Preparation of Cost Data

** total preparation (by stage & mode) and supervision costs as % of land and construction costs

*Mode	Prep:SI	Prep:PC	Prep:PR	Prep:OP	Prep:WC	Super
1	12.0	9.0	9.0	6.0	2.0	5.0
2	12.0	9.0	9.0	6.0	2.0	5.0
3	12.0	9.0	9.0	6.0	2.0	5.0

Appendix D COBA-LT WebTAG parameters file

D.1 COBA-LT economics file

COBALT Parameter File
Version 2017.1

Cost Base Year
2010

Appraisal Period
60

Discount Rate Years from Current Year	Discount Rate (%)
30	3.5
75	3
125	2.5

Cost per Casualty Severity	Cost
Fatal	1,556,244
Serious	174,878
Slight	13,481

Cost per Accident Severity	Insurance Administration	Damage to Property		
		Urban	Rural	Motorway
Fatal	285	7,441	12,621	16,054
Serious	178	3,998	5,753	13,698
Slight	108	2,353	3,814	6,930
Damage	51	1,682	2,515	2,417

	Police Cost		
	Urban	Rural	Motorway
Fatal	16,755	17,205	17,405
Serious	1,850	2,310	2,439
Slight	478	656	547
Damage	35	20	17

Compound Annual Range of Years	Rates of Growth of Accident Values Rate of Growth (%p.a.)
2010-2011	0.61
2011-2012	0.81
2012-2013	1.41
2013-2014	2.27
2014-2015	1.54
2015-2016	1.10
2016-2017	1.11
2017-2018	0.90
2018-2019	0.65
2019-2020	0.71
2020-2021	0.82
2021-2022	0.94
2022-2023	1.07
2023-2024	1.27
2024-2025	1.37
2025-2026	1.53
2026-2027	1.63
2027-2028	1.74
2028-2029	1.80
2029-2030	1.87
2030-2031	1.92
2031-2032	1.88
2032-2033	1.88
2033-2034	1.87
2034-2035	1.91
2035-2036	1.95
2036-2037	1.99
2037-2038	1.98
2038-2039	1.98
2039-2040	1.95
2040-2041	1.95
2041-2042	1.95
2042-2043	1.94
2043-2044	1.92
2044-2045	1.91
2045-2046	1.90
2046-2047	1.89
2047-2048	1.87
2048-2049	1.87
2049-2050	1.89
2050-2051	1.95

2051-2052	2.00
2052-2053	1.98
2053-2054	1.99
2054-2055	1.95
2055-2056	1.95
2056-2057	1.97
2057-2058	1.96
2058-2059	1.97
2059-2060	1.96
2060-2061	1.97
2061-2062	1.99
2062-2063	1.99
2063-2064	2.00
2064-2065	2.01
2065-2066	2.01
2066-2067	2.02
2067-2068	2.01
2068-2069	2.01
2069-2070	2.00
2070-2071	2.00
2071-2072	1.99
2072-2073	1.99
2073-2074	1.99
2074-2075	1.99
2075-2076	1.99
2076-2077	1.99
2077-2078	1.99
2078-2079	1.99
2079-2080	1.99
2080-2081	1.99
2081-2082	1.99
2082-2083	1.99
2083-2084	1.99
2084-2085	1.99
2085-2086	1.99
2086-2087	1.99
2087-2088	1.99
2088-2089	1.99
2089-2090	1.99
2090-2091	1.99
2091-2092	1.99
2092-2093	1.99
2093-2094	1.99
2094-2095	1.98
2095-2096	1.98
2096-2097	1.98
2097-2098	1.98
2098-2099	1.98
2099-2100	1.98
2100+	1.98

Number of Damage Only Accidents per PIA			
Damage	Urban	Rural	Motorway
	17.7	7.8	7.6

Link Only Accident Proportions

Base Year

2009

Road Type	Speed Limit (mph)	Accident Proportions			Road Description
		Fatal	Serious	Slight	
1-3	>40	0.019	0.104	0.877	Motorways
4-8	30/40	0.014	0.145	0.841	S2 A Roads
4-8	>40	0.046	0.206	0.748	S2 A Roads
9	30/40	0.010	0.145	0.846	Other S2 Roads
9	>40	0.026	0.193	0.780	Other S2 Roads
10-15	30/40	0.017	0.135	0.849	Dual Carriageways
10-15	>40	0.028	0.135	0.837	Dual Carriageways

Link and Junction Combined Accident Proportions

Base Year

2009

Road Type	Speed Limit (mph)	Accident Proportions			Road Description
		Fatal	Serious	Slight	
1-3	>40	0.018	0.101	0.882	Motorways
4-8	30/40	0.008	0.122	0.869	S2 A Roads
4-8	>40	0.034	0.187	0.779	S2 A Roads
9	30/40	0.007	0.126	0.867	Other S2 Roads
9	>40	0.024	0.187	0.789	Other S2 Roads
10-15	30/40	0.009	0.104	0.887	Dual Carriageways
10-15	>40	0.023	0.127	0.850	Dual Carriageways

Junction Only Accident Proportions

Base Year
2000

Junction Type	Speed Limit (mph)	Accident Proportions			Junction Description
		Fatal	Serious	Slight	
2,4	30/40	0.0072	0.1240	0.8688	Priority (3 Arm)
1,3	>40	0.0243	0.1883	0.7874	
6,8	30/40	0.0060	0.1162	0.8778	Priority (4 Arm)
5,7	>40	0.0271	0.2064	0.7665	
10,12	30/40	0.0060	0.1162	0.8778	Priority (5 Arm)
9,11	>40	0.0271	0.2064	0.7665	
14,16	30/40	0.0072	0.1240	0.8688	Priority w Ghost Island (3 Arm)
13,15	>40	0.0243	0.1883	0.7874	
18,20	30/40	0.0060	0.1162	0.8778	Priority w Ghost Island (4 Arm)
17,19	>40	0.0271	0.2064	0.7665	
22,24	30/40	0.0060	0.1162	0.8778	Priority w Ghost Island (5 Arm)
21,23	>40	0.0271	0.2064	0.7665	
26,28	30/40	0.0072	0.1240	0.8688	Priority w Single Lane Dualling (3 Arm)
25,27	>40	0.0243	0.1883	0.7874	
30,32	30/40	0.0060	0.1162	0.8778	Priority w Single Lane Dualling (4 Arm)
29,31	>40	0.0271	0.2064	0.7665	
34,36	30/40	0.0060	0.1162	0.8778	Priority w Single Lane Dualling (5 Arm)
33,35	>40	0.0271	0.2064	0.7665	
38,40	30/40	0.0060	0.1066	0.8874	Traffic Signals (3 Arm)
37,39	>40	0.0092	0.1171	0.8737	
42,44	30/40	0.0060	0.1069	0.8871	Traffic Signals (4 Arm)
41,43	>40	0.0088	0.1153	0.8759	
46,48	30/40	0.0060	0.1069	0.8871	Traffic Signals (5 Arm)
45,47	>40	0.0088	0.1153	0.8759	
50,52	30/40	0.0027	0.0746	0.9227	Roundabouts (Standard, 3 Arm)
49,51	>40	0.0056	0.0912	0.9032	
54,56	30/40	0.0027	0.0746	0.9227	Roundabouts (Standard, 4 Arm)
53,55	>40	0.0056	0.0912	0.9032	
58,60	30/40	0.0027	0.0746	0.9227	Roundabouts (Standard, 5/6 Arm)
57,59	>40	0.0056	0.0912	0.9032	
62,64	30/40	0.0027	0.0746	0.9227	Roundabouts (Small, 3 Arm)
61,63	>40	0.0056	0.0912	0.9032	
66,68	30/40	0.0027	0.0746	0.9227	Roundabouts (Small, 4 Arm)
65,67	>40	0.0056	0.0912	0.9032	
70,72	30/40	0.0027	0.0746	0.9227	Roundabouts (Small, 5/6 Arm)
69,71	>40	0.0056	0.0912	0.9032	
74,76	30/40	0.0028	0.0868	0.9104	Roundabout (Mini, 3 Arm)
73,75	>40	0.0056	0.0912	0.9032	
78,80	30/40	0.0028	0.0868	0.9104	Roundabout (Mini, 4 Arm)
77,79	>40	0.0056	0.0912	0.9032	
82,84	30/40	0.0028	0.0868	0.9104	Roundabout (Mini, 5/6 Arm)
81,83	>40	0.0056	0.0912	0.9032	
86,88	30/40	0.0031	0.0643	0.9326	Roundabouts (Signalised, 3 Arm)
85,87	>40	0.0039	0.0624	0.9337	
90,92	30/40	0.0031	0.0643	0.9326	Roundabouts (Signalised, 4 Arm)
89,91	>40	0.0039	0.0624	0.9337	
94,96	30/40	0.0031	0.0643	0.9326	Roundabouts (Signalised, 5/6 Arm)
93,95	>40	0.0039	0.0624	0.9337	

Link Only Accident Rates and Change Factors

Base Year
2009

Road Type	Speed Limit (mph)	Accident Rate	Beta Factor	Road Description
1	50/60/70	0.063	0.956	Motorways
2	50/60/70	0.063	0.956	Motorways
3	50/60/70	0.075	0.956	Motorways
4	30/40	0.175	0.964	Modern S2 Roads
4	>40	0.143	0.958	Modern S2 Roads
5	30/40	0.175	0.964	Modern S2 Roads with HS
5	>40	0.143	0.958	Modern S2 Roads with HS
6	30/40	0.206	0.964	Modern WS2 Roads
6	>40	0.082	0.958	Modern WS2 Roads
7	30/40	0.206	0.964	Modern WS2 Roads with HS
7	>40	0.082	0.958	Modern WS2 Roads with HS
8	30/40	0.206	0.964	Older S2 A Roads
8	>40	0.143	0.958	Older S2 A Roads
9	30/40	0.195	0.957	Other S2 Roads
9	>40	0.163	0.935	Other S2 Roads
10	30/40	0.148	0.965	Modern D2 Roads
10	>40	0.077	0.960	Modern D2 Roads
11	30/40	0.154	0.965	Modern D2 Roads with HS
11	>40	0.059	0.960	Modern D2 Roads with HS
12	30/40	0.154	0.965	Older D2 Roads
12	>40	0.077	0.960	Older D2 Roads
13	30/40	0.184	0.949	Modern D3+ Roads
13	>40	0.101	0.956	Modern D3+ Roads
14	30/40	0.184	0.949	Modern D3+ Roads with HS
14	>40	0.101	0.956	Modern D3+ Roads with HS
15	30/40	0.184	0.949	Older D3+ Roads
15	>40	0.101	0.956	Older D3+ Roads

Link and Junction Combined Accident Rates and Change Factors

Base Year
2009

Road Type	Speed Limit (mph)	Accident Rate	Beta Factor	Road Description
1	50/60/70	0.080	0.956	Motorways
2	50/60/70	0.067	0.956	Motorways
3	50/60/70	0.079	0.956	Motorways
4	30/40	0.532	0.959	Modern S2 Roads
4	>40	0.244	0.955	Modern S2 Roads
5	30/40	0.532	0.959	Modern S2 Roads with HS
5	>40	0.244	0.955	Modern S2 Roads with HS
6	30/40	0.863	0.959	Modern WS2 Roads
6	>40	0.163	0.955	Modern WS2 Roads
7	30/40	0.863	0.959	Modern WS2 Roads w. HS
7	>40	0.163	0.955	Modern WS2 Roads w. HS
8	30/40	0.863	0.959	Older S2 A Roads
8	>40	0.244	0.955	Older S2 A Roads
9	30/40	0.559	0.951	Other S2 Roads
9	>40	0.233	0.933	Other S2 Roads
10	30/40	0.553	0.967	Modern D2 Roads
10	>40	0.107	0.956	Modern D2 Roads
11	30/40	0.599	0.967	Modern D2 Roads with HS
11	>40	0.072	0.956	Modern D2 Roads with HS
12	30/40	0.599	0.967	Older D2 Roads
12	>40	0.107	0.956	Older D2 Roads
13	30/40	0.620	0.951	Modern D3+ Roads
13	>40	0.123	0.946	Modern D3+ Roads
14	30/40	0.620	0.951	Modern D3+ Roads w. HS
14	>40	0.123	0.946	Modern D3+ Roads w. HS
15	30/40	0.620	0.951	Older D3+ Roads
15	>40	0.123	0.946	Older D3+ Roads

Link Only and Link and Junction Combined Accident Beta Factor Changes over Time	
Range of Years	Change to Beta Factor
2004-2019	1
2020-2029	0.5
2030-2039	0.25
2040+	0

Link Only Casualty Rates

Base Year

2009

Road Type	Speed Limit (mph)	Casualties per P.I.A.			Road Description
		Fatal	Serious	Slight	
1-3	50/60/70	0.0210	0.1290	1.464	Motorways
4-8	30/40	0.0150	0.1620	1.154	S2 A Roads
4-8	>40	0.0520	0.2740	1.251	S2 A Roads
9	30/40	0.0100	0.1560	1.071	Other S2 Roads
9	>40	0.0280	0.2300	1.178	Other S2 Roads
10-15	30/40	0.0180	0.1480	1.183	Dual Carriageways
10-15	>40	0.0310	0.1610	1.328	Dual Carriageways

Link and Junction Combined Casualty Rates

Base Year

2009

Road Type	Speed Limit (mph)	Casualties per P.I.A.			Road Description
		Fatal	Serious	Slight	
1-3	50/60/70	0.0200	0.1230	1.455	Motorways
4-8	30/40	0.0090	0.1320	1.176	S2 A Roads
4-8	>40	0.0380	0.2380	1.300	S2 A Roads
9	30/40	0.0070	0.1340	1.132	Other S2 Roads
9	>40	0.0260	0.2220	1.218	Other S2 Roads
10-15	30/40	0.0090	0.1120	1.238	Dual Carriageways
10-15	>40	0.0250	0.1510	1.297	Dual Carriageways

Link Only Casualty Change Factors

Base Year

2009

Road Type	Speed Limit (mph)	Beta Factor			Road Description
		Fatal	Serious	Slight	
1-3	50/60/70	0.978	0.979	1.002	Motorways
4-8	30/40	0.971	0.995	1.001	S2 A Roads
4-8	>40	0.979	0.983	1.002	S2 A Roads
9	30/40	0.985	0.997	1.001	Other S2 Roads
9	>40	0.987	0.989	0.998	Other S2 Roads
10-15	30/40	0.998	0.990	1.002	Dual Carriageways
10-15	>40	0.984	0.985	0.998	Dual Carriageways

Link and Junction Combined Casualty Change Factors

Base Year

2009

Road Type	Speed Limit (mph)	Beta Factor			Road Description
		Fatal	Serious	Slight	
1-3	50/60/70	0.978	0.979	1.002	Motorways
4-8	30/40	0.971	0.995	1.001	S2 A Roads
4-8	>40	0.979	0.983	1.002	S2 A Roads
9	30/40	0.985	0.997	1.001	Other S2 Roads
9	>40	0.987	0.989	0.998	Other S2 Roads
10-15	30/40	0.998	0.990	1.002	Dual Carriageways
10-15	>40	0.984	0.985	0.998	Dual Carriageways

Link Only and Link and Junction Combined Casualty Beta Factor Changes over Time

Range of Years

1995-2019

2020+

1

0

Junction Only Accident Parameters

Base Year

1997

Junction Type	Speed Limit (mph)	Coefficient 'a'	Power 'b'	Arms	Highest Link (S/D)	Formula Junction Description	
						Type	
1	>40	0.195	0.460	3	S	C	Priority
2	20/30/40	0.195	0.460	3	S	C	Priority
3	>40	0.195	0.460	3	D	C	Priority
4	20/30/40	0.195	0.460	3	D	C	Priority
5	>40	0.361	0.440	4	S	I	Priority
6	20/30/40	0.361	0.440	4	S	I	Priority
7	>40	0.240	0.710	4	D	C	Priority
8	20/30/40	0.240	0.710	4	D	C	Priority
9	>40	0.361	0.440	5	S	I	Priority
10	20/30/40	0.361	0.440	5	S	I	Priority
11	>40	0.361	0.440	5	D	I	Priority
12	20/30/40	0.361	0.440	5	D	I	Priority
13	>40	0.195	0.460	3	S	C	Priority w Ghost Island
14	20/30/40	0.195	0.460	3	S	C	Priority w Ghost Island
15	>40	0.195	0.460	3	D	C	Priority w Ghost Island
16	20/30/40	0.195	0.460	3	D	C	Priority w Ghost Island
17	>40	0.361	0.440	4	S	I	Priority w Ghost Island
18	20/30/40	0.361	0.440	4	S	I	Priority w Ghost Island
19	>40	0.240	0.710	4	D	C	Priority w Ghost Island
20	20/30/40	0.240	0.710	4	D	C	Priority w Ghost Island
21	>40	0.361	0.440	5	S	I	Priority w Ghost Island
22	20/30/40	0.361	0.440	5	S	I	Priority w Ghost Island
23	>40	0.361	0.440	5	D	I	Priority w Ghost Island
24	20/30/40	0.361	0.440	5	D	I	Priority w Ghost Island
25	>40	0.195	0.460	3	S	C	Priority w Single Lane Dualling
26	20/30/40	0.195	0.460	3	S	C	Priority w Single Lane Dualling
27	>40	0.195	0.460	3	D	C	Priority w Single Lane Dualling
28	20/30/40	0.195	0.460	3	D	C	Priority w Single Lane Dualling
29	>40	0.361	0.440	4	S	I	Priority w Single Lane Dualling
30	20/30/40	0.361	0.440	4	S	I	Priority w Single Lane Dualling
31	>40	0.240	0.710	4	D	C	Priority w Single Lane Dualling
32	20/30/40	0.240	0.710	4	D	C	Priority w Single Lane Dualling
33	>40	0.361	0.440	5	S	I	Priority w Single Lane Dualling
34	20/30/40	0.361	0.440	5	S	I	Priority w Single Lane Dualling
35	>40	0.361	0.440	5	D	I	Priority w Single Lane Dualling
36	20/30/40	0.361	0.440	5	D	I	Priority w Single Lane Dualling
37	>40	0.223	0.610	3	S	I	Signals
38	20/30/40	0.223	0.610	3	S	I	Signals
39	>40	0.494	0.420	3	D	C	Signals
40	20/30/40	0.291	0.510	3	D	C	Signals
41	>40	1.378	0.200	4	S	C	Signals
42	20/30/40	1.378	0.200	4	S	C	Signals
43	>40	0.494	0.420	4	D	C	Signals
44	20/30/40	0.291	0.510	4	D	C	Signals
45	>40	0.254	0.620	5/6	S	I	Signals

45	>40	0.254	0.620	5/6	S	I	Signals
46	20/30/40	0.254	0.620	5/6	S	I	Signals
47	>40	0.238	0.850	5/6	D	I	Signals
48	20/30/40	0.160	0.970	5/6	D	I	Signals
49	>40	0.033	0.760	3	S	C	Roundabouts (Standard)
50	20/30/40	0.033	0.760	3	S	C	Roundabouts (Standard)
51	>40	0.033	0.760	3	D	C	Roundabouts (Standard)
52	20/30/40	0.033	0.760	3	D	C	Roundabouts (Standard)
53	>40	0.024	0.890	4	S	C	Roundabouts (Standard)
54	20/30/40	0.048	0.740	4	S	C	Roundabouts (Standard)
55	>40	0.063	0.690	4	D	C	Roundabouts (Standard)
56	20/30/40	0.022	0.850	4	D	C	Roundabouts (Standard)
57	>40	0.007	1.770	5/6	S	I	Roundabouts (Standard)
58	20/30/40	0.014	1.530	5/6	S	I	Roundabouts (Standard)
59	>40	0.019	1.420	5/6	D	I	Roundabouts (Standard)
60	20/30/40	0.006	1.730	5/6	D	I	Roundabouts (Standard)
61	>40	0.033	0.760	3	S	C	Roundabouts (Small)
62	20/30/40	0.033	0.760	3	S	C	Roundabouts (Small)
63	>40	0.033	0.760	3	D	C	Roundabouts (Small)
64	20/30/40	0.033	0.760	3	D	C	Roundabouts (Small)
65	>40	0.101	0.660	4	S	C	Roundabouts (Small)
66	20/30/40	0.263	0.540	4	S	C	Roundabouts (Small)
67	>40	0.101	0.660	4	D	C	Roundabouts (Small)
68	20/30/40	0.263	0.540	4	D	C	Roundabouts (Small)
69	>40	0.044	1.280	5/6	S	I	Roundabouts (Small)
70	20/30/40	0.095	1.140	5/6	S	I	Roundabouts (Small)
71	>40	0.044	1.280	5/6	D	I	Roundabouts (Small)
72	20/30/40	0.095	1.140	5/6	D	I	Roundabouts (Small)
73	>40	0.012	1.040	3	S	C	Roundabouts (Mini)
74	20/30/40	0.012	1.040	3	S	C	Roundabouts (Mini)
75	>40	0.012	1.040	3	D	C	Roundabouts (Mini)
76	20/30/40	0.012	1.040	3	D	C	Roundabouts (Mini)
77	>40	0.070	0.640	4	S	C	Roundabouts (Mini)
78	20/30/40	0.070	0.640	4	S	C	Roundabouts (Mini)
79	>40	0.070	0.640	4	D	C	Roundabouts (Mini)
80	20/30/40	0.070	0.640	4	D	C	Roundabouts (Mini)
81	>40	0.013	1.470	5/6	S	I	Roundabouts (Mini)
82	20/30/40	0.013	1.470	5/6	S	I	Roundabouts (Mini)
83	>40	0.013	1.470	5/6	D	I	Roundabouts (Mini)
84	20/30/40	0.013	1.470	5/6	D	I	Roundabouts (Mini)
85	>40	0.033	0.760	3	S	C	Roundabouts (Signalled)
86	20/30/40	0.033	0.760	3	S	C	Roundabouts (Signalled)
87	>40	0.033	0.760	3	D	C	Roundabouts (Signalled)
88	20/30/40	0.033	0.760	3	D	C	Roundabouts (Signalled)
89	>40	0.024	0.890	4	S	C	Roundabouts (Signalled)
90	20/30/40	0.048	0.740	4	S	C	Roundabouts (Signalled)
91	>40	0.063	0.690	4	D	C	Roundabouts (Signalled)
92	20/30/40	0.022	0.850	4	D	C	Roundabouts (Signalled)
93	>40	0.007	1.770	5/6	S	I	Roundabouts (Signalled)
94	20/30/40	0.014	1.530	5/6	S	I	Roundabouts (Signalled)
95	>40	0.019	1.420	5/6	D	I	Roundabouts (Signalled)
96	20/30/40	0.006	1.730	5/6	D	I	Roundabouts (Signalled)

Junction Only Accident Change Factors

Base Year

2000

Classification	Speed Limit (mph)	Beta Factor
Major	20/30/40	0.991
Major	>40	0.984
Minor	20/30/40	0.976
Minor	>40	0.996

Junction Only Accident Beta Factor Changes over Time

Range of Years Change to Beta Factor

1995-2010	1
2011-2020	0.5
2021-2030	0.25
2031+	0

Junction Only Casualty Rates

Base Year

2000

Junction Type	Casualties per P.I.A.		
	Fatal	Serious	Slight
1	0.0265	0.2413	1.355
2	0.0075	0.1350	1.144
3	0.0265	0.2413	1.355
4	0.0075	0.1350	1.144
5	0.0295	0.2793	1.459
6	0.0062	0.1292	1.244
7	0.0295	0.2793	1.459
8	0.0062	0.1292	1.244
9	0.0295	0.2793	1.459
10	0.0062	0.1292	1.244
11	0.0295	0.2793	1.459
12	0.0062	0.1292	1.244
13	0.0265	0.2413	1.355
14	0.0075	0.1350	1.144
15	0.0265	0.2413	1.355
16	0.0075	0.1350	1.144
17	0.0295	0.2793	1.459
18	0.0062	0.1292	1.244
19	0.0295	0.2793	1.459
20	0.0062	0.1292	1.244
21	0.0295	0.2793	1.459
22	0.0062	0.1292	1.244
23	0.0295	0.2793	1.459
24	0.0062	0.1292	1.244
25	0.0265	0.2413	1.355
26	0.0075	0.1350	1.144
27	0.0265	0.2413	1.355
28	0.0075	0.1350	1.144
29	0.0295	0.2793	1.459
30	0.0062	0.1292	1.244
31	0.0295	0.2793	1.459
32	0.0062	0.1292	1.244
33	0.0295	0.2793	1.459
34	0.0062	0.1292	1.244
35	0.0295	0.2793	1.459
36	0.0062	0.1292	1.244
37	0.0092	0.1631	1.444
38	0.0064	0.1157	1.214
39	0.0092	0.1631	1.444
40	0.0064	0.1157	1.214

41	0.0095	0.1423	1.467
42	0.0061	0.1177	1.253
43	0.0095	0.1423	1.467
44	0.0061	0.1177	1.253
45	0.0095	0.1423	1.467
46	0.0061	0.1177	1.253
47	0.0095	0.1423	1.467
48	0.0061	0.1177	1.253
49	0.0060	0.1019	1.214
50	0.0027	0.0806	1.163
51	0.0060	0.1019	1.214
52	0.0027	0.0806	1.163
53	0.0060	0.1019	1.214
54	0.0027	0.0806	1.163
55	0.0060	0.1019	1.214
56	0.0027	0.0806	1.163
57	0.0060	0.1019	1.214
58	0.0027	0.0806	1.163
59	0.0060	0.1019	1.214
60	0.0027	0.0806	1.163
61	0.0060	0.1019	1.214
62	0.0027	0.0806	1.163
63	0.0060	0.1019	1.214
64	0.0027	0.0806	1.163
65	0.0060	0.1019	1.214
66	0.0027	0.0806	1.163
67	0.0060	0.1019	1.214
68	0.0027	0.0806	1.163
69	0.0060	0.1019	1.214
70	0.0027	0.0806	1.163
71	0.0060	0.1019	1.214
72	0.0027	0.0806	1.163
73	0.0060	0.1019	1.214
74	0.0028	0.0965	1.182
75	0.0060	0.1019	1.214
76	0.0028	0.0965	1.182
77	0.0060	0.1019	1.214
78	0.0028	0.0965	1.182
79	0.0060	0.1019	1.214
80	0.0028	0.0965	1.182
81	0.0060	0.1019	1.214
82	0.0028	0.0965	1.182
83	0.0060	0.1019	1.214
84	0.0028	0.0965	1.182
85	0.0039	0.0703	1.258
86	0.0031	0.0705	1.221
87	0.0039	0.0703	1.258
88	0.0031	0.0705	1.221
89	0.0039	0.0703	1.258
90	0.0031	0.0705	1.221
91	0.0039	0.0703	1.258
92	0.0031	0.0705	1.221
93	0.0039	0.0703	1.258
94	0.0031	0.0705	1.221
95	0.0039	0.0703	1.258
96	0.0031	0.0705	1.221

Junction Only Casualty Change Factors

Base Year

2000

Classification	Speed Limit (mph)	Beta Factor		
		Fatal	Serious	Slight
Major	20/30/40	0.949	0.962	1.010
Major	>40	0.961	0.959	1.011
Minor	20/30/40	0.968	0.958	1.006
Minor	>40	0.976	0.972	1.011

Junction Only Casualty Beta Factor Changes over Time

Range of Years Change to Beta Factor

1995-2010

2011+

1
0

Appendix E Sectorised WITA analysis

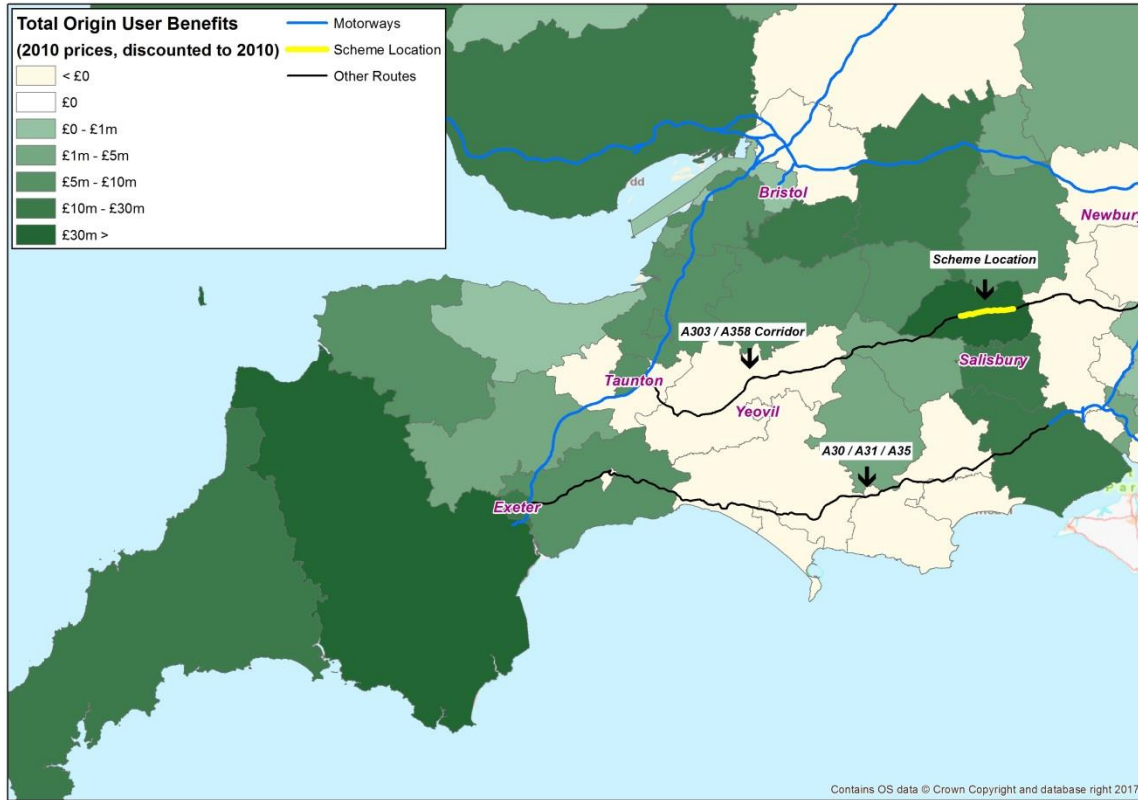
E.1 Core wider impacts results

TUBA Sectors	Agglomeration Impact	Labour Supply Impact
101,102,103,108	3,980	117
104	1,938	61
105	359	34
106	561	44
107	974	12
201	395	15
202	3,962	71
203	0	0
204	0	0
205	0	0
206	0	0
207	0	0
208	0	0
211	0	0
201,212	0	0
209,213	0	0
301	-21	0
302	-10	5
303	-264	1
304	-44	0
305	-15	0
401	655	4
405	62	1
404,406	444	0
403,407	1,254	0
402,408	-18	0
501	788	18
502	607	0
504	209	31
503,505,506	464	29
601	189	0
603	142	5
604	139	6
605	460	33
606	191	218
602,607	67	-4
701	0	0

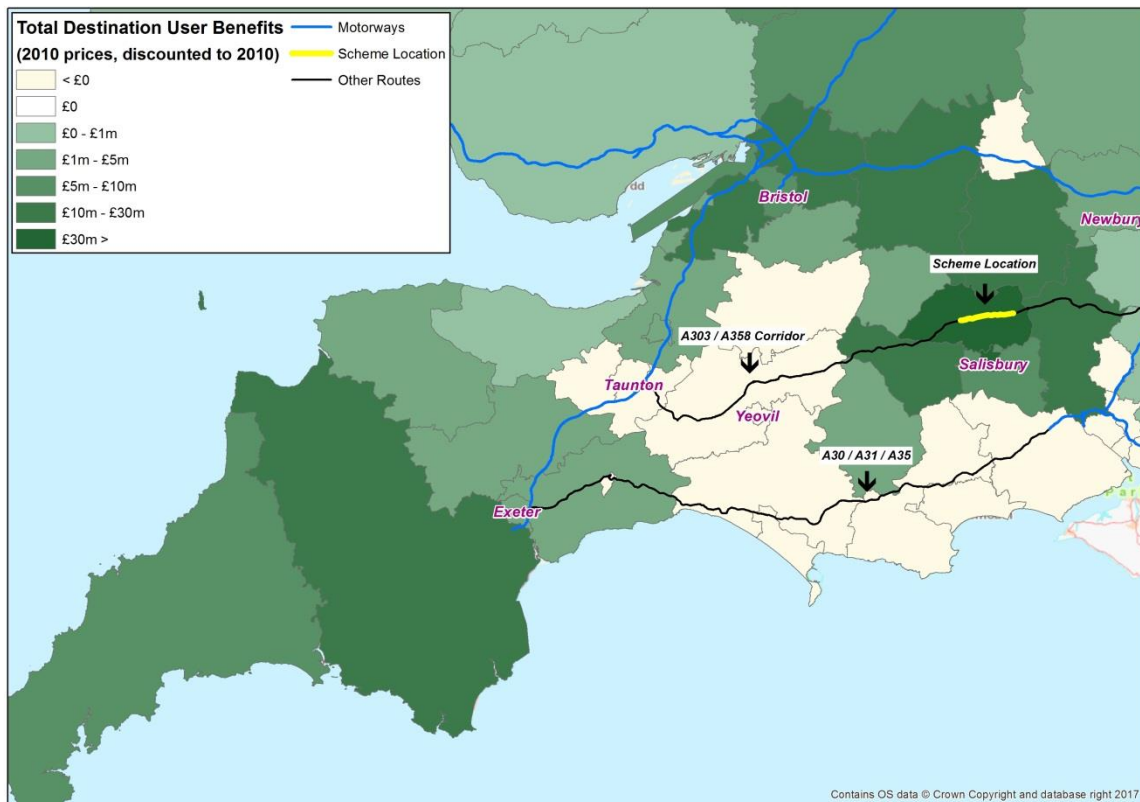
TUBA Sectors	Agglomeration Impact	Labour Supply Impact
702	0	0
703	0	0
801	0	0
802	0	0
901	0	0
902	0	0
903	0	0
904	0	0
905	0	0
906	0	0
907	0	0
908	0	0
909	0	0
910	0	0
920	0	0
921	0	0
922	0	0
930	0	0

Appendix F TUBA sensitivity test distributional benefits

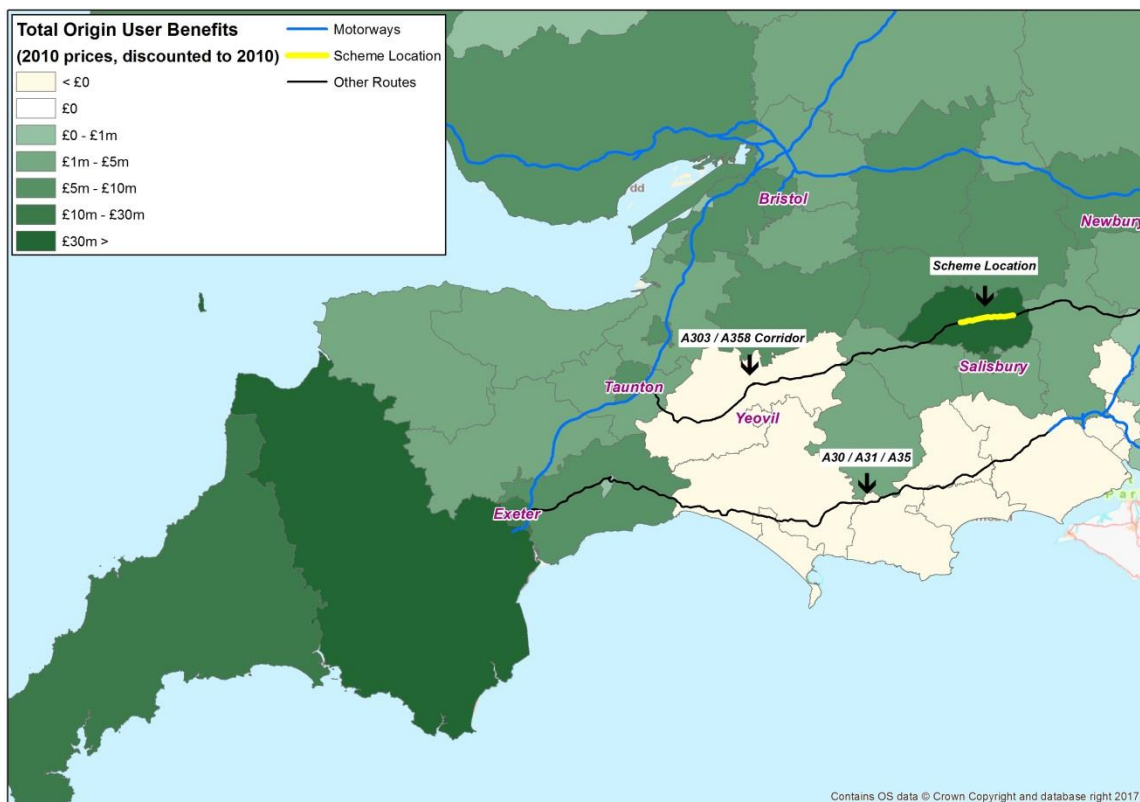
F.1 High growth scenario: Total origin user benefits



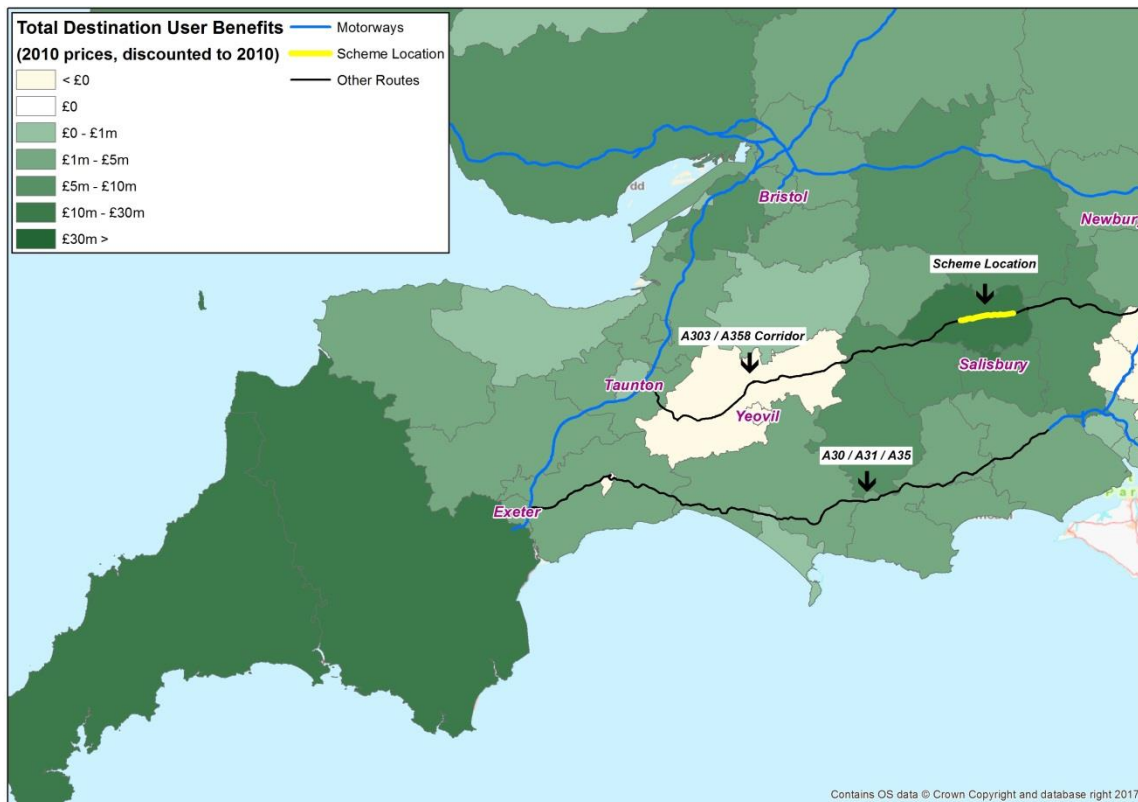
F.2 High growth scenario: Total destination user benefits



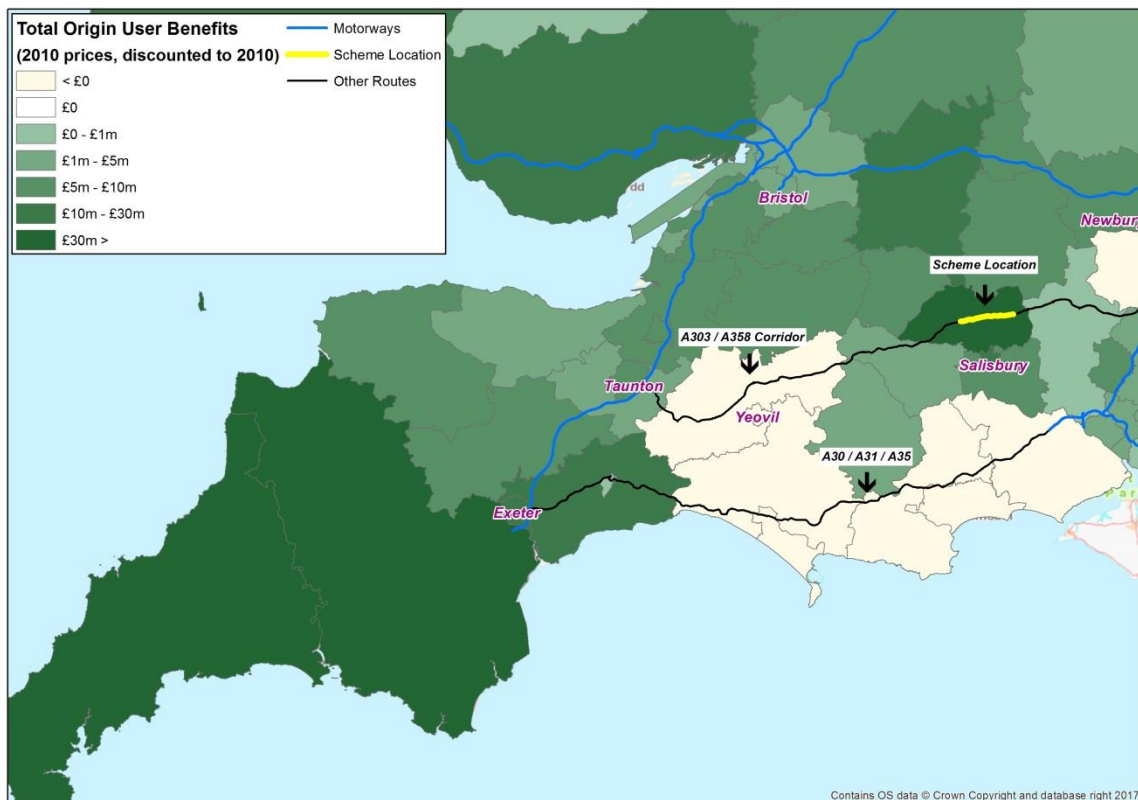
F.3 Low growth scenario: Total origin user benefits



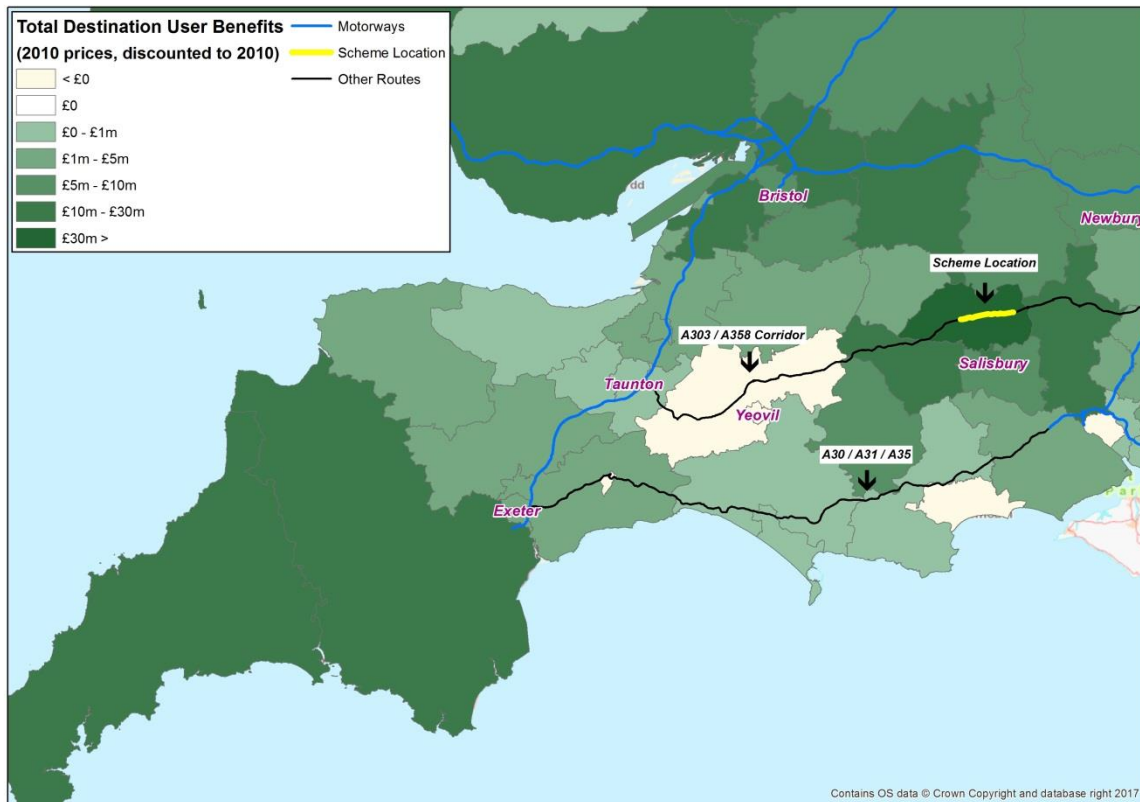
F.4 Low growth scenario: Total destination user benefits



F.5 Alternative scenario (Boscombe Down): Total origin user benefits



F.6 Alternative scenario (Boscombe Down): Total destination user benefits



Appendix G Environment summary tables

G.1 Air quality impacts summary table

Air Quality Valuation Workbook - Worksheet 3

Scheme Name: A303 Amesbury to Berwick Down

Present Value Base Year 2010

Current Year 2018

Proposal Opening year: 2026

Project (Road/Rail or Road and Rail) road

Overall Assessment Score:

Present value of change in NOx emissions (£):

-£513,554

Present value of change in PM10 concentrations (£):

£815,956

Total value of change in air quality (£):

£302,403

[upper and lower estimates of net benefit of air quality improvement]

Quantitative Assessment:

Net total route assessment (opening year) for PM10 :
(between 'with scheme' and 'without scheme' scenarios)

-314

Change in NOx emissions over 60 year appraisal period:
(between 'with scheme' and 'without scheme' scenarios)

1,123

Qualitative Comments:

DMRB predictions are not verified

Overall a net beneficial change in air quality is calculated as a result of the Scheme

For PM10 there is a net decrease in assessment score in the opening year.

For NOx there is a net increase in emissions over the 60 year appraisal period

Sensitivity Analysis:

Upper estimate net present value of change in air quality (£):

£338,474

Lower estimate net present value of change in air quality (£):

£26,337

Data Sources:

NOx emissions data from Emission Factor Toolkit V8.0.1

PM10 assessment score from Plan Level TAG assessment

G.2 Noise impacts summary table

Noise Workbook - Worksheet 1

Proposal Name: A303 Amesbury to Berwick Down

Present Value Base Year

Current Year

Proposal Opening year:

Project (Road, Rail or Aviation)

Net present value of change in noise (£):

-£330,798

[positive noise effects are added and negative noise effects are subtracted]

Net present value of impact on sleep disturbance (£):

-£156,743

Net present value of impact on amenity (£):

-£115,517

Net present value of impact on AMI (£):

-£24,473

Net present value of impact on stroke (£):

-£13,565

Net present value of impact on dementia (£):

-£20,494

Quantitative results

Households experiencing increased daytime noise in forecast year:

134

Households experiencing reduced daytime noise in forecast year:

81

Households experiencing increased night time noise in forecast year:

108

Households experiencing reduced night time noise in forecast year:

53

Qualitative Comments:

Total 1777 residential buildings in DRMB 600m quantitative noise prediction study area. In forecast year 1502 don't change 3dB band in the daytime and 1616 at night. Based on the facade with the worst case change 11% of residential buildings experience no change or a decrease in daytime traffic noise levels. The greatest reductions (moderate and major) are in Winterbourne Stoke, which is bypassed by the scheme, and Stonehenge Cottages on the tunnelled section. Significant reductions in traffic noise level are also predicted through the tunnelled section in the WHS including Stonehenge. Outside the noise modelling study area to the north minor or moderate reductions in traffic noise are anticipated on local roads through Larkhill, Shrewton and Chitterne currently used as alternatives to the A303. Based on the facade with the worst case change one residential building on the northern edge of Winterbourne Stoke at the closest approach to the bypass, and 4 residential buildings on High Street in Amesbury, are predicted to experience a major increase in daytime traffic noise levels. A further 17 residential buildings and 2 community facilities on High Street/Church Street in Amesbury are predicted to experience a moderate increase. This is due to the rerouting of traffic from the closure of the Stonehenge Road access onto the A303, absolute traffic flows on High Street/Church Street are low with and without the scheme. 3% of residential buildings experience a minor increase and 84% a negligible increase in traffic noise, not significant. This is due to the slight increase in traffic on the majority of roads in Amesbury which connect onto the A303. One property is provisionally identified as meeting the Noise Insulation Regulations criteria.

Data Sources:

DMRB detailed noise assessment predicted $L_{A10,10L}$ dB facade (day) and $L_{A9,9L}$ dB free-field (night)
 $L_{A10,10L}$ dB facade (day) converted to $L_{A9,9L}$ dB facade (day) by subtraction of 2 dB as per TAG guidance
 Residential buildings identified via addressbase and aerial photography
 Results are provided for the facade with the worst case change in the $L_{A10,10L}$ in the short term in 2026
 Results are provided for top floor of each residential building e.g. height 1.5m for 1 storey, 4m for 2 storey etc.

G.3 Greenhouse gas impacts summary table

Greenhouse Gases Workbook - Worksheet 1

Scheme Name: A303 Amesbury to Berwick Down

Present Value Base Year 2010

Current Year 2018

Proposal Opening year: 2026

Project (Road/Rail or Road and Rail) road

Overall Assessment Score:

Net Present Value of carbon dioxide equivalent emissions of proposal (£):

-£86,457,778

*positive score reflects a net benefit in CO2 emissions reduction

Quantitative Assessment:

Change in carbon dioxide equivalent emissions over 60 year appraisal period (tonnes) 1,955,503
(between 'with scheme' and 'without scheme' scenarios)

Of which Traded 0

Change in carbon dioxide equivalent emissions in opening year (tonnes): 23,390
(between 'with scheme' and 'without scheme' scenarios)

Net Present Value of traded sector carbon dioxide equivalent emissions of proposal £0

(N.B. this is not additional to the appraisal value in cell I17, as the cost of traded sector emissions is assumed to be internalised into market prices. See TAG Unit A3 for further details)

*positive score reflects a net benefit in CO2 emissions reduction

Change in carbon dioxide equivalent emissions by carbon budget period:

	Carbon Budget 1	Carbon Budget 2	Carbon Budget 3	Carbon Budget 4
Traded sector	0	0	0	0
Non-traded sector	0	0	0	48641.73603

Qualitative Comments:

There is a net increase in carbon over the 60 year appraisal period of 1,955,503 tonnes and in the opening year of 23,390 tonnes

Sensitivity Analysis:

Upper Estimate Net Present Value of Carbon dioxide Emissions of Proposal (£): -£133,818,345

Lower Estimate Net Present Value of Carbon dioxide Emissions of Proposal (£): -£39,097,211

Data Sources:

CO2 emissions data from Emission Factor Toolkit V8.0.1

Appendix H Valuing Heritage Impacts



ARUP **ATKINS**
SIMETRICA

A303 Amesbury to Berwick Down

Valuing Heritage Impacts

Arup Atkins Joint Venture

HE551506-AA-GEN-SWI-RP-JX-000025

P03, S3

13/06/2017

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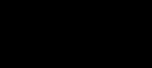
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1 Executive Summary

- 1.1.1 Stonehenge in Wiltshire is one of the best-known and most important archaeological sites in the world. The Stonehenge part of the Stonehenge and Avebury World Heritage Site (WHS) covers around 26km. The site currently suffers considerable intrusion in the form of the A303 road, which passes within 165 metres of the famous stone circle and cuts through some other features of the WHS such as The Avenue.¹ The Government has committed to improving the A303 between Amesbury and Berwick Down and, in doing so, reducing the impact of the road on the WHS.
- 1.1.2 Highways England is currently progressing through the options identification and selection stage of the project. Options considered involve diverting the A303 away from the Stonehenge monument, either through a tunnel or via a bypass. Diverting the road away from Stonehenge would have a number of beneficial effects on the cultural and heritage value of the Stonehenge WHS, including reduced noise, increased tranquillity, reduced visual intrusion and reduced landscape severance resulting from the existing route.
- 1.1.3 According to Government guidance, every large spending proposal such as this requires a five case business case.² Such a business case aims to set out the full benefits and costs of a spending project to enable the decision makers to take full account of the impact of a project. This study is part of a wider business case for a proposed change in the road layout of the A303. In particular, this study considers the impact of the proposed change on the heritage experience and non-use heritage values. Other impacts (such as economic and environmental) are considered in the overall business case and use the methods described in the Department for Transport's transport appraisal guidance (WebTAG). This study is carefully designed to exclude those other impacts to avoid double counting. This study focuses exclusively on the cultural heritage impacts of removing the A303 from its current location within the WHS in terms of noise reduction, increased tranquillity, visual amenity and reduced landscape severance.
- 1.1.4 The HM Treasury Green Book (2011) recommends the use of stated preference methods for the valuation of goods which do not have actual or revealed market prices, such as cultural heritage or biodiversity. The **contingent valuation method (CV)** is a stated preference survey-based methodology that seeks to elicit monetary values for non-market goods by directly asking individuals about their willingness to pay or willingness to accept compensation for a particular change (Bateman et al. 2002). Respondents are presented with a hypothetical market that describes in detail the proposed change, using baseline conditions as a reference point. The hypothetical scenario should be understandable, plausible, and meaningful to respondents so that they can give valid and reliable values despite possible lack of

¹ More detail can be found on <http://www.english-heritage.org.uk/visit/places/stonehenge/?gclid=CPTHamOqdACFUHGgwodrCEBpQ&gclidsrc=aw.ds>

² For more detail on the business case process see: Public sector business cases using the five case model (HM Treasury 2013).



experience with one or more aspects of the scenario (Mitchell and Carson 1989).

- 1.1.5 We applied CV surveys to elicit monetary values for a hypothetical change in noise, tranquillity, visual amenity and landscape severance within the Stonehenge WHS, by directly asking individuals about their willingness to pay (WTP) or willingness to accept (WTA) compensation for a hypothetical change in the layout of the A303 road through the Stonehenge WHS. The CV survey instrument design was informed by an extensive review of the valuation literature on heritage and cultural goods and services. The study has been peer reviewed by an academic expert and quality assured by Department for Transport (DfT) and Highways England (HE) economists.
- 1.1.6 The key methodological advantage of CV over other non-market valuation approaches is that it can measure use and non-use values and benefits that would not be revealed under market conditions. In this case **use values** stem from those visiting the site, those travelling on the A303 and viewing the site from the road, and those who experience Stonehenge remotely via other media such as the internet, film, books, photographs or social media. Use values can include an option value for those deriving value from the possibility of using Stonehenge in the future. **Non-use values** are made up of: *altruistic values* – welfare increases from knowing that others living will benefit; *bequest values* – welfare increases from knowing that future generations will benefit; and *existence values* – welfare changes from knowing that the road layout within the Stonehenge WHS has been changed (even if an individual does not experience the changed road layout now or in the future). It is likely that some people who have not visited and will not ever visit Stonehenge, or even engage with it remotely (e.g. through media), will nonetheless value the positive effects of the road layout scenarios if this improves experiences for visitors and others who care about Stonehenge. By the same token, non-users may value the positive effects for road users of maintaining the current road layout within the WHS.
- 1.1.7 This study was designed to assess both use values and non-use values associated with the removal of the A303 from its current location within the Stonehenge WHS, covering both positive and negative aspects of the hypothetical road scenario for users and non-users.
 - a) For those who positively valued the road option change, we estimate the willingness to pay, via an annual tax at the individual level, for the changes to noise, tranquillity, visual amenity and landscape severance associated with the removal of the A303 from its current location in the Stonehenge WHS and its redirection through a tunnel of approximately 2.9km.³
 - b) For those that negatively valued the road option change, and that therefore indicated they would not be willing to pay for the tunnel, we estimate the willingness to accept, via a one-off cash compensation, to put up with the

³ The current A303 would likely be replaced with a narrower footpath or other access way covered with a different material than the current tarmac.



removal of the A303 from its current location in the Stonehenge WHS and its redirection through a tunnel of approximately 2.9km.

- 1.1.8 We conducted three surveys on three sets of stakeholders who may be anticipated to hold different types of values for the hypothetical removal of the A303 from within part of the Stonehenge WHS:
- a) Visitors to the Stonehenge WHS (n=432): On-site face-to-face interviews (UK resident, aged 16+) estimating the following possible values associated with the removal of the road from the Stonehenge WHS:
 - i. Direct use value
 - ii. Non-use value (associated with effects on other cultural heritage within the Stonehenge WHS)
 - iii. Use and option value for changes in the view of Stonehenge from the A303 between Amesbury and Berwick Down.
 - b) Road users (Local residents as proxy) (n=1,001): Online survey of people living within a 50-mile radius of Stonehenge with quotas on gender and age, estimating the following possible values associated with the removal of the road from the Stonehenge WHS:
 - i. Direct use value
 - ii. Non-use value (associated with effects on other cultural heritage within the Stonehenge WHS)
 - iii. Use and option value for changes in the view of Stonehenge from the A303 between Amesbury and Berwick Down.
 - c) General population (n=2,102): On-line survey of people living in the UK (UK residents aged 16+, with quotas on age, gender, and region) estimating the following possible values associated with the removal of the road from the Stonehenge WHS:
 - i. Non-use value;
 - ii. Use values for those who have visited the site recently or have photos of it;
 - iii. Option value for changes in the view of Stonehenge from the A303 between Amesbury and Berwick Down.
- 1.1.9 The three surveys used the same basic structure and were divided into three sections. Respondents were provided with information about the route of the tunnel and the expected impact of the scheme on the World Heritage Site (both positive and negative).
- 1.1.10 In total, we received 3,535 completed survey responses composed of visitors N=432, Local Population N=1,001, General Population N=2,102. Following the surveys, the respondents were redistributed into three study groups of visitors, road users, and the general population. This was because some of the general population sample were regular road users, whilst some of the local resident survey (local residents as a proxy) were not. To ensure that the study groups maintained representativeness of their respective populations, the visitor group was weighted by age, and the general population group weighted by region,



gender, age group and income group to ensure representativeness of real-world populations. Road users were revealed through their responses to survey questions on past usage of the A303 between Amesbury and Berwick Down, and in this case we did not have relevant real-world population demographic data with which to make comparisons of representativeness.

- 1.1.11 We elicited WTP and WTA values across all three study groups for the following hypothetical scenario (from hereon, 'the road scheme'):

The construction of a dual carriageway between Amesbury and Berwick Down, including a 2.9km tunnel underneath the WHS with both portals located within the WHS but out of sight from the stone circle. By removing the road from the central portion of the World Heritage Site, those using the road will no longer be able to see Stonehenge while driving and those visiting the site will no longer be affected by the road. To either side of the tunnel itself, widening the road and constructing tunnel portals will have adverse impacts on other monuments (e.g. burial sites) within the WHS.

- 1.1.12 Respondents were presented with this hypothetical scenario including maps and photos (see Appendix A for the full survey and information material) and told that the project would be funded through national taxes. Respondents were first asked if they would, in principle, be willing to pay an increase in annual taxes over a three-year period to support the alternative road scheme. Those respondents that stated they would be willing to pay something for the alternative road option were then directed to the WTP valuation question.
- 1.1.13 Those who indicated that they would not be willing to pay anything for the alternative road scheme were asked a willingness to accept (WTA) compensation question for the removal of the current A303 using a hybrid wellbeing-contingent valuation WTA question developed in previous cultural valuation studies (Bakhshi et al. 2015). The WTA question involved asking respondents if the proposed road scheme would reduce their life satisfaction. Those who indicated that the road scheme would reduce their life satisfaction were asked about the minimum they would be willing to accept in compensation, using the same payment card range as the WTP question.
- 1.1.14 In designing the CV survey instrument we implemented best practice related to question wording and ordering, payment format, payment vehicle, prompts, use of images, entreaty scripts (reminders of budget constraints and requests to answer the WTP or WTA question realistically) to reduce the impact of hypothetical bias, and follow-up questions on motivations for WTP and WTA (Bateman et al. 2002; Bakhshi et al. 2015).
- 1.1.15 We apply validity testing to assess the WTP findings and provide supporting evidence that the WTP results reflect the welfare changes associated with the road scheme. The credibility of estimated values from CV studies is most commonly assessed by examining their theoretical validity (Bateman et al. 2002). Theoretical validity examines whether the relationship between WTP and other indicators are in accordance with prior expectations. Some of these indicators are predictors from economic theory, such as the positive association between income and WTP predicted by microeconomic theory

(Bateman and Willis 2001), or the higher values held by those with positive attitudes towards heritage conservation. The validation tests confirmed that WTP is associated with the key drivers of WTP (such as income and frequency of visits to Stonehenge), and in the expected direction (e.g. those with higher incomes report higher mean WTP).

- 1.1.16 We provide summary results of the contingent valuation of the hypothetical reduction in noise, increased tranquillity, increased visual amenity and reduced landscape severance associated with the removal of the A303 from part of the Stonehenge WHS. The main result is a total net benefit of £1.3bn resulting from the road scheme. The total net benefit aggregates those willing to pay for the road scheme, net of those requiring compensation for it. The aggregated net benefit sits within a 95% confidence interval of £1.1bn and £1.4bn. The values elicited comprise two drivers of welfare; (i) the use value derived from changes to the heritage experience; and (ii) the non-use value which people place on the existence of the altered WHS including bequest value to future generations. It is not possible to separate these values into use and non-use values.

Table: Aggregate net value of road scheme

	Lower bound of 95% confidence interval	Mean	Upper bound of 95% confidence interval
Visitors	£20million	£25million	£29million
Road Users	£42million	£49million	£56million
General Population	£1.1billion	£1.2billion	£1.3billion
Total	£1.1billion	£1.3billion	£1.4billion

- 1.1.17 To conclude, the study applies best practice stated preference methods (contingent valuation) to elicit the total net benefits associated with the hypothetical reduction in noise, increased tranquillity, increased visual amenity and reduced landscape severance associated with the removal of the A303 from part of the Stonehenge WHS for three population groups: Stonehenge visitors, road users, and the UK resident general population (aged 16 and over). Individual mean WTP and WTA values, as well as the number of zero responses, are in line with comparable results from heritage studies in the UK and international studies of World Heritage Sites. Validity tests show that WTP values are consistent with theoretically consistent drivers of value (Bateman et al. 2002), with additional sensitivity analyses performed on respondent certainty levels. Surveys were carefully designed following best practice to reduce known biases in CV surveys (Bakhshi et al. 2015).
- 1.1.18 While the values elicited in this study cannot be directly translated into cashable benefits, they represent the value that the improvements achieved by the road scheme will have for users and non-users of the WHS. They therefore



form a key component of the overall cost-benefit analysis of this scheme. They have been conducted in strict adherence to the Green Book guidance on appraisal and evaluation.

- 1.1.19 The comparison of these aggregate values with the earlier CV study that valued the benefits of removing the A303 and placing it in a tunnel in the Stonehenge WHS, by Maddison and Mourato (2001), shows comparable values once inflation, growth and factors specific to the studies such as survey mode are accounted for. This adds to the validity of the values in this CV study.

2 Introduction

2.1 Background

- 2.1.1 Stonehenge in Wiltshire is one of the best-known and most important archaeological sites in the world. The Stonehenge part of the Stonehenge and Avebury World Heritage Site (WHS) covers around 26km². Stonehenge is the most recognised monument, but the wider landscape contains features of similar archaeological importance. The site currently suffers considerable intrusion in the form of the A303 road, which passes within 165 metres of the famous stone circle and cuts through some other features of the WHS such as The Avenue.⁴ The Government has committed to improving the A303 between Amesbury and Berwick Down and, in doing so, reducing the impact of the road on the WHS. However, the current road layout also provides the public with a view of the stone circle from the road. As a result, a full CBA of the proposed policy is required.
- 2.1.2 Highways England is currently progressing through the options identification and selection stage of the road scheme. Options considered included the diversion of the A303 away from the Stonehenge monument, either through a tunnel or via a bypass. In January 2017, Highways England commenced a consultation on their plans for the Scheme. Highways England's proposed solution is to build a 1.8 mile (2.9 kilometre) tunnel under the World Heritage Site (WHS). Diverting the road away from Stonehenge would reduce the noise, visual intrusion and the landscape severance that results from the existing route, whilst increasing tranquillity.

2.2 Objectives

- 2.2.1 The unique nature of the A303 Stonehenge project, creates a significant challenge to appraisers when considering the value for money of the scheme. Impacts on the WHS are clearly central to the development and identification of a preferred scenario for the scheme. The objective of enhancing and protecting the WHS is likely to result in higher construction costs than for a 'typical' highway improvement project. Whilst it is reasonably easy to quantify construction costs, it is much more challenging to quantify some of the key potential benefits of the scheme. In this context, there is a possibility, therefore, that the cost-benefit analysis of the scheme provides a skewed picture of value for money with the potential benefits being under-represented.
- 2.2.2 According to Government guidance every large spending proposal such as this requires a full business case.⁵ Such a business case aims to set out the full benefits and costs of a spending project to enable the decision makers to take full account of the impact of a project. This study is part of a wider business case for a proposed change in the road layout of the A303. In particular, this study considers the impact of the proposed change on the heritage experience

⁴ More detail can be found on <http://www.english-heritage.org.uk/visit/places/stonehenge/?gclid=CPTHamOqdACFUHGgwodrCEBpQ&gclidsrc=aw.ds>

⁵ For more detail on the business case process see: Public sector business cases using the five case model (HM Treasury 2013).



and non-use heritage values. Other impacts (such as economic and environmental) are considered in the overall business case and use the methods described in the DfT's transport appraisal guidance (WebTAG). This study is carefully designed to exclude those other impacts to avoid double counting. For example, if respondents include the reduction in the journey time along the A303, once it has been moved into a tunnel, into their WTP value, this would be counted twice because time benefits are picked up in the WebTAG assessment as part of the wider cost-benefit analysis. Figure 1 illustrates how these considerations fit together. This study attempts to focus exclusively on the cultural heritage impacts of removing the A303 from its current location within the WHS in terms of noise reduction, increased tranquillity, visual amenity and reduced landscape severance.⁶ Impacts of a project such as this are complex. At the time of this study comprehensive information on the routing of the tunnel and its portals was not available. The construction of a tunnel is likely to have impacts on other elements of the WHS, most of which may not even be visible in the current state. While the removal of the A303 will increase the tranquillity and visual amenity around the WHS its further impacts may become apparent while exploratory work is conducted. These archaeological impacts are outside of the scope of this study but will be addressed in the consultation process.

- 2.2.3 The aim of this research is to produce a set of robust and defensible estimates for non-market benefits associated with the removal of the A303 from its current location within the Stonehenge WHS (hereon, 'the road scheme'). Simetrica was commissioned by AAJV (Arup Atkins Joint Venture) on behalf of Highways England to conduct this study. The Simetrica project team consisted of Daniel Fujiwara, Director, Professor Susana Mourato (London School of Economics and Simetrica), Dr. Ricky Lawton, Dr. Ulrike Hotopp, Kieran Keohane, Cem Maxwell, Augustin Lagarde and Vicky Clayton. The study builds on Susana Mourato's previous study in 1998 published in 2001. All survey materials were reviewed and approved by a project steering group, including members of Highways England, DfT, Defra, English Heritage, Natural England, and Historic England.
- 2.2.4 HM Treasury's Green Book is founded on the economic concept of cost-benefit analysis (CBA). What distinguishes economic approaches to appraisal and evaluation is that the outcomes of an action are what matter, and these outcomes are measured ultimately in terms of their welfare implications.
- 2.2.5 There are two ways of converting an impact on welfare into a monetary figure, which enables different policies to be appraised and evaluated on a consistent basis: **Compensating surplus (CS)** is the amount of money, paid or received, that will leave the agent in their initial welfare position following a change in the good; and **Equivalent surplus (ES)** is the amount of money, to be paid or received, that will leave the agent in their subsequent welfare position in absence of a change in the good. CS can be interpreted in terms of people's **willingness to pay (WTP)** for welfare-enhancing outcomes and **willingness to accept (WTA)** welfare-decreasing outcomes. In contrast, ES can be

⁶ Willingness to pay studies can be subject to biases, including strategic bias. See section 4.2 for details on potential biases and how they have been addressed in this study.

interpreted as peoples' **WTA to forego** a welfare enhancing outcome and **WTP to avoid welfare-decreasing** outcomes.

- 2.2.6 Where market prices do not exist for goods and services (termed 'non-market' goods) economists have traditionally turned to direct elicitation of WTP and WTA through non-market valuation methods such as survey-based **stated preference** valuation methods (HM Treasury 2011). The **contingent valuation method (CV)** is a stated preference survey-based methodology that seeks to elicit monetary values for non-market goods by directly asking individuals about their willingness to pay or willingness to accept compensation for a particular change (Bateman et al. 2002). Respondents are presented with a hypothetical market that describes in detail the proposed change under valuation, using baseline conditions as a reference point. The hypothetical scenario must be understandable, plausible, and meaningful to respondents so that they can give valid and reliable values despite possible lack of experience with one or more aspects of the scenario (Mitchell and Carson, 1989). Respondents are then asked how much they would be prepared to pay or accept for the change described.
- 2.2.7 The methods used for this study were subject to a review process by analysts from Highways England and the DfT and were discussed with an independent peer reviewer, Professor Danny Campbell from Stirling University.

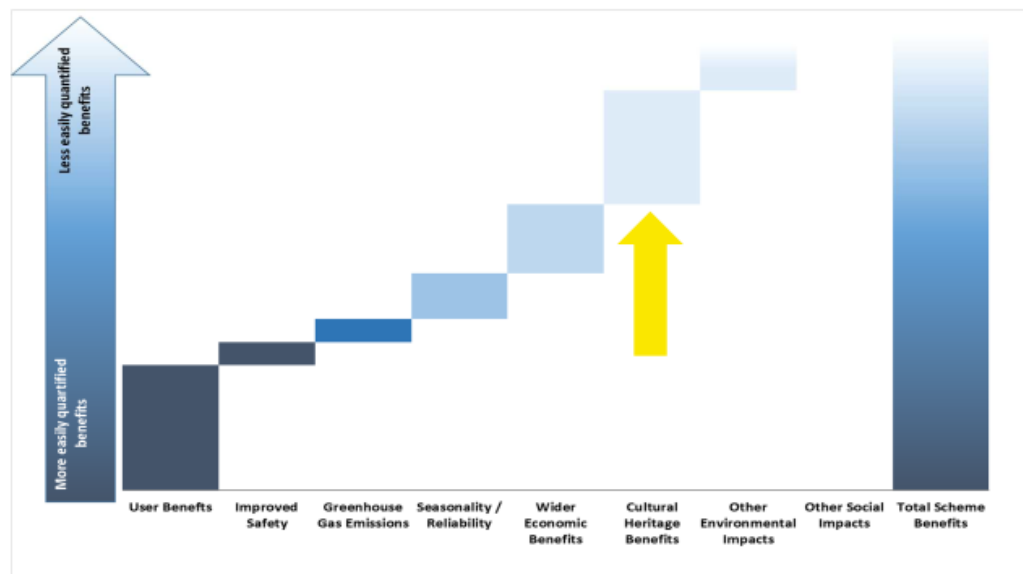


Figure 1 Benefits assessed in the A303 business case

Note: the size of the bars in this figure are examples of the size of the impact and are not based on data. The yellow arrow indicates the specific benefits considered by the study.

3 Literature review

3.1 Contingent valuation studies of road schemes

- 3.1.1 The key piece of research which guides this study is a contingent valuation study which assessed the heritage value of the removal of two roads – the A344 and the A303 – within the Stonehenge WHS, conducted by Maddison and Mourato (2001b). The data was collected in 1998 on a face-to-face basis, both on site and in households across the country.⁷ Respondents were asked to consider their WTP for the change or WTP to retain the status quo situation, in terms of a household tax. The net weighted average value was then aggregated using the total number of households in the UK. The majority of respondents (by a narrow margin) in 1998 would prefer to retain the existing scenario, but of these the majority did not express a positive WTP to retain it. Those who preferred the construction of the tunnel had higher levels of positive WTP. This study design was partly used as a benchmark for the current study. The net aggregate WTP for replacing the A303 with the construction of a tunnel was £149m. Appendix B explains the difference in the total valuation to our study. The main reasons for this difference are subsequent levels of inflation and that aggregation occurred on the household rather than individual level.⁸ In addition, the CV method has been developed further and the use of online panels via the internet allows for significantly larger surveys making studies more robust.
- 3.1.2 Sieber and Melichar (2014) used the CV method in their valuation of a road improvement in the Czech Republic. They focussed on one particular aspect of the road improvement – reduction of noise – and had to ensure that the information provided to survey respondents ensured this focus. The validity tests conducted showed that variability of WTP accorded with theoretically consistent drivers, such as demographic characteristics and where people lived. Mean WTP was estimated at 98 Koruna, which converts to £2.98 at 2015 prices.

3.2 Contingent valuation studies of cultural heritage

- 3.2.1 This project is not just concerned with the valuation of a road scheme in general but the impact of a road on cultural heritage. The A303 Stonehenge scheme is unique in that it seeks, as a key objective, to enhance a heritage assets. To assess these multifaceted effects, we also reviewed the literature on cultural heritage. Contingent valuation studies have been applied to a wide range of heritage sites within the UK (Willis 1994; Eftec 2005), Europe (Mourato et al. 2014; Mourato et al. 2002; Del Saz Salazar and Montagud Marques 2005; Ruijgrok 2006), and beyond (Kim et al. 2007; Lee 2014; Báez-Montenegro et al. 2012),

⁷ The A344 was removed in 2013. Part of the old road is now used as a footpath, the rest has been completely removed and grassed over.

⁸ The literature on aggregating contingent valuation upon review, points in the direction of aggregating on an individual level.

- 3.2.2 In 2003, Noonan (2003) provided a review of the state-of-the-art CV methods in the cultural and heritage sector. Noonan considered 116 studies which used CV or Dichotomous Choice Experiments (DCE) and assessed the differences in methods with respect to their impact on WTP. Of 53 CV studies of cultural sites published at the time, five were related to heritage sites (Boxall et al. 2003; Mourato et al. 2002; Creigh-Tyte 2000; Eftec 2005; Lockwood 1996) and 19 to historical sites (Noonan, 2003). The most common form of payment mechanism used across all studies were payment card and dichotomous choice methods.⁹ Noonan showed that, in 2003, the UK was one of the leaders in applying CV studies to assess the value of cultural goods, just behind the US.
- 3.2.3 In 2014 Bakhshi, Fujiwara, Mourato, Lawton and Dolan conducted a CV study of cultural heritage in the UK focussing on museums and galleries (Bakhshi et al. 2015). This report also updated Noonan's literature review related to museums and galleries. The authors undertook an explicit comparison between two methods of economic valuation: contingent valuation (CV) and subjective wellbeing valuation (SWV). The study found that CV performed well in measuring use and non-use/option values for cultural institutions, when undertaken using best-practice techniques for addressing well-known biases and implementation challenges. It demonstrated once more that CV can be a useful tool in assessing the value that cultural heritage creates, in the absence of markets, producing very realistic values. It should be noted that, in the current study, subjective well-being valuation would not have been suitable because it is based on experienced utility, requiring participants to experience both the current road and the tunnel options and compare their well-being. This is clearly not feasible in this case.
- 3.2.4 A persistent problem in CV studies is that estimates of WTA typically exceed that of WTP, which violates the underlying theory of economic preference satisfaction (Hausman 2012). Bakhshi et al. (2015) elicit the value of avoiding the closure of a cultural institution (with case studies of London's Natural History Museum and the Tate Liverpool gallery) for one year using a WTA approach, via a one-off cash compensation. The authors define this mostly as a use value and an option value, as closure would prevent access and future access to the institution but not, say, on-going research and conservation. The study addresses the well-known WTP-WTA disparity (Horowitz and McConnell 2002; Shogren et al. 1994), often described as an endowment effect, whereby people ascribe more value to things merely because they own them (Daniel Kahneman and Tversky 1979; Loewenstein and Adler 1995). The study addresses this by assessing whether constraining the WTA scenario by setting it explicitly in the context of changes in life satisfaction produces reasonable WTA values relative to WTP. The hypothesized mechanism for this is that respondents are asked explicitly to think about the WTA question within the framework of economic theory, i.e. they are compensated directly for changes in their welfare, in this case life satisfaction. Importantly, compensation is only offered for those that say their life satisfaction would be negatively affected in the first place, from the institutional closure. The study finds that the hybrid

⁹ More detail on the reasons for choosing CV compared to Dichotomous Choice Experiments in section 6.



wellbeing-contingent valuation WTA approach, based on life satisfaction and combining elements of both CV and SWV, delivers plausible values.

- 3.2.5 The Stonehenge WHS is listed in the UNESCO's list of World Heritage Sites. Sites included in this list must be of outstanding universal value.¹⁰ We reviewed some of the literature which considered other WHS. Tuan and Navrud (2007) conduct a study valuing the My Son WHS in Vietnam (a large complex of religious temples). They focus on the international relevance of this WHS to residents and foreign visitors in order to estimate benefits for visitors and assess optimal entrance fees to maximize revenues for the site. They are able to demonstrate the applicability of the CV method to value these sites by comparing CV results with the results of choice modelling, which reflects the same underlying preference structures. The mean WTP for preserving the My Son WHS in Vietnam (a large complex of religious temples) was about US\$7 per adult foreign visitor, as a one-time increase in entrance fee, and about US\$2 per household in the region, as a one-time local tax.
- 3.2.6 Kim et al. (2007) estimate use value of a WHS in Korea using a dichotomous choice CV. The study explicitly stated that the WHS status of the site recognised it as a representative heritage resource "indicating excellence of Korean national tradition and culture". The results from this study revealed the economic value of the World Heritage Site to domestic users or tourists in levels exceeding its financial benefits. The mean WTP values were 5706 Won (\$5.70) in a log-linear model, and 6005 Won (\$6.00) in a log-logit model. Taking into account only domestic visitors, the aggregate use value from the log-linear model was estimated to be approximately US\$1.93 million (at 2007 prices), while the aggregate use value from the log-logit model was estimated as US\$2.01 million.
- 3.2.7 More recently, Mourato et al. (2014) elicited visitor (UK resident and foreign) and general population WTP to support conservation and maintenance of built heritage interiors from climate change damage in the UK. Visitors to three heritage sites (Ham House, Knole House, and St Joseph and the English Martyrs Roman Catholic Church) were surveyed using a payment card mechanism, as part of a wider benefits transfer study of ten heritage sites in the European Union (EU). A top-up entry fee mechanism was used in the case of visitors to Ham and Knole, and an annual donation was adopted in the case of the parishioners visiting St Joseph's Church. The general population surveys focused on the protection of all built heritage interiors in the UK and used an annual tax payment mechanism. Mean WTP a top-up entry fee for Ham House and Knole was £2.46 and £2.47, respectively. Mean WTP for St. Joseph's Church was £24.12, as a yearly donation. Mean WTP annual taxes for the protection of all built heritage interiors in the UK was £33.40 for the general population.
- 3.2.8 A further challenge to valuing the heritage impact of a road is the size of the site. As outlined in the introduction, it is not just the stone circle's value that might be affected by the road options but also the value of the site surrounding

¹⁰ Selection criteria for UNESCO WHS are listed on the UNESCO's website: <http://whc.unesco.org/en/criteria/>

it which includes 'the Avenue', currently severed by the A303, and a number of other monuments and burial sites. One relevant study is the valuation of the setting of the ancient city of Valdivia in Chile (Báez and Herrero 2012). The authors use a CV approach with a clear description of the whole site. Báez and Herrero include foreign tourists in the valuation. The mean WTP for each tourist is 6,558 Chilean pesos (£7.93). This value reflects each tourist's mean willingness to pay for the guided walking tour, and is taken as an estimation of the direct use value of Valdivia's historical heritage, rather than the heritage impacts of a road. However, their study is of interest because it values an existing man-made structure, over a considerable area of land and combines the results of the CV study with a wider cost-benefit-analysis.

3.3 Summary

- 3.3.1 The studies we reviewed support the choice of the CV method in the case of a complex valuation project such as the heritage impact of the removal of the A303 from the WHS of Stonehenge and Avebury. We see that previous CV studies on UNESCO WHS in developing countries have focussed on the international relevance to both resident and foreign visitors. However, the focus in these studies was on maximising potential revenue for the sites. In the overwhelming majority of studies of cultural heritage, measures of WTP have been elicited; Bakhshi et al. (2015) is a notable exception, with their estimation of WTA, using the hybrid CV-SWV method.
- 3.3.2 The key piece of research which guides this study is Maddison and Mourato's (2001) CV study of the heritage value of the removal of two roads - the A344 and the A303 - within the Stonehenge WHS. We note that Maddison and Mourato considered the removal of two roads at the time but the A344 has since been removed. The study assumed a two-year period of payments, did not include a road user sample, and included foreign visitors within the survey. Given the long time period since the Maddison and Mourato study, it is not possible to simply 'uprate' these values to 2016 prices. Significant changes have since occurred in the Stonehenge site (with the removal of the A344 road and the construction of the new visitor centre); there have been changes in the tunnel project (which is no longer 2km as in 1998, but almost 3km); and, more generally, there have been many societal changes that might affect preferences and values (e.g. financial crisis, Brexit).
- 3.3.3 The most recent UK heritage valuation studies are contained in the Mourato et al. (2014) benefits transfer study. WTP ranges from £2.46 to £33.40. We note that this study used top-up entry fees, donations and taxes, and elicited values for sites of regional or local importance, in contrast to the broader international relevance of a WHS. This study also valued a very different good (changes to case study interiors) compared to removal of a main road from within a WHS.
- 3.3.4 The studies presented here outline the complexities for the contingent valuation of cultural heritage, but also highlight the flexibility of the CV method to isolate a particular aspect of a road programme or site to assess. The most relevant study for the present valuation study is the Maddison and Mourato (2001) study which elicited WTP in form of a tax to support the removal of the A303 and A344 roads from the Stonehenge WHS.



- 3.3.5 The Bakhshi et al. (2015) study provides the most relevant methodological structure to guide the current survey design. This study has been recommended as best practice for CV valuation in the cultural sector by the Department for Culture Media and Sport (DCMS) and the Arts and Humanities Research Council (AHRC).¹¹ In addition, the Bakhshi et al. study provides a novel hybrid wellbeing-contingent valuation WTA question that has been found to reduce the well-known disparity between WTA and WTP.

¹¹ <http://www.ahrc.ac.uk/newsevents/news/the-individual-experience-at-the-heart-of-cultural-value/>

4 Valuation Method

4.1 Stated preference methods

- 4.1.1 Stated preference methods such as contingent valuation (CV) and discrete choice experiments (DCE) are recommended methods in the HM Treasury Green Book. DCE is applied by economists in situations that are multi-dimensional in nature and where it is important to find the value attached to the various dimensions of interest. Respondents are presented with a series of policy scenarios, grouped into 'choice sets' that describe the alternatives on offer. Respondents are then asked to identify their most preferred scenario, amongst the scenarios contained in a choice set. Willingness to pay (or to accept) is therefore inferred indirectly by analysing the choices and trade-offs made between the various attributes.
- 4.1.2 Contingent valuation (CV) surveys elicit the monetary value of non-market goods and services (measured as CS or ES, recall section 2.2) by directly asking people what value they attach to them (Bateman et al. 2002).¹² By means of an appropriately designed questionnaire, a hypothetical market is described where the good or service in question can be traded. A sample of people (representative of the population of interest) are then directly asked about their WTP or WTA for a change in the level of provision of the good or service. CV is used to value full policy changes rather than changes in specific attributes of a policy or good (e.g. full change (removal) of the A303 from part of the WHS) rather than questions about attributes of the road scheme (e.g. width of the road or where the portals of the tunnel should be situated). For a review of the advantages and disadvantages of DCE vis-à-vis CV see Hanley, Mourato and Wright (2001).
- 4.1.3 In sum, we do not apply DCE in the current study for two main reasons. First, DCE is aimed at valuing attributes rather than complete policy changes and in the current study we are interested in the overall value of the road scheme rather than the values of their constituent parts and CV, rather than DCE, is designed to pick up overall value. Second, in the case of the A303 the hypothetical road scheme (and attributes associated with it) are fixed and it would not make sense to vary the level of the attributes (many of the attribute combinations would not be possible). Therefore, DCE is not a suitable valuation method for the removal of the A303 into a tunnel and CV presents itself as the best available method for this study.
- 4.1.4 In line with standard economic theory, WTP and WTA when correctly elicited from CV (i.e. they are unbiased estimates) map onto the technically correct CS and ES measures of welfare change as follows:

¹² Bateman, I. J., Carson, R. T., Day, B., Hanemann, M., Hanley, N., Hett, T., et al. (2002). Economic Valuation with Stated Preference Techniques: A Manual. Cheltenham, UK: Edward Elgar.

	Compensating surplus	Equivalent surplus
Welfare gain	WTP for the positive change	WTA to forego the positive change
Welfare loss	WTA the negative change	WTP to avoid the negative change

- 4.1.5 In the context of this study people who value the removal of the road will have a positive WTP value, whilst people who value the road as it currently is will have a non-positive WTA value.
- 4.1.6 We measure welfare changes (both losses and gains) as compensating surplus (CS) measures. There is some debate as to what measure of welfare change is appropriate to use in CBA and CV since a given welfare gain or loss can be framed both in terms of CS and ES and the results will not always be the same. Due to issues related to budget constraints, substitution effects and the endowment effect, CS for a welfare loss can be much higher than the ES for the same welfare loss (Ericson and Fuster 2014; Brown and Gregory 1999). This is known as the WTP-WTA disparity and WTA has been found to be up to seven times larger than WTP (to avoid) for the same outcome (Horowitz and McConnell 2002). It is fairly typical to use CS for both welfare losses and gains in CBA (US EPA 2000) but the WTP-WTA disparity must be dealt with. One possible method for dealing with this is to downward calibrate WTA figures by WTA-WTP ratios identified in the literature (see Horowitz and McConnell 2002). As noted above, we use a different approach here whereby we employ a hybrid wellbeing-contingent valuation WTA question developed by our research team for the Arts and Humanities Research Council (AHRC) economic valuation of the Natural History Museum and Tate Liverpool to elicit WTA compensation for removal of the A303 via a one-off cash compensation (Bakhshi et al. 2015).
- 4.1.7 The hybrid method asks respondents to think explicitly about compensation in terms of compensating for their welfare losses (in terms of changes in their wellbeing). The hybrid contingent-wellbeing valuation WTA has been shown to reduce the well-known disparity between WTP and WTA for two studies of cultural institutions (Bakhshi et al. 2015). In sum, the hybrid WTA method is employed here for welfare losses (those that value maintaining the A303 road in its current location) so that CS measures for welfare gains and losses can be measured and aggregated consistently.
- 4.1.8 Finally, CV questionnaires also contain a wealth of additional questions to gain information on a respondent's socio-demographic characteristics, their attitudes towards the good, and the reasons behind their stated valuations. The responses to these questions are typically used to model the determinants of WTP (or WTA). In particular, the importance of income as a driver of WTP relates to: (i) the marginal utility of income, such that each additional pound has greater value for those on a lower income, meaning that higher income groups are willing (able) to pay more for the same welfare gain, and; (ii) the capping effect of income, which constrains budgets and reduces the amount that a low income respondent is able to pay. For extensive discussion of income effects see Horowitz and McConnell (2002).

4.2 Contingent Valuation: Methodology

- 4.2.1 We outline below the main elements of our CV design, in terms of elicitation method (the type of question used to elicit monetary values), measurement of use and non-use values, choice of payment vehicle (the hypothetical means by which payments will be made, such as taxes, donations, and entry fees), and bias reduction strategies.

Elicitation method

- 4.2.2 The valuation questions can be presented in a number of different ways, including open-ended, bidding game, payment card, and dichotomous choice elicitation formats.
- 4.2.3 **Open-ended questions** represent the simplest direct elicitation technique where respondents simply state the amount they would be willing to pay. However, a number of problems have been associated with this technique, including large non-response rates, protest bids, and outliers that skew the data (Bateman et al. 2002; Mitchell and Carson 1989). At the opposite end of the spectrum, **single-bounded dichotomous choice questions** allow the researcher to randomly present a monetary figure to the respondent (Arrow and Solow 1993). This simplifies the cognitive task and is thought to provide incentives for truthful revelation of WTP (if their WTP is higher, say, than the amount offered, it is in their interest to accept this value). However, this approach may also encourage a larger number of protest bids than open-ended mechanisms. It also provides data only in a range above or below which we can be certain the respondent is willing to pay. **Double-bounded dichotomous choice** improves on this method by asking a follow-up question: if the respondent indicates that they would pay the initial amount (e.g., £2), would they pay the next amount up (i.e. £3)? Alternatively, if the respondent indicated that they would not pay the initial amount of £2, would they be willing to pay the next amount down (i.e., £1)? Although this improves on the single-bounded dichotomous choice approach, both mechanisms introduce so-called anchoring bias, by suggesting to the respondent the appropriate range of values to be elicited (Arrow and Solow 1993). **Payment card** approaches present respondents with a range of monetary amounts from which they are asked to pick their willingness to pay. This eliminates anchoring (and starting point) bias and provides a visual aid to the cognitive process of valuing the good (Bateman et al. 2002; Maddison and Foster 2003; Maddison and Mourato 2001b). However, this approach is in turn vulnerable to range bias, whereby respondents may scale their responses to the range of numbers they are presented with (Whynes, Wolstenholme, and Frew 2004). To reduce the effect of range bias we tested the value ranges in the payment card in the pilot surveys (see below) and also included an open-ended 'other amount' option.
- 4.2.4 Dichotomous choice (DC) elicitation methods are more consistent with welfare economic theory, in terms of mimicking consumer experience and incentivising truth telling. However, DC requires a large enough sample size to provide at least 100 respondents per bid level. For a sample of n=400 this would provide only 4 bid levels. Moreover, if we have a high proportion of respondents with a zero WTP (as in the Bakhshi et al. 2015 cultural valuation study), this will

further reduce the subsample answering the dichotomous choice question, which is problematic.

- 4.2.5 Given the particular characteristics of this study we decided to use a **payment card method** for both the tunnel and status quo valuations. The payment card method provides a balance the theoretical ideal with the practical constraints of the project (specifically, the small sample size, limited piloting time, and potentially high zero response) (Bateman et al., 2002).

Use and non-use values

- 4.2.6 The key methodological advantage of CV over other non-market valuation approaches such as revealed preference methods is that it can measure values and benefits that would not be revealed under market conditions, such as *non-use* values. Importantly, it also offers the opportunity to measure benefits associated with changes that have not yet happened, that is, *future* changes.
- 4.2.7 In this case **use values** stem from those visiting the site, those travelling on the A303 and viewing the site from the road, and those who experience Stonehenge remotely via other media (internet, film, books, photographs, social media, etc.) Use values can include an option value for those deriving value from the possibility of using Stonehenge in the future. **Non-use values** are made up of: *altruistic values* – welfare increases from knowing that others living will benefit; *bequest values* – welfare increases from knowing that future generations will benefit; and *existence values* – welfare changes from knowing that the road layout within the Stonehenge WHS has been changed (even if an individual does not experience the changed road lay out now or in the future). It is likely that some people who have not visited and will not ever visit Stonehenge, or even engage with it remotely (e.g. through media), will nonetheless value the positive effects of the road layout scenarios if this improves experiences for visitors and others who care about Stonehenge. By the same token, non-users may value the positive effects for road users of maintaining the current road lay out within the WHS.
- 4.2.8 We note that although valuation distinctions (between use and non-use) exist, it is very difficult to disentangle the different components of value from people's stated WTP and WTA values. This is because whilst non-use value can be ascertained from non-users (alongside possible option values for future use), users will typically hold both use and non-use value for the non-market good, and both of these contribute to their overall WTP/WTA responses. Therefore, it is not possible to distinguish between use and non-use value in the responses of visitors to Stonehenge or users of the A303.

Elicitation of values

- 4.2.9 A range of hypothetical scenarios and payment vehicles that have been applied in previous studies were considered for the Stonehenge WHS WTP question. We outline below the advantages and disadvantages of each:
- a) Increased **entrance charge** to Stonehenge: **Advantages:**
Compulsory, incentive compatible payment mechanism.

Disadvantages: Misleading because a national road scheme is not just paid for by visitors to Stonehenge.

- b) **Voluntary donation: Advantages:** Applicable to all survey populations. **Disadvantages:** Donations and other voluntary payment vehicles can lead to 'free-riding', as people are aware that they do not have to pay a donation to gain the benefit so long as others are willing to pay.
- c) **Annual tax: Advantage:** Compulsory, incentive compatible, and applicable to all survey samples. **Disadvantage:** Taxable period has to be constrained, for example, to apply only over the period of tunnel construction.
- d) **One-off tax: Advantages:** Compulsory, incentive compatible, and applicable to all survey samples. **Disadvantages:** One-off tax is unrealistic, because the costs occur over a number of years while the tunnel is constructed and the public do not realistically ever pay a one-off tax.
- e) **Road tax: Advantages:** Compulsory, incentive compatible. **Disadvantages:** Open to protest responses, because those who drive may feel they should not bear all of the cost, while those who do not are able to free-ride.
- f) **Road toll.** As above for Road tax.

4.2.10 The final payment vehicle used in the scenario of WTP for the construction of a tunnel to replace the A303 is a hypothetical increase in an individual's **annual national tax**. The project team and external peer reviewer were in agreement that a **non-voluntary national tax increase over three years** is the most realistic payment vehicle option for this survey, and the least likely to be subject to free-rider and hypothetical bias. The payment of the tax over three years reflects the expected construction time of the alternative tunnel option and hence realistically links increased tax payment with the costs of the road works. It is also a time horizon that respondents are arguably used to considering in their own private planning, without being unrealistically short, as a one-off payment would have been, or too long, as an unlimited tax would have been.

4.2.11 For those respondents who value the current status quo of keeping the road in its current location we employ a hybrid subjective wellbeing-contingent valuation WTA question, framed as a hypothetical one-off cash compensation payment. Given that the change (removal of the road) happens at one point in time, it is assumed that the compensation demanded to restore the individual to their initial welfare position (compensating surplus) is evaluated across the life course, and not as a continuous payment. This also accounts for adaptation effects, whereby individuals adapt for losses in their life and return to close to their original welfare position over a certain period of time, depending on the magnitude of the loss (Frederick and Loewenstein 1999).

Bias reduction

4.2.12 There are a number of well-known potential biases in CV that can be problematic if not adequately addressed in the survey instrument and analysis (Bateman et al. 2002; Pearce, Atkinson, and Mourato 2006). These include:

hypothetical bias, where respondents overstate the amount they are willing to pay in the hypothetical situation, in relation to what they would pay in reality; **insensitivity to scope**, where WTP is insensitive to the scope of the proposed change; **focusing bias** where the survey focuses respondents attention on the scenario in a way that does not reflect how people would actually experience these conditions or states in real life; **protest values**, where respondents have a principled objection to providing a monetary value; **framing and information bias** when people react to information in different ways depending on how it is presented and on the level of detail provided in the information; and **strategic bias**, where respondents seek to 'game' the study by providing values that they think will influence an actual resource allocation recommendation. Finally, **differences between WTP and WTA** can also occur, which violates the underlying theory of economic preference satisfaction (Hausman 2012). We outline below the main types bias that we expect might affect the current study, and the best-practice measures taken to deal with them.

- 4.2.13 **Strategic bias** refers to the act of when someone wishes to preserve a status quo or to achieve a specific change and purposefully influences the survey results (e.g. by stating an extremely high or low WTP/MTA value) in order to help achieve their wish. Strategic bias can, therefore, lead to over or under statement of WTP or MTA (Throsby and Withers 1986). The results in this study could have been affected by a number of different strategic biases, some of them balancing each other out. For example, respondents who want to preserve the status quo might have been tempted to exaggerate the necessary compensation and those who feel strongly about the need to remove the road may give an exaggerated WTP. The payment cards were capped at £200 and open-end responses above £250 were removed as unrealistically high and indicators of strategic bidding (see section 6.1 for discussion of rationale for excluding respondents from the study samples).
- 4.2.14 Strategic bias can also manifest in the self-selection into the survey of types of individuals seeking to influence the results. Ipsos Mori interviewers addressed this through measures to reduce the risk of self-selection by individuals aiming to influence the survey (choosing every third person exiting the site and avoiding those who directly approached them (this did not occur)).
- 4.2.15 For online surveys, we removed respondents who completed the survey quickly ('speedsters', see section 6.1). Speedsters are removed on the assumption that they are completing the survey for strategic purposes (for example monetary or political incentives), or a lack of understanding/ interest encouraging quick completion and are not giving fully considered and truthful answers.
- 4.2.16 **Framing and information bias** refer to the issue of when people react to information in different ways depending on how it is presented and on the level of detail provided in the information. The way the information is provided in a CV survey, therefore, has the potential to impact on WTP/MTA results. With this in mind, the information provided in our surveys was clearly set out in a neutral manner, describing both the positive and negative effects of the different road options.

- 4.2.17 The information provided in the surveys was tested within all three surveys during the pilots to ensure it was sufficiently clear to allow respondents to answer the questions (Ajzen, Brown, and Rosenthal 1996). During the pilot, we asked whether respondents felt the information was easy to understand and which benefits would arise from the road. This question tested whether they had understood the information at hand and whether they had been able to isolate the heritage effect within the survey (i.e., whether they were stating WTP for heritage effects or for aspects of road use, safety, travel time).
- 4.2.18 A bias caused by **insensitivity to scope** means that respondents are not responsive to the characteristics of the good valued (Carson 1997). Some degree of insensitivity to scope might have occurred when using CV to value different designs of the tunnel, with different lengths, different types of entrances and so on. However, here we just focus on a single generic 2.9 km tunnel, without providing a detailed description of its particular features. Insensitivity of scope should therefore be less of an issue.
- 4.2.19 We also asked respondents about their motivations for not being willing to pay/accept. This allows us to identify potential **protest** bids associated with the information or tax payment vehicle presented, which provides us with more confidence that respondents' stated values reflect the values they place in the heritage aspects of the road scheme.
- 4.2.20 **Focusing bias** occurs in CV studies when at the time of preference elicitation people are focusing only on the salient aspects of the condition or issue at hand (i.e. the road options) and this may not reflect in any way how people would actually experience these conditions or states in real life (Kahneman et al. 2006; Schkade and Kahneman 1998). This can lead to an overstatement of their WTP or WTA values.
- 4.2.21 We addressed the potential for focusing bias in our surveys through use of reminder statements and information about other service providers to ensure that respondents give full consideration to *substitutes*; and highlight other possible uses of an individual's time and money so that the value of the presence/absence of the A303 within the Stonehenge WHS is conceived of in the wider context of people's lives, experiences, and available budget, helping to avoid focussing biases.
- 4.2.22 The criticism of CV that has perhaps received greatest attention is **hypothetical bias** (Arrow and Solow 1993; Champ and Bishop 2001; Hausman 2012), where individuals' stated WTP may be significantly larger than actual WTP due to the hypothetical nature of the survey. This arises mostly when a *voluntary payment mechanism* is used. In the case of this study respondents had to compare the real situation of the existing road with a hypothetical situation of a tunnel with limited information on its position. The information provided to respondents included photoshopped images of the site without the road, but not of the potential tunnel portals.
- 4.2.23 To address this we included a certainty question in the surveys (e.g. "How certain are you that you would really pay the amount indicated if asked?") (Champ and Bishop 2001). This allows us to provide sensitivity analysis on



alternative levels of WTP associated with certainty of response, which is recommended when CV results are used in CBA (Haab et al. 2013). We aimed to use a payment vehicle which was as realistic as possible, a national tax over three years. We also use *cheap talk entreaties* (i.e. a script that explicitly describes this bias and asks respondents to avoid it) and *oath scripts* (i.e. asking respondents to agree to promise that they will respond to questions honestly), which were used effectively in our recent study for the AHRC (Bakhshi et al. 2015).

5 Contingent valuation methodology: design and implementation

5.1 Survey instrument

- 5.1.1 We applied best-practice methods for contingent valuation, developed from our review of the literature and our own prior work. We designed one on-site visitor survey and two online surveys of local road users and the UK general population. While international visitors and non-residents will also be affected by the changes, these are excluded from the valuation study in line with HM Treasury Green Book guidance.¹³
- 5.1.2 The Stonehenge visitor face-to-face survey was run in the field between 15th September and 7th October 2016. The road user survey was run online between 17th September and 3rd October 2016. The general population survey was run online between 22nd September and 5th October 2016. Each survey took about 15 to 20 minutes to complete. The initial number of respondents across all three surveys was 3,535. Survey instruments are provided in Appendix A.
- 5.1.3 We conducted three surveys on three sets of stakeholders who may be anticipated to hold different types of values for the hypothetical removal of the A303 from within part of the Stonehenge WHS (Figure 2). For instance, visitors and the general population may hold different use and non-use values for the Stonehenge WHS. Stonehenge is of national importance and well known and recognised across the UK. People who have never visited or seen Stonehenge are likely to have either learnt about it at school, seen it on national media or heard about it in another context. A WHS is a site of international significance and its maintenance is therefore of interest to the whole population. In addition, infrastructure investment such as the proposed tunnel will be funded from general taxation and is of interest to all taxpayers. People living in the area around Stonehenge may have different preferences for the road scheme associated with their higher frequency of using the A303 on a regular basis.
- a) Visitors to the Stonehenge WHS (n=432): On-site face-to-face interviews (UK resident, aged 16+) estimating the following possible values associated with the removal of the road from the Stonehenge WHS:
- i. Direct use value
 - ii. Non-use value (associated with effects on other cultural heritage within the Stonehenge WHS)
 - iii. Use and option value for changes in the view of Stonehenge from the A303 between Amesbury and Berwick Down.
- Road users (Local residents as proxy) (n=1,001): Online survey of people living within a 50-mile radius of Stonehenge with quotas on gender and age,

¹³ The Green Book (page 21) recommends to assess impacts on foreign nationals separately where reasonable and if they affect the result of the appraisal overall. In this case conducting a survey of foreign visitors in potentially multiple languages would not have been reasonable given the time constraint. In addition, the payment method (see below) would have to be refined for foreign visitors who don't pay income tax in the UK. Impacts on local businesses affected by tourism should be addressed in a different part of the appraisal.

estimating the following possible values associated with the removal of the road from the Stonehenge WHS:

- iv. Direct use value
- v. Non-use value (associated with effects on other cultural heritage within the Stonehenge WHS)
- vi. Use and option value for changes in the view of Stonehenge from the A303 between Amesbury and Berwick Down.

General population (n=2,102): On-line survey of people living in the UK (UK residents aged 16+, with quotas on age, gender, and region) estimating the following possible values associated with the removal of the road from the Stonehenge WHS:

- vii. Non-use value;
- viii. Use values for those who have visited the site recently or have photos of it;
- ix. Option value for changes in the view of Stonehenge from the A303 between Amesbury and Berwick Down.

5.1.4 The three surveys used the same basic structure and were divided into three sections. Respondents were provided with information about the route of the tunnel and the expected impact of the scheme on the World Heritage Site (both positive and negative).

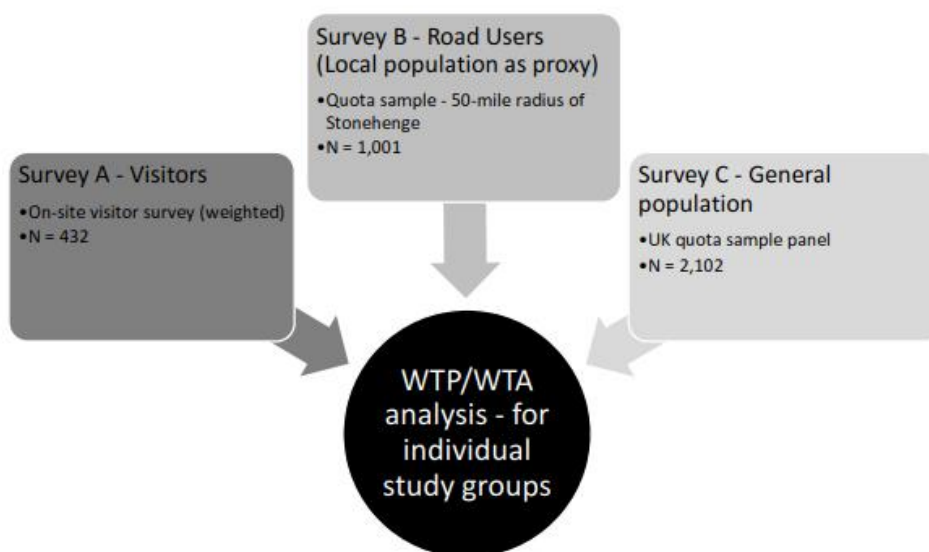


Figure 2 WTP/WT Surveys

Survey structures

- 5.1.5 Sample sizes are in line with existing UK Government guidance on stated preference surveys.¹⁴ Following DfT guidance we set a target sample size of 400¹⁵ for the visitor survey. This is within the lower range of sample size that is required for analysis of factors associated with WTP (socio-demographic factors, experience, visit behaviour etc.), but above the minimum n=300 sample size suggested in the literature for visitor samples of this size (given our estimate of 0.55m annual UK resident visitors to Stonehenge)¹⁶.
- 5.1.6 For the face-to-face visitor surveys Ipsos Mori were chosen as the fieldwork provider because they have extensive experience in delivering complex fieldwork surveys to time and addressing issues such as non-response bias. Ipsos Mori applied loose quotas on gender and age based on other heritage sites.¹⁷ Interviewer protocols were designed to avoid self-selection by strategic respondents (1 in every 3 were approached). We sought to reduce attrition during the survey by stating up front the length of the survey and offering shelter during the survey as well as an incentive of £5 for completion of the survey.
- 5.1.7 Online surveys were designed by Simetrica and delivered by the online panel provider Toluna. Toluna provide a representative online panel of the UK population, allowing quotas for age, gender, and region to be set at the local and national level. Sample selection is made randomly using the specified profile criteria. Panelists are awarded a small monetary incentive for each survey completed, and are restricted from taking the same survey more than once. Toluna takes account of predicted response rates by target demographic and country to avoid over-contacting panellists and to ensure that they do not introduce awareness bias in responses.¹⁸
- 5.1.8 The three surveys used the same basic structure and were divided into three sections (the questions in the valuation sections differed between the different surveys):
- a) **Section A. Background questions on:** respondents' visit to Stonehenge (survey A only); travel; attitudes towards the existing

¹⁴ Pearce and özdemiroglu (2002) provide guidance for the UK Government on estimating sample sizes for stated preference surveys (p45). Given that approximately 0.55million people visited Stonehenge in 2014, Assuming that 0.2 of the population is present in the true sample, a minimum sample size of around n=300 is required at the 5% confidence level. Pearce, D., & özdemiroglu, E. (2002). *Economic valuation with stated preference techniques*. London, UK: Department for Transport, Local Government and the Regions.

https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/191522/Economic_valuation_with_stated_preference_techniques.pdf

¹⁵ The target sample size for the visitor survey was 400. Ipsos achieved 432 within the time available.

¹⁶ English Heritage estimate annual visitor numbers to the Stonehenge site in 2015 of 1.3 million of which 540,000 are UK residents. Personal correspondence with English Heritage.

¹⁷ A loose quota in the context of a face to face survey is a request to the interviewers to ensure they reflect some of the diversity of the audience, i.e. in this case the visitors to the site within the sample they are selecting. They are not required to exactly adhere to a specific percentage, but for example to make sure that they have about 50% men and 50% women in their sample.

¹⁸ From (Toluna 2016)

road; experience of other heritage sites; and attitudes towards Stonehenge and heritage conservation.

- b) **Section B. Contingent valuation:** Questions on willingness to pay for a road scheme to remove the A303 from its current location within the WHS; and the willingness to accept compensation for the removal of the road (see section 5.2 for full discussion of contingent valuation scenarios).
- c) **Section C. Demographics:** Theoretical drivers of WTP/MTA developed from the literature, including income, education level, and labour force status (Bateman et al. 2002).

- 5.1.9 The information presented to respondents in CV surveys is important for the quality of the study (Boyle 2002). The layout, order in which information is presented and the quality of the information can affect the answers (For more information on bias reduction please see paragraphs under the Bias Reduction sub-section of section 4.2).
- 5.1.10 In this study, we also had to bear in mind that the design of the road was at a relatively early stage. For example, at the time of undertaking the research, the precise design and location of tunnel portals was yet to be determined. The survey therefore focused on the removal of the A303 and provided only limited information on precise alignment and design aspects of the tunnel. Due to the early stage of development of the scheme, respondents were shown the approximate position of the new tunnel portals and road leading up to the tunnel. The map provided and the description of the tunnel scenario in the questionnaire stated clearly that the tunnel portals and the new dual carriageway leading up to the tunnel would be within the WHS and would affect some elements within the site some of them not known. Whilst the precise location of the proposed scheme was not presented, the information was judged as being sufficient for respondents to consider the primary impacts of the scheme given the current state of information. This was confirmed by the results of the pilot study, in which the majority of respondents said that they felt that they had sufficient information to answer the questions.¹⁹
- 5.1.11 There was a degree of uncertainty as to the precise alignment and design of the road at the time the study was undertaken. This lack of information did not allow us to provide full information on the design and location of the portals to the survey respondents. The steering group discussed and agreed that further information would have been misleading because the heritage and archaeological impacts of the tunnel and its portals are not yet known. In practice, the impacts of the scheme on heritage and archaeology are highly complex and aspects of this require expert interpretation. As such, there are also practical barriers to the level of detail that can be provided to respondents. While this introduces additional elements of hypothetical bias, this was considered proportionate to the focus of the study on the visual amenity, noise reduction and reconnection of the landscape around Stonehenge.²⁰ Therefore, it should not be interpreted that this study captures or seeks to capture every aspect of the scheme's impacts on heritage and archaeology. As discussed in

¹⁹ See Appendix C.

²⁰ See also section 2.2



section 2.2 the wider assessment of the scheme includes detailed archaeological investigation and expert heritage assessment.

- 5.1.12 The following information was provided as part of the survey material:
- a) Current route and impacts of the A303 road (including impact of noise on tranquillity, visual amenity and landscape severance), including a very brief description of the history and archaeology of Stonehenge and the WHS.
 - b) Overhead map of A303 in relation to heritage sites within the WHS and photographs of the site as it currently is.
 - c) Diagrams and descriptive text for an alternative scenario: a 2.9 km tunnel through which the A303 road would pass.
 - d) Information on the impact of the removal of the road into a tunnel on tranquillity, visual amenity and landscape severance.
 - e) A clear statement that no policy scenario has been chosen yet.
- 5.1.13 The survey included follow-up questions on familiarity with the information provided and on the opinion of the respondents of the effect of the road on Stonehenge.
- 5.1.14 The material presented also included a clear statement that this study is not a public consultation, but that the information collected via the study would feed into a public consultation currently planned for January 2017. All survey materials were agreed by the steering group. The survey itself was agreed with DfT and HE analysts and the academic peer reviewer. The information material is in Appendix A.
- 5.1.15 In all surveys, we used payment card mechanisms to elicit WTP in terms of an increase in annual taxes over a three-year period. WTP values were elicited using a payment card with 35 values ranging from £0 to £200, including an open-end 'other' amount option to reduce anchoring bias set by the payment range (I. J. Bateman et al. 2002).
- 5.1.16 Those who indicate that the removal of the A303 road from within part of the Stonehenge WHS would reduce their life satisfaction are shown a payment card and asked the minimum they would be willing to accept in compensation, using the same payment card range as the WTP question.
- 5.1.17 In all surveys, respondents were asked a certainty question on the WTP amount which they had stated (Bedate et al., 2009; Champ and Bishop 2001). The last section of the survey included follow-up questions that asked the reasons for their willingness, or not, to pay - allowing us to identify protest responses in ex-post analysis – as well as standard sociodemographic questions (Bateman et al. 2002). In designing the contingent valuation scenarios we implemented best practice related to question wording and ordering, payment format, payment vehicle, prompts and use of images (Bateman et al. 2002; Bakhshi et al. 2015). Survey instruments are provided in Appendix A.

5.2 Valuation scenarios

- 5.2.1 The CV study has been carefully designed to value the impact of the A303 road between on Stonehenge and the WHS. This assessment focuses exclusively on the cultural heritage impacts of removing the A303 from its current location within the WHS, in terms of noise reduction, increased tranquillity, visual amenity and reduced landscape severance, which cannot be assessed through standard market-based economic valuation techniques.
- 5.2.2 This study was designed to assess both use values and non-use values associated with the removal of the A303 from its current location within the Stonehenge WHS, covering both positive and negative aspects of the hypothetical road scenario for users and non-users.
- a. For those who positively valued the road option change, we estimate the willingness to pay, via an annual tax at the individual level, for the changes to noise, tranquillity, visual amenity and landscape severance associated with the removal of the A303 from its current location in the Stonehenge WHS and its redirection through a tunnel of approximately 2.9km.²¹
 - b. For those that negatively valued the road option change, and that therefore indicated they would not be willing to pay for the tunnel, we estimate the willingness to accept, via a one-off cash compensation, to put up with the removal of the A303 from its current location in the Stonehenge WHS and its redirection through a tunnel of approximately 2.9km.
- 5.2.3 It is appropriate to apply different welfare measures to a policy change depending on whether they lead to gains or losses to the individual (Kim et al. 2015; Bateman et al. 2002). Where a change from the status quo leads to welfare improvements for the individual, resulting from noise reduction, increased tranquillity, visual amenity and reduced landscape severance, we elicit WTP to measure the compensating surplus for obtaining the improvement produced by the removal of the A303 from within part of the Stonehenge WHS. Where a change from the status quo leads to a loss of welfare, in terms of the ability to view Stonehenge from the road, we elicit WTA to measure compensating surplus to restore their welfare to the state it was in before the removal of the road. This ensures that we are capturing both positive and negative values associated with the alternative road scenario. We use life satisfaction here as the measure of welfare change for the purposes of CS and ES (following Bakhshi et al. 2015). This is in line with guidelines in the Green Book and in the OECD guidelines (2013) on measuring wellbeing. For a full discussion and rationale for using life satisfaction as a measure of welfare see Fujiwara and Dolan (2015). This part of the CV survey is important because users and non-users may value the ability/opportunity to see the stone circle

²¹ The current A303 would be replaced with a narrower footpath covered with a different material than the current tarmac.

from the road and the loss of this opportunity may be perceived as a negative aspect of the scheme for them.²²

- 5.2.4 As explained in section 2 all other impacts (such as economic and environmental) are considered in the overall business case and use the methods described in the DfT's transport appraisal guidance (WebTAG). It is, therefore, important to this study to exclude those other impacts to avoid double counting with the other elements in the business case (see Figure 1 above). We exclude these elements as far as possible through clear definition of the heritage good being valued, in terms of noise reduction, increased tranquillity, visual amenity and reduced landscape severance. The information provided on the status quo and the alternative road option focuses only on those aspects which we aim to measure, such as the impact of the road on the experience at the site. We exclude all reference to congestion and other traffic outcomes (except briefly in the introduction to the policy content)²³.
- 5.2.5 Respondents were provided with information about the route of the tunnel and the expected impact of the scheme on the World Heritage Site (both positive and negative).²⁴ We were unable to give very detailed information to respondents because at the time of the study, the precise route alignment and tunnel portal positions were yet to be determined (we set out the information provided to respondents and the full survey instruments in the Appendix A). The following scenarios were presented to respondents:
- a) the status quo (the current A303 road and route within the Stonehenge WHS)
 - b) the construction of a dual carriageway between Amesbury and Berwick Down, including a 2.9km tunnel underneath the WHS with both portals located within the WHS but out of sight from the stone circle. By removing the road from the central portion of the World Heritage Site, those using the road will no longer be able to see Stonehenge while driving and those visiting the site will no longer be affected by the road. To either side of the tunnel itself, widening the road and constructing tunnel portals will have adverse impacts on other monuments (e.g. burial sites) within the World Heritage Site.
- 5.2.6 Respondents were first asked if they would in principle be willing to pay an increase in annual taxes over a three-year period to support the alternative scheme using the following text.

"For the next set of questions, please imagine a situation where the tunnel scenario was selected and was paid for by an increase in national taxes, for three years. Please think for a moment about how much the proposed scenario to remove the A303 from the World Heritage Site would be worth to you and your

²² Vehicles here refer to any form of transport that can legally view Stonehenge from the A303

²³ The survey material which was provided to the participants includes a clear statement that the heritage site itself is not in any danger to ensure people are not valuing Stonehenge as such.

²⁴ More detail on the role of information provided to participants in a CV study in Burgess et al (Burgess, Clark, and Harrison 2000)



household, if anything. Would you be prepared to pay something, even if only a very small amount, to support the construction of a tunnel route?"

- 5.2.7 Those people that state they would be willing to pay something for the alternative road option are then directed to the WTP questions. In order to reduce the risk of strategic bias²⁵ and hypothetical bias²⁶, before the payment card questions we used the following entreaty (cheap talk) script, which has been shown to be effective in previous studies (Chakraborty and Harbaugh 2010; Cummings and Taylor 1999) as well as our own studies (Bakhshi et al. 2015; D. Fujiwara, Lawton, and Mourato 2015). The entreaty script reminds individuals of their budget constraints and existence of alternatives:

"Studies have shown that many people answering surveys such as this one, say they are willing to pay more than they would actually pay in reality. So please think about this question as if it were a real decision and you were actually making a payment for real. Please do not agree to pay an amount if you think you cannot afford it, if you feel you have paid enough already, or have other things to spend your money on. Also, this question is just about the proposed road scheme. We are not asking you about how much you value the Stonehenge site. Remember, Stonehenge is not in danger, this is a change to the lay out of the road around it."

- 5.2.8 In addition, the questionnaire includes follow up certainty and motivation questions to understand how certain a respondent is about their willingness to pay and the reasons why they state they are willing to pay.

- 5.2.9 For those who indicated that they would not be willing to pay anything for the alternative road scheme, we ask a willingness to accept (WTA) compensation question for the removal of the current A303 using the following hybrid wellbeing-contingent valuation WTA question.

"You indicated that you would not be willing to pay any additional taxes to fund the rerouting of the A303. In a hypothetical situation, imagine that the government chose to proceed and remove the A303 from its current location. The A303 would be redirected and you would no longer be able to view Stonehenge from the road. We would like you to think about how this decision would affect you, if at all. How would it affect your overall level of life satisfaction if the A303 was removed from its current location?"

- 5.2.10 For those who indicate that the removal of the A303 from its current location would reduce their life satisfaction, we present the following question:

"Assuming nothing else in your life would change, imagine that in order to compensate you for not being able to use the A303 in its current location you were given a publicly funded cash compensation. How much money would you have to receive, as a one-off payment, to give you the same life satisfaction that you have now (not better or worse but just the same) once the A303 is removed from its current location. Note that whatever compensation amount you receive will mean that money cannot be used on other public services."

²⁵ For detail on the potential biases see also section 4.2. Strategic bias: The wish to preserve a status quo or to achieve a specific change can lead to overstatement of WTP or WTA. (Throsby and Withers 1986)

²⁶ Hypothetical bias: When judging a hypothetical situation, people are often overestimating the impact. People often have not considered in detail how they would value unfamiliar goods. See section 4.2.

6 Analysis

6.1 Data cleaning

6.1.1 This section sets out the data cleaning steps we took to generate a robust and reliable data set and ensure sample representativeness to allow aggregation of WTP/WTa to the relevant national populations.

- a) 'Speedsters' who answered the online surveys in less than 4 minutes were excluded from the data.²⁷ This is because a proportion of those who complete the survey quickly are likely to be those that want to provide a pre-determined view of the road scheme (to influence policy) and have not read through and considered all of the materials properly. Speedsters may be motivated by the incentive to complete the maximum amount of surveys in a short time, thus reducing the reliability of their WTP bid function.
- b) In order to be conservative, we defined "other" responses as extreme outlier WTP and WTa values above the £250 level. This was based on a prior decision to cap WTP/WTa values at 25% of the highest amount on the payment card. We note that this led to the exclusion of only 14 responses (one of £500, four between £1,000-£5,000, and nine from £10,000-£35million).
- c) Those who did not indicate a monetary amount in an open-end response (i.e. gave some qualitative text comments) were also excluded.
- d) Inconsistent follow-up responses (those who indicated that their stated WTP was motivated by a belief that they would not really need to pay) were excluded (following best practice, see Bateman et al. 2002).
- e) Respondents who ascribed to an "other" gender or did not state their region were excluded since their inclusion would not make it possible to apply weights based on region and gender.

6.1.2 Overall, we removed 216 observations as per Table 1. This reflects about 6% of responses across all three surveys.

²⁷ The four-minute threshold is based on the dropping of speedsters based on a five-minute threshold in (Maddison and Mourato 2001a). The difference in threshold is proportionate to the differences in survey length and have been discussed with the peer reviewer.

Table 1 Number of responses removed from survey sample data sets

	Survey A (Visitors)	Survey B (Local population)	Survey C (General population)	Total
Total number of respondents	432	1,001	2,102	3,535
Incomplete	0	0	0	0
Speedsters	0	48	94	142
Inconsistent follow-up	3	11	23	37
Unacceptable WTP or WTA values	0	14	16	30
Gender: "Other"	0	1	2	3
Region missing	0	4	0	4
Number of responses removed	3	78	135	216
Number of responses kept in analysis (survey sample)	429	923	1,967	3,319

Note: These figures relate to the survey sample populations (which is distinct from the study group sample sizes).

Missing data

6.1.3 A significant proportion of people in the visitor survey (20%) were unwilling to reveal their income, noticeably higher than the local (10%) and general population (12%) surveys. This is a common finding for face to face surveys, where respondents may be biased by interviewer presence. Income is a key variable for population-weighting WTP and WTA calculations along with gender, age and region. For the individuals who did not answer the question on income within the general population study group, we imputed their income levels based on the distribution of income in the study group, on a one-off random basis when generating the variable used to weight the mean results. The peer reviewer notes that this approach can be biased, unless the randomisation is repeated at least 10,000 times. However, as conducting this exercise would have had led to 10,000 iterations of the population-weighting variable, it would have been complex to robustly implement and hence disproportionate to the evaluation process.

Study groups

6.1.4 We reconstructed the two populations of the road user and general population surveys into study groups based on whether respondents in the general population indicated that they had used the A303 in the past year, as illustrated

in Figure 3. Initially, we conducted survey B with the aim to isolate people most likely to be regular users of the A303. The criterion for inclusion into the sample for this survey was to live within 50 miles of Stonehenge. The respondents to survey B included people who had used the A303 as well as people who had not used the road. We also found that a number of respondents in the General population survey (survey C) had used the road. The study group of road users contains 465 road users from survey B, and 467 road users from survey C. The general population study group is made up of 458 non-road users from survey B and 1,500 non-road users from survey C. Note that with the reconstruction of the two populations the general population study group required re-weighting to ensure representativeness with the UK population. We therefore constructed weights formed by the demographic categories of gender, age and income for each region in the United Kingdom for the general population survey (given that income is a known driver of WTP/MTA we need to ensure that our sample is representative of the population income distribution). It was unnecessary to weight the road users, as the group revealed themselves directly from both surveys. As a result, the road user study group is the best available estimate of the demographic characteristics of the wider road user population.

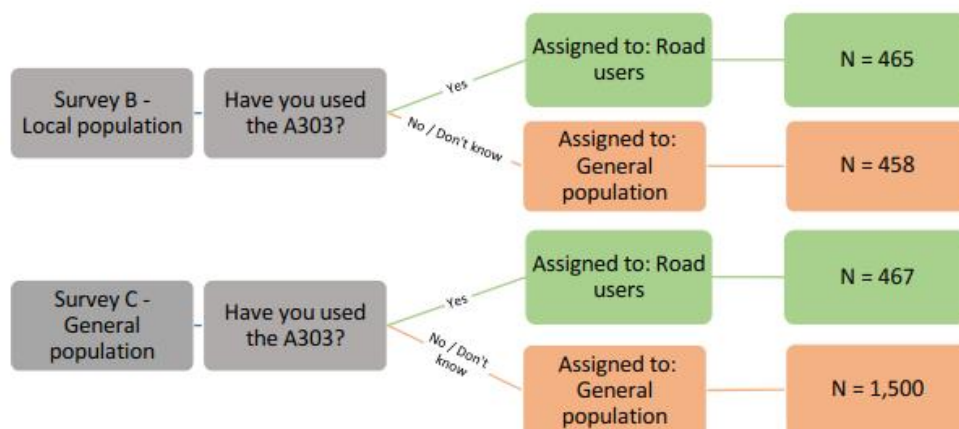


Figure 2 Composition of road user and general population study groups²⁸

6.2 Descriptive Statistics

6.2.1 Table 2 shows the population weighted descriptive statistics of the study groups.

²⁸ Note: These figures relate to the study group sample size. Please note that 92 individuals 'didn't know' whether they had used the A303 in the past 12 months. These individuals were added to the general population.

Table 2 Descriptive Statistics

	Visitors Study Group - Weighted	Road Users Study group	General population study group (non-use) – Weighted
Female (%)	53%	46%	53%
Age (mean)	47	45	45
Household income (£, mean)	£49,166	£41,730	£26,437
No response to income question (%)	20%	10%	12%
Dependent children under 16 years (%)	17%	39%	30%
Married/with partner (%)	69%	61%	49%
University education (%)	50%	44%	36%
In employment (full-time, part-time, self-employed) %	69%	64%	51%
London	3%	7%	8%
Health (good, very good, excellent) (%)	92%	83%	72%
Ethnicity (BME)	4%	10%	10%
Member (English Heritage/National Trust/Stonehenge preservation organisation) (%)	56%	33%	10%
Driving license (%)	89%	87%	70%
Total	429	932	1958

6.2.2 The visitor and road user surveys show a significantly higher household income level than the general population, a better health status and a very high membership in a heritage related organisations such as English Heritage. The visitor survey specifically had a lower percentage of Black and Minority Ethnic visitors when compared to the general population and road users.

6.3 Estimating WTP and WTA

6.3.1 Figure 4 sets out the process by which respondents were allocated to a WTP or WTA payment/compensation card.

6.3.2 All respondents were asked whether they would be willing to pay a tax levied over three years to fund the improvement of the heritage experience at the Stonehenge WHS via the removal of the A303. If they answered this question with 'yes' or 'maybe' they were shown a payment card. Those who said 'yes' / 'maybe' and selected £0, or those who said 'no' were then channelled to the WTA branch and first asked whether the removal of the road would have an impact on their life satisfaction. If they said that the removal of the A303 would reduce their life satisfaction they were shown the willingness to accept card to elicit the value of this reduction. Those who indicated that the road scheme would not affect their life satisfaction, or who indicated that it would reduce their life satisfaction but selected £0 were allocated the value zero.

- 6.3.3 We calculated non-parametric mean and median WTP from the mid-point between the amount chosen on the card and the next amount up, and mean and median WTA from the mid-point between the amount chosen on the card and the next amount down. The use of the mid-point estimate is a practical step to avoid having to use a continuous WTP or WTA card, as recommended by Bateman et al. (2002). This is theoretically consistent with the statistical theory for calculating WTP from interval data (Cameron and Huppert 1989). It means that for a person who, say, chose the value £10 (when the next value is £15) we can say that they are willing to pay £10 but not £15. However, we do not know where their willingness to pay sits in between the end points of £10.00 to £14.99). To address this Bateman et al. (2002) recommends using the mid-point, i.e. in this case this would be £12.50.
- 6.3.4 Within the study group samples, we calculated the mean WTP. Using the mean WTP rather than the median is good practice in CV studies (Darling et al 2000). The mean is relevant if the context of the valuation exercise is cost benefit analysis because it represents an average WTP for the population which can be aggregated (by the population size) to derive the total WTP across the population. In general it is recommended that if aggregated WTP for benefits outweighs costs, a project should proceed (Pearce and Özdemiroglu 2002).
- 6.3.5 We note that it is standard practice in the calculation of individual mean and median WTP/WTa to include zero responses (Bateman et al. 2002). This ensures that those who do not hold any value in the non-market good are included in the estimation process, and helps to avoid unrealistic and overestimated mean WTP/WTa figures. In the current case, the zero values are not included in the calculation of mean individual WTP and WTA (that refer to those with positive values only) but are instead included in the aggregation, when calculating population-level values. We feel this approach provides a clearer picture of the influence of zero answers. Specifically, we elicit both positive WTP values and 'negative' values, via WTA compensation questions, for the road tunnel scheme. Those who are not willing to pay are given the opportunity to state a WTA compensation value. This is somewhat equivalent to a negative WTP for the tunnel. Consequently, the valuation of the road scheme is not bounded at zero (as is the case in most CV studies). This leaves a third group of individuals who are neither willing to pay nor willing to accept compensation. We assume that this group represents those individuals who do not hold any value (positive or negative), and are likely to be indifferent to the proposed the road scheme. In other words, their welfare is unaffected by the road scheme, be it because the heritage impacts do not form part of their utility (welfare) function, or that the utility gains of the scheme are exactly offset by the utility losses. We deal with this zero-response group in the aggregation process. We calculate the proportion of positive WTP/WTa responses for each study group, and extrapolate positive WTP/WTa values to the same proportion in the relevant population (section 7.1). Figure 4 sets out the process to allocate respondents to the three groups. Following this logic, Table 3 demonstrates how each type of possible response is accounted for in aggregation.

Table 3 Aggregation formula

	Aggregation Formula
Annual tax (WTP over three years)	$NPV \text{ Mean positive WTP} \times \frac{\% \text{ Share of study group that has a positive WTP}}{\text{Population size}};$
	minus
Compensation (one off WTA)	$\text{Mean positive WTA} \times \frac{\% \text{ Share of study group that has a positive WTA}}{\text{Population size}};$
	plus
WTP and WTA = £0	$£0 \times \frac{\% \text{ Share of study group that is WTP \& WTA = 0}}{\text{Population size (Always zero)}}$

- 6.3.6 At the end points (i.e. the green box and orange boxes in Figure 4) the responses of the survey respondents were weighted by income, gender and age for the WTP and WTA calculations and sensitivity analysis (see section 8).

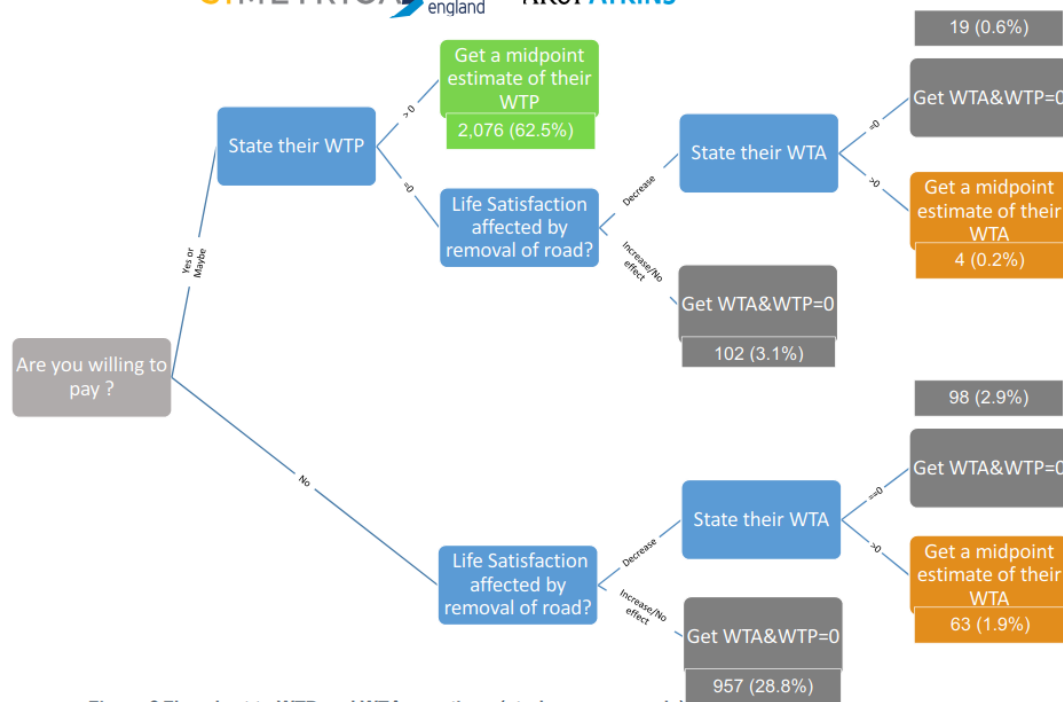


Figure 3 Flowchart to WTP and WTA questions (study group sample)

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6.4 Validity testing

- 6.4.1 It is a best-practice requirement to conduct a range of validity tests for CV studies (Bennett, Morrison, and Blamey 1998). There are a number of ways to test the validity of the results. Here, we discuss content validity and theoretical validity.

Content validity

- 6.4.2 Content validity tests look at the adequacy, realism and neutrality of the survey instrument as well as at respondents' understanding, perception and reactions to the questionnaire. Additionally, the rate of protest provides valuable information on how respondents reacted to the scenarios.
- 6.4.3 We conducted stakeholder meetings at the project inception stage with the steering group to agree the valuation scenarios for the contingent valuations (for both the visitor and online surveys). We then undertook extensive testing of the draft survey instruments with input from the fieldwork provider, Ipsos Mori. We used a face-to-face pilot survey followed by in-depth cognitive debriefing about all parts of the questionnaire with 15 visitors at Stonehenge; and online pilot surveys with some cognitive follow-ups on key parts of the questionnaire with 100 panel respondents in total, in both cases mimicking the conditions in which the final surveys would be implemented.
- 6.4.4 We provide pilot reports on each survey in Appendix C. Table 4 summarises the pilot survey results.

Table 4 Survey pilots

	Survey A	Survey B	Survey C
Number of respondents (who completed debrief questionnaire)	15	54	46
Date	12th September 2016	14 th -15th September 2016	20 th -21 st September 2016

- 6.4.5 Feedback from survey pilot respondents indicated that the instrument was of an appropriate length, clear and easy to answer. The pilots led to only a few small changes in the questionnaire and WTP/WTa payment card range. This included minor changes to wording and added values to the lower end of the payment range (i.e. the card starts with £0.05 and £0.10 instead of the previous level of £0.20).
- 6.4.6 In terms of protest answers, we asked those with a non-positive WTP or WTa follow-up questions on their reasons for their answer. Table 5 shows that around 15% of respondents across all three surveys could potentially be classified as protesters, i.e. stated they would not be WTP or WTa when in fact they might value the change being proposed. In order to be conservative, these respondents are not excluded from any calculations. The majority of

protest responses (12.6% of the total survey sample) indicated that they did not give a positive WTP/WTB due to the annual tax payment vehicle. In other words, they may have given a positive WTP if another payment vehicle (road tax, local tax, donation, or visitor fees) had been provided. Pre-empting our results in section 7, 85% of those who were not WTP also indicated that the removal of the A303 would not reduce their life satisfaction. We may assume that these individuals do have a positive WTP value for the road scheme, but are unwilling to give a positive WTP bid due to their protest over the tax payment mechanism. This could suggest that the current WTP figures represent a slight underestimation.

- 6.4.7 Other responses accord with what would typically be defined as protests, such as political views on reducing road use, uncertainties related to the current political climate, and protests related to perceived risk of damage within the WHS from tunnel construction (stating that there should be a longer tunnel). Overall, the relatively small protest rates within these three categories (highlighted in bold in the table, 3.8%) bode well for the validity of our estimated WTP measures. It should be noted that the interpretation of protests is subjective and therefore, the valuation presented by these protest respondents may be a valid representation of the utility impact of the road scheme.

Table 5 Protest responses

	Across all surveys	
	Number of responses	%
There should be a longer tunnel scenario	14	0.4%
We should be reducing road use, not building more roads	43	1.3%
Any changes to the road layout should be paid for through local council tax	106	3.2%
Any changes to the road layout should be paid for through road tax	192	5.8%
Any changes to the road layout should be paid for through voluntary donations	31	0.9%
Any changes to the road layout should be paid for through increases in visitor fees	88	2.7%
I do not feel confident stating a value that I would be willing to pay in the current uncertain political climate	70	2.1%
Total	544	15.4%
Total survey sample	3535	

Notes: Unweighted figures summed across the three surveys: visitor, road user, and general population. Non-protest responses not shown in table ('I have more important things to think about'; 'I would prefer to keep the A303 in its current location but do not require compensation'; 'I am not willing to pay increased taxes over a period of three years'; 'I do not care about Stonehenge'). Traditional protest categories highlighted in bold.

Theoretical validity and certainty of payment

- 6.4.8 The two main validity tests advocated by the literature are theoretical validity tests and certainty of payments (Bateman et al. 2002). We test both in the same model.
- 6.4.9 The credibility of estimated values from CV studies is commonly assessed by examining their theoretical validity (Bateman et al. 2002). Testing for theoretical validity is typically done by estimating a bid function, exploring how WTP responds to respondent characteristics and other variables collected in the survey to test whether the relationship between WTP and other indicators is in accordance with expectations. Some of these indicators are predictors from economic theory, while others reflect empirical regularities, which seem intuitively correct, from introspection and reasoned thought, and which have been found to hold across a large number of studies (Bateman et al. 2002). An example of the former is a positive relationship between WTP and income. An example of the latter is the effect on WTP of indicators such as interest in local history. Put another way, if key variables are found to be either statistically insignificant or, most importantly, to be associated with WTP in unexpected and illogical ways, this casts doubt on the theoretical validity of results. Typically, the following ordinary least squares regression (OLS) model is used as the base for all the WTP analyses:

$$WTP_i = \alpha + \beta_n X_i + \varepsilon_i \quad (1)$$

- 6.4.10 where WTP_i is the amount the individual i has stated they are willing to pay, α is the deterministic factor and ε is the error term containing unobserved factors that determine willingness to pay (Wooldridge 2010). In X_i controls for the n observed determinants of willingness to pay (Bateman et al., 2002). Regressions for validity tests only included those respondents who had responded to the income question due to the importance of income as a theoretical driver of WTP (Bateman et al., 2002) (recall section 4.1).
- 6.4.11 We test the distribution of residuals for heteroskedasticity using robust standard errors and for normality using kernel density estimates, and tested for multicollinearity using VIF (Variance Inflation Factor) tests. The results of these tests are given in Appendix D.
- 6.4.12 We test for differences in WTP between those who indicated that they were "certain" that they would pay (at least 3 on a 5-point scale with 1 being "Not certain at all" and 5 "Very Certain") and those that were either "uncertain" or "somewhat certain". We would anticipate that those who report greater certainty in their stated WTP value would hold higher values, since being uncertain about the WTP amount may lead people to state a lower amount.
- 6.4.13 Specifically, we estimate the following model using OLS regression based on (1) to test for theoretical validity and the impact of certainty:

$$WTP_i = \alpha + \beta_1 Cert_i + \beta_n X_i + \varepsilon_i \quad (2)$$

where WTP_i is the amount individual i states they are willing to pay; $Cert_i$ is the individual's stated certainty to pay that value; X_i is a vector of control variables



for the n determinants of WTP; and ε_i is the error term under the standard assumptions in OLS (Wooldridge 2010).

- 6.4.14 We process hypothetical bias by recoding WTP bids that fail to provide sufficient assurance of certainty as zero responses. Low certainty is defined in this case as those rating their certainty as 1 or 2 on a 5-point certainty scale, where 1 is not at all certain. This allows us to maintain all subjects in the sample while excluding low certainty responses from WTP analysis (following Champ et al. 1997). This allows us to perform sensitivity analysis by comparing aggregate values at different certainty levels (Haab et al. 2013).
- 6.4.15 The set of variables included in equation 2 is presented in Table 6. In our choice of predictors of WTP, we followed the recommendations of Bateman et al. (2002), which are common practice in modern applications of CV. In particular, we include a range of **socio-economic variables** (i.e. gender, age, children, education and income), variables relating to **usage** (number of visits to Stonehenge and seeing Stonehenge from the road) and **attitudinal** variables (member of English Heritage/National Trust). For some variables there are no clear priors on the sign of the impact; that is, for example, in some of these cases the relationship with WTP could plausibly be positive or negative (e.g. having dependent children).

Table 6 Variables used in validity tests

Variable	Description
Female	Dummy variable (1-female; 0-male)
Log age	Log of age (mid-point of intervals)
Log income	Log of annual household income before tax (mid-point of intervals)
Children	Dummy variable (1- dependent children under 16; 0-otherwise)
Married/with partner	Dummy variable (1- married or with partner; 0-otherwise)
University education	Dummy variable (1- university degree or higher; 0- otherwise)
In employment (full time, part time, self-employed)	Dummy variable (1- full time, part time or self-employed worker; 0- otherwise)
Health	Dummy variable (1- excellent, very good or good health; 0- fair or poor health)
Ethnicity	Dummy variable (1- all other ethnicities; 0- white)
Student	Dummy variable (1-student; 0-otherwise)
Retired	Dummy variable (1-retired; 0-otherwise)
Number of times visited Stonehenge	Number of visits to Stonehenge
Likely	Dummy variable (1-very likely or likely to visit Stonehenge again; 0 – otherwise)
Member	Dummy variable (1- Member of English Heritage / National Trust / Stonehenge preservation organisation; 0- otherwise)
Driver's license	Dummy variable (1- has a driver's license; 0-otherwise)
Familiar with the impact of the A303 on WHS	Dummy variable (1- Very or extremely familiar with information regarding the impact of the A303 on WHS; 0- Not at all, slightly or Moderately familiar with information)
Certainty	Dummy variable (1- very certain or certain regarding WTP (3-5 on a scale of 1-5); 0- quite uncertain or not certain at all regarding WTP)
Road User	Dummy variable (1- In road user study group; 0 – otherwise)
General Population	Dummy variable (1- In general population study group; 0 – otherwise)

6.5 Aggregation of values

- 6.5.1 To estimate overall values for the road options we aggregate the mean WTP and WTA values from the survey to the relevant national populations. This results in an estimate of the overall value the UK resident population places on the increased tranquillity, reduction in landscape severance, noise visual impact brought by the removal of the A303. The aggregation is conducted in the following steps:
- 6.5.2 **First**, we estimate the size of the visitor, road user and general populations as described in paragraphs 6.5.7. to 6.5.9.
- 6.5.3 **Second**, for each study group we calculate the proportions of people who are willing to pay for the road scheme (i.e. those with a utility gain), and those requiring compensation (i.e. those with a utility loss from the road scheme).



- 6.5.4 **Third**, we multiply the proportions estimated in the second step, by the relevant populations estimated in the first step. This results in an estimate of the number of people in each study group's wider population who are WTP/ WTA.
- 6.5.5 **Fourth**, for each study group we multiply the NPV of mean WTP by the wider populations' WTP (as estimated in third step) and subtract it by the mean WTA value multiplied by the estimate of the wider population that is WTA.
- 6.5.6 We outline below the methods used to estimate the size of the visitor, road user and general populations (Table 7).
- 6.5.7 **The total number of visitors** per year to Stonehenge was sourced from the English Heritage (EH) visitor data and the Association of Leading Visitor Attractions.²⁹

The total number of visitors to Stonehenge per year was 1.37 million in 2015. Of these 40% are estimated to be UK residents by EH³⁰.

This results in an estimate of 0.55 million UK resident visitors annually.

- 6.5.8 **Total number of road users** was calculated using survey responses from the general population survey due to a lack of reliable data available externally.
- 2.3% of the general population survey stated that they used the A303 road weekly (this includes drivers and passengers).
 - This represents a conservative estimate of road usage in the general population survey. This helps to correct for potential over-estimation of road usage frequency by survey respondents caused by failure to recall usage effectively (recollection bias) or focusing bias (caused by the focus of the survey on Stonehenge and the A303 road).
 - We applied this percentage to the UK resident population aged 16 and over (for details of UK population size, see 6.5.9), producing an estimate of just over **1.22 million A303 road users**.³¹
 - For the CV study, each individual road user counts once within the year. This means a person who uses the road several times a day counts the same as a passenger in a car driving past once a week.
- 6.5.9 **Total population figures (for Survey C)** are taken from the Annual Population Survey (APS) of the Office for National Statistics (ONS).
- The APS estimates the UK population on 30th June 2015.
 - We uprate these estimates to 2016 figures using ONS projections of 0.7% UK population growth.³²

²⁹ Source: <http://www.alva.org.uk/details.cfm?p=423>

³⁰ English Heritage Stonehenge annual Visitor Survey, summer 2015

³¹ Note this figure relates only to UK residents because the panel from which the survey sample was taken only includes UK residents.

³² Source: <http://webarchive.nationalarchives.gov.uk/20160105160709/http://www.ons.gov.uk/ons/rel/pop-estimate/population-estimates-for-uk--england-and-wales--scotland-and-northern-ireland/mid-2014/sty---overview-of-the-uk-population.html>

- This results in an estimated population size of 53.2m residents aged 16 and over.
- The estimated population numbers of Stonehenge WHS visitors and road users (see above) are subtracted to avoid double counting.³³
- This results in general population estimate of **51.43 million**.

Table 7 Aggregation: Study group to population

Study groups	Weighting method*	Study group (n)**	Population (N)	Population description
Visitors (those visiting in the previous 12 months??)	Weighting based on age	429	0.55m	Domestic annual visitors to Stonehenge (source: EH)
Road users	Quota-based sampling and study group formation	932	1.22m***	Domestic annual number of A303 road users (source: Survey C)
General Population	Quota-based sampling, study group formation, weighting based on income, gender, age and region.	1,958	51.43m	UK Population aged 16 and above ³⁴ less the Road Users and Visitors (source: ONS, 2016)

Notes: * see Figure 4; ** Study group sample size differs from survey sample size given in Table 2;

*** this figure is based on the number of respondents in the general population survey who responded that they use the A303 about once a week (for more precision, this figure was based on the full survey sample excluding only speedster respondents (N = 2,006)).

6.5.10 We consider the need to apply welfare weights to the respondents to adjust for differences in marginal utility of income. Following best practice (Fujiwara 2013; HM Treasury 2011), this overcomes issues around the marginal utility of income. This reflects differences in marginal utility of income between high and low income groups (see section 4.2 for further discussion). We test for differences in the mean income of individuals who were willing to pay (i.e. those with a welfare gain from the policy), and requiring compensation (i.e. those with a welfare loss from the road scheme). We find no significant differences, leading us to conclude that welfare weighting was not necessary in this case.

6.6 Time scale and appraisal period

6.6.1 **Willingness to pay:** Respondents were asked for their willingness to pay as an annual tax for three years. This time frame was approved by the steering

³³ The overall UK population is estimated to be 65.1m on 30th June 2015. Of these, 12.3m were aged 0-15 years old. Source:

<https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationestimates/bulletins/annualmidyearpopulationestimates/mid2015#uk-population-continues-to-age>

³⁴ We have included the total population above the age of 16. Including people under 16 in a survey requires written consent from a parent or guardian and a different formulation of the question as children are not constrained by income and budgets, and are unlikely to be paying tax. As a result, including respondents aged under 16 would be inconsistent with the microeconomic assumptions underlying the CV method (Shaw, Brady, and Davey 2011).



group as reflecting a realistic amount of time for the new tunnel to be built. Values for year two and year three were discounted using the Green Book's 3.5% discount rate (HM Treasury 2011, 26–28). This provides a net present value for those who are willing to pay for the road scheme.

- 6.6.2 Willingness to accept was asked as a one-off compensation payment in year one and therefore does not need to be discounted.
- 6.6.3 We note that the effects of the road scheme will have impacts into the future beyond the three-year tax payment period. It has the potential to impact on future generations who will also value the options for the A303 road. The WTP for the three-year tax payment represents the current generation's maximum WTP for the road scheme split into three annual instalments. Similarly, the WTA for the loss of the road represents the value that those that prefer the view of Stonehenge from the current road place on the road as a one-off payment.
- 6.6.4 Non-use value is contained in both the WTP and WTA values including the bequest value element of non-use value. This means that impacts on future users and future generations are internalised and captured in the WTP and WTA values of current generations (Frey 1997). Therefore, although the road options will impact on and be valued by future generations (and this is a genuine value that needs to be accounted for in transport policies with long term impacts) there is no need to apply the WTP and WTA values elicited now to population numbers in the future because this would lead to double counting of the benefits as impacts on future generations are already captured in the bequest value element of non-use value in our surveys.
- 6.6.5 The values estimated from our CV study can be added to the range of other impacts captured in the overarching appraisal. Such impacts – for example journey time savings – are assessed over a 60 year appraisal period. The length of the appraisal period reflects the fact that new transport infrastructure typically has an indefinite life. Towards the end of the appraisal period, values are heavily discounted, such that extending the appraisal period beyond 60 years would have a limited effect on the results. Whilst the CV study does not have a defined time period, the estimates are likely to capture impacts on current and future generations within this time period. While this might lead to an underestimate of the total value in cases where respondents in the current survey do not consider bequest values, it also avoids significant potential for double counting.

7 Results

7.1 Introduction

7.1.1 This section presents the results of the WTP and WTA analysis and the results of validity testing. We present the WTP and WTA results for the three different study groups: visitors to Stonehenge and the WHS, road users and the general population.

7.1.2 Following the methodology described in section 6, including the weighting by different income subgroups, gender and age the figures presented below reflect the weighted, aggregate values for the removal of the road.

7.2 Average WTP and WTA

7.2.1 Table 8 presents the percentage of people within three outcomes:

- a) Those willing to pay a positive amount for the road scheme (i.e. the green box in Figure 4)
- b) Those not willing to pay for the road scheme and requiring compensation (i.e. the two orange boxes in Figure 4), and;
- c) Those who are neither willing to pay nor require a compensation for the road scheme (i.e. the grey boxes in Figure 4).

7.2.2 The percentage of people willing to pay a positive amount for the road scheme was highest for visitors and road users (both 67.4%). 59.2% of the general population were willing to pay a positive amount for the road scheme.

7.2.3 The percentage shares of people requiring compensation were very low for all study group populations, and was lowest for Stonehenge visitors (0.5%). Across the three outcomes, between 30.5% and 38.5% of people neither required any compensation, nor were willing to pay. This suggests that the welfare of those who neither required any compensation, nor were willing to pay is unaffected by the road scheme, be it because the heritage impacts do not form part of their utility (welfare) function, or that the utility gains of the scheme are directly offset by the utility losses (recall section 6.3).

Table 8 Summary statistics of people willing to pay or requiring compensation for the removal of the A303 into a tunnel (the road scheme)

Outcome	Visitor study group		Road user study group		General population study group	
	N.	%	N.	%	N.	%
A - Willing to pay for road scheme	289	67.4%	628	67.4%	1,159	59.2%
B - Requiring compensation for road scheme	2	0.5%	20	2.1%	45	2.3%
C - Neither willing to pay nor requiring compensation	138	32.2%	284	30.5%	754	38.5%
Total	429	100%	932	100%	1,958	100%

Note: sample size is based on final study group samples. Protest responses highlighted in table 5 are included in all samples.

- 7.2.4 Mean WTP and WTA results for outcome groups (A) and (B) are provided in Table 9. These are values for those respondents who are willing to pay or require compensation. Individual level mean WTP values do not include the zero WTP/WTA group (outcome C). Zero WTP/WTA responses are instead accounted for in the aggregation process (recall section 6.3). Accordingly, individual level mean WTP values represent an average money metric impact for outcomes (A) and (B) in Table 8. Given that zero responses are not accounted for in these calculations, individual mean WTP values should not be interpreted directly as an overarching measure of the value that individuals place on the road scheme, or compared to individual mean WTP elicited in previous studies (e.g. Maddison and Mourato, 2002).
- 7.2.5 The mean WTP for the road scheme (Outcome A) was highest for visitors at **£23.39** per year for three years. It is only slightly lower for road users at **£21.51** per year for three years. The general population have a lower WTP than visitors and road users at **£14.41** per year for three years.
- 7.2.6 The mean WTA for the road scheme (Outcome B) was highest for visitors at **£187.50**. Note that this figure is based on a sample of n=2. The average WTA of the road users who required compensation is **£81.35** and lower at **£57.90** for the general population. There is a wide confidence interval surrounding these estimates due to the generally low number of people requiring compensation for the removal of the road.

Table 9 Mean and Median WTP and WTA values

Study group	Outcome (WTP/WTa variable)	N	Mean (£)	Low 95% CI	High 95% CI	Median (£)	Max (£)
Visitor	A - Willing to pay for road scheme (annual tax)	289	£23.39	£19.32	£27.46	£10.50	£200.00
	B - Requiring compensation for road scheme (one-off WTA)	2	£187.50	£187.50	£187.50	£187.50	£187.50
Road User	A - Willing to pay for road scheme (annual tax)	628	£21.51	£18.23	£24.80	£10.50	£250.00
	B - Requiring compensation for road scheme (one-off WTA)	20	£81.35	£45.40	£117.30	£53.75	£187.50
General population	A - Willing to pay for road scheme (annual tax)	1,159	£14.41	£12.74	£16.07	£5.50	£200.00
	B - Requiring compensation for road scheme (one-off WTA)	45	£57.90	£35.20	£80.61	£28.50	£187.50

Note: CI = Confidence interval. Note that individual mean WTP/WTa are estimated excluding zero responses. This is because we elicit both positive WTP values and negative WTA values at the individual level. Consequently, the valuation of the road scheme is not bounded at zero. This zero-response group who are neither willing to pay nor willing to accept compensation are accounted for in the aggregation process (section 6.5).

7.3 Aggregate population level values for the road scheme

7.3.1 Table 10 shows the average WTP and WTA values aggregated to the relevant population levels of each study group. We calculate the proportion of positive WTP/WTa responses for each study group (recall Table 8). We then extrapolate the mean levels of WTP and WTA from the survey samples up to the relevant proportions within the national levels of visitors (population weighted based on age), road users and the general population (weights based on income, gender, age and region). In this way, zero-response bids (Outcome C, Table 8) are accounted for in the aggregation figure, by essentially excluding the equivalent proportion of the relevant populations from aggregation.

7.3.2 For example, for the visitor group:



- **% study group** (column 4, Table 10): 67% of the study group were willing to pay for the road scheme (Outcome A, Table 8);
- **Relevant population** (column 5, Table 10): Mean visitor WTP (£23.39) is aggregated to the relevant population, which represents 67% of the annual UK resident visitors to Stonehenge (n=368,292).
- **% study group**: 0.5% of the visitor group were willing to accept compensation for the road scheme (Outcome B, Table 10);
- **Relevant population**: Mean visitor WTA (£187.50) is aggregated to the relevant population of 0.5% of annual Stonehenge resident visitors (n=2,549).

- 7.3.3 We discount (HM Treasury Green Book, 3.5%) aggregated WTP values, given that the WTP values represent annual taxes to support the road scheme broken down into three different years of payments. The net present value (NPV) of the three years' worth of WTP payments therefore represents the overall individual WTP for the road removal. The NPV WTP values are presented in Table 10 below.
- 7.3.4 As discussed above the WTA values are elicited as a one-off compensation amount for the removal of the road and therefore represent the overall cost to individuals (who value the road) for the removal of the road.
- 7.3.5 Net value is calculated for each study group by subtracting aggregate WTA from aggregate WTP. In other words, this creates the net value by subtracting the aggregated estimate of the dis-benefit for those whose welfare or utility would decrease due to the road scheme, from the aggregated estimate of the benefit for those whose welfare would increase.
- 7.3.6 As discussed in section 6.6.4, the WTP and WTA values incorporate future impacts (impacts on future users and generations) and hence do not need adding over time as this would lead to double-counting of the benefits.
- 7.3.7 The **aggregate net benefit** of moving the A303 road into a tunnel to **visitors** is **£24.50m**, for **road users** it is **£49.15m**, and for the **general population** it is **£1.20 billion**.³⁵ The aggregate net benefits figures calculated for whole population groups are driven by the individual WTP and WTA estimates and the size of the relevant population. The relative size of these figures is, therefore, as expected: while the individual WTP of visitors is higher than that of road users and the general population, the total number of visitors is a lot smaller than the number of road users and the general population.
- 7.3.8 The aggregate figures are consistent with the Maddison and Mourato study (2001). However, a direct comparison is not possible because of differences in road options, survey design etc. For example, Maddison and Mourato were considering the removal of two roads at the time – the A344 (which has since been removed) and the A303, they assumed a two-year period of payments, they did not include a road user sample, and the values were calculated at the

³⁵ All figures are Net Present Values in 2016 prices.

household and not individual level. More detail on this in section 3.3 and Appendix B.

- 7.3.9 This results in an estimated **aggregate net present value of £1.3 billion for the whole of the UK for the removal of the section of the A303 into a tunnel.**

Table 10 Aggregation to population values

	WTP/MTA variable	Number of responses	% of study group	Relevant population	Mean individual (£)	NPV individual WTP (£)	Aggregated values for population group
Visitors	Annual tax (WTP over three years)	289	67.4%	368,292	£23.39	£67.8	£24,501,877
	Compensation (one off WTA)	2	0.5%	2,549	£187.50	n/a	
	WTP and WTA = £0	138	32.2%	175,863	n/a	n/a	
Road Users	Annual tax (WTP over three years)	628	67.4%	822,033	£21.51	£62.3	£49,145,539
	Compensation (one off WTA)	20	2.1%	26,179	£81.35	n/a	
	WTP and WTA = £0	284	30.5%	371,747	n/a	n/a	
General Population	Annual tax (WTP over three years)	1159	59.2%	30,445,460	£14.41	£41.7	£1,203,428,521
	Compensation (one off WTA)	45	2.3%	1,182,093	£57.90	n/a	
	WTP and WTA = £0	754	38.5%	19,806,624	n/a	n/a	
Total net present value							£1,277,075,937

Notes: (i) The NPV calculation uses the standard HM Treasury discount rate (3.5%); (ii) The population sizes are described in section 6.1; (iii) The percentage calculations of relevant populations are based on four decimal places (only one decimal place reported in the table); (iv) For each study group, the aggregated value multiplies NPV individual WTP by the relevant population and subtracts it by the mean WTA multiplied by relevant population. (v) The relevant population column is calculated by multiplying the % of study group by the total population; (vi) The calculations presented in the table use numbers with multiple decimal places. The aggregated values for population group will not, therefore, exactly match the result if using the rounded numbers in the table.

7.4 Validity test results

- 7.4.1 Table 11 shows the results for equation (2) where we test for theoretical validity of the WTP estimates using a pooled regression model that includes data from all three study groups. We include variables which are relevant covariates of WTP (Bishop 2002) plus the variable which reflects the respondent's certainty that they would be willing to pay and a dummy variable

for each study group in the sample (with the baseline being the visitors group).³⁶ The dependent variable includes positive WTP responses only.

Table 11 Validity testing: Regression results for WTP

Variable	WTP	P-value
Female	-4.247***	0.01
Log age	1.552	0.63
Log income	6.500***	0.00
Children	4.541**	0.02
Married/with partner	-3.201*	0.06
University education	-2.908	0.11
In employment (full time, part time, self-employed)	-1.328	0.58
Health	0.870	0.55
Ethnicity	2.749	0.44
Student	-0.796	0.87
Retired	-0.348	0.90
Number of times visited Stonehenge	1.093*	0.06
Likely	2.979**	0.05
Member	7.064***	0.00
Drivers license	-0.442	0.80
Familiar with the impact of A303	7.798***	0.00
Certainty	6.802***	0.00
Road users	-4.541	0.16
General population	-4.057	0.18
Constant	-61.849	0.001
Observations	1666	
<i>Note: *** significance at <1%; ** significance at <5%; * significance at <10%.</i>		

Note: *** significance at <1%; ** significance at <5%; * significance at <10%. Respondents who had not answered the question on income are excluded from the validity tests. The WTP dependent variable only includes those with a positive WTP. The baseline for the sample dummies is the visitor study group.

7.4.2 Theoretical validity: As predicted by economic theory (Bateman and Willis 2001), **income** has a statistically significant and positive association with WTP; **certainty of paying** has a statistically significant and positive association with WTP; people that **visit Stonehenge more often** have a higher WTP, **Membership** in a heritage organisation has a statistically significant association with WTP; **Familiarity** with information provided on the impact of A303 on the WHS has a statistically significant and positive association with WTP. Despite visitors having a higher mean WTP in Table 9, the general population and road user group dummies are insignificant. This is likely to be

³⁶ Since the theoretical foundations of WTA values are less well-known and researched we focus on validity checks for WTP here.



due to controlling for the factors which drive the higher visitor WTP such as income, likelihood of future use or membership in a heritage organisations.

- 7.4.3 **Certainty:** the second element of validity testing is to test whether certainty of paying has an impact on people's stated WTP amount. Certainty has a statistically significant and positive association with WTP. A positive association implies that on average, those who are certain that they would make the payment have a higher WTP, which in itself adds validity to the mean WTP calculations. However, we note that previous studies have found inconsistencies in the reported direction of the association between certainty and WTP (Bakhshi et al. 2015). We therefore recommend further sensitivity analysis of certainty levels (see section 8).

8 Sensitivity Analysis

8.1 Confidence intervals

- 8.1.1 Table 12 shows aggregated net benefit and the 95% confidence intervals.³⁷ The lower/ upper bound aggregations use the lower/ upper bound WTP/ WTA amounts shown in Table 9, in place of the mean individual WTP/ WTA. This results in a range for the overall net WTP for the whole population. Table 12 shows the results:

Table 12 Confidence intervals for the aggregate WTP

	Lower bound of 95% confidence interval	Aggregated net benefit	Upper bound of 95% confidence interval
Visitors	£20,155,514	£24,501,877	£28,848,251
Road Users	£42,253,524	£49,145,539	£56,037,529
General Population	£1,083,180,378	£1,203,428,521	£1,323,675,770
Total	£1,145,589,416	£1,277,075,937	£1,408,561,550

- 8.1.2 These results show that even at the lower bound of the confidence interval the aggregate net WTP for the removal of the A303 into a tunnel is **£1.15 billion**, with an upper bound of **£1.41 billion**.

8.2 Certainty of payment

- 8.2.1 Willingness to pay studies can be subject to hypothetical bias, as discussed in section 5. Respondents know that they are unlikely to have to pay the amount they state. This can lead to an overclaiming of the WTP. While it is not possible to completely overcome this bias one way of addressing it is to ask respondents how certain they are (on a scale of 1 to 5 – with 5 being very certain) that they would pay the stated amount. Empirical studies such as Bakshi et al show that this has a positive impact on the validity of results (Bakshi et al. 2015).
- 8.2.2 To test the impact of those respondents who are not certain that they would pay the amount stated on the aggregate value we equalise their WTP to zero. Table 13 below shows the impact of assuming that the respondents who were uncertain about their stated WTP value had a £0 WTP.³⁸ This results in an aggregated value of **£1.17 billion**, which sits within the confidence interval described in Table 12. While this does not eliminate the hypothetical bias it

³⁷ A confidence interval is a statistical measure. It is a range of values so defined that we are 95% certain that the value provided lies within it.

³⁸ These were respondents who did not know how certain they were or responded as 1-2 on a 5 point scale where 1 = not at all certain and 5 = very certain about their WTP amount.

provides those who are uncertain with an opportunity to express this, and the researchers the opportunity to test the robustness of the valuation.

Table 13 Certainty sensitivity analysis impact on aggregated results

	WTP/WTa variable	Number of responses	% of study group	Relevant population	Mean individual (£)	NPV individual WTP (£)	Aggregated values for population group
Visitors	Annual tax (three year WTP)	262	61.1%	333,884	£24.59	£71.32	£23,333,387
	Compensation (one off WTA)	2	0.5%	2,549	£187.50	n/a	
	WTP and WTA = £0	165	38.5%	210,270	n/a	n/a	
Road Users	Annual tax (three year WTP)	577	61.9%	755,275	£22.25	£64.51	£46,590,044
	Compensation (one off WTA)	20	2.1%	26,179	£81.35	n/a	
	WTP and WTA = £0	335	35.9%	438,505	n/a	n/a	
General Population	Annual tax (three year WTP)	997	50.9%	26,189,925	£15.35	£44.51	£1,097,288,571
	Compensation (one off WTA)	45	2.3%	1,182,093	£57.90	n/a	
	WTP and WTA = £0	916	46.8%	24,062,158	n/a	n/a	
Total net present value							£1,167,212,003

Notes: (i) The NPV calculation uses the standard HM Treasury discount rate (3.5%); (ii) The population sizes are described in section 6.1; (iii) The percentage calculations of relevant populations are based on four decimal places (only one decimal place reported in the table); (iv) For each study group, the aggregated value multiplies NPV individual WTP by the relevant population and subtracts it by the mean WTA multiplied by relevant population. (v) The relevant population column is calculated by multiplying the % of study group by the total population; (vi) The calculations presented in the table use numbers with multiple decimal places. The aggregated values for population group will not, therefore, exactly match the result if using the rounded numbers in the table.

9 Conclusion

- 9.1.1 The study applies best practice stated preference methods (contingent valuation) to elicit the total net benefits associated with the hypothetical reduction in noise, increased tranquillity, increased visual amenity and reduced landscape severance associated with the removal of the A303 from part of the Stonehenge WHS for three population groups: Stonehenge visitors, road users, and the UK resident general population (aged 16 and over). Individual level mean WTP and WTA values and zero response rates are in line with comparable results from heritage studies in the UK and international studies of World Heritage sites. Validity tests show that WTP and WTA are consistent with theoretically consistent drivers of value (Bateman et al. 2002), with additional sensitivity analyses performed on respondent certainty levels. Surveys were carefully designed following best practice to reduce known biases in CV surveys (Bakhshi et al. 2015).
- 9.1.2 While the values elicited in this study cannot be directly translated into cashable benefits, they represent the value that the improvements achieved by the road scheme will have for users and non-users of the WHS. They therefore form a key component of the overall cost-benefit analysis of this scheme. They have been conducted in strict adherence to the Green Book guidance on appraisal and evaluation.

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Appendix I Willingness to Pay study and quality assurance

A303 Amesbury to Berwick Down – willingness to pay study summary and quality assurance

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Background

1. This note summarises the initial results (2nd November 2016) of the Arup Atkins Joint Venture (AAJV) commissioned report by Simetrica¹ on behalf of Highways England. This report aimed to value the heritage impacts of removing the A303 Amesbury to Berwick Down section of road within the World Heritage Site (WHS) at Stonehenge.
2. The aim of the study was to understand the value that UK residents put on the removal of the A303 from its current location within the Stonehenge WHS, in relation to noise reduction, increased tranquillity, visual amenity and reduced severance in the Stonehenge WHS.
3. The annex then provides details of a comprehensive quality assurance (QA) exercise undertaken by HE analysts including asking questions around the scope for challenge of the work, the risk or error and the residual uncertainty.

¹ [Simetrica](#) is an economic consultancy that “specialises in cutting-edge research on social impact analysis and policy evaluation”. The Chief Economist is Ulrike Hotopp, who spent four years as the Chief Economist at the Department for Environment, Food and Rural Affairs (DEFRA).

Methodology

4. The methodology used was a contingent valuation (CV)². Three different surveys were used to calculate the Willingness to Pay (WTP) and Willingness to Accept (WTA). The three groups were visitors to the WHS, road users³ and the general population.
5. Participants were asked whether they would be willing to pay to support the construction of a tunnel route in the form of increased yearly national taxes for three years⁴.
6. In the context of this study these values were interpreted as people's WTP for and WTA changes in welfare associated with the removal of the A303 from its current location within the Stonehenge WHS.
7. The overall value of the A303 road option was calculated by aggregating the values from the different study groups by the relevant samples in the general population.

Analysis

8. Within the samples the mean WTP was calculated rather than the median which is regarded as good practice for CV studies in the literature⁵.
9. The survey respondents were weighted by income, gender and age for the WTP and WTA calculations and sensitivity analysis.
10. Under economic theory WTP should be positively associated with income and with the attitude of the respondent towards the object valued (i.e. if they show interest in the good then they should value it higher).
11. To estimate overall values for the road options, the WTP and WTA values from the survey were aggregated to the relevant national populations⁶. The overall population within each study group was calculated and the mean WTP applied to this group.
12. Next, the percentage of this study group (e.g. % who were willing to pay) was applied to the total population and the overall results were added to the total WTP. This is net of WTA and therefore represents the overall value the UK resident population places on the increased tranquillity, reduction of severance and visual impact brought by the removal of the A303.

² CV surveys elicit the monetary value of non-market goods and services by directly asking people what value they attach to them.

³ Local population, people living within a 50-mile radius of Stonehenge as an approximation of frequent road users (online survey)

⁴ Relevant stated preference survey biases were controlled for in survey design e.g. payment card design for anchoring bias, selection bias, range bias, 'speedsters' who completed online surveys in <4mins were excluded and extreme values were excluded.

⁵ The mean calculation takes into account higher WTP values more, i.e. those who really care about the activity.

⁶ English Heritage data for number of WHS visitors, general population survey for number of road users and ONS population surveys for total population.

Results

13. As predicted by economic theory income has a statistically significant and positive association with WTP; respondents' certainty of paying has a statistically significant and positive association with WTP; and people that visit Stonehenge more have a higher WTP.
14. Of those who were willing to pay, the average WTP was highest for Visitors at **£23.39** per year for three years⁷. It is only slightly lower for road users at **£21.51** per year for three years. The general population have a noticeably lower willingness to pay than visitors and road users at **£14.41** per year for three years.
15. The aggregate net benefit to visitors is therefore £24.2m, for road users it is £51.1m, and for the general population it is £1.3 billion, **totalling around £1.33bn**⁸.

Sensitivity analysis

16. Initial checks focused on the statistical validity of results; confidence intervals were established around the overall NPV. These results show that a 95% confidence that the aggregate net WTP is between £1.2bn and £1.5bn.
17. Sensitivity analysis-proper was undertaken by varying income. The average annual income of Stonehenge visitors is £48,000 according to surveys. This is above the UK average of around £27,000. Since lower income groups have a lower WTP (as well as WTA to some extent), the WTP/WTa of the two lowest income categories of the surveys was used. Using these WTP/WTa figures to aggregate up to the various group's results in only a £160m drop in the total NPV to £1.2bn.

Strengths of analysis

18. The surveys elicited a relatively large number of respondents⁹ – above the initial target according to statistical robustness targets and margins of error. This in itself improves the statistical reliability of the results.
19. The survey was designed to control for any endogenous factors, i.e. instead of correcting for relationships that could affect our results after the fact, the online surveys restricted results from certain groups once the representative sample has been reached.

⁷ Converted to three year NPV for aggregation using Green Book guided discount rate of 3.5%.

⁸ All figures are Net Present Values in 2016 prices – note presented in IOBC as 2010 prices in line with CBA standards.

⁹ N=432 WHS visitors, N=1,001 local population, N=2,102 UK general population quota sample panel.

Weaknesses of analysis

20. A general weakness of the methodology is the issues that come with stated preference studies, e.g. exogenous factors affecting choice and biases in surveys etc. Revealed preference would be a superior experiment, but is not available in this context.
21. The study aims to isolate the WTP of removing the road in favour of a tunnel. It does not consider the WTP of removing the road in favour of a surface route bypass – which is an option in the business case. In practice removing the road to create a tunnel sees 3km of the road removed, whereas removing the road to create a surface route bypass sees the whole road being removed¹⁰. This is relevant because the business case that feeds off this study uses the same willingness to pay for both the tunnelled routes and surface routes i.e. using the removal of the road for a tunnelled route as a proxy. There may in fact be different willingness to pay values associated to these different activities, but these are being interpreted as the same in the business case.

Summary

22. There is an estimated **aggregate net present value of £1.3 billion for the removal of the section of the A303 into a tunnel.**
23. Statistical testing shows that there is a 95% confidence that the true figure will lie between £1.2bn and £1.5bn.
24. Even if we assumed the relevant populations were on relatively low incomes (~£20,000/year), the aggregate NPV would still be in this range.

¹⁰ The survey does not spell this out however, it merely asks regarding moving the road “from its current location”, with some prompting about a tunnel.

Annex 1 – Quality assurance of WTP study

Executive summary

1. The purpose of this annex is to set out our approach to quality assure the willingness to pay study submitted by Simetrica. We have broken up the QA into a) scope for challenge, b) risk of error, and c) residual uncertainty. Bringing these topics together leads us to believe there is **low/medium scope for challenge, low risk of error and low residual uncertainty**.

Scope of quality assurance

2. After the submission of the initial results (2nd November 2016) of the Arup Atkins Joint Venture (AAJV) commissioned report by Simetrica on behalf of Highways England, this annex seeks to quality assure the results and the inferences made on their behalf.
3. Whilst this note aims to be comprehensive, given limited time and resources, it has not been possible to fully audit the entire study which includes advanced statistical modelling. Spot check on statistical programming have been undertaken, alongside assessing the scope for challenge, risk of error and residual uncertainty HE analysts believe that may be present within the analysis.
4. This QA is set out as a series of questions and answers to test the analysis, the majority of which was done by an analyst independent of the project.

a) Scope for challenge

- **Is the Contingent Valuation approach taken to estimate the impact of the tunnel appropriate? For example, is the approach compliant with Treasury Green Book guidance? Suggest we might find a social researcher to comment on this.**
5. The [Treasury Green Book](#)¹¹ says “Economists attempt to attach a monetary value to non-market goods by looking at the impact that these things have on utility...the preferred method of estimating this change in utility is to simulate the market in order to estimate people’s ‘willingness to pay’ (WTP) or ‘willingness to accept’ (WTA) a project’s outputs or outcomes.” (p.57). This excerpt confirms the choice of using contingent valuation to estimate the impact.
 6. With regards the approach of the valuation it says “Contingent valuation studies elicit WTP or WTA via direct questions such as ‘What is the maximum amount you would be prepared to pay every year to receive good x?’ (the ‘open-ended’ format) or ‘Which of the amounts listed below best describes your maximum willingness to pay every year to receive good x?’ (the ‘payment card’ format).” (p.57). The method used for this study follows this approach – it uses a payment card format to elicit the maximum WTP over a number of years from a given number of values.

¹¹ The Green Book describes how the economic, financial, social and environmental assessments of a policy, programme or project should be combined.

- **Are the results credible? For example does it satisfy suitable realism tests? Are there any other realism tests we'd like to be undertaken?**
7. The results of this WTP study can be found in para 22 (£1.2bn). The total benefits estimated in an earlier (1998) survey (Maddison and Mourato 2001) were around £150m. There are a number of factors which account for the difference in values between this study and the 2001 paper by Maddison and Mourato. We would of course need to inflate the figures up to today's figures (31% according to GDP deflator); this alongside real per capita GPD growth since 1998 of around 30% gives an economic reason why the number is much smaller than this study's. This older study did not look at road user values unlike this study, the tunnel design was also different i.e. it was not valuing the same good. The population has also grown by around 5 million since the study, with the original aggregating the net benefit up to household level rather than individual level like this study. These factors show why the £150m figure may not be a realistic comparison for the heritage value of removing the A303.
- **Is the approach to use these results to infer the value of non-tunnel options appropriate (e.g. bypass options)?**
8. The study aims to isolate the WTP of removing the road in favour of a tunnel. It does not consider the WTP of removing the road in favour of a surface route bypass – which is an option in the business case. In practice removing the road to create a tunnel sees 3km of the road removed, whereas removing the road to create a surface route bypass sees the whole road being removed¹². This is relevant because the business case that feeds off this study uses the same willingness to pay for both the tunnelled routes and surface routes i.e. using the removal of the road for a tunnelled route as a proxy. There may in fact be different willingness to pay values associated to these different activities, but these are being interpreted as the same in the business case.
 9. It may be the case that the worse environmental outcomes in other options could weigh heavily against people associating a high value to the heritage benefits, meaning that the association of the same heritage benefit to these options may not be correct. This has not been investigated further.
 10. Although this is imperfect, the results are assumed to be broadly applicable to both tunnel and surface bypass options because respondents are likely to focus on the benefits of removing the road the vicinity of Stonehenge. This may increase the scope for challenge, but applying the tunnelled route values to the surface routes is preferable to not having any values.
- **Have suitable scenario and sensitivity tests been undertaken?**

¹² The survey does not spell this out however, it merely asks regarding moving the road “from its current location”.

11. Initial checks focused on the statistical validity of results; confidence intervals were established around the overall NPV. These results show that a 95% confidence that the aggregate net WTP is between £1.2bn and £1.5bn.
12. Sensitivity analysis-proper was undertaken by varying income. The average annual income of Stonehenge visitors is £48,000 according to surveys. This is above the UK average of around £27,000. Since lower income groups have a lower WTP (as well as WTA to some extent), the WTP/WTa of the two lowest income categories of the surveys was used. Using these WTP/WTa figures to aggregate up to the various group's results in only a £160m drop in the total NPV to **£1.2bn**.
13. It could be argued that more rigorous sensitivity analysis could have been undertaken with the aggregation of the survey results up to larger populations e.g. low/high scenarios surrounding visitor numbers, road users and population growth. This could present a larger range around the heritage benefit of removing the A303. However this analysis was purely interested in today's impact rather than a dynamic impact.
- **Is the approach to use this analysis to inform the scheme's value for money rating appropriate? For example is it compliant with DfT's new value for money guidance? Is there a risk that the benefits may be double-counted or that potential costs aren't being valued?**
14. The below table shows the DfT VfM guidance (box 4.4, pg.20, DfT VfM Framework) with the typical impacts that are included in the initial BCR, adjusted BCR and beyond. As we can see the historic environment category should not be included in an initial or adjusted BCR. The approach to use this analysis to inform the scheme's value for money rating is to calculate the initial and adjusted BCRs then add on the heritage benefit and other landscape benefits for an alternative BCR.
15. Therefore, the approach taken, whereby the willingness to pay value is not included in the initial BCR is correct.

<i>Established Monetised Impacts</i>	<i>Evolving Monetised Impacts</i>	<i>Indicative Monetised Impacts</i>	<i>Non-monetised Impacts</i>
<i>(included in initial and adjusted metrics)</i>	<i>(included in adjusted metric)</i>	<i>Considered after metric using switching values approach</i>	
Journey time savings Vehicle operating costs Accidents Physical activity Journey quality Noise Air quality Greenhouse gases	Reliability Static clustering Output in imperfectly competitive markets Labour supply	Moves to more/less productive jobs Dynamic clustering Induced investment	Security Severance Accessibility Townscape Historic environment Landscape** Biodiversity Water environment Affordability

Indirect tax impacts		Supplementary Economy Modelling***	Access to services Option and non-use values
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**These are a class of models rather than a specific economic impact*

*** A widely-used methodology for monetisation exists, but this is not included in WebTAG guidance because of concerns about its robustness Detailed guidance is found in the Supplementary Guidance on Landscape.*

- **Is the analysis suitably auditable and repeatable?**

16. The analysis is suitably auditable but requires STATA as an installed program. HE analysts do not have this capability currently, but are able to analyse text files from the STATA program.

17. We think the scope for challenge associated with this analysis is low/medium since:

- The approach taken is appropriate (this view is being checked with social researcher Deidre O'Reilly).
- The results are credible, but do not compare well with previous studies due to intuitive reasons.
- Using the WTP value elicited for other options may not be 100% correct, but is better than no WTP value.
- Sensitivity tests have been undertaken but there could always be more, the question is whether this approach is proportionate.
- The application of the WTP value onto VfM rating is correct.

b) Risk of error

18. We think the risk of error associated with this analysis is low since:

- The work has been QA'ed by Professor Danny Campbell, a specialist in economic valuation, whose comments have been addressed by Simetrica.
- We have quality assured the summary statistics for this study and not found any errors; however, we've only just received the raw data to undertake a more rigorous QA.
- The data validity tests produce intuitive results (e.g. people with higher incomes are willing to pay more for the tunnel), suggesting it's unlikely that there have been errors in the manipulation of the survey responses.
- The study uses a Contingent Valuation approach, for which supplementary green book guidance is available. Given the conventional nature of the techniques used the risk of error is unlikely to be large.
- The results are not expected to be affected by sampling bias due to the approach to weighting and the use of large sample sizes.

c) Residual uncertainty

- **Could the value of a Stonehenge tunnel fall outside of the 95% confidence interval estimated? Possible reasons might include:**
 - Unrepresentative sampling
 - Sample sizes not large enough
 - Changes in the number of visitors, users of the A303 (including traffic modelling) or UK population from current levels
 - Change in people's preferences over time
 - Results from other studies

19. The survey groups were weighted to account for differences in income, gender, age etc, (table below). This aimed to reduce the uncertainty surrounding unrepresentative sampling.

Variable	Description
Female	Dummy variable (1-female; 0-male)
Age	Age (mid-point of intervals) (in log)
Income	Annual household income before tax (mid-point of intervals) (in log)
Children	Dummy variable (1-dependent children under 16; 0-otherwise)
Married/with partner	Dummy variable (1- married or with partner; 0-otherwise)
University education	Dummy variable (1- university degree or higher; 0- otherwise)
In employment (full time, part time, self-employed)	Dummy variable (1- full time, part time or self-employed worker; 0- otherwise)
Health	Dummy variable (1- excellent, very good or good health; 0- fair or poor health)
Ethnicity	Dummy variable (1- all other ethnicities; 0- white)
Student	Dummy variable (1-student; 0-otherwise)
Retired	Dummy variable (1-retired; 0-otherwise)
Number of times visited Stonehenge	Number of visits to Stonehenge
Likely	Dummy variable (1= likely to visit Stonehenge again; 0- otherwise)
Member	Dummy variable (1- Member of English Heritage and/or National Trust; 0- otherwise)
Driver's license	Dummy variable (1- has a driver's license; 0-otherwise)
Road user	Dummy variable (1- is a road user, 0-otherwise)
General Population	Dummy (1- in the general population; 0-otherwise)
Certainty	Dummy variable (1- very certain or certain regarding WTP; 0- quite uncertain or not certain at all regarding WTP)

20. The sample sizes are in line with existing UK Government guidance on stated preference surveys¹³. A target sample size of 400¹⁴ is within the lower range of sample size that is required for analysis of factors associated with WTP (sociodemographic factors, experience, visit behaviour etc.). With a total number of visitors to the Stonehenge site of 1.3 million of which 540,000 are UK residents and therefore within the scope of this study the literature suggests a minimum of 300 respondents. Given this recommendation and the costs of a face to face survey and the time constraint for this study a sample of 400 is appropriate.
21. The survey was designed to measure the WTP of the current population, who also incorporate other's future utility into their own utility function. Incorporating forecasted users would lead to a classic infinite horizon problem. Because of this, if projections of traffic users were included, it would also lead to double counting. The survey was also designed to elicit the impacts only on the heritage experience and not the aggregate benefit of the tunnel.
22. It is correct that people's preferences may change over time, but there is no way to estimate this, we can use sensitivity analysis however; the low income scenario could be thought of as a proxy for reducing the benefit placed on heritage impacts in the future, assuming people currently earn more than this.
23. We think the observed residual uncertainty associated with this analysis is fairly low.

¹³https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/191522/Economic_valuation_with_stated_preference_techniques.pdf

¹⁴ The target sample size for the visitor survey was 400. Ipsos Mori achieved 432 within the time available.

Appendix J Derivation of costs

J.1 Introduction

J.1.1 This Appendix records the cost estimates provided for the economic appraisal of the A303 Amesbury to Berwick Down scheme. The interpretation of these costs to present costs incurred by the public sector, discounted to and expressed in 2010 market prices is then explained.

J.2 Cost estimates

J.2.1 Highways England Commercial Services Division estimated capital costs for the appraisal of the A303 Amesbury to Berwick Down scheme. The expenditure profiles were based upon cost estimates for each financial year prepared in Q1 2016 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 a GDP-deflator. The costs exclude all recoverable VAT. All historic costs have been removed - previous years and an approximate of this year's spend that occurs in the past. These cost estimates were provided on 24 July 2018.

J.2.2 The overall capital expenditure costs profile is shown in Table J-1. This includes a central estimate of the cost of risk. Should the Scheme be part funded by the private sector through a PF2 contract, assumptions were made about the allocation of works and risks between the public and private sector. The final column of in Table J-1 shows the cost of works assumed to be retained (i.e. funded directly by the public sector) under a private finance contract. The preparation, supervision and land costs were assumed to be borne directly by the public sector irrespective of the financing option.

Table J-1: Estimated scheme costs through public sector funding, 2010 calendar year prices, factor cost unit of account

Year	Preparation	Supervision	Land	Works	
				Fully public sector funded	Retained under PF2
2018	£23,671,381				
2019	£32,816,305			£265,676	£265,676
2020	£17,143,985	£9,527,547		£8,135,483	£8,135,483
2021	£5,448,484	£11,821,132	£20,344,271	£119,377,261	£25,885,794
2022		£9,983,595		£288,122,859	£12,223,611
2023		£10,771,802		£301,402,713	£8,683,629
2024		£10,332,868		£196,370,212	£4,077,162
2025		£3,344,101		£153,118,771	£3,068,792
2026		£1,124,100		£38,678,390	£333,117

J.2.3 Highways England Commercial Services Division estimated operating and maintenance costs for the appraisal of the A303 Amesbury to Berwick Down scheme in constant 2016 Q1 prices in factor cost unit of account and provided an estimate of project specific inflation, together with the GDP deflator assumed in deriving cost estimates, as shown in Table J-2.

J.2.4 Should the project be financed under PF2 then some of the operating and maintenance costs of the new infrastructure were assumed to be retained by the public sector as shown in Table J-2. The costs that would no longer be incurred maintaining the existing A303 are shown in the penultimate column. These are included in the overall cost estimate under public sector funding. The final section shows the estimated cost of maintaining the section of the existing A303 between Longbarrow and Winterbourne Stoke which would continue to be used and maintained as part of the Scheme.

Table J-2: Estimated operating and maintenance costs, 2016 Q1 Factor prices

Year	Project specific inflation	GDP deflator	cost estimate	HE retained (under PF2)	Existing Carriageway	
					O & M costs	Winterbourne Stoke
2026	1.56	1.34	£5,507,348	£213,251	-£145,251	£17,077
2027	1.61	1.37	£5,507,348	£213,251	-£145,251	£17,077
2028	1.67	1.40	£5,457,263	£213,251	-£195,336	£17,077
2029	1.73	1.44	£5,999,680	£213,251	-£906,872	£17,077
2030	1.79	1.47	£4,601,955	£213,251	-£1,611,709	£22,938
2031	1.86	1.50	£4,773,794	£213,251	-£908,936	£22,938
2032	1.93	1.54	£6,786,804	£213,251	-£276,733	£23,571
2033	2.00	1.57	£6,803,890	£213,251	-£195,106	£38,066
2034	2.08	1.61	£8,032,698	£213,251	-£347,287	£204,035
2035	2.15	1.65	£17,227,773	£213,251	-£583,133	£370,004
2036	2.22	1.68	£7,920,349	£213,251	-£367,772	£183,679
2037	2.30	1.72	£8,455,562	£213,251	-£249,199	£19,450
2038	2.38	1.76	£5,988,544	£213,251	-£299,284	£20,010
2039	2.47	1.80	£5,794,873	£213,251	-£1,387,956	£42,411
2040	2.55	1.84	£6,789,743	£213,251	-£2,474,335	£70,673
2041	2.64	1.89	£5,677,590	£213,251	-£1,305,703	£45,898
2042	2.73	1.93	£5,518,411	£213,251	-£219,324	£38,203
2043	2.83	1.97	£5,580,144	£213,251	-£219,324	£52,698
2044	2.93	2.02	£7,742,833	£213,251	-£1,156,438	£290,849
2045	3.03	2.07	£22,684,876	£213,251	-£2,107,337	£529,001
2046	3.14	2.11	£9,089,818	£213,251	-£1,097,816	£270,493
2047	3.25	2.16	£5,468,148	£213,251	-£240,036	£32,975
2048	3.36	2.21	£5,499,690	£213,251	-£208,495	£32,975
2049	3.48	2.26	£7,822,697	£213,251	-£842,777	£35,335
2050	3.60	2.32	£14,761,438	£213,251	-£1,547,614	£41,196
2051	3.73	2.37	£5,605,281	£6,377,487	-£772,206	£41,196

Year	Project specific inflation	GDP deflator	cost estimate	HE retained (under PF2)	Existing Carriageway	
					O & M costs	Winterbourne Stoke
2052	3.86	2.42	£5,737,025	£5,804,394	-£67,369	£42,936
2053	3.99	2.48	£8,317,131	£8,386,728	-£69,598	£57,431
2054	4.13	2.54	£8,056,593	£8,343,845	-£287,252	£348,593
2055	4.28	2.59	£23,723,197	£24,246,294	-£523,098	£639,755
2056	4.43	2.65	£7,955,366	£8,263,103	-£307,737	£322,945
2057	4.58	2.72	£6,908,357	£7,000,733	-£92,377	£57,300
2058	4.74	2.78	£5,632,638	£5,775,101	-£142,462	£57,907
2059	4.91	2.84	£4,921,102	£5,775,101	-£853,998	£57,907
2060	5.08	2.91	£15,883,979	£17,442,814	-£1,558,835	£63,768
2061	5.26	2.97	£7,890,984	£8,747,046	-£856,062	£63,768
2062	5.44	3.04	£5,519,911	£5,798,725	-£278,813	£64,402
2063	5.63	3.11	£5,748,359	£5,945,545	-£197,186	£78,896
2064	5.83	3.18	£9,623,131	£9,757,137	-£134,007	£587,312
2065	6.03	3.26	£31,378,327	£31,532,818	-£154,492	£1,095,728
2066	6.24	3.33	£8,788,603	£8,938,935	-£150,332	£526,733
2067	6.46	3.41	£6,891,232	£7,041,564	-£150,332	£20,057
2068	6.69	3.49	£5,461,318	£5,661,736	-£200,417	£20,616
2069	6.92	3.57	£5,662,054	£6,951,143	-£1,289,089	£43,017
2070	7.16	3.65	£6,864,942	£9,240,410	-£2,375,468	£71,279
2071	7.42	3.73	£4,510,408	£5,717,244	-£1,206,836	£46,505
2072	7.68	3.82	£5,561,333	£5,681,790	-£120,457	£24,104
2073	7.94	3.91	£8,650,670	£8,771,127	-£120,457	£38,599
2074	8.22	4.00	£8,886,949	£9,229,465	-£342,517	£204,568
2075	8.51	4.09	£26,025,679	£26,604,042	-£578,363	£370,537
2076	8.81	4.18	£7,442,271	£7,877,907	-£435,637	£184,212
2077	9.12	4.28	£7,247,047	£7,636,745	-£389,697	£18,876
2078	9.43	4.38	£5,493,319	£5,851,475	-£358,156	£18,876
2079	9.76	4.48	£4,768,338	£5,758,696	-£990,358	£21,236
2080	10.11	4.58	£4,617,613	£6,312,808	-£1,695,195	£27,097
2081	10.46	4.69	£7,496,267	£8,416,055	-£919,788	£27,097
2082	10.83	4.79	£5,611,513	£5,826,464	-£214,951	£43,543
2083	11.21	4.90	£5,656,772	£5,873,951	-£217,179	£58,038
2084	11.60	5.02	£7,672,947	£8,822,834	-£1,149,887	£421,382
2085	12.00	5.13	£32,692,525	£35,723,726	-£3,031,201	£1,148,072

J.2.5 Drawing on the same assumptions about the allocation of cost and risk between public and private sectors, and making assumptions about financing and contracting costs, PwC provided an estimate of the unitary charge for the Scheme, in nominal factor prices on 26 July 2018. This also included an estimate of the corporation tax revenues.

J.3 Expressing costs in consistent 2010 values and prices

- J.3.1 Capital costs were provided deflated in 2010 factor prices. These costs were discounted using the standard Department for Transport discount rates. This assumes a discount rate of 3.5% per year between 2010 and 2026. As described in WebTAG Unit A1.2 'Scheme Costs', all costs should be reported in the market price unit account, inclusive of any indirect taxation. The discounted costs were therefore converted from factor cost unit of account to market price unit of account using the standard indirect tax adjustment factor of 1.19.
- J.3.2 Operating and Maintenance costs were provided in constant 2016 prices. These were inflated to be expressed in nominal prices using the project specific inflation assumption provided, deflated to 2010 prices using the specified GDP deflator to 2010 real prices. These costs were discounted using the standard Department for Transport discount rates. This assumes a discount rate of 3.5% per year between 2010 and 2048, thirty years following the scheme appraisal year of 2018, and 3.0% per year from 2049 through the remainder of the appraisal period. Finally the costs were expressed in market rather than factor prices.
- J.3.3 The unitary charge was provided in nominal prices. These were allocated to calendar years, depreciated to 2010 real prices using the specified GDP deflator, and discounted using standard Department for Transport discount rates and expressed in market prices.
- J.3.4 The costs for maintenance cost savings of the existing A303 carriageway were included as summarised in Table J-3.

Table J-3: Estimated scheme costs, discounted 2010 market prices, £m

Cost source	Funding	
	Public	PF2
Unitary charge	N/A	860.2
Capital Costs	970.3	179.8
Operating and Maintenance	231.4	124.0
Operating and Maintenance of existing A303 Carriageway	(included)	-18.5
Operating and Maintenance of Longbarrow-Winterbourne Stoke	3.8	3.8
Total	1205.5	1149.3
Corporation tax	N/A	-5.5

J.4 P10 and P90 cost estimates

- J.4.1 Highways England Commercial Services Division has included an allowance for risk and optimism bias in the scheme cost estimates. Both portfolio (programme) level risks – risks which affect all projects being developed by Highways England – and project specific risks have been considered and valued in accordance with the Highways England cost manual.
- J.4.2 Recognising that there is a degree of uncertainty inherent in estimating construction costs two separate cost range estimates have been produced, informed using the outputs of the risk assessment. These produce low and high cost forecasts: a P10 cost representing a lower bound cost estimate; and a P90 cost representing an upper bound cost estimate. These bounds indicate the values at which there is a 10% chance the cost will end up lower or higher than the cost estimate.
- J.4.3 The P10 and P90 capital expenditure was estimated by Highways England Commercial Services Division using the same methodology as was used to produce estimated capital expenditure estimates for the wholly publicly funded solution. The costs were supplied in 2010 prices in the factor cost unit of account and are shown in Table J-4 and Table J-5.

Table J-4: Estimated P10 capital costs, 2010 calendar year prices, factor cost unit of account

Year	P10 Capital Expenditure				
	Preparation	Supervision	Works	Land	Total
2018	£16,706,071				£16,706,071
2019	£23,160,098		£187,501		£23,347,599
2020	£12,099,363	£6,724,064	£5,741,615		£24,565,042
2021	£3,845,266	£8,342,761	£84,250,468	£14,357,964	£110,796,459
2022		£7,045,919	£203,342,627		£210,388,546
2023		£7,602,196	£212,714,880		£220,317,077
2024		£7,292,419	£138,588,222		£145,880,641
2025		£2,360,098	£108,063,530		£110,423,628
2026		£793,334	£27,297,263		£28,090,596
Total	£55,810,797	£40,160,791	£780,186,106	£14,357,964	£890,515,658

Table J-5: Estimated P90 capital costs, 2010 calendar year prices, factor cost unit of account

Year	P90 Capital Expenditure				
	Preparation	Supervision	Works	Land	Total
2018	£35,808,350				£35,808,350
2019	£49,642,127		£401,896		£50,044,023
2020	£25,934,178	£14,412,583	£12,306,769		£52,653,530
2021	£8,242,071	£17,882,152	£180,585,265	£30,775,338	£237,484,827
2022		£15,102,458	£435,851,372		£450,953,830
2023		£16,294,802	£455,940,172		£472,234,974
2024		£15,630,814	£297,054,620		£312,685,434
2025		£5,058,713	£231,626,976		£236,685,689
2026		£1,700,458	£58,509,863		£60,210,321
Total	£119,626,726	£86,081,979	£1,672,276,934	£30,775,338	£1,908,760,977

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